ANNEX 2 – COIMBRA MERTS

M01.03 – Executive summary

The rise in oil prices and the pressure for greater environmental sustainability in Public Transportation led the Municipal Public Transportation Services of Coimbra (SMTUC) to test the use of biofuel in their bus fleet. Within this measure SMTUC tested 3 different mixes (30%, 40%, and 50%) of biofuel in 4 buses running in real operational conditions in order to assess the possibility of supplying its entire fleet with this kind of fuel in the future.

The measure began with the design of the test model and was followed by personnel training. The tests started with a 30% biofuel mix and 10 % increments were conducted in each new test cycle, which lasted for about 25'000 km (about 5 months), coinciding with the scheduled maintenance of buses. The analysis at the end of the test period considered the quality of lubricant oils, fuel consumption, number of repairs and maintenance, performance evaluation, and emissions, and the following conclusions have been established:

- No perceptible problems occurred with the 4 buses that reached the objective of 50% of biofuel mix, during a running test period of 20 months and by covering about 100.000 km each one;
- The average operating costs of the 4 buses tested with B30 and B50 biofuel blends resulted to be lower than average operating costs of similar vehicles running on diesel for the same period. The difference has been more evident for B30, where the average operating costs in the ex-post have been 10% lower if compared with similar vehicles running on diesel.
- The use of biofuel as a blend with diesel may lead to some changes in emissions, but for NOx, and CO2 the biofuel revealed in general only a marginal effect. For a B30 blend the savings in the CO and PM emissions will be 20%.
- In the future, if B30 will be used in all vehicles of the SMTUC bus fleet (100 vehicles), the total PM emissions of the fleet in a given year may decrease from about 2,4 tPM/year to 2,0 tPM/year, representing an overall reduction of approximately 17% in terms of PM abatement.
- The hypothetical introduction of B30 in the entire SMTUC bus fleet could represent savings in operating costs around 420.000 €/year and the replacement of approximately 268.000 litres of diesel.

Additionally, an important finding of the tests has been that buses with common rail technology are not suited for the use of biofuels.

The full-scale experimentation for the majority of the SMTUC bus fleet and on regular public service is under consideration. In case the response will be affirmative, priority will be given to using biofuel resulting from recycled oils, such as cooking oils from the university complexes and the two central hospitals. Contacts with the municipal waste management service are also being established to assess the possibility of collecting these oils in the future.

A. Introduction

A1 Objectives

The measure objectives are:

(A) High level / longer term:

- To decrease air pollution;
- To decrease the dependence on fossil fuels.

(B) Strategic level:

- To improve the city's air quality;
- To replace the use of fossil fuels by biofuels.

(C) Measure level:

(1) To test, by running at least 10 cycles per bus, the reliability of increasing the percentages of biofuel mixes in 4 different models of Urban PT buses in order to surpass 25% of biofuel mix of SMTUC[1] fleet in the future.

(2) To demonstrate that the emissions of CO may decrease by 15% in PT vehicles in Coimbra.

(3) To carry out awareness campaigns to highlight the importance of using alternative fuels.

A2 Description

Since CIVITAS is a demonstration project, this measure was not limited to a "laboratory analysis" of biofuel usage; moreover a full scale experimentation on regular public service lines has been carried out.

SMTUC (urban public transportation operator) tested different mixes of biofuel in 4 buses (with specifications EURO 3 and EURO 4) running in real operational conditions in order to assess the possibility of supplying its entire fleet with this kind of fuel in the future. The area affected corresponds to the SMTUC network influence, which means, all the urban area and also great part of the municipality of Coimbra. The tests have been carried out by using biofuel blended with different percentages included between 30% and 50% in order to obtain, namely, the following trial information:

- Energy consumption and atmospheric pollution caused by emissions;
- Percentage of biofuel tolerated by conventional motors of different bus models and manufacturers;
- Economic comparison between the use of biofuel and conventional diesel.

The first phase consisted in the test set-up, definition of the data assessment, the testing methods, the testing equipment, as well as the trial planning.

Similar projects were analysed and a site visit to a PT operator with large experience in biofuel was carried out. Also biofuel experts and technical departments of higher education entities and biofuel suppliers have been assessed.

[1] Urban public transportation operator

Market analysis has been performed including the possibility of using a portion of recycled organic biofuel collected by the municipal waste management services in the various hospitals and university facilities.

In this phase it was also decided that the tests will be more ambitious than initially foreseen, namely by using B_{30}, B_{40} and B_{50} biofuel mix, and the adequate testing equipment and methodology have been defined.

Four recent types of buses were selected to perform the tests in urban and suburban conditions and the planning activities took place.

The trial phase has been divided into three stages in which different fuel mixtures have been tested, beginning with 30% and increasing by 10% the mix in each stage until reaching a maximum of 50% – i.e., B_{30}, B_{40}, and B_{50} biofuel mix. Fuel mix tests have been conducted every 25 thousand kms (roughly 5 months), which coincides with the scheduled maintenances of the fleet.

At the end of each stage, SMTUC conducted a sequence of analysis to determine the results of the experiment, namely:

- Quality of lubricant oils (carried out by the lubricant oil supplier);
- Fuel consumption evaluation;
- Number of repairs and maintenance;
- Performance evaluation (through driver surveys on bus performance);
- Analysis of emissions - (CO), (CO2), (NOX), and small particles (with the support of an engineering school).

The analysis to the quality of the lubricant didn't detected any symptoms of abnormal engine wear, as well as the buses performances seems to be normal in the drivers perception through the related surveys.

With B30 the two buses equipped with "common rail" technology in the diesel injection, had problems in this fuel feed system, forcing the stop of the tests for this type of buses. Considering that the biofuel tests only involved 4 buses, it was considered important to change these buses by other 2 buses equipped with different technology. The time needed to prepare these buses caused a gap between the initial buses running the tests and the new ones. To allow a more complete and effective monitoring of all buses it was decided to extended the tests until September 2012. This fact obliged to a consequent 4 month extension of the measure duration to comprise the evaluation tasks.

No perceptible problem occurred with the 4 buses that reached the objective of 50% of biofuel mix, 2 during 20 months and about 100.000 km each one.

To increase the awareness level of the measure the buses tested had promotional material on the left and the rear sides communicating that these vehicles were running with biofuel. Also awareness campaigns involving other regional fleet operators have been carried out.

B. Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **New policy instrument, national** – In Portugal a 5% biofuel integration of all diesel commercialised is compulsory by law. However, higher mixtures are rarely used due to the manufacturers' warranty limitations. A full-scale experimentation on regular public service lines will permit to raise these limits, changing present practices.

  This measure will have an important impact on the practice of the general state of the art in Portugal, due the tests with high percentages of biofuel (blends until 50% biofuel).

B2 Research and Technology Development

The research and technology development consisted mainly in knowledge acquisition and the Test Model Design: Definition of the testing methods, the data assessment, the testing equipment and the trial planning (buses used, percentage of mixture per stage, duration of each stage, etc.).

Analysis of similar projects and experiences, including a site visit to the Urban Transports Company of Braga (TUB), has been carried out to increase the knowledge level of SMTUC technicians on biofuel issues.

Contacts with experts in engineering schools and with biofuel suppliers have been also carried out, as well as market analyses.

The specifications of tests and adequate testing equipment were defined:

- The initial plan, which expected 20% biofuel mix for the starting level and increments of 1% in each test cycle, was abandoned because it was considered that it was not ambitious enough and difficult to assess changes between each step. Taking into consideration the knowledge acquired and the TUB results, 3 tests steps with B_{30}, B_{40} and B_{50} were considered more appropriate;
- It was also decided that each bus would have run in real operational conditions during 25.000 km (about 5 months) in each of the 3 steps of biofuel mix, which coincides with the scheduled maintenances of the fleet.
- Tests performed: Quality of lubricant oils (carried out by the lubricant oil supplier); Fuel consumption evaluation; Number of repairs and maintenance; Performance evaluation (through driver surveys on bus performance); Analysis of emissions (with the support of an engineering school).

After this stage the 4 buses to be tested were selected. Model details are reported in the following table:

Table B2.1 – Type of buses to be tested

Type of Bus	Make/Model
Bus (Euro 3)	Mercedes O 530 CITARO
	Volvo B7L
Bus (Euro 4)	Volvo B7LE – 2 Buses

The biofuel market and the SMTUC needs concerning this fuel were also studied: Possible biofuel distributors were contacted to obtain prices, quantities and availability. It was decided that the biofuel was supplied directly to the SMTUC installations, where it was stored in specially dedicated reservoirs. Previously a study on the average consumption of the chosen trial buses was conducted and it was verified that in 2009 they consumed around 9600 litres of diesel. Taking into consideration the monthly consumption of diesel, and supposing that the consumption of biofuel will be equivalent, the same amount of fuel was applied (altering only the mix ratio).

The following table identifies the amount of fuel (Diesel / Biofuel) necessary for each mixture:

Table B2.2 – Monthly consumption of fuel

Fuel mix	Monthly Consumption	
	Diesel	**Bio fuel**
B30	6.720 (L)	2.880 (L)
B40	5.760 (L)	3.840 (L)
B50	4.800 (L)	4.800 (L)

The supplying of fuel proceeded according to the following process: The regular diesel has been used as a reference and for the mixtures it has been stored in an existing reservoir on the SMTUC lot. In regards to the biofuel (B100), it has been delivered and stored in external reservoirs also at the SMTUC site. The desired mixture has then been done by using an automatic pump with a measurement device.

The following figures exemplify the delivery, mixture and fuelling processes.

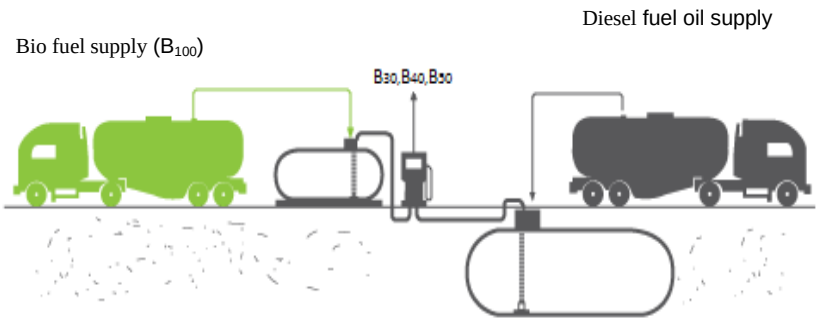


Figure B2.1 – Supplying the fuels and accomplishing the mixture

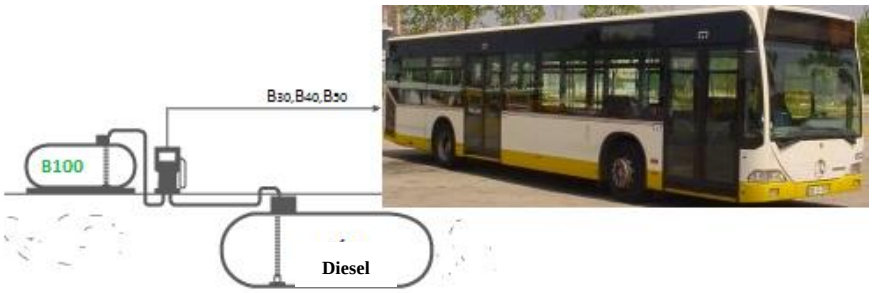


Figure B2.2 – Fuelling the Vehicles

The legislation in this field was also assessed: The reservoirs comply with the security norms in accordance with Class B1 and which are consecrated in the following Portuguese legal diplomas:

- Decree nº 36 270, 09 May, 1947
- Ordinance nº 131/2002, 09 February.

The fuelling process was in accordance with the national legislation in effect, namely:

- Decree nº 36270, 09 May, 1947;
- Ordinance nº 131/2002, 09 February;
- Ordinance nº 1188/2003, 10 October;
- Ordinance nº 1515/2007, 30 November;
- Decree nº 389/2007, 30 November.

The planning of the activities took into consideration also that the fuel mix stages must be balanced in order to have a representative sample of the routes and zones (urban and suburban) served by the SMTUC network.

It was also defined that no analysis to the wear in the motor and the injection system would be performed during each test stage due to the high costs associated with those tests. Accordingly, the monitoring of the engine performance and damages has been carried out in alternative and the maximum percentage for biofuel mixture was defined as 50% because beyond this limit the information available was scant and there was very little experience in other PT operators.

In this field the methodology to evaluate the measure impact was also carried out: An assessment of the available indicators was made, as well as the design of the necessary surveys. The methodology and equipment for the direct measurement of the buses emissions was also studied and a partnership with an engineering school of higher education has been defined to assure these instantaneous measurements (only for some of the gas emissions with the buses parked in the SMTUC garage).

Finally the risk management was assessed and the recovery actions / contingency plans were defined.

B3 Situation before CIVITAS

The rising price of oil and the detrimental consequences brought on by traffic pollution and energy inefficiencies have motivated authorities to implement more sustainable energy policies. The use of biofuel has been gaining considerable significance in the public transportation sector. However, in Portugal the use of biofuel is still relatively low.

Besides the 5% of bio diesel integration in all fuel oil commercialised in Portugal, generally little use of alternative fuels exists in fleets at national level.

In Coimbra, the situation is the same, though the Municipality has taken a first step in order to reverse the situation by buying a waste collection truck operated with Bio Diesel.

SMTUC, besides its commitment to the use of electric energy, through its fleet of trolley cars, electric mini-buses and buses with diesel-electric traction, is committed to transform its conventional bus fleet into energetically cleaner and efficient vehicles. This will anticipate, along the years, the legal deadlines to implement the measures proposed by several European Directives for Diesel Engines (Euro II, III and IV), but which never used natural gas or biofuel in their fleet.

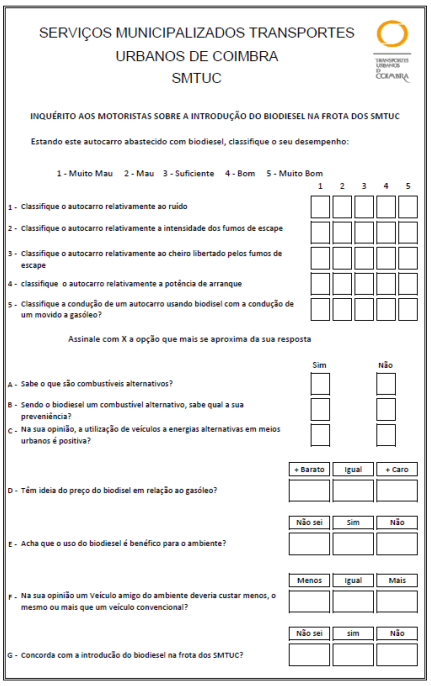
With this CIVITAS measure SMTUC intended to increase its knowledge on biofuel usage and verify if the tests with buses running in real operational condition fuelled by biofuel could demonstrate the environmental importance and the technical and economic feasibility for SMTUC to expand the use of Biofuel to a major part of its fleet.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Test model design *(October 2009 – September 2010) – Definition until August 2010 of the testing methods, the data assessment, the testing equipment, and the trial planning, namely:*

- *Analysis of similar projects and experiences, including a site visit to the Urban Transports Company of Braga. This company has a wide experience with biofuel, including the use of B_{100} in the daily service of public transportation for a long period.*
- *Contacts with experts and technical departments of higher education.*
- *Market analysis.*
- *Biofuel market experts and supplier consultation.*
  - *After prospecting market availability for biofuel, the supplier for the test phase selected is BIOMOVE. After the trial stage, the future supplier of biofuel will be chosen through public tender. However, there is the possibility of using a portion of recycled organic biofuel collected by the municipal waste management services (namely from the various Hospitals and University facilities).*
- *Definition of the types of tests and adequate testing equipment:*
  - *Biofuel mix will be 30% (B_{30}), 40% (B_{40}), and 50% (B_{50});*
  - *Tests to be performed to: Quality of lubricant oils); Fuel consumption evaluation; Number of repairs and maintenance; Performance evaluation (through driver surveys on bus performance – Fig. B4.1); Analysis of emissions.*



SERVIÇOS MUNICIPALIZADOS TRANSPORTES
URBANOS DE COIMBRA
SMTUC

INQUÉRITO AOS MOTORISTAS SOBRE A INTRODUÇÃO DO BIODIESEL NA FROTA DOS SMTUC

Estando este autocarro abastecido com biodiesel, classifique o seu desempenho:

1 - Muito Mau 2 - Mau 3 - Suficiente 4 - Bom 5 - Muito Bom

	1	2	3	4	5
1 - Classifique o autocarro relativamente ao ruído					
2 - Classifique o autocarro relativamente a intensidade dos fumos de escape					
3 - Classifique o autocarro relativamente ao cheiro libertado pelos fumos de escape					
4 - classifique o autocarro relativamente a potência de arranque					
5 - Classifique a condução de um autocarro usando biodisel com a condução de um movido a gasóleo?					

Assinale com X a opção que mais se aproxima da sua resposta

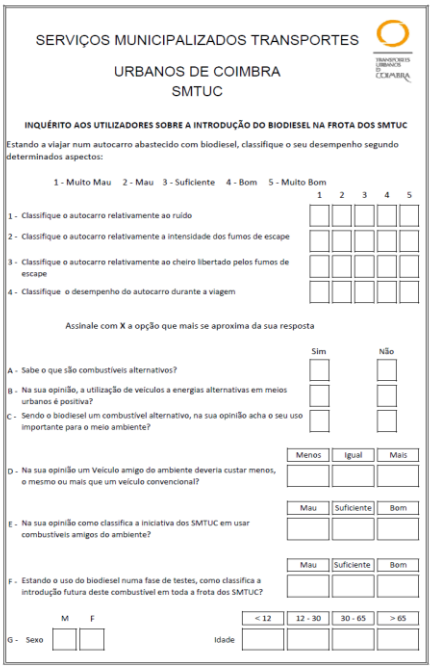
	Sim	Não
A - Sabe o que são combustíveis alternativos?		
B - Sendo o biodiesel um combustível alternativo, sabe qual a sua preveniência?		
C - Na sua opinião, a utilização de veículos a energias alternativas em meios urbanos é positiva?		

	+ Barato	Igual	+ Caro
D - Têm ideia do preço do biodisel em relação ao gasóleo?			

	Não sei	Sim	Não
E - Acha que o uso do biodiesel é benéfico para o ambiente?			

	Menos	Igual	Mais
F - Na sua opinião um Veículo amigo do ambiente deveria custar menos, o mesmo ou mais que um veículo convencional?			

	Não sei	sim	Não
G - Concorda com a introdução do biodiesel na frota dos SMTUC?			



SERVIÇOS MUNICIPALIZADOS TRANSPORTES
URBANOS DE COIMBRA
SMTUC

INQUÉRITO AOS UTILIZADORES SOBRE A INTRODUÇÃO DO BIODIESEL NA FROTA DOS SMTUC

Estando a viajar num autocarro abastecido com biodiesel, classifique o seu desempenho segundo determinados aspectos:

1 - Muito Mau 2 - Mau 3 - Suficiente 4 - Bom 5 - Muito Bom

	1	2	3	4	5
1 - Classifique o autocarro relativamente ao ruído					
2 - Classifique o autocarro relativamente a intensidade dos fumos de escape					
3 - Classifique o autocarro relativamente ao cheiro libertado pelos fumos de escape					
4 - Classifique o desempenho do autocarro durante a viagem					

Assinale com X a opção que mais se aproxima da sua resposta

	Sim	Não
A - Sabe o que são combustíveis alternativos?		
B - Na sua opinião, a utilização de veículos a energias alternativas em meios urbanos é positiva?		
C - Sendo o biodiesel um combustível alternativo, na sua opinião acha o seu uso importante para o meio ambiente?		

	Menos	Igual	Mais
D - Na sua opinião um Veículo amigo do ambiente deveria custar menos, o mesmo ou mais que um veículo convencional?			

	Mau	Suficiente	Bom
E - Na sua opinião como classifica a iniciativa dos SMTUC em usar combustíveis amigos do ambiente?			

	Mau	Suficiente	Bom
F - Estando o uso do biodiesel numa fase de testes, como classifica a introdução futura deste combustível em toda a frota dos SMTUC?			

	M	F
G - Sexo		

	< 12	12 - 30	30 - 65	> 65
Idade				

Fig. B4.1 – Driver Survey on bus performance

- *Test vehicle selection and test conditions definition:*
  - *4 recent types of buses were selected to perform the tests that will be carried out in urban and suburban conditions.*
- *Planning of the Activities.*

Stage 2: Training of test personnel *(July 2010 – September 2010) – Training of one technician and one skilled worker in bus engine behaviour analyses (including emissions and oils) and in the design and analysis of questionnaires for drivers of buses with biofuel mix.*

Stage 3: Biofuel Trials *(August 2010 – September 2012) – In a first phase a procedure for Biofuel supply and the purchase of equipment was launched, namely the reservoirs and fuel pump for the Biofuel mix and bus supply.*

The next step consisted in the installation and set-up of the infrastructure and equipment (fig. B4.2), namely:

- *Acquisition of biofuel reservoirs;*
- *Acquisition and installation of fuel pump;*
- *Installation of fuelling infrastructure (piping system);*
- *Provision for testing equipment installation in the SMTUC garage (equipment provided by local establishment of Higher Education, i.e., engineering school).*

Fig. B4.2 – Bus approaching the bio fuel refuelling area equipped with the reservoirs and pump. The bus has stickers informing that is running with bio fuel.

The trial phase has been divided into three periods in which different fuel mixtures have been tested, beginning with 30% and increasing the mix by 10% in each period until achieving a maximum of 50% – i.e., B_{30}, B_{40}, and B_{50} bio fuel mix. Fuel mix tests have been conducted every 25 thousand km (roughly 5 months), which coincides with the scheduled maintenances of the fleet.

The start-up of the tests occurred in February 2011 with the Biofuel mix at 30% (B30):

- *The replacement or cleaning of bus engine parts (engine feed system) in order to receive the biofuel mix has been carried out (Due to the biofuels cleansing properties, the bus engines and reservoirs must first be cleaned with biofuel in order to avoid clogging resulting from particles unleashed from the feed system).*
- *4 buses ran in real operational conditions in the entire SMTUC urban and suburban PT network*
- *The yield tests focused on the quality of lubricant oils (carried out by the lubricant oil supplier), fuel consumption evaluation, number of repairs and maintenance, performance evaluation (through driver surveys on bus performance), and analysis of emissions (with the support of an engineering school).*
- *The activity of monitoring of the tests has been also carried out and included surveys on bus performance and reliability carried out by the buses drivers.*
- *Two buses that have "common rail" technology in the diesel injection, had problems in this feed system, namely with "gel" in the filters and injectors, forcing the stoppage of the tests on 5th and 10th May 2011 (mix at 30%). The other 2 buses continued the tests without problems and the tests began with the Biofuel mix at 40% on 11th July 2011.*

The above mentioned methodology was also used with the 40% biofuel mix and with B_{50} after February 2012. To reach the initial and more significant sample, another 2 buses were added to the tests in replacement of the 2 stopped with problems in the "common rail" system.

The biofuel tests ended in September 2012 allowing for a large period and extension running of the tests. The analysis to the quality of the lubricant didn't detected any symptoms of abnormal engine wear, as well as the buses performances seems to be normal in the drivers perception through the related surveys.. So, no perceptible problem occurred with the 4 buses that reached the objective of 50% of biofuel mix, 2 during 20 months and about 100.000 km each one.

To increase the awareness level of the measure the buses in test had promotional material on the left side and in the rear communicating of the buses that they are running with biofuel. Also awareness campaigns have been carried out, involving other regional fleet operators.

B5 Inter-relationships with other measures

Measures 01.03 and 01.08 were grouped because they both have direct impact on SMTUC emissions. However, measure 01.08 is a feasibility study and therefore has no potential to generate impacts on SMTUC emissions during CIVITAS MODERN implementation. Thus, measure 01.08 is related to measure 01.03 but they are not identified as a bundling of measures for impact evaluation purpose.

- **Measure no. 01.08** – The production of renewable energies for trolleybus lines in Coimbra could have also impact on the SMTUC emissions if the results of the feasibility study will be positive and the generation of renewable energies will be implemented in the future.

C. Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1.1 – Considered Indicators.

No.	Impact	Indicator	Data used	Comments
1	Operating Costs	Average Operating Costs (€/vkm)	Total operational costs; Total vehicle-km	SMTUC Data
2	Fuel consumption	Average Vehicle fuel efficiency (MJ/vkm)	Total energy consumed; Total vehicle-km	SMTUC Data
3	Fuel consumption	Fuel Mix (% per type of fuel)	Energy consumption for the fuel considered; Total energy consumed	SMTUC Data
4	Emissions	Average CO Emissions (g CO/vkm)	Fuel; Vehicle; Diesel Consumption; Pollutant; Emission Factor	SMTUC Data Portuguese National and Informative Inventory Report 2012
5	Emissions	Average CO_2 Emissions (g CO_2/vkm)	Fuel; Vehicle; Diesel Consumption; Pollutant; Emission Factor	SMTUC Data Portuguese National and Informative Inventory Report 2012
6	Emissions	Average NOx Emissions (g NOx/vkm)	Fuel; Vehicle; Diesel Consumption; Pollutant; Emission Factor	SMTUC Data Portuguese National and Informative Inventory Report 2012
7	Emissions	Average PM Emissions (g PM/vkm)	Fuel; Vehicle; Diesel Consumption; Pollutant; Emission Factor	SMTUC Data Portuguese National and Informative Inventory Report 2012
8	Awareness	Awareness level – bus drivers	Total number of SMTUC bus drivers with knowledge of the measure; Total number of responding SMTUC bus drivers	SMTUC Data
9	Acceptance	Acceptance level – bus drivers	Total number of SMTUC bus drivers who favourably receive the measure; Total number of responding SMTUC bus drivers	SMTUC Data
10	Awareness	Awareness level - Marketing	Number of buses running with biofuel having sticker; Number of buses running with biofuel.	SMTUC Data

The biofuel tests have been carried out in 4 buses of different brands, running in operation conditions with 30%, 40% and 50% biofuel mixes. Each mix stage had a duration according to the maintenance program (25.000 km - 5 to 7 months) **and other 4 buses with the same brand, but fuelled with 100% mineral diesel, operated simultaneously in similar conditions** (buses tested and reference buses were all of the same series, so in addition to have the same brand, they have been purchased at same time and had similar mileages – between 371.483km and 376.770 km for series of Volvo B7L and between 557.097km and 594.729km for the other series). This procedure allowed the comparison between the scenario after measure implementation (ex-post) and the scenario in case the measure would have not been implemented (comparison between the ex-post and the business-as-usual scenario in similar conditions).

To allow the comparison between the ex-post scenario and the conditions before measure implementation (ex-ante scenario), **the recorded SMTUC data related to the 4 buses involved in the tests has been assessed**. This data refers to a complete 12 months set of indicators during the year before the beginning of the measure implementation **with these 4 buses fuelled with 100% mineral diesel**. The comparison for each blend has been carried out with similar periods in the baseline to mitigate the effect of the seasonality.

This methodology allowed the assessment of the measure impacts on indicators 1 to 7, the comparison with the baseline and business-as-usual (BAU) scenarios, but the comparison between different mixes wasn't convenient because the tests periods were different (the weather variations have influence in the performance of engines powered by biofuel). This situation has been aggravated by the fact that the composition of the brand of the 4 buses tested changed from the B30 stage to the B50 stage. In fact 2 buses equipped with "common rail" technology in the injectors stopped the tests 3 months after the tests began, due to problems in the fuel feed system caused by the biofuel use. The 2 buses have been changed by other 2 buses of different brand, but having consequent different impacts too. Any case this problem hadn't influence in the comparison Ex-post – Ex-ante or Ex-post – BAU because the reference buses have been also changed in accordance.

The detailed description of the indicator methodologies is as follows:

- **Indicator 1 (*Average Operating Costs*)** – Ratio of total operating costs incurred in the operation of the 4 vehicles being tested with biofuel, divided by the total number of vehicle-km of these 4 vehicles (€/vehicle-km).

  A = B / C, where:

  - ✓ A = Average operational costs for the bus service (€/vehicle-km).
  - ✓ B = Total operational costs of the 4 vehicles being tested, including fuel consumption and maintenance costs with material and personnel (€).
  - ✓ C = Total vehicle-km performed by the 4 vehicles being tested.

  Both data are related to the 4 vehicles being tested, excepted for the BAU scenario, in which 4 reference buses has been used, all operating in similar public transport network conditions. The reference buses have the same brands of the buses being tested and operated simultaneously. For the baseline and BAU scenario the buses has been fuelled with 100% mineral diesel. Results from the total operational costs have origin in SMTUC regular procedure of registering its expenditures with fuel consumption and other related operating costs like maintenance costs (including material and personnel costs). The number of vehicle-kilometres, results from the subtraction of non-performed trips data to the scheduled ones. The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 2 (*Vehicle fuel efficiency*)** – Ratio of energy consumed by the 4 vehicles being tested, divided by the total number of vehicle-km of these 4 vehicles (MJ/vehicle-km).

  A = B / C, where:

  ✓ A = Average vehicle efficiency (MJ/vehicle-km)

  ✓ B = Total energy consumed by the 4 vehicles being tested (MJ)

  ✓ C = Total vehicle-km performed by the 4 vehicles being tested

  All data are related to the 4 vehicles being tested, excepted for the BAU scenario, in which 4 reference buses has been used, all operating in similar public transport network conditions. The reference buses have the same brands of the buses being tested and operated simultaneously. For the baseline and BAU scenario the buses has been fuelled with 100% mineral diesel. Results from energy consumption by the SMTUC bus vehicles is metered using SMTUC regular procedure of registering fuel consumption by these vehicles every time each vehicle is fuelled and converting it into total energy consumption using bibliographic sources. The number of vehicle-kilometres, results from the subtraction of non-performed trips data to the scheduled ones. The data reliability is maximised due to an objective data collection among SMTUC records on performed trips, which in turn are recorded following reliable procedures. In fact, each driver registers the trips performed, being the extension of the trip recognized. The number of trips is validated by the software of the Automatic Vehicle Management system that gives back up to the network operation.

- **Indicator 3 (*Fuel Mix*)** – Percentage of the market share of transport fuel for each type of fuel used in a given period (%).

  A = B / C × 100, where

  ✓ A = Fuel mix, or percentage for the fuel considered (%)

  ✓ B = Total energy consumption for the fuel considered (MJ)

  ✓ C = Total energy consumed for all SMTUC vehicles (MJ)

  All data are related to the SMTUC fleet. Results from energy consumption by the SMTUC fleet is metered using SMTUC regular procedure of registering fuel consumption for each type of fuel every time each vehicle is fuelled and converting it into total energy consumption using bibliographic sources. The data reliability is maximised due to an objective data collection.

- **Indicator 4 (*CO Emissions*)** – Average CO emissions per vehicle-km (g CO/vehicle-km)

  A = B / C, where:

  ✓ A = Average CO emissions per vehicle-km (g/vehicle-km)

  ✓ B = Total CO emissions of the 4 vehicles being tested (g)

  ✓ C = Total vehicle-km performed by the 4 vehicles being tested

All data are related to the 4 buses being tested, excepted for the BAU scenario, in which 4 reference buses has been used, all operating in similar public transport network conditions. The reference buses have the same brands of the buses being tested and operated simultaneously. For the baseline and BAU scenario the buses has been fuelled with 100% mineral diesel.

The calculation of total CO emissions is based on country data given by the Portuguese Environment Agency (Portuguese National Inventory and Informative Report on Greenhouse Gases, 2012). More precisely, it was used a CO implied emission factor, expressed in kg/MJ, that according to the Portuguese Environment Agency was determined using a Tier 3 methodology (based model with COPERT).

Data from vehicle-kilometres performed by SMTUC vehicles is coming from report reading. Results from vehicle-kilometres come from the subtraction of non-performed trips data to the scheduled ones. The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 5 (CO_2 Emissions)** – Average CO_2 emissions per vehicle-km (gCO_2/vehicle-km)

  A = B / C, where:

  - ✓ A = Average CO_2 emissions per vehicle-km (g/vehicle-km)
  - ✓ B = Total CO_2 emissions of the 4 vehicles being tested (g)
  - ✓ C = Total vehicle-km performed by the 4 vehicles being tested

  All data are related to the 4 buses being tested, excepted for the BAU scenario, in which 4 reference buses has been used, all operating in similar public transport network conditions. The reference buses have the same brands of the buses being tested and operated simultaneously. For the baseline and BAU scenario the buses has been fuelled with 100% mineral diesel.

  The calculation of total CO_2 emissions is based on country data given by the Portuguese Environment Agency (Portuguese National Inventory and Informative Report on Greenhouse Gases, 2012). More precisely, it was used a CO_2 implied emission factor, expressed in kg/MJ, that according to the Portuguese Environment Agency was determined using a Tier 3 methodology (based model with COPERT).

  Data from vehicle-kilometres performed by SMTUC vehicles is coming from report reading. Results from vehicle-kilometres come from the subtraction of non-performed trips data to the scheduled ones. The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 6 (*NOx Emissions*)** – Average NOx emissions per vehicle-km (gNOx/vehicle-km)

  A = B / C, where:

  - ✓ A = Average NOx emissions per vehicle-km (g/vehicle-km)

- ✓ B = Total NOx emissions of the 4 vehicles being tested (g)
- ✓ C = Total vehicle-km performed by the 4 vehicles being tested

All data are related to the 4 buses being tested, excepted for the BAU scenario, in which 4 reference buses has been used, all operating in similar public transport network conditions. The reference buses have the same brands of the buses being tested and operated simultaneously. For the baseline and BAU scenario the buses has been fuelled with 100% mineral diesel.

The calculation of total NOx emissions is based on country data given by the Portuguese Environment Agency (Portuguese National Inventory and Informative Report on Greenhouse Gases, 2012). More precisely, it was used a NOx implied emission factor, expressed in kg/MJ, that according to the Portuguese Environment Agency was determined using a Tier 3 methodology (based model with COPERT).

Data from vehicle-kilometres performed by SMTUC vehicles is coming from report reading. Results from vehicle-kilometres come from the subtraction of non-performed trips data to the scheduled ones. The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 7 (*Small Particulate Emissions*)** – Average Small Particulate emissions per vehicle-km (g/vehicle-km)

A = B / C, where:

- ✓ A = Average Small Particulate emissions per vehicle-km (g/vehicle-km)
- ✓ B = Total Small Particulate emissions of the 4 vehicles being tested (g)
- ✓ C = Total vehicle-km performed by the vehicles being tested

All data are related to the 4 buses being tested, excepted for the BAU scenario, in which 4 reference buses has been used, all operating in similar public transport network conditions. The reference buses have the same brands of the buses being tested and operated simultaneously. For the baseline and BAU scenario the buses has been fuelled with 100% mineral diesel.

The calculation of total PM emissions is based on country data given by the Portuguese Environment Agency (Portuguese National Inventory and Informative Report on Greenhouse Gases, 2012). More precisely, it was used a PM implied emission factor, expressed in kg/MJ, that according to the Portuguese Environment Agency was determined using a Tier 3 methodology (based model with COPERT).

Data from vehicle-kilometres performed by SMTUC vehicles is coming from report reading. The number of vehicle-kilometres, results from the subtraction of non-performed trips data to the scheduled ones. The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 8** (*Awareness level – bus drivers*) – Percentage of the SMTUC bus drivers with knowledge of the measure on account of provided information (%).

  A = B / C × 100, where:

  - ✓ A = Percentage of bus drivers with knowledge of the measure (%)
  - ✓ B = Total number of respondents with knowledge of the measure
  - ✓ C = Total number of respondents

  The Awareness level of the measure is measured through a Survey, set up to measure the Awareness and Acceptance Level of the SMTUC bus drivers.

  This survey is composed of specific questions that resume the bus driver's attitude towards the actions undertaken on the scope of the measure. The first survey has been carried out to the entire SMTUC bus drivers (284) from 2nd November 2009 to 11th December 2009, before measure start, and the survey was repeated from 7th November 2011 to 16th December 2011, when all SMTUC bus drivers (281) had experienced the driving of buses running with biofuel. The surveys were delivered directly to each driver and were accompanied with direct contacts made to promote its success. Concerning the ex-ante survey 176 responses has been received back from the 284 inquired and in relation to the 281 ex-post surveys 193 responses has been received back.

- **Indicator 9** (*Acceptance level - bus drivers*) – Percentage of the SMTUC bus drivers who favourably receive the measure (%).

  A = B / C, where:

  - ✓ A = Percentage of bus drivers who favourably receive the measure (%)
  - ✓ B = Total number of respondents who favourably receive the measure
  - ✓ C = Total number of respondents

  The Acceptance level of the measure is measured through a Survey, set up to measure the Awareness and Acceptance Level of the SMTUC bus drivers.

  This survey is composed of specific questions that resume the bus driver's attitude towards the actions undertaken on the scope of measure. The first survey has been carried out to the entire SMTUC bus drivers from 2nd November 2009 to 11th December 2009, before measure start, and the survey was repeated from 7th November 2011 to 16th December 2011, when all SMTUC bus drivers had experienced the driving of buses running with biofuel. The surveys were delivered directly to each driver and were accompanied with direct contacts made to promote its success.

- **Indicator 10** (*Awareness level – marketing*) – Percentage of the vehicles being tested that have a sticker communicating that the bus is running with biofuel (%).

  A = B / C, where:

  - ✓ A = Percentage of vehicles being tested that have a sticker communicating the use of biofuel (%)

- ✓ B = Total number of vehicles being tested that have a sticker communicating the use of biofuel
- ✓ C = Total number of vehicles being tested with biofuel.

C1.2 Establishing a Baseline

In order to verify the achievement of the targets associated with the measure implementation, for the indicators 1 to 7 it was established a baseline, **using ex-ante recorded data of the 4 buses being tested** (with specifications EURO 3 and EURO 4 fuelled 100% mineral diesel) from January 2010 to January 2011, just before the beginning of the start-up tests with the Biofuel mix at 30% (B30), in February 2011.

To mitigate the seasonality effect, the baseline has been split in 3 periods that corresponds each one to the similar periods used later to test each biofuel blend in these buses. This methodology **allowed later the comparison of the impacts of the use of biofuel blends in the same buses running previously with mineral diesel in similar conditions**. For example, for the baseline of the tests with B30 fuel mix carried out from February 2011 to June 2011 has been selected the recorded data of the same buses running with 100% mineral diesel from February 2010 to July 2010.

The evaluation of the measure results are based on the SMTUC operational records and particular data required for indicators presented in point C1.1, with exception of the indicators 8 and 9, for which was used a drivers survey carried out by SMTUC, in order to assess the measure acceptance level by the buses drivers. As mentioned above, the emissions were determined using country data given by the Portuguese Environment Agency (Portuguese National Inventory and Informative Report on Greenhouse Gases, 2012). More precisely, it was used implied emission factors for diesel, expressed in kg/MJ, that according to the Portuguese Environment Agency were determined using the Tier 3 methodology (based model with COPERT). So the emissions has been calculated using the fuel consumption and the correct emission factors.

The next table shows the emission factors that were used for emissions calculations (Ex-Ante and Business As Usual), taking into consideration the vehicle type (bus) and the fuel (diesel).:

Table C1.2.1: Emission Factors, Diesel.

Pollutant	**Emission Factors (kg/MJ)**
CO	0,0001732
CO_2	0,074
NOx	0,0007429
PM	0,0000223

Source: Portuguese Environmental Agency, 2012.

The results of the baseline, for each indicator, are presented in the following specific tables:

Indicator 1: Average Operating Costs

Table C1.2.2: Average Operating Costs (€/vkm), Ex-Ante.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Fuel Consumption Costs (€) [1]	42.908	49.933	58.005
Maintenance costs with personnel (€) [2]	3.455	4.906	4.434
Maintenance costs with material (€) [3]	8.406	11.936	10.788
Total costs (€) 4 = [1+2+3]	54.769	66.774	73.227
Total vehicle-km (vkm) [5]	109.017	120.756	148.190
Average Fuel Costs (€/vkm) [1/5]	0,394	0,414	0,391
Average operating costs (€/vkm) [4/5]	**0,502**	**0,553**	**0,494**

Indicator 2: Average Vehicle fuel efficiency

Table C1.2.3: Average Vehicle fuel efficiency (MJ/vkm), Ex-Ante.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Total energy consumed by the vehicles (MJ) [1]	1.777.544	2.018.953	2.416.273
Total vehicle-km (vkm) [2]	109.017	120.756	148.190
Average Fuel Efficiency (MJ/vkm) [1/2]	**16,305**	**16,719**	**16,305**

Indicator 3: Fuel Mix

Table C1.2.4: Fuel Mix (% per type of fuel), Ex-Ante.

Indicator and Data Used (SMTUC bus fleet)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Total Energy consumed by the Diesel vehicles (MJ)	45.056.215	53.348.939	63.177.078
Total Energy consumed by the Biofuel vehicles (MJ)	0	0	0
Total Energy consumed by the Electric vehicles (MJ)	1.222.186	721.674	1.587.409
Fuel Mix		**-**	**-**
- Diesel %	**97,36%**	**98,67%**	**97,55%**
- Biofuel %	**0,00%**	**0,00%**	**0,00%**
- Electric %	**2,64%**	**1,33%**	**2,45%**

Indicator 4: Average CO Emissions

Table C1.2.5: Average CO emissions per vehicle-km (g CO/vkm), Ex-Ante.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Total energy consumed by the vehicles (MJ) [1]	1.777.544	2.018.953	2.416.273
Emission Factor (kg CO/MJ) [2]	0,0001732		
Total CO emissions of the vehicles (g) [3=1x2]	307.871	349.683	418.499
Total vehicle-km (vkm) [4]	109.017	120.756	148.190
Average CO emissions per vehicle-km (g CO/vkm) [3/4]	**2,824**	**2,896**	**2,824**

Indicator 5: Average CO_2 Emissions

Table C1.2.6: Average CO_2 emissions per vehicle-km (g CO_2/vkm), Ex-Ante.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Total energy consumed by the vehicles (MJ) [1]	1.777.544	2.018.953	2.416.273
Emission Factor (kg CO_2/MJ) [2]	0,074		
Total CO_2 emissions of the vehicles (g) [3=1x2]	131.538.271	149.402.492	178.804.224
Total vehicle-km (vkm) [4]	109.017	120.756	148.190
Average CO_2 emissions per vehicle-km (g CO_2/vkm) [3/4]	**1.206,585**	**1.237,226**	**1.206,588**

Indicator 6: Average NOx Emissions (g NOx/vkm)

Table C1.2.7: Average NOx emissions per vehicle-km (g NOx/vkm), Ex-Ante.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Total energy consumed by the vehicles (MJ) [1]	1.777.544	2.018.953	2.416.273
Emission Factor (kg NOx/MJ) [2]	0,0007429		
Total NOx emissions of the vehicles (g) [3=1x2]	1.320.538	1.499.880	1.795.049
Total vehicle-km (vkm) [4]	109.017	120.756	148.190
Average NOx emissions per vehicle-km (g NO_x/vkm) [3/4]	**12,113**	**12,421**	**12,113**

Indicator 7: Average PM Emissions (g PM/vkm)

Table C1.2.8: Average PM emissions per vehicle-km (g PM/vkm), Ex-Ante.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Total energy consumed by the vehicles (MJ) [1]	1.777.544	2.018.953	2.416.273
Emission Factor (kg PM/MJ) [2]	0,0000223		
Total PM emissions of the vehicles (g) [3=1x2]	39.639	45.023	53.883
Total vehicle-km (vkm) [4]	109.017	120.756	148.190
Average PM emissions per vehicle-km (g PM/vkm) [3/4]	**0,364**	**0,373**	**0,364**

Indicator 8: Awareness level – bus drivers

Taking into account that for the considered baseline, the measure was not in implementation yet, the awareness level, defined as the % of the number of bus drivers with knowledge of the measure in the universe of total responding operators, must be equal to 0%.

Indicator 9: Acceptance level - bus drivers

The acceptance level was quantified by means of a survey carried out by SMTUC between 2 November 2009 and 11 December 2009, with a question placed to all buses drivers (284): "Do you agree with the introduction of biofuel in fleet of SMTUC?". It must be clear that the acceptance level in the baseline was measured between Nov 2009-Dec 2009, well before the beginning of the measure implementation.

The next table shows the Acceptance level of the SMTUC bus drivers before the measure implementation.

Table C1.2.9: Acceptance level (%), Ex-Ante.

Indicator and Data Used	Time Period	Ex-Ante Values
Number of Positive Answers to the Question "Do you agree with the introduction of biofuel in fleet of SMTUC?" [1]	2 Nov 2009- 11 Dec 2009	118
Total number of responding bus drivers [2]		176
Acceptance level (%) [1/2]		**67,05**

Indicator 10: Awareness level - marketing

For the same motive stated for indicator 8, the awareness level - marketing for the considered baseline must be equal to 0% (no buses could had the sticker communicating that they run with biofuel before the biofuel usage).

C1.3 Building the Business-as-Usual scenario

As mentioned in the Project Evaluation Plan document, the business as usual (BAU) scenario should consider the possible autonomous city development if a certain measure is not going to be implemented. For this measure particular case, the BAU is used to predict what would have happened in terms of possible adoption of biofuel blends for PT fleet if the measure would not have been implemented.

The CIVITAS MODERN was crucial to implement the testing of biofuel in SMTUC buses and without it, the testing would never take place within the period of the project. Taken into account that without CIVITAS no intervention would be foreseen, the BAU scenario will describe the autonomous trend to be followed by each of the indicators presented above, considering that in the BAU scenario, the 4 vehicles being tested would have run on 100% diesel instead of a biofuel mix.

The methodology used for the calculation of the emissions is similar to the one used for the baseline.

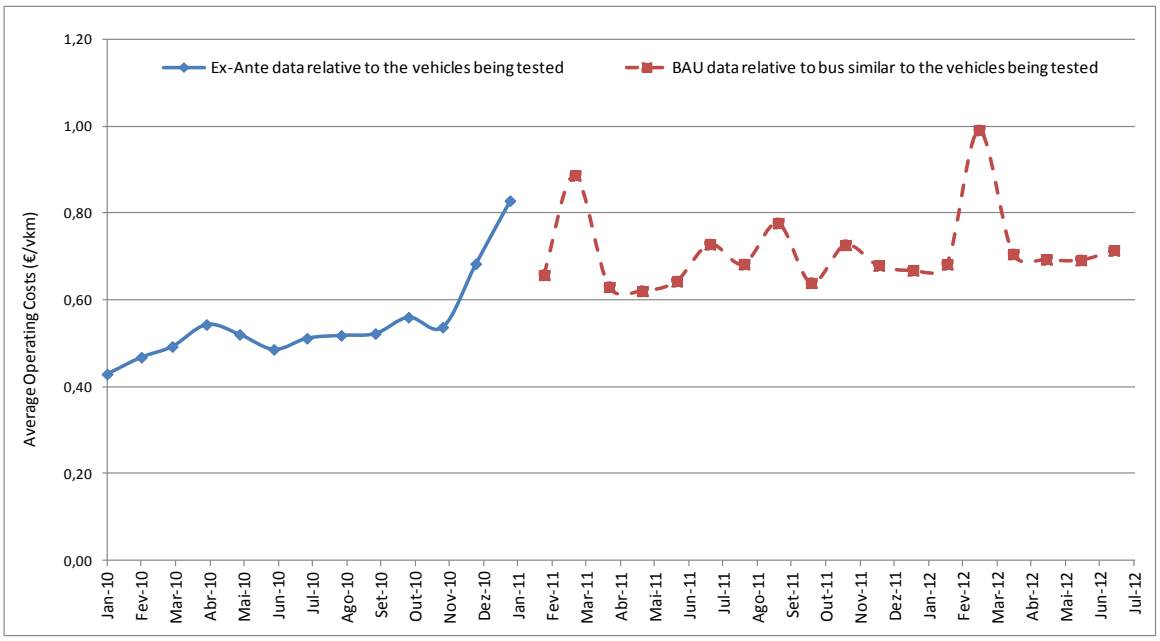
Indicator 1: Average Operating Costs

The BAU is in fact the average operating costs of 4 buses similar to the 4 vehicles being tested (same brand and series), running simultaneously and in similar operation conditions, but fuelled only on diesel instead of a biofuel mix. The BAU includes data registered in the period after the measure implementation, more precisely after Jan 2011 when the first buses where tested with B30, and the subsequent periods were coincident with the periods of the tests for each biofuel blend.

It is considered that there are no effects of other factors that may have influence in this indicator. In this case the BAU is just the real evolution of the baseline situation for 4 buses similar to the 4 vehicles being tested with biofuel during the same period, but consuming only diesel.

The same kind of rational was applied to the indicators of energy and emissions, taking into consideration the specific data used for calculation purposes.

The following Graph and tables, present Ex-Ante data and BAU associated to indicator 1 – Average Operating Costs.



Graph C1.3.1– Evolution of the average operating costs (€/vkm) of the vehicles being tested, Ex-ante and BAU scenario (Jan 2010 – Jul 2012).

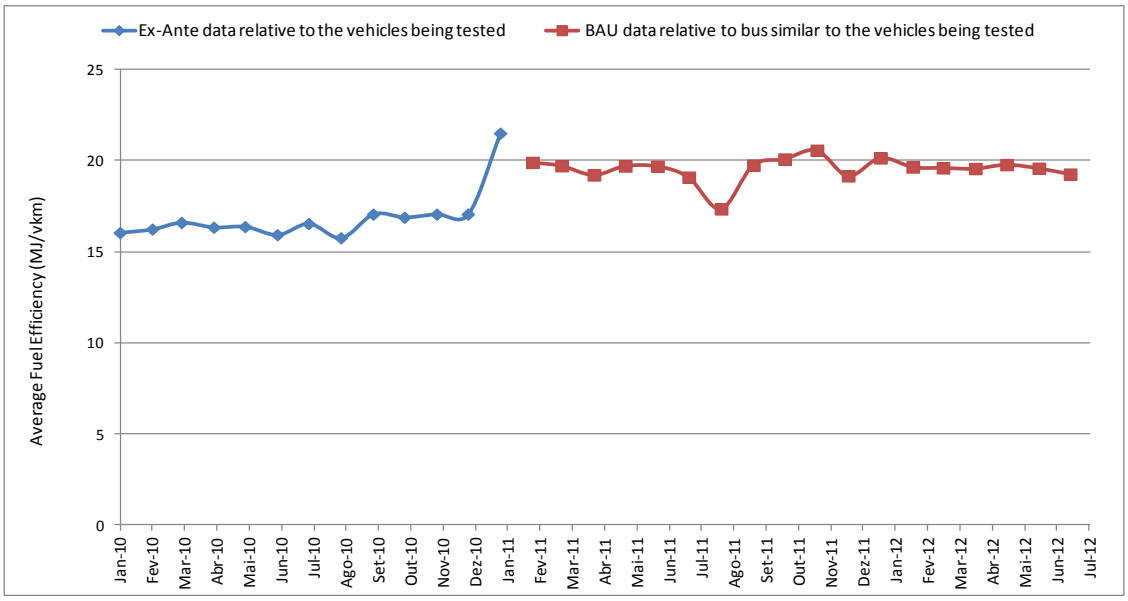
Overall the BAU trend reflects the increase of fuel and maintenance costs. This fact is particular evident in March 2011 and March 2012 where the maintenance costs, both for material and personnel, are higher in comparison with other months, but similar to January 2011 (ex-ante), and results mainly from regular engine revisions made each 25.000 Km (moment also used by SMTUC for change the biofuel mix). The BAU comprises 3 periods between Feb 2011 and July 2012, each one equal to the correspondent period for the specific bio fuel blend to allow the comparison with results achieved in homologous months of the ex-post period.

Table C1.3.1: Average Operating Costs (€/vkm), BAU.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12
Fuel Consumption Costs (€) [1]	48.194	52.715	64.444
Maintenance costs with personnel (€) [2]	2.714	3.704	5.961
Maintenance costs with material (€) [3]	8.089	9.875	9.533
Total costs (€) 4 = [1+2+3]	58.997	66.293	79.937
Total vehicle-km (vkm) [5]	85.969	93.827	108.748
Average fuel costs (€/vkm) [1/5]	0,561	0,562	0,593
Average operating costs (€/vkm) [4/5]	**0,686**	**0,707**	**0,735**

Indicator 2: Average Vehicle fuel efficiency

The same kind of rational was applied for establishing the BAU of the Average Vehicle fuel efficiency and the data is shown in Graph C1.3.2 and in the following tables.



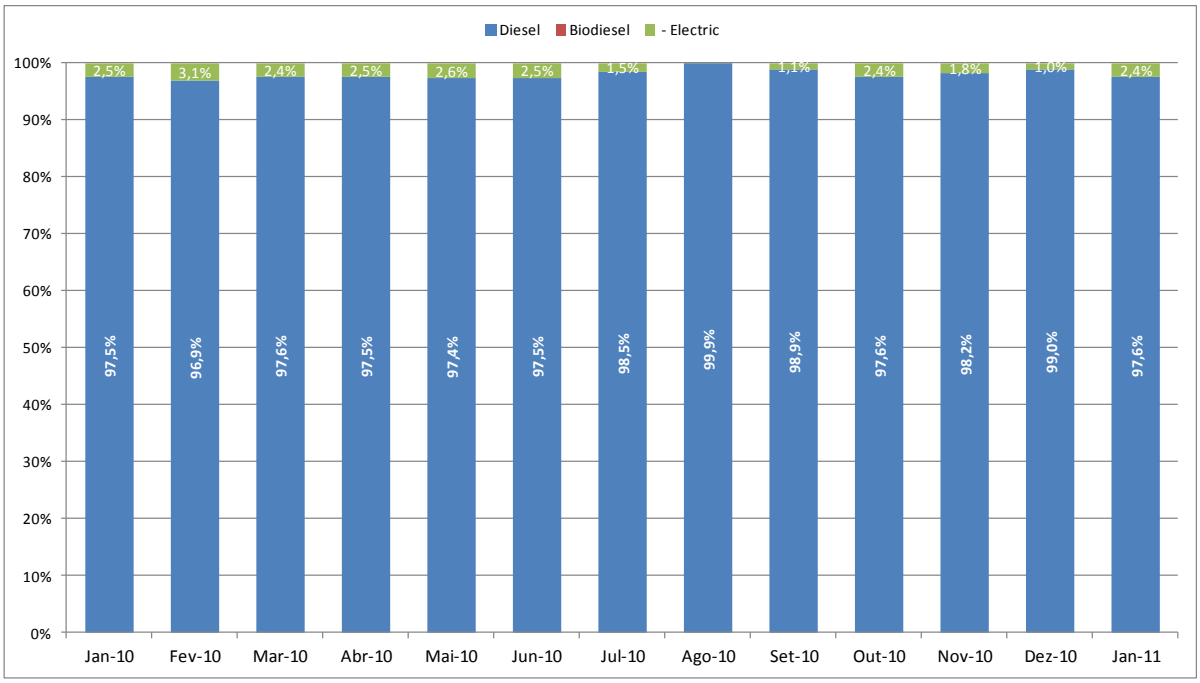
Graph C1.3.2 - Evolution of the average fuel efficiency (MJ/vkm) of the vehicles being tested, Ex-Ante and BAU scenario (Jan 2010 – Jul 2012).

Table C1.3.2: Average Vehicle fuel efficiency (MJ/vkm), BAU.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.688.733	1.824.193	2.139.196
Total vehicle-km (vkm) [2]	85.969	93.827	108.748
Average Fuel Efficiency (MJ/vkm) [1/2]	**19,644**	**19,442**	**19,671**

Indicator 3: Fuel Mix

If the measure had not been implemented, the BAU would have followed the same trend of the baseline, which means that the contribution of the biofuel to the SMTUC fuel mix would have continued to be null, and the diesel would have probably kept the main role, with percentages in fuel mix above 96%, and with a minor contribution of the electric vehicles, between 1-2,5% (Graph C1.3.3).



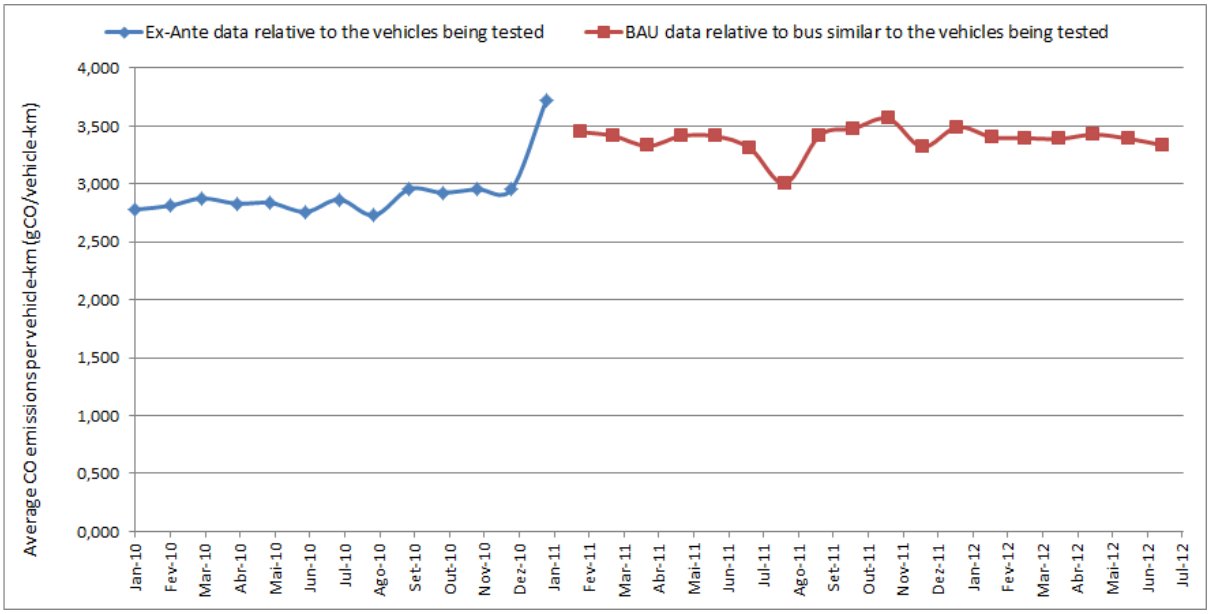
Graph C1.3.3 - Evolution of the fuel mix (% of type of fuel) of the SMTUC bus fleet, Ex-Ante and BAU scenario (Jan 2010 – Jul 2012).

Indicator 4 (CO Emissions)

For this indicator, the BAU is represented by the emissions associated with diesel consumption of 4 buses similar to the 4 vehicles being tested with biofuel in terms of technology, given the fact that if the measure had not been implemented this would have been the real situation.

In addition, the BAU scenario assumes that the 4 vehicles being tested with biofuel would not be replaced for another technology with lower emission factors.

Considering this criteria, for the BAU, the average CO emissions per vehicle km (vehicles running on diesel), are presented in , Graph C1.3.4 and Table C1.3.3



Graph C1.3.4 - Evolution of the average CO emissions per vehicle km of the vehicles being tested, Ex-Ante and BAU scenario (Jan 2010 – Jul 2012).

Table C1.3.3: Average CO emissions per vehicle-km (g CO/vkm), BAU.

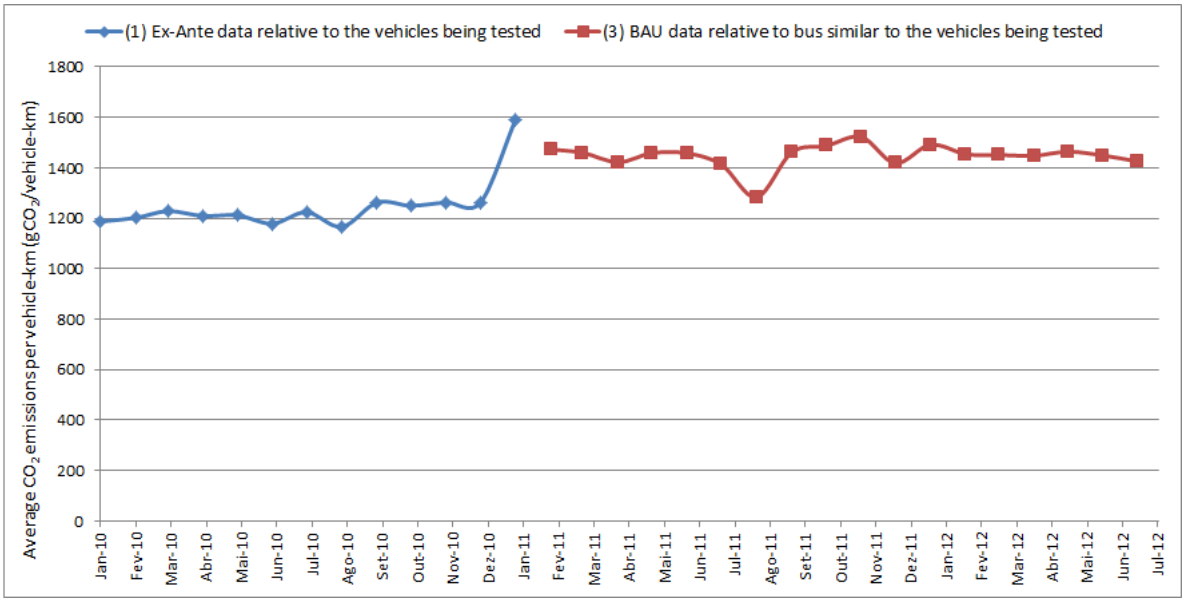
Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.688.733	1.824.193	2.139.196
Emission Factor (kg CO/MJ) [2]	0,0001732		
Total CO emissions of the vehicles (g) [3=1x2]	307.871	349.683	418.499
Total vehicle-km (vkm) [4]	85.969	93.827	108.748
Average CO emissions per vehicle-km (g CO/vkm) [3/4]	**3,402**	**3,367**	**3,407**

Indicator 5 (CO_2 Emissions)

For this indicator, the BAU is represented by the emissions associated with diesel consumption of 4 buses similar to the 4 vehicles being tested with biofuel in terms of technology, given the fact that if the measure was not implemented that will be the real situation.

In addition, the BAU scenario assumes that 4 vehicles being tested with biofuel will not be replaced for another technology with lower emission factors.

Considering this criteria, for the BAU, the average CO_2 emissions per vehicle km (vehicles running on diesel), are presented in , Graph C1.3.5 and Table C1.3.4



Graph C1.3.5 - Evolution of the average CO_2 emissions per vehicle km of the vehicles being tested, Ex-Ante and BAU scenario (Jan 2010 – Jul 2012).

Table C1.3.4: Average CO_2 emissions per vehicle-km (g CO_2/vkm), BAU.

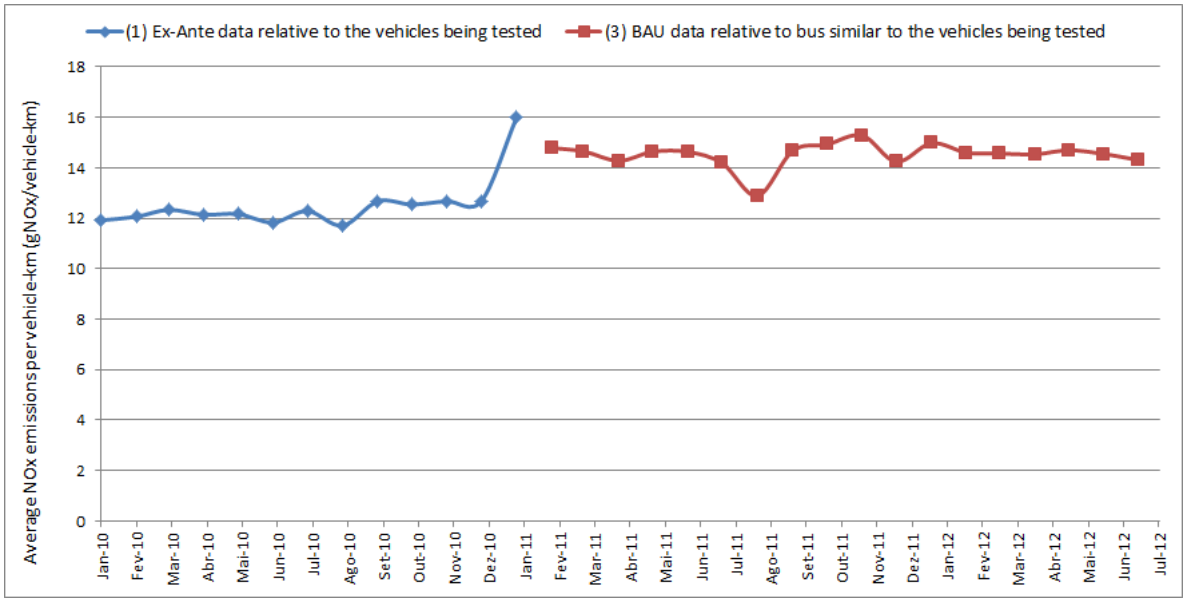
Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.688.733	1.824.193	2.139.196
Emission Factor (kg CO_2/MJ) [2]	0,074		
Total CO_2 emissions of the vehicles (g) [3=1x2]	124.966.253	134.990.273	158.300.500
Total vehicle-km (vkm) [4]	85.969	93.827	108.748
Average CO_2 emissions per vehicle-km (g CO_2/vkm) [3/4]	1.453,620	1.438,715	1.455,664

Indicator 6 (NOx Emissions)

For this indicator, the BAU is represented by the emissions associated with diesel consumption of 4 buses similar to the 4 vehicles being tested with biofuel in terms of technology, given the fact that if the measure was not implemented that will be the real situation.

In addition, the BAU scenario assumes that 4 vehicles being tested with biofuel will not be replaced for another technology with lower emission factors.

Considering this criteria, for the BAU, the average NOx emissions per vehicle km (vehicles running on diesel), are presented in , Graph C1.3.6 and Table C1.3.4



Graph C1.3.6 - Evolution of the average NOx emissions per vehicle km of the vehicles being tested, Ex-Ante and BAU scenario (Jan 2010 – Jul 2012).

Table C1.3.5: Average NOx emissions per vehicle-km (g NOx/vkm), BAU.

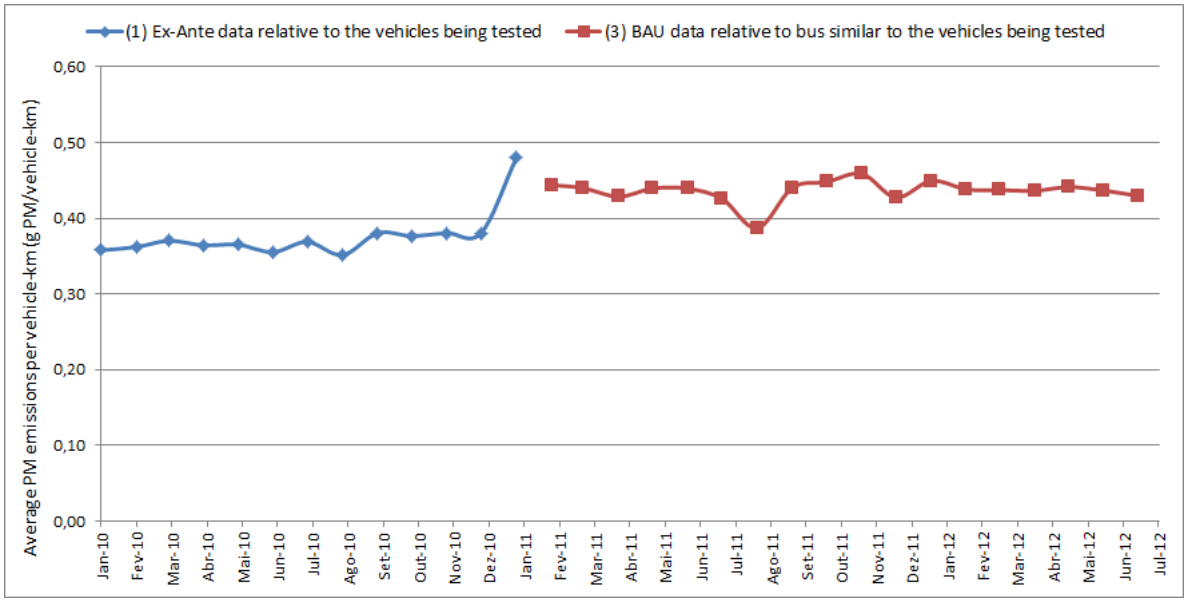
Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.688.733	1.824.193	2.139.196
Emission Factor (kg NOx/MJ) [2]	0,0007429		
Total NOx emissions of the vehicles (g) [3=1x2]	1.254.560	1.355.193	1.589.209
Total vehicle-km (vkm) [4]	85.969	93.827	108.748
Average NOx emissions per vehicle-km (g NO_x/vkm) [3/4]	14,593	14,444	14,614

Indicator 7 (Small Particulate Emissions)

For this indicator, the BAU is represented by the emissions associated with diesel consumption of 4 buses similar to the 4 vehicles being tested with biofuel in terms of technology, given the fact that if the measure was not implemented that will be the real situation.

In addition, the BAU scenario assumes that 4 vehicles being tested with biofuel will not be replaced for another technology with lower emission factors.

Considering this criteria, for the BAU, the average PM emissions per vehicle km (vehicles running on diesel), are presented in , Graph C1.3.7 and Table C1.3.6.



Graph C1.3.7 - Evolution of the average PM emissions per vehicle km of the vehicles being tested, Ex-Ante and BAU scenario (Jan 2010 – Jul 2012).

Table C1.3.6: Average PM emissions per vehicle-km (g PM/vkm), BAU.

Indicator and Data Used (4 Vehicles Being Tested)	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.688.733	1.824.193	2.139.196
Emission Factor (kg PM/MJ) [2]	0,0000223		
Total PM emissions of the vehicles (g) [3=1x2]	37.659	40.680	47.704
Total vehicle-km (vkm) [4]	85.969	93.827	108.748
Average PM emissions per vehicle-km (g PM/vkm) [3/4]	0,438	0,434	0,439

Indicator 8: Awareness level - bus drivers

The awareness level is measured by considering the % of the SMTUC bus drivers with knowledge of the measure. For this indicator, the BAU is equal to the baseline situation, because if the measure had not been implemented, the awareness level would have been as before, equal to 0%. It is considered that there are no effects of other factors that have any influence in this indicator.

Indicator 9: Acceptance level - bus drivers

In the baseline situation, the acceptance level, measured as the % of buses drivers that agree with the introduction of biofuel in SMTUC fleet was about 67%. If the measure had not been implemented, there would be no reasons to assume that this acceptance level would have been different. In this case the BAU is equal to the baseline situation, meaning that bus drivers would have the same kind of

acceptance level if the measure was not going to be implemented. The acceptance level in the baseline was measured between Nov 2009-Dec 2009, before the measure implementation, by means of a specific question placed on the Driver's Survey.

Table C1.3.7: Acceptance level (%), Ex-Ante and BAU.

Indicator and Data Used	Time Period	Ex-Ante and BAU Values
Number of Positive Answers to the Question "Do you agree with the introduction of biofuel in fleet of SMTUC?" [1]	2 Nov 2009- 11 Dec 2009	118
Total number of responding operators [2]		176
Acceptance level (%) [1/2]		**67,05**

Indicator 10: Awareness level - marketing

This indicator is measured as the percentage of the vehicles being tested that have a sticker communicating that the bus is running with biofuel. For the BAU, and considering that the measure was not implemented, the awareness level will be equal to a 0%, just like in the baseline situation.

C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport. When relevant, the data is illustrated by graphs in order to analyze trends, values and be more readable.

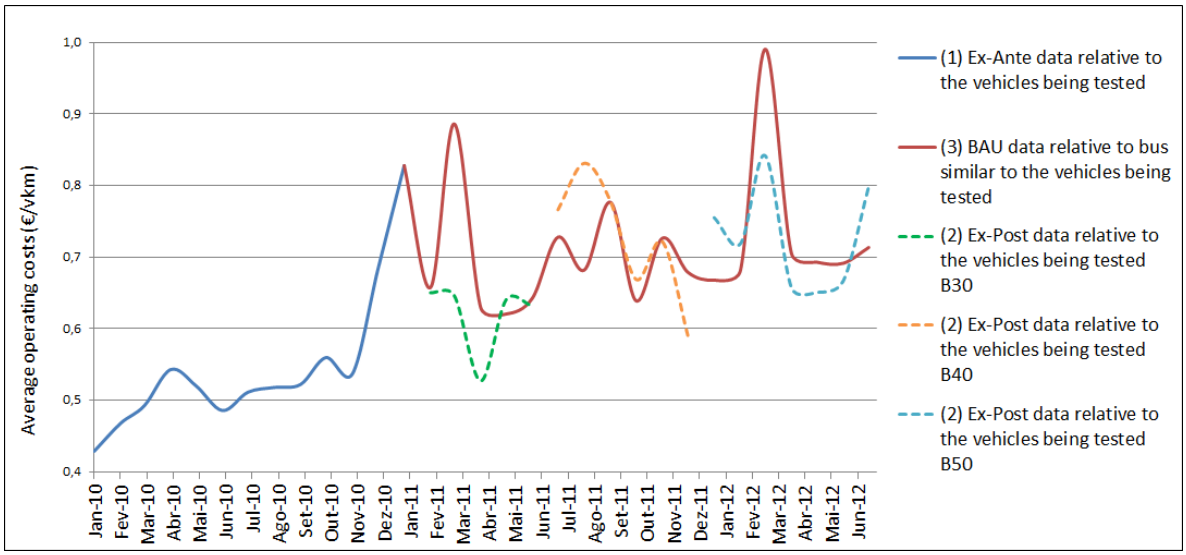
C2.1 Economy

Table C2.1.1: Average Operating Costs (€/vkm), Ex-Post.

Indicator and Data Used (4 vehicles being tested with biodiesel)	B30, Feb 11-Jun 11	B40, Jul 11-Dec 11	B50, Jan 12-Jul 12
Fuel Consumption Costs (€) [1]	34.530	23.387	50.531
Maintenance costs with personnel (€) [2]	3.024	1.921	3.434
Maintenance costs with material (€) [3]	5.787	8.592	8.144
Total costs (€) 4 = [1+2+3]	43.341	33.901	62.108
Total vehicle-km (vkm) [5]	70.312	46.917	86.234
Average Fuel costs (€/vkm) [1/5]	**0,491**	**0,498**	**0,586**
Average operating costs (€/vkm) [4/5]	**0,616**	**0,723**	**0,720**

In the majority of the ex-post period (Table C2.1.1 and Graph C2.1.1), it is possible to observe that the 4 vehicles being tested with B30 and B50, have lower average operating costs in comparison to BAU scenario for buses similar to the vehicles being tested, but running on diesel instead of biofuel mix. This is mainly a result of lower fuel consumption costs in the ex-post period in comparison with BAU due to lower biodiesel costs with respect to the diesel.

As explained in the section C1 the difference between different blending is due to the variation of weather conditions and of the buses composition (type) from a stage of biofuel mix to another.



Graph C2.1.1 - Evolution of the average operating costs (€/vkm) of the vehicles being tested, (Jan 2010 – Jul 2012).

Table C2.1.2: Average Operating Costs results.

Indicator	Ex-Ante		
	Feb-Jun 10	**Jul-Dec 10**	**Jan-Jul 10**
Average Fuel Costs (€/vkm)	0,394	0,414	0,391
1. Average Operating Costs (€/vkm)	**0,502**	**0,553**	**0,494**

Indicator	BAU			Ex-Post			Difference Ex Post- Ex Ante			Difference Ex Post - BAU		
	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12	B30 Feb-Jun 11	B40 Jul-Dec 11	B50 Jan-Jul 12	B30	B40	B50	B30	B40	B50
Average Fuel Costs (€/vkm)	0,561	0,562	0,593	0,491	0,498	0,586	0,097	0,084	0,195	-0.07	-0,064	0,007
1. Average Operating Costs (€/vkm)	**0.686**	**0,707**	**0,735**	**0,616**	**0,723**	**0,720**	**0,114**	**0,170**	**0,226**	**-0,070**	**0,016**	**-0,015**

Comparing the ex-post and ex-ante results, it's possible to conclude that the average operating costs are higher in the ex-post period. However it should be highlighted that the fuel consumption costs were higher in 2011 and 2012 (ex-post period) in comparison with ex-ante period (Jan 2010-Jan 2011), as a result of higher oil prices. The average operating costs of B30 in the ex-post period is approximately 20% higher than the ex-ante values just in line with the increase of fossil fuel costs between periods.

Centring the focus of the analysis in the BAU and ex-post average operating costs, the results shows that the average operating costs with B30 and B50 biofuel blends are lower, respectively -0,007€/vkm (-10%) and -0,015 €/vkm (2%), than the BAU costs for the same time periods, Table C2.1.1.

After the below analyse of the fuel efficiency this phenomenon could be better addressed. The problem is the increase in the fuel consumption that didn't has been compensated by the decrease in the biofuel prices comparing to the diesel prices. The results could be others if more quantity of biofuel will be purchased, namely the prices of the biofuel will decrease if SMTUC negotiate the prices to fuel all the fleet in spite the 4 buses used for the tests.

C2.2 Energy

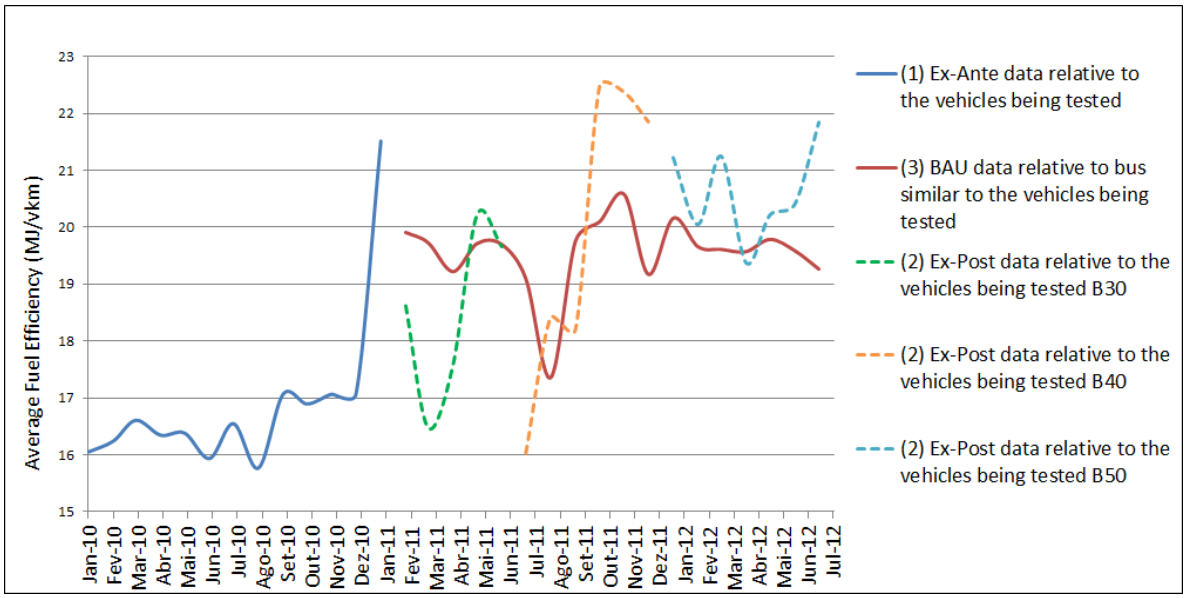
C2.2.1 Average Fuel Efficiency

Table C2.2.1.1: Average Fuel Efficiency (MJ/vkm), Ex-Post.

Indicator and Data Used (4 vehicles being tested with biodiesel)	B30, Feb 11-Jun 11	B40, Jul 11-Dec 11	B50, Jan 12-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.269.194	929.102	1.775.449
Total vehicle-km (vkm) [2]	70.312	46.917	86.234
Average Fuel Efficiency (MJ/vkm) [1/2]	**18,051**	**19,803**	**20,589**

The results presented in the graph, C2.2.1.1 and Table C2.2.1.2, show that excluding a particular period (between January and April of 2011) when the vehicles were tested with B30, the average fuel efficiency of the 4 vehicles being tested with biofuel blends is normally not as good as the ones registered for similar vehicles running on diesel. This difference is worst when comparing the results with the baseline than the comparison with the BAU scenario. The reasons seems to be the difference in the weather conditions between the 2 periods (the baseline during 2010 and the ex-post results

during 2011 and 2012), while the BAU scenario has been assessed with the 4 reference buses running simultaneously with the 4 buses being tested.



Graph 2.2.1.1 - Evolution of the average fuel efficiency (MJ/vkm) of the vehicles being tested, (Jan 2010 – Jul 2012).

Table C2.2.1.2: Average Fuel Efficiency results.

Indicator	Ex-Ante		
	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
2. Average Fuel Efficiency (MJ/vkm)	16,305	16,719	16,305

Indicator	BAU			Ex-Post			Difference Ex Post - Ex Ante			Difference Ex Post - BAU		
	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12	B30 Feb-Jun 11	B40 Jul-Dec 11	B50 Jan-Jul 12	B30	B40	B50	B30	B40	B50
2. Average Fuel Efficiency (MJ/vkm)	19,644	19,442	19,671	18,051	19,803	20,589	1,746	3,084	4,283	-1,593	0,361	0,918

C2.2.2 Fuel Mix

Table C2.2.2.1: Average Fuel Mix (%), Ex-Post.

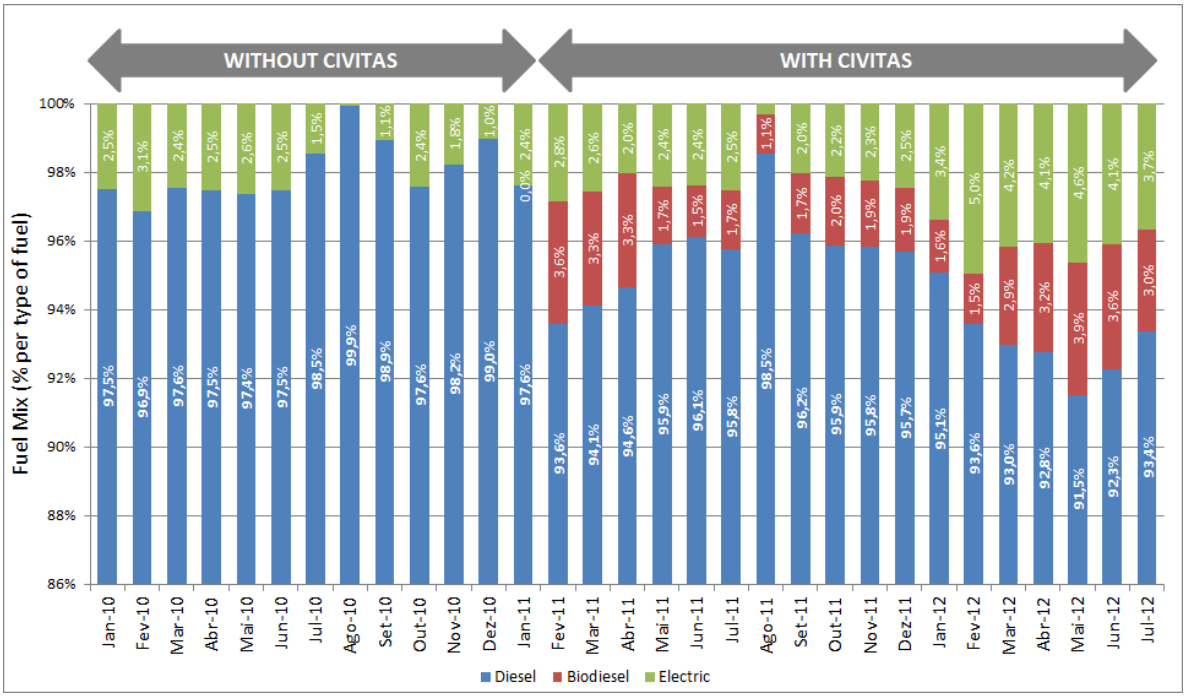
Indicator and Data Used (SMTUC bus fleet)	B30, Feb 11-Jun 11	B40, Jul 11-Dec 11	B50, Jan 12-Jul 12
Total Energy consumed by the Diesel vehicles (MJ)	45.215.585	51.376.541	59.966.092
Total Energy consumed by the Biofuel vehicles (MJ)	1.269.194	929.102	1.775.449
Total Energy consumed by the Electric vehicles (MJ)	1.170.022	1.065.894	2.654.155
Fuel Mix (%)		-	-
- Diesel	**94,88%**	**96,26%**	**93,12%**
- Biofuel	**2,66%**	**1,74%**	**2,76%**
- Electric	**2,46%**	**2,00%**	**4,12%**

The impact of measure implementation is clear (Table C2.2.2.1). The biofuel contribution in SMTUC fuel mix, increases from 0% to 2,76%. On the contrary, the weight of diesel in SMTUC overall fuel mix decreases approximately 4,43%, Table C2.2.2.2 and Graph C2.2.2.1.

Table C2.2.2.2: Average Fuel Mix results.

Indicator	Ex-Ante		
	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
3. Fuel Mix (% per type of fuel)			
- Diesel	97,36%	98,67%	97,55%
- Biofuel	0,00%	0,00%	0,00%
- Electric	2,64%	1,33%	2,45%

Indicator	BAU			Ex-Post			Difference Ex Post - Ex Ante			Difference Ex Post - BAU		
	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12	B30	B40	B50	B30	B40	B50	B30	B40	B50
				Feb-Jun 11	Jul-Dec 11	Jan-Jul 12						
3. Fuel Mix (% per type of fuel)												
- Diesel	97,36%	98,67%	97,55%	94,88%	96,26%	93,12%	-2,48%	-2,40%	-4,43%	-2,48%	-2,40%	-4,43%
- Biofuel	0,00%	0,00%	0,00%	2,66%	1,74%	2,76%	2,66%	1,74%	2,76%	2,66%	1,74%	2,76%
- Electric	2,64%	1,33%	2,45%	2,46%	2,00%	4,12%	-0,19%	0,66%	1,67%	-0,19%	0,66%	1,67%



Graph C2.2.2.1 - Evolution of the fuel mix of the SMTUC bus fleet, with and without CIVITAS implementation (Jan 2010 – Jul 2012).

C2.3 Environment

Given the fact that there is no specific data coming from direct emissions measurements, is important to state that according to EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[2], the use of biofuel as a blend with diesel may lead to some change in emissions, and this fact was taken into consideration on the calculations. The values proposed in the following table are differences in emissions caused by different biofuel blends with fossil diesel, and correspond to a Euro 3 vehicle/engine technology, just like the vehicles that were tested in the context of this specific measure.

Pollutant	Vehicle Type	B10	B20	B100
CO_2	Passenger Cars	-1.5%	-2.0%	
	Light duty vehicles	-0.7%	-1.5%	
	Heavy duty vehicles	0.2%	0.0%	0.1%
NO_x	Passenger Cars	0.4%	1.0%	
	Light duty vehicles	1.7%	2.0%	
	Heavy duty vehicles	3.0%	3.5%	9.0%
PM	Passenger Cars	-13.0%	-20.0%	
	Light duty vehicles	-15.0%	-20.0%	
	Heavy duty vehicles	-10.0%	-15.0%	-47.0%
CO	Passenger Cars	0.0%	-5.0%	
	Light duty vehicles	0.0%	-6.0%	
	Heavy duty vehicles	-5.0%	-9.0%	-20.0%
HC	Passenger Cars	0.0%	-10.0%	
	Light duty vehicles	-10.0%	-15.0%	
	Heavy duty vehicles	-10.0%	-15.0%	-17.0%

Source: (EEA/EMEP, 2009)

Taking into account that the EMEP/EEA emission inventory guidebook does not explicitly refer biodiesel blends similar to the ones that were tested, B30, B40 and B50, the differences in emissions caused by different biofuel blends expressed in %, were derived from linear regression of the values presented in the table above.

Table C2.3.1: Derived emission factors, Diesel+Biodiesel.

Pollutant	Emission Factors (kg/MJ)		
	B30	B40	B50
CO	0,000157	0,000154	0,000152
CO_2	0,074		
NOx	0,000775	0,000779	0,000785
PM	0,0000182	0,0000173	0,0000163

Source: Adapted from EMEP/EEA 2009.

According to the EMEP/EEA emission inventory guidebook, the effect of biofuel on other technologies may vary, but the extent of the variation is difficult to estimate in the absence of detailed data. With regard to NO_x, CO_2 and CO, any effect of technology should be negligible, given the marginal effect of biofuel on these pollutants in general.

In the next results of the average emissions 2 general issues have been addressed, both related to the results of the indicator Average Fuel Efficiency:

[2] http://eea.europa.eu/emep-eea guidebook

- The already reported difference in the fuel efficiency that is low when comparing the results with the baseline than with the BAU scenario, due different whether conditions. This fact influenced the related indicator of the emissions, causing worst results in the comparison between the ex-post and the baseline scenario.
- For some blends and some pollutants seems that the above assessed decrease in the fuel efficiency have a higher influence than the decrease in the emissions factor related to the biofuel use, causing an increase in the emissions.

The next tables show the results of the emissions (CO, CO_2, NO_X and PM), as well as the comparison with the baseline and the BAU.

Indicator 4: Average CO Emissions

Table C2.3.2: Average CO emissions per vehicle-km (g CO/vkm), Ex-Post.

Indicator and Data Used (4 Vehicles Being Tested)	**B30 Feb-Jun 11**	**B40 Jul-Dec 11**	**B50 Jan-Jul 12**
Total energy consumed by the vehicles (MJ) [1]	1.269.194	929.102	1.775.449
Emission Factor (kg CO/MJ) [2]	0,000157	0,000154	0,000152
Total CO emissions of the vehicles (g) [3=1x2]	199.381	143.541	269.377
Total vehicle-km (vkm) [4]	70.312	46.917	86.234
Average CO emissions per vehicle-km (g CO/vkm) [3/4]	2,836	3,059	3,124

The results presented in Table C2.3.3, shows that when comparing the results of the ex-post period with the BAU scenario the average CO emissions have a reduction, with the major relevance for the B30 blend (-20%). Comparing with the baseline, the average CO emissions increases by a small percentage for all biodiesel blends that were tested. Considering only B30, the average emissions increased from 2,824 gCO/vkm in the baseline period to 2,836 gCO/vkm in the ex-post, representing an overall increase of about 0,4%.

Table C2.3.3: Average CO emissions results.

Indicator	**Ex-Ante**		
	Feb-Jun 10	**Jul-Dec 10**	**Jan-Jul 10**
Average CO emissions per vehicle-km (g CO/vkm)	2,824	2,896	2,824

Indicator	**BAU**			**Ex-Post**			**Difference: Ex Post – Ex ante**			**Difference: Ex-post-BAU**		
	Feb-Jun 11	**Jul-Dec 11**	**Jan-Jul 12**	**Feb-Jun 11**	**Jul-Dec 11**	**Jan-Jul 12**						
				B30	**B40**	**B50**	**B30**	**B40**	**B50**	**B30**	**B40**	**B50**
Average CO emissions per vehicle-km (g CO/vkm)	3,402	3,367	3,407	2,836	3,059	3,124	0,012	0,164	0,300	-0,567	-0,308	-0,283

Indicator 5: Average CO_2 Emissions

Table C2.3.4: Average CO_2 emissions per vehicle-km (g CO_2/vkm), Ex-Post.

Indicator and Data Used (4 Vehicles Being Tested)	B30 Feb-Jun 11	B40 Jul-Dec 11	B50 Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.269.194	929.102	1.775.449
Emission Factor (kg CO_2/MJ) [2]	0,074	0,074	0,074
Total CO_2 emissions of the vehicles (g) [3=1x2]	93.920.341	68.753.539	131.383.237
Total vehicle-km (vkm) [4]	70.312	46.917	86.234
Average CO_2 emissions per vehicle-km (g CO_2/vkm) [3/4]	1.335,765	1.465,429	1.523,567

As mentioned above, the use of biofuel has a marginal effect in terms of CO_2 emissions. The results presented in Table C2.3.5 reflect this aspect, but in any case for B30 has been assessed a decrease in the emissions when comparing the results with the BAU scenario.

Table C2.3.5: Average CO_2 emissions results.

Indicator	Ex-Ante		
	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Average CO_2 emissions per vehicle-km (g CO_2/vkm)	1.206,585	1.237,226	1206,588

Indicator	BAU			Ex-Post			Difference: Ex Post – Ex ante			Difference: Ex-post-BAU		
	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12						
				B30	B40	B50	B30	B40	B50	B30	B40	B50
Average CO_2 emissions per vehicle-km (g CO_2/vkm)	1.453,620	1.438,715	1.455,664	1.335,765	1.465,429	1.523,567	129,181	228,203	319,979	-117,854	26,715	67,903

Indicator 6: Average NOx Emissions (g NOx/vkm)

Table C2.3.6: Average NOx emissions per vehicle-km (g NOx/vkm), Ex-Post.

Indicator and Data Used (4 Vehicles Being Tested)	B30 Feb-Jun 11	B40 Jul-Dec 11	B50 Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.269.194	929.102	1.775.449
Emission Factor (kg NOx/MJ) [2]	0,00077	0,00078	0,00078
Total NOx emissions of the vehicles (g) [3=1x2]	983.428	724.051	1.392.844
Total vehicle-km (vkm) [4]	70.312	46.917	86.234
Average NOx emissions per vehicle-km (g NOx/vkm) [3/4]	13,987	15,433	16,152

As mentioned in the EMEP/EEA emission inventory guidebook, the introduction of biofuel in the diesel normally implies an increase in terms of NOx emissions. For B30, the average NOx emissions increased lightly from an average value of 12,113 g NOx/vkm in the baseline period to 13,987 g NOx/vkm in the ex-post period. But the assessed results for a B30 blend shows a reduction in the emissions when comparing the ex-post with the BAU scenario.

Table C2.3.7: Average NOx emissions results.

Indicator	Ex-Ante		
	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Average NOx emissions per vehicle-km (g NOx/vkm)	12,113	12,421	12,113

Indicator	BAU			Ex-Post			Difference: Ex Post – Ex ante			Difference: Ex-post-BAU		
	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12						
				B30	B40	B50	B30	B40	B50	B30	B40	B50
Average NOx emissions per vehicle-km (g NOx/vkm)	14,593	14,444	14,614	13,987	15,433	16,152	1,873	3,012	4,039	-0,607	0,989	1,538

Indicator 7: Average PM Emissions (g PM/vkm)

Table C2.3.8: Average PM emissions per vehicle-km (g PM/vkm), Ex-Post.

Indicator and Data Used (4 Vehicles Being Tested)	B30 Feb-Jun 11	B40 Jul-Dec 11	B50 Jan-Jul 12
Total energy consumed by the vehicles (MJ) [1]	1.269.194	929.102	1.775.449
Emission Factor (kg PM/MJ) [2]	0,0000182	0,0000173	0,0000163
Total PM emissions of the vehicles (g) [3=1x2]	23.039	16.036	29.021
Total vehicle-km (vkm) [4]	70.312	46.917	86.234
Average PM emissions per vehicle-km (g PM/vkm) [3/4]	0,328	0,342	0,337

The results presented in Table C2.3.9, shows that when comparing the results of the ex-post period with baseline and BAU scenario, the average PM emissions decreases for all biofuel blends that were tested. Considering only B30, the average emissions decreased 20% when comparing the ex-post with the BAU scenario and 10% in the comparison with the baseline.

Table C2.3.9: Average PM emissions results.

Indicator	Ex-Ante		
	Feb-Jun 10	Jul-Dec 10	Jan-Jul 10
Average PM emissions per vehicle-km (g PM/vkm)	0,364	0,373	0,364

Indicator	BAU			Ex-Post			Difference: Ex Post – Ex ante			Difference: Ex-post-BAU		
	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12	Feb-Jun 11	Jul-Dec 11	Jan-Jul 12						
				B30	B40	B50	B30	B40	B50	B30	B40	B50
Average PM emissions per vehicle-km (g PM/vkm)	0,438	0,434	0,439	0,328	0,342	0,337	-0,036	-0,031	-0,027	-0,110	-0,092	-0,102

C2.4 Society

C2.4.1 Awareness level – bus drivers

After measurement implementation, 100% of the SMTUC bus drivers have now knowledge of the measure extent, Table C2.5.1.1.

Table C2.4.1.1: Awareness level results.

Indicator	Ex-Ante Baseline	BAU	Ex Post	Difference: Ex Post –Ex Ante	Difference: Ex Post – BAU
	Jan 2010-Jan 2011	Feb 2011-Jul 2012	Feb 2011-Jul 2012		
8. Awareness Level (%)	0	0	100	100	100

C2.4.2 Acceptance level – bus drivers

Next tables show results of the Acceptance level of the SMTUC bus drivers after the measure implementation and the comparison with the baseline and BAU cases.

Table C2.4.2.1: Acceptance level (%), Ex-Post.

Indicator and Data Used	Time Period	Ex-Post Values
Number of Positive Answers to the Question "Do you agree with the introduction of biofuel in fleet of SMTUC?" [1]	7 Nov 2011-16 Dec 2011	167
Total number of responding drivers [2]		193
Acceptance level (%) [1/2]		**86,53**

Table C2.4.2.2: Acceptance level results.

Indicator	Ex-Ante Baseline	BAU	Ex Post	Difference: Ex Post –Ex Ante	Difference: Ex Post – BAU
	2 Nov 2009-11 Dec 2009		Nov 2011-Dec 2011		
9. Acceptance Level (%)	67,05	67,05	86,53	19,48	19,48

The measure acceptance level increases from 67% to 86%, approximately 20%, which indicates that the measure has a significant level of acceptance in SMTUC universe.

C2.4.3 Awareness level - marketing

All of the four vehicles being tested with biofuel have now a sticker and so the percentage of the vehicles being tested that have a sticker communicating the measure is in fact 100% (Table C2.5.3.1).

Table C2.4.3.1: Awareness level- marketing, results.

Indicator	Ex-Ante Baseline	BAU	Ex Post	Difference: Ex Post –Ex Ante	Difference: Ex Post – BAU
	Jan 2010-Jan 2011		Feb 2011-Jul 2012		
10. Awareness Level – Marketing (%)	0	0	100	100	100

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To test by running at least 10 cycles per bus the reliability of increase the percentages of biofuel mixes in 4 different brands of Urban PT fleet in order to surpass the 25% of biofuel mix of SMTUC fleet in the future. The buses being tested ran a different cycle each week (changing the real operation conditions between cycles). So each bus ran between 20 to 81 cycles largely surpassing the objectives. The tests has been carried out with biofuel mixes from 30% to 50% that largely exceeded the initially foreseen	***
2	To demonstrate that with this measure may decrease by 15% emissions of CO related to PT vehicles in Coimbra. To reduce the emission of greenhouse gases related to PT vehicles in Coimbra by 2%. CO and PM emissions could achieve a decrease of 20% with the low biofuel mix tested (30%)	***
3	To carry out awareness campaigns to highlight the importance of using alternative fuels. All the buses running biofuel mix have a sticker informing this fact. Other campaigns have been also carried out and the measure has been presented in several events and to other fleet operators.	**
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

As described above, the measure consisted in testing different biofuel mix's (B30, B40 and B50) in 4 buses running in real operation conditions, in order to assess the possibility of supply SMTUC entire fleet. For this measure, up-scaling will be a necessary process to estimate the impacts of the measure, not only on 4 vehicles, but on the entire SMTUC bus fleet, of about 100 buses.

Operating Costs

Table C4.1: Average operating costs (€/vkm).

Average Operating Costs (€/vkm)	B30	B40	B50
	Feb 11 – Jun 11	Jul 11 – Dec 11	Jan 12 – Jul 12
Ex-Post data relative to the vehicles being tested [1]	0,616	0,723	0,720
BAU data relative to bus similar to the vehicles being tested [2]	0,686	0,707	0,735
Difference (A-B) [1-2]	**-0,07 (-10%)**	0,016	-0,015

Considering the data collected and the results presented in the above table, it's possible to estimate the impact that biofuel will have in the entire SMTUC fleet in terms of average operating costs. For this exercise it will be assumed two main issues: 1) The 100 vehicles of the SMTUC fleet will run on B30, which would be a conservative perspective; 2) Based on historical data, the entire fleet would have an annual value of approximately 6.000.000 vkm. Based on this assumptions the introduction of B30 in the entire SMTUC bus fleet could represent savings of about 420.000 €/year.

Fuel Consumption

Table C4.2: Average vehicle fuel efficiency (MJ/vkm)

	B30	B40	B50
	Feb 11 – Jun 11	Jul 11 – Dec 11	Jan 12 – Jul 12
Ex-Post data relative to the vehicles being tested (A)	18,051	19,803	20,589
BAU data relative to bus similar to the vehicles being tested (B)	19,644	19,442	19,671
Difference (A-B)	-1,593 (-8%)	0,361	0,918

Taking into consideration the above assumptions, 100 vehicles running on B30 and 6.000.000 vkm for the entire SMTUC fleet, the measure up-scaling could result in savings of approximately 9.555.769 MJ of diesel consumption. Based on data of Portuguese Environment Agency, diesel Low Heating Value is 42,60 GJ/t and average density is 0,835 kg/l, and so the measure up scaling will represent the replacement of approximately 268.000 l of diesel.

Emissions

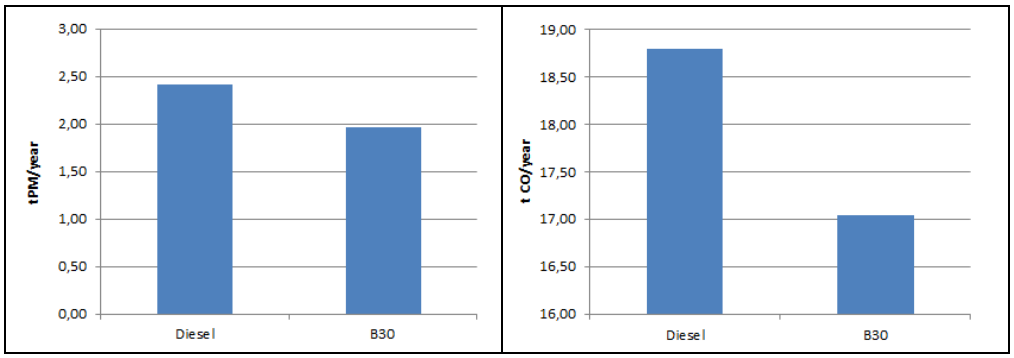
As mentioned in point C2.3 of the report, the use of biofuel as a blend with diesel may lead to some change in emissions. According to EMEP/EEA emission inventory guidebook 2009, the more relevant changes in terms of emissions are related to two specific pollutants, PM and CO.

Table C4.3: Emission factors for PM and CO,kg/MJ.

Average Emission Factors (4 vehicles being tested with biodiesel)	PM		CO	
	Diesel	B30	Diesel	B30
	0,0000223	0,0000182	0,000173	0,000157

Source: Portuguese Environmental Agency 2012 and EMEP/EEA, 2009.

If B30 was used in all vehicles of the SMTUC bus fleet, and assuming an annual diesel consumption of 3.026.128,64 litres, the total PM emissions of the fleet in a given year, may fall from about 2,4tPM/year to 2,0 tPM/year, representing an overall reduction of approximately 17%. For CO, the reduction may not be so dramatic, but will still represent a decrease of 10%, from 18,8 tCO/year to 17,0 tCO/year.



Graph C4.1and C4.2: Measure up scaling potential results on emissions per year.

C5 Appraisal of evaluation approach

Taken into consideration that was not made direct measurements of the vehicles exhaust emissions, the approach to emissions estimation was based on average European emission factors that were determined using based model methodology with COPERT.

The calculation of total emissions of the vehicles being tested and of the rest of the SMTUC bus vehicles, is based on emission factors, specific for pollutant and type of vehicle technology (e.g. Conventional, Euro 1, ...), according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[3]. These average European emission factors were determined using the Tier 3 methodology (based model with COPERT) which follows in using typical values for driving speeds, ambient, temperatures, highway-rural-urban mode mix, trip length.

The EMEP/EEA air pollutant emission inventory guidebook (formerly referred to as the EMEP CORINAIR emission inventory guidebook) provides guidance on estimating emissions from both anthropogenic and natural emission sources. It is designed to facilitate reporting of emission inventories by countries to the UNECE Convention on Long-range Trans boundary Air Pollution and the EU National Emission Ceilings Directive.

Overall, the approach to emissions estimations was based in a solid bibliographic source. Taking into account that exist some uncertainties related to the effect of biofuel for different technologies and pollutants, the direct measurements would probably be a more accurate method for emissions indicators.

During a second phase after POINTER revision the split of the baseline data in 3 periods corresponding to each test period per bio fuel blend has been carried out. This methodology allowed a more correct comparison ex-post – baseline scenarios, namely taking into consideration the seasonality effects.

[3] http://eea.europa.eu/emep-eea guidebook

C6 Summary of evaluation results

The key results are as follows:

- **Average Operating Costs Reduction** – The average operating costs of the 4 vehicles tested with B30 and B50 biofuel blends, are lower than average operating costs of similar vehicles running on diesel for the same period. The difference is more evident for B30, were the average operating costs in the ex-post are 10% lower than the BAU scenario (similar vehicles running on diesel).

- **PM Emissions Reductions** – The use of biofuel as a blend with diesel may lead to some change in emissions, but for NO_x and CO_2, biofuel has in general a marginal effect. Considering the average PM emissions per vehicle-km, the results with B30 shows that a reduction from 0,438 g PM/vkm in the BAU scenario to 0,328 g PM/vkm after measure implementation (-20%). For the same blend the reduction in the CO emissions has also been 20%.

  In the future, if B30 was consumed in all vehicles of the SMTUC bus fleet (100 vehicles), the total PM emissions of the fleet in a given year (assuming an annual diesel consumption of 3.026.128,64 litres), may fall from about 2,4 tPM/year to 2,0 tPM/year, representing an overall reduction of approximately 19%.

- **Biofuel Penetration in the Fuel Mix** – The measure implementation, enabled the penetration of biodiesel in the SMTUC fuel mix, from 0% to 2,76%, and at the same time, the weight of diesel in overall fuel mix decreased approximately 4,43%.

- **Acceptance Level Increase** – The measure implementation resulted in a sharp increase of the measure acceptance level by the buses operators, increasing from 67,05% to 86,53%;

- **Measure Upscale –** According to the measure results, the introduction of B30 in the entire SMTUC bus fleet (100 vehicles) could represent savings in operating costs of about 420.000 €/year and a replacement of approximately 268.000 litres of diesel.

C7 Future activities relating to the measure

A full-scale experimentation for the major part of the SMTUC bus fleet and on regular public service is in analysing. In case positive priority will be given to oil residues, such as cooking oils from the large university complexes and the two central hospitals. Contacts with the municipal waste management service is in course to allow the oil collection in the future.

D Process Evaluation Findings

D.1 Deviations from the original plan

The deviations from the original plan comprised:

- **The start level of the percentage of biofuel mix to be tested was higher than the initially planned** – In the planning of the CIVITAS MODERN project there was no experience about biofuel use in Portugal and the bus manufactures advised not surpass 20% biofuel use. For this reason the initial plan forecast that the test start with 21% of biofuel mix, incrementing only 1% between each set of tests. During the measure setup SMTUC technicians carried out visits to other PT operators having fleets running biofuel, namely TUB – the public transportation company of the city of Braga. Using the knowledge obtained during these visits it was decided to start the tests with 30% biofuel mix, incrementing 10% each test set until 50%, the level that TUB considered acceptable for their entire fleet, after having problems when using higher biofuel percentages – they experimented mixes until 100% biofuel percentage, but without important results assessment concerning certain areas as the emissions. This decision allowed more ambitious results but without important risks related to the expected buses performances.

- **The measure was extended more 4 months to allow a more complete and effective monitoring and evaluation of the buses running with biofuel –** Two buses equipped with "common rail" technology in the diesel injection, had problems in this fuel feed system, namely with "gel" in the filters and injectors, forcing the stop of the tests for this type of buses on 5th and 10th May 2011 (mix at 30%). Considering that the biofuel tests only involved 4 buses, it was considered important to change these buses by other 2 buses equipped with different technology. The time needed to prepare these buses caused a gap between the initial buses running the tests and the new ones. For this reason in May 2012 the last buses performed only 10 thousand kilometres with 50% biofuel mix. To allow a more complete and effective monitoring of all buses it was decided to extended the tests until September 2012. This fact obliged to a consequent 4 month extension of the measure duration to comprise the evaluation tasks.

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Barrier 1.1 – Technological Barrier** – Lack of know-how and experience about Biofuel use at National level required key measures persons to spend more time in training and knowledge acquisition that the initially foreseen for the preparation phase. In addition there is a cultural resistance to the biofuel use caused by environmental reservations concerning some fuel sources and by some bus manufacturer opinions emphasising the risks of the biofuel use.

Implementation phase

- **Barrier 2.1 – Technological Barrier** – The equipment available by the ISEC (College of Engineering of Coimbra) for the analysis of buses emissions, didn't allow the measure of the weight of gases as foreseen in the evaluation methodology, but

only in parts of elements. Also this equipment only measure emissions with the buses stopped in the garage and not in operation. Anyway these data has been used for other monitoring purposes and has been used modelling for the emissions assessment.

Operation phase

- **Barrier 3.1 – Institutional Barrier** – Due to the financial crisis period, the new national legislation didn't allow any more to employ any kind of personnel, causing that all the work in the measure has been carried out by already existing personnel that accumulate with other functions and for some tasks they weren't sufficiently specialized, namely to allow the performance of some special analysis of mechanical wear.

- **Barrier 3.2 – Technological Barrier** – Two buses equipped with "common rail" technology in the diesel injection, had problems in this fuel feed system, namely with "gel" in the filters and injectors, forcing the stop of the biofuel tests for this type of buses on 5th and 10th May 2011 (mix at 30%).

D.2.2 Drivers

Preparation phase

- **Driver 1.1 – Organizational Driver** – Possibility of exchange of experiences with other Portuguese PT operator (Urban PT of Braga) that had already begun the use of biofuel in large scale in their fleet and with other MODERN partners involved in similar measures. The experience transmitted by Urban PT of Braga allowed that people involved in the measure were more confident in the achievement of the results and with more knowledge of the nature and extension of the potential risks.

Implementation phase

- **Driver 2.1 – Involvement Driver** – Offer of support by ISEC (College of Engineering of Coimbra) for the tests involving emissions analysis. Without this expensive equipment it will be impossible to SMTUC make direct measurements of the buses emissions.

Operation phase

- **Driver 3.1 – Involvement Driver** – The participation in the CIVITAS MODERN Project created legal obligations and high motivation for the compromises achievement. These facts were very important always problems occurred during the measure demonstration, avoiding the delay in the decisions (or lack of decisions).

D.2.3 Activities

Preparation phase

- **Activities 1 – Planning Activities** – Taking into consideration the lack of knowledge of SMTUC technicians about biofuel use (barrier 1.1) and the good relationship with the Urban PT of Braga technicians (driver 1.1), it was decided to visit this PT operator and learn with their experience. This activity results in more confident people and a better perception of the risks and allowed the planning of more ambitious test levels – star of the tests with 30% of biofuel mix and steps of 10% between each set of tests, instead of the values initially planned (start with 21% and steps of only 1%).

Implementation phase

- **Activities 2 – Planning Activities** – Taking advantage of the partnership with ISEC (driver 2.1), the equipment for the monitoring of the buses emissions has been tested and demonstrated great utility for the assessment to the emissions with the buses in garage (instantaneous measurement). But the impossibility of using this equipment to measure emissions during the buses operation and the type of the outputs of these measurements (barrier 2.1) avoided the use of the equipment for evaluation purposes. For this reason the direct measurement has been only used for the SMTUC internal monitoring of the tests, including the buses performances, while modelling has been planned to be used for the evaluation activities.

Operation phase

- **Activities 3 – Planning Activities** – Taking into consideration the impossibility to carry out some special analysis of mechanical wear in the engines of the buses running biofuel (barrier 3.1), it was decided to evaluate the buses performances by using surveys designed for the buses drivers perception and by analysing the recorded list of repairs, the engine oil and the emissions.

- **Activities 4 – Technological Activities** – Taking into consideration the minor number of buses running biofuel mixes due the mechanical problems caused by this kind of fuel on the buses with "common rail" technology in the Diesel injection (barrier 3.2) and to allow the achievement of the objectives of the measure (driver 3.1), it was decided to replace the 2 stopped buses by equal number of buses equipped with other technology in the fuel feed system. So SMTUC could conclude the measure with the test of 4 buses, as initially planned.

D.3 Participation

D.3.1 Measure partners

- **Measure partner 1 - Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Leading role**

SMTUC was responsible for the coordination of the activities of the measure, the work of research, knowledge acquisition and planning of the biofuel tests. Had also made the setup of the measure and it implementation, namely by the installation of the equipment for the fuelling and monitoring of the biofuel tests.

The tests have been also carried out by SMTUC, running the 4 buses dedicated to the tests in real operation in the SMTUC public transportation network.

The data collection regarding the evaluation was also carried out by SMTUC.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC); City; Principle participant**

CMC supported SMTUC with their experience with the use of biofuel in one waste collection vehicle and has been analysed the possibility of future partnership for the use of a portion of recycled organic biofuel collected by the municipal waste management services in the various hospitals and university facilities. Municipality has been also sensitized for the use of biofuel in their important fleet.

Since October 2011 the Municipality has been also responsible for the dissemination of the CIVITAS MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

PRODESO was responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

D.3.2 Stakeholders

- **Stakeholder 1 – General Public –** The general public will beneficiate with the energy and environmental impacts in case of up-scaling the measure to the entire SMTUC fleet and they could constitute target groups for the biofuel use.

- **Stakeholder 2 – Biomove** – This enterprise was the responsible for the supply of the biofuel used in the tests **(**www.biomove.pt).

- **Stakeholder 3 – Galp energia (Galp)** – This enterprise is a national supplier of energy, mainly fuel and gas. Galp was supplying SMTUC buses with gasoil and lubricants and carried out lubricants analysis on the buses tested (www.galpenergia.com).

- **Stakeholder 4 – Instituto Superior de Engenharia de Coimbra (ISEC)** – ISEC is a public College of Engineering of Coimbra and was responsible for the tests involving emissions, providing the measurement equipment and knowledge, as well as supporting the measurement sessions.

- **Stakeholder 5 – Transportes Urbanos de Braga (TUB)** – TUB is the Urban Public Transport operator of the City of Braga and allowed the exchange of experiences concerning the biofuel use due the fact they already used high level of biofuel percentages before SMTUC started their tests. TUB facilitated a study tour to their site and gave important information that allowed SMTUC to begin the tests with 30% of biofuel mix.

- **Stakeholder 6 – Public Transport Operators** – The public transport operators were a target group for the biofuel use and have been sensitized for the use of biofuel in their fleet.

- **Stakeholder 7 – Media** – Media has been a channel for the dissemination and promotion of the measure and all the events organized had the participation at least of the local media.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **Cultural resistance to the biofuel use –** Resistance to biofuel use comes from environmental and social opinion makers which protest against some sources of biofuel, namely those originating from industrial vegetable plantations. The use of recycled oils resulting from industrial and manufacturing uses, e.g., cooking oils and motor oils – can be used to try to convince society of the benefits of using biofuels. However, the use of recycled biofuels places extra demands on the suppliers since the availability of this type of biofuel is usually limited.

- **Limitations of common rail technology -** The use of biofuel in vehicles with common rail technology in the fuel feed system is not recommended. The trials demonstrated that even with a reduced amount of biofuel, buses revealed mechanical problems, namely with the appearance of gel-like substance in the filters and injectors.

D.4.2 Recommendations: process

- **More detailed analysis and testing –** When possible, the evaluation process should take into account tests and analyses to the wear of the bus engines. This implies greater financial and technical capacity since the motors will have to be dismounted and every section tested and subsequently remounted.

- **Assess market availability of biofuel** – Before applying biofuel at the fleet level, PT companies should first prospect the market in order to assess the availability of sufficient biofuel to meet the fuel demands. Many times PT companies will have to reach out to several suppliers in order to meet their biofuel needs, since in some countries suppliers still maintain limited stocks.

ANNEX: 1

Ex-Ante data relative to the vehicles being tested: Average Operating Costs

Data	Unit	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	TOTAL
Costs with fuel consumption	€	6909	6813	9140	8395	9643	8917	8188	8090	8599	9433	7573	8049	8473	**108222**
Maintenance costs with personnel	€	360	542	679	857	780	598	619	813	642	978	583	1271	1700	**10422**
Maintenance costs with material	€	877	1318	1652	2084	1898	1454	1505	1977	1561	2379	1420	3093	1811	**23029**
Total vehicle-km	vkm	19000	18546	23304	20882	23692	22593	20173	21010	20693	22855	17843	18182	14473	**263246**
Average Operating Costs	€/vkm	0,429	0,468	0,492	0,543	0,520	0,486	0,511	0,518	0,522	0,560	0,537	0,683	0,828	**0,538**

Ex-Ante data relative to the vehicles being tested: Average Vehicle Fuel Efficiency

Data	Unit	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	TOTAL
Total energy consumed by the vehicles	MJ	304935	301196	386979	341295	388071	360003	333795	331202	353092	386073	304461	310329	311361	**4412792**
Total vehicle-km	vkm	19000	18546	23304	20882	23692	22593	20173	21010	20693	22855	17843	18182	14473	**263246**
Average Fuel Efficiency	MJ/vkm	16,049	16,240	16,606	16,344	16,380	15,934	16,547	15,764	17,063	16,892	17,063	17,068	21,513	**16,763**

Ex-Ante data relative to the vehicles being tested: Fuel Mix

Data	Unit	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	TOTAL
Total Energy consumed by the Diesel vehicles	MJ	8831514	8265989	9623217	8991462	9500229	8675318	9289349	8052517	9505281	9182606	8709137	8610049	9418660	116655328
Total Energy consumed by the Biofuel vehicles	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy consumed by the Electric vehicles	MJ	226066	266558	241531	232204	256493	225400	139158	6538	101347	228830	156553	89248	231577	2401502

M01.08 – Executive summary

This measure comprises the elaboration of a technical, environmental, economical and financial feasibility study to implement a small-hydro power plant in the existing local river dam and use this electricity to supply Coimbra's trolleybus and electric minibus fleet with renewable energy.

The innovative aspects of this measure – the use of the existing river dam for the production of renewable energy to supply the trolley bus lines and the electric bus batteries used in PT operations – are very relevant because they contribute to improve the economic and environmental performance of a clean PT system with reduced investments.

The feasibility study prepared within the CIVITAS MODERN period concluded that this measure is viable at a relatively low cost and has the potential to generate revenues that support the operation and permit the gradual recuperation of the investment.

The results of the measure indicate that in a short period of time the operation small-hydro would generate positive impacts over the average operating revenues and over the decrease of green-house gas emissions at the national level (decrease of 1 million ton CO2 per year) . With the implementation of the measure it is estimated a revenue of 200 k€/year and the investment (1,7 million Euros) has a simple pay-back period of 8,5 years, which is considered cost effective in terms of other investments in small hydro plants.

The feasibility study for the small-hydro power generation in the existing local river dam is the CIVITAS MODRN measure with the major media coverage in Coimbra and had a very positive impact in the scientific community.

The implementation of the study showed that:

- Direct feed of the fleet should be carefully considered given the irregularities in the energy production that may affect the transport system and the considerable costs of energy transformation.
- It is important to analyse with anticipation the possibility of the appearance of several constraints, mainly at the environmental level (impacts on the biodiversity, consequences in case of flooding), but also at the dam specifications level, and to involve experts of several specialities (ex: experts in zoology to study the issues linked to the fish passage) to deal with those constraints.
- Special attention must be given to the administrative / legal aspects because the processes of licensing and request for authorizations could be long and complicated and the involvement of high level decision-makers could be very important to clear the communication channels with national authorities.
- Considering that capital costs in this kind of projects could be significant, positive external factors such as environmental impacts and the importance of the project for the city should be taken into consideration in the economic feasibility study.

A Introduction

A1 Objectives

The measure objectives are:

(D) High level / longer term:

- To improve the global air quality
- To decrease the dependence on fossil fuels

(E) Strategic level:

- To produce renewable energies to use in PT fleet
- To contribute to the reduction of emission of greenhouse gases at national level

(F) Measure level:

(1) To make a technical, economical, environmental and legal feasibility study to implement an electric energy production system (small-hydro) inserted in the existing Coimbra Dam-bridge (Producing at least 750.000 kWh per year)

(2) To produce a digital model of the small-hydro

(3) To carry out awareness campaigns on the benefits of future self production of electricity to supply the trolleybuses lines of the Urban PT operator (SMTUC)

A2 Description

The city of Coimbra has always given priority to clean transport means (trolley cars, electric mini buses, diesel-electric buses, elevators). In this context, a technical, environmental, economical and financial feasibility study has been developed to implement renewable energy production (small-hydro power plant) in an existing local river dam (Fig. 1A and 1B), using the electricity produced to supply the trolleybus and electric minibus fleet of Municipal Public Transportation Services of Coimbra (SMTUC).

Fig. 1A –Existing Dam – Bridge of the Mondego River.

Fig. 1B – The Dam is located near the centre of the City and SMTUC site.

The energy, economic and environmental impacts of possible different locations, as well as of different turbine technologies, for the small-hydro plant were researched in detail, in order to identify the best possible solutions for implementation. These solutions aimed to optimize economic benefits, while at the same time ensuring minimal disturbance to the functioning of the recently built fish-ladder (the media coverage of this CIVITAS measure had catalyses the construction of this fish passage that has long been demanded by the population of Centre Region).

The characteristics of the dam structure (including its location, general data, the hydrological characteristics), the characteristics of the reservoir, dam and spillway, and the main features of the dam and its hydro-mechanical equipment were assessed.

During this stage several small hydro projects were analyzed in the regional water authority (ARHC) to support the Coimbra dam-bridge feasibility study and the administrative procedures. Technical visits were made abroad to 2 turbine manufacturers and 3 similar small-hydro dams.

Important data and technical know-how was collected. A preliminary analysis was performed based on reviewed literature and the characteristics of the fish passage project documents. This analysis aimed to assess the best possible location of the turbines, surveillance of fish migrations, and the required water management to allow the maximum performance of all devices (dams, turbine-generators, and fish passage).

A preliminary feasibility analysis for using groups of turbine-generators specifically designed for very low head small hydro turbines in the downstream lochs of Coimbra's dam was also conducted, but this technology was abandoned because the capital costs were must higher than those originally foreseen and the flow needed to have a regular production of energy was higher than the existing average flow.

Some preliminary laboratorial tests were also done in a hydraulic channel to evaluate the performance of key system components.

The best solution for the feed of the trolleybus traction lines was also analysed and all the parts agreed that the sale of the energy produced in the small-hydro to the electricity grid of EDP – the Portuguese electricity supplier – is better than the direct feed, mainly because this last solution will have higher capital costs for the energy transformation and could imply the loss of the surplus of energy.

Finally the main outcomes for the technical feasibility were achieved and a working document was delivered in November 2009 with the description of the methodology and work undertaken in the study, as well as with the analysis of the several layouts and respective results.

In a second stage three solutions remain as the most recommended taking also into consideration the spatial constraints resulting from the fact that the dam was already built but without the objective of energy production in the original project. These solutions were analysed in more detail to find the best compromise between the environmental impact (mainly in the fish passage and in case of flooding) and the economical point of view.

A detailed small hydropower operation computational model was concluded and applied to all possible layouts, in order to estimate the annual revenue of each one. The detailed small hydropower operation computational model provides a DEMO layout of the Coimbra Dam Bridge equipped with turbine-generator units, namely the overture state of each of the 9 radial gates, the flow in each radial gate, the number of operating turbine-generator units and respective energy production.

At the end the layout chosen consists of a VLH-MJ2 turbine generator unit installation in a short channel to be built between the irrigation channel intake and the river area downstream the dam. The lateral location of the water intake makes it easier to divert the fish that are descending the river. This layout will comprise civil construction works of similar type to those involved in the new fish ladder.

Financial issues and institutional arrangements were analysed for the real implementation of the small-hydro in the future. An informal agreement for the authorization of the use of the dam for the production of electric energy for the trolleybus and electric mini-bus transport system was achieved in a meeting with the attendance of the President of the Portuguese Water Authority (INAG), the Mayor and the Mobility Councillor of the Municipality of Coimbra and other stakeholders. Nevertheless, INAG has not yet replied to the administrative request for the addition of the hydropower plant in the Coimbra Dam Bridge made by the Municipality of Coimbra in the beginning of the CIVITAS MODERN project.

The dissemination of the main measure outcomes and technical features was made by the media (e.g., newspapers, magazines, websites) and in presentations in several workshops, seminars and conferences, highlighting the presentation in 3 international events and the publication of papers in 2 indexed international journals.

In June 2012 the final report with the economical, environmental and legal feasibility study, including the financial engineering and institutional arrangements, was delivered.

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **New conceptual approach, internationally**
  - The use of an existing river dam (located in the city centre) for the self-production of renewable energy, in order to supply (indirectly) the trolleybus traction lines, is a project that has not been applied in any other city. The innovation has 3 aspects: 1 - The main capital costs have already been made, because the dam has already been built (in 1981 but with other objectives - control the river flow, supply water for the agriculture and for the paper industry and the improvement of the city landscape and environment – not for the energy production); 2 – The fact that the dam is located in the centre of the city of Coimbra, avoids energy losses and additional costs with the transport of energy (which is usually the case when the energy source is distant from Coimbra); 3 – All the revenues of the electricity production will be used in the exploitation and improvement of the electric dimension of city transport system.

B2 Research and Technology Development

The main work undertaken in this measure was research and technology development as described in the stage 1 of section B.4 of this document. Mainly the energy, economic and environmental impacts of possible different locations have been analysed in detail, as well as the different turbine technologies for the small-hydro plant in order to identify the best solutions for implementation. These solutions aimed to optimize the economic benefits, while at the same time ensuring minimal disturbance to the operation of the recently built fish-ladder. Hydrological analysis of the River Mondego flow has been also carried out.

Accordingly, we can highlight some aspects as following:

- Recent new turbines specially developed for very low head have been identified and these technologies (Straflo Matrix and VLH MJ2 turbo generating units) were considered in several possible layouts that were designed to allow hydropower addition to the existing Coimbra dam bridge.

- A computational simulation model was developed and used to test the hydraulic operational aspects connected to hydropower addition and to evaluate electric energy production revenue.

  The detailed small hydropower operation computational model provides a DEMO layout of the Coimbra Dam Bridge equipped with turbine-generator units, namely the overture state of each of the 9 radial gates, the flow in each radial gate, the number of operating turbine-generator units and respective energy production.

- Some laboratorial tests were conducted in an open flume channel to evaluate tail-water levels in case turbo generating units were installed in the spillway sill.

  The headwater level curve is conditioned by two distinct hydraulic behaviour mechanisms:

  1) When inflow is low the headwater level curve can be modelled by computing the water mass balance in the upstream reservoir;

  2) However, when the inflows become considerably high, all the radial gates are fully opened and the headwater level is no longer resulting from water mass balance in the upstream reservoir. Instead the headwater levels results from the natural hydraulic upstream river rating curve once human intervention is no longer possible.

  To compute the aspects referred to above, a simulation model was used with decision criteria to guide the operation of the hydropower plant. This model was being tested and will be used also in the forthcoming studies.

  In a first stage a correlation between headwater level and upstream inflow has been used, based on the analysis of historical records collected after the construction of the Coimbra Dam Bridge.

  The downstream river tailwater level curve is derived from historical hydrometric data.

  The tailwater curve at the end of the spillway sill required some further investigation. Laboratorial tests showed that it was possible to ensure adequate tailwater submergence of the Turbine Generators Units (TGU) using a flap gate at the end of the spillway sill. The scale model tests provided an experimental tailwater curve slightly different from the theoretical tailwater curve approximation assumed in previous computations. This experimental tailwater curve was obtained using the sill end flap gate to ensure adequate tailwater submergence of the TGU.

  Besides headwater and tail water curves, approximate efficiency curves were derived based on data provided from the manufacturers. The minimum and maximum operating heads and the minimum and maximum operating flows, for both technologies, were also included in the study.

Both TGU technologies present the same prevailing advantage: they do not need a powerhouse. The TGU are compact units that can be installed directly in contact with the flow in the exterior environment.

Another advantage of StrafloMatrix™ and VLH-MJ2 technologies is the ability of the units' removal in case of exceptional high flows.

In our study it was predicted that for flows superior to 1200m3/s (the flood flow capacity of the Coimbra Dam Bridge is 2000 m3/s) the units would be removed from the river flow.

After careful analysis 3 possible layouts for each of the two TGU technologies were selected, totalizing 6 possibilities to be analysed at economical and fish-pass impact level.

- These three locations for the turbines were analyzed in more detail, namely a location close to the fish-pass of the dam, a location between the fish-pass and the central gate, and a location near the irrigation channel in the right margin of the dam (Fig. 2). In general, it is admissible that the implementation of turbines on any of the above mentioned locations may interfere with the attraction ability performed by the fish-pass, meaning that its minimization constituted a goal for the working team.

The location close to the fish-pass is the most disruptive in terms of introducing a possible source of diversion of the fish migration, and therefore is not recommended.

The other possible location for the turbines (between the fish-pass and central gate) would be the one which will bring lower differences to the flow distribution, in comparison to the present water management situation. In this case, the location should be closer to the gate operating regularly, used to perform the water discharge operation in the Coimbra's dam-bridge. The gates can be manipulated in agreement to the water flow needed by the turbine to produce energy. The final result will be nearly the same in terms of distribution of the water flow, with the main water volume discharged through the central part of the river, as it is presently (with no turbine implemented).

However the turbine placement on the irrigation channel on the right margin seems the best location for the turbine-generator, since it is located as far as possible away from the upstream entrance of the fish-pass and will minimize the competition in the attraction of the fish.

The location in this area will reduce the turbulence near the left margin, allowing the fish shoals to use this space to reorganize and orient before proceeding with the ascending migration. Concerning the selection of the best model to use, the VLH-MJ2 model is more cost-effective and more fish-friendly than the StrafloMatrix model, especially due to the blades' lower rotation speed.

Therefore, the best solution, from an economical point of view, was also identified as this last layout (Layout V2 in the figure 2), which is similar to the very successful Millau small hydropower plant in France, in operation since 2007 (which have survived several large floods). Exactly like the Coimbra Dam Bridge V2 layout, the Millau small hydropower plant has a short right river bank channel that bypasses the river weir and feeds a single VLH-MJ2 4500 mm diameter turbine. In the Millau small hydropower there is a fish ladder in the opposite river bank, that is, the fish ladder is in the left river bank exactly as in the Coimbra Dam Bridge V2 layout.

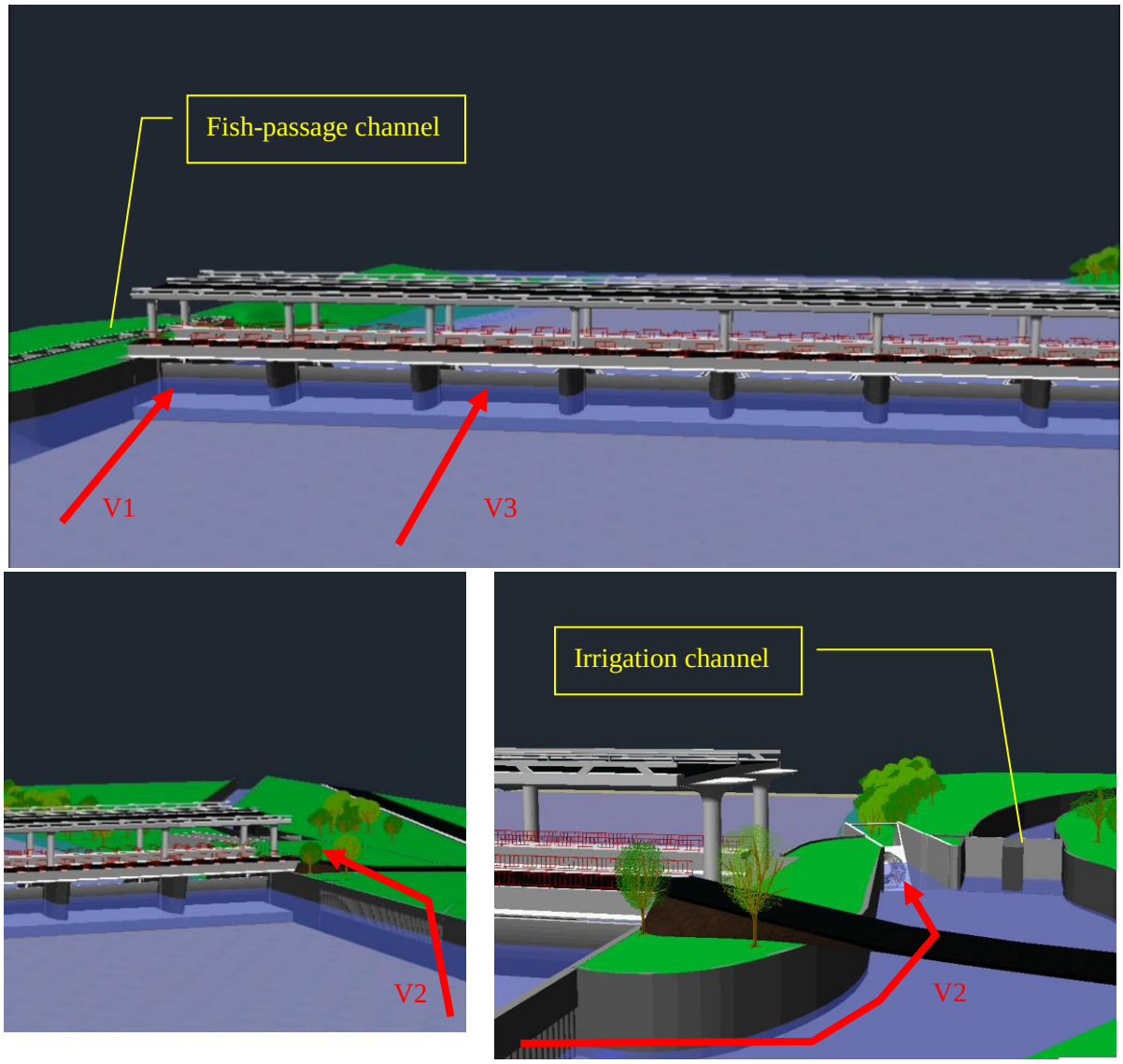


Fig. 2 – The 3 possible layouts for the VLH-MJ2 turbine generator unit installation – V1 in the first gate of the dam, near the fish-passage channel, V2 using the existing irrigation channel intake and V3 in the third gate.

The V2 layout consists of a VLH-MJ2 turbine generator unit installation in a short channel to be built between the irrigation channel intake and the river area downstream the dam (Fig. 3 and 4). The lateral location of the water intake makes it easier to divert the fish that are descending the river. This layout will comprise civil construction works of similar type to those involved in the new fish ladder.

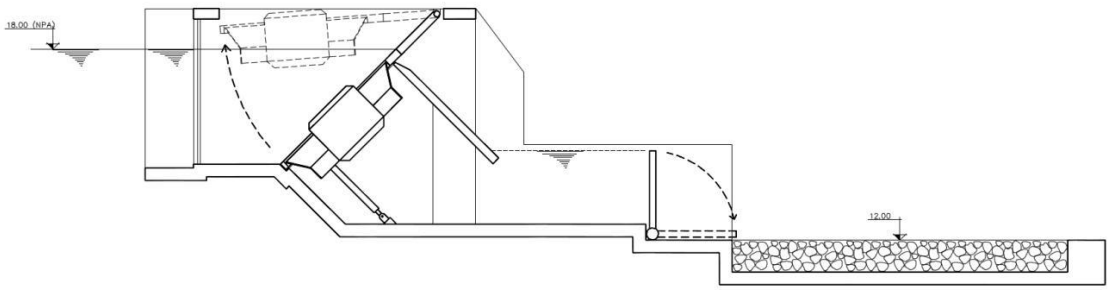


Fig.3 – Side view of layout V2

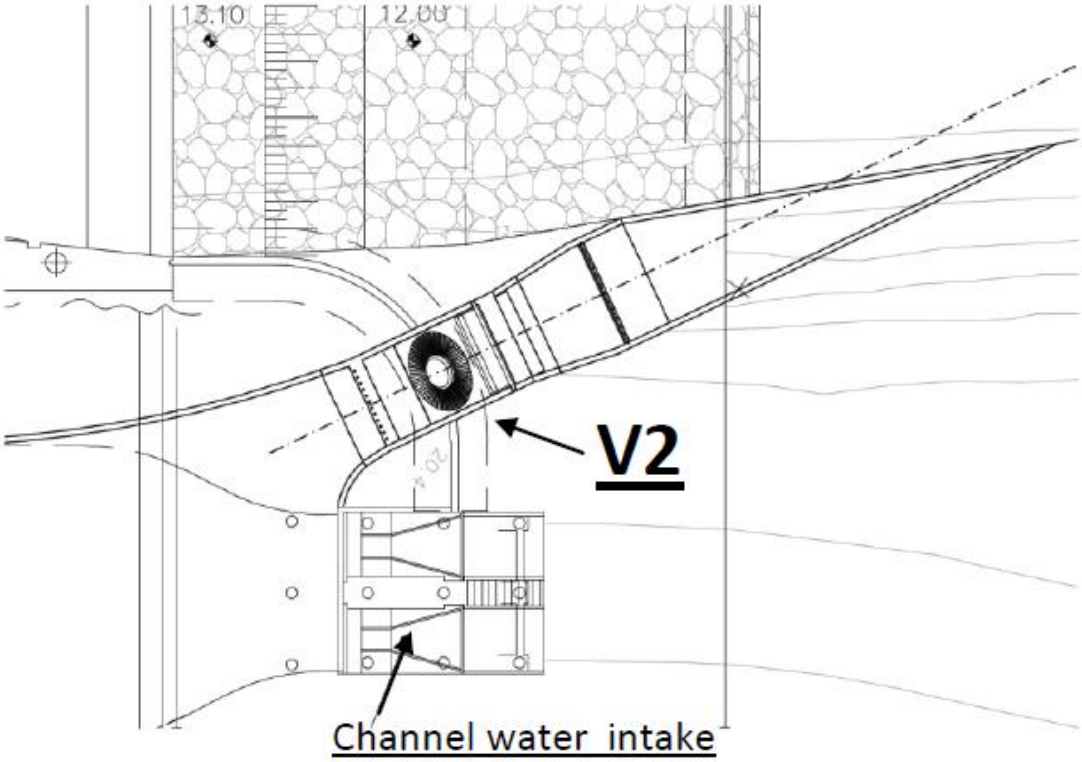


Fig.4 – Top view of layout V2

In conclusion, the research and development work allowed for am analysis which provided the best solution from the technological, economic and environmental point of view (particularly in terms of project feasibility). The solution recommended was a VHL-MJ2 turbine generator unit installed in a derivation of the existing irrigation channel intake. The investment will be 1 700 000 € for an annual energy production of 2,6 GWh, more then 3,5 times the energy needed to feed the trolleybus fleet. The annual revenues from this production will be 200 000 € and the simple payback period will be 8,5 years.

The study has been delivered and disseminated through several channels, including papers and publications in specialized media.

B3 Situation before CIVITAS

Coimbra's trolleybus electric traction network is fed by grid energy from the national supplier (EDP). The energy mix contained about 38% renewable energies in 2006 (45% in 2010). In 2006, the electric energy consumption of the trolleybus corresponded to 748.000 kWh and implied a cost of 78.600 Euros for SMTUC, plus electric energy to charge the batteries of its 3 electric minibuses.

Coimbra has a 60 year history of trolleybus, being the only Portuguese city, which did not abandon its network; to the contrary, in recent years the network has increased.

One of the factors, which hinders trolleybus network extension, is the increasing cost of electric energy. That is one of the main motivations of SMTUC to find solutions allowing for an energetically "cleaner", efficient and economically favourable supply.

Introducing a renewable energy source (hydro) into the system generates social benefits related with the local production of electric energy (reducing energy grid losses) and associated reduction of greenhouse gases that will improve the energy and environment footprint of the SMTUC transport fleet. In addition to these social benefits, this measure will increase the operating revenues by generating a new income related with the sale of the surplus of the small hydro plant energy production. The new income will be used to cover the depreciation of the investment at short time but in the future SMTUC could benefit from these extra revenues by increasing and renewing the electric fleet, as well as to raising the offer of public transportation made by these environmentally friendly vehicles.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Research to implement an electric energy production system (small- hydro) *(Oct 2008—Oct 2011) During this stage the research activities to implement an electric energy production system (small-hydro) to supply the electricity for the trolleybuses and the electric mini-buses of SMTUC was carried out. The work undertaken included the research in terms of applicable technologies, implementation and simulation of the exploration of the small hydropower plant. It was a technical, economic, environmental and legal feasibility study to implement the small-hydro inserted in the existing Coimbra dam bridge and began with the following activities:*

- Regional and national activities coordination in order to obtain information for the study.

- Preliminary feasibility analysis for using groups of turbine-generators specifically designed for very low head small hydro turbines in the downstream lochs of Coimbra's dam.

- Gathering national and administrative legislation and procedures concerning electricity production from hydropower.

- Data collection regarding trolleybuses and electric mini buses lines (characteristics, load diagrams...). Seasonal water supply variation, optimal dimensioning of the generator system, and fish migrating facilities were also studied.

In order to identify the best solutions to be implemented, the energy, economic and environmental impacts of possible different locations, as well as the different turbine technologies for the small-hydro plant was investigated in detail. These solutions aimed at optimising the economic benefits, while at the same time ensuring minimal disturbance to the operation of the fish passage though the dam. The impact in the fish migration was studied initially with the data provided in the project for the fish-ladder. The media coverage of this CIVITAS measure helped catalyse the construction of the fish passage that has long been demanded by the population of centre region. For this reason at the end of this stage some data was provided directly by measurements in the recently built fish-ladder.

In the meantime, several small hydro projects were analyzed with the regional water authority (ARHC) to support the Coimbra dam-bridge feasibility study and administrative procedures. Technical visits were made to the ANDRITZ HYDRO turbine laboratory in Linz, to the Agonitz small hydropower (pilot project of Hydromatrix and Straflomatrix turbines) and to the Chievo small hydro power plant, which has considerable similarities to the Coimbra dam-bridge. Important data and technical know-how was collected. Also technical visits were made to the MJ2 Technologies S.A.R.L. design office and the small hydropower pilot project equipped with a VLH-MJ2 turbine, in Millau, France, which also has considerable similarities to the Coimbra dam-bridge project. Important data and technical know-how was again collected.

A preliminary analysis was made based on reviewed literature and documents with the characteristics of the fish passage project for the Coimbra dam. The referred analysis was performed on the best possible location of turbines, surveillance of fish migrations, and the required water management to allow the maximum performance of all devices (dams, turbine-generators, and fish passage).

Preliminary feasibility analysis for using groups of turbine-generators specifically designed for very low head small hydro turbines in the downstream lochs of Coimbra's dam were also conducted, but this technology was abandoned for two reasons: 1 - the capital costs were much higher than those originally foreseen taking into consideration the values provided by the manufacturers; 2 - The flow needed to have a regular production of energy was higher than the existing average flow (the risk of flooding is augmented if gates have top be closed to increase the water level / flow rate).

Some preliminary laboratorial tests have also been done in a hydraulic channel to evaluate the performance of key system components (Fig. 5).

Fig. 5 - Laboratorial tests considering 3 turbines in a scale model of the Coimbra Dam spillway sill.

The technical feasibility of hydropower addition to the Coimbra Dam Bridge was developed considering an international survey of similar sites. Based on the research two hydropower small impact technologies with strong resemblances with the Coimbra Dam Bridge project were identified: the Chievo project where the StrafloMatrix™ technology is installed and the Millau project were the VLH-MJ2 technology is installed. Taking into account the space constraints in the Coimbra Dam Bridge, three possible locations were considered for turbines installation (Straflomatrix-S1, S2, S3 and VLH-V1, V2, V3 as shown in fig.6).

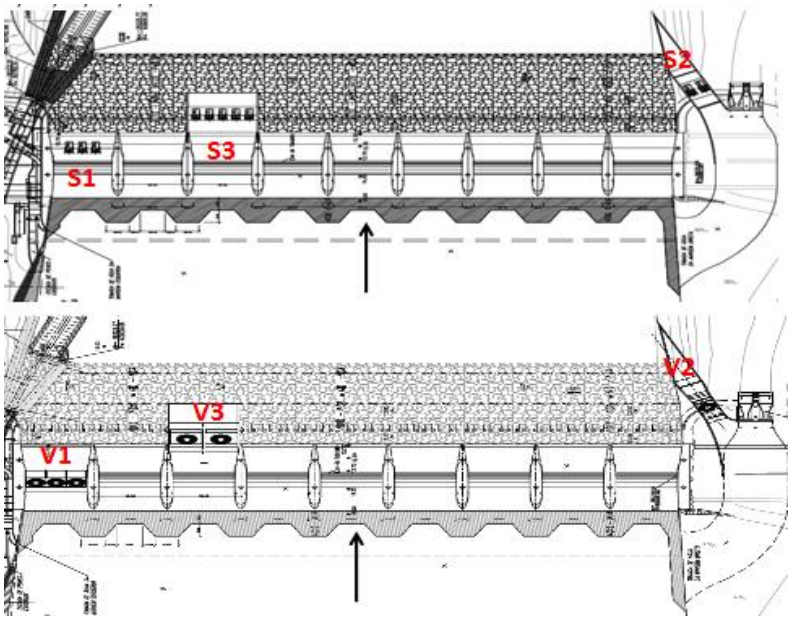


Fig. 6 -Top view of the different layouts.

The best solution for the feed of the trolleybus traction lines was also an alysed: the direct feed or the sale of the energy produced in the small-hydro to the electricity grid of EDP – the Portuguese electricity supplier. The solution agreed to was the last one taking in account that the direct feed needs very high capital costs for the energy transformation and could imply the loss of the surplus of energy (these vehicles don't run during some hours in the night and the foreseen energy production will be higher than the energy used by the trolleybuses). The first hydrological analysis to the available flows for the production of electric energy also showed a strong irregularity of current in the Mondego River, raising the probability of the occurrence in some summer days of insufficient energy production for the trolleybuses needs (if the direct feed was applied).

Finally the main outcomes for the technical feasibility were achieved and a working document was delivered in November 2009 with the description of the methodology and work undertaken in the study, as well as with the analysis of the several layouts and respective results.

In a second stage three solutions remained as the most recommended taking also into consideration the space constraints resulting from the fact that the dam was already built but without considering energy production in the original project. These solutions were analysed in more detail to find a good compromise between the environmental impact (mainly in the fish passage and in case of flooding) and the economic factors.

The small-hydro configuration costs and the annual revenue of the average hydrologic year were also calculated, and are presented in the following Figure:

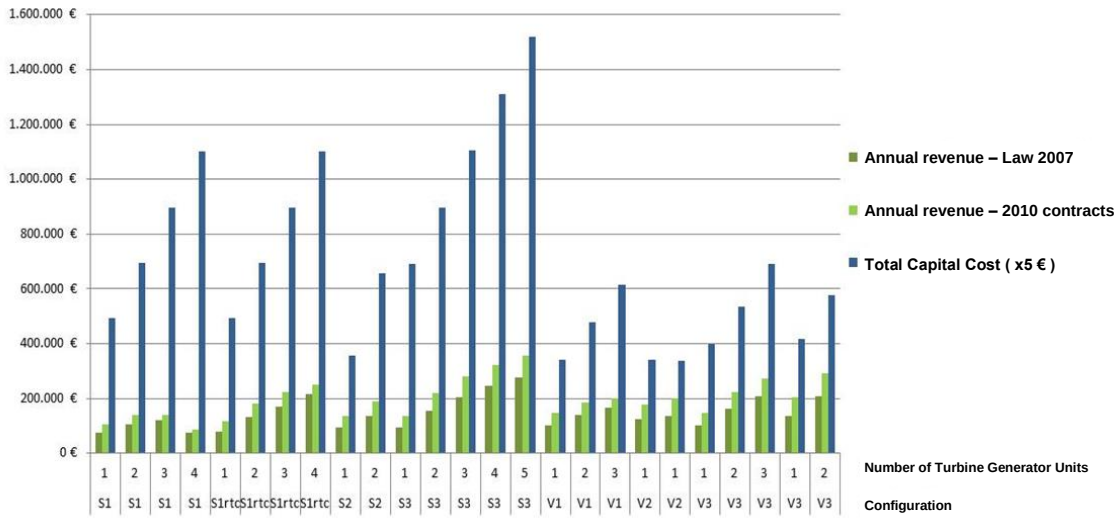


Fig.7- Annual revenue of the average hydrologic year.

Three locations for the turbines were analyzed, namely a location close to the fish-pass (in the same place where the S1 and V1 layouts were represented in Figure 6), a location between the fish-pass and the central gate (approximately in the same place where the S3 and V3 layouts were represented in Figure 6), and a location near the irrigation channel on the right margin of the dam (in the same place where the S2 and V2 layouts were represented in Figure 6). In general, it was considered admissible that the implementation of turbines on any of the above mentioned locations may interfere with the attraction ability performed by the fish-pass, meaning that its minimization constituted a goal for the working team.

Finally the best solution to mitigate the impact onthe fish-pass was achieved and pointed to the turbine placement on the irrigation channel on the right margin (in the same place where the S2 and V2 layouts were represented in Figure 6).

Analyses concerning the selection of the model of turbines to use were also carried out and the option selected was the VLH-MJ2 model because it is more cost-effective (Table B4.1) and more "fish-friendly" than the StrafloMatrix model (particularly due to the lower rotation speed of the blades).

Table B4.1-Ranking of the Net Present Value, considering a discount rate of 4% using the electricity rates in "Decreto-Lei n.º 225/2007".

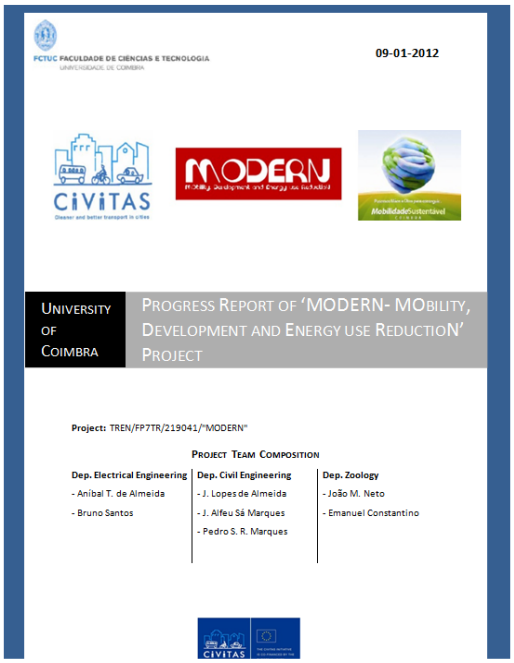
Layout	Number of Units	Units Type	NPV	IRR	Ranking (NPV)
V2	1	VLH 4000-45-4.0	1.222.220 €	8,9%	1 st
V3	2	VLH 4000-45-4.0	1.098.422 €	6,7%	2 nd
V2	1	VLH 4000-45-3.5	808.248 €	7,3%	3 rd

Therefore, the best solution, from an economic point of view, was also identified as layout V2, which is similar to the very successful Millau small hydropower plant in France, in operation since 2007.

The study also analysed the best location for the turbine generator unit installation and the construction requirements. The proposal was to locate in a short channel to be built between the irrigation channel intake and the river area (downstream of the dam). This layout will comprise civil construction works of a similar type to those involved in the new fish ladder, allowing for smaller costs with the project.

Financial issues and institutional arrangements were analysed for the real implementation of the small-hydro in the future. The capital costs for the small hydro are shown to be higher than the initial prediction. So the economic feasibility study, in order to reduce payback time and increase the internal rate of return, takes into consideration positive external factors such as environmental factors (CO2 emissions) and the importance of the project for the city. It was assumed that some funding programs (European, National or Regional) and institutional arrangements could support the initial investment, improving the economic feasibility of the project.

Despite the difficulties in having regular feed-back from the Portuguese Water Authority (INAG), an informal agreement for the authorization of the use of the dam for the production of electric energy for the trolleybus and electric mini-bus transport system was achieved (in a meeting with the President and other members of INAG, the Mayor and the Mobility Councillor of the Municipality of Coimbra, the CIVITAS MODERN site Coordinator and the measure leader and other experts involved in the measure). However, although a substantial amount of effort has been dedicated to the technical, economic and environmental feasibility report, the National Water Authority (INAG) has not yet replied to the administrative request for the addition of the hydropower plant in the Coimbra Dam Bridge. The request was made by the Municipality of Coimbra in the beginning of the CIVITAS MODERN project and in January 2012 a progress report of the project has been sent to the INAG (Fig. 8).


FCTUC FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE DE COIMBRA

09-01-2012

CIVITAS

MODERN

UNIVERSITY OF COIMBRA

PROGRESS REPORT OF 'MODERN- MOBILITY, DEVELOPMENT AND ENERGY USE REDUCTION' PROJECT

Project: TREN/FP7TR/219041/"MODERN"

PROJECT TEAM COMPOSITION

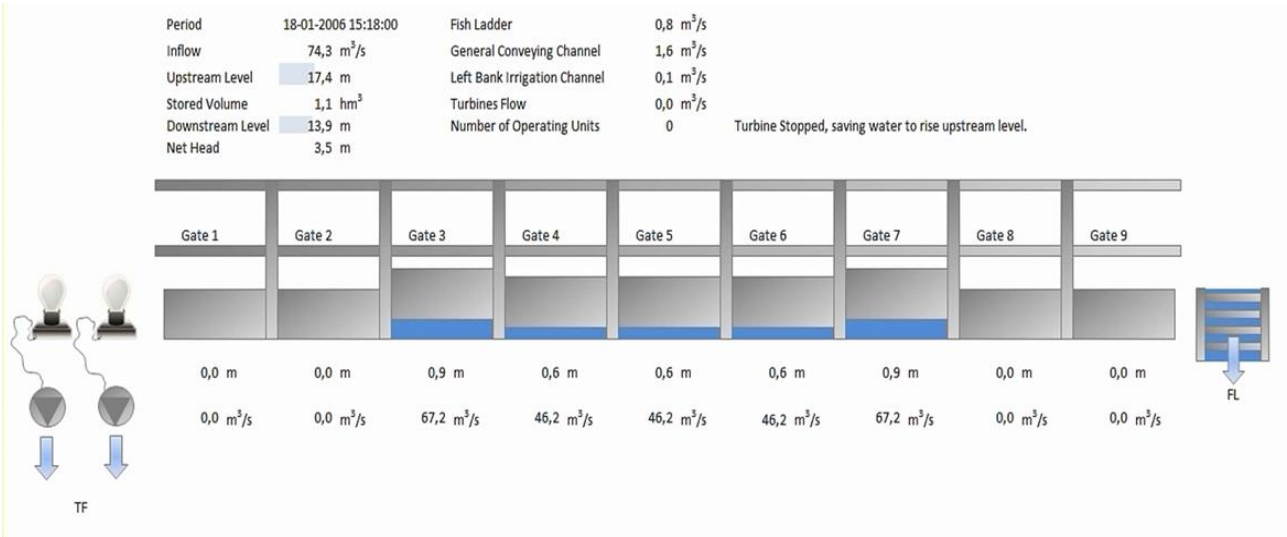
Dep. Electrical Engineering	Dep. Civil Engineering	Dep. Zoology
- Aníbal T. de Almeida	- J. Lopes de Almeida	- João M. Neto
- Bruno Santos	- J. Alfeu Sá Marques	- Emanuel Constantino
	- Pedro S. R. Marques	

CIVITAS

Figure 8-Progress report of CIVITAS MODERN project delivered to INAG – National Water Institute

Stage 2: Small-hydro projected basic layout *(June 2010 – October 2012) - Although this stage was devoted to the demonstration of the measure, it was also used for the monitoring of results and the support for the demand of the best solution.*

Accordingly, during this stage the budgetary cost of all layouts was computed taking into account the specific unitary construction costs information of the fish ladder in the Coimbra Dam Bridge, provided by INAG (National Water Institute), as well as considering the cost information obtained from equipment manufacturers. A detailed small hydropower operation computational model was concluded and applied to all possible layouts, in order to estimate the annual revenue of each one (Fig. 9). The detailed small hydropower operation computational model provides a DEMO layout of the Coimbra Dam Bridge equipped with turbine-generator units, namely the overture state of each of the 9 radial gates, the flow in each radial gate, the number of operating turbine-generator units, and respective energy production. This computational model is user-friendly and can be used in normal PC.



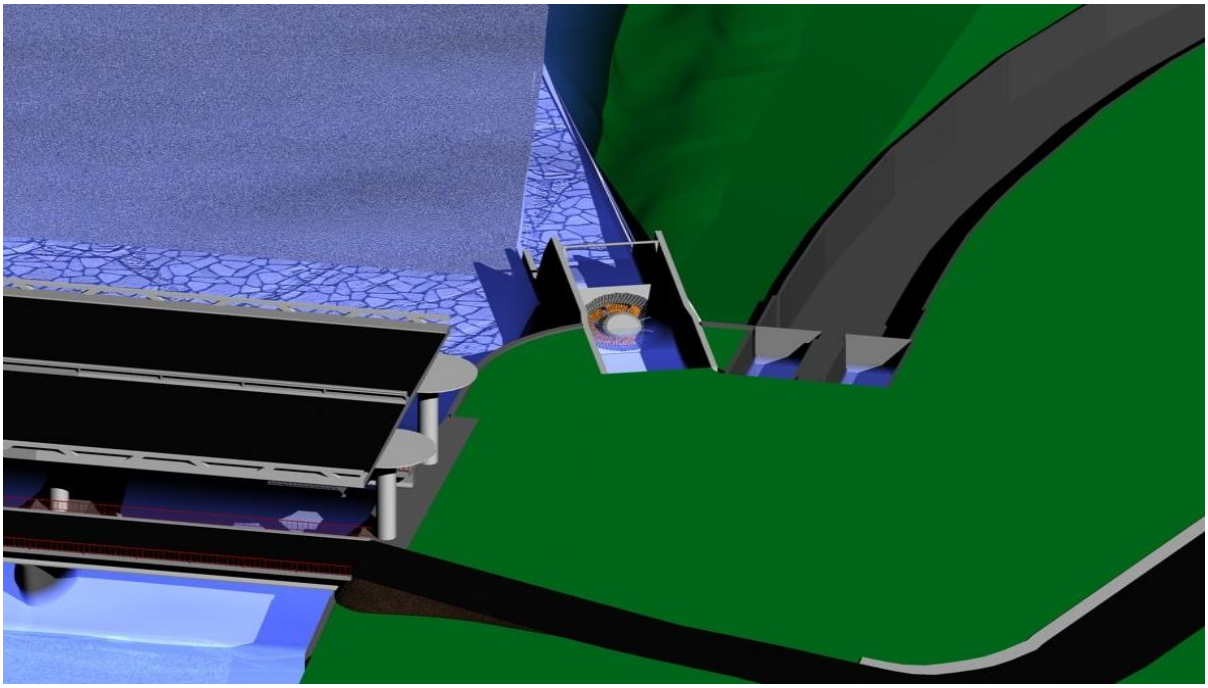


Figure 9-Computer Simulation Model output example (above) and Small Hydro 3D model (below).

Stage 3: Dissemination activities and release of deliverable with the feasibility study *(October 2008 – October 2012) – Despite the fact that this measure is only a study during CIVITAS, it had the most media coverage because the population also elected this measure as the most important and welcomed.*

The dissemination of the main measure outcomes and technical features predominantly was carried out by the media and presentations in several workshops, seminars and conferences (highlighting the presentation of the CIVITAS measures in the Conference Land Use, Accessibility and Mobility Management organized by EPOMM and IMTT – Portuguese Institute of Mobility and Inland Transportation in Lisbon, 12-14th April 2010 and the measure in the 24th World Electric Vehicle Symposium – EVS24 Norway, 13-16th May 2009) and in the CIVINET Spain and Portugal Forum (Coimbra, 8th June 2011).

Several news articles were published in news papers, magazines and online sites. At the international level, 2 papers were published in indexed academic journals: a revised paper of EVS24 presentation was published in the International Journal World Electric Vehicle Journal, ISSN 2032-6653, Volume 3, December 2009 and the paper entitled "Small-hydropower addition to Coimbra dam-bridge for sustainable urban mobility" was submitted to the journal "Renewable & Sustainable Energy Reviews", Elsevier, and was available online on 16th September 2011.

In June 2012 the final report with the economic, environmental and legal feasibility study was delivered, including the financial engineering and institutional arrangements.

The digital model of the small hydro power generation plant has been developed and used for dissemination activities, which included several presentations (workshops, seminars, CIVINET Spain and Portugal Forum 2011, ...), Some dedicated videos with the 3D model version and 4 generic videos that included this model have been also produced and used in presentations, namely in the CIVITAS Forum 2012, or placed on-line (including the CIVITAS website).

B5 Inter-relationships with other measures

The measure does not have any inter-relation with other measures because it is a study.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1.1: Indicators

No.	Impact	Indicator	Data used	Comments
1	Operating Revenues	Average Operating Revenues	Total income generated from the small hydro power plant production; Total vehicle-km	Revenues were provided by small-hydro feasibility study
2	Operating Costs	Average Operating Costs	Total operating costs from of electric supply to the trolleybus fleet; Operation and maintenance costs of the small-hydro plant); Total vehicle-km	Costs were provided by SMTUC and small-hydro feasibility study
3	Costs	Capital Costs	Total capital costs spent in setting up the measure	Capital costs were provided by small-hydro feasibility study
4	Awareness	Awareness level	Number of respondents with knowledge of the measure on account of provided information.; Total number of respondents	Awareness level was provided by SMTUC cusom satisfaction survey in the scop of the Quality Management activity of SMTUC
5	Emissions	CO2 emissions	Average CO2 emissions in the supply of 1 MJ of electric energy; Total energy consumption by the Trolleybus fleet; Total vehicle-km	Bibliographic sources
6	Emissions	NOx emissions	Average NOx emissions in the supply of 1 MJ of electric energy; Total energy consumption by the Trolleybus fleet; Total vehicle-km	Bibliographic sources

This measure consists in the elaboration of a feasibility study. The implementation of the measure includes the definition of the methodology to determine the costs and benefits related to the Production of Renewable Energies for Trolleybus Lines of SMTUC, the Urban Public Transport operator in Coimbra, and the estimation of those costs and benefits according to the defined methodology. Without any practical action during the CIVITAS MODERN project, no measureable impacts (apart from the Awareness level) will result from this measure. Therefore, the concept of

impact evaluation is not straightforward – only potential impacts of the measure may be derived from the study.

All the chosen indicators reflect the impact of the measure when it will be implemented. The indicators also consider that the energy production of the small hydro plant do not feed directly the fleet of trolley bus and the associated positive income of selling energy will be used for depreciation of the investment and not for increasing the offer of the PT service. For these reason was not chosen indicators related with the fleet performance (fuel mix, fuel efficiency, emissions concerning the SMTUC fleet).

Detailed description of the indicator methodologies:

- **Indicator 1** (*Average Operating Revenues*) – Ratio between the income generated from the power generator in charge of the "Production of Renewable Energies for Trolleybus Lines in Coimbra" divided by the total vehicle-km per year of trolleybus fleet (€/vehicle-km).

  A = B / C

  where: A = Average operational revenue for the small hydro power plant (€/vehicle-km)

  B = Revenues from sale of energy produced in the small-hydro plant (€)

  C = Total vehicle-km of the trolleybus fleet per year (vehicle-km)

  All data are related to the SMTUC Trolleybus fleet. Results from vehicle-kilometres coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded every day/month/year. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedure: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the Automatic Vehicle Management (AVM) system.

  The value of sale of energy produced in the small-hydro in the ex-ante situation is zero. Revenues from sale of energy produced in the small-hydro (in relation to the ex-post situation) come from the Progress report of the small-hydro (economical, environmental and legal) feasibility study[4] and from the measure leader. The value is calculated by the product of the estimated annual production (2,6 GWh) of the small hydro plant and a fixed feed-in tariff of 77 €/MWh. The annual production is obtained from the 500 kW hydro turbine configuration in VLH-MJ 2 mode and the feed-in tariff is derived from the Portuguese legislation of renewable energy source production stated in "Decreto-Lei n. º 225/2007", actualised by the 15-10-2010 Contest.

  It is important to stress that that it is not foreseen at short term using the revenues derived from the energy income to increase the PT offer, as well as the increase in the trolley bus network infrastructure or fleet renewal. These revenues will be used only for the depreciation of the small hydro capital costs. For this reason the impact of the small hydro in the tickets sales revenues is not foreseen.

- **Indicator 2** (*Average Operating Costs*) – Ratio between the total operating costs associated with small hydro plant and the total vehicle-km of the trolleybus fleet per year (€/vehicle-km).

[4] This information was included in the in the second year report, in feasibility study.

A = (B + C) / D

where: A = Average operational costs for the power supply to the Trolleybus fleet (€/vehicle-km)

B = Purchase of electric energy from the mains for the trolleybus lines (€)

C = Operation and Maintenance of the small-hydro plant costs (€)

D = Total vehicle-km of the trolleybus fleet (vehicle-km)

All data are related to the SMTUC trolleybus fleet. Results from vehicle-kilometres coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded every day/month/year. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the AVM system.

The value of personnel costs (Operation and Maintenance – O&M) of the small-hydro in the ex-ante situation is zero. The Personnel costs are related with the O&M of the small-hydro (in relation to the ex-post situation) and is 5% of the small hydro plant energy annual revenues. This percentage is considered in the feasibility study and it includes the costs related with personnel for regular maintenance and operation of the plant, spare parts and insurance.

- **Indicator 3** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

  Expenditures with the purchase of the power generator (€)

  The data about the power generator purchase cost coming from the measure leader and is referenced in the Progress report of the small-hydro (economical, environmental and legal) feasibility study[5].

- **Indicator 4** (*Awareness level*) – Percentage of the users with knowledge of the measure on account of provided information (%).

  A = B / C × 100

  where: A = Percentage of users with knowledge of the measure (%)

  B = Total number of respondents with knowledge of the measure

  C = Total number of respondents

  The Awareness level of the measure is measured during customer satisfaction surveys carried out in the scope of the Quality Management System of SMTUC (for more details, see annex dedicated to the customer satisfaction survey) by introducing the following specific question relative to the knowledge of the respondent about the measure – Are you aware about the SMTUC intention in producing renewable energy for trolleybus lines from Coimbra's Bridge-Dam?

[5] This information was included in the in the second year report, in feasibility study.

Indicator 5 (*CO2 Emissions*) – Average CO2 emissions per vehicle-km (g/vehicle-km)

A = B × (C – D)

where: A = Average CO2 emissions per vehicle-km (g/vehicle-km)

B = Average CO2 emissions in the supply of 1 MJ of electrical energy (g/MJ)

C = Total energy consumption by the Trolleybus fleet (MJ)

D = Total energy production by the small-hydro (MJ)

The data about the Average CO2 emissions in the supply of 1 MJ of electric energy is based on bibliographic sources: the Portuguese environment agency (average emissions in electricity production related to each energy source) and the regulatory entity of the Portuguese energy market.

All data are related to the SMTUC Trolleybus fleet. Results from vehicle-kilometres coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded every day/month/year. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following a reliable procedure: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the GPS/GPRS Operation Support System.

- **Indicator 6** (*NOx Emissions*) – Average NOx emissions (vehicle-km)

A = B × (C – D)

where: A = Average NOx emissions per vehicle-km (g/vehicle-km)

B = Average NOx emissions in the supply of 1 MJ of electric energy (g/MJ)

C = Total energy consumption by the Trolleybus fleet (MJ)

D = Total energy production by the small-hydro (MJ)

The data about the Average CO2 emissions in the supply of 1 MJ of electric energy is based on bibliographic sources: the Portuguese environment agency (average emissions in electricity production related to each energy source) and the regulatory entity of the Portuguese energy market.

All data are related to the SMTUC Trolleybus fleet. Results from vehicle-kilometres coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded every day/month/year. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following a reliable procedure: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the GPS/GPRS Operation Support System.

C1.2 Establishing a Baseline

2007 is considered as the baseline, before the start of the study in October 2008 and the release of any news about SMTUC's intention in producing renewable energy for trolleybus lines from Coimbra's Bridge-Dam.

The measure results are obtained from the measure leader, the feasibility study and SMTUC records on indicators 1, 2 and 3 and from the customer satisfaction survey periodically carried out by SMTUC on indicator 4.

Indicators 1, 2 and 3 (Operating Revenues, Operating Costs and Capital Costs):

The transport company SMTUC provided information on both the costs of operating the SMTUC PT system and revenues coming from ticket sales to passengers in relation to the operation of SMTUC transport services. Similarly, SMTUC provided information on the number of passengers as well as the vehicle-km performed both by the trolleybus (and overall) fleet.

For the Operating revenues and the capital costs it was considered that before the implementation of the small-hydro power plant any revenues and capital costs occurred.

For the operating costs was considered that before the referred implementation occurred costs with the purchase of electric energy to supply the trolleybuses fleet (values of the energy purchase and trolleybuses vehicle-km recorded by SMTUC and shown in the table

The results of baseline for each indicator are the following (tables C1.2.1 to C1.2.3).

Table C1.2.1: Baseline operating revenues indicator

Indicators and respective parameters	Ex-Ante values
Operating revenues from the small hydro plant (2007)	0,00 €
Total vechicle-km (2007)	206.797 vkm
Average operating renevues	0,00 €/vkm

Table C1.2.2: Baseline operating costs indicator

Indicators and respective parameters	Ex-Ante values
Total Operationg Costs (2007)	83.204 €
Purchase of electric energy from the mains for the trolleybus lines	83.204 €
Operation and Maintenance of the small-hydro plant costs	0 €
Total vechicle-km (2007)	206.797 vkm
Average operating costs	0,40 €/vkm

Table C1.2.3: Baseline capital cost indicator

Indicators and respective parameters	Ex-Ante values
Total capital cost (2007)	0,00 €

Indicator 4 (Awareness level)

This question was not applied before the launch of the "Feasibility Study" because it was considered that it is non sense to ask people if they know something that still doesn't exist. Thus, it is considered that before something exist awareness is zero because it's impossible to know it.

The Table C1.2.4 shows the results of the baseline for this indicator.

Table C1.2.4: Baseline awarness level indicator

Indicators and respective parameters	Ex-Ante values
Awareness level – users	0 %

Indicator 5 and 6 (Green-house gas emissions – CO2 and NOx)

In order to determine the ex-Ante values for this indicator, the measure leader provided information on the green-house gases emissions related to the measure (trolleybus lines and small-hydro operation). For that purpose, it has been used the available data about the consumption of energy of the trolleybus as well the average emission factor of CO2 and NOx reported from a 2007 data (table 3 and 4 of Annex 3).

The results of baseline for this indicator are shown in the table C1.2.5.

Table C1.2.5: Baseline average emission indicators

Indicators and respective parameters	Ex-Ante values
Average CO2 emissions (ton)	269,29
Average NOx emissions (ton)	0,81

C1.3 Building the Business-as-Usual scenario

The CIVITAS MODERN accelerated the implementation of the feasibility study and without it the implementation of the study would not have take place within a 4 or 5 year period (certainly not within the period of the project).

Without the implementation of the measure (business-as-usual scenario) no changes were likely to occur in the indicator 4 - Awareness level. Therefore, the B-a-U scenario for this indicator equals to the respective Ex-Ante value.

In relation to the indicators 1 - Average Operating Revenues, 2 - Average Operating Costs and 3 - Capital Costs, which were evaluated considering a scenario of real implementation of the measure, the available historic data showing the current trends in these indicators, correspond themselves to the BAU scenario.

Indicator 1 (Average Operating Revenues)

Without setting up the small hydro plant implementation the B-a-U scenario for Average Operating Revenues is considered zero (Table C1.3.1).

It is considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Table C1.3.1: BAU Operating Revenues indicator

Indicators and respective parameters	BAU values
Average Operating Revenues (2008)	0,00 €/vkm
Average Operating Revenues (2009)	0,00 €/vkm
Average Operating Revenues (2010)	0,00 €/vkm
Average Operating Revenues (2011)	0,00 €/vkm

Indicator 2 (Average Operating Costs)

Without setting up the small hydro plant the B-a-U scenario for Average Operating Costs is considered the energy costs to feed the trolleybuses (Costs per item and the trolleybuses vehicles-km in the table C1.3.2 and the summary of the BAU Average Operating Costs in the table C1.3.3).

Any costs for the operation and maintenance of the small-hydro has been considered, despite these costs were already incurred, but not by the PT operator (SMTUC).

Table C1.3.2: Costs per item and the vehicles-km in the BAU conditions

Year	A Energy Costs (€)	B Small Hydro Plant O&M Costs (€)	C=A+B Total O&M Costs (€)	D Vehicle-km Trolleybuses vkm	E=C/D Average Operating Costs €/vkm
2000	74.756,00	0,00	74.756,00	222.461,00	0,34
2001	72.587,00	0,00	72.587,00	195.801,00	0,37
2002	66.053,00	0,00	66.053,00	233.873,00	0,28
2003	71.428,00	0,00	71.428,00	235.175,00	0,30
2004	73.852,00	0,00	73.852,00	221.576,00	0,33
2005	75.007,00	0,00	75.007,00	211.555,00	0,35
2006	78.668,00	0,00	78.668,00	210.945,00	0,37
2007	83.204,00	0,00	83.204,00	206.797,00	0,40
2008	75.663,00	0,00	75.663,00	179.565,00	0,42
2009	70.625,00	0,00	80.625,00	147.025,00	0,48
2010	80.457,00	0,00	90.457,00	179.644,00	0,45
2011	93.818,00	0,00	103.818,00	195.507,00	0,48

Table C1.3.3: BAU Operating Costs indicator

Indicators and respective parameters	BAU values
Average Operating Costs (2008)	0,42 €/vkm
Average Operating Costs (2009)	0,48 €/vkm
Average Operating Costs (2010)	0,45 €/vkm
Average Operating Costs (2011)	0,48 €/vkm

Indicator 3 (Capital Costs)

The capital costs related to the installation of the power generator is considered in the year of setting up the measure (2008). Therefore, without the implementation of the measure, the capital costs would be as before. It is considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation (Table C1.3.4).

Table C1.3.4: BAU Capital Costs indicator

Indicators and respective parameters	BAU values
Capital Costs (2008)	0 €
Capital Costs (2009)	0 €
Capital Costs (2010)	0 €
Capital Costs (2011)	0 €

Indicator 4 (Awareness level – users)

The change in the Awareness level – users related to SMTUC's intention in producing renewable energy for trolleybus lines from Coimbra's Bridge-Dam is obtained after setting up the measure (i.e. after the "start of the study" in October 2008 and the release of news about SMTUC's intention in producing renewable energy for trolleybus lines from Coimbra's Bridge-Dam). Therefore, if this measure wasn't implemented, the Awareness level – users would be as before. It is considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Therefore, the results of BAU scenario for this case (Table C1.3.5) are equal to the baseline.

Table C1.3.5: BAU awarness level indicator

Indicators and respective parameters	BAU values
Awareness level – users (2008)	0 %
Awareness level – users (2009)	0 %
Awareness level – users (2010)	0 %
Awareness level – users (2011)	0 %

Indicator 5 and 6 (Green-house gas emissions – CO2 and NOx)

The change in the Green-house gas emissions related to the installation of the power generator is obtained after setting up the measure. Therefore, without the implementation of the measure, the Green-house gas emissions would be as before. It is considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation. It was considered the impact resulting of the change in the energy source from the usual production at national level to the local small-hydro production. The emissions were related to the energy used to feed the SMTUC trolleybuses and were obtained from the emissions factor of CO2 and NOx reported from a 2011 monthly data series (table 3 of Annex 3) and the energy consumption of the trolleybuses recorded by SMTUC (Table 4 of Annex 3)

The tables C1.3.6 and C1.3.7 show the results of BAU scenario for the emissions.

Table C1.3.6: BAU CO2 emissions indicator

Indicators and respective parameters	BAU values
Average CO2 emissions (2008)	236,48 (ton)
Average CO2 emissions (2009)	202,35 (ton)
Average CO2 emissions (2010)	228,89 (ton)
Average CO2 emissions (2011)	239,94 (ton)

Table C1.3.7: BAU NOx emissions indicator

Indicators and respective parameters	BAU values
Average NOx emissions (ton) (2008)	0,71
Average NOx emissions (ton) (2009)	0,61
Average NOx emissions (ton) (2010)	0,69
Average NOx emissions (ton) (2011)	0,72

C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

C2.1 Economy

In the same way as for the baseline, the results of the indicators for the situation after implementing the measure were obtained. Indicators 1 - Average Operating Revenues, 2 - Average Operating Costs and 3 Capital Costs were evaluated considering a scenario of real implementation of the measure during CIVITAS MODERN. The table C2.1.1 shows the small-hydro implementation scenario considered.

Table C2.1.1: Measure implementation timeline

Year	Stage
2008	Purchase and Installation of the power generator
2009	Operation of the small hydro power plant
2010	
2011	

The tables C2.1.2 and C2.1.3 show the data obtained relative to the operating revenues. This indicator is calculated taking in consideration the revenues coming from the sale of the energy produced in the small-hydro to the national grid per the vehicle-km in SMTUC trolleybus fleet. The revenues results of the annual energy production obtained in the feasibility study (2,6 GWh) and the feed-in tariff (0,077 €/kWh).

Table C2.1.2: Operating revenues coming from the energy produced in the small-hydro

Year	A Annual Small Hydro Plant Production (GWh)	B Feed-in tariff (€/kWh)	C= A/B Revenues Small Hydro (€)	D Vehicle-km - Trolleys (vkm)	**E=C/D Operating Revenues (€/vkm)**
2001	0	-	0,00	195.801	**0**
2002	0	-	0,00	233.873	**0**
2003	0	-	0,00	235.175	**0**
2004	0	-	0,00	221.576	**0**
2005	0	-	0,00	211.555	**0**
2006	0	-	0,00	210.945	**0**
2007	0	-	0,00	206.797	**0**
2008	0	-	0,00	179.565	**0**
2009	2,6	0,077	200.000,00	147.025	**1,36**
2010	2,6	0,077	200.000,00	179.644	**1,11**
2011	2,6	0,077	200.000,00	195.507	**1,02**

Table C2.1.32: Ex-Post Operating Revenues indicator

Indicators and respective parameters	Ex-Post Values
Average operating revenue (2009)	1,36 €/vkm
Average operating revenue (2010)	1,11 €/vkm
Average operating revenue (2011)	1,02 €/vkm

The table C2.1.4 show the data obtained from SMTUC relative to costs related to the trolley buses lines and the costs concerning the small-hydro operation and maintenance.

Table C2.1.43: Costs per item and total operating costs

Year	Energy Costs (€)	Small Hydro Plant O&M Costs (€)	Total O&M Costs (€)	Vehicle-km Trolley vkm	O&M costs / vkm €/vkm
2009	70.625,00	10.000,00	80.625,00	147.025,00	0,55
2010	80.457,00	10.000,00	90.457,00	179.644,00	0,50
2011	93.818,00	10.000,00	103.818,00	195.507,00	0,53

The table C2.1.5 summarize the Ex-Post Operating Costs

Table C2.1.5: Ex-Post Operating costs indicator

Indicators and respective parameters	Ex-Post Values
Average operating costs (2009)	0,55 €/vkm
Average operating costs (2010)	0,50 €/vkm
Average operating costs (2011)	0,53 €/vkm

The capital costs were obtained in the feasibility study and was considered that the implementation of the small-hydro took place in 2008 and no other investments will occur in the subsequent years (Table C2.1.6).

Table C2.1.6: Ex-Post capital costs indicator

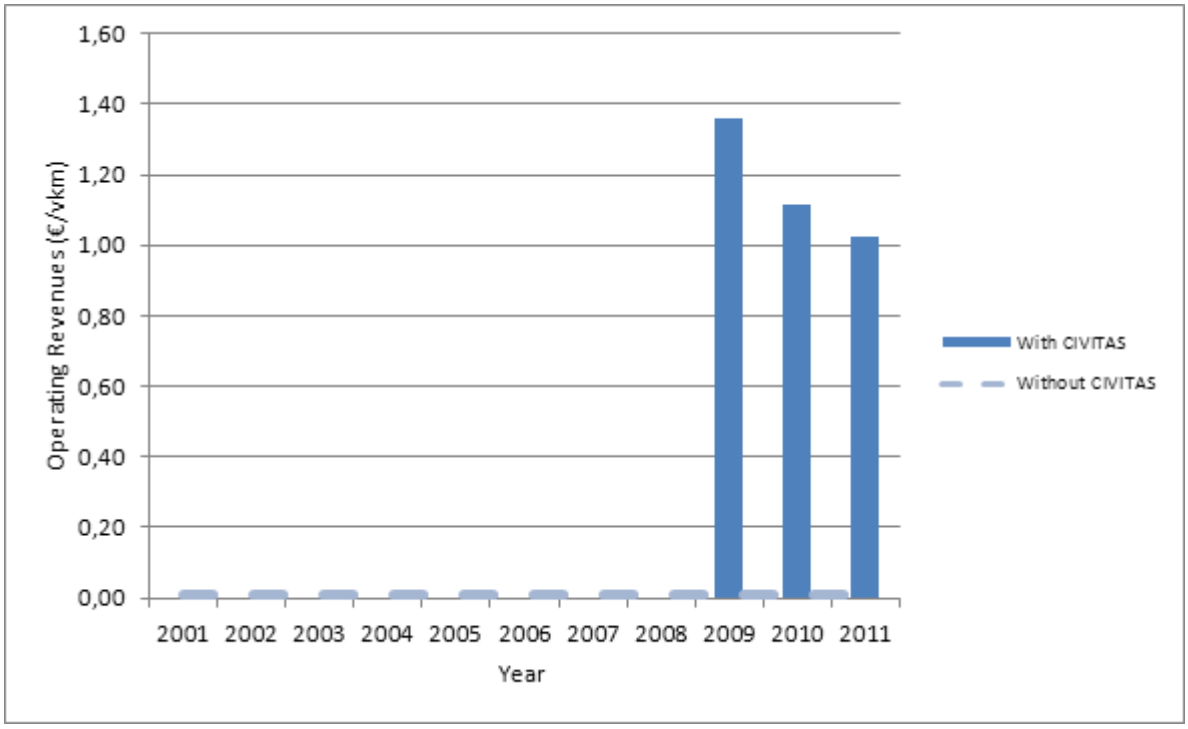
Indicators and respective parameters	Ex-Post Values
Total capital cost (2008)	1.700.000 €
Total capital cost (2009)	0 €
Total capital cost (2010)	0 €
Total capital cost (2011)	0 €

The table C2.1.7 summarises the results of indicators 1, 2 and 3.

Table C2.1.7: Summary of the indicators impact

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
1. Average Operating Revenues	0,00 €/vkm (2007)	0,00 €/vkm (2008) 0,00 €/vkm (2009) 0,00 €/vkm (2010) 0,00 €/vkm (2011)	1,36 €/vkm (2009) 1,11 €/vkm (2010) 1,02 €/vkm (2011)	1,36 €/vkm (2009) 1,11 €/vkm (2010) 1,02 €/vkm (2011)	1,36 €/vkm (2009) 1,11 €/vkm (2010) 1,02 €/vkm (2011)
2. Average Operating Costs	0,00 €/vkm (2007)	0,42 €/vkm (2008) 0,48 €/vkm (2009) 0,45 €/vkm (2010) 0,48 €/vkm (2011)	0,42 €/vkm (2008) 0,55 €/vkm (2009) 0,50 €/vkm (2010) 0,53 €/vkm (2011)	0,42 €/vkm (2008) 0,55 €/vkm (2009) 0,50 €/vkm (2010) 0,53 €/vkm (2011)	0,00 €/vkm (2008) 0,07 €/vkm (2009) 0,05 €/vkm (2010) 0,05 €/vkm (2011)
3. Capital Costs	0,00 € (2007)	0,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	1,700.000,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	1,700.000,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	1,700.000,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)

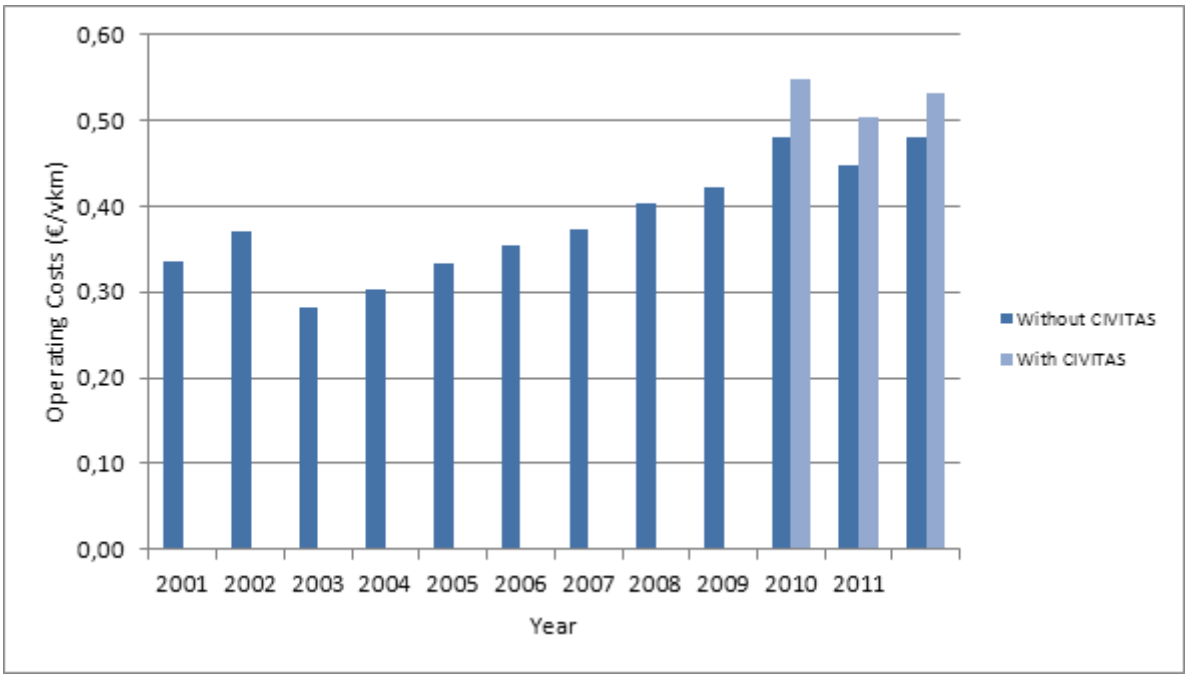
The graph C2.1.1 shows the evolution of average operating revenues (€/vkm) with the implementation of CIVITAS MODERN measure and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).



Graph C2.1.1 - Operating Revenues - trend without CIVITAS (BAU) and results with CIVITAS.

With the implementation of CIVITAS MODERN measure it is obtained 200 k €/year with the revenues of selling all the energy produced in the small-hydro, contributing to an increase in the overall operating revenues.

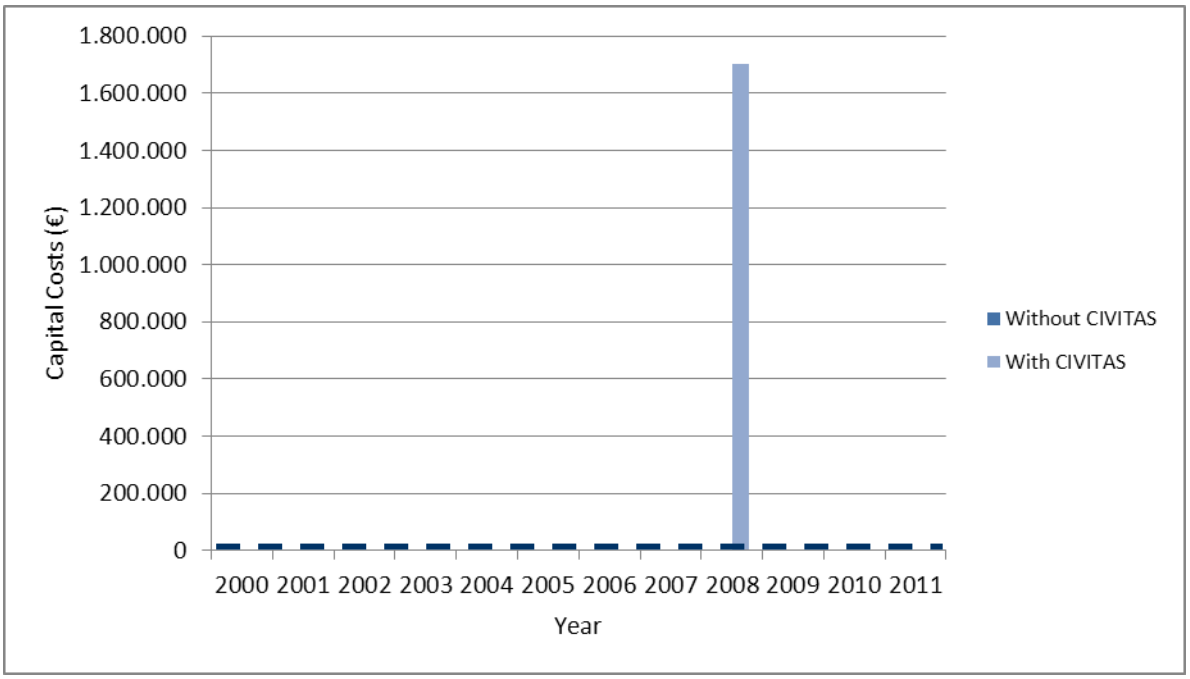
The graph C2.1.2 shows the evolution of average operating costs (€/vkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).



Graph C2.1.2 - Operating Costs - trend without CIVITAS and results with CIVITAS.

With the implementation of CIVITAS MODERN project, there is an increase on the operating costs due to the costs of operation and maintenance of the power generator which represents about 5% of the value of the revenues of selling the energy produced in the small-hydro.

The graph C2.1.3 shows the evolution of capital costs (€) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).



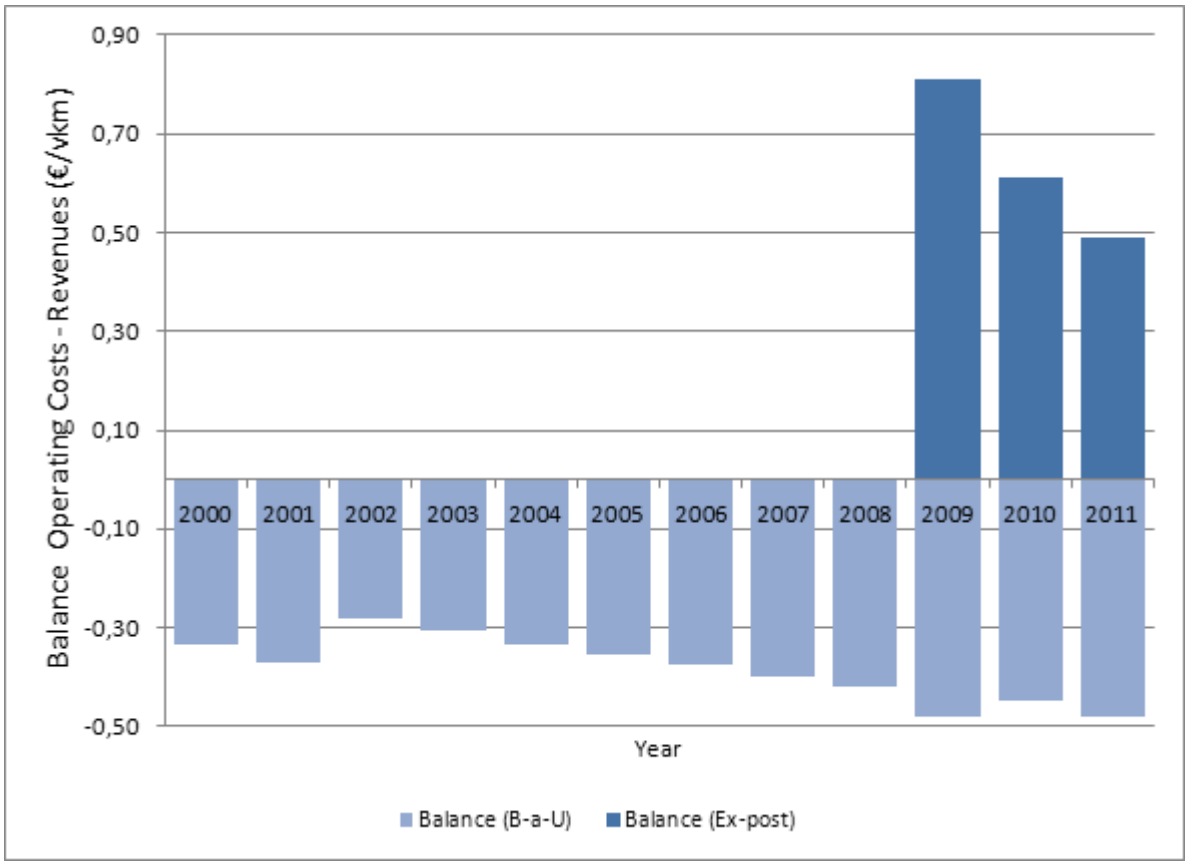
Graph C2.1.3 -Capital Costs - trend without CIVITAS and results with CIVITAS

In summary, the indicator 1(average operating revenues) associated with the small hydro plant reveals a generated income related to the revenue of selling the produced electrical energy to the grid after operating the plant (2009). As expected, the indicator 2 (average operating costs) reflects an extra costs related to the Operation and Maintenance (O&M) of the plant. Indicator 3 (Capital Costs) reflects the investment in 2008 for the small hydro plant. The table C2.1.8 shows the balance between indicator 1 and 2. Analysing the difference between the scenario ex-post and B-a-U it is possible to conclude that the measure revealed itself to be efficient since there are surpluses given by the difference between the average operating revenues and the average operating costs.

Table C2.1.8: Balance between average operating revenues and costs

Year	Difference: After – B-a-U (€/vkm)		
	Average Operating Revenues (A)	Average Operating Costs (B)	**Balance (A-B)**
2007	0,00	0,40	**-0,40**
2008	0,00	0,42	**-0,42**
2009	1,36	0,55	**0,81**
2010	1,11	0,50	**0,61**
2011	1,02	0,53	**0,49**

The balance of the operating revenues and costs from 2000 to 2011 for the B-a-U and Ex-post scenario is illustrated in the following histogram (Graph C2.1.4).



Graph C2.1.4 - Balance of the B-a-U scenario and Ex-post results

By analysing the figure it is possible to observe that in the B-a-U scenario the balance between revenues and costs are negative due to the fact that the implementation of the CIVITAS measure are not previewed. Observing the Ex-post scenario it is possible to perceive the impact of the measure on the balance between revenues and costs by changing the trend from negative to positive, i.e., the revenues obtained with selling the small hydro energy production to the grid generates a surplus when compared with the operating costs associated with the small hydro plant. Due to this fact it is possible to conclude that the introduction of the measure has a positive impact in financial terms.

Besides this economical evaluation it is also important to stress that the investment in the small hydro plant will have a simple payback period of 12 years. This value is based on the feasibility study in which values are expressed in the following table.

Table C2.1.9: Summary of the pay-back period

Investiment (M€)	1,7
Production (MWh)	2.600
Feed-in tariff (€/MWh)	77
Annual revenues (M€)	0,20
Simple Pay-back	**8,5**

C2.2 Society

To assess the knowledge towards the changes specific questions were added to the customer satisfaction survey to PT users - *Are you aware about the SMTUC intention in producing renewable energy for trolleybus lines from Coimbra's Bridge-Dam?* (according to the indicator definition). In this way, it has been obtained the results of the indicator after implementing the measure in 2009. The table C2.2.1 shows the results of indicator 4.

Table C2.2.1: Ex-post awareness level users

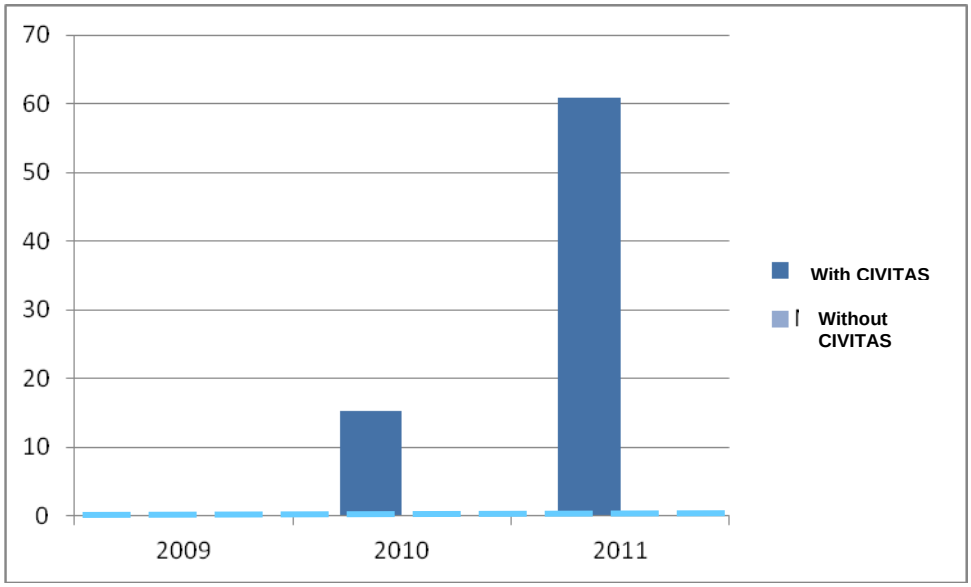
Indicators and respective parameters	Ex-Post values
Awareness level users (2010-03-23 a 2010-03-29)	15%
Awareness level users (2011-03-29 to 2011-04-04)	61%

The table C2.2.2 shows the results of the indicator:

Table C2.2.2: Ex-post awareness level balance

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
1. Awareness level – users	0 % (2009)	0 % (2010) 0 % (2011)	15 % (2010) 61 % (2011)	15 % (2010) 61 % (2011)	15 % (2010) 61 % (2011)

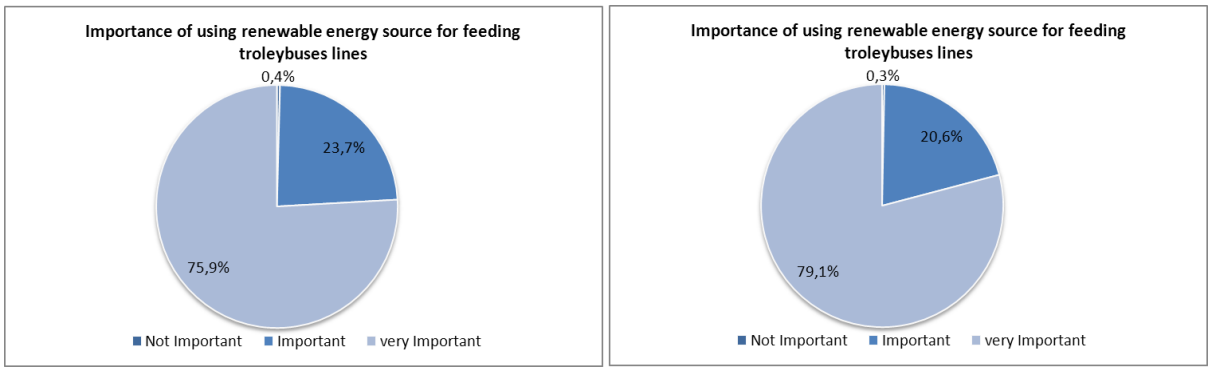
The next graph shows the evolution of the Awareness Level (%) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).



Graph C2.2.1-Awarness Level with CIVITAS and without CIVITAS

This evolution shows that the awareness level increased steadily along with the implementation of the measure (more rapidly from 2010-2011 than from 2009-2010 due the increase in the media coverage).

In addition a survey was developed in order to assess the acceptance level. A question related to the importance of using renewable energy sources to feed the trolley bus lines was introduced into the yearly customer satisfaction survey to PT users. Meanwhile, the impacts on society did not included the acceptance level because the measure had an initial high social media impact which did not allow for the assessment of the ex-ante data for this indicator (the first survey was conducted in 23-29 March 2010). The results of these surveys demonstrated a high acceptance level and it improved between 2010 and 2011, as it is shown in the Graph C2.2.2.



Graph C2.2.2- Renewable energy introduction acceptance level of PT users

C2.3 Environment

Indicator 5 and 6 (Green-house gas emissions – CO2 and NOx)

In order to determine the ex-Post values for this indicator, the measure leader provided information on the green-house gases emissions related to the measure (trolleybus lines and small-hydro operation). For that purpose, the available data about the consumption of energy of the trolleybus and the average emission factor of CO2 and NOx reported from a 2011 monthly series data as well as the total production of renewable energy at the small-hydro has been used.

The ex-post emissions reduction corresponds to the difference between the emissions due the energy production in the small-hydro (zero emissions) and the comparatively emissions for the same energy production at national level. According the feasibility study the foreseen energy production will be 9.360.000 MJ per year. So with the emission factors for the greenhouses gases incurred in the energy production at national level (table C2.3.1) we obtain the reduction in the emissions per year with the implementation of the small-hydro power generator (table C2.3.2).

Table C2.3.1: Emission factor for the greenhouse gases incurred in the global electricity production (at national level)

Average CO2 emissions incurred in electricity production (g/MJ)	99,4
Average NOx emissions incurred in electricity production (g/MJ)	0,30

Table C2.3.2: Ex-post average CO2 emissions

Indicators and respective parameters	Ex-Post values
Average CO2 emissions (ton) – 2008	+ 236,48
Average CO2 emissions (ton) – 2009 / 2010 / 2011	-930,38
Average NOx emissions (ton) – 2008	+ 0,71
Average NOx emissions (ton) – 2009 / 2010 / 2011	-2,81

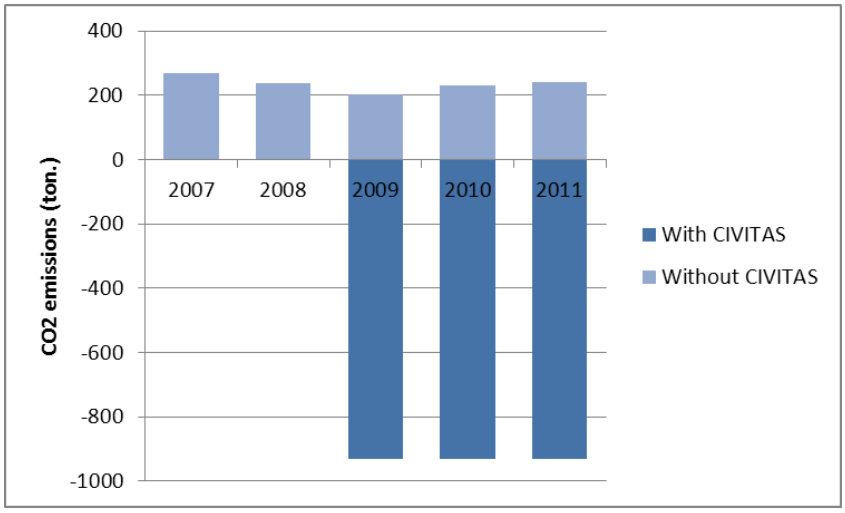
These results (negative emissions) show that the production of renewable energy at the small-hydro largely exceeds the consumption of energy of the trolleybus lines. Thus, the measure contributes to an reduction of GHG emissions at national level.

The table C2.3.3 sumarises the results of the indicators.

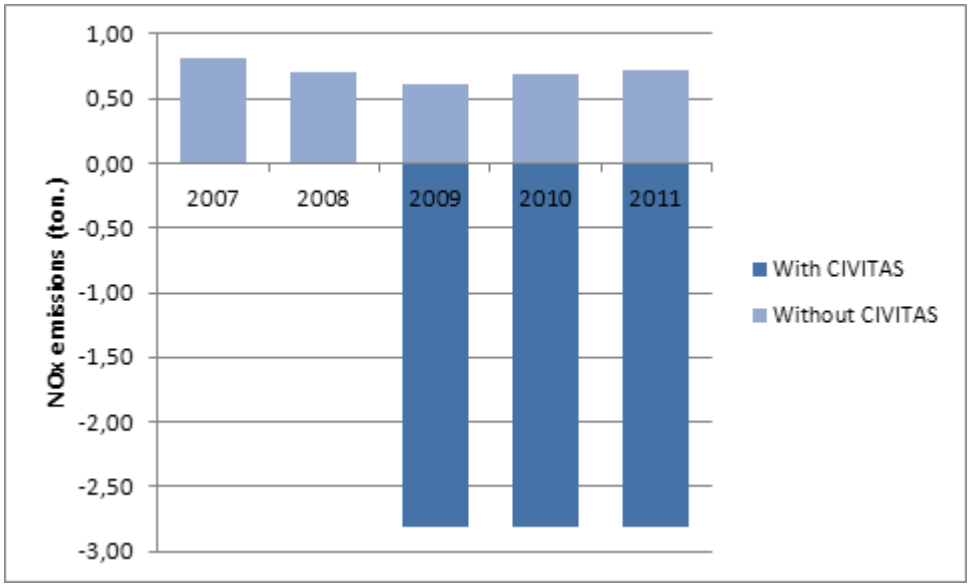
Table 2.3.3: Ex-post average CO2 emissions balance

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
2. CO2 emissions	239,98 ton (2007)	236,48 ton (2008) 202,35 ton (2009) 228,89 ton (2010) 239,98 ton (2011)	236,48 ton (2008) -930,38 ton (2009) -930,38 ton (2010) --930,38 ton (2011)	0 ton (2008) -930,38 ton (2009) -930,38 ton (2010) -930,38 ton (2011)	0 ton (2008) -1132,73 ton (2009) -1159,27 ton (2010) -1170,32 ton (2011)
3. NOx emissions	0,81 ton (2007)	0,71 ton (2008) 0,61 ton (2009) 0,69 ton (2010) 0,72 ton (2011)	0,71 ton (2008) -2,81 ton (2009) -2,81 ton (2010) -2,81 ton (2011)	0 ton (2008) -2,81 ton (2009) -2,81 ton (2010) -2,81 ton (2011)	0 ton (2008) -3,42 ton (2009) -3,50 ton (2010) -3,53 ton (2011)

The graphs C2.3.1 and C2.3.2 show the evolution of the CO2 emissions (ton) and NOx (ton) With CIVITAS and the evolution of these indicators according to the B-a-U scenario (Without CIVITAS).



Graph C2.3.1 -CO2 emissions – trend without CIVITAS and results with CIVITAS



Graph C2.3.2 -NOx emissions B-a-U with CIVITAS and No CIVITAS

These graphs show that the measure has a significant positive impact in terms of emission abatement. Indeed, the operation of the small-hydro generates an amount of energy significantly higher than the energy consumption of the trolleybus fleet.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	**To make a technical project and economical, environmental and legal feasibility study to implement an electric energy production system (small-hydro) inserted in the already existing Coimbra Dam-bridge (Producing at least 0,75 GWh per year).** The study has been carried out and the feasibility was demonstrated with an energy production of 2,6 GWh per year (that largely exceeds the initial objective)	***
2	**To release a digital model of the small hydro** The digital model was delivered including a 3D version	**
3	**To carry out awareness campaigns of the benefits of future self-production of electricity to supply the trolleybuses lines of the Urban PT operator (SMTUC)** This measure had a high media coverage with several pieces in magazines, newspapers and TV. In the scientific community the measure also had a very positive impact, since it was presented in 3 international conferences and a publication in the International Journal World Electric Vehicle Journal, ISSN 2032-6653, Volume 3, December 2009 and another paper entitled "Small-hydropower addition to Coimbra dam-bridge for sustainable urban mobility" was submitted to the journal "Renewable & Sustainable Energy Reviews", Elsevier, and is available online since on 16th September 2011.	***
4	**To contribute to the reduction of emission of greenhouse gases at national level** Since the energy production is higher than expected (0,75 GWh) then the emissions were largely reduced (1.170 ton of CO2, 3,53 ton of NOx)	***
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

The scenario considered about installing a power station at the existing dam to produce electric energy for trolleybus lines in Coimbra is not object of up-scaling because no other means to produce renewable electric energy to the trolleybus lines in Coimbra are currently available to STMUC.

C5 Appraisal of evaluation approach

The evaluation strategy of this measure sought to focus on a number of indicators across the areas of economy, energy, environment and society, which were to be measured in different ways.

The idea of direct feeding of trolleybus by the energy produced at the Coimbra power station initially considered was abandoned because in technical and economic terms was not recommended. For this reason it was introduced a solution based on feed-in tariff and selling all the produced energy to the electrical grid. Also SMTUC will not use the surplus in energy (and revenues) in the increase of the offer in the trolleybus PT network in a first stage but for the payback of the investment. For this reason it is not expected changes at short time in the operational revenues coming from ticket sales and consequently this item was not considerate nor the global operational costs of SMTUC.

In the new scenario, the only energy and environment impacts resulting from the production of electricity at the small-hydro occur at national level. For these reason was not chosen indicators related directly with the SMTUC fleet (fuel mix, fuel efficiency, GHG emissions). Instead of this approach it was evaluated the impacts of CO2 and NOx emissions generated in the well (Portuguese electrical power generation system).

C6 Summary of evaluation results

The key results are as follows:

- **Increase of operating revenues** – Average Operating Revenues are expected to increase as result of the implementation of the measure because it will be introduced a new income to the company related with production of renewable energy production. A. With the implementation of CIVITAS MODERN measure it is estimated a revenue of 200 k€/year by selling all energy production (2 600 MWh) associated with a feed-in tariff scheme.

- **Small increase of operating costs** – After the measure implementation period, the Operating Costs are likely to have a small increase related with the O&M costs. The O&M costs are estimated to be 5% of the annual receipt of energy production. It is estimated an increase of 0,05€/vkm with the introduction of the measure.

- **Additional capital Costs** – The implementation of the measure have an initial capital cost of 1.700 k€. It is estimated that this investment has a simple pay-back period of 8,5 years, which is considered cost effective in terms of other investments in small hydro plants.

- **Positive financial balance** – The implementation of the measure generates a positive balance between average operating costs and revenues, giving a financial surplus. It is estimated that with the implementation of the measure the average balance between 2009-2011 is 0,64 €/vkm. This surplus it will contribute the company to enhance the environment and energy efficiency performance.

- **Positive energy balance and GHG emissions abatement** – The results of the measure allows that the production of renewable energy at the small-hydro is expected to largely exceed the energy consumption of the trolleybus lines. This means that the operation of the small-hydro would have a significant positive impact in terms of greenhouse gas emission abatement at national level once it generates an amount of energy significantly higher than the energy consumption of the trolleybus fleet.

- **Positive awareness impact and stimulation of the R&D activities** – The results of the measure had a high media coverage with several pieces in magazines, newspapers and TV. In scientific community the measure also had a very positive impact, since it was presented in 3 international conferences and generates publications for the scientific energy and environment community.

C7 Future activities relating to the measure

The real implementation of the small-hydro power plant in the future is forecasted. For this purpose will continue the search for opportunities for financial and partnership arrangements. As soon as the funding is decided a final project for the power plant will be made and provided to the INAG – Portuguese Water Institute – to allow for the quick start of the small-hydro implementation.

During the first years the revenues of the energy sold will be used mainly in the depreciation of the small-hydro implementation and in the energy supply of the trolleybus and electric mini-bus fleet. After the payback period the surplus in energy sold will be used for renewing the fleet.

D Process Evaluation Findings

D.1 Deviations from the original plan

The deviations from the original plan comprised:

- **The direct electric feed of the trolleybus traction lines was not considered, but rather the study centred on the sale of the energy to the national electricity grid** – The original plan considered that the electric energy produced in the small-hydro would be used to directly feed the trolleybus traction lines. But this solution had many disadvantages: very high capital costs for the energy transformation; strong irregularity of the Mondego river flow which could cause peaks in the energy supply (including periods of insufficient feed of trolleybuses system, namely during the summer); loss of the surplus of energy, mainly during the night period (in which trolleybuses don't run) and during the major part of the days of the year (that the foreseen energy production must higher than the trolleybuses and electric mini-buses energy consumption). So all the parts agreed to consider that the energy produced in the small-hydro would have to be sold to the electricity grid of EDP – the Portuguese electricity supplier – and the revenues applied in the electric dimension of the public transportation system in Coimbra.
- **A detailed small hydropower operation computational model has been developed instead of the construction of a small-hydro scale model plant** – The original plan had foreseen the construction of a physical scale model of the small-hydro, but these models are more frequently used for the building projects of the dams and in the Coimbra's case the dam was already built. For this reason, it the decision was to develop of a detailed small hydropower operation computational model, which provides a DEMO layout of the Coimbra Dam Bridge equipped with turbine-generator units. This approach is more useful for the objectives of the study, because the model allows for the immediate monitoring of the overture state of each of the 9 radial gates, the flow in each radial gate, the number of operating turbine-generator units, and the respective energy production. This model is also more portable, which is more convenient for dissemination activities.
- **The achievement of the technical feasibility had a delay of 8 months** – The reply of the Portuguese Water Authority (INAG) and some other governmental departments to the administrative procedures and requests for data was quite sluggish, which delayed the first part of the study that had the objective of assess the technical feasibility of the measure. In any case this delay was totally recovered in the other parts of the measure.

D.2 Barriers and drivers

D.2.1 Barriers

<u>Preparation phase</u>

- **Barrier 1.1 – Technological Barrier** – The hydrological analysis to the available flows for the production of electric energy shows a strong irregularity of the Mondego River. This feature could produce peaks in the energy supply and periods in which the energy produced is lower than that consumed by the trolleybuses (namely in the summer). The direct electric feed of the trolleybus traction lines couldn't absorb these fluctuations nor the surplus energy production that occurs during large part part of the

year and during the evening period in which trolleybuses don't run. This technology also implies high capital costs for the energy transformation.

- **Barrier 1.2 – Technological Barrier** – More technical constraints occurred than originally foreseen, namely the above mentioned irregularity of the Mondego River flow, the limited space available in the existing dam bridge, the need for carefully analysing the impacts in the fish-pass, and the impossibility of achieving the maximum flow rates without the risk of flooding. These constraints forced the study of several layouts for the power plant implementation. Also for this reason a physical scale model of the small-hydro isn't the optimal solution to model and to monitor the several layouts for the power plant. Also the physical model could be too expensive in comparison with the benefits received. These models are more frequently used for the entire modulation of the dam, but in Coimbra's case the dam was already built.

Implementation phase

The measure was only a study, so no implementation phase was foreseen during CIVITAS. Nevertheless, the following barriers could be critical reasons for the initial decision to carry out only a feasibility study during CIVITAS instead of implementing the measure:

- **Barrier 2.1 – Financial Barrier** – The idea of using the existing dam located in the city centre to feed the trolleybus traction lines happen only during the last period of the preparation for the CIVITAS call. For this reason it was impossible to have time to develop a preliminary study to assess the feasibility of the measure, mainly at the financial level, and to find funding for its actual implementation. So SMTUC decided to avoid the risk of an unsuccessful implementation and opted to carry out the only the feasibility study, involving the University of Coimbra for this purpose.
- **Barrier 2.2 – Institutional Barrier** – The reply of the Portuguese Water Authority (INAG) and some other governmental departments to administrative procedures and requests for data was quit sluggish, revealing long periods without receiving any feed-back. INAG has not yet replied to the administrative request for the addition hydropower plant in the Coimbra Dam Bridge. The request was made by the Municipality of Coimbra at the beginning of the CIVITAS MODERN project.

Operation phase

The measure was only a study, so no operation phase was foreseen during CIVITAS, Accordingly, and as described in the barrier 1.2, a digital model of the dam, the turbines and the small hydro power generation has been developed for the demonstration and dissemination of the measure. Thus this task can be considered the integration of the operation phase. No important barrier occurred, but the institutional barrier described for the implementation phase (2.2) also influenced the development of the digital model due the difficulty brought on by the unavailability of timely data. This problem didn't avoid the conclusion of the model before the foreseen date, but caused delays that hindered the conclusion of this work sooner, (with less efforts spent on human resources and allowing more time for demonstration).

D.2.2 Drivers

Preparation phase

- **Driver 1.1 – Financial Driver** – This feasibility study needed a great deal of research in several areas and critical issues were analysed, namely those that could have impacts at the environmental and safety level. For this reason the costs foreseen for the study have a significant value that only could be covered with the availability of CIVITAS funds.

- **Driver 1.2 – Involvement, communication Driver** – Despite this measure only consisting of a study during CIVITAS, it received the most media coverage because the population also elected this measure as the most important and welcomed. The reasons for this involvement of the population of Coimbra (and of the personnel responsible for the study) were mainly the innovation of the measure and the possibility to have an environmentally friendly use of the dam.

Implementation phase

The measure was only a study, so no implementation phase was foreseen during CIVITAS. Nevertheless the following driver helps catalyse the possibility of real implementation of the measure:

- **Driver 2.1 – Financial Driver** – The possibility using the revenues from the sale of the surplus energy produced in the existing dam for the feeding of the trolleybus traction lines, mainly because the capital costs will be smaller due to the fact that the dam already exists.

Operation phase

The measure was only a study, so no operation phase was foreseen during CIVITAS, However, as referred to for the barriers, a digital model of the dam has been developed and it can be considered that this activity was integrated in the operation phase. The following driver occurred in this phase:

- **Driver 3.1 – Technological Driver** – The high quality of the digital model allowed for identifying the best solutions and reaching faster conclusions, namely about the specifications and location for the energy power generation system: Equally important, the digital model also served as a good instrument for the dissemination activities.

D.2.3 Activities

Preparation phase

- **Activities 1.1 – Technological Activities** – Taking into consideration that the technology for the energy supply, based on the direct electric feed of the trolleybus lines, wasn't advisable due to the irregularity of the energy production in the small-hydro and the possibility of frequently surpassing the needed energy production (barrier 1.1), it was considered that the energy produced in the small-hydro will be sold to the public electricity grid of EDP and the revenues will be used in the electric part of the public transportation system in Coimbra.

- **Activities 1.2 – Technological Activities** – The physical scale model of the small-hydro isn't the best solution to model and to monitor the different layouts for the power plant (barrier 1.2). For this reason the development of a detailed small hydropower operation computational model, which provides a DEMO layout of the Coimbra Dam Bridge equipped with turbine-generator units, was chosen as the best option. This approach is more useful for the objectives of the study and more convenient for the dissemination activities. The occurrence of delays caused by the technical constraints referred to in barrier 1.2 was avoided by involving experts of several areas in the study, taking advantage of the availability of the CIVITAS funds (driver 1.1) and the fact that these experts are highly motivated (driver 1.2).

Implementation phase

The measure was only a study, so no implementation phase was foreseen during CIVITAS.

Operation phase

The measure was only a study, so no operation phase was foreseen during CIVITAS. Nevertheless, the use of the digital model of the small hydro power plant for demonstration and dissemination actions could be included in this phase. The following activity is highlighted:

- **Activities 3.1 – Involvement, Communication Activities** – Taking advantage of the driver 3.1 several tests with the digital model have been carried out and the model has been used in several presentations (workshops, seminars, CIVINET Spain and Portugal Forum 2011, …), Some dedicated videos with the 3D model version and 4 generic videos that included this model have been also produced and used in presentations, namely in the CIVITAS Forum 2012, or placed on-line (including the CIVITAS website).

D.3 Participation

D.3.1 Measure partners

- **Measure partner 1 – University of Coimbra (UC); University; Leading role**

The University was responsible for the development of the technical, environmental, economic and financial feasibility study to implement a renewable energy production (small-hydro power plant) in an existing local river dam, using this electricity to supply Coimbra's trolleybus and electric minibus fleet.

They also made some laboratorial tests in an open flume channel and developed a computational simulation model used to test the hydraulic operational aspects connected to hydropower addition and to evaluate electric energy production revenue.

Accordingly, the University carried out all the research and technical development activities in the measure and also participated in some dissemination actions, namely with the release of papers that were published in indexed international journals as well as the

presentation of the measure in several international conferences and workshops. They demonstrated a great interest and involvement in the measure.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC); City; Principle participant**

The Municipality assisted the University and the SMTUC in the activities made in order to increase the involvement in the measure of some governmental departments, namely the Portuguese Water Authority (INAG). Since October 2011 the Municipality has also been responsible for the dissemination of the MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

While responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA, PRODESO also provided some support in the dissemination and promotion of this measure, including the assistance of SMTUC in the organization of the CIVINET Spain and Portugal Forum where the small-hydro project was presented.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

- **Measure partner 5 - Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Occasional participant**

SMTUC is the partner that will benefit from the measure if the small-hydro project is implemented and the revenues of the energy produced will be used in the trolleybus and electric mini-bus fleets. For this reason they also have an important role in the collection and release of data concerning the public transport service.

SMTUC also assisted the University and the Municipality in the activities in order to increase the involvement in the measure of some governmental departments, namely the Portuguese Water Authority (INAG).

Additionally, SMTUC organized some events where the measure was presented, namely the CIVINET Spain and Portugal, and participated in several events for its dissemination.

D.3.2 Stakeholders

- **Stakeholder 1 – Portuguese population –** The measure had a great interest and involvement of the population in general, supported by important media coverage. As the main beneficiaries of this measure, at the environmental or mobility level, the inhabitants of Coimbra are pushing for the real implementation of the small-hydro.

- **Stakeholder 2 – Portuguese Water Authority (INAG – Instituto da Água) –** INAG is responsible for the management of the national water issues, including the Mondego River, and the owner of the existing river dam where the implementation of the small-hydro is foreseen. They provided some data about the dam and the Mondego River and participated in some meetings, which also involved the University, the Municipality and the SMTUC, with the objective of having a greater involvement of the national departments.

- **Stakeholder 3 – Portuguese Electric Energy Supplier (EDP – Electricidade de Portugal) –**EDP will be an important part of business if the measure is implemented because it is expected that the supply of electric energy for the trolleybus and electric mini-bus fleet will be made with the revenues of the sale of the electric energy produced in the small-hydro plant to EDP. So preliminary informal contacts occurred, but a higher involvement in the future to evaluate the possibility of partnerships in this project is expected.

- **Stakeholder 4 – Media** – This measure was the best covered by the media and it was frequent for people to associate the CIVITAS project to the implementation of the small-hydro in Coimbra for the (indirect) supply of the trolleybus and electric mini-bus fleet. The media has been a channel for the dissemination and promotion of the measure and all the events organized in Coimbra had the participation at least of the local media with several news articles published (in the international events the specialised media also participated, namely the magazines "Transportes em Revista" e "Água e Ambiente").

The specialised international journals "World Electric Vehicle Journal" and "Renewable & Sustainable Energy Reviews" have published papers of the small-hydro project.

- **Stakeholder 5 – Electric Vehicle Portuguese Association (APVE – Associação Portuguesa do Veículo Eléctrico)** – Taking into consideration that the electric energy produced in the small-hydro will be also used for the electric mini-bus system (if the measure is implemented in the future), the APVE demonstrated great interest in this project and assisted the University and SMTUC in some dissemination activities, with special emphasis on the presentation of the measure in the 24th World Electric Vehicle Symposium – EVS24 (Norway, 13-16th May 2009).

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **To sell the energy to the public grid is better than the direct feeding of the vehicles used in the public transport system –** The measure replication will be not easy because it is difficult to find similar conditions in other cities: an existing river dam (major capital costs already made), located in the centre of the city (local production which avoids energy transport losses), for the production of renewable electric energy for the use in the electric part of the transport system. If similar conditions are available avoiding the direct electric feed of the fleet is recommended because the costs of energy transformation could be high and irregularities could occur in the energy production that will affect the transport system (peaks or insufficient energy production) or a surplus of unused energy production can occur. As in Coimbra's case, it would be better to consider the sale of the energy to the public grid and the use of the revenues for the electric part of transport system.

- **Possibility of environmental and technical constraints** – In this kind of projects the anticipation of analysing possible constraints, mainly at the environmental level (impacts on the biodiversity, consequences in case of flooding), but also at dam specifications level (including the space for the turbines and generator and the flood rates available), is recommended. The involvement of experts of several different fields is also advisable (in Coimbra's case, the University also involved experts in zoology to study the issues linked to the fish passage)

- **Special attention must be given to the administrative / legal procedures** –The processes of licensing and request for authorisations could be longer and complicated than initially predicted, so they must be started as soon as possible. If negotiations with entities are

needed, some anticipation could be also important - as the case in Coimbra (the demand for meetings with the Portuguese Water Authority (INAG) and the request for the small-hydro implementation were made at the beginning of the CIVITAS MODERN project). The involvement of the Municipality in the activities of viability and strengthening of the communication channels with national authorities could be very important (in Coimbra's case the Mayor and the Mobility Councillor attended 2 meetings with the decision-makers at INAG).

- **The capital costs for the implementation of the small-hydro could be significant, so it is recommended to consider the external benefits, as well as the availability of funding programs and institutional arrangements.** – Despite the dam already being built, as the case of Coimbra, the capital costs for the small-hydro could be significants (1.700 thousand euros in Coimbra). It is recommended that the economic feasibility study, in order to reduce payback time and increase the internal rate of return, take into consideration positive external factors such as environmental issues and the importance of the project for the city (the measure will contribute for an reduction of 930 tons per year in the CO2 emissions and 2,79 tons per year in the NOx emissions, but these values could be augmented when the revenues of the surplus energy production is applied in the increase of the offer of trolleybus services). Some funding programs (European, National or Regional) and institutional arrangements could also support the initial investment, improving the economic feasibility of the project.

D.4.2 Recommendations: process

- **It is recommended to motivate the staff and involve experts of several fields to face eventual constraints due the complexity of this kind of projects –** The involvement of experts from several fields is recommended in this kind of project in order to deal competently and promptly with the different constraints that can occur. The University of Coimbra used this technique with success, taking advantage of the funds available and the fact that these experts are highly motivated by the innovation and media coverage of the measure. Despite some critical technical barriers – i.e., the strong irregularity of the flow rate of the Mondego river, the impossibility of achieving the maximum flow rate without the risk of flooding, the difficulties in solving the problems with the fish passage, the space constraints due the fact that the dam was already built, the higher costs of the technology needed for the small-hydro, and the delay in the reply for request to some national departments - the University of Coimbra concluded the feasibility study on time and with great quality and outcomes.

ANNEX 1: Average Operating Costs Data

The next table shows the data obtained obtained from SMTUC relative to operating costs for the trolley buses lines:

Table 1: Operating Costs related to the purchase of energy to suply the trolleybuses fleet and for the operation and maintenance of the small-hydro

Year	A Energy Costs (€)	B Small Hydro Plant O&M Costs (€)	C = A+B Total O&M Costs (€)	D Vehicle-km Trolley vkm	E=C/D O&M costs / vkm €/vkm
2000	74.756,00	0,00	74.756,00	222.461,00	0,34
2001	72.587,00	0,00	72.587,00	195.801,00	0,37
2002	66.053,00	0,00	66.053,00	233.873,00	0,28
2003	71.428,00	0,00	71.428,00	235.175,00	0,30
2004	73.852,00	0,00	73.852,00	221.576,00	0,33
2005	75.007,00	0,00	75.007,00	211.555,00	0,35
2006	78.668,00	0,00	78.668,00	210.945,00	0,37
2007	83.204,00	0,00	83.204,00	206.797,00	0,40
2008	75.663,00	0,00	75.663,00	179.565,00	0,42
2009	70.625,00	10.000,00	80.625,00	147.025,00	0,55
2010	80.457,00	10.000,00	90.457,00	179.644,00	0,50
2011	93.818,00	10.000,00	103.818,00	195.507,00	0,53

Source: SMTUC

ANNEX 2: Small-hydro feasibility study Data

The next table shows the data obtained from the feasibility study in relation to the small-hydro:

Table 2: Outputs of the smal-hydro feasibility study

Layouts		V2-1T
Turbines Type		VLH-4000-4.0
Estimated cost of small-hydro (M€)		1,7
Annual Revenue (M€)	DL 225 / 2007 (average of 35 years)	0,14
	15-10-2010 Context (average of 45 years)	0,2
Annual energy (GWh)		2,6

University of Coimbra, Progress report of the small-hydro (economical, environmental and legal) feasibility study

In relation to the Annual Revenues it has been considered the 15-10-2010 Context (which corresponds to an average of 200.000,00 €/year).

Additionally, the measure leader provided information in relation to the Personnel costs (maintenance and operation) of the small-hydro. According to this information, the Personnel costs (maintenance and operation) of the small-hydro correspond to an average of 5% of the Revenues comming from the sale of energy produced in the small-hydro (which corresponds to an average of 10.000,00 €/year).

ANNEX 3: Green-house gas emissions data

The next table shows the data obtained from the measure leader in relation to the average emission factor of CO2 and NOx reported from a 2011 monthly serie data:

Table 3: Emission factor for the green gases incurred in the global electricity production (at national level)

Average CO2 emissions incurred in electricity production (g/MJ)	99,4
Average NOx emissions incurred in electricity production (g/MJ)	0,30

The table 4 shows the data obtained from SMTUC in relation to the energy consumption of the trolleybus fleet per year:

Table 4: Evolution of the offer (vkm) and the energy consumption in the SMTUC trolleybus lines and emissions related to the energy production

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total vehicle-km (Vkm)	222.461	195.801	233.873	235.175	221.576	211.555	210.945	206.797	179.565	147.025	179.644	195.507
Total energy consumption (kWh)	770.220	709.633	769.038	840.190	833.136	771.833	748.164	752.556	660.845	565.474	639.637	670.518
Total energy consumption (MJ)	2.772.792	2.554.679	2.768.537	3.024.684	2.999.290	2.778.599	2.693.390	2.709.202	2.379.042	2.035.706	2.302.693	2.413.865
Total costs with the electricity consumption (€)	74.756	72.587	66.053	71.428	73.852	75.007	78.668	83.204	75.663	70.625	80.457	93.818
kWh / Vkm	3,4623	3,6243	3,2883	3,5726	3,7600	3,6484	3,5467	3,6391	3,6803	3,8461	3,5606	3,4296
CO2 (ton)	275,62	253,94	275,19	300,65	298,13	276,19	267,72	269,29	236,48	202,35	228,89	239,94
NOx (ton.)	0,83	0,77	0,83	0,91	0,90	0,83	0,81	0,81	0,71	0,61	0,69	0,72
€ / kWh	0,0971	0,1023	0,0859	0,0850	0,0886	0,0972	0,1051	0,1106	0,1145	0,1249	0,1258	0,1399
€ / vkm	0,3360	0,3707	0,2824	0,3037	0,3333	0,3546	0,3729	0,4023	0,4214	0,4804	0,4479	0,4799

1kWh =3,6 MJ

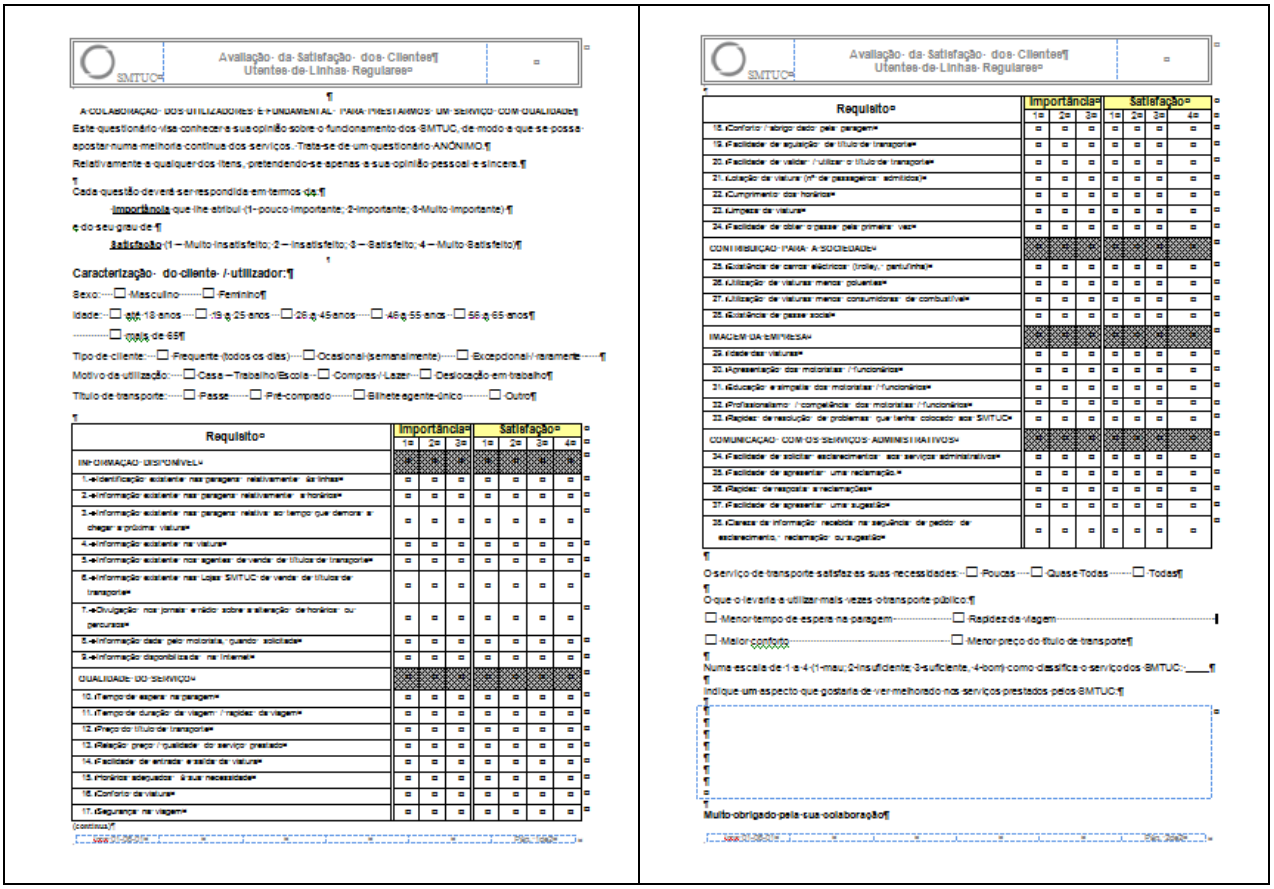
The table 5 shows the data obtained from the feasibility study in relation to the total annual production of renewable energy at the small-hydro.

Table 5: Energy production in the small-hydro power generator

Total energy produced by the power generator (MJ/year)	9.360.000

ANNEX 4: Quality Survey

ANNEX 4.1 Questionnaire model



SMTUC

Avaliação da Satisfação dos Clientes
Utentes das Linhas Regulares

A COLABORAÇÃO DOS UTILIZADORES É FUNDAMENTAL PARA PRESTARMOS UM SERVIÇO COM QUALIDADE

Este questionário visa conhecer a sua opinião sobre o funcionamento dos SMTUC, de modo a que se possa apostar numa melhoria contínua dos serviços. Trata-se de um questionário ANÓNIMO.

Relativamente a qualquer dos itens, pretendendo-se apenas a sua opinião pessoal e sincera.

Cada questão deverá ser respondida em termos de:

Importância que lhe atribui (1- pouco importante; 2-importante; 3-Muito importante)

e do seu grau de

Satisfação (1 – Muito insatisfeito; 2 – Insatisfeito; 3 – Satisfeito; 4 – Muito Satisfeito)

Caracterização do cliente / utilizador:

Sexo: ☐ Masculino ☐ Feminino

Idade: ☐ até 18 anos ☐ 19 a 25 anos ☐ 26 a 45 anos ☐ 46 a 55 anos ☐ 56 a 65 anos ☐ mais de 65

Tipo de cliente: ☐ Frequente (todos os dias) ☐ Ocasional (semanalmente) ☐ Excepcional / raramente

Motivo da utilização: ☐ Casa – Trabalho/Escola ☐ Compras / Lazer ☐ Deslocação em trabalho

Título de transporte: ☐ Passe ☐ Pré-comprado ☐ Bilhete avulso ☐ Outro

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
INFORMAÇÃO DISPONÍVEL							
1. Identificação existente nas paragens relativamente às linhas							
2. Informação existente nas paragens relativamente aos horários							
3. Informação existente nas paragens relativa ao tempo que demora a chegar a próxima viatura							
4. Informação existente na viatura							
5. Informação existente nos agentes de venda de títulos de transporte							
6. Informação existente nas Lojas SMTUC de venda de títulos de transporte							
7. Divulgação nos jornais e rádio sobre alteração de horários ou percursos							
8. Informação dada pelo motorista, quando solicitada							
9. Informação disponibilizada na Internet							
QUALIDADE DO SERVIÇO							
10. Tempo de espera na paragem							
11. Tempo de duração da viagem / rapidez da viagem							
12. Preço do título de transporte							
13. Relação preço / qualidade do serviço prestado							
14. Facilidade de entrada e saída da viatura							
15. Horários adequados à sua necessidade							
16. Conforto da viatura							
17. Segurança na viagem							

(continua)

SMTUC

Avaliação da Satisfação dos Clientes
Utentes das Linhas Regulares

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
18. Conforto / abrigo dado pela paragem							
19. Facilidade de aquisição do título de transporte							
20. Facilidade de validar / utilizar o título de transporte							
21. Adaptação da viatura (nº de passageiros admitidos)							
22. Cumprimento dos horários							
23. Limpeza da viatura							
24. Facilidade de obter o passe pela primeira vez							
CONTRIBUIÇÃO PARA A SOCIEDADE							
25. Existência de carros eléctricos (trolley, pantufinha)							
26. Utilização de viaturas menos poluentes							
27. Utilização de viaturas menos consumidoras de combustível							
28. Existência de passe social							
IMAGEM DA EMPRESA							
29. Idade das viaturas							
30. Apresentação dos motoristas / funcionários							
31. Educação e simpatia dos motoristas / funcionários							
32. Profissionalismo / competência dos motoristas / funcionários							
33. Rapidez de resolução de problemas que tenha colocado aos SMTUC							
COMUNICAÇÃO COM OS SERVIÇOS ADMINISTRATIVOS							
34. Facilidade de solicitar esclarecimentos aos serviços administrativos							
35. Facilidade de apresentar uma reclamação							
36. Rapidez da resposta a reclamações							
37. Facilidade de apresentar uma sugestão							
38. Clareza da informação recebida na sequência de pedido de esclarecimento, reclamação ou sugestão							

O serviço de transporte satisfaz as suas necessidades: ☐ Poucas ☐ Quase Todas ☐ Todas

O que o levaria a utilizar mais vezes o transporte público:

☐ Menor tempo de espera na paragem ☐ Rapidez da viagem

☐ Maior conforto ☐ Menor preço do título de transporte

Numa escala de 1 a 4 (1-mau; 2-insuficiente; 3-suficiente, 4-bom) como classifica o serviço dos SMTUC: ____

Indique um aspecto que gostaria de ver melhorado nos serviços prestados pelos SMTUC:

Muito obrigado pela sua colaboração

ANNEX 4.2 Structure and questions

The questionnaire starts with 4 questions related to the interviewee – Sex, Age (<18, 19-25, 26-45, 56-65, >65),type of client (frequent, occasional, exceptional/rare use), motive of the trip (home-work/school, shopping/leisure, in service), type of ticket (pass, single ticket bought on the selling point, single ticket bought on the vehicle, other).

The main part of the questionnaire is composed of 38 specific questions related to various items related to 5 areas of the service (1-Available information, 2-Quality of service, 3-Contribution to society, 4-Image of the company, 5-Communication with the administrative services) and a specific global customer satisfaction question that resume quality of service. In each question the people interviewed express a judgement choosing between very satisfied – satisfied – unsatisfied – very

unsatisfied and about the importance of each of the 38 items choosing between very important – important – low importance.

Each question is assessed in terms of importance given (1-Not important, 2-Important, 3-Very Important) and level of satisfaction (1-Very Dissatisfied 2-Dissatisfied 3-Satisfied 4-Very Satisfied) of the user in relation to the respective item.

AVAILABLE INFORMATION
1. Identification of existing lines at stops
2. Information at stops about timetables
3. Information at stops about the waiting time until the next vehicle
4. Information inside the vehicle
5. Information at ticket selling points
6. Information at SMTUC ticket selling shops
7. Disclosure of information in the newspapers and radio about timetable or routes changing[6]
8. Information given by the driver, upon request
9. Information available on the Internet
QUALITY OF SERVICE
10. Waiting time at stop
11. Trip duration / speed of travel
12. Price of the ticket
13. Relation Price / Quality of the service
14. Ease of entry and exit of the vehicle
15. Adjustment of the timetable to your needs
16. Comfort of the vehicle
17. Safety during the trip
18. Comfort / protection given by the stop shelter
19. Ease of ticket purchase
20. Ease of ticket validation / utilization
21. Capacity of the vehicle (nr. of passengers allowed)
22. Compliance with the timetable
23. Cleanliness of the vehicle

[6] This question was eliminated on the 2010 and 2011 surveys.

24. Facility in obtaining the travelcard for the first time
CONTRIBUTION TO SOCIETY
25. Existence of electric vehicles (trolleybuses, electric mini-buses)
26. Utilization of less polluting vehicles
27. Utilization of less fuel consuming vehicles
28. Existence of social travelcard
IMAGE OF THE COMPANY
29. Age of the vehicles
30. Presentation of drivers / staff
31. Education and friendliness of the drivers / staff
32. Quality of driving performance of SMTUC drivers[7]
33. Professionalism / competence of the drivers / staff
34. Quickness in the resolution of problems you may have submitted to SMTUC
COMMUNICATION WITH THE ADMINISTRATIVE SERVICES
35. Facility in requesting clarifications to the administrative services
36. Facility in submitting a complaint.
37. Response quickness in respect to complaints
38. Facility in presenting a suggestion
39. Clarity of the information obtained in response to a request for information, complaint or suggestion

The questionnaire concludes with 5 questions in relation to the respondent's general attitude towards the service supplied by SMTUC:

1. The transportation service meets your needs (1-Few, 2-Nearly all, 3-All)

2. What would make you consider using public transportation more often (1-Shorter waiting time at stops, 2-Higher speeds, 3-Increased comfort, 4-Lower price of the ticket)

3. How do you rate the SMTUC service on a scale of 1 to 4 (1-bad, 2-poor, 3-sufficient, 4-good)

4. Indicate a point you would like to see improved in the SMTUC service:

[7] This question was not included on the 2009 survey.

ANNEX 4.3 Customer satisfaction survey results

Quality of service is measured by means of customer satisfaction survey periodically carried out by SMTUC:

The survey is repeated 1 time a year and is carried out to customers on face to face interviews on board of the SMTUC busses.

The sample is drowned on the basis of the lines used by the passengers, i.e., the number of interviewees chosen in each line is defined according to the demand of the line relative to the overall SMTUC demand.

The dimension of the sample is defined according to the specifications of the quality management auditors which supervise the all process in line with the ISO9001 standard.

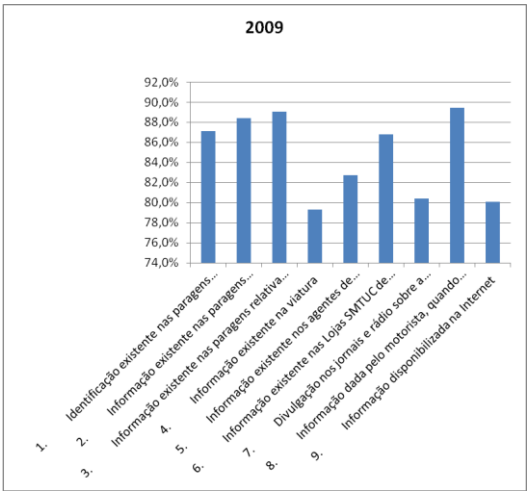
The quality management auditors considered 500 interviews as (a minimum) suitable to assess quality evaluation by PT passengers in Coimbra. However, SMTUC volunteered to go above this number. Thus, the following number of interviews and valid answers were achieved:

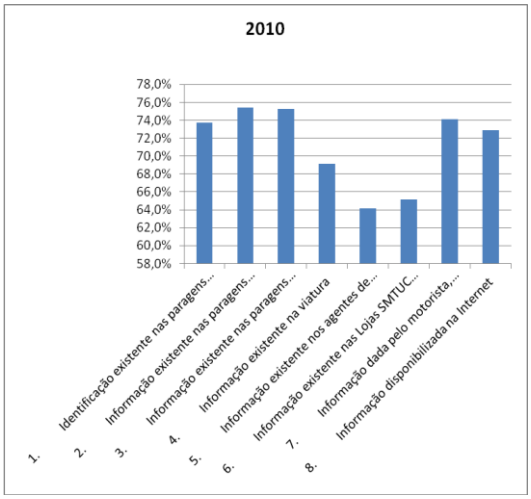
In 2009 it was defined a sample of 1000 interviews and it was obtained 984 valid answers

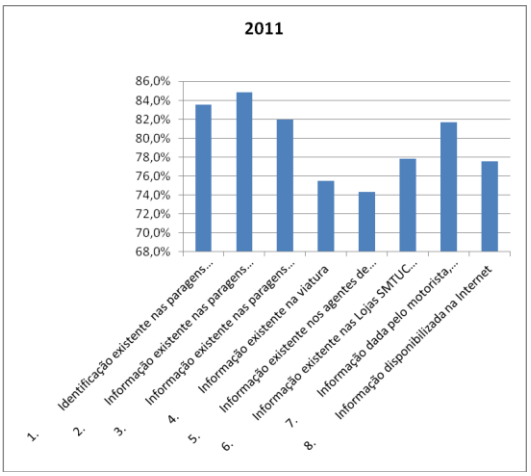
In 2010 and 2011 it was defined a sample of 750 interviews and it was obtained 750 valid answers due surveys with errors were rejected and repeated.

The folowing graphs show the several results of the susveys

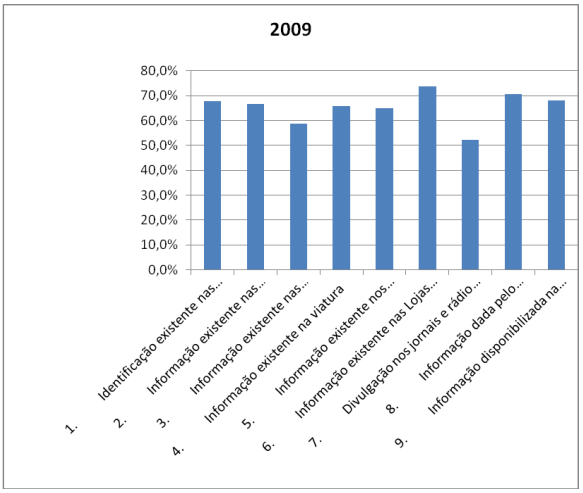
Importance given to the Available Information

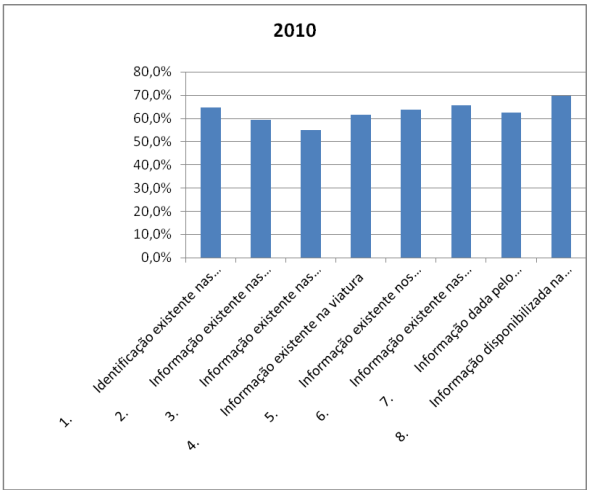


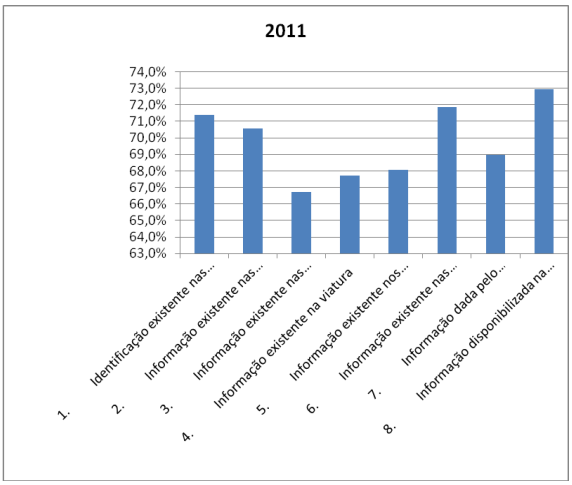


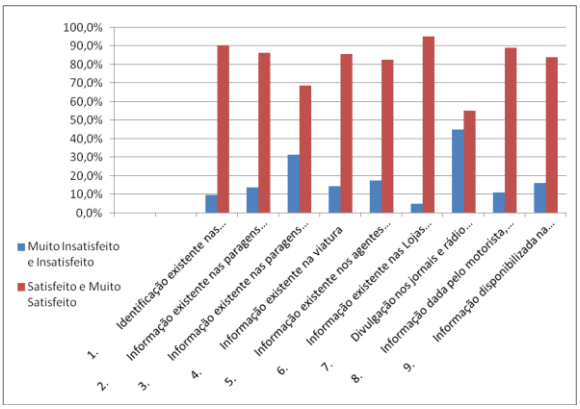


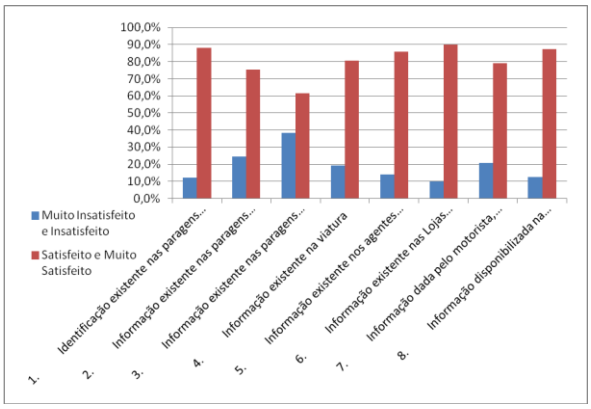
Level of satisfaction in relation to the Available Information

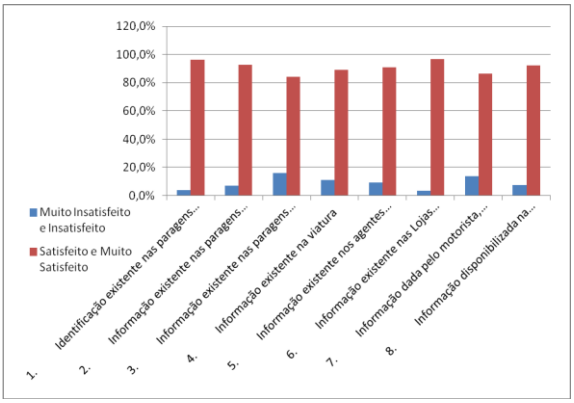




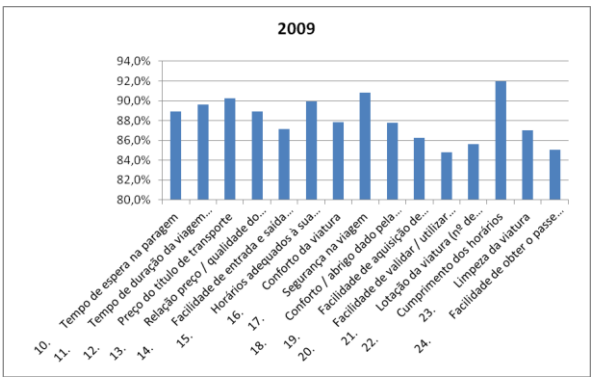


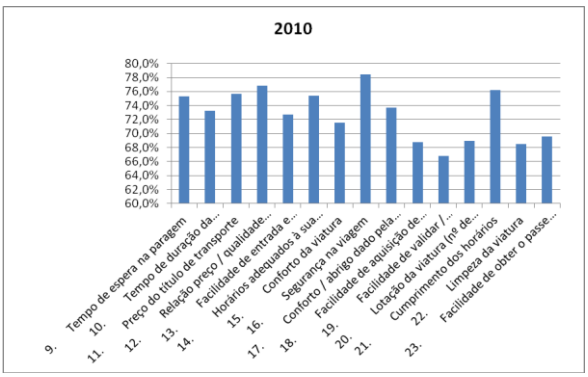


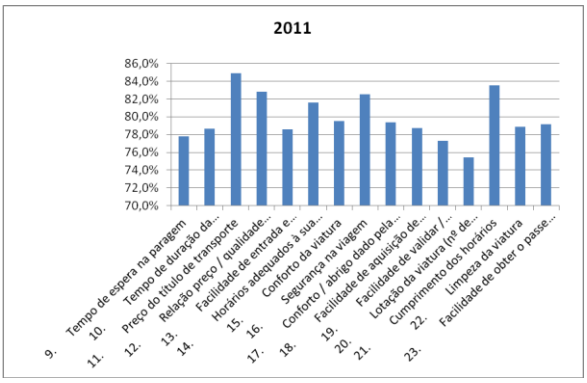




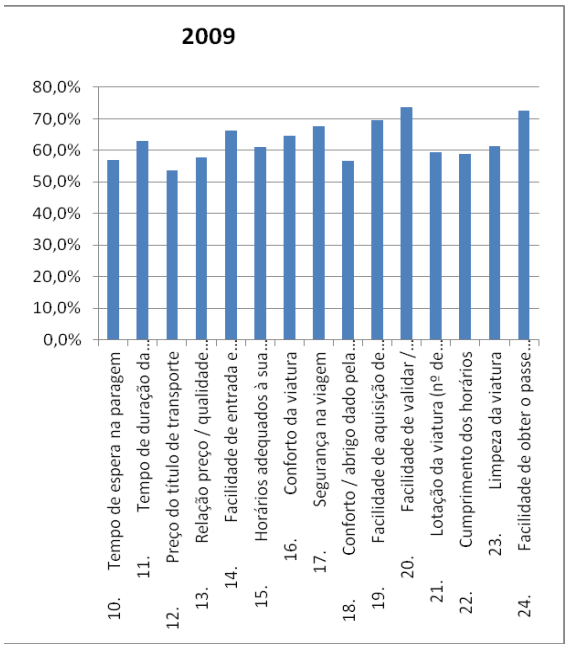
Importance given to the Quality of Service

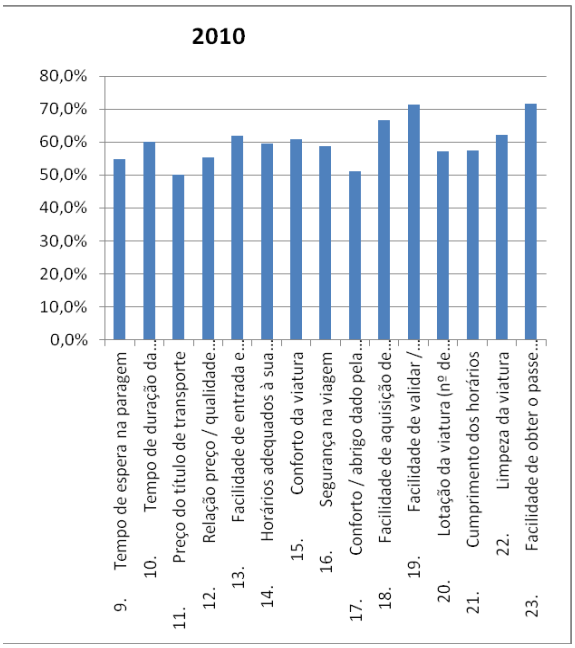


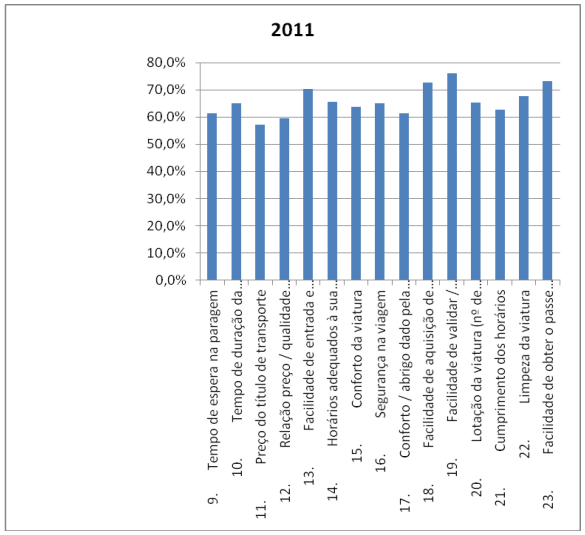


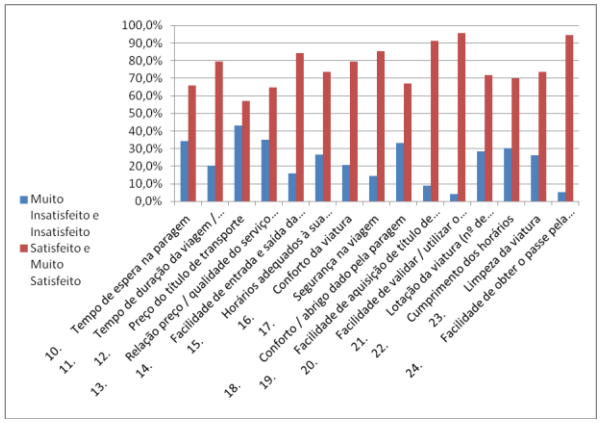


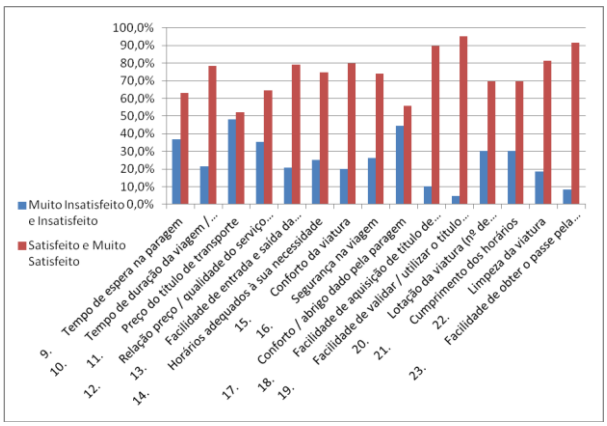
Level of satisfaction in relation to the Quality of Service

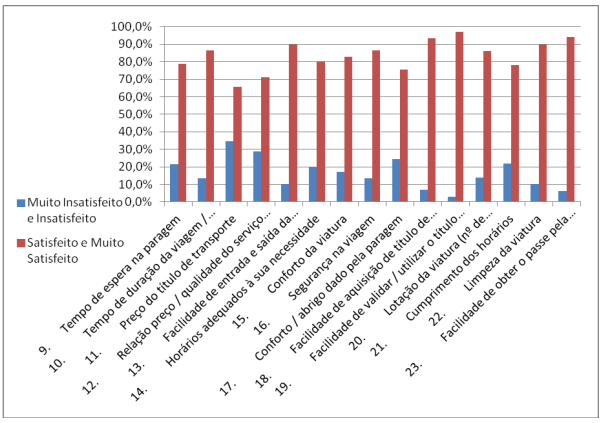




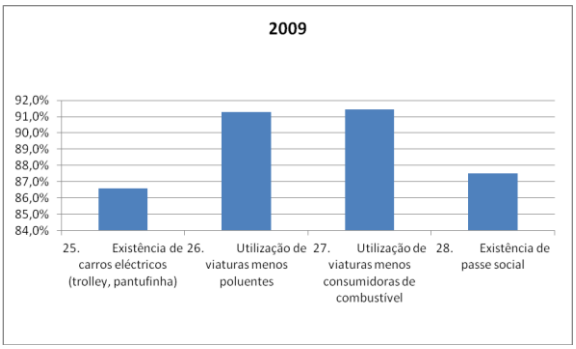


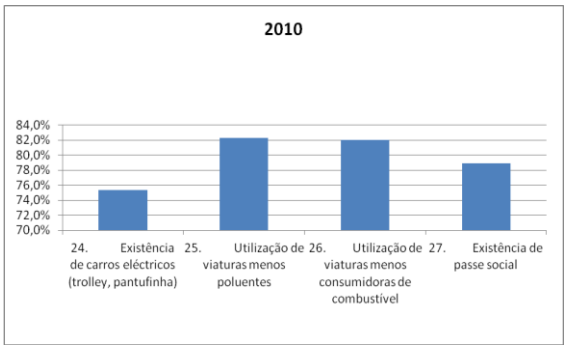


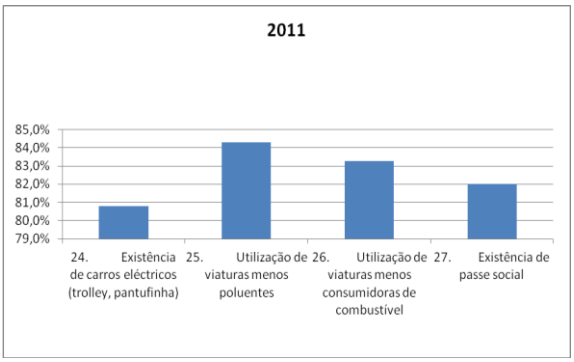




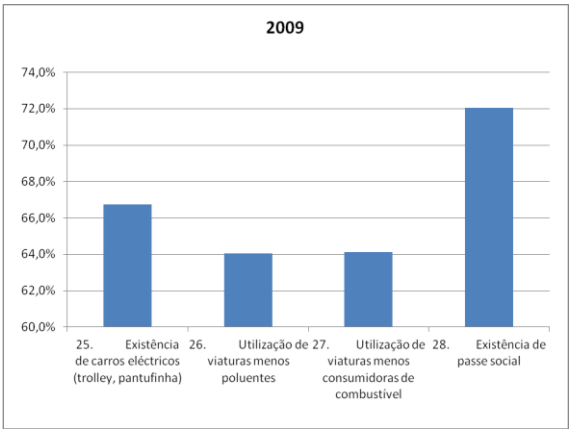
Importance given to the Contribution to Society

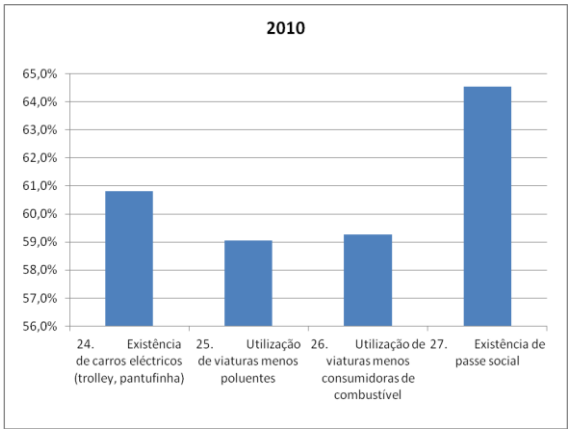


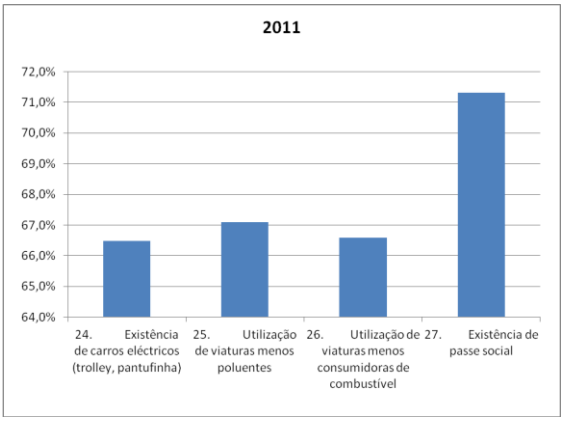


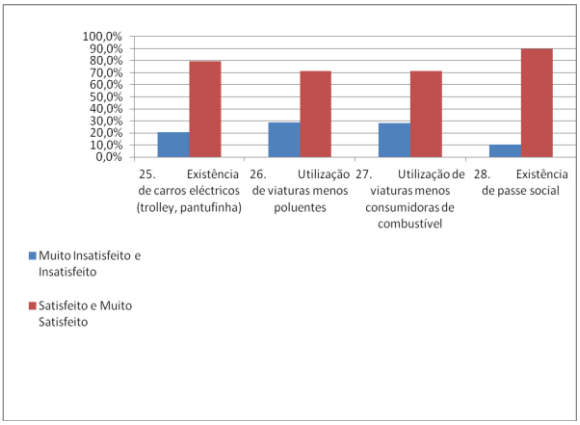


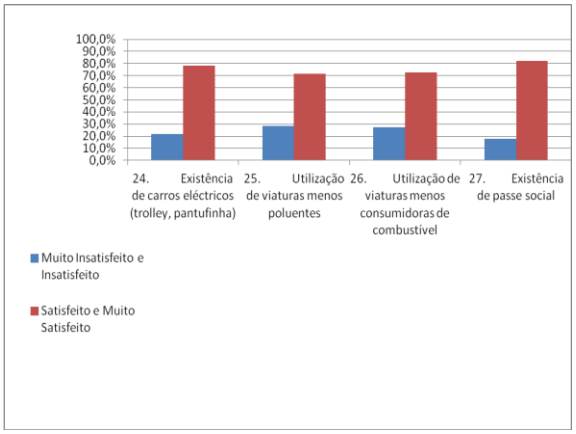
Level of satisfaction in relation to the Contribution to Society

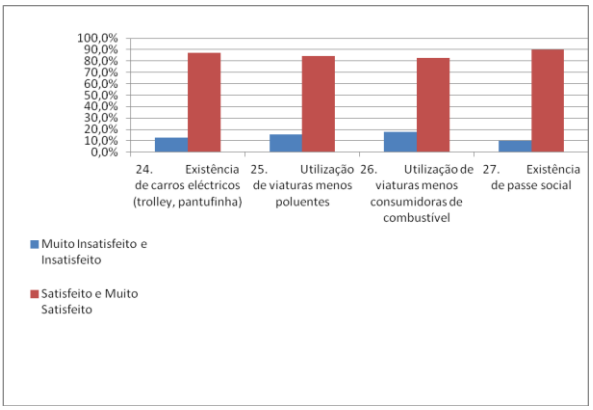




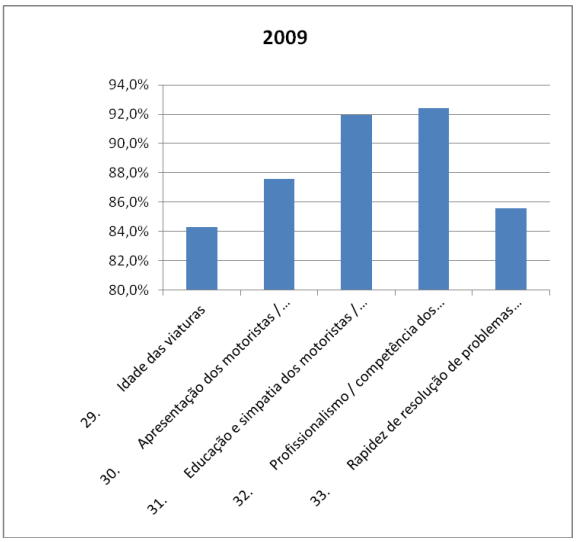


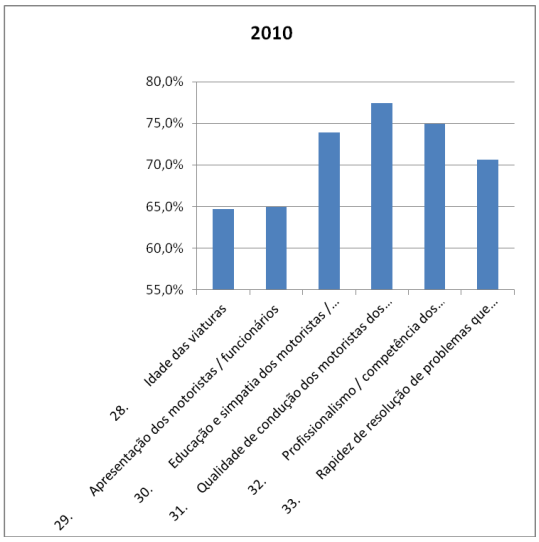


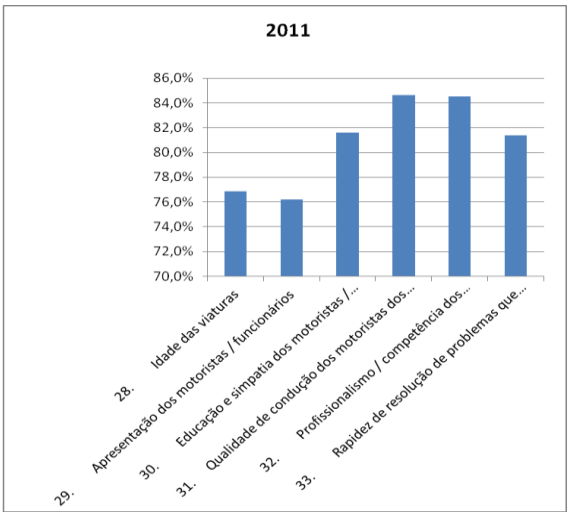




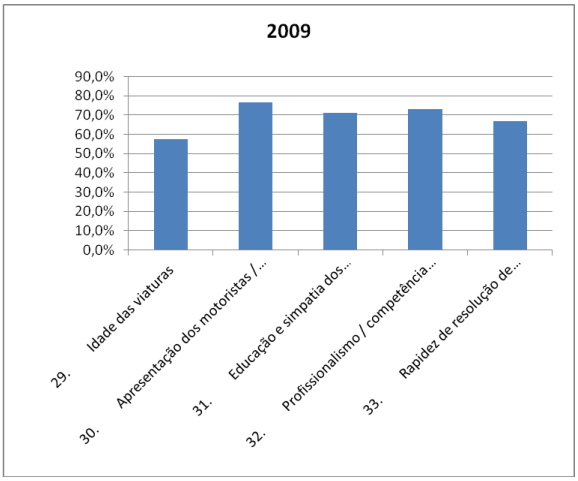
Importance given to the Image of the Company

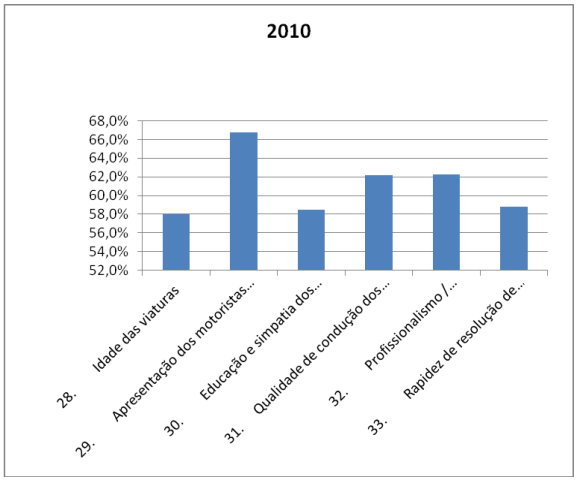


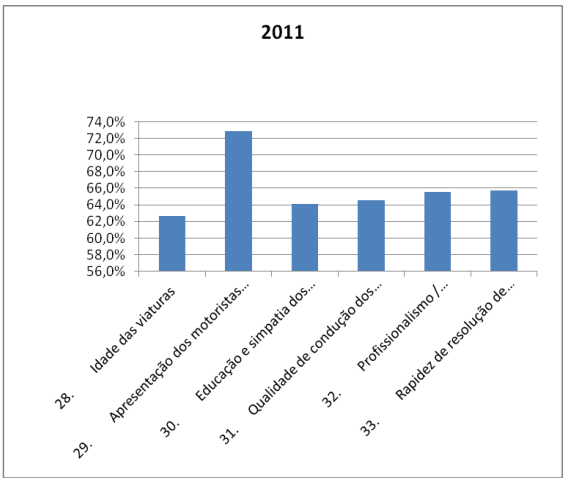


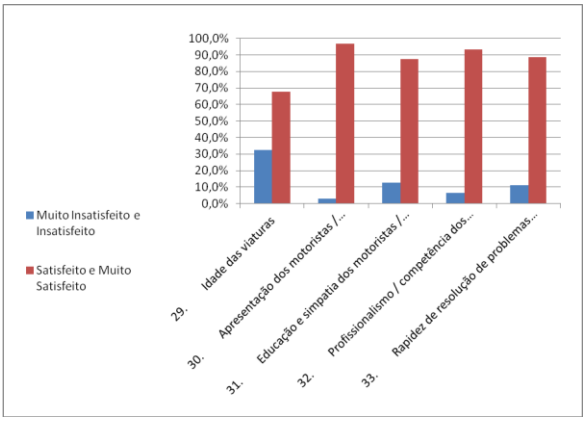


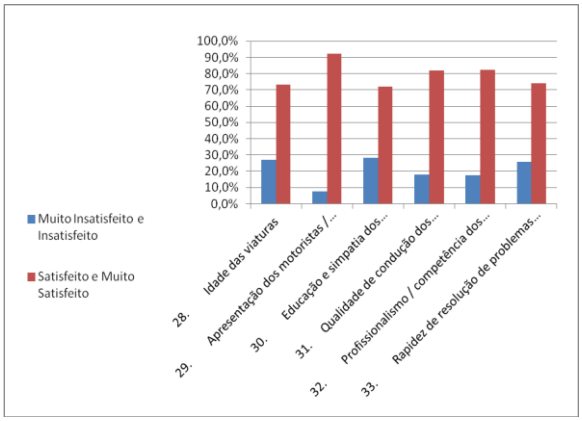
Level of satisfaction in relation to the Image of the Company

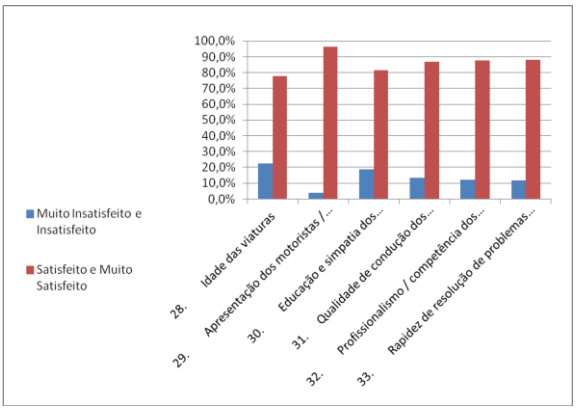




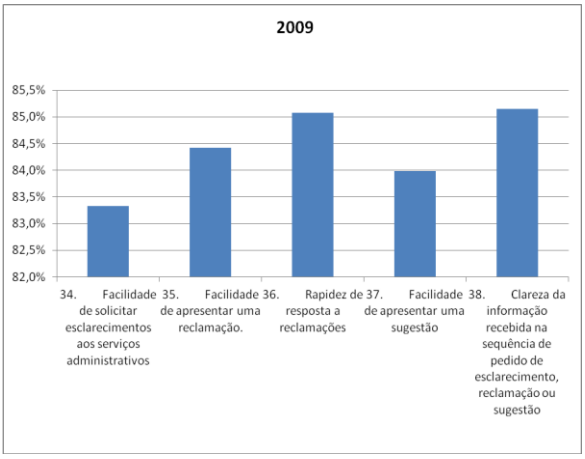


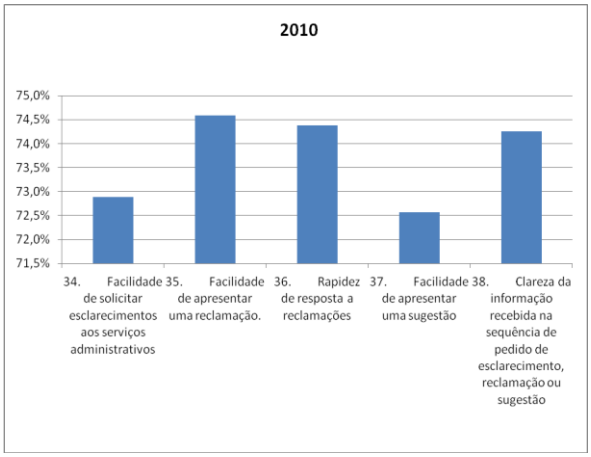


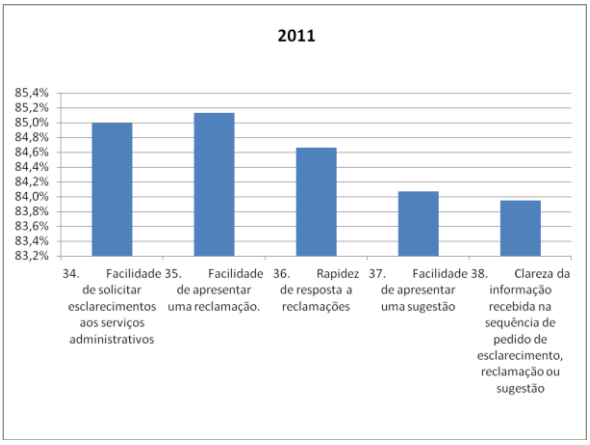




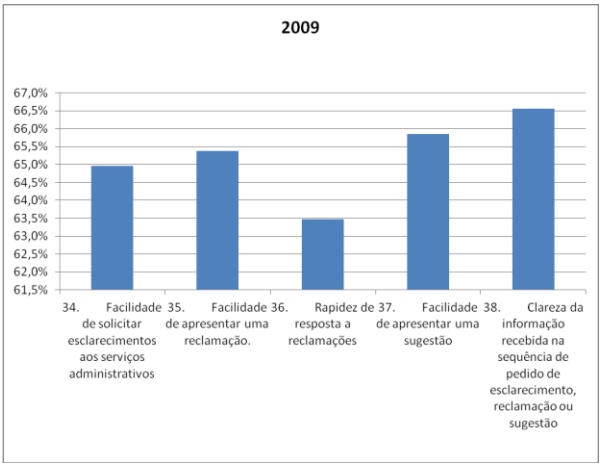
Importance given in relation to the Communication with the Administrative Sevices

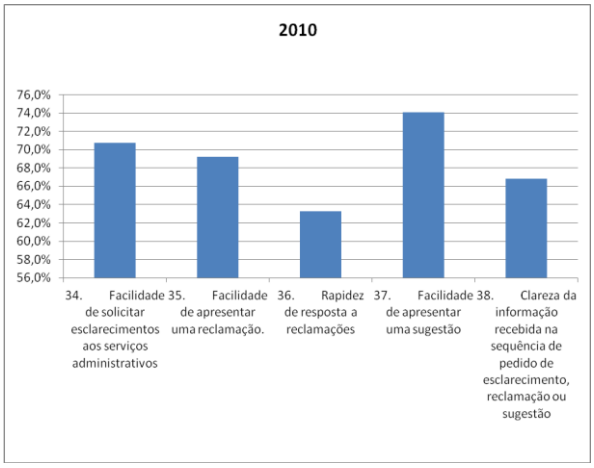


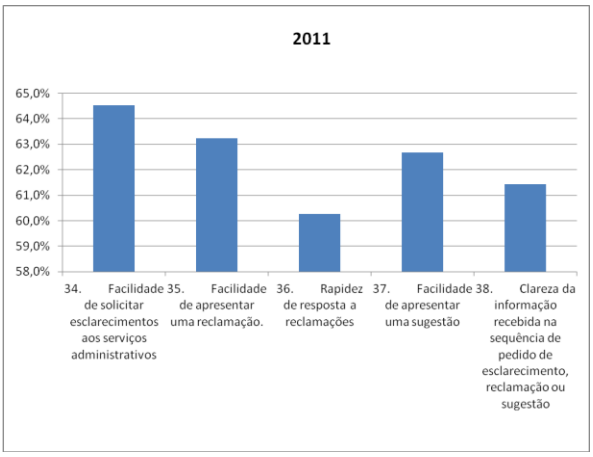


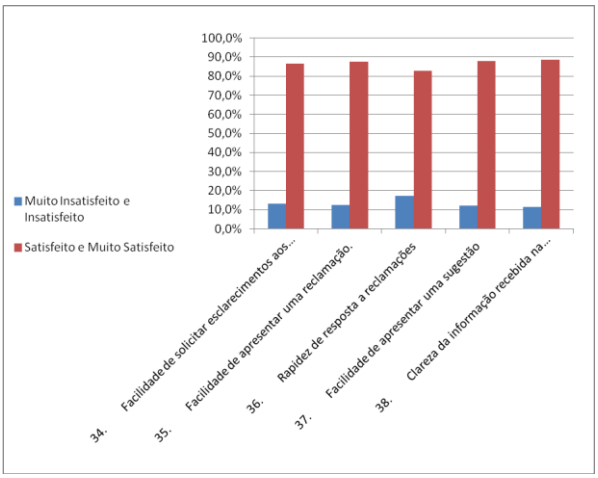


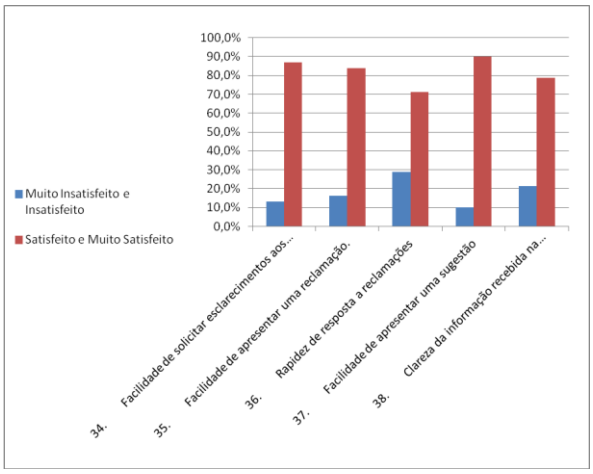
Level of satisfaction in relation to the Communication with the Administrative Sevices

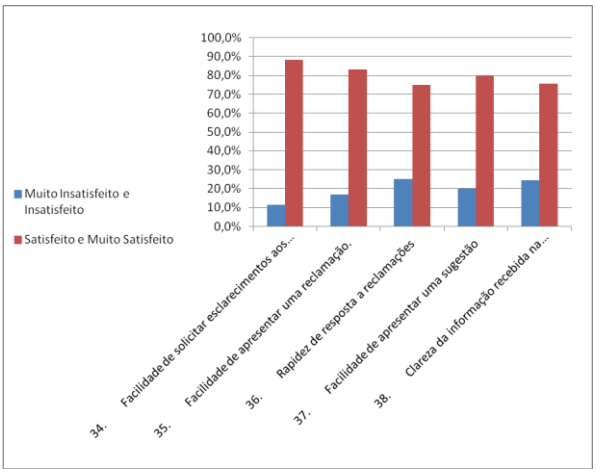






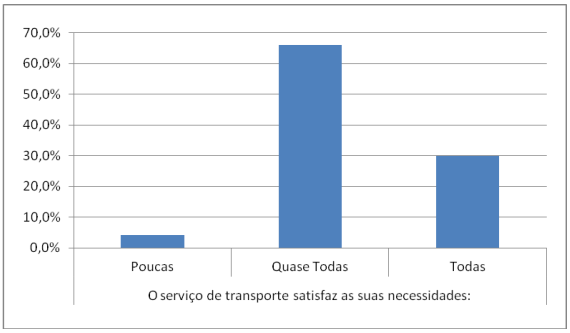




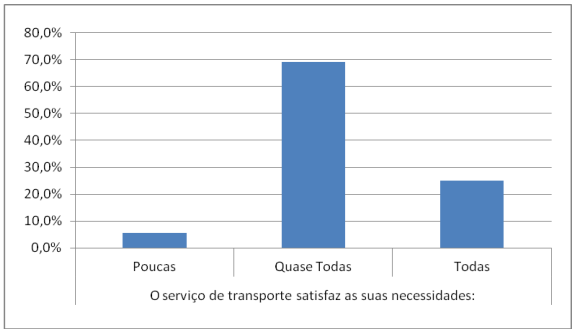


Results of the question "The transportation service meets your needs?"

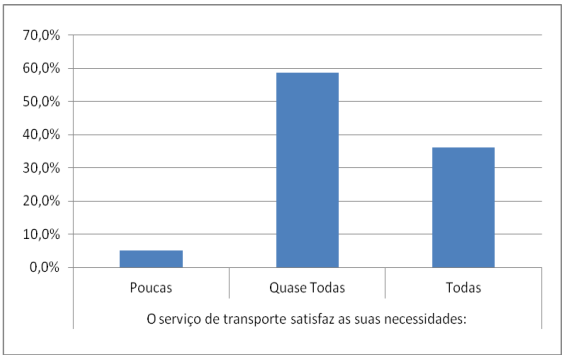
2009



2010

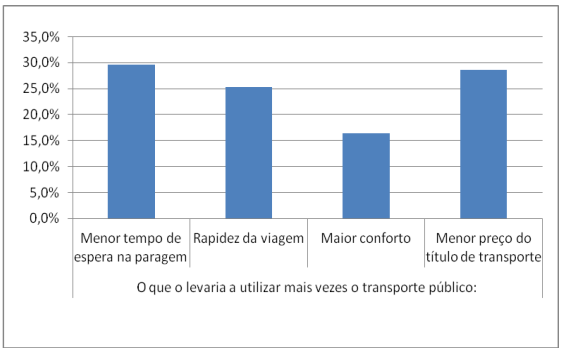


2011

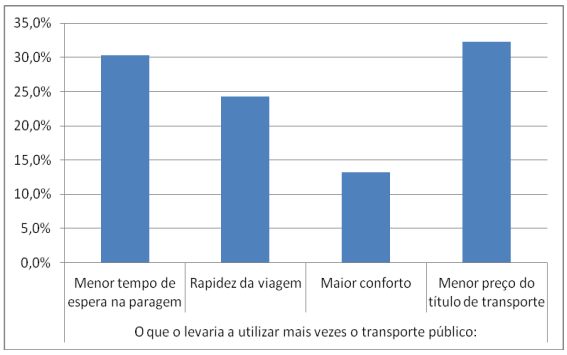


Results of the question "What would make you consider using public transportation more often?"

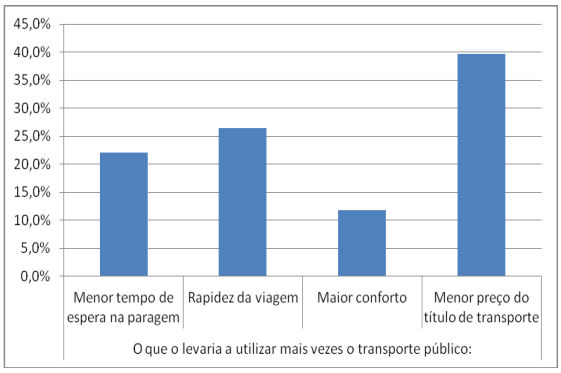
2009



2010



2011



M02.05 – Executive summary

Coimbra intended to increase the effectiveness of the system of inter relation among Public Transport (PT) operators and extend it to the municipalities around Coimbra, by using both single and combined fares, as well as to develop new products in terms of inter modality, since this has always been a priority strategy to the Municipality of Coimbra throughout the years.

For these reasons Coimbra implemented a new e-ticketing system in the Urban PT Service owned by the Municipality (SMTUC). The system has been based on technologies allowing "contact less" validations for all kinds of transport e-cards and e-tickets, the creation of a wider range of products and a greater reliability of the systems performance. Also fraud control has been facilitated. A more complete on demand database has been provided, enabling monitoring and benchmarking as well as dynamic network and supply planning and the adaptation of the transport network to the real needs of the populations' mobility.

The major advantage of the new e-ticketing system has been the great increase in the interopearability between systems and PT operators and in the intermodality. In this field took special highlight the creation of new e-tickets for the Park&Ride system, the establishment of a partnership with an association of PT operators and the complete integration with the Automatic Vehicle Management system of SMTUC.

Despite some delays in the measure implementation resulting from financial and bureaucratic issues, the less time for the demonstration period didn't affected the achievements of some key results, namely:

- An increase of the average operating revenues (+0,02 €/v-km) due to a shift from private cars to public transport (+ 1,2% PT users) and a decrease of the average operating costs (- 0,0095 €/v-km). Adding the effects of the operating revenues and costs it can be concluded that the measure has a positive impact from an economic view point. This fact has been confirmed by the Cost-Benefit Analysis showing that the measure can generate a positive NPV of 1,82 M € over a 15 year period with a payback of the investment expected to be between the 5th and 6th year of implementation.
- Significant energy savings due to the assessed reduction of the energy consumption per passenger (-0,24 MJ/pkm) and generates a positive impact on CO2, NOx, and PM emissions with a decrease of 17,081 g/pkm, -0,698 g/pkm, and 0,03 g/pkm, respectively. The CO emissions remained constant.
- An increase of the Park & Ride system usage with a growth of 10% of the e-tickets sold.

In the future the e-ticketing system will continue functioning, as well as the development of the on-line payment system. Once the legal issues relating to national legislation and the financial crisis will be overcome, the payment and reload of the e-cards through ATM machines will also be implemented. The contacts created for the establishment of an inter-municipal pass will continue, namely by searching for new ways to avoid financial barriers and involve both the surrounding Municipalities and PT operators in a common project.

A Introduction

A1 Objectives

The measure objectives are:

(G) High level / longer term:

- To combat the social exclusion and guarantee good life quality, with special attention to populations in the surrounding towns and municipalities.
- To promote intermodality and interoperability in the regional / urban mobility systems, including integration of services, such as parking.

(H) Strategic level:

- To increase the importance of the social role of PT in the region.
- Increase the use of PT in the city.
- To decrease city traffic levels.

(I) Measure level:

(1) To install a new e-ticketing system on board of 125 PT vehicles.

(2) To create products, including the improvement of the integration of services (such as those linked to parking), that will also contribute to increase by 1% the passengers in the municipality PT service and 3% the usage of Park & Ride.

(3) Expansion of public transport in the metropolitan area.

A2 Description

Coimbra intended to increase the effectiveness of the system of inter relation among PT operators and extend it to municipalities around Coimbra, by using both single and combined fares, as well as to develop new products in terms of inter modality, including the multimodal “railway – bus” pass and a service related to private vehicles, since this has always been a priority strategy to the Municipality of Coimbra throughout the years.

One of the main aims was in fact to facilitate the access to PT, to make it faster and more comfortable, in order to attract new users.

For these reasons Coimbra implemented a new e-ticketing system based on technologies allowing “contact less” validations for all kinds of transport e-cards and e-tickets, the creation of a wider range of products and a greater reliability in the systems performance. Also fraud control has been facilitated. A more complete on demand database has been provided, enabling monitoring and benchmarking as well as dynamic network and supply planning and the adaptation of the transport network to the real needs of the populations mobility.

Taking into consideration the great importance of the project at regional level and the interest showed by the National Authority of Inland Transportation[8] for the support of measures that could increase the integration of several PT operators and other modes of transportation in the metropolitan areas, the Municipality of Coimbra, through its municipal public transport service (SMTUC), began the contacts for the national funding of the e-ticketing system purchase before the CIVITAS application.

Despite this anticipation, a large amount of the time for implementation of this measure has been spent on solving administrative and bureaucratic problems:

a. First the governmental decision for the co-financing of the system purchase only occurred on 29th December 2009, 7 months after the technical conclusion of the tender process (with the proposal for adjudication on 11th May 2009) – SMTUC carried out recovery actions, launching a loan contract for the purchase of the e-ticketing system, taking into consideration that in Portugal the final adjudication only could be authorized after all funds are designated. But the loan contract procedure was equally time consuming, due in large part to the financial crisis in Portugal that obliged more rigorous procedures during the contract validation by the National Court of Accounting;

b. A contention on the final results and hierarchical appeals to several instances occurred during the procedure of the international public tender for the e-ticketing system was carried out by one of the tender contestants. Despite no reasons being attributed to the contestant, these appeals led to the suspension of the procedure until the final decision, allowing the final adjudication to happen only on 30th August 2010.

c. Finally, the loan contract validation by the National Court of Accounting occurred in December 2010, the signature of the contract for the e-ticketing system took place on 23rd December 2010 and the new validation by the National Court of Accounting (now for the system purchase) was released on 17th February 2011.

To recover the time lost, several planned activities have been anticipated or ran in parallel with these administrative procedures:

d. Accordingly, for the technical specifications of the new system, while solving the financial and administrative issues, SMTUC carried out a market analyse through the available online information or using the information provided by the manufacturers during presentations of their products. SMTUC took also advantage of the visits made to other existing systems and of the experience of the staff of OTLIS (the association of the public transport operators of the Lisbon region). These activities included a partnership with OTLIS aiming at the establishment of a national standard of e-ticketing systems – the partnership allowed for a common data base model and the same application programming interface (API) and the same security access module (SAM). These solutions benefited the interoperability and intermodality on the national level and allowed for economically more favourable tender proposals due the fact that a great amount of the work needed for the development of the system for Coimbra region has been already made by the major part of the manufacturers when they supplied Lisbon region in the past.

e. Moreover, the period between the contract signature and the validation by the Court (almost 2 months) has been used for the planning of the system installation with the supplier, allowing the shortening the implementation time (that was 1 year by contract).

[8] General Directorate of Inland Transportation (DGTT) and National Institute of Mobility and Inland Transportation (IMTT) since November 2007

f. Finally, in parallel, SMTUC created the concept of "Coimbra ConVIDA" for e-cards and "Viagem ConVIDA" for e-tickets and carried out procedures for the purchase of 50.000 e-cards and 220.000 e-tickets.

Thus, until December 2011 the equipment was installed in the central office for the system management, the on line data collection and data processing, and also on board of 150 vehicles (SMTUC assisted and supervised the installation of the equipment on board of all the fleet). The on board equipment consist in one console adjacent to the driver for the on board system management, for on board tickets sale (supported on thermal paper), and for the "contact less" reading and reloading of the pre-paid e-tickets and the fares supported on e-cards, as well as one validator for the main task of reading the e-tickets and e-cards (Fig. A2.1).

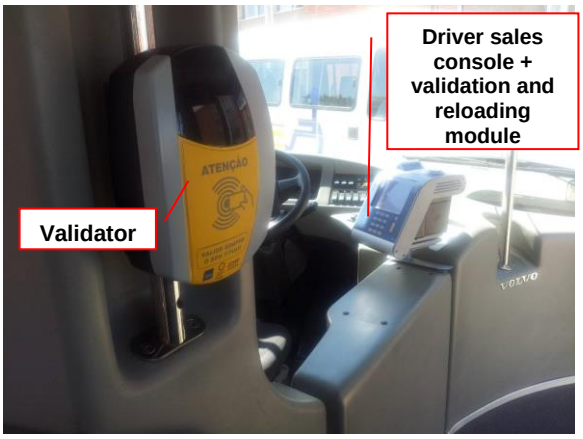


Fig. A2.1 – The on-board equipment of the new e-ticketing system

The other equipment that was purchased and installed is the following:

g. 8 "Contactless" Reader Terminals for Controllers

h. 9 Vending, Card Load and Personalization Machines

i. 28 Vending and Card Load Portable Terminals

j. 2 Transaction / Accounting Posts

k. 4 Automatic Machines for Driver Accounting Transactions

l. 1 Central Server

m. 1 Middleware Platform

The launch of the system in test mode was carried out in September 2011 for specific fares and public transport lines considering that up to this date the major part of the system was already installed.

The vending equipment and the 4 automatic machines for PT drivers account activities related with on board tickets sales have also been installed by the end of 2011.

Training has been provided to the SMTUC maintenance and accounting personnel, supervisors and to all other users of the new system, including the drivers.

During the last week of December 2011 an info mail about the new e-ticketing was delivered to all the Coimbra residents (to 84.007 mail boxes).

On 1st January 2012 the new e-ticketing system started in the entire SMTUC PT network and fleet for the on board thermal tickets and the e-tickets (pre-paid) – The system allowed in this phase the sale on board by the driver of thermal tickets for the occasional passengers that didn't have pre-paid e-tickets and the vending and on board validation of "contact-less" pre-paid e-tickets.

In February 2012 the remaining fares (supported in the e-cards "Coimbra ConVIDA) was launched for the whole SMTUC public transport network, despite the existence of a transition period running up to the end of May 2012 in which the 2 systems functioned in parallel for the e-card passes.

The new e-ticketing system is an "open" system that will not depend on the actual system integrator for it expansion in the future, and in which all kinds of card technologies can be read (facilitating the integration of other PT operators and more mobility products in the future – car sharing, bike sharing).

In any case, the new system has already allowed for the creation of an intermodal new product – The Park & Ride e-ticket that provides 1 day free parking in the parks of the system and 2 or 4 displacements, now in all PT lines during 1 hour each displacement. The existing combined fare between SMTUC and the other PT operators involving all inhabitants of the Municipality of Coimbra also benefited from the improvements of the new system, namely with the new channels for purchasing and reloading the new SMTUC e-card.

The system was initially developed to allow for the future integration of multiple PT operators (public and/or private), namely in view of the creation of an inter-municipal pass. However, the financial crisis has led many of the municipalities involved to reconsider their investment priorities. Accordingly, urban mobility issues have many times taken a back seat to other considerations, namely those associated with social themes and economic recovery.

On the other hand, the automatic accounting system for the PT drivers is experiencing good results and allowed for savings in human resources. The personnel dedicated in the past to these operations has now been liberated for other activities. Also the development by OTLIS of the application that will allow for the on-line payment and reloading of the passes is on-going. The situation is the same for the possibility of providing this activity through ATM machines (in this case already developed by OTLIS and in functioning in Lisbon, but waiting for a decision in the case of Coimbra– due to some legal impositions caused by the new legislation provided by the national government to combat the financial crisis in Portugal).

The new e-ticketing system was also integrated with SMTUC's automatic vehicle management (AVM) system – a GPS/GPRS technology based system. This has allowed for the new on-board consoles to manage the AVM system and avoid the need for drivers to repeat operations on other devices. This integration has also permitted the georeferencing of passenger entries.

In the near future, the new information e-panels at the buses stops will provide real time information on bus arrivals and will have also the capability to read the e-tickets (informing the number of remaining trips) and reload the e-cards.

The implementation of the new e-ticketing system also had organisational and economical impacts.

First a great improvement in the reliability of this system was verified in comparison with the previous system, mainly due to the change in the validation of the tickets from magnetic technology (involving

mechanisms and material wear) to "contact less" technology (without mechanical wear). This fact allowed for important savings in maintenance, both in material and personnel – for example, the technician responsible for the coordination and monitoring of the system installation delayed the retirement until its conclusion and has been not replaced, allowing for the decrease of 1 individual of the maintenance personnel dedicated to the IT systems in SMTUC.

Also the automatic accounting system for the PT drivers is experiencing good results and allowed for savings in human resources. The personnel dedicated in the past to these operations have now been shifted to other activities. Namely 2 employees have been transferred to the ticket sales and have been supported the maintenance of the Infomobility Centre in functioning after the end of the CIVITAS MODERN co-financing period.

In any case, the implementation of the automatic accounting machines hasn't been pacific, namely because these machines only have a ATM module for the settlement of accounts (machines that allow coins and notes for the transfers were twice as expensive and continue needing manual services to collect and count the money, as well as have more risks concerning fraud and safety). Before the installation of the new e-ticketing system drivers had to request tickets (paper support with magnetic band) for the on-board sale at SMTUC the accounting office. They would then carry the tickets with them in each of their driving services. Afterwards, drivers had to return to the accounting office in the following 2 days after tickets sale for the settling of accounts (the entire process was manual). They also could use a safe-deposit box placed in the city but this procedure didn't avoided the need to confirm the reckoning with the accounting office in a latter date. With the new system, drivers do not need to order and to bring tickets with them. The on-board sale is now being made through the driver console (that dispenses tickets supported in thermal paper) and the vending values are automatically transferred to the 4 automatic machines located in strategic locales in the city and SMTUC site. With the start-up of the new e-ticketing system ATM bank cards have been distributed to all SMTUC drivers with an initial financial advancement. This bank card (or the driver personal bank card) is used for the settlement of accounts trough the automatic machines that have an ATM module. These procedures created some strong contestation from the drivers, with support of the trade unions, during the beginning of the system operation. Initially, they claimed that they didn't want to use their personal bank card, reason for which SMTUC distributed the already mentioned dedicated ATM cards. But the major concern has been the fact that they didn't want to carry the coins received from the users, taking into consideration that before they had the safe-deposit box and now they need to go to a bank to deposit them. Despite this situation has not been a major problem to the measure implementation, required some special attention to it resolution and was solved while drivers had the perception that there are more advantages then disadvantages.

Finally it is important to summarise the major advantages and disadvantages of the 2 systems. In fact the main differences between the new system and the old (magnetic) system is being the major reliability of the system (the magnetic system required mechanical operations that produce material wear) and the new and enhanced functionalities, since in terms of investments the costs should be similar.

The first advantage implied the reduction of the maintenance costs (so more economic advantages) and the second allowed the creation of new mobility products, the personnel saves in the organisational field, the quickest access to better and major quantity of operational and financial data, as well as more comfortable and fastest access to the public transport. In this last filed (and contrary to the ancient system), the new system allowed the reload of the tickets and it fastest validation on board buses (contact less validation in spite magnetic validation). Also the new system provides more channels for the e-cards reload and the integration of several products simultaneously in the same card (the e-cards of the ancient system only supported public transport fares of an unique kind in each moment).

The unique disadvantage assessed in the new system is related to the fact that the system doesn't allow the display of the users' remaining trips in the pre-paid e-tickets (the remaining trips is displayed in the console or validator screen). While the ancient system, with magnetic validation for the pre-paid tickets, write the remaining trips in the ticket. This contrariety obliged more users' attention, mainly for the elders.

It is important to highlight that despite all the bureaucratic problems that have been very time consuming, the implementation of this measure has been crucial to the quality of the services provided by SMTUC, contributing to an improved urban mobility. It has also been indispensable for the ticketing activity, because during the last months of 2011 it had been very difficult to maintain the previous ticketing system functioning.

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure were:

- **Use of new technology/ITS, nationally**
    - The e-ticketing system has been developed to allow the on-line payment of the e-cards and reloading at home (through the eventual acquisition of a portable loading device) or through the validators on board the buses, allowing people to make this action at home and then travel without passing through point of sales. The same for the reload of the e-cards through ATM machines, because in Portugal only Lisbon and Oporto are implementing this system.
    - The e-ticketing system has been integrated with other SMTUC systems, more specifically the System of Exploitation's Information Treatment, GPS – Operation Support System and the Integral Transport System Management. In particularly this will provide geo-referenced information about passengers entry for the support of studies about the demand and real time monitoring of on board validation and vending.
    - The electronic panels at bus stops with the real time information about buses arriving, provided by the GPS/GPRS – Operation Support System (integrated in measure 08.03), has been equipped with another module closer to the users with a second display and equipment that allows the loading of the transport e-tickets and the verification of its balance, (in addition to the duplication of the information provided in the main display).

Figure B1.1 – Real time information panel at bus stops powered by solar energy (left) and detail of the secondary module with second information screen and "contact less" reader (right)

- **New policy and economic instrument, regionally**
    - The e-ticketing system uses "Calypso" technology and the same data model and security and protocol technology used in OTLIS (Lisbon Metropolitan Area Entity of Public Transport Operators) facilitating and giving more credibility and security for the intermodality and interoperability, allowing, namely, the creation of an inter municipal pass through which the resident population of the municipalities around Coimbra, transported by private operators, will be able to use SMTUC lines with discounts and the same card. The partnership with OTLIS allowed SMTUC to benefit from discounts in the purchase of cards from the manufacturer due the major quantity of cards involved (summing Coimbra users with Lisbon Metropolitan Area users).

- **New economic instrument, nationally**
    - The SMTUC bus drivers are providing automatically in machines the provision of accounts for the on board sales, reducing the staff previously needed for this activity.

B2 Research and Technology Development

The Research and Technology Development consisted mainly by the Model's Conception and Definition of Technical Specifications, namely the definition of the needs and design of the new integrated system that included:

- Specification of the Validation's Model (contact less type);
- Specification of transport fares structure, types and of its integration with other PT operators and other means of transportation, as well as with parking and Park & Ride. Special attention was given to the activities and studies to support the creation of an inter-municipal pass (with the partnership of surrounding municipalities and operators) through which the resident population of the municipalities around Coimbra, transported by private operators, will be able to use SMTUC lines with discounts;
- How and where to install the system on board of the PT vehicles and personnel necessary;
- Which information the system shall produce;
- Integration with other SMTUC systems, more specifically the System of Exploitation's Information Treatment, GPS – Operation Support System and the Integral Transport System Management;
- Coordinate the ending of the old service and the beginning of the new system;
- Planning the maintenance, who assures it and type of the equipment necessary;

In order to prepare the technical specifications of the new system, while solving the financial and administrative issues, SMTUC carried out a market analysis through the available online information or using the information provided by the manufacturers. SMTUC also took advantage of the visits made to other existing systems and of the experience of the staff of OTLIS (the association of the public transport operators of the Lisbon region). These activities included a partnership with OTLIS aiming at establishing a national standard for e-ticketing systems. This partnership allowed for SMTUC to adopt a common data base model, standard application programming interface (API), and security access module (SAM). These solutions not only benefited the interoperability and

intermodality at the national level, but also allowed financial savings due the fact that a great amount of the work needed for the development of the Coimbra system has been already implemented by the major part of the manufacturers operating in Portugal.

Special attention was also given to the system specifications in order to avoid the dependency from the e-ticketing suppliers for the interoperability, for the expansion of the system / purchase of new equipment, and for the creation of new fares and products. Today there are 2 standards for the e-tickets and validators technology (the A type and the B type or Calypso) and the option for equipment that could support this kind of technologies could be a good approach for the interoperability but might not be enough – the systems must have a compatible data model for the products, mainly the fares, as well as for the API (responsible for the communication protocol between systems), and the SAM (Protocol of security between systems, avoiding that a ticket from a not allowed operator can't be used in the system).

The technology with the standard "Calypso" (B type) was chosen to permit greater security in the validation and load processes (avoiding the falsification of e-tickets and e-cards), as well as more "chip" memory than the e-cards based on A type technology - and consequently more capacity to support a large variety of contracts (fares, services, products). But all the equipment installed has the capability to interpret both A type or B type standards, facilitating future integration of other PT operators or systems supported in A type technology.

The e-ticketing system was specified to be an "open" system with the possibility of customising features so as to avoid the dependency on system suppliers in future developments. This part has been the most difficult to achieve. However, SMTUC had good results, mainly in the integration with the Automatic Vehicle Management (AVM) system and achieving independence in the creation and update of new fares or the purchase of new equipment such as validators.

The new e-ticketing system was also integrated with SMTUC's automatic vehicle management (AVM) system – a GPS/GPRS technology based system. As already mentioned, this has allowed for the new on-board consoles to manage the AVM system and avoid the need for drivers to repeat operations on other devices. This integration has also permitted the georeferencing of passengers' boarding and the 2 system has a common communication device (wifi) to transfer the data recorded on buses to the respective servers based on SMTUC site (back-office and control centre of each system). The automatic data transfer besides allowed a quicker and secure process for this activity, also avoided the manual work carried out by SMTUC personnel to discharge the data recorded on the ancient validators (directly bus by bus).

Specifically for the new e-ticketing system, SMTUC created the concept "Coimbra ConVIDA" for the e-cards and "Viagem ConVIDA" for the e-tickets, including the design of dedicated layouts (Fig. B2.1).

Fig. B2.1 - The layout for the e-cards of the "Coimbra ConVIDA" system (left) and "Viagem ConVIDA" system (right)

The e-card (ISO 14443B) is oriented for regular users and can support up to 4 different contracts in simultaneous. Accordingly, it is the support per excellence for the intermodal products. The e-ticket CTS512B (ISO 14443B) is defined for less frequent users, despite that the model chosen by SMTUC allows for reloading and has enough memory for the creation of some more simple intermodal products. Also the studies for the implementation of car sharing and bike sharing services in the city point to the importance of having a common e-card to access these services, to the public transport services, and to other products or services linked to the mobility area. So the new e-ticketing system has been designed and developed to permit these functionalities.

During the implementation of the measure some additional results that were not foreseen in the workplan have been considered. The development by OTLIS of the application that will allow for the on-line payment and reloading of the passes is on-going, as far as the possibility of providing this activity through ATM machines (Fig. B2.2).

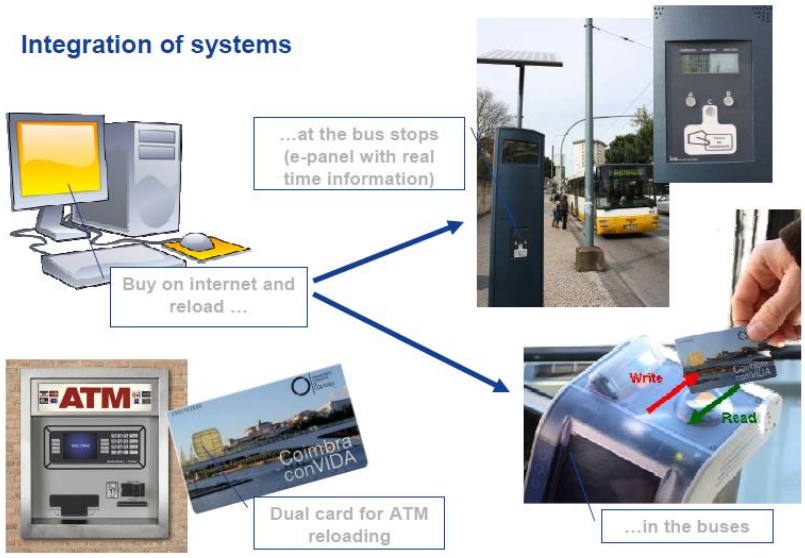


Fig. B2.2 – Integration of systems

The system will permit users to pay the pass by internet and make the reload by "contact less" devices (at home, for example, but also in the driver console of the buses simultaneously with the validation, because this equipment has the capability to read and write in the e-cards). Also the e-cards used in the "Coimbra ConVIDA" system are "Dual card" standard (i.e. each card has 2 chips, 1 hidden chip with antenna – for the "contact less" communication with other similar interfaces – and 1 standard chip similar to the ATM cards for the use in ATM machines, allowing for the reload of the passes and charge of other products based in the e-card). The development of the ATM payment system has already been concluded by OTLIS.

B3 Situation before CIVITAS

Coimbra has already a wide range of products concerning public transports and their inter-relation with other means of transport, namely through SMTUC:

- Combined pass with private bus operators since 1988 (free travel in SMTUC lines) and multimodal pass railway – bus;
- Park & Ride system integrated with PT fares, since 1997 (first Portuguese city);
- Door-to-door mini buses for reduced mobility, since 1985;

- Lift / funicular since 2001 to connect lower and upper city centre;
- Sightseeing tours since 2004;
- Management of parking spaces since 1988;
- Historic centre line with blue line operation concept (boarding and enlightening on demand), with electric mini buses, since 2003 (first Portuguese city).

In 1997, SMTUC introduced a new ticketing system with the magnetic validation of tickets and in 2000 Coimbra expanded the system to "contact less" pass validation. Before the beginning of the CIVITAS project the system was not very reliable in terms of its maintenance, especially in its magnetic validation component. Due to technological evolution, the system presented certain limitations on the types and diversity of transport titles allowed.

The inter-modal level was lagging – namely because the multimodal pass "railway-bus" was not integrated in the ticketing system for technical reasons. The multimodal pass "railway-bus" was not used very often due to its weak economic attractiveness to the user (26 passes /month). There was also the need to expand combined titles (with free rides on SMTUC lines) to municipalities around Coimbra.

The systems of information anciently in use were outdated in relation to the new IT (Information Technologies) and machines for this ticketing system are no longer available on the market which can provide for the demand of SMTUCs growing fleet, as well as with the eventual extension of the system to other operators.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Model's conception and definition of technical specifications for the new e-ticketing system *(October 2008 – November 2008) – The major part of the studies started before the beginning of the CIVITAS MODERN project and have been used by the measure, namely the study of the creation of an Inter-municipal pass demanded by Municipality to SMTUC in December 2005 (Fig. B4.1). It took place several meetings and contacts with Municipalities Mayor or Councillors, as well as with PT operators responsible for the Inter-municipal pass specifications and the agreement conditions.*

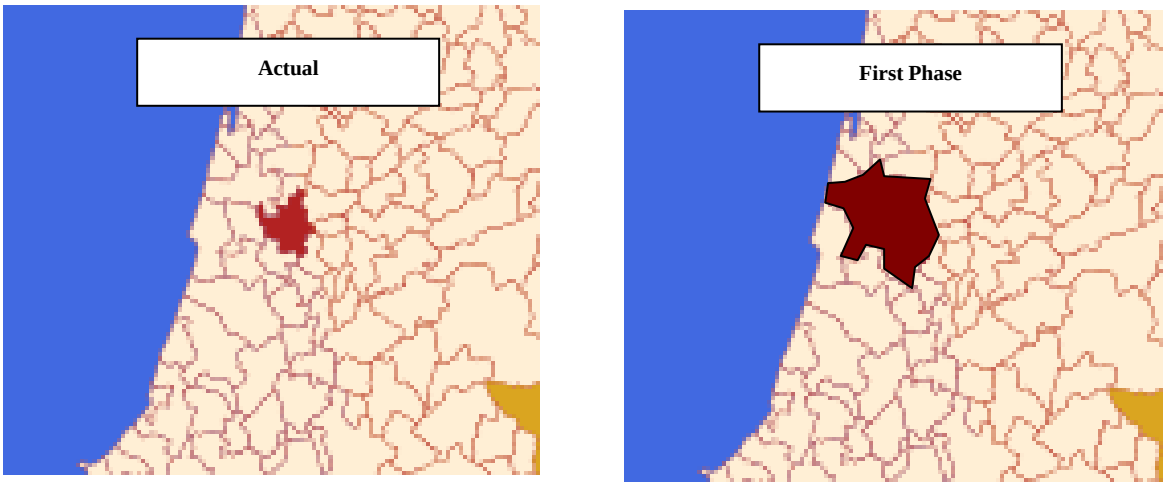


Figure B4.1-Limits of the inter-municipal pass

Also the decision to purchase a new ticketing system that will have as a priority the intermodality and interoperability capabilities occurred in July 2007, after the end of the call for CIVITAS plus funding.

At the same time SMTUC began the procedures to claim for national funding, namely:

- *Delivery of documents to IMTT (Portuguese Mobility and Transport Institute) with ticketing system definitions and claim for co-financing (July 2007).*
- *Answers to IMTT questions (December 2007 and November 2008, the last one already after CIVITAS measure began).*

Between October 2007 and November 2008 the technical specifications of the new e-ticketing system and definitions of new fares and other products or services to integrate in the ticketing system took place, namely:

- *Contacts, meetings and demonstrations with all interested suppliers of ticketing systems and related software developers to improve SMTUC's know-how about this matter;*
- *Specification of the Validation Model (contact less type);*
- *Specification of transport fares structure, types, its integration with other PT bus and rail operators as well as with the future tram train system, and other means of transportation and mobility services, such as parking and Park & Ride;*
- *Specification of vending / accounting processes and automatic transactions, including for PT Drivers;*
- *Specification of new concepts for tickets acquisition / cards load (Internet, ATM, Pay shop, Mobile Phones);*
- *Planning the installation of the system on board of the PT vehicles and means necessary for this activity;*
- *Planning the information that the system shall produce;*
- *Specification of the Integration with other SMTUC systems, more specifically the Supply Data Treatment System, GPS / GPRS – Operation Support System and the Integral Transport System Management;*
- *Coordination of actions to allow the end of the old service and the beginning of the new one without problems at users comfort level and ticketing continuance level;*
- *Planning of the maintenance, including equipment and personnel necessary.*

Release of the technical specifications for the tender procedure in July 2008 and the working document "Operation concept report and terms of references of equipment acquisitions" in November 2008.

Stage 2: Purchase and installation of the new e-ticketing system *(October 2008 – December 2011) – The launch of the purchase and installation procedure occurred in July 2008, before the start of the CIVITAS MODERN project. During CIVITAS procedures*

concerning the claim for national funding and the loan contract to grant self financing by municipality / SMTUC were carried out. The procedures of the tender, the claim for national funding and the loan contract had the following steps:

- *Opening ceremony of the tender proposals for the purchase and installation of the e-ticketing system in October 2008;*
- *In December 2008 the claim for national funding process was authorized by IMTT with transition to the Deputy Secretary of Transportation for final decision;*
- *Analysis of tender proposals for the purchase and installation of the e-ticketing system and jury final report with proposal for adjudication until May 2009;*
- *several More contacts with IMTT officials and meeting with its President to press national government to send to SMTUC the official communication of the authorization of co-financing took place between April and December 2009, taking in attention that, legally in Portugal, the adjudication of a purchase can only be done after all funds are defined;*
- *National funding for the purchase and installation of a new e-ticketing system was authorized by the Government on 29th December 2009. Only after this confirmation was it possible for the Municipality to begin the authorization process of the loan contract concerning the remaining funds. SMTUC made the process for this loan contract that was integrated with the loan needed for the measure 05.07;*
- *Final adjudication of the e-ticketing purchase in 17th March 2010 because the process was delayed due to a tender applicant contention of the final results, despite the prompt analysis and reply made by SMTUC. On 30th April the same initial contestant interposed a hierarchical appeal to the Municipality which had suspensive effects on the process and oblige a new and complicated process of analysis and reply;*
- *Analysis of proposals and final adjudication concerning the loan contract for co-financing the purchase of the e-ticketing system on 14th June and its validation by the Municipal Assembly on 29th June 2010;*
- *Reply of Municipality to the hierarchical appeal concerning the process of e-ticketing system purchase on 12th July 2010 (the Municipality asked the jury of the tender process to better substantiate the decision, causing the repositioning of the process in a new adjudication phase). New provisional adjudication for the purchase of the e-ticketing system on 29th July 2010 after the jury (SMTUC) delivered a new substantiation report, maintaining the same scores and classification;*
- *The loan contract was signed on 9th August 2010 and sent to the National Court of Accounting for validation;*
- *Concerning the purchase procedure, a new contestation occurred on 12th August 2010 with the same arguments, but the Municipality, being in accordance with the jury and seeking to hasten the process, called back the right to make the final adjudication, occurring on 30th August. On 7th October 2010 the period for the contestant appeals to the Court, asking for a preliminary injunction, ended without any appeal;*
- *Only in December 2010 the loan contract was authorized by the National Court of Accounting, allowing the celebration of the purchase contract;*

- *The contract concerning the purchase and installation of the new e-ticketing system was signed on 23rd December 2010 and sent to the National Court of Accounting on 28th December;*

Taking into consideration that the system installation can only begin after the court validation, some preliminary tasks were done, such:

- *Definition of the entire installation plan, including the place and method of the installation on board of the buses and the issues due to the period of transition between the actual and the new system that will have different types of fares.*

- *Contacts for the establishment of a partnership with OTLIS (Organization of public transportation operators of Lisbon and national railway company) with the objective of achieving common specifications, allowing better interoperability of e-ticketing systems.*

- *Visits to CARRIS site (urban public transportation company of Lisbon) to verify equipments and functionalities of a system similar to the system that SMTUC has purchased.*

- *Selection of the model data base, Security Protocol (SAM) for the "contact less" cards and the Application Programming Interface (API) for the bus-validators and driver console.*

- *Definition of the relationship between the e-ticketing system and the SMTUC accounting system as well as the specification of the new procedures in this area that the system will need.*

On 17th February 2011 the National Court of Accounting authorized the purchase and installation of the new e-ticketing system. The installation process began at this time with the commitment of the supplier to ensure a short time for the installation process, namely with the advancement of the organization and definition of the tasks. It eas also assured the organization of the supply in an incremental and modular way to allow early start of test and validation stage (for example, shifting to the end the modules that don' have relationship with the public, such as automatic accountability process for drivers or the middleware for interoperability of SMTUC systems). With this commitment it was possible to end the installation of the main equipment until the end of August 2011.

During this stage new contacts and meetings with Municipalities and regional operators took place to highlight the importance of the creation of the inter-municipal pass, in order to avoid problems with its implementation in the future.

Also the preparatory phase of the system installation included:

- *Specification of the security protocol for de SAM (Secure Application Modules) and its production;*

- *Final layout for the cards and tickets physical supports with the creation of the brand "Viagem ConVIDA[9]" (trip with life / inviting trip) for the tickets and "Coimbra*

[9] ConVIDA spelling could have 2 meanings in Portuguese. *Com Vida* that means with life or *Convida* that means invites / inviting.

ConVIDA" (Coimbra with life / Coimbra invites you) for the cards and other intermodal products.

- *Establishment of a partnership with OTLIS (Organization of public transportation operators of Lisbon and national railway company) with the objective of achieving common specifications as a national standard, allowing for better interoperability of e-ticketing systems, technical support for the mobility products and economies of scale resulting for large-scale demands of tickets and cards in tenders together the Lisbon Metropolitan area.*

- *Final definition of the relationship between the e-ticketing system and the SMTUC accounting system as well as the final adjustments concerning the specification of the new procedures in this area induced by the new system requirements.*

The on board equipment that has been purchased consists in:

- *one console next to the driver for the on-board management of the system, for the on-board sales of tickets on thermal paper support, and for the "contact less" reading and reloading of the e-cards and reading of the pre-paid e-tickets;*

- *one validator for the main task of reading the e-tickets and e-cards.*

  These 2 equipments with validation capabilities allowed for quicker passenger entry and for the extra equipments which are useful in case of equipments damages. The console also allows for the command of the Automatic Vehicle Management system, avoiding drivers to repeat operations that are similar between the 2 systems. This fact also allowed the redundancy of equipments between these 2 systems.

The other equipment that was purchased and installed is the following:

- *8 "Contactless" Reader Terminals for Controllers (these terminals are being used in fraud control but also have vending and e-card load capabilities – namely for events)*

- *9 Vending, Card Load and Personalization Machines (this equipment has been designed for the SMTUC point of sales, allowing the vending and personalization of the new e-cards and the reload of the e-tickets and e-cards).*

- *28 Vending and Card Load Portable Terminals (the terminals has been designed for the vending and reload of e-tickets and e-cards, namely for sales points in agencies, but also for the tickets sale in the Park&Ride system and events)*

- *2 Transaction / Accounting Posts (Equipment installed in the SMTUC settlement of accounts office designed for drivers and tickets sellers make the reckoning with the support of SMTUC personnel)*

- *4 Automatic Machines for Driver Accounting Transactions (Equipment designed for the drivers making the settlement of accounts autonomously)*

- *1 Central Server (Equipment for the management and monitoring of the e-ticketing system and provided of connections with other systems, sale points and equipments)*

- *1 Middleware Platform (sub-system used for the interoperability between the e-ticketing system and other systems, with emphasis with the Automatic Vehicle Management System).*

The installation process has been carried out until the end of August 2011 to allow for the launching of the system functioning in test mode since September 2011, but some remaining equipment has been installed until the end of December 2011. The installation process consisted namely of:

- *Installation of the equipment on board 150 buses (namely the new console for tickets sales and validation and the infrastructure for the new validator – the validators stocked in SMTUC will be placed during the period of transition between the new and old system taking in account the period of coexistence of the new system during which the validation will be assured by the new console).*
- *Installation of the system for the sale and loading of fares and its connection to the accounting system.*
- *Installation of 4 automatic machines for PT drivers account activities resulting from the tickets sales on board buses (Fig. B4.2).*

Figure B4.2 - The automatic machines for PT drivers account activities is allowing the payment by ATM of the results of the tickets sales on board buses with economies of resources on the accounting office

- *Installation of the e-ticketing system laboratory for equipment and system tests and for the functioning of the training sessions (Fig. B4.3).*

Figure B4.3 - Training session on the new SMTUC e-ticketing laboratory

- *Launch of 2 procedures to purchase the physical supports for the "contact less" tickets and cards. Despite that initially it was foreseen that these physical supports for the fares could be available through the protocol of partnership signed with OTLIS, like another PT operators in the Lisbon region, since in June legal opinions didn't allow that the tickets and cards could be provided directly by this entity, it was decided to launch the procedures for:*
  - *Purchase of 220 000 "Contact less" tickets CTS512B (ISO 14443B) for "Viagem ConVIDA" system:*
    - *Launch of the procedure by SMTUC on 22nd July 2011 (Direct Agreement procedure taking in attention that only 1 manufacturer produce this kind of tickets)*
    - *It was expected to be an easy and quick process but important delays of the supplier to provide the legal and mandatory documentation for the contract signature occurred. This fact pushed the contract signature into the end of November 2011. According to the supplier, taking in attention the small quantity of tickets, the SMTUC order has less priority on the manufacturing chain, so the usual delivery time for these cases was 8 weeks after contract signature. SMTUC demanded the supplier to shorten this gap, to allow the launch of the system for the public on 12th December 2011. Due to some additional problems with the e-tickets delivery the launch of the system for the e-tickets took place on 1st January 2012.*
  - *Purchase of 50 000 "Contact less" cards (ISO 14443B) for "Coimbra ConVIDA" system:*
    - *Launch of the procedure by SMTUC on 29th June 2011 (Public Tender).*
    - *Proposal opening ceremony on 17th August 2011 and beginning of the proposals analysis.*
    - *Procedure for the tests of the card samples with final adjudication on 19th September 2011. Card tests in the OTLIS laboratory until 4th October 2011 (the tests also included cards physical resistance and the cards to be used in the new system passed the tests).*
    - *Conclusion of the analysis of the proposals for the cards supply tender with the preliminary report of the jury and provisional adjudication on 18th October 2011. The final adjudication took place on 31st October 2011. The delivery time was 40 days after contract signature, but some recover actions*

allowed that the e-cards were delivered in time to allow the complete e-ticketing system start-up on 1st February 2012.

Stage 3: Training of the maintenance personnel and System operational users *(June 2011 – December 2011) – The training sessions occurred mainly in June and July 2011 for the maintenance personnel and in November 2011 for the SMTUC drivers and consisted mainly by:*

- *Training of the maintenance personnel for expertise in the coordination and accomplishment of the system installation and for the tasks of equipment maintenance and small repairs.*
- *Training of the SMTUC operational users of the system, namely for the accounting and vending staff on the management of the system and on the sales, load and personalisation of the e-tickets and e-cards, as well as of the bus drivers on the on-board console and on the automatic accounting machine.*

Stage 4: Information to the passengers *(July 2011 – January 2012) – The activities carried out during this stage consisted in the information to the citizens about the new system and occurred mainly during November and December 2011. Information to the citizens focused on the advantages of the new system and how to travel with it, namely through several news and promotional campaigns provided.*

On the last week of December 2011 an info mail about the measure and the new e-ticketing system to all the Coimbra residents was delivered (to 84.007 mail boxes).

Stage 5: Beginning of the e-ticketing system functioning in test conditions, internal evaluation of the failures and operational management of the system *(September 2011 – February 2013) – The operational stage of the measure began with the launch of the new e-ticketing system in test conditions for the on-board tickets on 22nd September 2011 (Fig. B4.4), in the blue line operated by electric mini-buses equipped with the new console – providing the on-board tickets (thermal paper) together with the old tickets. The blue line is a specific service for the historical centre of Coimbra using electric mini-buses in restricted access areas. The route of these buses is identified by a blue line in the street and the buses stop anywhere by passengers demand. The on-board sale allowed for testing the functioning of the console– in the beginning only in the blue line to facilitate the monitoring and avoid the proliferation of any problem to a major area. With the continuation of the good results, the on board sale with the new console was extended to the entire PT network until the end of 2011. The tests were conclusive and no major problems were detected.*

Figure B4.4 - Launch of the new e-ticketing system in test conditions for the on-board tickets on 22nd September 2011 with a inaugural trip in the new trolleybus and the continuation of the functioning of the system in the blue line. Detail of the console on the right figure

On 1st January 2012 the launch of the system for the e-tickets in all SMTUC fleet and network was carried out. The sale of the on-board tickets was made using the new console as well as the validation of the new "contact less" tickets ("Viagem ConVIDA" system), while current magnetic tickets and "contact less" passes were validated in the old validator during this transition phase. In the last week of 2011 the entire system was already operational, including the part that concerns the e-cards, allowing for a verification of its functioning by IMTT (National Institute of Mobility and Inland Transportation, which co-financing the system purchase). During the technical visit the IMTT validated the system and SMTUC signed the provisional reception of the system.

With the new system a new intermodal ticket was launched on the 1st January 2012. It was designated for the employees / students of large entities that use the park&ride system. The ticket is being provided by the entity with 25% discount allowing the user to park for free during one day in any park of the system and to make 2 displacements of 1 hour each in the urban PT network (transfers allowed). The 25% discount is being assured by SMTUC in the totality. With this framework and integrated within the mobility plans of CIVITAS MODERN measure 04.05, a protocol was already signed with IPOC hospital. A similar e-ticket has been created for all the park&ride users, allowing for the transfers between lines during the displacements of 1 hour.

On 2nd February 2012 the remaining fares (supported in the e-cards "Coimbra ConVIDA) were launched for the whole SMTUC public transport network, despite the existence of a transition period running up to the end of May 2012 in which the 2 systems functioned in parallel for the e-card passes. During this period the users of the new system validated their fares in the driver console while the users of the previous system used the old validator. This transition period allowed the users to transfer to the new system gradually, avoiding queues in the card personalisation service. After the transition period the old validators were exchanged for the new validators. Also the fact that the driver console has validation capabilities allowed for the change of validators to be processed in a gradual way, avoiding the need for a flash installation that certainly would imply an over-load of work and the risk of failures or less quality in the installation.

The new e-ticketing system is an "open" system that will not depend on the actual system integrator for it expansion in the future, and in which all kinds of card technologies can be read (facilitating the integration of other PT operators and more mobility products in the future – car sharing, bike sharing).

In any case the existing combined fare between SMTUC and the other PT operators involving all inhabitants of the Municipality of Coimbra also benefited of the improvements of the new system, namely with the new channels for the purchase and reload of the new SMTUC e-card.

The system was initially developed to allow for the future integration of multiple PT operators (public and/or private), namely in view of the creation of an inter-municipal pass. However, the financial crisis has led many of the municipalities involved to reconsider their investment priorities. Accordingly, urban mobility issues have many times taken a back seat to other considerations, namely those associated with social themes and economic recovery.

On the other hand, the automatic accounting system for the PT drivers is experiencing good results and allowed for savings in the human resources. The personnel dedicated in the past to these operations is now used for other activities.

In the meantime OTLIS developed the system that allows the payment and reloading of the e-cards through ATM machines,(already in functioning in Lisbon, but waiting for a decision in

the case of Coimbra due to some legal impositions caused by the new legislation provided by the national government to combat the financial crisis in Portugal).

Also the development by OTLIS of an application that will allow the on-line payment of the passes and it reloading at home or on board buses is on-going.

Another advantage of the new e-ticketing system has been its integration with the SMTUC automatic vehicle management (AVM) system – A GPS/GPRS technology based system. So the new on-board console can also command the AVM system to avoid repeating operations by the drivers related to the common data to the 2 systems. The communication channel to transfer data between the buses and the central is also common to the 2 systems and the AVM system provide in each moment the localisation of the buses, allowing the automatic information about the geo-referenced entry of the passengers. In the future the new e-panels already installed at the buses stops to provide real time information about the time remaining for the buses passage will have also the capability to read the e-tickets (informing the remaining trips loaded) and read and reload the e-cards.

Taking into consideration the delays in the measure implementation an extension has been requested allowing for more time to evaluate the measures impacts, namely in the modal shift to the SMTUC public transport and related indicators, that were assessed through a survey carried out to the SMTUC passengers at the end of October 2012.

B5 Inter-relationships with other measures

The measures **02.05, 04.02, 04.05 and 08.03** were identified as a group of measures because each one of them has potential to generate impacts on modal split. These measures also have potential to generate impacts on emissions. However, those impacts derive from modal split changes. Measure 04.05 will be applied only to a health cluster that involves 3 hospitals and modal split impacts will be measured with specific surveys on these hospitals, making possible to determine separated impacts on modal split due to measure 04.05. For this reason, only measures 02.05, 04.02 and 08.03 are included in the modal shift bundle of measures.

In particular, the measure is related to other measures as follows:

- **Measure no. 04.02 – Infomobility Centre and Mobility Marketing in Coimbra** – The Infomobility Centre in Coimbra will have also impacts in the modal shift and at functional aspect the Centre will be also a point of tickets and cards sale / load;

- **Measure no. 04.05 – Mobility Management Actions in Coimbra** – The Mobility Management in Coimbra will have also impacts in the modal shift, but in a controlled area, and at functional aspect it is foreseen to use the system to provide new ticketing products for the entities involved in the mobility plans;

- **Measure no. 08.03 – Infomobility Tools for Traffic Data Management in Coimbra** – The infomobility tools for traffic data management in Coimbra will have also impacts in the modal shift and at functional aspect the e-panels of the GPS/GPSR – Operation Support System will have capabilities linked to the e-ticketing system, namely the read of cards and tickets.

But the fact that these measures have begun their implementation in completely different periods contributed to the possibility evaluating the impacts separately.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1.1: Indicators. *Impacts and Indicators for the measure*

No.	Impact	Indicator	Data used	Comments
1	Operating Revenues	Average Operating Revenues	Total operating revenues; Total vehicle-km	Operating revenues and vehicles-km are provided by SMTUC and by the modal shift survey.
2	Operating Costs	Average Operating Costs	Operating costs spent with the measure operation; Total vehicle-km	Operating costs and vehicles-km are provided by SMTUC and by the modal shift survey
3	Costs	Capital Costs	Total capital costs expended in setting up the measure	Capital costs are provided by SMTUC
4	Fuel consumption	Vehicle fuel efficiency	Total energy consumed by the passengers that transferred from private car to PT; Total passenger-km	Fuel consumption results of the displacements assessed by survey. Bibliographic sources "Study on internal and external costs from transport in Portugal, issued by University of Aveiro, March 2011"; the average consumption of each type of vehicles and passenger-km is computed by the data obtained by the survey
5	Emissions	CO Emissions	Fuel type; average consumption, Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
6	Emissions	CO2 Emissions	Fuel type; average consumption; Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
7	Emissions	NOx Emissions	Fuel type; average consumption; Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
8	Emissions	Small Particulate Emissions	Fuel type; average consumption; Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
9	Quality of Service	Quality of PT Service	Index of the "perception" of service quality"	Data provided by the SMTUC passengers satisfaction survey
10	Modal Shift	Average modal shift passengers	Total passenger km for the transport mode considered; Total passenger km	Data provided by the SMTUC services and the satisfaction survey
11	Modal Split	Park & Ride Usage	Total number of Park & Ride usage	Data provided by the SMTUC services
12	Acceptance	Acceptance level – users	Total number of users who favourably receive the measure; Total number of respondents	Acceptance level is provided by the SMTUC satisfaction survey

The selection of the indicators took into consideration that it is expected that this measure should contribute for the improvement of the quality of Public Transport service, materialised by a better accessibility (user friendly) to the PT service, as well as for the launch of new mobility products and services. These facts should have effects on **the modal shift from private car to Public Transport**.

For these reason the indicator Average Modal Shift has been selected together with the related indicators – the Vehicle Fuel Efficiency and Emissions, due the savings in fuel consumption per passenger, and the Average Operating Revenues, due the increase in the tickets sales, all resulting of the transfer from private car to Public Transport. The impacts in the modal shift and related indicators also supported to evaluate the achievement of the objectives of the measure, namely concerning the strategic level: To increase the importance of the social role of PT in the region, to increase the use of PT in the city and to decrease city traffic levels.

The new ticketing system also allows better reliability of the equipment, more automatisms in several operations and improvements at organizational level. These facts have impacts in the maintenance costs (personnel and material) and in the costs with personnel appointed for the tickets sale and accounting operations. For these reasons the impact in the economy has been assessed and consequently the indicators Average Operating Costs and Capital Costs have been selected together with the already mentioned Average Operating Revenues.

The creation of new products for the Park&Ride system, resulting of one of the measure objectives, implied the selection of the indicator Park&Ride Usage that evaluated the number of tickets sold in the parks of this system.

Finally the indicators Quality of the PT Service and Acceptance level have been selected to evaluate the impact of the measure implementation in the passengers opinion.

Concerning the methodology, also the assessment to the modal shift to public transport has been the main concern (Coimbra hadn't values updated of modal split and the assessment to this indicator was impracticable due the great costs involved).

Since it was not possible to measure the impacts of the measure directly, a different methodological assessment was carried out. The methodology to assess the indicators was based on the modal shift from private cars to public transport (PT) associated to the CIVITAS measure – implementation of a new ticketing system. **The source of information was based on the findings of the SMTUC Modal Shift focused survey (new ticketing system) that was performed in September 2012** (9 months after the beginning of the measure operation in January 2012) in a universe of 750 passengers (68% Female and 31% male – details of the survey in the annex 6). **The same survey has been used to assess the baseline scenario (situation before measure implementation) and the Businees-as-usual scenario (situation expected if the measure willl be not implemented), using for the effect specific questions**.

The sample has been selected on the basis of the lines used by passengers, i.e., the number of interviewees chosen in each line has been defined according to the demand of the line relative to the overall SMTUC demand. Then it was distributed by gender and age in similar proportions of the SMTUC global passengers. <u>The survey used the same methodology and sample that has been used yearly in the custom satisfaction survey carried out in the scope of the Quality Management System of SMTUC (certificated by several audits).</u>

Taking into account the previous year (before measure implementation), the survey asked the passengers about the reason for changing their travel mode. As a result, 9,1% (67 responses) of the respondents replied that they changed to PT. Focusing the analysis on respondents who changed their pattern of mobility to PT, it was noted that 77,6% of respondents shifted from private car. By these statements it has been possible to realize that 7,1% (9,1%×77,6%) had changed for PT and the source was the private car.

In the same survey the passengers were asked about the reasons for changing the mode of travel. For this question 1,2% of the respondents stressed that the change was due to CIVITAS measure and all these answers concerned people moving from private car to PT.

The analysis started by introducing in the total 2011 SMTUC passengers (number of trips) the results deriving from the survey questions illustrated above. The next figure shows a diagram with the methodology and evidences for constructing the analysis scenario.

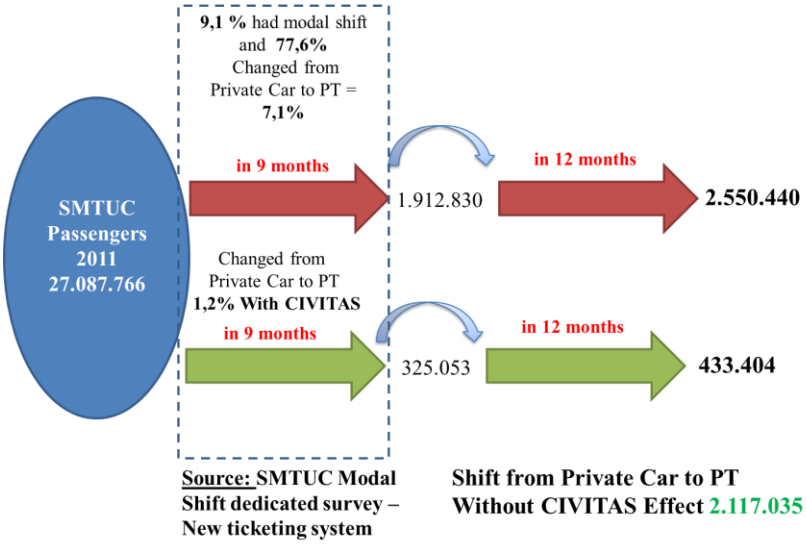


Figure C1.1.1 – Inputs for measure assessment (n.º passengers)

According to the above figure it is possible to observe that, in a 12 month period, a total of 2.550.440 passengers had changed to PT and they originated in private car and included 433.404 passengers that had changed due to the CIVITAS measure. The difference between them is the passengers that shift from private car to PT without the CIVITAS measure influence (Business-as-usual scenario).

The next figure shows the flux of passengers that are in each scenario.

SCENARIO	EX-ANTE	BAU	EX-POST
		(A)-(B) 2.117.035	2.550.440
	2.550.440	(B) 433.404	
TOTAL	2.550.440	(A) 2.550.440	2.550.440

Figure C1.1.2 – Assessment methodology - Private Car / Public Transport

As demonstrated in the survey, the passengers transferred to PT due to the CIVITAS measure (433.404) were at a first stage using private car and due the financial crisis it is considered that the passengers that uses at the moment PT do not transfer to private car. By this reason in the BAU scenario for 2012 (without influence of the measure) these 433.404 passengers are using private car. The number of PT users (BAU) are computed by the difference between the ex-post (the 2.550.440 passengers that changed to PT with origin of private car) and the referred 433,404 passengers that shift due CIVITAS measure, i.e., 2.117.035 passengers in SMTUC PT for the 2012 BAU scenario.

By analysing the modal shift of passengers between the scenarios it is possible to evaluate the influence in terms of operational revenues (indicator 1), fuel consumption (indicator 4) and emissions (indicator 5-8). In any case for indicator 1 (Average operating revenues) have been used the overall SMTUC average operating revenues, while for indicators 4 to 8 have been used only the consumptions and emissions related to the passengers that transferred from private car to SMTUC public transport service

For indicators 2 and 3 the analysis was based on the operational and management data of SMTUC.

For indicators 9 the analysis was carried out with the information assessed by the SMTUC customer satisfaction survey. This survey is carried out yearly (details of the survey in the Annex 7).

In relation to indicator 11, the Park&Ride Usage was assessed by the SMTUC operation records.

Indicator 12, Acceptance level, was assessed in the same above mentioned survey that has been carried out to evaluate the modal shift (details of the survey in the Annex 6).

Another assumption was considering a unidirectional way of modal change. In Portugal, due to the economic crisis it is not assumed that there will be modal changes between the public transport to the private car, the modal changes that could occurred will be to more sustainable transport mode than to the private car.

It is important to stress that for indicator 4, the results from energy consumption from private car and from PT bus vehicles are based on data about the total vehicle-kilometres performed on those vehicles. The average vehicle consumption (l/100km) is based on both bibliographic data and from real SMTUC fleet for private car and bus, respectively. For private car the source of data is the "study on internal and external costs from transport in Portugal, issued by University of Aveiro, March 2011" (9,2 l/100km). For public transport the source is the real data of the average fleet consumption (50,1 l/100km). A load factor for both private car and public transport was considered. The load factor for private car is 1,3 passenger per vehicle (Source: IMTT – Portuguese Institute for Mobility and Inland Transportation) and for public transport is given by the SMTUC operational data from company management report (16,4 passengers per bus).

For private cars, the average energy consumption in litres of Diesel per 100 km, is converted into energy (MJ) by a factor of 34,80 MJ/litre that is calculated by mixing 2 fuel types (Diesel -35,86 MJ/litre and Gasoline – 32,18 MJ/litre) with the Portuguese 2011 fleet fuel mix 77,7% for Diesel and 21,8% gasoline. For public transport the average energy consumption (litres) is converted by a factor of 35,86 MJ/litre.

All the other data shown in the next table were directly obtained from the modal shift survey (B, C) and from the SMTUC management report (A, F, G, K, M). The load factor for private car (J) is given by the IMTT – Portuguese Institute for Mobility and Inland Transportation and for public transport (k) is given by the SMTUC operational data taken from the company management report. The other items in bold are computed as shown in Table C1.1.2.

Table C1.1.2 – Survey Analysis

Note	Survey Analysis	
A	N.º Passengers SMTUC 2011	27.087.766
B	% that changed for PT	9,1%
C	% of Private Car that changed to PT (9,1%x77,6%)	7,1%
D	N.º Passengers of Private Car to PT (9 months)	1.912.830
E=D/9x12	Δ N.º Passengers of Private Car that changed to PT (12 months)	2.550.440
F	Passenger.kilometre - pkm PT 2011	96.639.509
G	Vehicle.kilometre - vkm PT 2011	5.886.329
H=F/A	**Average distance per passenger (km/passenger)**	**3,57**
I=E×H	**Δ N.º Passengers.km of Private Car that changed to PT (12 months)**	**9.099.061**
J	Load factor – Private Car	1,3
k	Load factor – PT	16,4
L=I/J	**N.º vehicles.km in Private Car made by the passengers that changed to PT (12 months)**	**6.999.278**
M	Annual Revenue 2011 (€)	7.704.515

With the assumptions expressed above and using Table C.1.2.1 it is possible to compute the indicators 1, 4, 5, 6, 7 and 8.

Detailed description of the indicator methodologies:

- **Indicator 1** (*Average Operating Revenues*) – Ratio of total income generated from fares and tickets of the SMTUC PT users divided by the vehicle-km per year (€/vehicle-km)

  A = B / C

  where: A = Average operating revenues (€/vehicle -km)

  B = Total operating revenues, including revenues coming from tickets/fare sales supported by the ticketing system (€)

  C = Total vehicles –km

  All data are related to the overall SMTUC services

- **Indicator 2** (*Average Operating Costs*) – Ratio of total operating costs incurred in the operation of the ticketing system divided by the total vehicle-km per year (€/vehicle-km).

  A = B / C

where: A = Average operating costs for the service (€/vehicle-km)

B = Total operational costs incurred in the operation of the ticketing system, including expenditures with personnel, material –stock, material - purchase for the operation and maintenance of the ticketing system (€)

C = Total vehicle-km

Operating costs are related to the operation with the ticketing system. Vehicle-km are related to the overall SMTUC services.

- **Indicator 3** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

  Expenditures with the purchase and installation of the ticketing system (€)

- **Indicator 4** (*Vehicle fuel efficiency*) – Ratio between the total energy consumption, divided by the total passenger-km performed per year (MJ/passenger-km).

  A = B / C

  where: *A* = Average vehicle fuel efficiency (MJ/passenger-km)

  B = Total energy consumption (MJ)

  C = Total passenger-km performed by SMTUC PT passengers

  All data is related to the private car and public transport passengers used in trips carried out among the new ticketing system action.

- **Indicator 5** (*CO Emissions*) – Average CO emissions per passenger -km (g/ passenger -km)

  A = B / C

  where: A = Average CO emissions per passenger -km (g/ passenger -km)

  B = Total CO emissions of the private car and public transport (g)

  C = Total passenger-km performed by SMTUC PT passengers

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by European Energy Agency, "the Emission Inventory Guidebook", dated on 23rd August 2007.

- **Indicator 6** (*CO2 Emissions*) – Average CO2 emissions per passenger -km (g/ passenger -km)

  A = B / C

  where: A = Average CO2 emissions per passenger -km (g/ passenger -km)

  B = Total CO2 emissions of the private car and public transport (g)

C = Total passenger-km performed by SMTUC PT passengers

The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by European Energy Agency, "the Emission Inventory Guidebook", dated on 23rd August 2007.

- **Indicator 7** (*NOx Emissions*) – Average NOx emissions per passenger-km (g/ passenger-km)

  A = B / C

  where: A = Average NOx emissions per passenger-km (g/passenger-km)

  B = Total NOx emissions of the private car and public transport (g)

  C = Total passenger-km performed by SMTUC PT passengers

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by European Energy Agency, "the Emission Inventory Guidebook", dated on 23rd August 2007

- **Indicator 8** (*Small Particulate Emissions*) – Average Small Particulate emissions per passenger-km (g/ passenger-km)

  A = B / C

  where: A = Average Small Particulate emissions per passenger-km (g/passenger-km)

  B = Total Small Particulate emissions of the private car and public transport (g)

  C = Total passenger-km performed by SMTUC PT passengers

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by European Energy Agency, "the Emission Inventory Guidebook", dated on 23rd August 2007.

- **Indicator 9** (*Quality of PT Service*) – User's perspective of the quality of the service provided by the ticketing system.

  Quality of service is already measured by means of customer satisfaction survey periodically carried out by SMTUC: this survey is composed of 38 specific questions related to various items and a specific global customer satisfaction question that resume quality of service. In each question the people interviewed express a judgement choosing between very satisfied – satisfied – unsatisfied – very unsatisfied and about the importance of each of the 38 items choosing between very important – important – low importance. The survey is repeated 1 time a year (March) and is carried out to 750 SMTUC customers with face to face interviews on buses. The sample has been drowned on the basis of the lines used by the passengers.

This indicator responds to 2 specific questions that summarise quality of service related to the ticketing system.

- **Indicator 10** (*Average modal shift passengers*)

  A specific survey to new PT users is carried out to assess changes in their travel behaviour, such as the modes formerly used by the new PT users and the passengers.km made by the new PT users, before and after the measure implementation.

- **Indicator 11** (*Park & Ride Usage*) – number of tickets sold in the Park&Ride

  Number of transport titles sold in the parks, per year before and after the implementation of the measure.

  All data is related to the overall SMTUC services and results from the total number of Park & Ride usage by year based on ticket validation data taken from SMTUC database about ticket validations on the ticketing system.

- **Indicator 12** (*Acceptance level – users*) –

Percentage of the users who favourably receive the measure (%).

A = B / C

where: A = Percentage of users who favourably receive the measure (%)

B = Total number of respondents who favourably receive the measure

C = Total number of respondents

The Acceptance level of the measure will be measured during customer satisfaction surveys introducing specific questions relative to the respondent's attitude towards the measure.

C1.2 Establishing a Baseline

The year 2011 is considered as the baseline, before the beginning of the measure in January 2012, excepted for the capital costs. In this case the baseline has been the year 2010, before the beginning of the system installation in February 2011.

All the data used for the analysis is related to the SMUTC services and to the information collected in the survey.

Indicators 1, 2 and 3 (Operating Revenues, Operating Costs and Capital Costs)

The source of the information has been the SMTUC recorded data through the normal accounting procedures.

Indicator 1 (*Average Operating Revenues*)

Table C1.2.1 – Indicator 1 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Operating Revenues (2011)	7.709.515 €
Total vehicle-km	5.886.329 vkm
Average operating revenue	1,31 €/vkm

Indicator 2 (*Average Operating Costs*)

The year 2011 is considered as the baseline. The values of the operating costs are atypically lower because for the previous SMTUC ticketing system the related costs of personnel and material were not imputed to the SMTUC accounting system. The reason was that the system was in the final phase (no parts to replace). This situation still lower maintenance was more pronounced because the supplier of the new system has borrowed at this stage validators of the old system (which had also supplied). For more details please consult Annex 3.

Table C1.2.2 – Indicator 2 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total Operating Costs - 2011	154.726 €
Total vehicle -km	5.886.329 vkm
Average operating costs	0,0263 €/vkm

Indicator 3 (*Capital Costs*)

Table C1.2.3 – Indicator 3 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total capital cost (2010)	0 €

Indicator 4 (*Vehicle fuel efficiency*)

The energy consumption was related to the shift of 7,1% of passengers that occurred in 9 months extrapolated to 12 months (2.550.440 passengers) from the private car to the SMTUC public transport service.

All the steps to achieve the vehicle fuel efficiency are illustrated in the Table C1.2.4.

Table C1.2.4 – Indicator 4 – Ex-ante

Note		**Ex-ante**
E	Δ N.º Passengers of Private Car that changed to PT (12 months)	2.550.440
I	Δ N.º Passengers.km of Private Car that changed to PT (12 months)	9.099.061 p-km
L	Δ N.º vehicle.km of Private Car that changed to PT (12 months)	6.999.278 v-km
O	Average Consumption Private car (l/100km)	9,2
P=L×O/100	**Consumption Private Car**	643.933,5
Q	Total consumption private car (MJ)	22.462.791
R=Q/I	**Vehicle Fuel efficiency (MJ/pkm)**	**2,47**

Analysing the above Table C1.2.4 it can be established that in the initial stage the vehicle fuel efficiency is 2,47 MJ/pkm that use private car (2.550.440 passengers) – 100% that are willing to have a modal split change from private car to PT.

Indicators 5, 6, 7 and 8 (CO, CO2, NOx, PT)

The source of the information has been the fuel emission factors for each pollutant given by bibliographic sources, as is displayed in Annex 4. The study considered the following emission factors (g/kg.fuel) and converted to g/MJ (by Annex 2) for the ex-ante scenario (private car) (Table C1.2.5). The conversion of kg fuel to MJ as assumed a conversion factor based on the density and the gross calorific value of the fuel.

Table C1.2.5 – Indicators 5, 6, 7 & 8 – Emissions Factors

POLLUTANT	**CO**	**NOx**	**CO2**	**PT**
Diesel Passenger Car (g/kg.fuel)	3,2	11,28	3 140	0,72
Gasoline Passenger Car (g/kg.fuel)	61,56	9,18	3 180	0,03
Diesel Passenger Car (g/MJ)	0,075	0,263	73,115	0,017
Gasoline Passenger Car (g/MJ)	1,430	0,213	73,867	0,001

With the emissions factors (g/MJ) computed in the above Table C1.2.5 and weighting with the fuel mix 2011 (Annex 1) and multiplying by the average private car fuel consumption (9,15 l/100km) the overall fleet weighted emissions factors for each pollutant is obtained. Table C.1.2.6 shows the emissions for each pollutant (CO, NOx, CO2, PT).

Table C1.2.6 – Indicators 5, 6, 7 & 8 – Emissions

Pollutant	**CO**	**NOx**	**CO2**	**PT**
Emissions Private Car (g) - *weighted*	8.317.980	5.629.097	1.638.167.784	295.924

The indicators are displayed by the ratio between the emissions (g) and the passengers km travelled per year (pkm) (9.099.061pkm). The results of baseline for each indicator are indicated in the Table C1.2.7.

Table C1.2.7 – Indicators 5, 6, 7 & 8 – Ex-Ante

Indicators and respective parameters	Ex-Ante values
CO emissions	0,91 g/pkm
CO2 emissions	180,04 g/pkm
NOx emissions	0,62 g/pkm
PT emissions	0,03 g/pkm

Indicator 9 (*Quality of PT Service*)

The quality of service was assessed by the SMTUC customer survey (more details in the Annex 7). Before the measure was introduced an initial survey to 739 customers was developed in 2011. Two specific questions were asked. The first question was related with how easy it is to purchase the tickets and the second on how easy it is to validate the tickets. These questions were scored from 1 – dissatisfied - to 4 - very satisfied and the overall responses were weighted as shown in Table C 1.2.8.

Table C1.2.8 – Indicator 9 – Ex-Ante

Indicators and respective parameters	Ex-Ante values
Facility to purchase the tickets	3,18
Facility to validate the tickets	3,28

Indicator 10 (*Average modal shift - passengers)*

The modal shift was assessed through the modal shift survey (more details in the Annex 6). Before the measure implementation all the passengers (9.099.061 pkm) that are suitable to change to public transport used private car. Table C.1.2.9 shows the ex-ante situation for modal shift.

Table C1.2.9 – Indicator n.10 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Private Car	9.099.061 pkm
Public Transport SMTUC Bus	-

Indicator 11(*Park & Ride Usage*)

The use of the Park &Ride system was evaluated by the sales of two trip tickets that were sold only on-site. After 2012 it was noted that the other entities that contributed for the Park &Ride (e.g. University) stopped buying the tickets. The main reason for this fact is the economic crisis and budgetary cuts. To be comparable was harmonized this usage in the period 2007 - 2012 only the tickets sold at the parks.

On the other hand in 2012 only two peripheral car parks were active. Before (2007-2011) three parks were active. Also, in order to be comparable within the entire period the usage 2007-2012 was harmonized just for the usage of two parks. The ex-ante values are related to the two parks.

Table C1.2.10 – Indicator n.11 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Number of tickets (2 trips) sold - year 2011	12.117

Indicator 12 (*Acceptance level – users*)

The specific question for the acceptance level of the previous ticketing system was carried out in the SMTUC Modal Shift dedicated survey – New ticketing system - that was performed in September 2012. (more details of the survey in the Annex 6).This survey shows a high degree of satisfaction of as is shown in Table C1.2.11.

Table C1.2.11 – Indicator n.12 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Acceptance- users	
Very satisfied	47,1%
Satisfied	49,1%
Dissatisfied	3,8%

C1.3 Building the Business-as-Usual scenario

The year 2012 has been considered as the starting point for the BAU. All the data used for the analysis are related to SMUTC services and to the information collected from the survey.

The BAU scenario was built by considering the shift of the number of passengers that transferred from private car to PT. As it was considered in C.1.1, the number of passengers that transferred from private car to PT without the effect of the measure is obtained by the difference between the total passengers that was capable of changing (2.550.440) and the passengers that will change to PT due to the measure (433.404). The total passengers that will change without the effect of the measure will be 2.117.035 passengers in PT.

Indicators 1, 2 and 3 (Operating Revenues, Operating Costs and Capital Costs)

The source of the information has been the modal shift survey – New ticketing system - carried out in September 2012 where it was possible to develop a methodology that allows analysing the evolution of the above indicators.

Table C1.3.1 – Indicator 1 – BAU

Indicators and respective parameters	**BAU**
Revenues from SMTUC PT users transferred from private transport	7.496.988 €
Total vehicle-km	5.886.329 vkm
Average operating revenue	1,27 €/vkm

The value of the revenues of new SMTUC PT users are computed by the product of the number of passengers (2.117.035) by the average SMTUC revenue (0,28 €/passenger) – see Table C.1.1.2. The average operating revenue for BAU scenario is 1,27 €/vkm.

Table C1.3.2 – Indicator 2 – BAU

Indicators and respective parameters	BAU
Total Operating Costs – 2012	170.848 €
Total vehicle –km	5.886.329 vkm
Average operating costs	0,0290 €/vkm

The value of the total operating costs is based on the 2011 value with a 2% decrease. This reduction is related to SMTUC expectations for continuing operating the existent ticketing system. For further details please consult Annex 3.

Indicator 3 (*Capital Costs*)

The change in the capital costs related to the operation of the new ticketing system is obtained after setting up the measure. Therefore, without the implementation of the measure, the capital costs would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case, the Business-as-usual is equal to the baseline situation.

Therefore, the Table C1.3.3 shows the results of BAU scenario for this case.

Table C1.3.3 – Indicator 3 – BAU

Indicators and respective parameters	BAU
Total capital cost	0 €

Indicator 4 (*Vehicle fuel efficiency*)

The energy consumption was related to the shift of the 7,1% of passengers that occurred in 9 months extrapolated to 12 months (2.550.440 passengers) from the private car to the SMTUC PT service. From these passengers it is possible to know that 433.404 uses private car and in 2.117.035 uses PT without the effect of the measure – further information consult item C.1.1.

All the steps to achieve the vehicle fuel efficiency are illustrated in the Table C1.3.4.

Table C1.3.4 – Indicator 4 – BAU

		BAU
N.º Passengers.km that changed to PT (12 months) ***[A]***		9.099.061 pkm
Private Car	N.º Passengers of Private Car (12 months) – before CIVITAS measure	433.404
	N.º vehicles.km of Private Car that changed to PT (12 months)	1.189.409 vkm
	Average Consumption (l/100km)	9,2
	Consumption (l)	109.425,7
	Total consumption (MJ) $[B_{PC}]$	3.817.173
PT	N.º Passengers of PT (12 months) – before CIVITAS measure	2.117.035
	N.º vehicles.km of Private Car that changed to PT (12 months)	460.538 vkm
	Average Consumption (l/100km)	50,5
	Consumption (l)	232.572
	Total consumption (MJ) $[B_{PT}]$	8.340.027
Vehicle Fuel efficiency (MJ/pkm) $[B_{PC}+B_{PT}]/[A]$		**1,34**

Analysing the above Table C1.3.4 it can be established that in the initial stage the vehicle fuel efficiency is 1,34 MJ/pkm for all passengers that use private car (2.550.440 passengers).

Indicators 5, 6, 7 and 8 (CO, CO2, NOx, PT)

The source of the information has been the fuel emission factors for each pollutant given by bibliographic sources, as is displayed in Annex 4. The study considered the following emission factors (g/kg.fuel) and converted to g/MJ (by Annex 2) for the ex-ante scenario (private car) (Table C1.3.5). The input for computing the emissions is the energy consumption of private car (3.817.173 MJ) and PT (8.340.027 MJ) as displayed in Table C1.3.4.

Table C1.3.5 – Indicators 5, 6, 7 & 8 – Emissions Factors

POLLUTANT	CO	NOx	CO2	PT
Diesel Buses (g/kg.fuel)	11,88	40,75	3 140	1,85
Diesel Passenger Car (g/kg.fuel)	3,2	11,28	3 140	0,72
Gasoline Passenger Car (g/kg.fuel)	61,56	9,18	3 180	0,03
Diesel Buses (g/kg.fuel)	0,277	0,949	73,115	0,043
Diesel Passenger Car (g/MJ)	0,075	0,263	73,115	0,017
Gasoline Passenger Car (g/MJ)	1,430	0,213	73,867	0,001

With the emissions factors (g/MJ) computed in the above Table C1.3.5 it is possible to obtain the emissions per pollutant. This is possible by the product of the pollutant emission factor (g/MJ) with the energy consumption of private car and PT.

Table C1.3.6 – Indicators 5, 6, 7 & 8 – Emissions

Pollutant	CO	NOx	CO2	PT
Emissions Private Car (g) - *weighted*	1.413.501	956.570	278.379.028	50.287
Emissions PT (g)	2.307.066	7.913.548	609.780.151	359.265
TOTAL	**3.720.567**	**8.870.118**	**888.159.179**	**409.553**

The indicators are displayed by the ratio between the emissions (g) and the passengers km travelled per year (pkm) (9.099.061 pkm). The results of baseline for each indicator are indicated in the Table C1.3.7:

Table C1.3.7 – Indicators 5, 6, 7 & 8 – BAU

Indicators and respective parameters	BAU
CO emissions	0,41 g/pkm
CO2 emissions	97,61 g/pkm
NOx emissions	0,97 g/pkm
PT emissions	0,05 g/pkm

Indicator 9 (*Quality of PT Service*)

The change in the quality of PT Service related to the new ticketing service is obtained after setting up the measure. In this case the Business-as-usual is equal to the baseline situation.

Table C1.3.8 – Indicator 9 – BAU

Indicators and respective parameters	BAU
Facility to purchase the tickets s	3,18
Facility to validate the tickets	3,28

Indicator 10 (*Average modal shift passengers)*

The modal shift was assessed through the modal shift survey (more details of the survey in the Annex 6). A ratio of passengers km (1.546.231 pkm) change to PT without the effect of the measure. Table C.1.3.9 shows the BAU situation for modal shift.

Table C1.3.9 – Indicator n.10 – BAU

Indicators and respective parameters	BAU
Private Car	1.546.231 pkm
Public Transport SMTUC Bus	7.552.830 pkm

Indicator 11(*Park & Ride Usage*)

In the BAU scenario to evaluate the use of the Park &Ride system a projection to 2012 with the historical values for the period between 2007 and 2011 and concerning the trips tickets sold in the 3 parks were taken. Resulting from the trend, the computed value for 2012 was harmonized to 2 parks (since in 2012 only 2 parks were in functioning).

Table C1.3.10 – Evolution of the tickets sale in the Park&Ride System

Number of tickets (2 way)	2007	2008	2009	2010	2011	2012
3 Parks	32.175	26.028	22.747	20.733	18.175	13.983
2 Parks	21.450	17.352	15.165	13.822	12.117	9.322

Note: In yellow the projected value (linear). In blue the harmonized value for the already existing 2 parks

Table C1.3.11 – Indicator n.11 – BAU

Indicators and respective parameters	BAU values
Number of tickets (2 trips) - year 2012	9.322

Indicator 12 (*Acceptance level – users*)

The specific question for the acceptance level of the previous ticketing system was carried out together with the 2012 modal shift survey (more details of the survey in the Annex 6). This survey shows a high degree of satisfaction as is shown in table C1.2.12. The BAU scenario is equal to ex-ante.

Table C1.3.12 – Indicator n.11 – BAU

Indicators and respective parameters	BAU
Acceptance- users	
Very satisfied	47,1%
Satisfied	49,1%
Dissatisfied	3,8%

C2 Measure results

After the implementation of the measure a dedicated survey was carried out to assess the changes in modal shift due to the measure. This survey has 750 responses and also helped to assess the satisfaction level of the new ticketing service in comparison with the previous ticketing system. Taking into account this modal change the next sub headings present the measure results for the indicators – economy, energy, environment, transport and society.

C2.1 Economy

With the implementation of the measure, the Operating Revenues are related to the increase of the 1,2% of the users that changed to public transport (bus) due to the new ticketing system.

Therefore, the following tables shows the ex-post results for these cases.

Table C2.1.1 – Indicator n.1 – Ex-post values

Indicators and respective parameters	Ex-Post values
Revenues variance of new SMTUC PT users transferred from private transport (2012)	7.618.341 €
Total vehicle-km	5.886.329 vkm
Average operating revenue	1,29 €/vkm

The value of the revenues of new SMTUC PT users are computed by the product of the total number of passengers (2.550.440) by the average SMTUC revenue (0,28 €/passenger) – see Table C1.2.1. The average operating revenue for BAU scenario is 1,27 €/vkm, that is an increase of 0,02 €/vkm related with the BAU scenario.

Table C2.1.2 – Indicator n.2 – Ex-post values

Indicators and respective parameters	Ex-Post Values
Total Operating Costs (2012)	115.192,53 €
Total Operating Costs (2013)	117.802,71€
Total Operating Costs (2014)	132.792,94 €
Total Operating Costs (2015)	135.448,80€
Total vehicle –km	5.886.329 vkm
Average Operating cost (2012) - System under Warranty	0,0196 €/vkm
Average Operating cost (2013) - System under Warranty	0,0200 €/vkm
Average Operating cost (2014)	0,0226 €/vkm
Average Operating cost (2015)	0,0230 €/vkm

For the ex-ante scenario the values for 2012 and 2013 are lower than the real value because the system is covered by the warranty. For the period 2014 - 2015 it is expected that more realistic costs and the values are provided by new ticketing system supplier.

Table C2.1.3 – Indicator n.3 – Ex-post values

Indicators and respective parameters	Ex-Post values
Total capital cost	1.201.097€

The following Table summarise the comparison of the indicators 1, 2 and 3 after the implementation of the measure with the baseline and the BAU scenario.

Table C2.1.4 – Summary – Balance between economy indicators (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
1. Average Operating Revenues	1,31 €/passenger-km (2011)	1,27 €/passenger-km	1,29 €/passenger-km (Sept 12)	-0,02 €/passenger-km	+0,02 €/passenger-km
2. Average Operating Costs	0,0263 €/passenger-km (2011)	0,0290 €/passenger-km (2012)	0,0196 €/passenger-km (2012) 0,0200 €/passenger-km (2013) 0,0226 €/passenger-km (2014) 0,0230 €/passenger-km (2015)	-0,0067€/passenger-km (2012) -0,0063 €/passenger-km (2013) - 0,0037 €/passenger-km (2014) - 0,0033 €/passenger-km (2015)	- 0,0095 €/passenger-km (2012) - 0,0090 €/passenger-km (2013) - 0,0065 €/passenger-km (2014) - 0,0060 €/passenger-km (2015)
3. Capital Costs	0,00 €	0,00 €	1.201.097 €	1.201.097 €	1.201.097 €

The following graph shows the evolution of average operating revenues (€/vkm) with CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

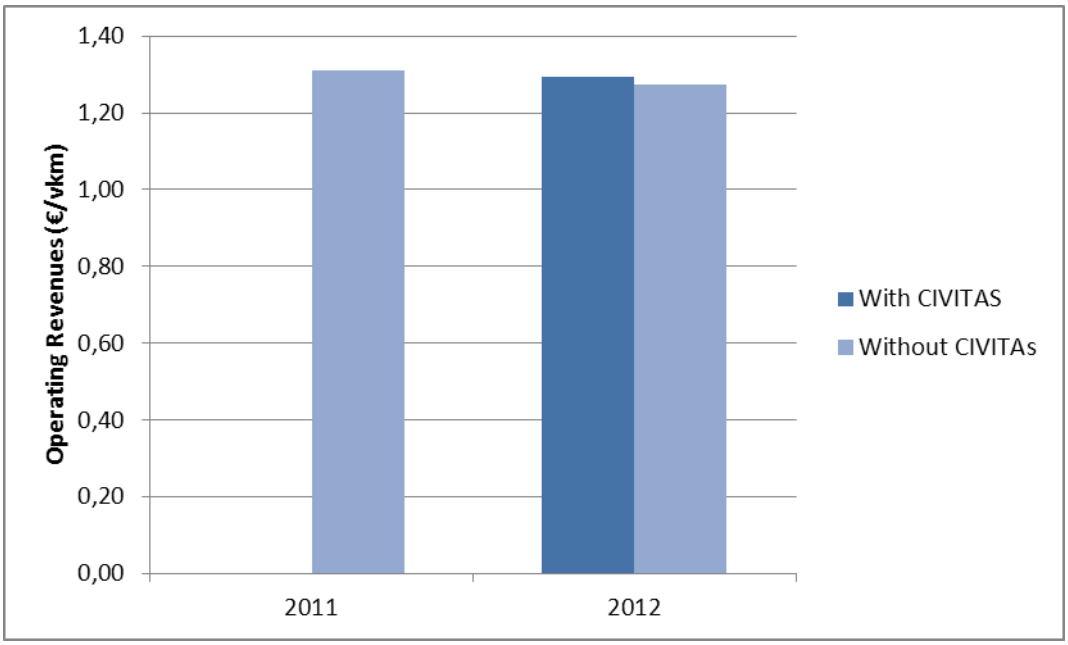


Figure 2.1.1 – Average operating revenues without/with CIVITAS

The following graph shows the evolution of average operating costs (€/vkm) with CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

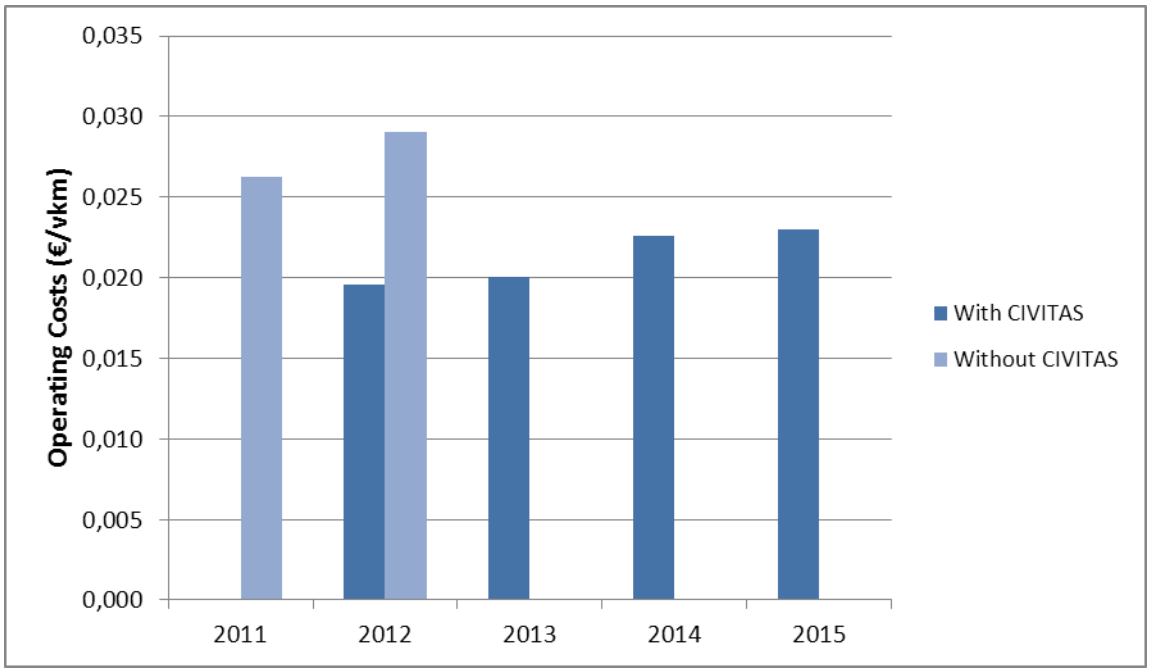


Figure 2.1.2 – Average operating costs without/with CIVITAS

The following graph shows the evolution of capital costs (€) with CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

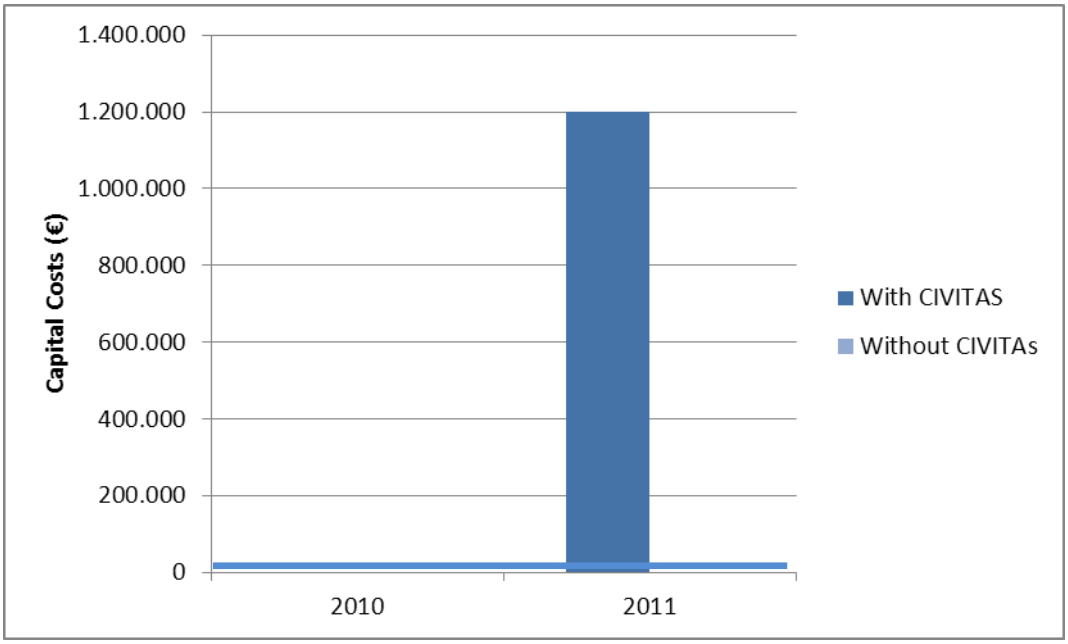


Figure 2.1.3 – Capital costs without/with CIVITAS

C2.2 Energy

The energy consumption was related to the shift of the 7,1% of passengers that occurred in 9 months extrapolated to 12 months (2.550.440 passengers) from the private car to the SMTUC public transport service.

Table C2.2.1 – Indicator 4 – Ex-Post

	Ex-Post
N.º Passengers.km of Private Car that changed to PT (12 months)	9.099.061 pkm
N.º Passengers of PT (12 months) – with CIVITAS measure	2.550.440
Δ N.º vehicles.km of PT (12 months)	554.821 vkm
Average Consumption PT (l/100km)	50,5
Consumption PT (l)	280.185
Total consumption private car (MJ)	10.047.416
Vehicle Fuel efficiency (MJ/pkm)	**1,10**

Analysing the above Table C2.2.1 it can be established that in the initial stage the vehicle fuel efficiency is1,10 MJ/pkm for the passengers that use public transport (2.550.440 passengers).

Table C2.2.2 – Summary – Balance between energy indicator (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After – Before	Difference: After – B-a-U
1. Fuel efficiency	2,47 MJ/passenger-km (2011)	1,34 MJ/passenger-km (2012)	1,10 MJ/passenger-km (2012)	-1,35 MJ/passenger-km	-0,24 MJ/passenger-km

Analysing the indicator it is possible to observe an increase of energy efficiency of 1,35 MJ/pkm from ex-post and ex-ante. With the implementation of the measure the energy efficiency is 0,24 MJ/pkm (i.e. 17% energy efficiency increase).

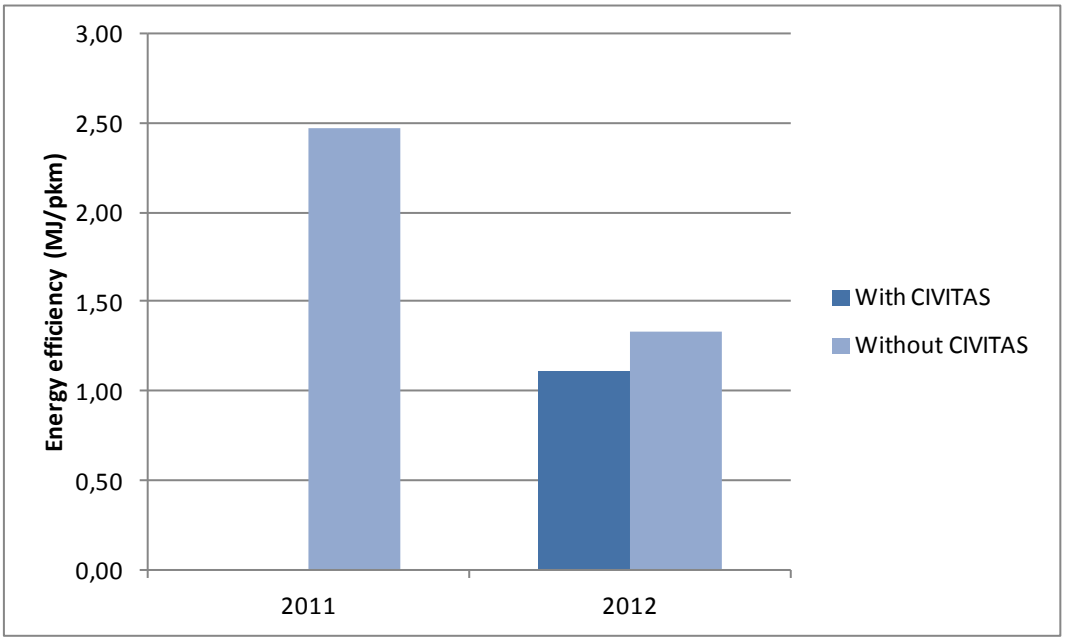


Figure 2.2.1 – Energy Efficiency without/with CIVITAS

C2.3 Environment

For the ex-post scenario it is assumed that all the passengers (2.550.440) use PT and for the ex-ante scenario all the passengers use private car for their travels. The energy consumption of these passengers in PT is converted into energy (C2.2) 10.047.416 MJ. With this amount of energy the emissions will be computed by the related emission factor (Table C1.3.5).

Table C2.3.1 – Indicators 5, 6, 7 & 8 – Emissions

Pollutant	**CO**	**NOx**	**CO2**	**PT**
Emissions Private Car (g) - *weighted*	0	0	0	0
Emissions PT (g)	3.720.562	2.517.848	732.738.563	132.364
TOTAL	**3.720.562**	**2.517.848**	**732.738.563**	**132.364**

The indicators are displayed by the ratio between the emissions (g) and the passengers km travelled per year (pkm) (9.099.061 pkm). The results of baseline for each indicator are indicated in the Table C2.3.2.

Table C2.3.2 – Indicators 5, 6, 7 & 8 – Ex-Post

Indicators and respective parameters	Ex-post
CO emissions	0,41 g/pkm
CO2 emissions	80,53 g/pkm
NOx emissions	0,28 g/pkm
PT emissions	0,01 g/pkm

Table C2.3.3 – Environmental indicators - Summary– Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
6. CO emissions	0,91 g/pkm (2011)	0,41g/pkm (2012)	0,41g/pkm (2012)	-0,50 g/pkm	0,00 g/pkm
7. CO2 emissions	180,40 g/pkm (2011))	97,61 g/pkm (2012)	80,53 g/pkm (2012)	-99,87 g/pkm	-17,08 g/pkm
8. NOx emissions	0,62 g/pkm (2011)	0,97 g/pkm (2012)	0,28 g/pkm (2012)	-0,03 g/pkm	-0,07 g/pkm
9. PT emissions	0,03 g/pkm (2011))	0,05 g/pkm (2012)	0,01 g/pkm (2012)	-0,02 g/pkm	-0,03 g/pkm

The following graph shows the evolution of CO emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

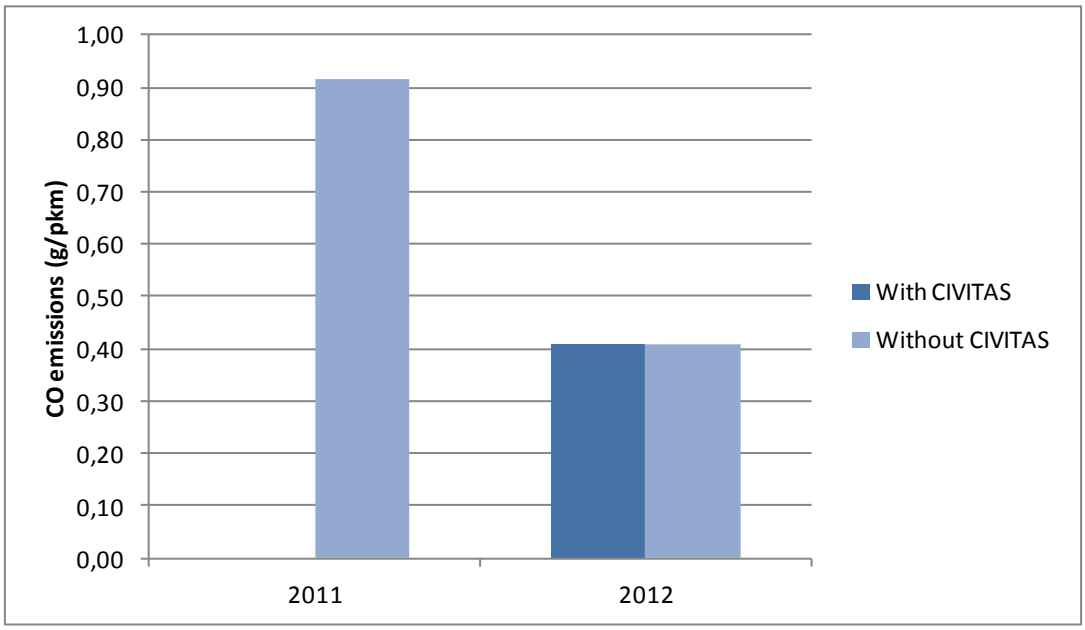


Figure C2.2.3 - CO emissions (with/without CIVITAS)

The following graph shows the evolution of CO2 emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

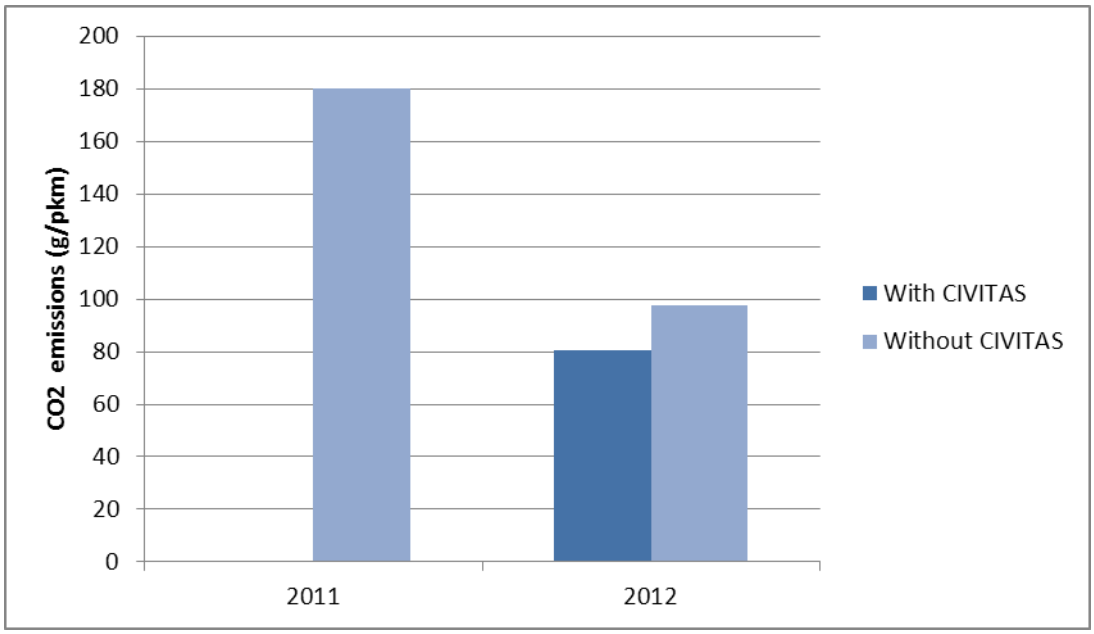


Figure C2.2.4 – CO2 emissions (with/without CIVITAS)

The following graph shows the evolution of NOx emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

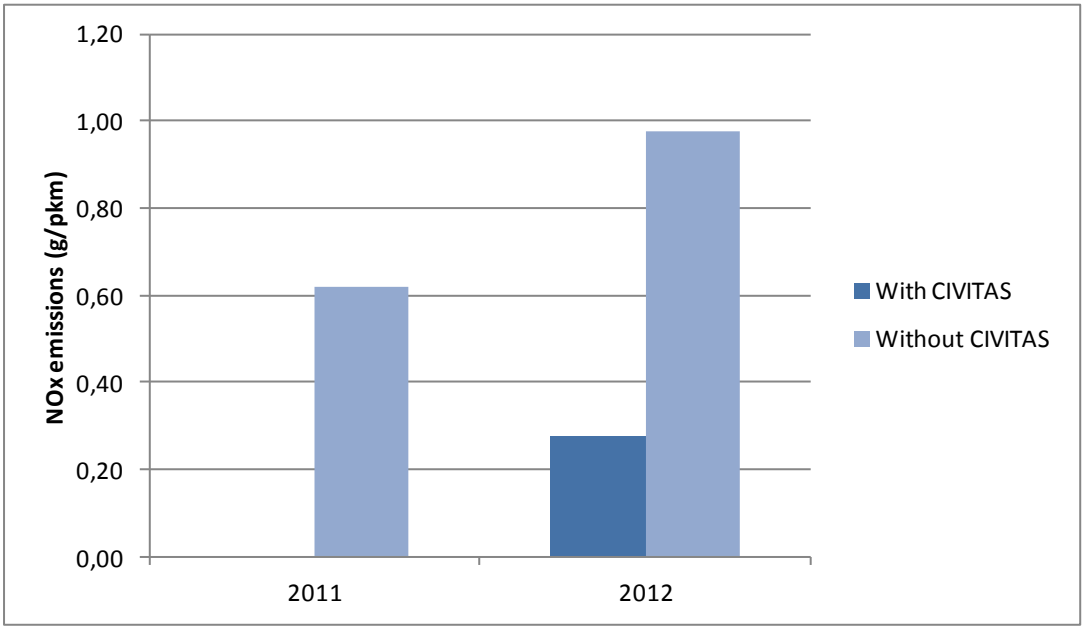


Figure C2.2.5 – NOx emissions (with/without CIVITAS)

The following graph shows the evolution of PT emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

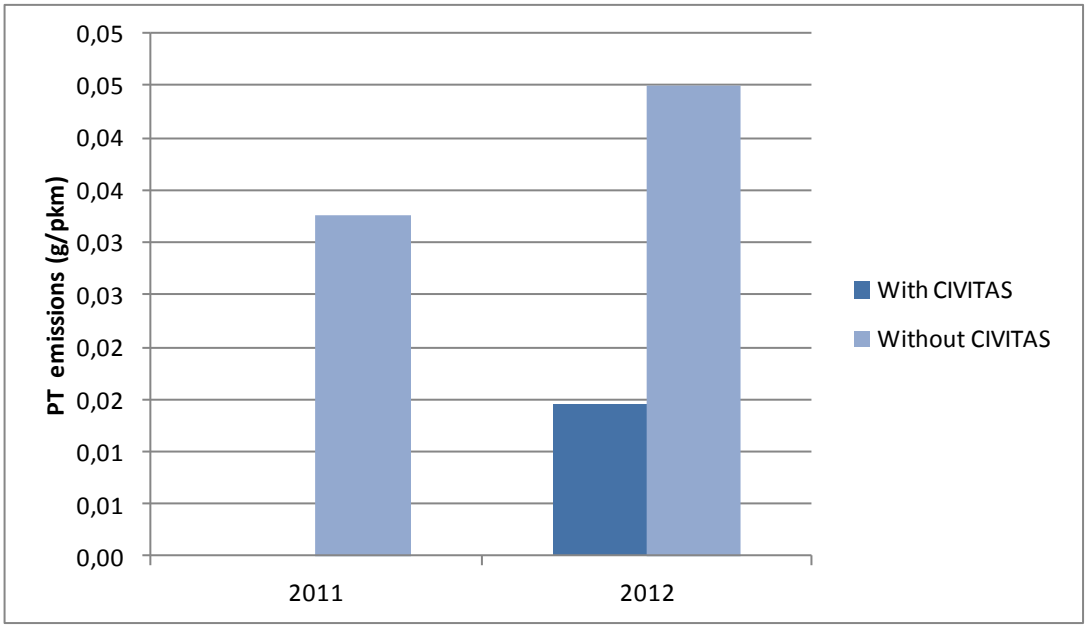


Figure C2.2.6 – PT emissions (with/without CIVITAS)

As expected, with a modal shift to public transport using 100% diesel fuel, instead of using a share of gasoline vehicles, there have been impacts on the emissions. The measure has positive impacts on the mitigation of CO2, NOx and PT and NOx.

In terms of emissions the CIVITAS measure has a positive impact of CO2, NOx and PT with -17,081 g/pkm, -0,698 g/pkm and 0,03 g/pkm, respectively. The CO remains emissions constant.

This assessment was performed considering a modal shift with an increase of the PT demand . But in reality this increase in demand did not affect the PT offer. Thus, a real emissions of pollutants was not verified.

C2.4 Transport

The transport indicators for the ex-post scenario are indicator 9. Quality of PT Service, indicator 10. Modal Split and indicator 11. Park&Ride usage.

The quality of the service was assessed by the SMTUC customer survey (More details of the survey in the Annex 7). Before the measure was introduced an initial survey to 719 customers was developed in 2012. Two specific questions were carried out. The first question was related with how easy it is to purchase the tickets and the second how easy it is to validate the tickets. These questions were scored from 1 - unsatisfied to 4 - very satisfied and the overall responses were weighted as shown in Table C 2.4.1.

Table C2.4.1 – Indicator 9 – Ex-Post

Indicators and respective parameters	Ex-post values
Facility to purchase the tickets s	2,99
Facility to validate the tickets	3,03

The modal shift was assessed by the modal shift survey (more detail of the survey in the Annex 6). After the measure implementation 2.550.440 passengers that used private car change to public transport (9.099.061 p-km). Table C.1.2.9 shows the ex-post situation for modal shift.

Table C2.4.2 – Indicator n.10 – ex-post values

Indicators and respective parameters	Ex-post values
Private Car	-
Public Transport SMTUC Bus	9.099.061 pkm

The Park & Ride usage is related with the tickets sold in the 2 active parks until September 2012 and inferred for the year.

Table C2.4.3 – Indicator 11 – Ex-Post

Indicators and respective parameters	Ex-post values
Number of tickets (2 trips) - year 2012	13.279

A graphical trend of the number of tickets sold harmonized for the 2 parks is shown in the next figure.

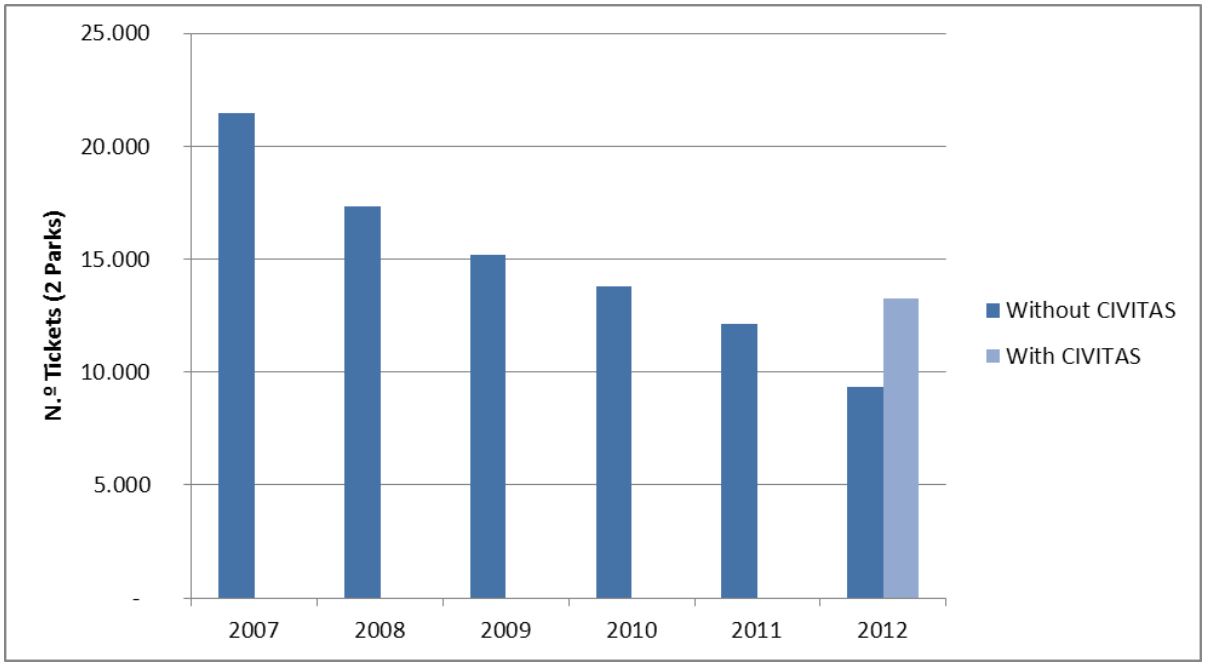


Figure C2.4.1 – Park&Ride Usage without/with CIVITAS

Table C2.4.4 – Transport indicators - Summary– Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
9. Quality of PT service					
Facility to purchase tickets	3,18 (2011)	3,18 (2012)	2,99 (2012)	-0,19	-0,19
Facility to validate tickets	3,28 (2011)	3,28 (2012)	3,03 (2012)	-0,25	-0,25
10. Modal shift					
Private Car	9.099.061 pkm (2011)	1.546.231 pkm (2012)	- (2012)	-9.099.061 pkm	-1.546.231 pkm
Public Transport	(2011)	7.552.830 pkm (2012)	9.099.061 pkm (2012)	9.099.061 pkm	1.546.231 pkm
11. Park&Ride users N.º Tickets (2 trips) – 2 parks	12.117 (2011)	9.322 (2012)	13.279 (2012)	1.162	3.957

The decrease in the perception of the users about the PT quality, related to the questions involving the new e-ticketing system, could be related to the recent implementation of the ticketing system. In the survey period, it was noted that the SMTUC passengers felt some difficulties in adapting to the ticket validation system. It is expectable that the passengers will get used to the new system and feel the benefits resulting from it.

In the other hand the measure implementation had a positive impact in the modal shift with an increase of 1,2% of the SMTUC passengers.

Analysing the ex-post scenario it is possible to observe that the CIVITAS measure has induced an increase of the number of tickets sold in the Park%Ride system. Comparing the ex-post with the BAU scenario an increase of the number of tickets by 42% has been encountered. When comparing the ex-post with the ex-ante scenario an increase of 10% can be observed.

C2.5 Society

The specific question of the acceptance level of the new ticketing system was carried out together with the modal shift survey (more details of the survey in the Annex 6). This survey shows a low degree of satisfaction as illustrated in Table C2.5.1 (result of the acceptance level).

Table C2.5.1 – Indicator n.12 – Ex-post

Indicators and respective parameters	Ex-post
Acceptance- users	
Very pleased	15,0 %
Pleased	46,1 %
Unsatisfied	32,0%

Table C2.5.2 – – Society indicators - Summary– Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
12. Acceptance level - users	Very satisfied 47,1% Satisfied 49,1% Dissatisfied 3,8% (2011)	Very satisfied 47,1% Satisfied 49,1% Dissatisfied 3,8% (2012)	Very satisfied 15,0% Satisfied 46,1% Dissatisfied 32,0% (2012)	- 32,1% -3,0% 28,2%	- 32,1% -3,0% 28,2%

It can be observed by analysing the acceptance level that the reduction of the satisfaction level is very low. Like for the results in the PT quality, the main reason is related to the recent implementation of the ticketing system. In the survey period, it was noted that the SMTUC passengers felt some difficulties in adapting to the ticket validation system. It is expectable that the passengers will get used to the new system and feel the benefits resulting from it.

C2.6 Cost benefit analysis

C2.6.1 Evaluation period for CBA

Cost-benefit analysis was conducted using the CBA Guideline for CIVITAS Plus Evaluation (Draft 1.0) document developed by Transportation Research Group (TRG), School of Civil Engineering and the Environment, University of Southampton, UK. The output of the CBA was the Net Present Value (NPV) of the measure, which computes the changes of economic costs and benefits, discounted over the 15 years expected lifetime of the measure, which matches the evaluation period of CBA (2012-2027).

The analysis was performed by comparing the costs and benefits of the new ticketing system (no-contact for pre-purchased tickets) (CIVITAS Case) with an old system (for magnetic pre-purchased tickets) (BAU Case).

The generated benefit of the technological change is due to the increase of:

- Revenues from the passengers (transferred from private car due to the measure);

- Time savings due the quicker validation process of the e-tickets comparatively to the ancient tickets with magnetic band technology (this approach has been chosen in alternative to the assessment of the Average PT Network speed initially foreseen, because has been considered more correct, taking in attention that has been a direct measurement, while the assessment to the commercial speed could be influenced by several other factors external to the measure implementation);
- Air Pollutant Reductions (NOx, CO2, volatile compounds (HC), particulates (PM)).

In terms of costs the main beneficiaries were the personnel and the maintenance (material stock and purchase).

The balance between costs and benefits was computed using the NPV by discounting the aggregated annual cash flow (sum of the 15 year annual cash flows). The discount rate considered is 3% per year.

C2.6.2 Method and values for monetisation

Capital cost for the year 2012 has been monetised considering the investment of the new ticketing system.

Operating costs for the years 2012-2027 have been monetised considering the value of SMTUC Operating Costs related to the measure. The enrolled costs are the (A.) Personnel and (B.) Maintenance. The costs of maintenance are related to the material stock and equipment purchase.

These costs were also updated in the analysis period by considering the following:

Table C2.6.2.1 – Explanation of source and assumptions for construction the CBA analysis

Operating Cost	BAU Case	CIVITAS Case	OBS.
A. Personnel (O&M new ticketing system + ticket sales staff)	For 2012 is a computed value obtained by the 2007-2009 annual personnel cost average. For the period 2013-2027 was considered an increase of 2% per year. For ticket sales staff was considered the wages from 24 workers	2012-2013 the personnel cost were very low due the warranty contract of the system. The 2014 value is the real value provided by the ticketing system supplier. For the period 2015-2027 was considered an increase of 2% per year. For ticket sales staff was considered the wages from 22 workers (2 less then BAU case, already transferred to other activities)	Estimated by SMTUC
B. Maintenance	For 2012 is a computed value obtained by the 2007-2009 annual personnel cost average. For the period 2013-2027 was considered 2% increase.	For 2012 was considered less 20% of the average of the last 5 years (new system and in Warranty). Thereafter (2013-2027) was considered 2% increase.	Estimated by SMTUC

On the benefits side, it is expected benefits in terms of revenue of the new passengers (433.404) that had changed from private car to PT due to the measure. This value is monetised considering an average revenue in 2012 of 0,28 €/passenger. This value is actualised by the inflation rate till 2027. A inflation rate of 3,0% is considered in 2012 (Bank of Portugal previsions) and thereafter a fixed tax of 1,5%. As been considered that the 1,2% increase rate in the passengers, assessed in the modal shift survey, will be maintained during the other years.

Table C2.6.2.2 – Determinations of the revenues in the CBA analysis

Year (€)	New Passengers	Inflation	Total Revenues Ex-post (€)	Total Revenues BAU (€)	Ex-Post - BAU (€)	Notes
2012	433.404	3,0%	7.618.341	7.496.987	121.353	Total revenues Ex-Post (2012) is previewed by SMTUC manegement. 2012 BAU value is Ex-post value minus 433.404 passengers x revenue per pessenger (0,28 €/passenger). The SMTUC passengers was admited an constant increase of 1,2% per year. All the values are corrected by the inflation rate that is 3% for 2012 and 1% in 2013 (Bank of Portugal forecast) and for the next period (2014-2027) constant (1,5%).
2013	438.605	1,0%	7.846.891	7.720.397	126.494	
2014	443.868	1,5%	7.925.360	7.796.068	129.292	
2015	449.195	1,5%	8.044.240	7.911.434	132.806	
2016	454.585	1,5%	8.164.904	8.028.488	136.415	
2017	460.040	1,5%	8.287.377	8.147.254	140.123	
2018	465.560	1,5%	8.411.688	8.267.756	143.932	
2019	471.147	1,5%	8.537.863	8.390.019	147.844	
2020	476.801	1,5%	8.665.931	8.514.069	151.862	
2021	482.522	1,5%	8.795.920	8.639.930	155.990	
2022	488.313	1,5%	8.927.859	8.767.629	160.230	
2023	494.172	1,5%	9.061.777	8.897.192	164.585	
2024	500.103	1,5%	9.197.703	9.028.645	169.058	
2025	506.104	1,5%	9.335.669	9.162.016	173.653	
2026	512.177	1,5%	9.475.704	9.297.331	178.373	
2027	518.323	1,5%	9.617.840	9.434.618	183.221	

The time savings resulting from the difference between the average time of the Old system (for magnetic pre-bought tickets – 3,1 seconds) and the average time new system (no-contact for pre-purchased tickets - 1.8 seconds). The net time savings per passenger is 1,3 seconds. Of the total passengers, there are 23,8% that use pre-bought tickets (magnetic) in 2010 and 2011. In 2012 and subsequent years are all without contact.

The time savings for BAU situation are monetised considering the value 0 and only exist for CIVITAS measure situations. Time savings from time reductions (CIVITAS Measure) are monetised considering the following expression:

$A = B \times C \times D \times E$

where,

A – Time reduction savings (€)

B – Total SMTUC passengers

C – Percentage of passengers that uses magnetic tickets (23,8%)

D – Time benefit of using the new ticketing system (s)

E – Average value of time (€/h)

The values for the times saving benefit are showed in the following Table.

Table C2.6.2.3 – Determinations of the time savings in the CBA analysis

Year	Total Passengers	Pre-bought tickets (magnetic)	Time Savings (hour)	Inflation	Time Savings (€/hour) - inflation adjusted	Time Savings (€) - inflation adjusted
2012	26.942.731	6.412.370	2.316	3,0%	12,29	**28.458**
2013	27.265.158	6.489.108	2.343	1,0%	12,41	**29.087**
2014	27.402.977	6.521.909	2.355	1,5%	12,54	**29.526**
2015	27.451.561	6.533.472	2.359	1,5%	12,73	**30.022**
2016	27.306.707	6.498.996	2.347	1,5%	12,92	**30.312**
2017	27.256.675	6.487.089	2.343	1,5%	13,11	**30.710**
2018	27.299.703	6.497.329	2.346	1,5%	13,31	**31.220**
2019	27.237.795	6.482.595	2.341	1,5%	13,51	**31.617**
2020	27.084.716	6.446.162	2.328	1,5%	13,71	**31.910**
2021	27.102.402	6.450.372	2.329	1,5%	13,91	**32.410**
2022	27.087.992	6.446.942	2.328	1,5%	14,12	**32.879**
2023	27.256.979	6.487.161	2.343	1,5%	14,33	**33.580**
2024	27.333.929	6.505.475	2.349	1,5%	14,55	**34.180**
2025	27.362.679	6.512.318	2.352	1,5%	14,77	**34.729**
2026	27.286.661	6.494.225	2.345	1,5%	14,99	**35.152**
2027	27.256.901	6.487.143	2.343	1,5%	15,21	**35.641**

References of values used - Time Savings

The pondered Average value of time (€/h) is obtained considering the following:

$$B = (H \times I + J \times K) / (H + J)$$

where,

H – Proportion of passengers travelling for work related motives (46,1%)

I – Average value of time for passengers travelling for work related motives (19,56 €/h)

J – Proportion of passengers travelling for non-work related motives (53,9%)

K – Average value of time for passengers travelling for non-work related motives (6,06 €/h)

This implies that the value of time is **12,29 €/h for 2012** (for more detail consult ANNEX 5 Cost-Benefit Analysis Data). For the period 2012-2027 value was adjusted by an inflation rate.

For emissions was considered benefits associated to the modal shift from private car to PT. the total monetisation for the emission factors are expressed in the next Table. (further details please consult annex 5).

Table C2.6.2.4 – Determinations of the emissions savings in the CBA analysis

Year	BAU CASE (A) -€				CIVITAS CASE (B) - €				BENEFIT (A-B) - €			
	NOx	HC	CO2	PT	NOx	HC	CO2	PT	NOx	HC	CO2	PT
2012	15,72	692,36	23.739,16	18,70	16,90	666,57	19.635,18	19,77	-1,18	25,79	4.103,99	-1,06
2013	15,88	699,28	23.976,55	18,89	17,06	673,23	19.831,53	19,96	-1,19	26,05	4.145,03	-1,07
2014	16,11	709,77	24.336,20	19,17	17,32	683,33	20.129,00	20,26	-1,21	26,44	4.207,20	-1,09
2015	16,36	720,42	24.701,25	19,46	17,58	693,58	20.430,94	20,57	-1,22	26,83	4.270,31	-1,11
2016	16,60	731,22	25.071,76	19,75	17,84	703,99	20.737,40	20,88	-1,24	27,24	4.334,36	-1,12
2017	16,85	742,19	25.447,84	20,05	18,11	714,55	21.048,46	21,19	-1,26	27,65	4.399,38	-1,14
2018	17,10	753,32	25.829,56	20,35	18,38	725,26	21.364,19	21,51	-1,28	28,06	4.465,37	-1,16
2019	17,36	764,62	26.217,00	20,66	18,66	736,14	21.684,65	21,83	-1,30	28,48	4.532,35	-1,17
2020	17,62	776,09	26.610,26	20,97	18,94	747,18	22.009,92	22,16	-1,32	28,91	4.600,34	-1,19
2021	17,89	787,73	27.009,41	21,28	19,22	758,39	22.340,07	22,49	-1,34	29,34	4.669,34	-1,21
2022	18,15	799,55	27.414,55	21,60	19,51	769,77	22.675,17	22,83	-1,36	29,78	4.739,38	-1,23
2023	18,43	811,54	27.825,77	21,92	19,80	781,31	23.015,30	23,17	-1,38	30,23	4.810,47	-1,25
2024	18,70	823,72	28.243,16	22,25	20,10	793,03	23.360,53	23,52	-1,40	30,68	4.882,63	-1,26
2025	18,98	836,07	28.666,80	22,59	20,40	804,93	23.710,94	23,87	-1,42	31,14	4.955,87	-1,28
2026	19,27	848,61	29.096,81	22,92	20,71	817,00	24.066,60	24,23	-1,44	31,61	5.030,21	-1,30
2027	19,56	861,34	29.533,26	23,27	21,02	829,26	24.427,60	24,59	-1,46	32,08	5.105,66	-1,32

C2.6.3 Life time cost and benefit

Tables C2.6.3.1 to C2.6.3.4 shows the economic data used for the Cost Benefit Analyses.

The new ticketing system was acquired and installed during 2011 (installation all concluded only in December 2011). For these reason it was assumed in the CBA analysis the capital costs in 2012 to allow a easy understanding of the measure effects..

Table C2.6.3.1 – Capital cost in the evaluation period (not discounted)

Year	CIVITAS measure	BAU
2012	1.201.097	0,00
2013-2027	0,00	0,00

The capital costs it is broken down as the following:

Table C2.6.3.2 – Specification of capital costs

NAME	COST (€)
Board Equipment	511.310,30
Inspection of Terminals	23.528,80
Data Collection Station and Surveillance Terminal	8.631,14
Sales and Load Stations	114.807,80
Sale Terminals	36.386,80
Equipment for Settlement of Accounts	17.238,20
Automatic Machines for the Settlement of Accounts	51.586,00
Server	153.743,00
Integration Platform of Computer Applications - Middleware	42.978,00
Wireless Communication Infrastructure	8.953,53
Installation, Testing and Commissioning	150.000,00
SUB-TOTAL	**1.119.163,57**
Agents Sale Terminals	81.934,00
TOTAL	**1.201.097,57**

Table C2.6.3.3 –Costs in the evaluation period (not discounted)

		0 2012	1 2013	2 2014	3 2015	4 2016	5 2017	6 2018	7 2019	8 2020	9 2021	10 2022	11 2023	12 2024	13 2025	14 2026	15 2027
A. Personnel	CIVITAS Case	115.192	115.192	128.139	130.701	133.315	135.982	138.701	141.475	144.305	147.191	150.135	153.138	156.200	159.324	162.511	165.761
	BAU Case	163.958	167.237	170.581	173.993	177.473	181.022	184.643	188.336	192.102	195.944	199.863	203.861	207.938	212.097	216.338	220.665
B. Maintenance	CIVITAS Case	300	306	312	319	325	332	338	345	352	359	366	373	381	388	396	404
	BAU Case	530	540	551	562	574	585	597	609	621	633	646	659	672	685	699	713
TOTAL (€)	CIVITAS Case	115.492	115.498	128.451	131.020	133.641	136.313	139.040	141.820	144.657	147.550	150.501	153.511	156.581	159.713	162.907	166.165
	BAU Case	164.487	167.777	171.133	174.555	178.046	181.607	185.239	188.944	192.723	196.578	200.509	204.519	208.610	212.782	217.038	221.378
Changes (€)		**-48.995**	**-52.279**	**-42.682**	**-43.535**	**-44.406**	**-45.294**	**-46.200**	**-47.124**	**-48.066**	**-49.028**	**-50.008**	**-51.008**	**-52.029**	**-53.069**	**-54.131**	**-55.213**

Note: The decrease in personnel costs with the new system was due to its better reliability, more automatisms on several operations and improvements at organizational level that implied in a consequent reduction of personnel allocated to the maintenance and accounting services..

Table C2.6.3.4 - Savings for the evaluation period (not discounted)

		0 2012	1 2013	2 2014	3 2015	4 2016	5 2017	6 2018	7 2019	8 2020	9 2021	10 2022	11 2023	12 2024	13 2025	14 2026	15 2027
Renevues - New users	CIVITAS Case	7.618.341	7.846.891	7.925.360	8.044.240	8.164.904	8.287.377	8.411.688	8.537.863	8.665.931	8.795.920	8.927.859	9.061.777	9.197.703	9.335.669	9.475.704	9.617.840
	BAU Case	7.496.987	7.720.397	7.796.068	7.911.434	8.028.488	8.147.254	8.267.756	8.390.019	8.514.069	8.639.930	8.767.629	8.897.192	9.028.645	9.162.016	9.297.331	9.434.618
Time Savings	CIVITAS Case	28.458	29.087	29.526	30.022	30.312	30.710	31.220	31.617	31.910	32.410	32.879	33.580	34.180	34.729	35.152	35.641
	BAU Case	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Pollutant Reductions NOx	CIVITAS Case	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
	BAU Case	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Pollutant Reductions HC	CIVITAS Case	26	26	26	27	27	28	28	28	29	29	30	30	31	31	32	32
	BAU Case	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Pollutant Reductions CO2	CIVITAS Case	4.104	4.145	4.207	4.270	4.334	4.399	4.465	4.532	4.600	4.669	4.739	4.810	4.883	4.956	5.030	5.106
	BAU Case	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Pollutant Reductions PM	CIVITAS Case	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
	BAU Case	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (€)	CIVITAS Case	7.650.927	7.880.147	7.959.117	8.078.557	8.199.575	8.322.512	8.447.399	8.574.038	8.702.468	8.833.027	8.965.504	9.100.195	9.236.794	9.375.383	9.515.916	9.658.615
	BAU Case	7.496.987	7.720.397	7.796.068	7.911.434	8.028.488	8.147.254	8.267.756	8.390.019	8.514.069	8.639.930	8.767.629	8.897.192	9.028.645	9.162.016	9.297.331	9.434.618
Changes (€)		**153.939**	**159.749**	**163.049**	**167.123**	**171.087**	**175.258**	**179.643**	**184.019**	**188.399**	**193.096**	**197.875**	**203.003**	**208.149**	**213.367**	**218.585**	**223.997**

Table C2.6.3.5 – Balance between costs and benefits due to measure (lifetime period)

	0 2012	1 2013	2 2014	3 2015	4 2016	5 2017	6 2018	7 2019	8 2020	9 2021	10 2022	11 2023	12 2024	13 2025	14 2026	15 2027
Undiscounted Cash Flow (€)																
Changes in total costs	1.201.097	-52.279	-42.682	-43.535	-44.406	-45.294	-46.200	-47.124	-48.066	-49.028	-50.008	-51.008	-52.029	-53.069	-54.131	-55.213
Changes in total benefits	153.939	159.749	163.049	167.123	171.087	175.258	179.643	184.019	188.399	193.096	197.875	203.003	208.149	213.367	218.585	223.997
Net Cash Flow	-1.047.158	212.028	205.731	210.658	215.493	220.552	225.843	231.143	236.466	242.124	247.883	254.012	260.178	266.436	272.715	279.210
Discounted Cash Flow (€)																
Changes in total costs	1.152.102	-50.756	-40.231	-39.841	-39.454	-39.071	-38.692	-38.316	-37.944	-37.576	-37.211	-36.850	-36.492	-36.138	-35.787	-35.439
Changes in total benefits	153.939	155.097	153.690	152.941	152.008	151.179	150.448	149.624	148.724	147.992	147.238	146.654	145.992	145.292	144.510	143.775
Net Cash Flow	-998.163	205.853	193.921	192.782	191.462	190.250	189.140	187.940	186.668	185.568	184.449	183.503	182.483	181.430	180.297	179.214
Cumulative cash flow	-998.163	-792.310	-598.389	-405.607	-214.144	-23.894	165.246	353.186	539.854	725.422	909.871	1.093.374	1.275.857	1.457.287	1.637.584	1.816.798
Changes in NPV (€)	**1.816.798**															

C2.6.5 Summary of CBA results

The results of CBA demonstrate that the measure could produce a NPV of 1,82 M € over a 15 year period analysis, based on the updated balance of costs and benefits of the new ticketing system.

In order to evaluate the sensitivity due to the discount rate an analysis has been carried out (Table C2.6.5.1). A 3% rate per year was assumed and 2 scenarios have been consider to analyse a high discount rate with 5,5% and a low discount rate (2,5%).

Table C2.6.5.1 – Sensitivity analysis (low and high scenario)

Analysis	NPV (M€)
Low (discount rate 2,5%)	1,93
Current (discount rate 3%)	1,82
High (discount rate 5%)	1,43

The analysis demonstrated that the discount rate has a small impact in the NPV and it always remains positive.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To install a new e-ticketing system on board of 125 PT vehicles. The e-ticketing has been installed on board of 139 PT vehicles, in the lift and in the park&ride service, totalizing 150 on board sets. Each set has 2 equipment that allow the validation function in duplicate (Duple function Console near the driver and passengers entry + the Validator at passengers passage)	***
2	To create fare products, including for the improvement of the integration of services (such as those linked to the parking), that will also contribute to increase by 1% the passengers in the municipality PT service and 3% the Park & Ride usage. New fare products have been created, including for the park&ride system. During the first 9 months of the new e-ticketing functioning the passengers increased 1,2 % due the system implementation and the tickets sale in the 2 remaining parks of the park&ride system increased 9,6% when compared 2012 with 2011.	***
3	Expansion of public transport in the metropolitan area. During CIVITAS MODERN project 2 new PT lines for the surroundings has been created, as well as the expansion of 1 line to one hospital involved in the scope of the mobility management actions of the CIVITAS MODERN measure 04.05. All these inhabitants served by these lines is benefiting of the new e-ticketing system and SMTUC fares.	**
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

Since the new ticketing system was implemented in all of the SMTUC vehicles there are no up-scaling.

C5 Appraisal of evaluation approach

The evaluation strategy of this measure sought to focus on a number of indicators across the areas of economy, transport, energy, environment, and society, which were to be measured in different ways.

This strategy that was based on the Local Evaluation Plan (LEP) was defined a long time before the final definition of the measure and during the LEP elaboration the hypothesis considered in relation to the foreseen evaluation approach of the measure was very different from the approach that was actually taken.

An extension of the measure has been required to allow for a longer evaluation period and better assessment of the impacts, taking into consideration that the new e-ticketing system started the full operation for all types of passes in February 2012 and until the end of May 2012 a transition period was applied with the 2 systems working together. Additionally, in this period the summer holidays contributed to a drop in passengers. Due to the time available for evaluation, it was not possible to measure directly the impacts of the measure in the behaviour of the citizens.

Accordingly the methodology to assess the indicators was based on the modal shift from private car to public transport associated to the New Ticketing System (due to the financial crisis in Portugal it was considered that a shift from PT to the private cars was not likely).

For this effect in September 2012 a survey was carried out amongst 750 SMTUC passengers, inquiring about their modal behaviour and changes since the beginning of the operation of the new e-ticketing system (9 months earlier).

With the data provided by the surveys an assessment was carried out in terms of average operating revenues, fuel energy, and environmental indicators. For the remaining economic indicators, transport, and society indicators the source of the information was based on SMTUC operational data and the customer satisfaction survey carried out in the scope of SMTUCs normal procedures of the Quality Management System.

Also the impact of the measure in the Average PT Network Speed has been abandoned to be evaluated in this measure because it was difficult to assess the direct influence of the measure in the indicator and there are other CIVITAS MODERN measures that had a major impact in the Average PT Network Speed, like the measure 08.03, in which the indicator has been assessed.

C6 Summary of evaluation results

The key results are as follows:

- **Increase of the average operating revenues -** The measure induced an increase of the average operating revenues related to the passengers that transferred to public transport (+0,02 €/v-km).

- **Decrease of the average operating costs -** The measure induced a decrease of the average operating costs (- 0,0095 €/v-km). Adding the effects of the operating revenues and costs it can be concluded that the measure has a positive impact in the economic indicators.
- **Positive NPV and attractive pay-back period -** The Cost-Benefit Analysis (CBA) of the measure demonstrates that it generates a positive NPV of 1,82 M € over a 15 year period and a payback of the investment is expected between the 5th and 6th year of implementation. A sensitivity analysis of the discount rate impact into the NPV demonstrated that it generates a small influence between the factors.
- **Positive impacts on the attractiveness of the new system - 15% of users are** very satisfied and about 46% consider the measure satisfactory. The percentage of not satisfied compared to the previous system can be justified by the fact that the system was recently implemented and the users are not sufficiently familiar with its use, mainly the elders.
- **Contribution to energy efficiency in the city** – The implementation of the measure would result in significant savings in energy due to the assessed reduction of the energy consumption per passenger (-0,24 MJ/pkm).
- **Positive impact on emissions mitigation –** The measure generates a positive impact on CO2, NOx, and PT emissions with a decrease of -17,081 g/pkm, -0,698 g/pkm, and 0,03 g/pkm, respectively. The CO emissions remain constant.
- **Increase of the usage of the Park & Ride system –** Comparing the ex-post with the BAU scenario an increase 42% of the number of tickets sold can be foreseen. When comparing the ex-post with the ex-ante scenario an increase of 10% can be observed. All the comparisons indicate that the measure generate an increase of the Park & Ride usage.

C7 Future activities relating to the measure

The e-ticketing system will continue functioning, as well as the development of the on-line system for the payment of the fares.

The payment and reload of the e-cards through ATM machines will be also implemented when the legal issues relating to national legislation (provided for the combat of the financial crisis) are surpassed.

The contacts carried out for the creation of an inter-municipal pass will continue, namely by searching for new ways to avoid the financial barriers and involve the surrounding Municipalities and PT operators in the project.

In any case, the launch of new fares and the development of new features for the improvement of intermodality and interoperability will be a priority.

D Process Evaluation Findings

D0 Measure / focussed measure

1	The measure fits into the EU policy towards clean urban transport (five pillars of the EU Green Paper)
2	The measure fits into the city policy towards sustainable urban transport and / or towards sustainability in general
3	The expected impact on the transport system, environment, economy and/ or society / people is very high
4	The high level of innovativeness of the measure with respect to technique, consortium, process, learning etc
5	The measure is typical for a group of measures or a specific context
6	The possibility of carrying out a good Cost Benefit Analysis
7	Participation of a range of different actors
8	The high degree of complexity of managing the measure
9	The measure is regarded as an example measure
10	Other, *please describe*

Which are the three most important reasons for selecting this measure as a focused measure?

1 The measure fits into the EU policy towards clean urban transport (five pillars of the EU Green Paper)	1	Most important reason
6 The possibility of carrying out a good Cost Benefit Analysis	2	Second most important reason
2 The measure fits into the city policy towards sustainable urban transport and sustainability in general	3	Third most important reason

D1 Deviations from the original plan

The deviations from the original plan comprised:

- **Extended administrative and bureaucratic procedures delayed the implementation of the measure**– Taking into consideration the importance of the project at the regional level and the interest manifested by the National Authority of Inland Transportation (IMTT) for supporting of measures which can increase the integration of several PT operators and other modes of transportation in the metropolitan areas, the Municipality of Coimbra, through its municipal public transport service (SMTUC), began contacts for national funding of the e-ticketing system before the CIVITAS candidature. Despite this anticipation, a large part of the time for the measure implementation has been spent in solving administrative and bureaucratic problems. First the governmental decision for the co-financing of the system purchase only occurred on 29th December 2009, more than 1 year after the expected and 7 months after the technical conclusion of the tender process. To recover the time lost, the tender process began before the authorization of the national co-financing, but national legislation established that the final adjudication only could be authorized after all funds were identified. For this reason Municipality and SMTUC launched a loan contract procedure. This procedure has also been time consuming, in part due the financial crisis in Portugal which obliged even more rigorous procedures during the contract validation by the National Court of Accounting. Also a contention to the final results and hierarchical appeals to several judicial instances occurred during the procedure of the international public tender for the e-ticketing system. Despite the contestants' lack of reasons, these appeals obliged a suspension of the procedure until the final decision, allowing that the final adjudication could only be concluded on 30th August 2010. Finally, the loan contract validation by the National Court of Accounting occurred in December 2010, the signature of the contract for the e-ticketing system took place on 23rd December 2010, and the new validation by the National Court of Accounting (now for the system purchase) was released on 17th February 2011. Despite the fact that the contract stipulated 1 year for the development and installation of the e-ticketing system, recovery actions allowed the start-up of the new system on 1st January 2012 (for the tickets). On 2nd February 2012 the system was fully

operational for all kind of passes. Due to this delay the measure duration has been extended 4 months in order to allow for a longer evaluation period and a better assessment of the impacts.

- **The objective related to the increase of the passengers in the municipal public transport operator has been changed from the 2% initially foreseen to the actual 1%** – The objectives of the measure have been reformulated due to the above mentioned delay in the implementation of the e-ticketing system. Taking into consideration that during CIVITAS the time available for the e-ticketing system to have any impact was reduced and did not allow a change in citizens behaviour, the expected increase in the SMTUC passengers has been fixed in 1%, instead of the 2% initially foreseen.

- **The initial objective leading to the creation of an Inter-municipal pass during CIVITAS has been suspended** – To offer better interoperability to the inhabitants of the surrounding municipalities that need to travel to Coimbra through private PT operators and to use SMTUC in the city, the Municipality of Coimbra and SMTUC envisioned the creation of an inter-municipal pass during CIVITAS.. This product would imply discounts to the passengers from the municipalities, SMTUC, and the other PT operators, as well as some costs with the adaptation of the e-ticketing systems (despite in SMTUCs case the new system is already interoperable and open to other e-card technologies). But the financial crisis in Portugal made many of these Municipalities and PT operators to reconsider their priorities, delaying their decision to join Coimbra in this initiative, subsequently forcing an adaptation in this objective. Accordingly, the Municipality of Coimbra and SMTUC opted to plan (and carried out) some extensions of their PT network during CIVITAS and abandoned the creation of the Inter-municipal pass (despite during CIVITAS several meetings and contacts continued with the surrounding municipalities and PT operators to achieve this objective as soon as possible). The already existing multimodal railway – bus pass was also involved in this process. This pass already had an insignificant demand due any discount was being applied for this fare and the old system didn't allow the integration of systems, obliging the user to have cards of the 2 operators. So the pass wasn't appealing, but with the new e-ticketing system using the same data base model of the railway operator, has been expected that during CIVITAS this situation could change with it integration in the inter-municipal pass. The suspension of the launch of this pass also implied that didn't make any sense to maintain the initial objective to increase 100% the multimodal railway – bus pass,

D2 Barriers and drivers

D2.1 Barriers

Preparation phase

- **Barrier 1.1 – Financial Barrier:** Despite SMTUCs early request (before CIVITAS) for national co-financing of the e-ticketing system, only on 29th December 2009 did the government approve for the co-financing (over 1 year after the expected). This fact delayed the beginning of the measure implementation. Also the financial crisis in Portugal influenced the process of creation of an inter-municipal pass involving the surrounding municipalities of Coimbra Municipality. To turn the product more attractive to customers, discounts for the purchasing the passes were foreseen.

However, the crisis implied a reconsideration of the priorities for the municipalities and the PT operators.

- **Barrier 1.2 – Technological Barrier:** Before the CIVITAS MODERN project SMTUC already possessed a ticketing system that provided "contact less" technology (but only for the passes). This system was based in a technology dependent on the integrators that caused many problems in the past. Accordingly, SMTUC wanted to apply "open" technology in the new system. Thus comprehensive knowledge of such systems was required for the definition of the correct specifications for the tender procedure of the system purchase. This process revealed to be very complicated and time consuming, carrying the risk of delays if recovery actions had not been put in practice.

Implementation phase

- **Barrier 2.1 – Institutional Barrier:** In Portugal the final adjudication, related to a purchase procedure, could only be authorized after all funds are identified. The above mentioned delay in the definition of the national funds for the e-ticketing system purchase obliged the Municipality of Coimbra and SMTUC to carry out a loan contract procedure to grant all funds for the system purchase. But this process has very time consuming due to the long administrative and bureaucratic procedures existing in Portugal,, namely in the National Court of Accounting. For this reason the major part of the implementation time was spent in the resolution of legal and financial problems, as well as in the planning and implementation of recovery actions. Also, significant work and time were spent answering a contestation to the tender results carried out by a contestant to the tender procedure. Despite the contestant's lack of legal reasons, the contestation and subsequent hierarchical appeals obliged the suspension of the procedures until reaching a final decision, contributing to a greater delay in the implementation process.

- **Barrier 2.2 – Institutional Barrier:** It was initially foreseen that the supply of the new e-tickets and e-cards (physical supports for the fares) could be available trough the partnership protocol signed with OTLIS (Organization of public transportation operators of Lisbon and national railway company) as a national standard and taking advantage of the economies of scale resulting from large-scale demands of tickets and cards resulting from tender processes organised with the Lisbon Metropolitan area (SMTUC has the same data base model, application programming interface – API – and Security Protocol – SAM – as the OTLIS PT operators). Since in June 2011 legal interpretations did not allow for the tickets and cards to be supplied directly by this entity, it was decided to launch a procedure for the purchase of the e-tickets and e-cards. But this tardy unexpected decision, associated with the delays caused by the bureaucratic procedures, as well as some problems with errors in the e-cards, caused new delays that hindered the success of the recovery actions undertaken for the combat to the other delays.

Operation phase

- **Barrier 3.1 – Problem related Barrier:** The accumulated delays, due to the problems mentioned above, also caused a significant delay in the beginning of the operation phase, implying and extension of the duration of this phase in order to have time to

assess the impacts of the measure implementation and to revise some methodologies (to carry out these assessments and the values of some quantifiable objectives).

D2.2 Drivers

Preparation phase

- **Driver 1.1 – Involvement Driver:** The Municipality (with emphasis on the decision makers), and SMTUC staff were very motivated for the measure implementation and were aware of the commitments assumed with the citizens and the CIVITAS MODERN project. This involvement and responsibility was crucial for the recovery actions undertaken during the preparation phase .

- **Driver 1.2 – Technological Driver:** OTLIS has a large experience in ticketing issues and some months before the beginning of the CIVITAS MODERN project it launched an international public tender for the implementation of e-ticketing system in several PT operators in the Lisbon region. This experience and knowledge were available to SMTUC staff.

Implementation phase

- **Driver 2.1 – Organisational Driver:** SMTUC dedicated a large part of it organizations in the implementation of the e-ticketing system to recover more quickly the time lost and to achieve better quality and results with the new system.

Operation phase

- **Driver 3.1 – Involvement Driver:** The participation in the CIVITAS MODERN project served as a driver per se for the quick resolution of problems, using the motivated SMTUC staff which was aware of their responsibilities Equally significant, SMTUC counted on the advice and experience of other MODERN partners and technical managers.

D2.3. Activities

Preparation phase

- **Activities 1 – Involvement Activities:** Municipality of Coimbra and SMTUC were very motivated and aware of their responsibilities for the task of implement the e-ticketing system in Coimbra and the remaining actions in the scope of the CIVITAS MODERN measure (Drive 1.1). To mitigate the effects of the delay in the authorization by the national government of the co-financing for the e-ticketing system purchase and to allow for the anticipation of the definition of all the funds for this investment (Barrier 1.1), the Municipality and SMTUC decided to carry out a loan contract for the e-ticketing purchase and anticipated and developed in parallel several other tasks – e.g., specifications of the system and the update of the implementation planning; meetings and other contacts with decision makers of IMTT demanding a quicker reply on national co-financing; meetings with several surrounding municipalities and all the PT operators for the launch of the inter-municipal pass.

- **Activities 2 – Technological Activities:** Taking into consideration the technical complexity of the implementation of the e-ticketing system, and the need to avoid future dependency on suppliers for upgrades (Barrier 1.2), SMTUC took advantage of the exchange of experience and knowledge by several stakeholders, with emphasis on OTLIS. Therefore, for the technical specifications of the new system, while solving the financial and administrative issues, SMTUC carried out a market analysis through the available online information and the information provided by the manufacturers. SMTUC also took advantage of the visits to other existing systems and of the experience of the OTLIS staff. These activities included a partnership with OTLIS aiming at the establishment of a national standard for e-ticketing systems – the partnership allowed for a common data base model and the same application programming interface (API) and the same security access module (SAM). These resolutions benefited the interoperability and intermodality at a national scale and allowed for economically more favourable tender proposals due to the fact that a great part of the work needed for the development of the system for Coimbra region was already developed by the major part of the manufacturers which supplied the Lisbon region in the past.

Implementation phase

- **Activities 1 – Organisational Activities:** The major part of the implementation time was spent in the resolution of legal and financial problems (Barriers 2.1 and 2.2). Taking advantage of the important allocation of SMTUC resources in the support of the measure implementation (Driver 2.1), it was possible to carry out several activities in parallel and in less time. These organisational and planning activities avoided the accumulation of delays, directed available experienced technicians to the resolution of technical problems, and allowed to reply correctly, promptly, and quickly to legal solicitations, including those from the National Court of Accounting.

Operation phase

- **Activities 1 – Problem related Activities:** Despite the recovery actions, the accumulation of delays, due to the multiple problems that happened during the preparation and implementation phase, caused an inevitable delay of the beginning of the operation phase and, subsequently, less time for the assessment of the measure impacts (Barrier 3.1). The importance of the measure for the citizens and the awareness of the staff involved about their responsibilities concerning the obligations with the CIVITAS MODERN project (Driver 3.1), contributed to the decision of carrying out a systematic monitoring and accomplishment of the measure demonstration – with focus on the correct functioning of the e-ticketing system and the data collection, but also working for the creation of new mobility products. Also it was decided to carry out a survey to SMTUC passengers, allowing fort the assessment of the modal shift.

D3 Participation of stakeholders

D3.1 Measure partners

- **Measure partner 1 - Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Leading role**

  SMTUC was responsible for the specification, purchase, and installation process of the new e-ticketing system, as well as the training of the system users (drivers, controllers, and maintenance staff). Also, SMTUC carried out the management of operational and monitoring activities, as well as some dissemination activities.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC); City; Principle participant**

  CMC was responsible for carrying out with SMTUC the loan contract for the e-ticketing system purchase and for the approval of the fares.

  Since October 2011, CMC assumed the responsibility for the dissemination of the MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

  While responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA, PRODESO gave some support in the promotion of this measure.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

  PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

D3.2 Stakeholders

- **Stakeholder 1 – Public transport users**

  SMTUC passengers are the main beneficiaries of this measure since it has allowed for an enhancement of the quality and feasibility of the ticketing system.

- **Stakeholder 2 – Public in general**

  The public in general also benefit of the new e-ticketing system purchase because this system allowed for the establishment of a standard of interoperability and intermodality that is allowing for the creation of new mobility products.

- **Stakeholder 3 – Supplier of the new e-ticketing system**

  The group NOVA BASE / BCCM was the supplier of the new e-ticketing system and has also been responsible for it installation and integration with other systems, with emphasis for the Automatic Vehicle Management System (AVM) – namely allowing for a single

console to command both systems and to receive information on the coordinates of the bus stops for the geo-referencing of passenger entrances.

- **Stakeholder 4 – Instituto da Mobilidade e Transportes Terrestres (IMTT)**

  IMTT is the National Institute of Mobility and Inland Transportation and co-financed the purchase new e-ticketing system in 50%.

- **Stakeholder 5 – Associação de operadores de transportes públicos da região de Lisboa (OTLIS)**

  The Organization of public transportation operators of Lisbon region and national railway company (OTLIS) supported SMTUC in the specifications of the e-ticketing system and established a partnership for a common data base model and the same application programming interface (API) and security access module (SAM). These resolutions benefit the interoperability and intermodality in a national range.

- **Stakeholder 6 – Surrounding municipalities.**

  Some surrounding municipalities of Coimbra metropolitan area have been involved in meetings and other contacts with the objective of the creation of an inter-municipal pass.

- **Stakeholder 7 – PT operators of Coimbra region**

  The regional PT operators and the national railway operator have been involved in meetings and other contacts with the objective of the creation of an inter-municipal pass and for the integration of its systems with SMTUCs e-ticketing system.

- **Stakeholder 8 – Media**

  The media has been a channel for the dissemination and promotion of the measure.

D4 Recommendations

D4.1 Recommendations: measure replication

- **Special attention must be given to the specification of e-ticketing systems, mainly concerning the interoperability of systems and the independence from suppliers for future upgrades –** The e-ticketing systems are technologically complex and have technological requirements that hinder the interoperability between ticketing systems from different PT operators or between systems specific to each operator (such as AVM systems). For this reason special attention must be given to the system specifications in order to facilitate the future integrations of systems and to avoid the dependency from the e-ticketing suppliers for this task. Today there are 2 standards for the e-tickets and validators technology (the A type and the B type or Calypso) and the option for equipment that could support this kind of technologies could be a good approach for the interoperability but could not be enough – the systems must have a compatible data model for the products, mainly the fares, and the same for the Application Programming Interface (API – responsible for the communication protocol between systems) and the Security Access Module (SAM – Protocol of security between systems, avoiding that a

ticket from a not allowed operator can't be used in the system). For this reason the establishment of a common standard for a city or a region could be very useful – SMTUC already uses a common standard with the Lisbon region and the national railway company envisioning the creation of a national standard. In any case, the e-ticketing system must be an "open" system with the possibility of customising features so as to avoid the dependency on system suppliers in future developments. This part is the most difficult to achieve. However, SMTUC had good results, mainly in the integration with the AVM system and achieving independence in the creation and update of new fares or the purchase of new equipment such as validators.

- **It is recommended involving technicians of several areas during the implementation of the measure and to give importance to the monitoring process during the start-up of the e-ticketing system –** The e-ticketing systems normally have impacts in many areas of a PT operator –operation of the PT network, maintenance, accounting, data processing, etc. For this reason, it is recommended involving these areas since the beginning of the process to provide correct specifications and to make the technicians aware of all these issues. They were also important in the phase of the system monitoring, allowing for prompt detection and resolution of the problems. Accordingly the more contact and experience they had with the system, the better the results achieved in this phase.

D4.2 Recommendations: process

- **The procedure for the purchase of the physical supports for the e-tickets or e-cards could be time consuming and with less favourable prices for medium or small size cities –** Medium or small size cities do not have the advantage as larger cities in negotiating the purchase of e-tickets (or e-cards) with the suppliers due to the quantity factor. Also the production of great quantities is a priority and pushes the production of small quantities to the dates that they have available between the other productions – so it is also expected that smaller quantities will imply greater delivery times. To mitigate these problems some actions could be undertaken: In the tender procedure some advantages for the supplier which shorten delivery time could be considered (but this methodology may not be enough – mainly if some kind of "Calypso" e-tickets are used that are manufactured by an unique enterprise that could "impose" the delivery conditions; if economically advantageous, it is recommended to plan the needs of tickets for some years, to allow more quantities in the purchase process); another possibility is trying to establish partnerships with other cities or PT operators to have common specification for the e-tickets or e-cards and acquire the tickets through common purchase procedures – but this methodology have several barriers to its application, namely because in a great part of the cases the layout of the e-tickets (or e-cards).

- **The financial crisis could change priorities in the cities objectives from the mobility worries to the resolution of other issues –** With the financial and economic crisis in Portugal, the social role of the national government (or of the municipalities) in the support of some activities is being discussed. Some decisions that implied the allocation of public funds for the financing of some mobility measures could be delayed and other issues can be given priority, such as health care, education, or unemployment. In Coimbra, mobility issues continue to be one of the Municipality priorities, considering that the support to this activity could aid the social and economic recovery (as was demonstrated by the maintenance during 2013 of the same fares price practiced during 2012 and the continuation of the process for the creation of an inter-municipal pass with some surrounding municipalities that involves some discounts for the passengers granted for all

the parts. But on the other hand these municipalities and the respective PT operators have not been interested in the measure after the beginning of the referred crisis, despite their citizens / passengers continue to be the most benefited if the measure is implemented).

ANNEX 1: Fuel Mix Data

The next table shows the data obtained in relation to the evolution of the Share of different fuels (diesel, gasoline) in the Fuel consumption in Portugal since 2004:

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
% Diesel	n.a.	n.a.	n.a.	n.a.	71,1%	72,2%	73,0%	74,5%	75,4%	75,9%	76,9%	77,7%
% Gasoline	n.a.	n.a.	n.a.	n.a.	28,6%	27,4%	26,6%	25,2%	24,2%	23,6%	22,7%	21,8%
% GPL	n.a.	n.a.	n.a.	n.a.	0,3%	0,3%	0,3%	0,4%	0,4%	0,5%	0,4%	0,5%

Source: DGEG - General Directorate for Energy and Geology, Statistics

ANNEX 2: Energy Density and Conversion Factors

Energy Density				
1 litre Diesel	35,86 MJ	1 litre Diesel	0,835	kg
1 litre Gasoline	32,18 MJ	1 litre Gasoline	0,7475	kg

ANNEX 3: Operating costs

Year	Personnel (€)	Personnel Ticket Shops (€)	Material - stock (€)	Material - purchase (€)	Total (€)
2007	26.429,98	143.041,38	591,74	2.392,25	172.455,35
2008	19.234,40	143.041,38	720,38	2.997,71	165.993,87
2009	17.085,20	143.041,38	277,40	13.690,21	174.094,19
2010 (Atypical year)	6.937,30	143.041,38	31,63	4.411,39	154.421,70
2011 (Atypical year)	7.199,70	143.041,38	255,85	4.229,10	154.726,03
2012 (System under Warranty)	0,00	115.192,53	300,32 [3]	0,00	115.192,53
2013 (System under Warranty)	0,00	117.496,38	306,33	0,00	117.802,71
2014 [1]	12.634,18	119.846,31	312,45	0,00	132.792,94
2015 [2]	12.886,86	122.243,23	318,70	0,00	135.448,80
Baseline (2011)	7.199,70	143.041,38	255,85	4.229,10	**154.726,03**
BAU 2012 [3]	20.916,52	143.041,38	529,84	6.360,05	170.847,79
BAU 2013	21.334,86	145.902,21	540,44	6.487,26	174.264,76
BAU 2014	21.761,55	148.820,25	551,25	6.617,00	177.750,05
BAU 2015	22.196,79	151.796,66	562,27	6.749,34	181.305,06

OBS.:
1 - Value provided by the supplier in the tender
2 - 2% increase on the previous year
3 - Less 20% from the 2007-2011 average
4 - 2007, 2008 and 2009 average - further years it is considered an increase of 2%

Actual values recorded in SMTUC (Without CIVITAS measure)
With CIVITAS extrapolation
Without CIVITAS extrapolation

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Without CIVITAS	172.455,35	165.993,87	174.094,19	154.421,70	154.726,03	170.847,79	174.264,76	177.750,05	181.305,06
With CIVITAS								132.792,94	135.448,80
Without CIVITAS - Atypical year									
With CIVITAS - Atypical year						115.192,53	117.802,71		

ANNEX 4: Emission Factors

Table 4-18: Bulk emission factors (g/kg fuel) for Portugal, year 2005.

Category	Portugal					
	CO	NO_x	NMVOC	CH_4	PM	CO_2 [kg/kg fuel]
Gasoline PC	61.56	9.18	8.50	0.71	0.03	3.18
Diesel PC	3.20	11.28	0.57	0.04	0.72	3.14
Gasoline LDV						
Diesel LDV	9.39	17.91	1.72	0.11	2.05	3.14
Diesel HDV	7.14	34.09	1.14	0.24	1.04	3.14
Buses	11.88	40.75	4.18	0.31	1.85	3.14
Mopeds	403.89	3.62	360.25	6.55	6.32	3.18
Motorcycles	590.71	5.89	128.94	4.57	2.80	3.18

ANNEX 5: Cost-Benefit Analysis Data

The next table shows the values obtained for travel time savings:

Year: 2002	Time savings (€/h)
Work related trips (Bus, Portugal)	15,52
Non-work related trips (Bus, Portugal)	4,81

Source: HEATCO Project. Deliverable D5 Proposal for Harmonised Guidelines (2006) (URL: http://heatco.ier.uni-stuttgart.de/), taken from J. Piao and J. Preston, CBA Recommendations for CIVITAS Evaluation, Transportation Research Group, Southampton University, UK

The following table shows the evolution of inflation rates from 2002-2027:

Year	2002	2003	2004	2005	2006	2007
Inflation Rate (%)	3,6%	3,3%	2,4%	2,3%	3,1%	2,5%

Source: Bank of Portugal, National institute of Statistics

Year	2008	2009	2010	2011	2012	2013
Inflation Rate (%)	2,6%	-0,8%	1,4%	3,8%	3,0%	1,0%

Source: Bank of Portugal, National institute of Statistics

2012 - 2013Government and Bank of Portugal Previsions

Year	2013-2027
Inflation Rate (%)	1,5%

Analysis Prevision

The following table shows the estimated values of travel time savings:

Year: 2012	Time savings (€/h)
Work related trips (Bus, Portugal)	19,56
Non-work related trips (Bus, Portugal)	6,06
AVERAGE	**12,29**

The estimation of these values is based on the values of travel time savings obtained from POINTER and on the evolution of inflation rates from 2002-2012.

The projection for the period 2012-2027 was adjusted by the expected inflation rate.

Year	Total Passengers	Pre-bought tickets (magnetic)	Time Savings (hour)	Inflation	Time Savings (€/hour) - inflation adjusted	Time Savings (€) - inflation adjusted
2012	26.942.731	6.412.370	2.316	3,0%	12,29	**28.458**
2013	27.265.158	6.489.108	2.343	1,0%	12,41	**29.087**
2014	27.402.977	6.521.909	2.355	1,5%	12,54	**29.526**
2015	27.451.561	6.533.472	2.359	1,5%	12,73	**30.022**
2016	27.306.707	6.498.996	2.347	1,5%	12,92	**30.312**
2017	27.256.675	6.487.089	2.343	1,5%	13,11	**30.710**
2018	27.299.703	6.497.329	2.346	1,5%	13,31	**31.220**
2019	27.237.795	6.482.595	2.341	1,5%	13,51	**31.617**
2020	27.084.716	6.446.162	2.328	1,5%	13,71	**31.910**
2021	27.102.402	6.450.372	2.329	1,5%	13,91	**32.410**
2022	27.087.992	6.446.942	2.328	1,5%	14,12	**32.879**
2023	27.256.979	6.487.161	2.343	1,5%	14,33	**33.580**
2024	27.333.929	6.505.475	2.349	1,5%	14,55	**34.180**
2025	27.362.679	6.512.318	2.352	1,5%	14,77	**34.729**
2026	27.286.661	6.494.225	2.345	1,5%	14,99	**35.152**
2027	27.256.901	6.487.143	2.343	1,5%	15,21	**35.641**

The next table shows the age of SMTUC passengers:

Age (%)	2009	2010	2011	2012
<18	12,6	12,5	6,1	9,9
19-25	28,3	32,4	41,2	35
26-45	23,9	19,6	23,6	17,6
46-55	15,2	13,5	15,2	15,1
56-65	13,2	10,3	7,9	13,2
>62	6,8	11,7	6	9,2

Source: SMTUC – Customer satisfaction Surveys (2009-2012)

The following table shows the motive of the trips of SMTUC passengers

Motive (%)	2009	2010	2011	2012
Home-Work/School	66,8	63,9	70,2	59,5
Shopping/Leisure	29,6	31,4	25,5	35,4
Work trip	3,6	4,7	4,3	5,1

Source: SMTUC – Customer satisfaction Surveys (2009-2012)

The following table shows the percentage of work related trips and non-work related trips among SMUTC passengers:

Motive (%)	2009	2010	2011	2012	**Average**
Work related trips	47,8	45,1	48,5	48,5	**46,1**
Non-work related trips	52,2	54,9	51,5	51,5	**53,9**

The assumption in this table is that Home-Work/School trips among passengers <18 are 100% Non-work related trips, that Home-Work/School trips among passengers 19-25 are 75% Non-work related trips and that Home-Work/School performed by each age group is proportional to the percentage of SMTUC passengers belonging to that group.

The next table shows the values obtained for emissions savings:

Year	Inflation Rate	NOx (€/ton.)	HC (€/ton.)	CO2(€/ton.)	PM (€/ton.)
2000	-	1,3	500,0	-	33,5
2001	4,40%	1,4	522,0	-	35,0
2002	3,6%	1,4	540,9	-	36,2
2003	3,3%	1,5	558,7	-	37,4
2004	2,4%	1,5	571,9	-	38,3
2005	2,3%	1,5	584,9	-	39,2
2006	3,1%	1,6	603,0	-	40,4
2007	2,5%	1,6	617,8	-	41,4
2008	2,6%	1,6	633,8	-	42,5
2009	-0,8%	1,6	628,7	-	42,1
2010	1,4%	1,7	637,5	25,0	42,7
2011	3,8%	1,7	661,8	26,0	44,3
2012	3,0%	1,8	681,6	26,7	45,7
2013	1,0%	1,8	688,4	27,0	46,1
2014	1,5%	1,8	698,8	27,4	46,8
2015	1,5%	1,8	709,2	27,8	47,5
2016	1,5%	1,9	719,9	28,2	48,2
2017	1,5%	1,9	730,7	28,7	49,0
2018	1,5%	1,9	741,6	29,1	49,7
2019	1,5%	2,0	752,8	29,5	50,4
2020	1,5%	2,0	764,0	30,0	51,2
2021	1,5%	2,0	775,5	30,4	52,0
2022	1,5%	2,0	787,1	30,9	52,7
2023	1,5%	2,1	798,9	31,3	53,5
2024	1,5%	2,1	810,9	31,8	54,3
2025	1,5%	2,1	823,1	32,3	55,1
2026	1,5%	2,2	835,4	32,8	56,0
2027	1,5%	2,2	848,0	33,3	56,8

Source:

INE - National Statistic Institute

BP - Bank of Portugal

Source: CBA Guideline for CIVITAS Plus Evaluation (Draft 1.0), Transportation Research Group (TRG), School of Civil Engineering and the Environment, University of Southampton, UKIMPACT 2008, pg 13

The estimation of these values is based on the energy savings (MJ) and the bulk emissions factor (Annex 4). These energy savings per mode of transports is converted in g of pollutant by the density and the gross calorific factor of the fuel, weighted by the percentage of the fuel consumption in Portugal (annex 1). With these conversion is possible to have the emission factor per pollutant in g/MJ.

Emissions	CO	NOx	HC	CO2	PT
Diesel Buses (g/kgfuel)	11,88	40,75	4,18	3140	1,85
Diesel Passenger Car (g/kgfuel)	3,2	11,28	0,57	3140	0,72
Gasoline Passenger Car (g/kgfuel)	61,56	9,18	8,5	3180	0,03
Diesel Buses (g/MJ)	**0,277**	**0,949**	**0,097**	**73,115**	**0,043**
Diesel Passenger Car (g/MJ)	0,075	0,263	0,013	73,115	0,017
Gasoline Passenger Car (g/MJ)	1,430	0,213	0,197	73,867	0,001
Private Car - *weighted*	**0,370**	**0,251**	**0,053**	**72,928**	**0,013**

The total emissions per pollutant are:

- **BAU**

Energy Consumption	BAU
Energy Consumption (MJ) Private Car	**3.817.173**
Energy Consumption (MJ) PT	**8.340.027**
Passengers.km	**9.099.061**

	CO	NOx	HC	CO2	PT
Emissions Private Car (g)	1.413.501	956.570	204.019	278.379.028	50.287
Emissions PT (g)	2.307.066	7.913.548	811.746	609.780.151	359.265
TOTAL	**3.720.567**	**8.870.118**	**1.015.764**	**888.159.179**	**409.553**
TOTAL (ton.)	**3,72**	**8,87**	**1,02**	**888,16**	**0,41**

- **EX POST**

Energy Consumption	EX POST
Energy Consumption (MJ) PT	**10.047.416**
Passengers.km	**9.099.061**

	CO	NOx	HC	CO2	PT
Emissions Private Car (g)					
Emissions PT (g)	2.779.374	9.533.628	977.928	734.615.722	432.815
TOTAL	**2.779.374**	**9.533.628**	**977.928**	**734.615.722**	**432.815**
TOTAL (ton.)	**2,78**	**9,53**	**0,98**	**734,62**	**0,43**

The overall monetisation for emissions savings are shown in the next table.

Year	BAU CASE (A) -€				CIVITAS CASE (B) - €				BENEFIT (A-B) - €			
	NOx	HC	CO2	PT	NOx	HC	CO2	PT	NOx	HC	CO2	PT
2012	15,72	692,36	23.739,16	18,70	16,90	666,57	19.635,18	19,77	-1,18	25,79	4.103,99	-1,06
2013	15,88	699,28	23.976,55	18,89	17,06	673,23	19.831,53	19,96	-1,19	26,05	4.145,03	-1,07
2014	16,11	709,77	24.336,20	19,17	17,32	683,33	20.129,00	20,26	-1,21	26,44	4.207,20	-1,09
2015	16,36	720,42	24.701,25	19,46	17,58	693,58	20.430,94	20,57	-1,22	26,83	4.270,31	-1,11
2016	16,60	731,22	25.071,76	19,75	17,84	703,99	20.737,40	20,88	-1,24	27,24	4.334,36	-1,12
2017	16,85	742,19	25.447,84	20,05	18,11	714,55	21.048,46	21,19	-1,26	27,65	4.399,38	-1,14
2018	17,10	753,32	25.829,56	20,35	18,38	725,26	21.364,19	21,51	-1,28	28,06	4.465,37	-1,16
2019	17,36	764,62	26.217,00	20,66	18,66	736,14	21.684,65	21,83	-1,30	28,48	4.532,35	-1,17
2020	17,62	776,09	26.610,26	20,97	18,94	747,18	22.009,92	22,16	-1,32	28,91	4.600,34	-1,19
2021	17,89	787,73	27.009,41	21,28	19,22	758,39	22.340,07	22,49	-1,34	29,34	4.669,34	-1,21
2022	18,15	799,55	27.414,55	21,60	19,51	769,77	22.675,17	22,83	-1,36	29,78	4.739,38	-1,23
2023	18,43	811,54	27.825,77	21,92	19,80	781,31	23.015,30	23,17	-1,38	30,23	4.810,47	-1,25
2024	18,70	823,72	28.243,16	22,25	20,10	793,03	23.360,53	23,52	-1,40	30,68	4.882,63	-1,26
2025	18,98	836,07	28.666,80	22,59	20,40	804,93	23.710,94	23,87	-1,42	31,14	4.955,87	-1,28
2026	19,27	848,61	29.096,81	22,92	20,71	817,00	24.066,60	24,23	-1,44	31,61	5.030,21	-1,30
2027	19,56	861,34	29.533,26	23,27	21,02	829,26	24.427,60	24,59	-1,46	32,08	5.105,66	-1,32

ANNEX 6: Structure and questions of the Survey

SECTION A: PERSONAL DATA

Main residence

A1 Postcode ☐☐☐ ☐☐☐☐

Place _____
Parish _____
District _____

A2 Sex

(1) Male ☐

(2) Female ☐

A3 Age

(1) Less than 25 ☐
(2) 25 – 34 ☐
(3) 35 – 44 ☐
(4) 45 – 55 ☐
(5) Over 55 ☐

SECTION B: DAILY TRAVEL

B1 Usually how many trips you make daily?

Nº of trips ☐

B2 Did you made any transfer on this trip?

Indicate the number transfer made ☐

B3 Until the end of last year did you usually travelled in SMTUC public transportation?

(1) Yes ☐
(2) No ☐

B4 If you answered No, please indicate how normally you travelled by that date?

(1) Car driver ☐
(2) Passenger car ☐
(3) Bike ☐
(4) Walking ☐
(5) Taxi ☐
(6) Bus ☐
(7) Train ☐
(8) Motorcycle ☐
(9) Other (specify) _____

B5 If you have changed your mode of travel, the new ticketing system (tickets or bus pass) had an influence on your decision making?

(1) Yes ☐
(2) No ☐

B6 What is your level of satisfaction with the ticketing systems? (1 - Very Dissatisfied 2 - Dissatisfied; 3- Satisfied; 4 - Very Satisfied)

Satisfaction	1	2	3	4
New system?				
Old system?				

This survey has been carried out in September 2012 and has been used for the assessment of the modal shift for the ex-post results, as well as the Baseline and Business as Usual scenarios through specific questions (B3, B4 and B5). The survey has been also used for the assessment of the Acceptance level (Question B6).

The survey was carried out to customers by face to face interviews on board of the SMTUC buses.

The sample was drowned on the basis of the lines used by the passengers, i.e., the number of interviews chosen in each line is defined according to the demand of the line relative to the overall SMTUC demand.

The dimension of the sample was defined according to the specifications of the quality management auditors which supervise the all process in line with the ISO 9001 standard.

The quality management auditors considered 500 interviews as (a minimum) suitable to assess quality evaluation by PT passengers in Coimbra. However, SMTUC volunteered to go above this number

From the total universe of passengers, 775 surveys, adjusted proportionately to the various lines that make up the network of public transport (PT) in Coimbra were carried out of which 750 were validated.

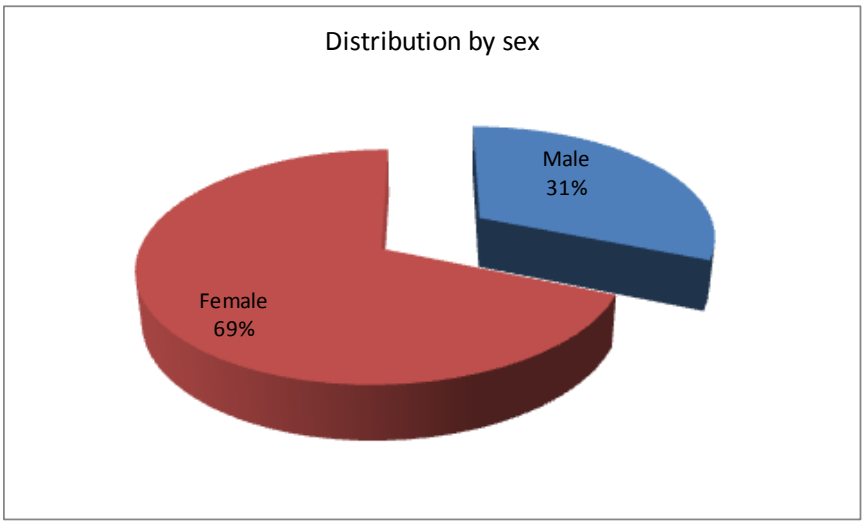
This sample is considered significant compared to the universe of users of public transport, was based on the Assessment Survey of Customer Satisfaction - Users of Liner for the year 2012, focusing on a sample universe of 750 surveys.

The survey was divided into two sections, the first relating to the identification of the respondent's personal data, including the main residence, sex and age.

The second part, aimed at determining the commuting of respondents, the number of daily trips and transfer. Similarly, this second part sought to evaluate the change in mode of transport registered, as well as the shifting of the universe of respondents who made this change.

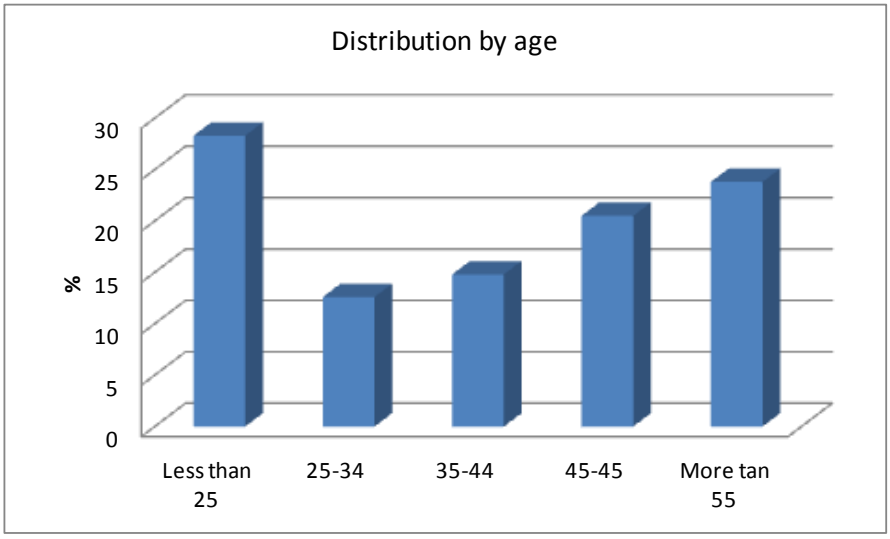
Finally, sought to determine the degree of satisfaction of the new ticketing system implemented in 2012, as well as the old system was replaced.

For the analysis investigations conducted, the responses highlight a universe of respondents that are spread over about 68% female and 31% male.



With respect to the distribution of respondents by age, they are divided with particular for younger step (less than 25) and which corresponds mostly to the age population school.

Moreover, the weight of the population over 55 years, although at a lower expression level than younger also proves decisive in the universe consulted. In other distributions, it is evident that the weight older ages (45-55) have the universe of passengers, to the detriment of younger ages (25-34) showing a trend in the use of TP on the part of the population aged more advanced.



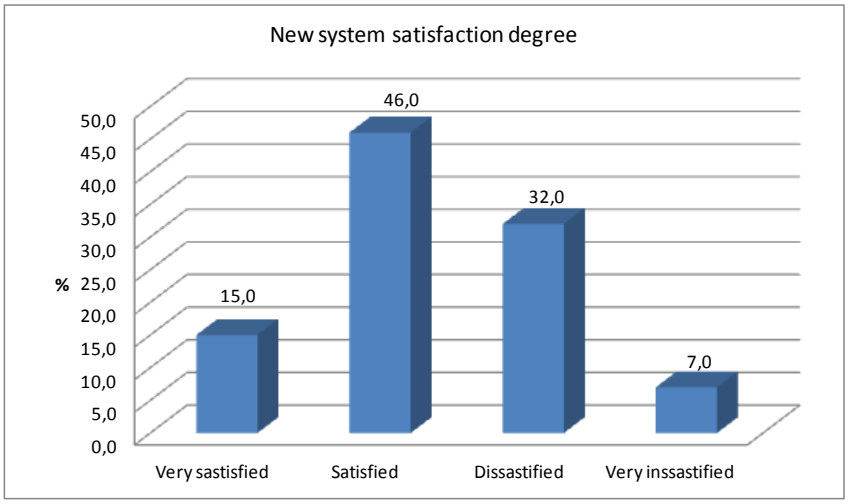
Concerning the mode of travel used this period as well as the influence of the new ticketing system, implemented in 2012, as a determining factor in this change, from the total number of responses (736), about 91% of respondents revealed not have changed their mode of travel, which means they were already regular users of public transport, over the previous year.

The remaining 9.1% answered affirmatively to the question, indicating that there was a change in their usual mode of travel, that is, began to use the TP in the previous year.

Regarding the influence of the new ticketing system as a key factor in changing the mode of travel 13.4% revealed that this was the reason that led to the transfer of individuals to TP , which corresponds to 1.2% of the total 736 respondents in this survey.

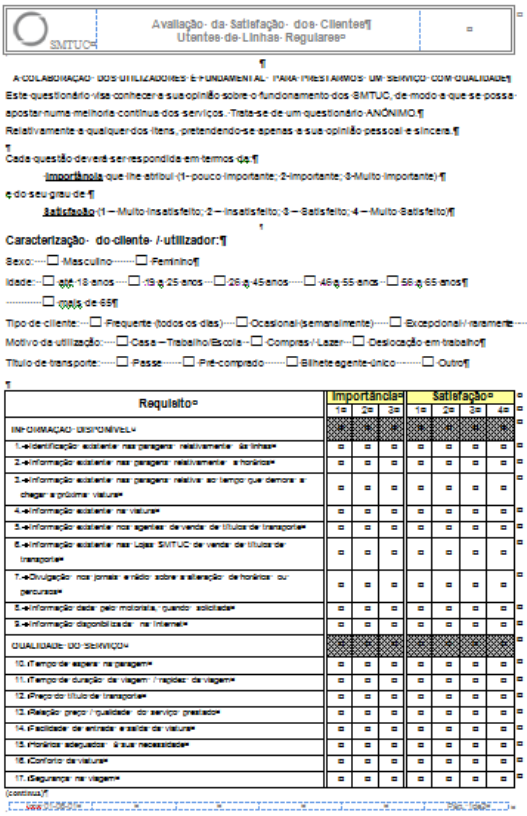
This result proves the modernity factor of this system, coupled with its functionality, as key factor in the decision of the respondents.

The evaluation of the degree of satisfaction of respondents on the new ticketing system as well as the old system replaced, revealed that regarding the new system, 15% reported being very satisfied and about 46% consider it satisfactory. Furthermore, a significant percentage (32%) showed dissatisfaction with this system and indicated a 7% high dissatisfaction.



The responses regarding the degree of satisfaction of ancient ticketing system revealed high satisfaction rates, particularly for individuals 47% very satisfied and 49% of respondents satisfied. The values for degrees of dissatisfaction are low and not even reach 5% in both cases.

ANNEX 7: Quality PT Service – Custom Satisfation Survey



SMTUC

Avaliação da Satisfação dos Clientes
Utentes de Linhas Regulares

A COLABORAÇÃO DOS UTILIZADORES É FUNDAMENTAL PARA PRESTARMOS UM SERVIÇO COM QUALIDADE

Este questionário visa conhecer a sua opinião sobre o funcionamento dos SMTUC, de modo a que se possa apostar numa melhoria contínua dos serviços. Trata-se de um questionário ANÓNIMO.

Relativamente a qualquer dos itens, pretendendo-se apenas a sua opinião pessoal e sincera.

Cada questão deverá ser respondida em termos da:

Importância que lhe atribui (1- pouco importante; 2 – importante; 3-Muito importante)

e do seu grau de **Satisfação** (1 – Muito insatisfeito; 2 – Insatisfeito; 3 – Satisfeito; 4 – Muito Satisfeito)

Caracterização do cliente / utilizador:

Sexo: ☐ Masculino ☐ Feminino

Idade: ☐ até 18 anos ☐ 19 a 25 anos ☐ 26 a 45 anos ☐ 46 a 55 anos ☐ 56 a 65 anos ☐ mais de 65

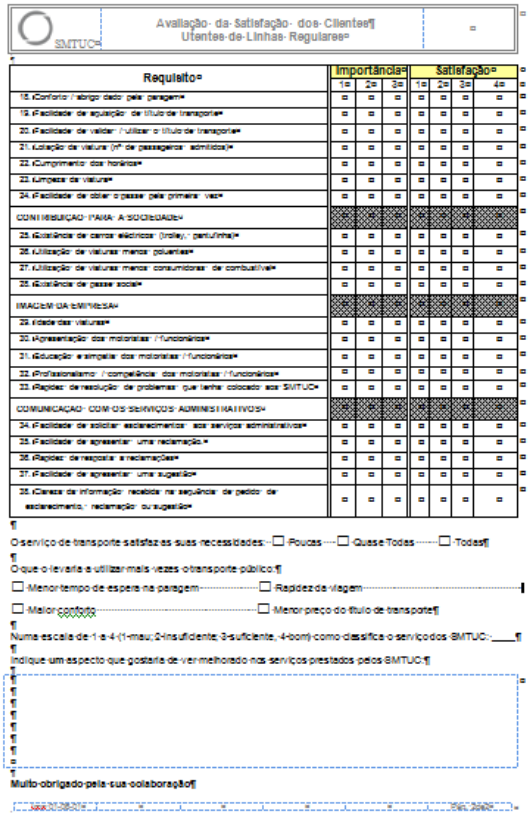
Tipo de cliente: ☐ Frequente (todos os dias) ☐ Ocasional (semanalmente) ☐ Excepcional/raramente

Motivo da utilização: ☐ Casa – Trabalho/Escola ☐ Compras/Lazer ☐ Deslocação em trabalho

Título de transporte: ☐ Passe ☐ Pré-comprado ☐ Bilhete agente único ☐ Outro

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
INFORMAÇÃO DISPONÍVEL							
1. Identificação existente nas paragens relativamente às linhas	☐	☐	☐	☐	☐	☐	☐
2. Informação existente nas paragens relativamente a horários	☐	☐	☐	☐	☐	☐	☐
3. Informação existente nas paragens relativa ao tempo que demora a chegar a próxima viatura	☐	☐	☐	☐	☐	☐	☐
4. Informação existente na viatura	☐	☐	☐	☐	☐	☐	☐
5. Informação existente nos agentes de venda de títulos de transporte	☐	☐	☐	☐	☐	☐	☐
6. Informação existente nas Lojas SMTUC de venda de títulos de transporte	☐	☐	☐	☐	☐	☐	☐
7. Divulgação nos jornais e rádio sobre alteração de horários ou percursos	☐	☐	☐	☐	☐	☐	☐
8. Informação dada pelo motorista, quando solicitada	☐	☐	☐	☐	☐	☐	☐
9. Informação disponibilizada na Internet	☐	☐	☐	☐	☐	☐	☐
QUALIDADE DO SERVIÇO							
10. Tempo de espera na paragem	☐	☐	☐	☐	☐	☐	☐
11. Tempo de duração da viagem / rapidez da viagem	☐	☐	☐	☐	☐	☐	☐
12. Preço do título de transporte	☐	☐	☐	☐	☐	☐	☐
13. Relação preço / qualidade do serviço prestado	☐	☐	☐	☐	☐	☐	☐
14. Facilidade de entrada e saída da viatura	☐	☐	☐	☐	☐	☐	☐
15. Horários adequados à sua necessidade	☐	☐	☐	☐	☐	☐	☐
16. Conforto da viatura	☐	☐	☐	☐	☐	☐	☐
17. Segurança na viagem	☐	☐	☐	☐	☐	☐	☐

(continua)



SMTUC

Avaliação da Satisfação dos Clientes
Utentes de Linhas Regulares

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
18. Conforto / abrigo dado pela paragem	☐	☐	☐	☐	☐	☐	☐
19. Facilidade de aquisição de título de transporte	☐	☐	☐	☐	☐	☐	☐
20. Facilidade de validar / utilizar o título de transporte	☐	☐	☐	☐	☐	☐	☐
21. Lotação da viatura (nº de passageiros admitidos)	☐	☐	☐	☐	☐	☐	☐
22. Cumprimento dos horários	☐	☐	☐	☐	☐	☐	☐
23. Limpeza da viatura	☐	☐	☐	☐	☐	☐	☐
24. Facilidade de obter o passe pela primeira vez	☐	☐	☐	☐	☐	☐	☐
CONTRIBUIÇÃO PARA A SOCIEDADE							
25. Existência de carros eléctricos (tróley), pentolinha	☐	☐	☐	☐	☐	☐	☐
26. Utilização de viaturas menos poluentes	☐	☐	☐	☐	☐	☐	☐
27. Utilização de viaturas menos consumidoras de combustível	☐	☐	☐	☐	☐	☐	☐
28. Existência de passe social	☐	☐	☐	☐	☐	☐	☐
IMAGEM DA EMPRESA							
29. Idade das viaturas	☐	☐	☐	☐	☐	☐	☐
30. Apresentação dos motoristas / funcionários	☐	☐	☐	☐	☐	☐	☐
31. Educação e simpatia dos motoristas / funcionários	☐	☐	☐	☐	☐	☐	☐
32. Profissionalismo / competência dos motoristas / funcionários	☐	☐	☐	☐	☐	☐	☐
33. Rapidez de resolução de problemas que tenha colocado aos SMTUC	☐	☐	☐	☐	☐	☐	☐
COMUNICAÇÃO COM OS SERVIÇOS ADMINISTRATIVOS							
34. Facilidade de solicitar esclarecimentos aos serviços administrativos	☐	☐	☐	☐	☐	☐	☐
35. Facilidade de apresentar uma reclamação	☐	☐	☐	☐	☐	☐	☐
36. Rapidez de resposta a reclamações	☐	☐	☐	☐	☐	☐	☐
37. Facilidade de apresentar uma sugestão	☐	☐	☐	☐	☐	☐	☐
38. Clareza da informação recebida na sequência de pedido de esclarecimento, reclamação ou sugestão	☐	☐	☐	☐	☐	☐	☐

O serviço de transporte satisfaz as suas necessidades: ☐ Poucas ☐ Quase Todas ☐ Todas

O que o levaria a utilizar mais vezes o transporte público:

☐ Menor tempo de espera na paragem ☐ Rapidez da viagem

☐ Maior conforto ☐ Menor preço do título de transporte

Numa escala de 1 a 4 (1-mau; 2-insuficiente; 3-suficiente, 4-bom) como classifica o serviço dos SMTUC: ____

Indique um aspecto que gostaria de ver melhorado nos serviços prestados pelos SMTUC:

Muito obrigado pela sua colaboração

Quality of service is measured by means of customer satisfaction survey periodically carried out by SMTUC:

The survey is repeated 1 time a year and is carried out to customers on face to face interviews on board of the SMTUC busses.

The sample is drowned on the basis of the lines used by the passengers, i.e., the number of interviwees choosen in each line is defined according to the demand of the line relative to the overall SMTUC demand.

The dimension of the sample is defined according to the specifications of the quality management auditors which supervise the all process in line with the ISO9001 standard.

The quality management auditors considered 500 interviews as (a minimum) suitable to assess quality evaluation by PT passengers in Coimbra. However, SMTUC voluntered to go above this number.

The questionnaire starts with 4 questions related to the interviewee – Sex, Age (<18, 19-25, 26-45, 56-65, >65),type of client (frequent, occasional, exceptional/rare use), motive of the trip (home-work/school, shopping/leisure, in service), type of ticket (pass, single ticket bought on the selling point, single ticket bought on the vehicle, other).

The main part of the questionnaire is composed of 38 specific questions related to various items related to 5 areas of the service (1-Available information, 2-Quality of service, 3-Contribution to society, 4-Image of the company, 5-Communication with the administrative services) and a specific

global customer satisfaction question that resume quality of service. In each question the people interviewed express a judgement choosing between very satisfied – satisfied – unsatisfied – very unsatisfied and about the importance of each of the 38 items choosing between very important – important – low importance.

Each question is assessed in terms of importance given (1-Not important, 2-Important, 3-Very Important) and level of satisfaction (1-Very Dissatisfied 2-Dissatisfied 3-Satisfied 4-Very Satisfied) of the user in relation to the respective item.

The next table shows the translation of the questionaires – some questions changed between questionaires, but the questions used in this measure has been maintained during all the years, only changing the order in the questionaire (questions 19 and 20 in this questionaire):

AVAILABLE INFORMATION
1. Identification of existing lines at stops
2. Information at stops about timetables
3. Information at stops about the waiting time until the next vehicle
4. Information inside the vehicle
5. Information at ticket selling points
6. Information at SMTUC ticket selling shops
7. Disclosure of information in the newspapers and radio about timetable or routes changing[10]
8. Information given by the driver, upon request
9. Information available on the Internet
QUALITY OF SERVICE
10. Waiting time at stop
11. Trip duration / speed of travel
12. Price of the ticket
13. Relation Price / Quality of the service
14. Ease of entry and exit of the vehicle
15. Adjustment of the timetable to your needs
16. Comfort of the vehicle
17. Safety during the trip
18. Comfort / protection given by the stop shelter
19. Ease of ticket purchase

[10] This question was eliminated on the 2010, 2011 and 2012 surveys.

20. Ease of ticket validation / utilization
21. Capacity of the vehicle (nr. of passengers allowed)
22. Compliance with the timetable
23. Cleanliness of the vehicle
24. Facility in obtaining the travelcard for the first time
CONTRIBUTION TO SOCIETY
25. Existence of electric vehicles (trolleybuses, electric mini-buses)
26. Utilization of less polluting vehicles
27. Utilization of less fuel consumming vehicles
28. Existence of social travelcard
IMAGE OF THE COMPANY
29. Age of the vehicles
30. Presentation of drivers / staff
31. Education and friendliness of the drivers / staff
32. Quality of driving performance of SMTUC drivers
33. Professionalism / competence of the drivers / staff
34. Quickness in the resolution of problems you may have submited to SMTUC
COMMUNICATION WITH THE ADMINISTRATIVE SERVICES
35. Facility in requesting clarifications to the administrative services
36. Facility in submmiting a complaint.
37. Response quickness in respect to complaints
38. Facility in presenting a suggestion
39. Clarity of the information obtained in response to a request for information, complaint or suggestion

The questionnaire concludes with 5 questions related to the respondent's general attitude towards the service supplied by SMTUC:

1. The transportation service meets your needs (1-Few, 2-Nearly all, 3-All)

2. What would make you consider using public transportation more often (1-Shorter waiting time at stops, 2-Higher speeds, 3-Increased comfort, 4-Lower price of the ticket)

3. How do you rate the SMTUC service on a scale of 1 to 4 (1-bad, 2-poor, 3-sufficient, 4-good)

4. Indicate a point you would like to see improved in the SMTUC service:

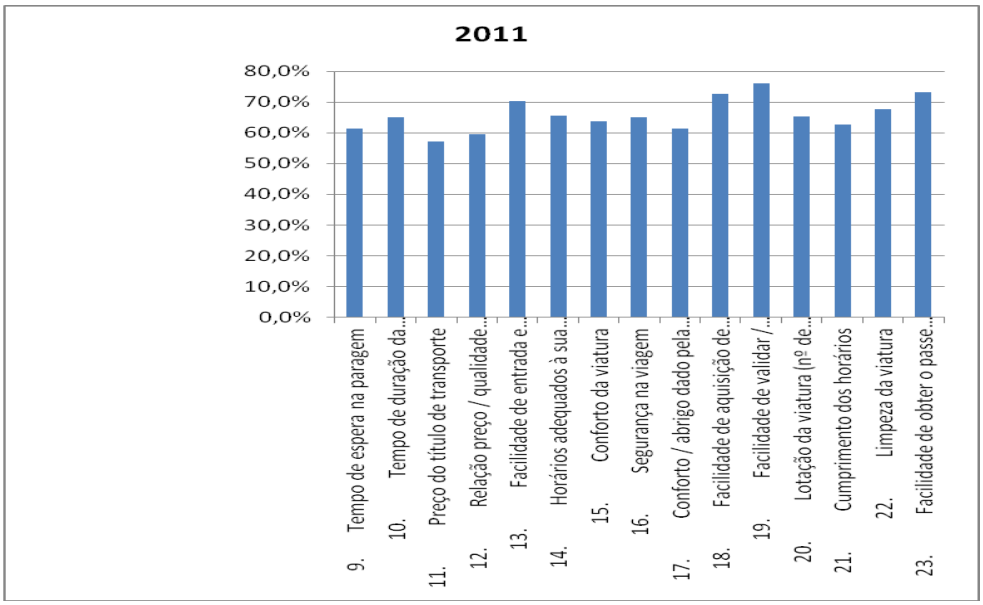
So the two questions that were considered in this measure were:

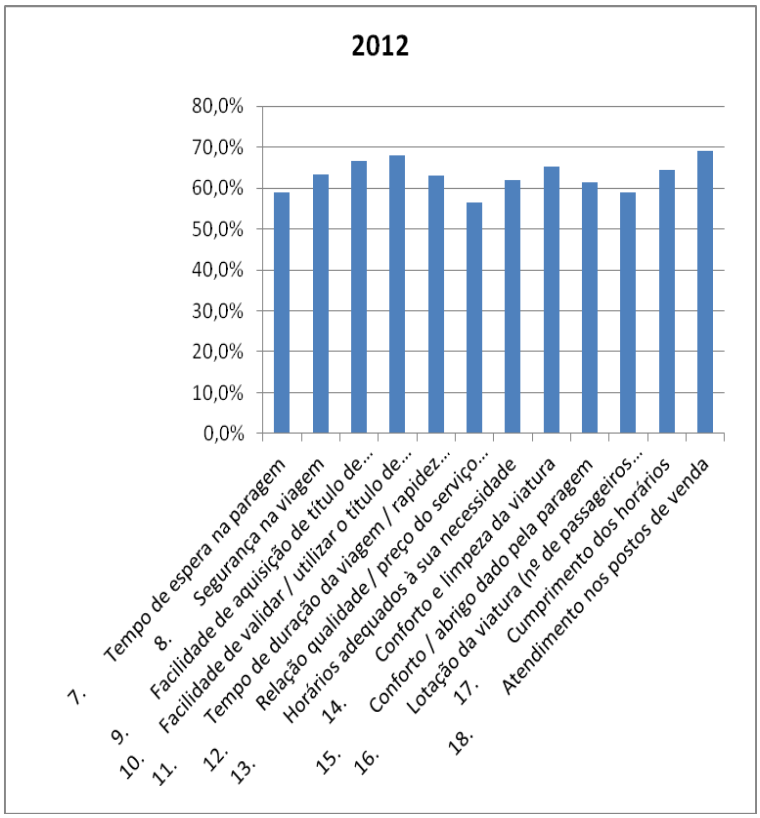
- Ease of ticket purchase

- Ease of ticket validation / utilization

The next graphs show the results of the impo

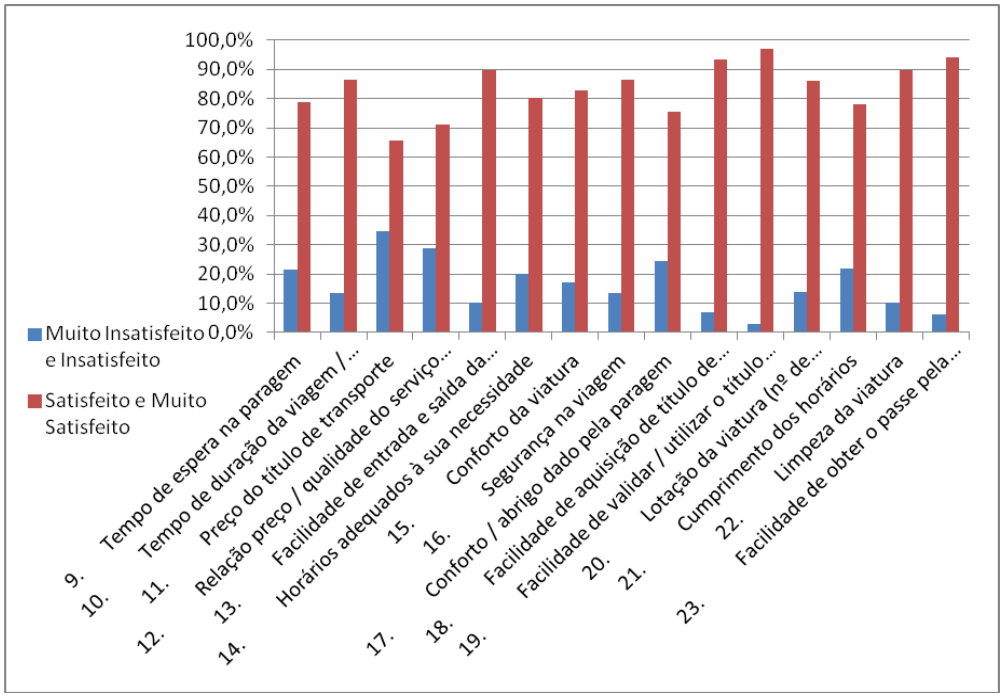
Importance given to the Quality of Service (Questions 19 and 23 in 2011 and 9 and 10 in 2012)

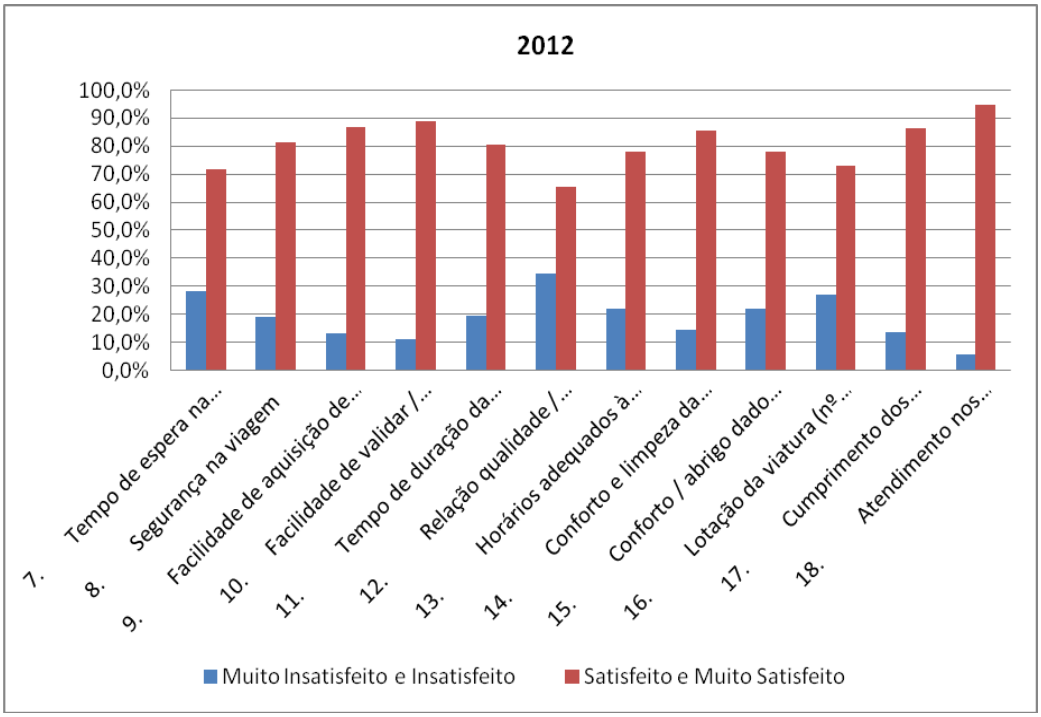




Level of satisfaction in relation to the Quality of Service (Questions 19 and 23 in 2011 and 9 and 10 in 2012 – red-satisfied or very satisfied / blue-unsatisfied of very unsatisfied)

2011





M04.02 – Executive summary

This measure comprises the creation of an important mobility centre in Coimbra that integrates all the transport operators as well as the development of a planning tool for the Municipal Public Transportation Services of Coimbra's (SMTUC) internet website (i.e., RUMOS – **R**otas **U**rbanas em **MO**bilidade **S**ustentável - Urban Routes in Sustainable Mobility) allowing any user to know how to travel in an optimised way by defining the desired temporal, economic or sustainability criteria.

The innovative aspects of this measure – the use of new technologies in the trip planner based in a geographic information system (GIS) (whose acquisition has been useful for other tasks in SMTUC, such as the network planning), and the implementation (one of) the first mobility centre in Portugal – are very significant at national level.

These innovations are very relevant because they help to overcome an old problem in Coimbra that is the lack of integrated information on multi-modal trips and thus allow users to take full advantage of the support that the Coimbra Municipality has given by financing the creation of tickets combining different transport operators.

The demonstration of the measure within the CIVITAS MODERN period showed that this measure is feasible at a relatively low cost in comparison to those of other PT operations.

The demonstration of the measure resulted in a short period of time in an increase of the awareness level of population, and also in the increase of the acceptance level of the users and in the level of the quality of PT service. The results demonstrated that the acceptance level of the measure is very high (95% in 2011) and 95,1% were satisfied or very satisfied with the service provided by the Infomobility Centre in 2011. The acceptance level of the public transport operators was 100% in all the surveys carried out.

In 2011 the Infomobility Centre registered 34.040 customers (an average of 2.836 per month). There are 4688 accesses to "RUMOS" trip planner per month, greatly exceeding the 1500 accesses that were initially foreseen.

With the implementation of the measure we learnt that:

- Risk management is important taking into consideration that licensing procedures, linked to the centre location (in the historic centre), could be time a consuming activity, Rigorous planning and follow-up of the process is fundamental;
- The involvement of the municipality is critical to achieving commitments among all stakeholders, as well as in the negotiation process concerning the financial issues;
- Promoting meetings about good practices on sustainable mobility and urban development is of paramount importance in order to involve all the stakeholders;
- It is essential in the implementation of a trip planner to involve the developers of the systems during all the stages to know exactly what is needed and required in the initial specification stage, including system interoperability, which is increasingly important as more PT operators are included within the system.

A Introduction

A1 Objectives

The measure objectives are:

(J) High level / longer term:

- To improve the city air quality.
- To decrease city traffic levels.

(K) Strategic level:

- To increase the number of trips made in a sustainable way over the use of private car, in particular trough better information and the promotion about new mobility services and PT, with a special attention to female public.

(L) Measure level:

(1) To establish a mobility centre facility in town integrating all transport operators in order to reach at least 75% of PT operators accepting the measure and 80% of PT users accepting the measure.

(2) To implement a public web service, which will provide an online trip planner interfaced with the SMTUC automated vehicle management (AVM) system that provides the data updates, in order to surpass 1500 accesses per month to the RUMOS trip planner.

(3) To promote mobility marketing.

(4) To increase 1,5% percentage of female passengers transported by the SMTUC.

A2 Description

In the scope of this measure it was implemented an important mobility centre in Coimbra that integrates all the regional transport operators, answering the diverse transport needs of the population and giving them a capable and ready information on the most sustainable way of travelling.

This is because the mobility centre includes not only ticket sales and an information area about transports, but the centre has also became a permanent forum to exchanging ideas on sustainable mobility, allowing for more personalized assistance to the general public. This forum has been used for the launching of mobility campaigns and the venue of related initiatives, including those of other entities.

The Infomobility Centre has been installed in a new and modern place located in the City centre, near the railway station and the main interfaces of all PT operators.

The management of the Infomobility Centre is carried out by SMTUC – the public transportation service dependent on the Municipality and functioning as municipal mobility entity – that also

supports all the costs with the centre's personnel - helped by CIVITAS funds during the MODERN project. These facts helped achieve a good partnership, involving all the local public transport operators, and to increase the overall sustainable of the mobility operations. The Centre renting was supported by the other PT operators (3 regional bus operators and the national railway operator)

The Centre runs at least with 2 staff members simultaneously from 7:30 to 19:30 (Monday to Friday) and one from 8:00 to 13:00 (on Saturdays) that sell and reload e-tickets and e-cards, customise new e-cars, provide information about the services, namely trough promotional and informative flyers / leaflets, and help in the organization of events hosted at the Centre. These staff members had training to be able to provide information on all PT operators and to evaluate and monitor the functioning of the centre (including the attendance of the Centre by each PT operator and task, as well as analyse customer suggestions and complaints).

The centre has 3 attendance points voted for any PT operator (fig.1) with equipment for sale and re-load the e-tickets and e-cards, as well as the customising of the new e-cards or the consultation of trip planners. The lobby was also equipped with a Queue machine, an Automatic Vending Machine, a display to show promotional videos and exhibitors and shelves for promotional material (leaflets / flyers).

Fig. 1 – The Infomobility Centre with 3 attendance points (left), the Queue Machine (centre) and an Automatic Vending Machine (right).

To guarantee the quickest and highest quality information possible in customer travel information, either at the Infomobility Centre or at any other place, a tool was launched in the SMTUC's internet website allowing any user to know how to travel in an optimised way, defined by rapidity, costs or sustainability criteria. This included also geo-reference cartographic information.

For this reason the online trip planner RUMOS (**R**otas **U**rbanas em **MO**bilidade **S**ustentável - Urban Routes in Sustainable Mobility) was based on a geographic information system (GIS) whose acquisition has been useful for other SMTUC tasks , such as the network planning.

This application, developed by Critical Software, a CIVITAS MODERN partner, allows the user to insert the origin or destination places by typing places names, by choosing interest points or bus stops through a list or by indicating directly the places in the City map. The user can also choose date and hour, as well as several other parameters to customise the travel, such as the travel transport mode, the travel specifications (more economic, quicker) or the duration of the pedestrian travel.

The resulting route will pay attention to several criteria for optimising the travel (quickness, economic or ecological costs, pedestrian efforts linked to the ground characteristics, …) and the output is the

travel description that includes streets, bus stops, bus lines, travel costs and CO^2 emissions. The route is also displayed in the City map.

Concerning the RUMOS SQL Database structure, it is composed by different geographic data elements, which are merged into a unique Geographic Data Base (GDB). It is compose by the *TELEATLAS MultiNet* digital mapping, *the Network Dataset* and the individual bus information, such as departures, arrivals, duration and estimated distance throughout specific time tables for different seasons of the year.

The Centre personnel make also the monitoring of the RUMOS trip planner (mainly the data base consistency and the failures during the test phase of this system).

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure were:

- **New conceptual approach, nationally**
  - In Portugal there is no tradition in using Mobility Centres to facilitate the intermodality and interoperability of citizens mobility needs, or to promote sustainable mobility. "Coimbra Infomobility Centre" is, together with the "Oporto Mobility Shop" integrated in the CIVITAS ELAN measure, are only mobility centres in Portugal.
- **Use of new technology/ITS, nationally**
  - Optimisation of geo-referenced travel planning through the online trip planner RUMOS, with a multi-modal option in the choice criteria (motorized or non-motorized ways) and the possibility of enhancing the solutions that most contribute to sustainable mobility, with the information of the price of the trip using Public Transport and the information about CO2 emissions (comparatively to the trip in a private car).

B2 Research and Technology Development

The research and development activities have been carried out to set-up the Infomobility Centre and to develop the RUMOS trip planner and could be summarized as follows:

- The conception and definitions of technical specifications of the Infomobility Centre, in relation to the above mentioned objectives has been made by SMTUC, the urban public transport operator. To enhance the knowledge on this field, it has been carried out on-line research to analyse other mobility centres, as well as contacts with experts and the visit to the mobility centre of Genoa, The site coordinator and the measure leader also participated in a CIVITAS ELAN workshop on mobility shops. Technicians of SMTUC participated in the design of the centre and of the logo and defined the trade mark. Some achieved requirements defined for the centre were:

- The specifications established that the placement of the new Infomobility Centre should be in the historic centre in new installations instead of the remodelling of an existing point of sales.
- The space should be pleasant and modern to improve the image of PT for the public, in particular for young people.
- The Infomobility Centre should be able to integrate the information and the products of all the local PT operators and sustainable mobility strategies in general, using modern communication tools, as well as to provide conditions to host events and campaigns.

- Several meetings and work sessions have been made with the other PT operators to define the functionalities of the centre and the repartition of costs (SMTUC support all the costs excepted the Centre renting, that is supported by the other PT operators).

- The development of a public web service with RUMOS (**R**otas **U**rbanas em **MO**bilidade **S**ustentável - Urban Routes in Sustainable Mobility) was made by Critical Software, a CIVITAS MODERN partner. The work undertaken in this task was the research of the best technologies to achieve the objectives, including the analyse of similar products, several work sessions with SMTUC technicians to define the best solutions and specifications, the development and delivery of the trip planner, the tests and corrections of the first versions of the application, the implementation of the RUMOS back-office and the delivery of the application users manual. The main aspects of this work can be summarised as follows:

The objective of the research and development of the "RUMOS" was to provide a user-friendly trip planner (WEB Interface) offering *optimized journey information for Coimbra's Public Transport users*. The success of the innovative deployment of the RUMOS software application has been to allow the end-user to select the best journey information according to his needs - *POWER TO THE USER* - depending on the following decision criteria:

- Environmental impact assessment, contributing to a greener environment, by presenting the direct comparison of the Carbon Dioxide (CO2) emissions between public transport and the use of the automobile - necessary in the competition against growing private car usage;
- Walking cut-off threshold option with respect to the end users with reduced mobility;
- Optimization of the bus routes supported by dynamic timetables (each bus stop follows-up a predefined daily schedule according to the defined user date);
- Reduced mobility criteria with respect to the optimization of the final route based on both pedestrian effort (kJ) and distance (m);
- Maximum number of end-user required "transhipments / interchanges" with respect to the whole planned journey.

The key research was focused on using a real case study to provide an extension to currently existing GIS Framework APIs and solve the "*MultiObjective Shortest Path Problem*".

This required a software solution based on an optimization of the decision algorithm for the construction of the network (bus and pedestrian route), accordant to the "state of the art" - Combinatorial Optimization.

Finding such a solution and quantifying which one is the best to be exposed to the end user was the major challenge in providing a solution to this "*MultiObjective Optimization*" problem.

The first approach to this problem has used the *monocriteria* model, whose optimal solutions have not met the requirements of the SMTUC users. Next, we have tried the *multicriteria* formulation which fit customer expectations.

The criteria used in the optimization process were, essentially, the distance, the travel time, and the number of *transfers*. However, other criteria should be included at a later stage. The optimization of the number of transfers required further investigation because the properties of the *multicriteria* shortest path problem, involving distance and travel time, were not valid when using the number of transfers. Therefore, an adaptation of the dominant concept was proposed.

During the research process, criteria such as pedestrian time and pedestrian effort where included. The total number of criteria increased from two to four simultaneous optimized objectives, allowing us to define the best path, just by balancing the criteria chosen (number of transhipments, total time, pedestrian time and pedestrian effort) so that we can establish a more user friendly result. The paths are then selected by the emphasis that each user gives to a single criterion.

The fig.2 shows the architecture of the system:

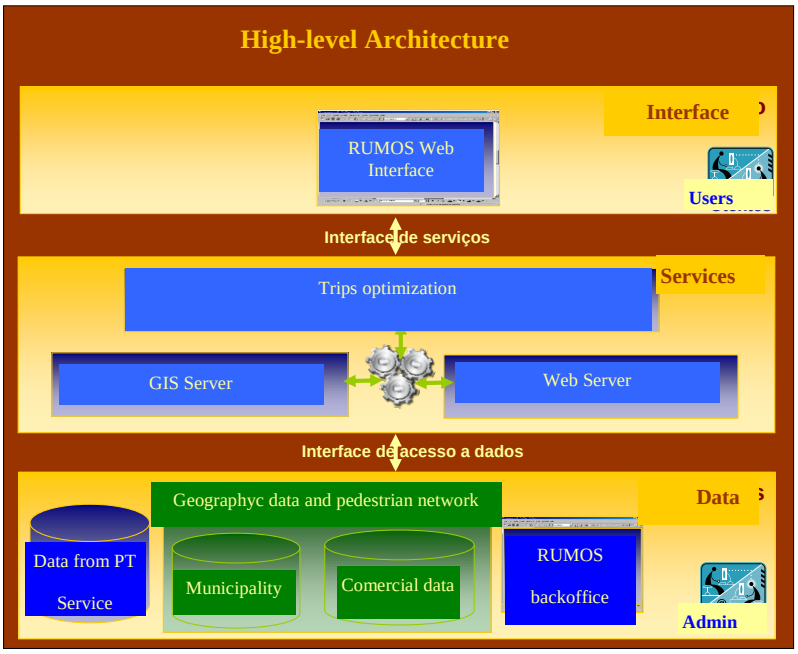


Fig.2 – The Architecture of the RUMOS Trip planner

The ***WEB Interface*** provides the abstract end-user functionalities to interact with the application. Concerning the ***RUMOS SQL Database*** structure, it is composed by different geographic data elements, which are merged into a unique Geographic Data Base (GDB). It is compose by the *TELEATLAS MultiNet* digital mapping, *the Network Dataset* and the individual bus information, such as departures, arrivals, duration and estimated distance throughout specific time tables for different seasons of the year. The *Network Dataset* is built with a GIS framework (ESRI) capable of providing the required data for a structured network topology to be extracted and built – the ***RUMOS (SMTUC/Coimbra) Network*** (fig.3), which is a structured data input to the developed software, decision and optimization, algorithm.

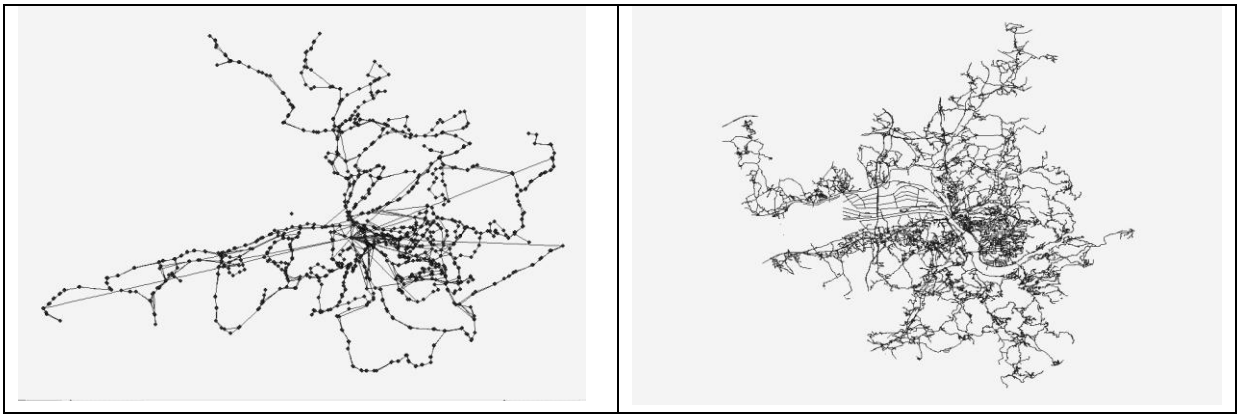


Fig. 3 – *Shape Files* of SMTUC PT Routes and Bus stops (Left) and of the streets network of Coimbra municipality (Right)

The maintenance of the data is ensured by a set of tools – ***the Back-Office***, providing direct access for the system administrator to work on the database avoiding any data inconsistency.

B3 Situation before CIVITAS

Before CIVITAS Coimbra had 7 public information offices (excluding the train station), four of them owned by the Urban Public transport operator (SMTUC) and the others owned by each of the private public transport operators.

Essentially, these offices work with information and ticket sales of each individual operator, except for the combined pass involving the SMTUC and the other operators. Concerning information, the public attendance was registered only to collect suggestions / complaints and to provide operator specific information.

However, part of the population doesn't use public transports due to the general lack of information, a low level of overall awareness of each individual possible contribution to sustainable mobility, as well as a lack of knowledge about the different options in using local public transportation.

From this aspect, it is necessary to give special attention to the increased difficulty in the women's mobility needs. This happens also because the majority of women have specific displacements related to the family duties, a fact resulting from a traditional Portuguese family structure.

Coimbra Municipality has supported, namely financially, the population's needs for inter-operational and multi-modal displacements, specifically through the provision of several products combining tickets between the different bus operators and SMTUC and between SMTUC and the railway operator. However, this strategy does not totally result because each public office does not provide general information – the information is mainly about the individual operator. The citizen has difficulty accessing all the information about his mobility options, mainly when they need to use several modes of transport or operators. Before CIVITAS these citizens needed to move through several sales points in the City to have information about each operator or purchase combined fares.

For this reason, there is a lack of a mobility centre which is able to integrate all the mobility information and products of all the operators as well as the existing sustainable mobility strategies using modern communication tools. This would allow citizens to take advantage of all the information available and would simplify the consultation by each individual citizen. Thus each citizen could be viewed as a unique consumer or a member of a group sharing the same mobility requirements (e.g., professional working class, students).

Also the 7 existing sales points are very narrows, so without conditions to host more equipment resulting of the mix of all PT operators functionalities in a common place or to host mobility events that could sensitise the citizens for the best mobility practices (promotional campaigns, public presentations, workshops, meetings with users associations / stakeholders, …). These facts advised the Municipality and SMTUC to opt for the implementation of the mobility centre in a new facility which was renewed and is located in the City centre.

As a catalyst of the process of the implementation of the Infomobility Centre, CIVITAS allowed the inhabitants of Coimbra region to benefit sooner of the advantages provided by the centre, namely those provided by the association of all the PT operators in the Coimbra region – all the information about mobility and the sale of tickets of all the PT operators provided in a single place – and the possibility to concentrate the promotion and launching of mobility actions and the hosting of

campaigns and press conferences. This will allow for a better and more efficient intermodality and interoperability.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Conception and definition of technical specifications for the Infomobility Centre *(October 2008 – February 2009) – The concept of the mobility centre was developed until December 2008 according to the following lines:*

- *Initial planning and conception of the centre, according to the sketch of architectural project:*
  - *Selection of the logo and the trade mark "Centro de Infomobilidade" for the centre.*
  - *The new Infomobility Centre should be located in the historic centre (fig.4).*

Fig. 4 – The Infomobility Centre is located in the historic centre

  - *The space should be pleasant and modern to improve the image of PT for the public, in particular among young people.*

- *Definition of the functions of the centre. Namely, the Infomobility Centre should be able to integrate the information and the products of all the PT operators and the sustainable mobility strategies in general, using modern communication tools.*

- *Option for installing the Infomobility Centre in a new place instead of the remodelling of an existing point of sale because the objectives concerning MODERN Project require more features than those provided and the several new functions couldn't be adapted to the space existing in the other points of sale.*

In February 2009 a document with the Infomobility Centre concept was delivered.

Stage 2: Purchase and installation of the Geographic Information System (GIS) *(October 2008 – October 2009) – The following activities have been carried out:*

- *A pre-evaluation of the technologies / specifications and costs was requested to ESRI-Portugal, Tele Atlas Multinet-Portugal and NAVETEQ.*
- *Research on open source products with GIS functionalities and tests to their operability were carried out on the internet.*
- *The purchase of the GIS and collections of data needed for the "RUMOS" was achieved with the option for no open sources products, taking into consideration, the issues dealing with the integration with the municipality GIS system and existing cartography.*
- *In August 2009 the installation of test's software concerning the GIS began and in October the definitive version was installed.*

Stage 3: Infomobility Centre Installation *(March 2009 – September 2009) – As specified the centre was installed in a new place that was renewed and hosted all PT operators (Fig. 5). For this propose the following activities were carried out:*

Fig. 5 – The Infomobility Centre – the exterior (Left) and interior view (Right)

- *Process of urban ordinance licensing of the new local for the Centre.*
- *Set up of agreements with all local PT operators.*
- *Building interiors:*
  - *Work concerning adjustments in the front door, survey and settlement of pavement on the sidewalk to the existing ground level.*
  - *Work for demolition of walls and for construction of news walls, ceilings, and floors, including thermal and acoustic isolation.*
  - *Work concerning the construction of WC's and assembly of its accessories, including the equipment for the mobility impaired.*
  - *Work of carpentry.*
  - *Painting and decoration of interiors.*

- *Painting of the building's façade.*
- *Application of PT operators' logos and CIVITAS' logo on the building's façade.*
- *Registration of the Infomobility Centre's logo;*
- *Purchase and installation of furniture and several equipments;*
- *Installation of the equipments concerning other operators;*

Stage 4: Training of Infomobility Centre Personnel *(December 2008 – December 2009) – The initial training (without claim for funding within CIVITAS) took place before the start of the project and in December 2008.*

On 3rd July 2009, in the City of Porto, the Coimbra Site Coordinator of MODERN project made a presentation of the Infomobility Centre of Coimbra in the training workshop "Mobility Shops: what services and for whom?" integrated into one of the activities at the CIVITAS ELAN Porto meeting. The workshop integrated presentations of several cities, including ELAN Project cities, along with the presence of European and national experts on the field. The objectives were focused on the examples of success factors based on past experiences and the objectives and targets of Centres implementations projects. The contents of this training session will be transmitted to the workers of the Infomobility Centre in Coimbra by the Measure Leader that has also attended the training.

A new training for the Infomobility Centre personnel was given in September 2009, just before the opening of the Centre and another important training of Infomobility Centre personnel took place at the start up of the "Beta" version of RUMOS.

Stage 5: Research and development of a public web service with RUMOS (Rotas Urbanas em MObilidade Sustentável - Urban Routes in Sustainable Mobility) *(October 2008 – December 2009) – Development of a public web service with RUMOS (**R**otas **U**rbanas em **MO**bilidade **S**ustentável - Urban Routes in Sustainable Mobility) that provides online trip plans. The research and technical development work was, namely:*

- *Identification of the end user requirements for the infomobility solution and assessment of the necessary preparation activities and support infra-structure and tools.*
- *A specification report was provided stating the identified technology, the necessary data and an overview of the envisaged solution.*
- *Establishment of the RUMOS cartographic basis.*
- *Test with initial models of software.*
- *It was analysed the advantages and disadvantages for the users of the link between "RUMOS" and the automated vehicle management (AVM), to allow real time trip plans or only to obtain data (always PT network and time tables changes). Between the following 2 solutions it was decided by the last hypothesis:*
    - *A link to provide real time information directly to the users (with the advantage of being considered the real conditions but with the disadvantage*

of a continuous adjustment in the conditions. This solution is a disaster to most of the users, because they usually consult the service in advance)

- *Or a link to provide PT network information, including historical data to the calculation of more accurate trip time (with the advantage of producing more consistent information with the only disadvantage of not provide real time information).*

- *The "first" version of the RUMOS software tool according to the specified system requirements and architecture design was completed and released (Fig. 6);*

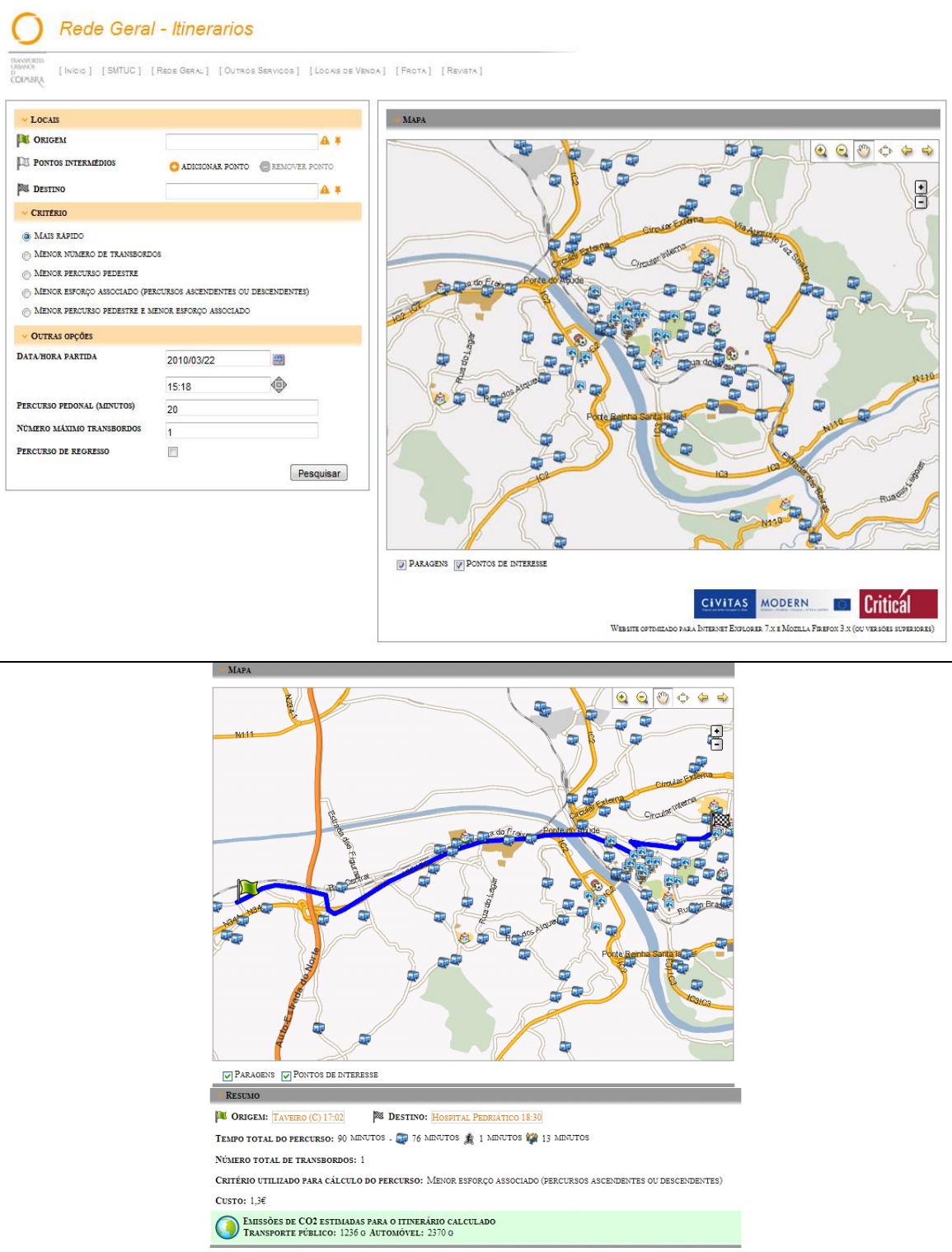


Fig. 6 – The user interface of the RUMOS Trip planner. The screen for the input data that allow the user to choose the travel criteria (fig .above) and the travel route suggested by the application (Fig. below).

- *Software testing was performed, which included software pre-acceptance testing. During this phase numerous tests were performed by SMTUC and CSW to evaluate the performance and quality of the 'journey summary' and the 'route details';*

- *New software requirements and performance improvements were identified and coded. New software versions were released.*

- *Update of the User & Administration Manual, with reference to the new implemented requirements and the definition of the new RUMOS "Back-office" procedures;*

- *Release of the "draft" version of the RUMOS Back-Office software tool according to the specified requirements;*

- *The RUMOS/Back-Office training activities were carried out. Additional new features were identified and minor software issues were detected and fixed;*

- *The Back-Office SW acceptance testing was successfully achieved. the "final" version of the RUMOS Back-Office software tool was released;*

- *The final version of the RUMOS user and administration manual "Manual do Utilizador e Administrador" was delivered.*

Stage 6: Operational functioning of the Infomobility Centre *(September 2009 – October 2012) – The Infomobility Centre was inaugurated on 15th September 2009, functioning with at least 1 worker in permanence during 12 hours at workable days. Currently the Centre runs with 2 staff members simultaneously from 7:30 into 19:30 (Monday into Friday) and one from 8:00 to 13:00 (Saturday). The activities carried out in the centre have been mainly the following:*

- *Information and sales of tickets and services of all operators of PT in the region and provision of other products and services concerning the mobility area.*

- *Customization and loading of "contact-less" cards for passes.*

- *Survey, among users of the centre, of needs in terms of mobility, for future establishment of mobility and travel plans, including for enterprises and other entities.*

- *Promotion of several campaigns and hosting of events, namely the public presentation of "SMTUC MOBILE" and "RUMOS" services and press conferences. Actions of promotion of the centre and of the "RUMOS" trip planner have been carried out, resulting in several news in the press. Highlight of the activities of the European Car Free Day that began in the Centre with a press conference and the launch ceremony of the new e-ticketing system (CIVITAS MODERN measure 02.05). Afterwards, the Mayor of the Coimbra Municipality participated in the demonstration of a bike sharing service, riding a bike from the centre to the municipal market (Fig. 7).*

- *Monitoring of the centre and RUMOS functioning.*

Fig.7 - Activities in the Infomobility Centre during the European Car Free Day – Mayor of Coimbra launched the e-ticketing system (left) and tried a bike sharing system in a ride that began in the centre (right).

Stage 7: Training about RUMOS trip planner *(October 2009 – May 2010) – RUMOS has been installed, and training sessions provided, as well as "on-the-job" training activities to the operators for the RUMOS Back-Office (reference also to the Geographical Information System). New training activities 2010 of an improved version of the Back-Office were carried out in April and May.*

Stage 8: RUMOS promotion near the users *(November 2009 – May 2010) – Information and dissemination of the RUMOS, namely through the following:*

- *RUMOS service has been promoted at various workshops and conferences, namely at the Lisbon IMTT-EPOMM Conference, and Workshops in Aveiro and Beja. At the local level, SMTUC promoted RUMOS at the meeting with the local Chamber of Industry and Commerce which also involved various stakeholders, such as PT operators, municipal district political representatives, political parties, local opinion-makers, and news media.*

- *RUMOS is being publicized to the general population through its trials at the Infomobility Centre, as well as other SMTUC points of sale.*

- *The Coimbra Site Coordinator presented the RUMOS trip planner in the 2011 National Convention of a World Leader in Geographic Information Systems (ESRI), held on 3 March 2011 and attended by more than 1,000 participants.*

A document concerning the RUMOS development and implementation report was delivered in March 2010.

The installation of the RUMOS application in new Multimedia Outdoor Kiosks is being studied and evaluated (Fig. 8). These interactive kiosks will offer other complementary services, such as mobility information, weather forecasting, touristic and commercial information, pharmacies, advertisement, etc.

Fig. 8 – Multimedia Outdoor Kiosk

Stage 8: Operational functioning and management of the RUMOS system *(October 2009 – October 2012) – In this phase the management of the system consists mainly of the following:*

- *First operations with the "Back-Office" of RUMOS system, namely the importation, consolidation and consistency validation of the data.*
- *Monitoring the system in the Infomobility Centre and on-line.*
- *Data updated using the Back-Office whenever occurred changes in the PT network.*

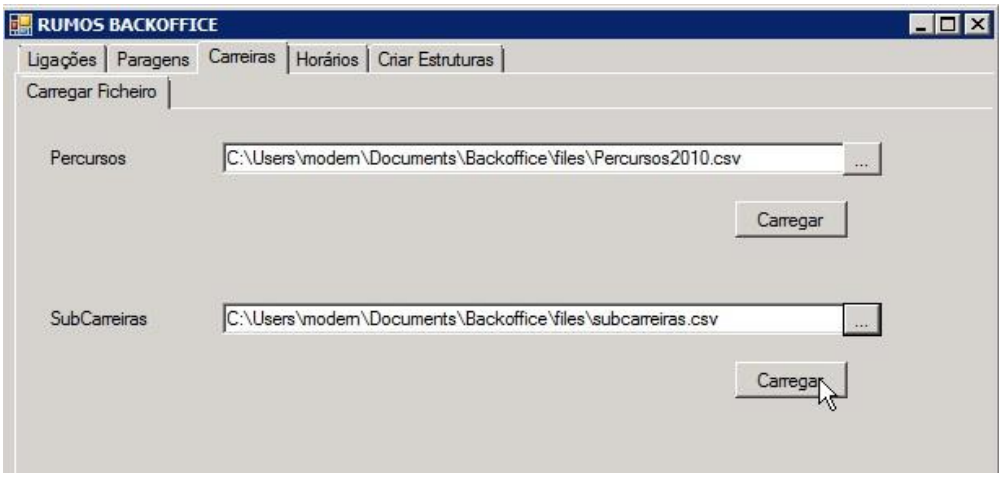


Fig. 9 – RUMOS Back-Office Interface

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

- **Measure no. 02.05** – The new e-ticketing System in Coimbra is related with the Infomobility Centre because this centre is also a point of tickets and cards sale / load;

- **Measure no. 04.05** – The Centre also promotes the mobility campaigns and travel plans concerning the entities involved in the mobility management actions;

- **Measure no. 08.03** – The data provided by the GPS/GPSR – Operation Support System have capabilities linked to the "RUMOS trip planner", also integrated in measure no. 04.02. In any case these 2 systems are not integrated, but only the data base of RUMOS is updated with the data of the GPS/GPSR – Operation Support System.

Concerning the impacts of these systems we can consider that the fact that each one started in different dates avoided the bundle of these measures. The measure 08.03 started in 2008 before CIVITAS MODERN project beginning, so the ex-post data was assessed before the start of the measure 04.02 in September 2009 with the opening of the Infomobility Centre. The same for the measure 02.05, that only began in January 2012, after the evaluation of the other 2 measures.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1.1: Indicators.

No.	Impact	Indicator	Data used	Comments
1	Operating Costs	Operating costs	Operating costs with the Infomobility centre and the RUMOS trip planner;	Operating revenues are provided by SMTUC
2	Costs	Capital Costs	Total capital costs expended in setting up the measure (Infomobility centre and the RUMOS trip planner)	Costs are provided by SMTUC
3	Quality of Service	Quality of PT Service	Index of the "perception" of service quality at sales points and on the SMTUC webpage	The RUMOS Trip planner is based in the main web page of SMTUC, the urban public transport operator. The data source was the customers satisfaction survey
4	Quality of Service	RUMOS Trip planner usage	Number of RUMOS accesses per month	Automaticaly recorded in the RUMOS back office
5	Quality of Service	Attendance at the Infomobility Centre	Number of attendances per year at the Centre	Recorded in the Queu machine of the Centre
6	Awareness	Awareness level	Total number of users with knowledge of the measure; Total number of respondents	Awareness level is by the customers satisfaction survey
7	Awareness	Mobility Marketing	Number of great promotional campaigns	Only great events or campaigns that were hosted in the Centre
8	Acceptance	Acceptance level – users	Total number of users who favourably receive the measure; Total number of respondents	Acceptance level is by the customers satisfaction survey
9	Acceptance	Acceptance level – operators	Total number of operators who favourably receive the measure; Total number of responding operators	Acceptance level is by the operators survey

Due to the characteristics of that mesure, the selection of the indicators is mainly connected with the impact of the Centre in terms of the improvement of the quality of the service that is expected to be provided to the actual users of the public transport and the expected attractiviness to the future users.

The information related to capital and operational costs is compledeted with indicators about quality of the service and the awareness and acceptance levels of the measure.

Detailed information regarding the possible and desirable change in the modal shift, due to more accessible and diverse information of the transport system of the city and the region , came out to be difficult to be assessed.

Due to the fact that the measure was started-up very early and concluded before.the evaluation plan was consolidated, ex-ante modal shift data was not collected. Accordingly this indicator, and related indicators (e.g., operational revenues and emissions) were not evaluated.

Detail of the Survey

Indicators n. 3, 6 and 8 are based on the main results of the yearly survey carried out by SMTUC in the scope of the Quality Management procedures in accordance with the ISO 9001 standard

We present the main characteristics of this survey:

The questionnaire starts with the characterisation of the interviewee – Sex, Age (<18, 19-25, 26-45, 56-65, >65), type of client (frequent, occasional, exceptional/rare use), motive of the trip (home-work/school, shopping/leisure, in service), type of ticket (pass, single ticket bought on the selling point, single ticket bought on the vehicle, other).

The main part of the questionnaire is composed of 38 specific questions related to various items related to 5 areas of the service (1-Available information, 2-Quality of service, 3-Contribution to society, 4-Image of the company, 5-Communication with the administrative services) and a specific global customer satisfaction question that resume the quality of the service. In each question the people interviewed express a judgement choosing between very satisfied – satisfied – unsatisfied – very unsatisfied and about the importance of each of the 38 items choosing between very important – important – low importance.

The survey is repeated once a year and is carried out to customers in face to face interviews on board of the SMTUC buses.

The sample is selected on the basis of the lines used by the passengers, i.e., the number of interviewees chosen in each line is defined according to the demand of the line relative to the overall SMTUC demand.

The dimension of the sample is defined according to the specifications of the quality management auditors which supervise the whole process in accordance with the ISO9001 standard.

The quality management auditors considered 500 interviews as (a minimum) suitable to assess the quality evaluation by PT passengers in Coimbra. However, SMTUC volunteered to go above this number. Thus, the following number of interviews and valid answers were achieved:

In 2009 a sample of 1000 interviews was defined.

In 2010 and 2011 a sample of 750 interviews was defined.

All the interviews were validated since incomplete or incorrect surveys were refused and repeated with other interviewee.

Detailed description of the indicator methodologies:

Indicator 1 (*Operating Cost*) – The operating costs considered are those related with the maintenance, personnel cost and renting.of the Infomobility Centre and the costs with the RUMOS trip planner maintenance service (€).

This data has been recorded through the normal of SMTUC accountig system procedure.

- **Indicator 2** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

  Expenditures with the building renovation of the Infomobility Centre and respective purchase of furniture and equipment, as well as the capital cost concerning the development of RUMOS system (€)

  This data has been recorded through the normal procedure of SMTUC accountig system procedure.

- **Indicator 3** (*Quality of PT Service*) – User's perspective of the overall quality of the service provided according to the index of the "perception" of service quality.

  $A = \sum [(1 \times B + 2 \times C + 1 \times D + 1 \times E) / (B + C + D + E)]_i / N$

  Where: A = Quality of PT Service

  B = Number of respondents Very Unsatisfied with the corresponding service item

  C = Number of respondents Unsatisfied with the corresponding service item

  D = Number of respondents Satisfied with the corresponding service item

  E = Number of respondents Very Satisfied with the corresponding service item

  i = Items concerned with the measure, rating from 1 to N

  N = Total number of items concerned with the measure

  The Quality of the PT Service is measured during customer satisfaction surveys (for more details, see annex dedicated to the customer satisfaction survey) by the following specific questions relating the satisfaction level of the respondent about the measure – Question 6 (relative to item 1): How do you rate your satisfaction level about the information at SMTUC sales points? Question 9 (relative to item 2): How do you rate your satisfaction level about the Information available on the Internet?

- **Indicator 4** (*RUMOS Trip planner usage*) – Number of accesses to the RUMOS trip planner per month.

  The number of users' accesses is automatically recorded in the back office of the RUMOS trip planner

- **Indicator 5** (*Attendance at the Infomobility Centre*) – Number of costumers attendance at the Infomobility Centre.

  The number of costumers attendance is automatically recorded in the Queue machine / Ticket dispense machine of the Infomobility Centre

- **Indicator 6** (*Awareness level*) – Percentage of the users with knowledge of the measure on account of provided information (%).

  $A = B / C \times 100$

  where: A = Percentage of users with knowledge of the measure (%)

  B = Total number of respondents with knowledge of the measure

  C = Total number of respondents

  The Awareness level of the measure is measured during customer satisfaction surveys (for more details, see annex dedicated to the customer satisfaction survey) by introducing the following specific question relative to the knowledge of the respondent about the measure – Are you aware about the existence of the Infomobility Centre and about the services provided there?

- **Indicator 7** (*Mobility Marketing*) – Number of promotional campaings hosted by the Infomobility Centre

  Number of large-scale events / large-scale promotional campaigns hosted by the Infomobility Centre

- **Indicator 8** (*Acceptance level – users*) – Percentage of the users who favourably receive the measure (%).

  $A = \sum [B / C \times 100]_i / N$

  where: A = Percentage of users who favourably receive the measure (%)

  B = Total number of respondents who favourably receive the measure (by saying that they are satisfied or very satisfied about the measure)

  C = Total number of respondents

  i = Items concerned with the measure, rating from 1 to N

  N = Total number of items concerned with the measure

  The Acceptance level of the measure is calculated through the customer satisfaction surveys (for more details, see annex dedicated to the customer satisfaction survey) by the following specific questions relative to the attitude of the respondent about the measure – Question 6 (relative to item 1): How do you rate your satisfaction level about the information at SMTUC ticket selling shops? Question 9 (relative to item 2): How do you rate your satisfaction level about the Information available on the Internet?

- **Indicator 9** (*Acceptance level – PT operators*) – Percentage of the PT operators who favourably receive the measure (%).

  $A = B / C$

where: A = Percentage of PT operators who favourably receive the measure (%)

B = Total number of respondents who favourably receive the measure

C = Total number of respondents

The Awareness level of the measure is measured during the so called Operator's Survey, set up to measure the Awareness and Acceptance Level of PT Operators about the measure.

This survey is composed of specific questions that resume the operator's attitude towards the actions undertaken on the scope of the measure. The survey is repeated once a year and is carried out through direct contacts to the full number of operator providing public transportation in the Coimbra region.

C1.2 Establishing a Baseline

2008 is considered as the baseline, before the start of the "Operational functioning of the Infomobility Centre" in September 2009.

Nevertheless for the indicator 2 (Capital Cost) 2007 was considered the baseline year because in 2008 there was already costs with the software development of the RUMOS trip planner that didn't have impact on the others indicators.

The measure results are obtained from SMTUC records for indicators 1 ,2, 4, 5 and 7 , from the customer satisfaction survey periodically carried out by SMTUC for indicator 3, 6 ,and 8, , and from the operator's survey carried out by SMTUC to assess the acceptance level of the several PT operators of the Coimbra Metropolitan Area about the indicator 9.

Indicators 1 and 2 (Operating Costs and Capital Costs):

The transport public operator SMTUC provided information on costs of operating the Infomobility Centre and the RUMOS Trip planner as well as on capital costs for setting up the measure

Since the RUMOS Trip planner development began in October 2008 and the Infomobility Centre began functioning in September 2009 the baseline for the Capital Costs has been considered the year 2007 while for the Operating Costs the year 2008 has been considered, booth with the value of zero, due the fact that before these dates no mobility centre or trip planner with similar characteristics existed. The next table shows the baseline for indicators 1 and 2:

Table C1.2.1: Baseline for indicators 1 and 2.

Indicators and respective parameters	Ex-Ante values
Total Operational Costs (2008)	0,00 €
Total capital cost (2007)	0,00 €

Indicator 3 (Quality of Service)

To get a qualitative assessment of service, a survey to PT users was conducted in December 2008 and January 2009 on board of SMTUC bus services in Coimbra. The survey model is detailed in C1.1 and in the Annex 7. The results obtained for this indicator are detailed in Annex 1.

The next table shows the baseline for the Quality of PT Service:

Table C1.2.2: Baseline for indicator 3

Year	Quality of PT Service (from 1 to 4) – Ex Ante
2008*	3,12

* Data collection has been performed from 2008-12-04 to 2009-01-09

Indicator 4 (RUMOS Trip planner usage) and Indicator 5 (Attendance at the Infomobility Centre)

Both these indicators were considered having the baseline value equal to zero, because before 2008 there did not exist any mobility centre or trip planner with similar characteristics. Before the implementation of the measure Coimbra only had sales points that didn't have the PT operators integrated in the same point and didn't have the capabilities to host events.

The next table shows the baseline for indicators 4 and 5:

Table C1.2.3: Baseline for indicators 4 and 5

Indicators and respective parameters	Ex-Ante values
RUMOS Trip planner usage (2008) – Number of accesses	0
Number of attendances at the Infomobility Centre (2008)	0

Indicator 6 (Awareness – Users)

To get a qualitative assessment of knowledge towards change a specific question was added to the customer satisfaction survey to PT users. However, this question was not applied during the survey conducted in December 2008 and January 2009 considering that before the launch of the "Mobility Centre" it made no sense to ask people if they knew this service. Accordingly, it has been established that before something exists no one can have knowledge of that fact. In relation to the attitude towards changes, results from specific questions of the customer satisfaction survey conducted in December 2008 and January 2009 were considered.

The indicator has been assessed by introducing the following specific question relative to the knowledge of the respondent about the measure – Are you aware about the existence of the Infomobility Centre and about the services provided there?

The survey model is detailed in Annex 7. The results obtained for this indicator are detailed in Annex 2 and 3.

Therefore, the next table shows the results of baseline for the awareness level of the PT users about the Infomobility Centre:

Table C1.2.4: Baseline for indicator 6

Year	Awareness Level – Users – Ex Ante
2008*	0%

* Data collection has been performed from 2008-12-04 a 2009-01-09

Indicator 7 (Mobility Marketing)

Before the implementation of this measure no mobility centre existed and in the existing sales points there were no conditions to host promotional campaigns. For this reason the baseline for this indicator has been considered zero.

The next table shows the results of the baseline for the indicator 7:

Table C1.2.5: Baseline for indicator 7

Indicators and respective parameters	Ex-Ante values
Mobility Marketing (2008) – Number of promotional campaigns	0

Indicator 8 (Acceptance – Users)

To get a qualitative assessment of knowledge towards change a specific question was added to the customer satisfaction survey to PT users. In relation to the attitude towards changes, results from specific questions of the customer satisfaction survey conducted in December 2008 and January 2009 were considered.

The indicator has been assessed by the following specific questions relative to the attitude of the respondent about the measure – Question 6 (relative to item 1): How do you rate your satisfaction level about the information at SMTUC ticket sales points? Question 9 (relative to item 2): How do you rate your satisfaction level about the Information available on the Internet?

The survey model is detailed in Annex 7. The results obtained for this indicator are detailed in Annex 2 and 3.

Therefore, the next table shows the results of baseline for the indicator 8:

Table C1.2.6: Baseline for indicator 8

Year	Acceptance Level – Users – Ex Ante
2008*	89,5%

* Data collection has been performed from 2008-12-04 a 2009-01-09

Indicator 9 (Acceptance – PT Operators)

To get a qualitative assessment of attitude of PT operators towards the measure, a survey was conducted to the 4 PT operators of the Coimbra Metropolitan Area (during the period from 1st July to 13th July 2011). Although the survey was conducted after the implementation of the measure, the interviewees were asked to report their answers to their attitude before the implementation of the measure (i.e., to the baseline period- 2008).

Additional details about Acceptance Level- PT Operators Data in Annex 6

The next table shows the results of baseline for this indicator:

Table C1.2.7: Baseline for indicator 9

Indicators and respective parameters	Ex-Ante values
Acceptance level (2008)	100 %

C1.3 Building the Business-as-Usual scenario

The CIVITAS MODERN was crucial to implement the Mobility Centre and the other actions developed within the scope of the measure and without it the implementation of the Mobility Centre and of the other actions developed within the measure would not have take place within the period of the project.

Without the implementation of the measure (business-as-usual scenario) no changes were likely to occur in any indicators of the measure..

It is considered that there are no effects of other factors that have any influence on these indicators

Therefore, the B-a-U scenario for these indicators equals to the respective baseline situation (Ex-Ante value).

Indicator 1 (Operating Costs) and 2 (Capital Costs)

Without this CIVITAS MODERN measure the RUMOS trip planner and the Infomobility Centre would not have been implemented in the time span of the project and accordingly the capital costs and the operating cost would be zero.

Therefore, tables C1.3.1 and C1.3.2 show the results of BAU scenario for these cases.

Table C1.3.1: Results of the BAU scenario for indicator 1

Indicators and respective parameters	BAU Values
Average operating cost (2009)	0,00 €
Average operating cost (2010)	0,00 €
Average operating cost (2011)	0,00 €

Table C1.3.2: Results of the BAU scenario for indicator 2

Indicators and respective parameters	BAU values
Total capital cost (2009)	0,00 €
Total capital cost (2010)	0,00 €
Total capital cost (2011)	0,00 €

Indicator 3 (Quality of PT Service)

If this measure wasn't implemented, the Quality of PT Service would be as before. It is considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation as shown in the next table.

Table C1.3.3: Results of the BAU scenario for indicator 3

Indicators and respective parameters	BAU values
Quality of service (2008) *	3,12 (from 1 to 4)

* Data collection performed from 2008-12-04 a 2009-01-09

Indicator 4 (RUMOS Trip planner usage) and Indicator 5 (Attendance at the Infomobility Centre)

If this measure wasn't implemented, the RUMOS Trip planner usage and the Attendance at the Infomobility Centre did not exist. It is considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is zero like the baseline situation as shown in the tables C1.3.4 and C1.3.5.

Table C1.3.4: Results of the BAU scenario for indicator 4

Indicators and respective parameters	BAU values
RUMOS Trip planner usage (2009) – Number of accesses	0
RUMOS Trip planner usage (2010) – Number of accesses	0
RUMOS Trip planner usage (2011) – Number of accesses	0

Table C1.3.5: Results of the BAU scenario for indicator 5

Indicators and respective parameters	BAU values
Number of attendances at the Infomobility Centre (2009)	0
Number of attendances at the Infomobility Centre (2010)	0
Number of attendances at the Infomobility Centre (2011)	0

Indicator 6 (Awareness level – users)

If this measure has not been implemented the users would not be aware of the measure. In this case the Business-as-usual would have continued equal to the baseline situation (0%).

Therefore, the next table shows the results of BAU scenario for this case.

Table C1.3.6: Results of the BAU scenario for indicator 6

Indicators and respective parameters	BAU values
Awareness level – users (2009)	0 %
Awareness level – users (2010)	0 %
Awareness level – users (2011)	0 %

Indicator 7 (Mobility Marketing)

If this measure has not been implemented no mobility centre existed and in the existing sales points there were no conditions to host promotional campaigns. For this reason the Business-as-usual scenario for this indicator continue to be considered zero and equal to the baseline.

Therefore, the next table shows the results of BAU scenario for this case.

Table C1.3.7: Results of the BAU scenario for indicator 7

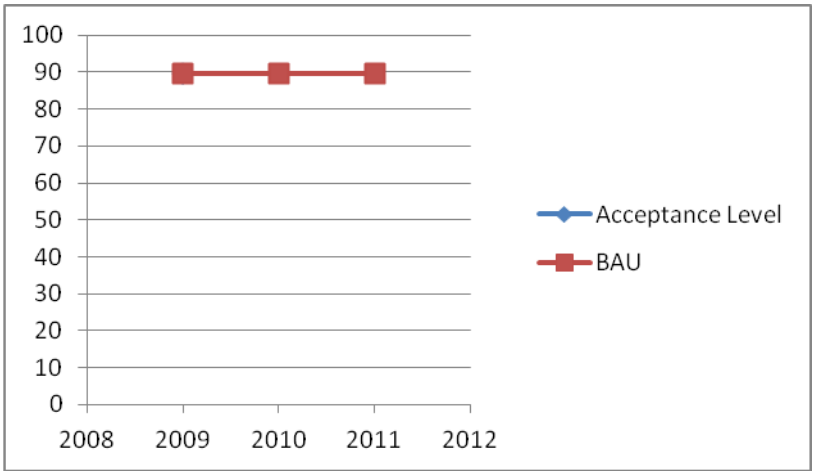
Indicators and respective parameters	BAU values
Mobility Marketing (2009) – Number of promotional campaigns	0
Mobility Marketing (2010) – Number of promotional campaigns	0
Mobility Marketing (2011) – Number of promotional campaigns	0

Indicator 8 (Acceptance level – users)

If this measure has not been implemented, the Acceptance level – users related to the Infomobility Centre and RUMOS trip planner would have been as before. It is considered that there are no effects of other factors that have any influence in this indicator.

In this case the Business-as-usual is equal to the baseline situation.

The next graph shows the evolution of the Acceptance Level (%) obtained for the B-a-U scenario.



Graph C1.3.1 – Acceptance level of users - trend without CIVITAS (BAU)

Therefore, the next table shows the results of BAU scenario for this case.

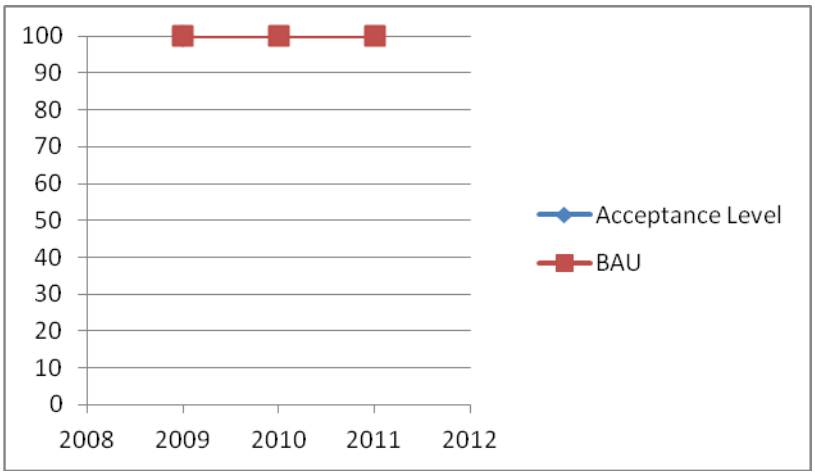
Table C1.3.8: Results of the BAU scenario for indicator 8

Indicators and respective parameters	BAU values
Acceptance level – users (2009)	89,5 %
Acceptance level – users (2010)	89,5 %
Acceptance level – users (2011)	89,5 %

Indicator 9 (Acceptance level – PT operators)

If this measure wasn't implemented, the Acceptance level – PT operators related to the Infomobility Centre would be as before (i.e. 100%).

The next graph shows the evolution of the Acceptance level (%) obtained for the B-a-U scenario.



Graph C1.3.2 – Acceptance level of PT operators - trend without CIVITAS (BAU)

Therefore, the nest table shows the results of BAU scenario for this case.

Table C1.3.9: Results of the BAU scenario for indicator 9

Indicators and respective parameters	BAU values
Acceptance level – operators (2009)	100 %
Acceptance level – operators (2010)	100 %
Acceptance level – operators (2011)	100 %

C2 Measure results

The results are presented under specific sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

C2.1 Economy

In the same way as for the baseline, the results from the indicators after implementing the measure in September 2009 have been calculated. The total operating costs concerning the measure ("Operational functioning of the Infomobility Centre", "RUMOS trip planner" and respective "divulgation campaigns"), including personnel, material and energy, both in terms of maintenance and operation were calculated. The following table shows the results of indicators 1:

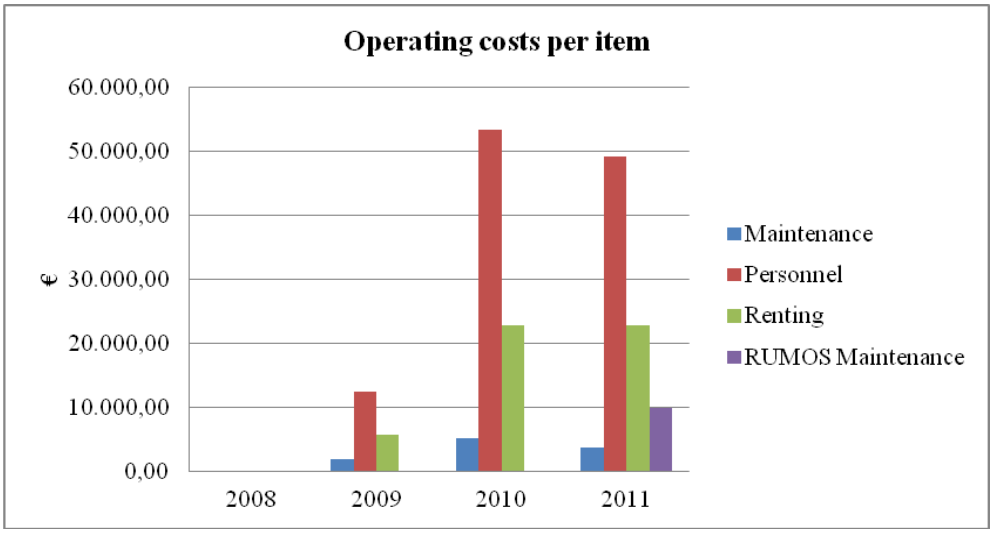
Table C2.1.1: Ex-Post results of the indicator 1

Operating Costs (€)

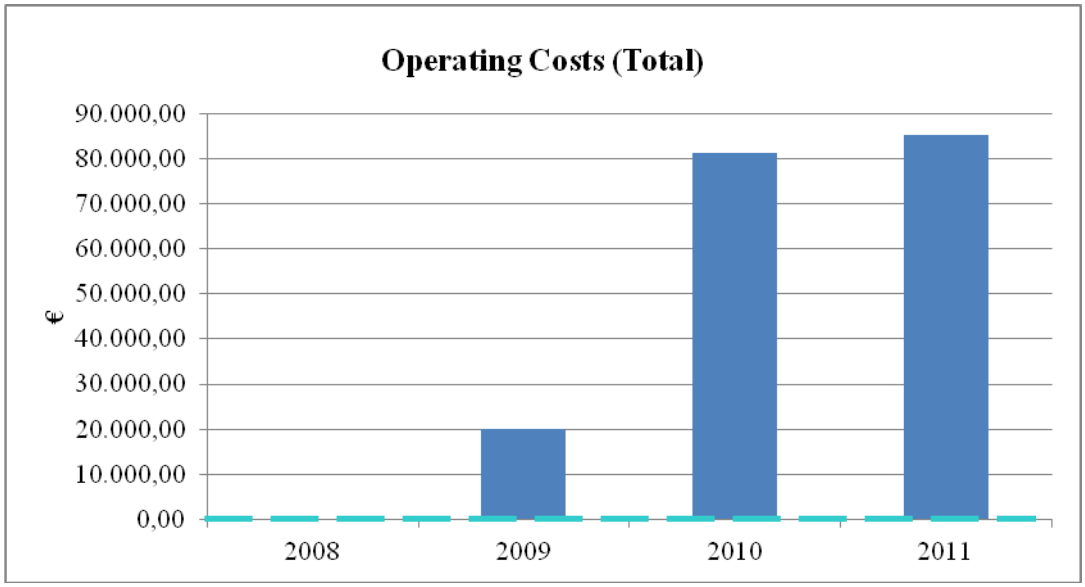
	2009	2010	2011	**TOTAL**	
Infomobility Centre					
Maintenance	1.791,70	5.180,51	3.604,57	10.576,78	5,7%
Personnel	12.416,04	53.354,76	49.140,88	114.911,68	61,6%
Renting (*)	5.700,00	22.800,00	22.800,00	51.300,00	27,5%
Total	19.907,74	81.335,27	75.545,45	176.788,46	
RUMOS Trip planner					
Maintenance			9.900,00	9.900,00	5,3%
TOTAL	**19.907,74**	**81.335,27**	**85.445,45**	**186.688,46**	100,0%

(*) Since Oct-09 1.900€/month

Nearly 95% of the total operational costs are attributed to the Infomobility Centre. The personnel costs are responsible for a high share of these expenses (61%), while also the rent has a quite high impact on costs (27,5%). On the other hand, the RUMOS trip planner has low operating costs since they are limited to the maintenance. The graph C2.1.1 shows the operating costs per item and graph C2.1.2 shows the total operating costs.



Graph C2.1.1 – Results of the operating costs per item with the measure implementation



Graph C2.1.2 – Results of total operating costs with the measure implementation (BAU is zero)

Also the capital total costs were accounted. As expected, the results confirm an increase in the operating costs and in the total capital costs as result of the introduction, promotion, operation and maintenance of the new features introduced in the scope of the measure in the PT operation in Coimbra, i.e, the "Infomobility Centre" and the "RUMOS trip planner".

Concerning the capital costs the table …contains the data for the Infomobility Centre and RUMOS trip palnner.

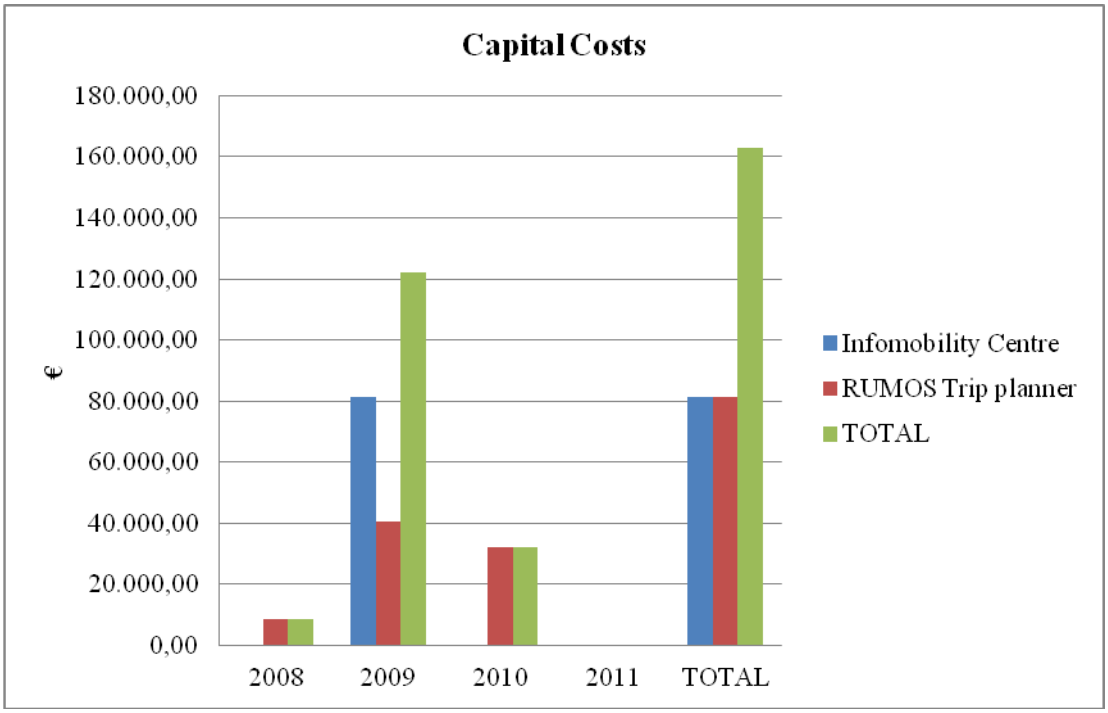
Table C2.1.2: Ex-Post results of the indicator 2

Capital Costs €

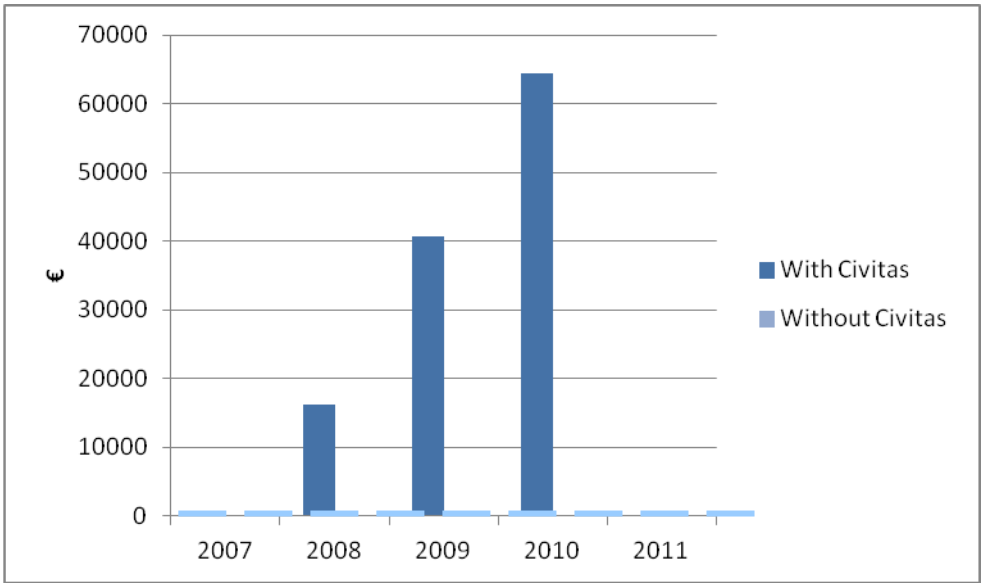
	2008	2009	2010	2011	**TOTAL**
Infomobility Centre	0,00	81.379,52	0,00	0,00	81.379,52
RUMOS Trip planner	8.483,68	40.721,68	32.237,99	0,00	81.443,35
TOTAL	**8.483,68**	**122.101,20**	**32.237,99**	**0,00**	**162.822,87**

A careful analysis of the overall capital costs reveals that the two interventions have similar costs. However, those costs are dissimilar in their temporal dimension, i.e., the Infomobility Centre has the total share of costs in 2009 while the expenditures for RUMOS are spread throughout a three year period.

The graph C2.1.3 shows the capital costs per item and graph C2.1.4 shows the total capital costs.



Graph C2.1.3 – Results of the capital costs per item with the measure implementation



Graph C2.1.4 - Capital Costs - trend without CIVITAS (BAU) and results with CIVITAS

The graphs above show that capital and the operating cost experienced an increase as result of the implementation of the measure.

The next table shoes the balance between the economic indicators.

Table C2.1.3: Summary – Balance between economy indicators (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
4. Operating Costs	0,00 € (2007)	0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	19.907,74 € (2009) 81.335,27 € (2010) 85.445,45 € (2011)	19.907,74 € (2009) 81.335,27 € (2010) 85.445,45 € (2011)	19.907,74 € (2009) 81.335,27 € (2010) 85.445,45 € (2011)
5. Capital Costs	0,00 € (2007)	0,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	8.483,68 € (2008) 122.101,20 € (2009) 32.237,99 € (2010) 0,00 € (2011)	8.483,68 € (2008) 122.101,20 € (2009) 32.237,99 € (2010) 0,00 € (2011)	8.483,68 € (2008) 122.101,20 € (2009) 32.237,99 € (2010) 0,00 € (2011)

C2.4 Transport

Indicator 3 (Quality of PT Service)

In a similar fashion with the baseline, the results of the indicators were obtained after implementing the measure in September 2009. The next table shows the results of indicator 3:

Table C2.4.1: Ex-Post results of the indicator 3

Year	Quality of PT Service (from 1 to 4) – Ex Post
2010	3,03
2011	3,17

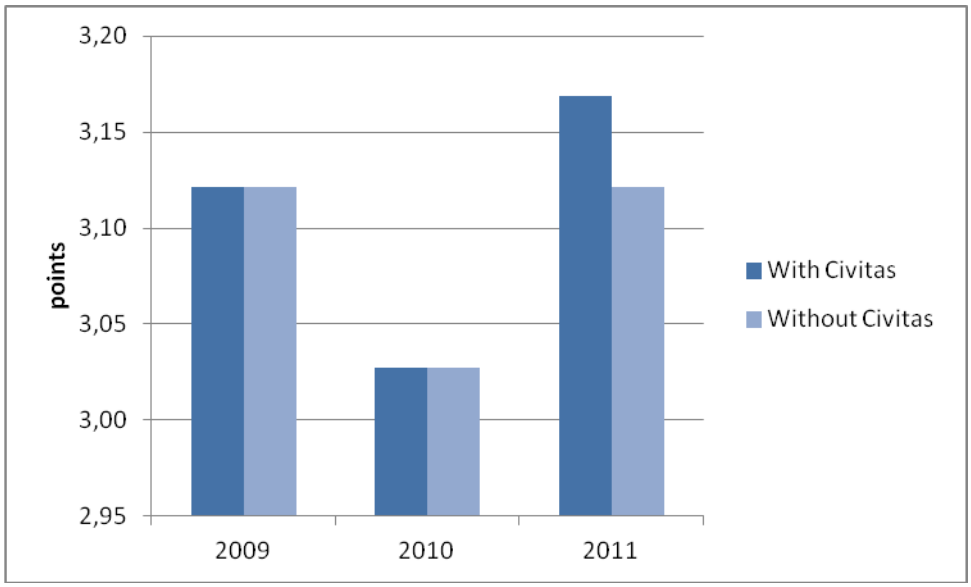
Regarding the evolution in passenger perception about the quality of the service, by means of the results taken from the quality survey made to assess the satisfaction of passengers about the SMTUC PT service, these results reflect specifically the changes introduced by the measure.

The next table shows the balance between the indicator 3.

Table C2.4.2: Summary – Balance between Quality of PT service indicator (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
3.Quality of PT Service	3,12 points (2009)	3,12 points (2010) 3,12 (2011)	3,03 points (2010) 3,17 (2011)	-0,09 points (2010) 0,05 (2011)	-0,09 points (2010) 0,05 (2011)

The next graph shows the evolution of the Quality of PT Service (from 1 to 4) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

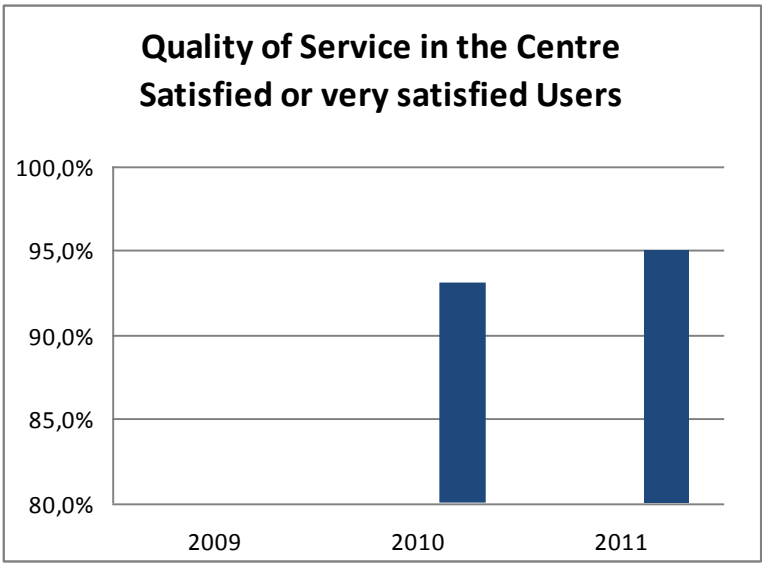


Graph C2.4.1 – Quality of PT Service - trend without CIVITAS (BAU) and results with CIVITAS

The results demonstrated that the Quality of PT Service continued higher (superior to 3 in a maximum of 4) and the evolution shows that the results after the implementation of the measure are lower in 2010 in comparison to those before and higher in 2011. According to information from SMTUC, 2009 PT strikes may have influenced negatively respondents' answers and therefore the 2010 results (for additional information see Annex 3 Quality of PT Service Data). Also, the fact that the 2010 survey has been carried out in March / beginning April - less of 6 months after the Centre oppened - could have contributed to a low level of perception about the Infomobility Centre's advantages.

Also an evaluation of the Quality of the Service provided in the Infomobility Centre has been carried out through the same yearly survey that was fulfilled in the scope of the Quality Management procedures to the SMTUC passengers (sample between 750 and 1.000 passengers). The respondents should indicate from 1 to 4 their satisfaction with the services provided in the Infomobility Centre and 93,1% were satisfied or very satisfied in 2010 and this number grew for 95,1% in 2011.

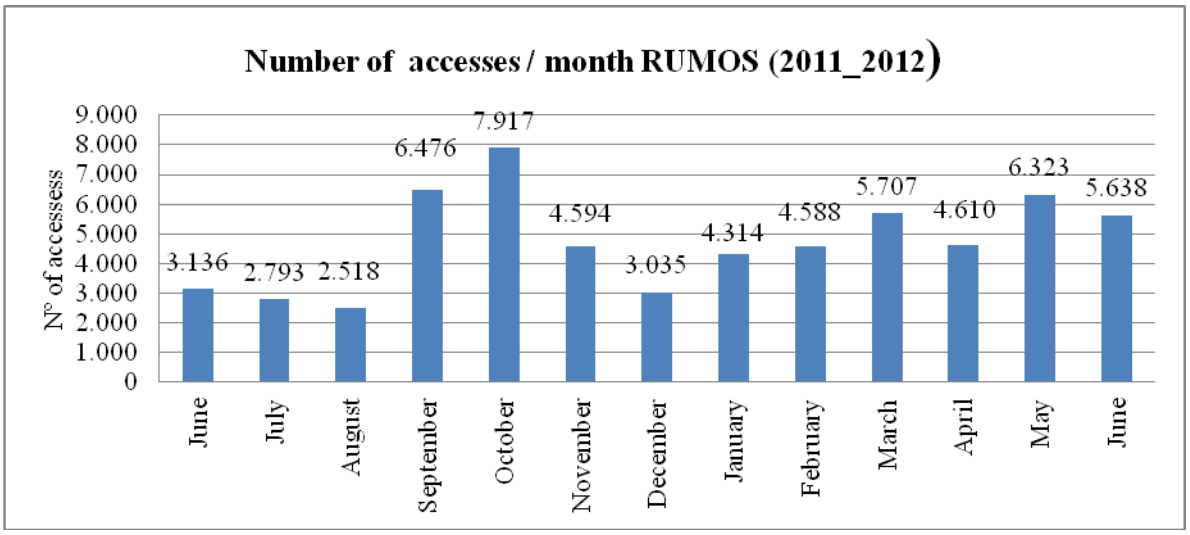
The next graph shows the evolution of the perception of the PT users about the Quality of Service in the Infomobility Centre.



Graph C2.4.2 – Quality of the service in the Infomobility Centre (saisfied or very satisfied users)

Indicator 4 (RUMOS Trip planner usage)

Regarding the other indicator for the quality of the service, which comprehends the number of monthly accesses to the RUMOS trip planner site, data is available for the period of June – December 2011 and January – June 2012. These results are illustrated in the following graphic.



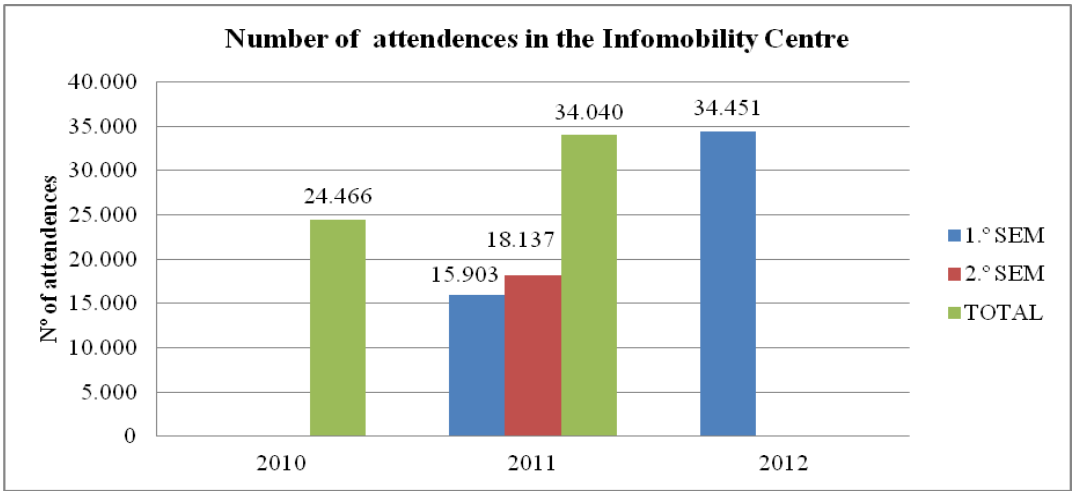
Graph C2.4.3 – RUMOS trip planner usage – Number of accesses

It is worth noting that the average number of visits per month to the site was 4688 in the first year, and after an initial period of lower number of accesses, after the month of November the number of visits augmented considerably (with special emphasis in September and October 2011 and May 2012).

Indicator 5 (Attendance at the Infomobility Centre)

The number of attendances at the Infomobility Centre is an important indicator for the qualitative evaluation of the centres attractiveness throughout time.

The next graph shows the results of the indicator 5.



Graph C2.4.4 – Number of attendances in the Infomobility Centre

The evaluation begins with the data for 2010 (the first year of complete data) due to the fact that the start-up occurred in September 2009. An increase of 39% in the number of annual attendances was registered between 2010 and 2011.

As for 2011 and 2012, data is also available by semesters. The number of attendances for the first semester of 2012 already surpasses those of the entire year of 2011, demonstrating the great positive impact the Centre has on customer behaviour.

C2.5 Society

In the same way as for the baseline, the results of the indicators were obtained after implementing the measure in September 2009. The tables C2.5.1 to C2.5.4 show the results of indicators 6, 7, 8 and 9:

Table C2.5.1: Ex-Post results of the indicator 6

Year	Awareness Level (%) – Ex-Post
2010	17 %
2011	41 %

Table C2.5.2: Ex-Post results of the indicator 7

Year	Mobility Marketing (Number of Campaigns)– Ex-Post
2009	3
2010	4
2011	3

Table C2.5.3: Ex-Post results of the indicator 8

Year	Acceptance Level – Users (%) – Ex-Post
2010	88,7 %
2011	94,5 %

Table C2.5.4: Ex-Post results of the indicator 4

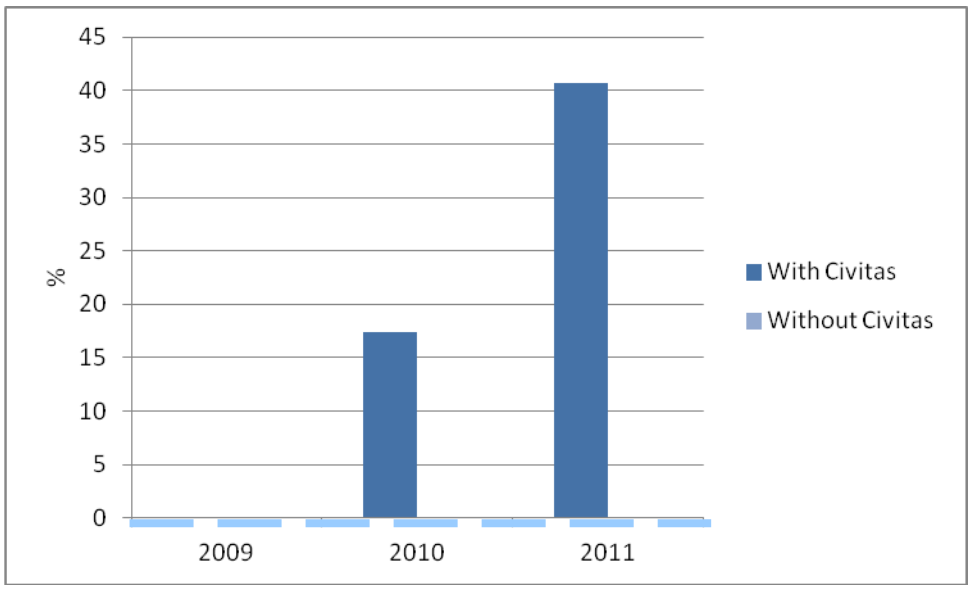
Year	Acceptance Level – Operators (%) – Ex-Post
2010	100 %
2011	100 %

The next table shows the balance of results of the Society indicators.

Table C2.4.2: Summary – Balance between Quality of PT service indicator (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
6. Awareness Level	0 % (2008)	0 % (2010) 0 % (2011)	17 % (2010) 41 % (2011)	+17 % (2010) +41 % (2011)	+17 % (2010) +41 % (2011)
7. Mobility Campaigns	0 (2008)	0 (2009) 0 (2010) 0 (2011)	3 (2009) 4 (2010) 3 (2011)	+3 (2009) +4 (2010) +3 (2011)	+3 (2009) +4 (2010) +3 (2011)
8. Acceptance Level – Users	89,5 % (2008)	89,5 % (2010) 89,5 % (2011)	88,7 % (2010) 94,5 % (2011)	-0,82 % (2010) 5,03 % (2011)	-0,82 % (2010) 5,03 % (2011)
9. Acceptance Level – Operators	100 % (2008)	100 % (2010) 100 % (2011)	100 % (2010) 100 % (2011)	0 % (2010) 0 % (2011)	0 % (2010) 0 % (2011)

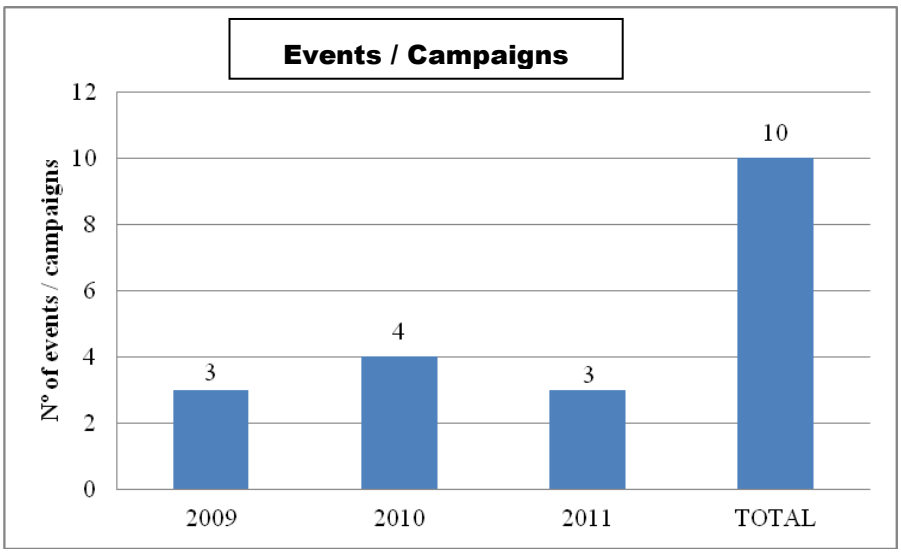
The next graph shows the evolution of the Awareness Level (%) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).



Graph C2.5.1 – Awareness level - trend without CIVITAS (BAU) and results with CIVITAS

This evolution shows that the awareness level increased steadily along with the implementation of the measure (more rapidly from 2010-2011 than from 2009-2010). The lower value of 2010 (17%) could be explained by the fact that the survey of 2010 has been carried out in March / beginning April - less than 6 months after the Centre oppened – could have contributed to a lower level of perception about the Infomobility Centre advantages.

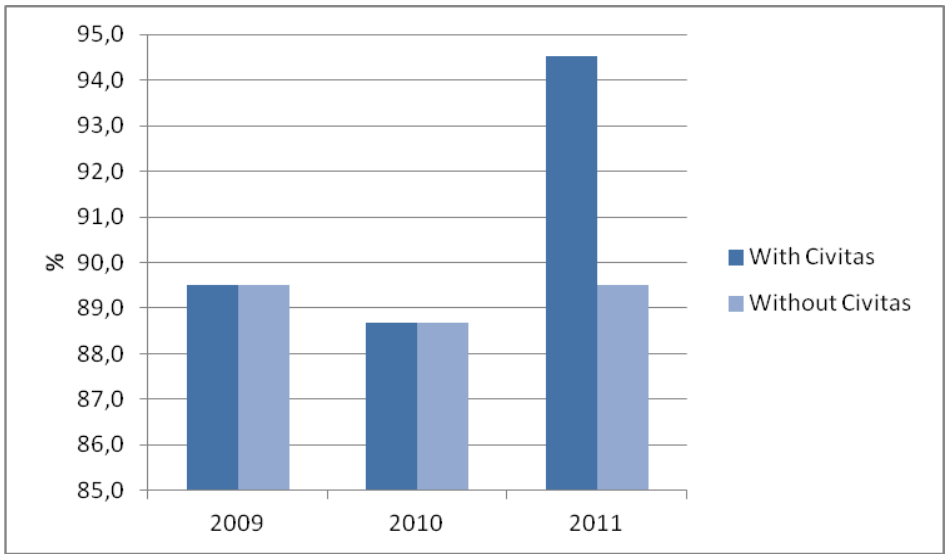
Next graph shows the ex-post results of indicator 7.



Graph C2.5.2 – Number of large-scale events hosted in the Infomobility Centre

Concerning the mobility marketing we can verify a consistency in the promotional campaigns, with 3 or 4 events / campaigns every year.

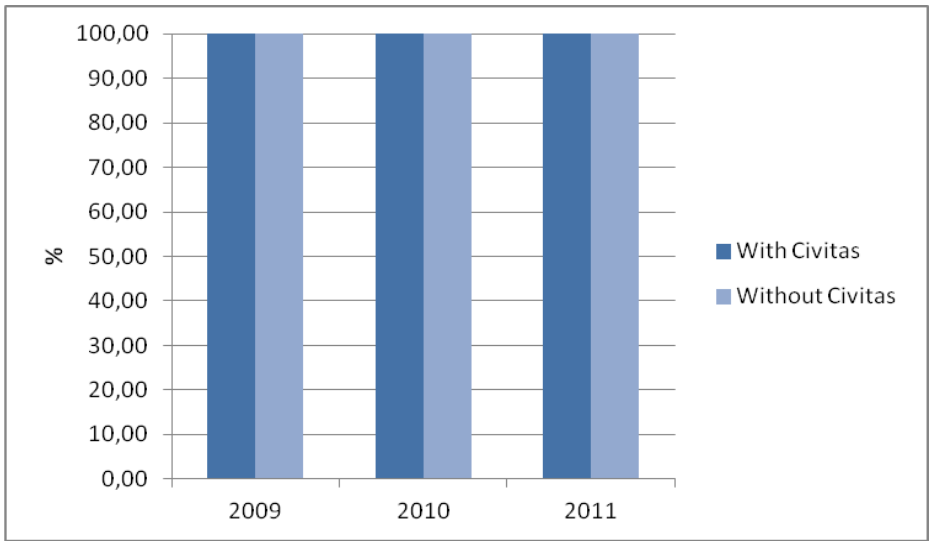
The next graph shows the evolution of the Acceptance Level – Users (%) With CIVITAS and the evolution of the Acceptance Level – Users according to the B-a-U scenario (Without CIVITAS).



Graph C2.5.3 – Acceptance level of the PT users - trend without CIVITAS (BAU) and results with CIVITAS

The results demonstrated that the Quality of PT Service continued higher (superior to 88%) and the evolution shows that the results after the implementation of the measure are lower in 2010 in comparison to those before and significantly higher in 2011. According to information from SMTUC, 2009 strikes may have influenced negatively respondents answers and therefore the 2010 results. Also the fact that the survey of 2010 has been carried out in March / beginning April - less than 6 months after the Centre oppened – could have contributed to a lower level of perception about the Infomobility Centre advantages.

The next graph shows the evolution of the Acceptance Level – Operators (%) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).



Graph C2.5.4 – Acceptance level of the PT operators - trend without CIVITAS (BAU) and results with CIVITAS

In relation to the acceptance level of the operators, it kept the same, at the maximum level (due to a high awareness level of this target group and because the Municipality and SMTUC long ago aspired to implement a Mobility Centre in Coimbra and involved all the PT operators since the beginning of the process).

The total acceptance before measure implementation was confirmed by the fact that after the specifications of this measure in the CIVITAS proposal, but before its implementation, a period of promotion and negotiations occurred and all the PT operators agreed to participate in the Infomobility Centre.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To establish a mobility centre facility in town integrating all transport operators in order to reach at least 75% of PT operators accepting the measure and 80% of PT users accepting the measure. The mobility centre facility has been established reaching 100% of PT operators accepting the measure and 95% of PT users accepting the measure. In 2011 the Infomobility Centre received 34.040 visits with an increase of 54% when compared the firsts semesters of 2011 and 2012.	***
2	To implement a public web service, which will provide an online trip planner interfaced with the SMTUC automated vehicle management (AVM) system that provides the data updates, in order to surpass 1500 accesses per month to the RUMOS trip planner. A public web service, providing an online trip planner interfaced with the SMTUC automated vehicle management (AVM) system has been implemented, reaching 4688 accesses per month to the RUMOS trip planner between 1st June 2011 and 31st May 2012.	***
3	To promote mobility marketing. Mobility marketing has been promoted through the implementation of several campaigns and events many of them happening within the mobility centre or with origin there (10 large-scale events in the total).	**
4	To increase 1,5% percentage of female passengers transported by the SMTUC. The percentage of female passengers transported by SMTUC increased by 6,2% in 2009, 6,9% in 2010 and 2,4% in 2011	***
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

The Operational functioning of the Infomobility Centre, the RUMOS trip planner and the respective promotional campaigns were implemented throughout the entire SMTUC network. However, considering the specific needs of travellers arriving in town from the hinterland, and given the success of the measure, the chance for the creation of a second Mobility Centre in Coimbra's railway station is being considered. However, due to the current financial crises situation in Portugal it is difficult to predict the date of construction.

The potential interest of a second Mobility Centre near the main railway station is high since the localization is very attractive for the passengers that came from outside of the city by train and need to travel in the city or in the region.

If this centre is implemented it is expected that the capital costs will be very low because the site already exists and is owned by SMTUC (less then 40 000 € for facility renewal and equipment). For this reason the operating costs will also be lower, since the renting value will be null, but also because the expected need of less personnel. Accordingly, so a yearly operating costs of 30 000 € could be a good forecasted.

Concerning the other indicators it can be expected that the new centre could contribute to an augment in the PT Service Quality and achieve the acceptance of all the PT operators, despite the acceptance level of the PT users would not be so important, because this centre will be located in a less central place than the existing one. For this reason also the Centre attendance will be certainly more reduced (approximately 20 000 customer per year).

C5 Appraisal of evaluation approach

The evaluation strategy of this measure sought to focus on a number of indicators across the areas of economy, transport and society, which were to be measured in different ways.

Taking into consideration that this measure should not have a great impact on the modal split at the city level in comparison with other CIVITAS measures implemented in Coimbra and that a survey to assess this impact concerning all the inhabitants of Coimbra would have been very expensive, it was decided that this impact will not be evaluated directly.

Since we do not have the information concerning the modal shift it was not possible to evaluate the impact of the Infomobility Centre in the change of the ticketing system.

Concerning the operating cost indicator several analyses were carried out taking in to consideration the operating costs of all the service or just those concerning the measure. The final decision was not to include all the operational revenues and the operational costs of the SMTUC services but only the operational costs directly associated with the measure.

Moreover, by taking into consideration that the objectives of the measure were the increase in the female passengers usage of PT and not the raise of this gender in the gender split, it has been decided not to include the Indicator Gender Split in the evaluation (as instead included in the Evaluation Plan). These modifications of course induced also a redefinition of the B-a-U scenario.

Another aspect to highlight is the modal split indicator removal. For this indicator it was considered that the improvements introduced along with the measure implementation had low impact in the modal split at city level comparatively with other CIVITAS measures implemented in Coimbra. For this reason it has been assumed that during the evaluation period the mitigations of environmental emissions will be null.

The final phase of the evaluation process determined the redefinition of the indicator Quality of PT Service which was related to the overall SMTUC PT service and on the final version was restricted to those quality items directly related to the measure.

C6 Summary of evaluation results

The key results are as follows:

- **Operating costs sharing** – Near 95% of the total operating costs (about 187 k€) are refered to the Infomobilty Centre with a significant ratio of personal costs (61%) and facilities hiring cost (27,%).
- **Capital costs sharing –** The capital costs of the Infomobility Centre (about 85 k€) and RUMOS Trip planner were almost similar, althought the total costs of the Infomobility Centre were ended in 2009.
- P**ositive results of the measure in terms of Quality of PT service and of centre customers satisfaction** – PT users are likely to continue satisfied after the measure implementation. These positive impacts of the measure are likely to have a positive impact in PT ridership and therefore in PT revenues due to their contribution to the increase of PT customer satisfaction. The customers satisfaction about the quality of the Centre services is also very high (more than 93% in the 2 yearly surveys).
- **High accesses growth rate of RUMOS –** The monthy avarage access to RUMOS Trip Planner during the 1st year were 4.688 accesseses in a total of 56.011 access.
- **Important growth rate of attendees at the Infomobility Centre** – At the 1st semester of 2012 the number of attendees (34.450) was higher than the annual figures of 2011 (34.040).
- **Events or campaigns promotions** – By organizing 10 campaigns and events about the measure have positive impacts revealed by the significant growth of the number of the attendees at the Infomobility Centre.
- **Good acceptance level of the Users** – Users continued to have a very good acceptance level after the implementation of the measure (between 88,7% and 94,5%). The analysis of its evolution demonstrated that these indicators after the implementation, in comparison to 2009, are lower in 2010 and higher in 2011. However, Acceptance Level had increased significantly during 2011. Strikes may have influenced negatively respondents' answers and therefore the 2010 results.
- **Increase of the awareness level –** The awareness level increased steadily along with the implementation of the measure (more rapidly from 2010-2011 than from 2009-2010) - this is a sign of the importance of measure implementation to raise awareness.
- **High Acceptance level of the Operators** – The acceptance level of the operators was already high before the implementation of the measure because the Municipality and SMTUC long ago

aspire the implementation of a Mobility Centre in Coimbra and involved all the PT operators since the beginning.

C7 Future activities relating to the measure

The mobility centre will keep working in the same way it has been working during the CIVITAS MODERN. There is the intention to open a second mobility centre close to the railway station.

The PT operator SMTUC will keep the operation of the trip planner RUMOS and promoting the implementation of mobility marketing campaigns.

Also the possibility of the extension of the "RUMOS" application to several of Coimbra's several "outdoor" Multimedia/Information check-points is being evaluated.

D Process Evaluation Findings

D1 Deviations from the original plan

The deviations from the original plan comprised:

- **Infomobility Centre functioning in a new modern place instead of an upgraded point of sales** – The Municipality and SMTUC decided to install the Centre in a new place instead of remodelling an existing point of sales. The new place, in a historic zone, required licensing with a long process of permissions that forced to change the opening date. Also the time required for the installation of the Centre had a delay given the need for more work, namely the building of interiors. So the functioning of the Centre started on September 2009 instead February 2009.

D2 Barriers and drivers

D2.1 Barriers

Preparation phase

- **Barrier 1.1 – Institutional Barrier:** Long process of procedures and routines for the licensing of the Infomobility Centre, due to the decision of its installation in a new place in the historic zone instead of the upgrade of an already existing point of sales, delayed the start-up of the installation of the Centre.

- **Barrier 1.2 – Organizational Barrier:** Despite an excellent acceptance of the measure, risk of some public transport operators not integrating the Infomobility Centre occurred in the beginning of this phase, namely while the centre costs repartition were not defined. This problem was solved since SMTUC assure the entire costs with personnel, resulting in the agreement for the participation of all operators in the centre.

Implementation phase

- **Barrier 2.1 – Technological Barrier:** The time required for the installation of the Centre had an increment given the need of more work due the decision of its installation in a new place instead of the upgrade of an already existing sales point.

- **Barrier 2.2 – Technological Barrier:** Technical complexity due to the stat-of-the-art model of trip planner chosen with RUMOS, that has required more time for the improvement of the first version delivered.

Operation phase

- **Barrier 3.1 – Cultural Barrier:** Infomobility Centre priorities were yet much more based on vending success than the sustainable mobility promotion, mainly due some operators attitude.

- **Barrier 3.2 – Technological Barrier:** Lack of digital data from regional public transport operators avoided more interoperability in the "RUMOS" trip planner until now, despite the fact that the application has achieved the objectives foreseen.

D2.2 Drivers

Preparation phase

- **Driver 1.1 – Political/Strategic Driver:** The Municipality of Coimbra City and SMTUC have a great tradition in sustainable mobility, innovation and life quality, traduced in the mobility policies that leaded to the installation of a modern mobility centre in the historic centre of the city and in a new and central place instead of the upgrade of a already existing point of sales.

- **Driver 1.2 – Financial Driver:** Availability of CIVITAS and SMTUC funding for the centre setup.

Implementation phase

- **Driver 2.1 – Financial Driver:** Availability of SMTUC funding to support all the centre installation.

- **Driver 2.2 – Organizational Driver:** SMTUC technicians motivated and involved in CIVITAS issues.

Operation phase

- **Driver 3.1 – Financial Driver:** Availability of CIVITAS and SMTUC funding for the centre management, functioning and monitoring and of the public transport operators for the Centre rent.

- **Driver 3.2 – Political/Strategic Driver:** Commitment of the Municipality of Coimbra in this measure demonstrated by the public recognition about the great interest of the centre and the availability of the Mayor and municipal councillors to participate in events linked to the centre.

- **Driver 3.3 – Technological Driver:** The "RUMOS" trip planner has been developed to allow upgrades in the future for the integration of other operators.

D2.3. Activities

Preparation phase

- **Activities 1 – Planning Activities:** The specifications of the Infomobility Centre had a special attention to include the objectives referred in driver 1.1 and the specifications of the CIVITAS measure. Great care with the planning of the design of the centre and

its installation process, including risk management and contingency plans, that allowed a fast installation time and the recovery of some of the time lost with barrier 1.1.

- **Activities 2 – Organizational Activities:** Contacts, meetings, promotions and procedures allowed the agreement of all public transport operators for its integration in the Centre during the implementation phase, avoiding the problems with the barrier 1.2. For this agreement it was important too the availability of SMTUC to support the major part of the costs.

Implementation phase

- **Activities 1 – Organizational Activities:** Taking advantage of driver 2.2, occurred a great care of SMTUC technicians in the coordination and accomplishment of the installation process of the Infomobility Centre to recover time lost with barrier 2.1. The decisions are facilitated by the fact that SMTUC was responsible for all the work (driver 2.1).

- **Activities 2 – Organizational Activity:** It was been decided to launch "RUMOS" trip planner in test conditions in the Infomobility Centre and for the SMTUC technicians in a first phase. This methodology allowed a more effective and quicker accomplishment of the system and avoided delays that could be made by the barrier 2.2.

Operation phase

- **Activities 1 – Involvement, communication Activities:** It has been carried out the promotion of the Infomobility Centre at local and national level by workshops, conferences, expert meetings, public awareness campaigns about the sustainability problems to be solved and about the measure through media activities, involvement of key stakeholders in the measure, namely politicians, commerce and industry representatives and public transport operators. These actions had also the aim to combat barrier 3.1. Could be highlighted that the activities of the European Car Free Day began in the Centre with a press conference and the launch ceremony of the new e-ticketing system chaired by the Mayor of Coimbra Municipality (taking advantage of driver 3.2). Three public transport operators participated in this event.

- **Activities 2 – Financial Activities:** The involvement of SMTUC concerning the guarantee of the infrastructure maintenance and the personnel costs of the Centre, aided by CIVITAS during the first 3 years (driver 3.1), also was contributing for the maintenance of all public transport operators in the Centre and for the achievement of the objectives defined, helping to reduce the effects of the barrier 3.1.

- **Activities 3 – Technological Activities:** The "RUMOS" trip planner has been developed to allow upgrades in the future for the integration of other operators and avoid barrier 3.2.

D3 Participation of stakeholders

D3.1 Measure partners

- **Measure partner 1 – Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Leading role**

  SMTUC was responsible for the conception and implementation of the Infomobility Centre, as well as the inherent costs for the related activities. SMTUC also manage the Centre and supply the staff members which are responsible for selling the transport tickets and providing customer information on the regional public transport services.

  Additionally, SMTUC played an important role in the design of the technical specifications of the trip planner RUMOS and accompanied its development. After its implementation, SMTUC assumed the management of the RUMOS system as well as its maintenance expenses.

  The monitoring and data collection regarding the RUMOS Trip Planner, including evaluation material, were also carried out by SMTUC.

  The events and campaigns held at the Infomobility Centre were also promoted by SMTUC. This partner played an important role in the dissemination of the Centre and the RUMOS trip planner, namely publicising these services and products in numerous events such as conferences, workshops, seminars, etc.

- **Measure partner 2 – Critical Software (CSW); Private company; Principle participant**

  CSW was responsible for the development of the RUMOS Trip Planner and provides SMTUC with maintenance services

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

  While responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA, PRODESO gave some support in the promotion of the Infomobility Centre and RUMOS trip planner.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

  PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

- **Measure partner 5 – Câmara Municipal de Coimbra (CMC); City; Occasional participant**

  CMC supported SMTUC in its decision to launch the Infomobility Centre and in its promotion, revealing a great commitment, namely with the Mayor and political involvement in the numerous events, such as the official celebration of the 2011 European Car Free Week. Since October 2011 has been also the responsible for the dissemination of the MODERN project of Coimbra.

D3.2 Stakeholders

- **Stakeholder 1 - Regional PT Operators**

  All the regional Public Transport operators and the national railway operator jointed SMTUC in the Infomobility Centre with great interest since the beginning of it functioning.

  The public transport operators are responsible for the payment of the Infomobility Centre rent since November 2009.

  Only SMTUC has organized events in the Centre, so it is not so clear that others public transport operators are motivated in the promotion of sustainability trough the centre. They seem consider the centre more as a point of sales that a mobility centre. In any way they have leaflets with information about owner services. Some actions had been taken by SMTUC to involve public transport operators, namely inviting him to participate in the events carried out in the centre.

- **Stakeholder 2 – Car drivers**

  The target group of the events organized in the centre is mainly the car drivers. Usual media channels have been used to promote these events near the car drivers and the "RUMOS" trip planner was also a useful tool to catalyse the modal shift. The local automobile club has been represented in all the events organized in the centre.

- **Stakeholder 3 – Public transport users**

  The public transport passengers of all public transport operators were the main users of the Infomobility Centre and also a target group of the SMTUC campaigns. The integration of all these operators in the centre increased very much the quality of the service and its functionalities. The "RUMOS" trip planner has been also an important tool to help these users to plan its travels.

- **Stakeholder 4 – Visitors (shops / leisure)**

  The Infomobility Centre and the "RUMOS" trip planner help visitors to know how to travel in the city, namely such that don't know the city.

- **Stakeholder 5 – General public**

  People that had mobility needs used the Infomobility Centre to get information on the way to travel and to purchase / load tickets or passes. Events and campaigns on the centre were been also directed to the general public.

  The "RUMOS" trip planner, as an online tool, can be used by all the population anywhere.

  The dissemination and promotion of the Infomobility Centre and the "RUMOS" trip planner have been also made at regional and national level (workshops, internet, news papers and magazines,…)

- **Stakeholder 6 – Media**

Media has been a channel for the dissemination and promotion of the measure and all the events organized in the Infomobility Centre had the participation at least of the local media.

D4 Recommendations

D4.1 Recommendations: measure replication

- **A mobility centre could be important in cities with several Public Transport operators and / or want to promote good mobility practices –** The Infomobility Centre is very important in cities with several public transport operators. It helps passengers who use several different operators and modes of transport because it concentrates various operators and services in one place. Infomobility Centres also contribute to promoting soft measures and consequently can be justified in terms of improving sustainable mobility practices in most cities.

- **Attention should be done for the involvement of stakeholders and for the business model of the mobility centre –** An effort should be made to involve the largest possible number of public transport operators and other agents such as tourism services, rent-a-car, car sharing, bike sharing, renting, etc. However, business models should be well planned in advance. In Coimbra it was possible to involve all the local public transport operators, but the fact that SMTUC supported all the installation and major part of operational costs certainly contributed to this situation (74% of the operational costs are supported by SMTUC). In different conditions it is stipulated that things might not be so straightforward, namely if there are operators insensitive to customer services. However, the involvement of the municipal authorities seems indispensible. An incentive to the participation of the private operators is the fact that while SMTUC has the largest public transport service area in the municipality of Coimbra, of the 34000 customer attendances at the Centre in 2011, 55% was for services with other operators.

- **Attention to the location of the mobility centre and the need of licensing procedures –** The location of the Infomobility Centre in a central part of the city and close to the different public transport interfaces is recommended. The need of any special licensing must be took in account in advance because could delay the process.

- **Training of the mobility centre staff is very important –** Employee training is essential. In the case of Coimbra each staff member had training on the services of all the public transport operators enlisted in the Centre. Employees with a good knowledge of English were also sought out.

- **The facility of the mobility centre should consider all the expected functions –** The locale of the Centre should be able to host different sorts of events (e.g., meetings and press conferences) in order for it to be a platform for mobility promotion.

- **An on-line trip planner is crucial for cities that have public transportation services –** One of the main reasons for people not using public transport is the lack of travel information. Accordingly, the availability of an on-line trip planner is extremely important to help customers plan their travels, especially in a sustainable manner. In the case of the RUMOS trip planner, customers can choose between different options in order to customize the travel plans to their specific needs.

D4.2 Recommendations: process (related to barrier-, driver- and action fields)

- **Planning process and follow-up of the work are very important–** The delays in the installation of the Infomobility Centre could have been avoided if there was more time to plan its location. A new site was chosen in the historic centre, instead of upgrading and existing ticket centre, and implied a complex licensing period. Nevertheless, this problem is not easy to surpass considering the recommendation of locating the Centre in a central place, close to the major public transport interfaces. A rigorous planning process and follow-up of the work is also essential.

- **Negotiation process with the stakeholders must be managed carefully and the involvement of municipal entities could important–** The negotiation process with all the operators which we wish to integrate is also time-demanding. The involvement of the municipality or one of its representatives (in the case of Coimbra it was the municipal public transport operator SMTUC) is crucial to convince all the agents to commit. This barrier was surpassed due to the fact that SMTUC assumed most of the financial costs of the installation of the Centre, except for the rent (CIVITAS also contributed to staff expenses during the first three years).

- **Involvement of all measure actors and promotional events could be important to change mentalities–** Private public transport operators are more concerned with the financial aspects, rather than the issues of urban sustainability. Accordingly, they invest more in ticket sales than on the promotion of good mobility practices and information for the public. In order to change this situation, the Municipality of Coimbra and SMTUC have held several different events, such as meetings with private public transport operators and promotion of good practices, using the Centre for press conferences and other initiatives on sustainable mobility. There has been a great effort to involve all the stakeholders in order to promote more sustainable mobility behaviour.

- **Good and in time assessment to the needs and cooperation between developers and customers are important to avoid technical problems –** The greatest challenge to the implementation of the RUMOS trip planner system was its technical complexity and the need to integrate it with other systems. Accordingly, it is essential to know exactly what is needed and required in the initial specification stage, including system interoperability. Developers of the systems should be involved in all the stages. The issue is more complicated when trying to integrate other public transport operators, especially when they are not motivated. However, the more operators integrated in the trip planner the better, so the system should be developed with the possibility of integrating more operators and services. Nevertheless, the lack of established standards in this domain implies an increased dependence on system integrators, with the associated costs.

ANNEX 1: Quality of PT Service Data

Question: How do you rate your satisfaction level about the following items?

Satisfaction Level (2008)	1 - Very uns.	2 - Unsatisf.	3 – Satisfied	4 - Very Sat.	Average
6. Information at SMTUC ticket selling shops	3	45	681	257	3,21
9. Information available on the Internet	22	128	575	204	3,03
Total	25	173	1256	461	3,12

Data collection from 2008-12-04 a 2009-01-09

Satisfaction Level (2010)	1 - Very uns.	2 - Unsatisf.	3 – Satisfied	4 - Very Sat.	Average
6. Information at SMTUC ticket selling shops	3	69	593	55	2,97
9. Information available on the Internet	9	49	295	105	3,08
Total	12	118	888	160	3,03

Data collection from 2010-03-23 a 2010-03-29

Satisfaction Level (2011)	1 - Very uns.	2 - Unsatisf.	3 - Satisfied	4 - Very Sat.	Average
6. Information at SMTUC ticket selling shops	1	24	576	141	3,15
9. Information available on the Internet	6	40	398	163	3,18
Total	7	64	974	304	3,17

Data collection from 2011-03-29 a 2011-04-04

Source: SMTUC

The next table shows the evolution of the average number of days with strike on SMTUC network in each year between 2005 and 2012.

Year	2005	2006	2007	2008	2009	2010	2011	2012
Days with strike	1,2	6	4	5	11,2	5	3,1	1,2

Source: SMTUC

ANNEX 2: Awareness level Data

Question: Are you aware about the existence of the Infomobility Centre and about the services provided there?

Year of the survey (period of data collection)	Positive answers – Yes (Nr.)	Negative answers – No (Nr).	Positive answers – Yes (%)
2008 (2008-12-04 a 2009-01-09)	0	0	0

2010 (2010-03-23 a 2010-03-29)	129	611	17
2011 (2011-03-29 a 2011-04-04)	300	438	41

Source: SMTUC

ANNEX 3: Acceptance level – users Data

Question: How do you rate your satisfaction level about the following items?

Acceptance (2008)	Positive answers – Satisf. or Very Satisf. (Nr.)	Total answers (Nr.)	Positive answers – Satisf. or Very Satisf. (%)
6. Information at SMTUC ticket selling shops	938	986	95
9. Information available on the Internet	779	929	84
Total	1717	1915	89

Data collection from 2008-12-04 a 2009-01-09

Acceptance (2010)	Positive answers – Satisf. or Very Satisf. (Nr.)	Total answers (Nr.)	Positive answers – Satisf. or Very Satisf. (%)
6. Information at SMTUC ticket selling shops	648	720	90
9. Information available on the Internet	400	458	87
Total	1048	1178	89

Data collection from 2010-03-23 a 2010-03-29

Acceptance (2011)	Positive answers – Satisf. or Very Satisf. (Nr.)	Total answers (Nr.)	Positive answers – Satisf. or Very Satisf. (%)
6. Information at SMTUC ticket selling shops	717	742	97
9. Information available on the Internet	561	607	92
Total	1278	1349	95

Data collection from 2011-03-29 a 2011-04-04

Source: SMTUC

ANNEX 4: Acceptance level – operators Data

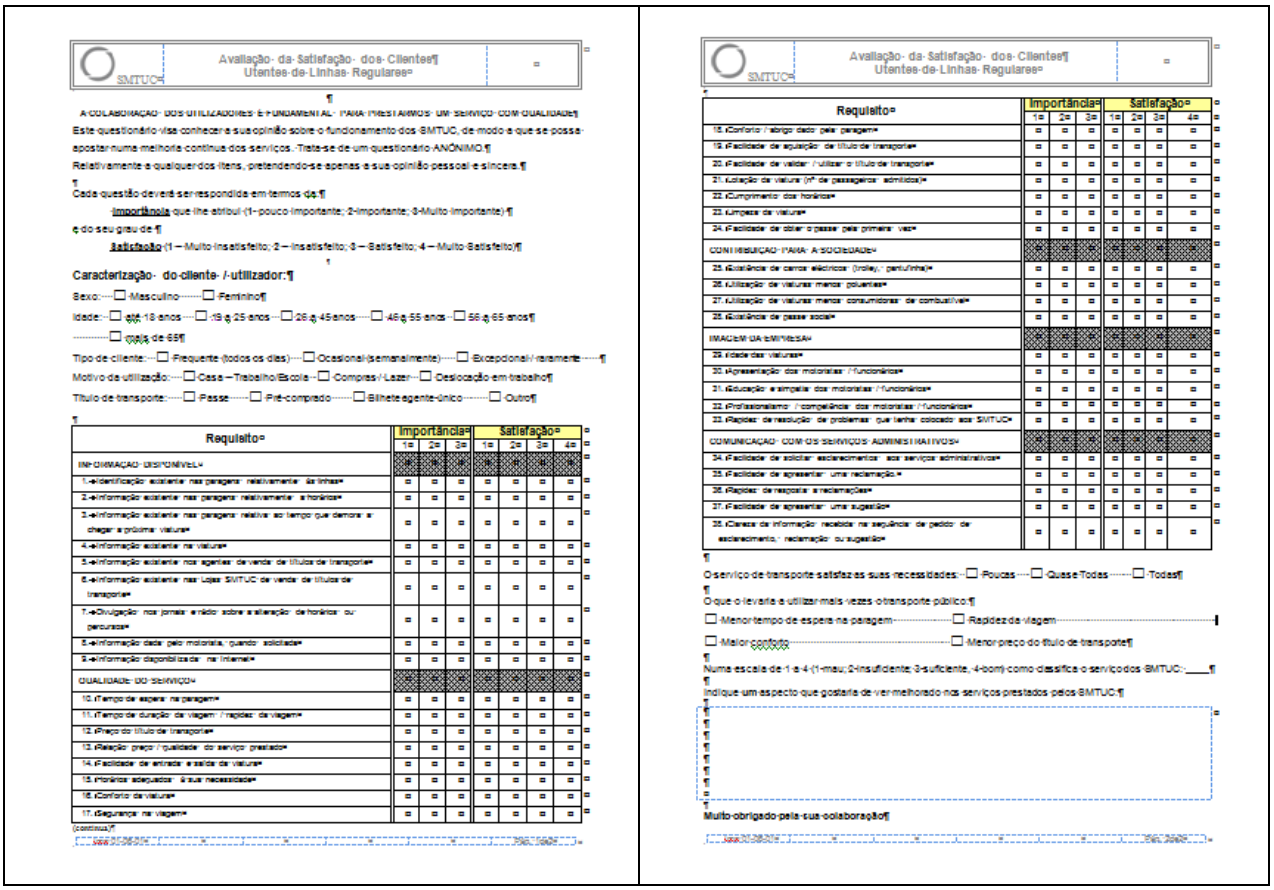
To get a qualitative assessment of attitude of operators towards the measure (before the implementation in September 2009 and after its implementation) a survey was conducted to the 4 PT operators of the Coimbra Metropolitan Area in July 2011. Although the survey was conducted after the implementation of the measure, for the e-ante data the interviewee was asked to report his answer to his attitude before the implementation of the measure (i.e., to the baseline period- 2008). The results obtained are presented in the next table:

Indicators and respective parameters	Ex-Ante values	Ex-Post values
Number of positive answers (2011-07-01 to 2011-07-13)	4	4
Number of respondents (2011-07-01 to 2011-07-13)	4	4
Acceptance level (2011-07-01 to 2011-07-13)	100 %	100 %

Source: SMTUC

ANNEX 5: Quality Survey

ANNEX 5.1 Questionnaire model



SMTUC

Avaliação da Satisfação dos Clientes
Utentes de Linhas Regulares

A COLABORAÇÃO DOS UTILIZADORES É FUNDAMENTAL PARA PRESTARMOS UM SERVIÇO COM QUALIDADE

Este questionário visa conhecer a sua opinião sobre o funcionamento dos SMTUC, de modo a que se possa apostar numa melhoria contínua dos serviços. Trata-se de um questionário ANÓNIMO.

Relativamente a qualquer dos itens, pretendendo-se apenas a sua opinião pessoal e sincera.

Cada questão deverá ser respondida em termos da:

Importância que lhe atribui (1- pouco importante; 2-importante; 3-Muito importante)

e do seu grau de

Satisfação (1 – Muito Insatisfeito; 2 – Insatisfeito; 3 – Satisfeito; 4 – Muito Satisfeito)

Caracterização do cliente /-utilizador:

Sexo: ☐ Masculino ☐ Feminino

Idade: ☐ até 18 anos ☐ 19 a 25 anos ☐ 26 a 45 anos ☐ 46 a 55 anos ☐ 56 a 65 anos ☐ mais de 65

Tipo de cliente: ☐ Frequente (todos os dias) ☐ Ocasional (semanalmente) ☐ Excepcional/-raramente

Motivo da utilização: ☐ Casa – Trabalho/Escola ☐ Compras/-Lazer ☐ Deslocação em trabalho

Título de transporte: ☐ Passe ☐ Pré-comprado ☐ Bilhete agente-único ☐ Outro

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
INFORMAÇÃO DISPONÍVEL							
1. Identificação existente nas paragens relativamente às linhas							
2. Informação existente nas paragens relativamente aos horários							
3. Informação existente nas paragens relativa ao tempo que demora a chegar a próxima viatura							
4. Informação existente na viatura							
5. Informação existente nos agentes de venda de títulos de transporte							
6. Informação existente nas Lojas SMTUC de venda de títulos de transporte							
7. Divulgação nos jornais e rádio sobre alteração de horários ou percursos							
8. Informação dada pelo motorista, quando solicitada							
9. Informação disponibilizada na Internet							
QUALIDADE DO SERVIÇO							
10. Tempo de espera na paragem							
11. Tempo de duração da viagem / rapidez da viagem							
12. Preço do título de transporte							
13. Relação preço / qualidade do serviço prestado							
14. Facilidade de entrada e saída da viatura							
15. Horários adequados à sua necessidade							
16. Conforto da viatura							
17. Segurança na viagem							

(continua)

SMTUC

Avaliação da Satisfação dos Clientes
Utentes de Linhas Regulares

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
18. Conforto / abrigo dado pela paragem							
19. Facilidade de aquisição do título de transporte							
20. Facilidade de validar / utilizar o título de transporte							
21. Adaptação da viatura (nº de passageiros admitidos)							
22. Cumprimento dos horários							
23. Limpeza da viatura							
24. Facilidade de obter o passe pela primeira vez							
CONTRIBUIÇÃO PARA A SOCIEDADE							
25. Existência de carros eléctricos (trolley, pentufinha)							
26. Utilização de viaturas menos poluentes							
27. Utilização de viaturas menos consumidoras de combustível							
28. Existência de passe social							
IMAGEM DA EMPRESA							
29. Idade das viaturas							
30. Apresentação dos motoristas / funcionários							
31. Educação e simpatia dos motoristas / funcionários							
32. Profissionalismo / competência dos motoristas / funcionários							
33. Rapidez de resolução de problemas que tenha colocado aos SMTUC							
COMUNICAÇÃO COM OS SERVIÇOS ADMINISTRATIVOS							
34. Facilidade de solicitar esclarecimentos aos serviços administrativos							
35. Facilidade de apresentar uma reclamação							
36. Rapidez de resposta a reclamações							
37. Facilidade de apresentar uma sugestão							
38. Clareza da informação recebida na sequência de pedido de esclarecimento, reclamação ou sugestão							

O serviço de transporte satisfaz as suas necessidades: ☐ Poucas ☐ Quase Todas ☐ Todas

O que o levaria a utilizar mais vezes o transporte público

☐ Menor tempo de espera na paragem ☐ Rapidez da viagem

☐ Maior conforto ☐ Menor preço do título de transporte

Numa escala de 1 a 4 (1-mau; 2-insuficiente; 3-suficiente, 4-bom) como classifica o serviço dos SMTUC: ____

Indique um aspecto que gostaria de ver melhorado nos serviços prestados pelos SMTUC

Muito obrigado pela sua colaboração

ANNEX 5.2 Structure and questions

The questionnaire starts with 4 questions related to the interviewee – Sex, Age (<18, 19-25, 26-45, 56-65, >65),type of client (frequent, occasional, exceptional/rare use), motive of the trip (home-work/school, shopping/leisure, in service), type of ticket (pass, single ticket bought on the selling point, single ticket bought on the vehicle, other).

The main part of the questionnaire is composed of 38 specific questions related to various items related to 5 areas of the service (1-Available information, 2-Quality of service, 3-Contribution to society, 4-Image of the company, 5-Communication with the administrative services) and a specific global customer satisfaction question that resume quality of service. In each question the people interviewed express a judgement choosing between very satisfied – satisfied – unsatisfied – very unsatisfied and about the importance of each of the 38 items choosing between very important – important – low importance.

Each question is assessed in terms of importance given (1-Not important, 2-Important, 3-Very Important) and level of satisfaction (1-Very Dissatisfied 2-Dissatisfied 3-Satisfied 4-Very Satisfied) of the user in relation to the respective item.

AVAILABLE INFORMATION
1. Identification of existing lines at stops
2. Information at stops about timetables
3. Information at stops about the waiting time until the next vehicle
4. Information inside the vehicle
5. Information at ticket selling points
6. Information at SMTUC ticket selling shops
7. Disclosure of information in the newspapers and radio about timetable or routes changing[11]
8. Information given by the driver, upon request
9. Information available on the Internet
QUALITY OF SERVICE
10. Waiting time at stop
11. Trip duration / speed of travel
12. Price of the ticket
13. Relation Price / Quality of the service
14. Ease of entry and exit of the vehicle
15. Adjustment of the timetable to your needs
16. Comfort of the vehicle

[11] This question was eliminated on the 2010 and 2011 surveys.

17. Safety during the trip
18. Comfort / protection given by the stop shelter
19. Ease of ticket purchase
20. Ease of ticket validation / utilization
21. Capacity of the vehicle (nr. of passengers allowed)
22. Compliance with the timetable
23. Cleanliness of the vehicle
24. Facility in obtaining the travel card for the first time
CONTRIBUTION TO SOCIETY
25. Existence of electric vehicles (trolleybus, electric mini-bus)
26. Utilization of less polluting vehicles
27. Utilization of less fuel consuming vehicles
28. Existence of social travel card
IMAGE OF THE COMPANY
29. Age of the vehicles
30. Presentation of drivers / staff
31. Education and friendliness of the drivers / staff
32. Quality of driving performance of SMTUC drivers[12]
33. Professionalism / competence of the drivers / staff
34. Quickness in the resolution of problems you may have submitted to SMTUC
COMMUNICATION WITH THE ADMINISTRATIVE SERVICES
35. Facility in requesting clarifications to the administrative services
36. Facility in submitting a complaint.
37. Response quickness in respect to complaints
38. Facility in presenting a suggestion
39. Clarity of the information obtained in response to a request for information, complaint or suggestion

The questionnaire concludes with 5 questions in relation to the respondent's general attitude towards the service supplied by SMTUC:

1. The transportation service meets your needs (1-Few, 2-Nearly all, 3-All)

[12] This question was not included on the 2009 survey.

2. What would make you consider using public transportation more often (1-Shorter waiting time at stops, 2-Higher speeds, 3-Increased comfort, 4-Lower price of the ticket)

3. How do you rate the SMTUC service on a scale of 1 to 4 (1-bad, 2-poor, 3-sufficient, 4-good)

4. Indicate a point you would like to see improved in the SMTUC service:

ANNEX 5.3 Customer satisfaction survey results

Quality of service is measured by means of customer satisfaction survey periodically carried out by SMTUC:

The survey is repeated 1 time a year and is carried out to customers on face to face interviews on board of the SMTUC busses.

The sample is drowned on the basis of the lines used by the passengers, i.e., the number of interviewees chosen in each line is defined according to the demand of the line relative to the overall SMTUC demand.

The dimension of the sample is defined according to the specifications of the quality management auditors which supervise the all process in line with the ISO9001 standard.

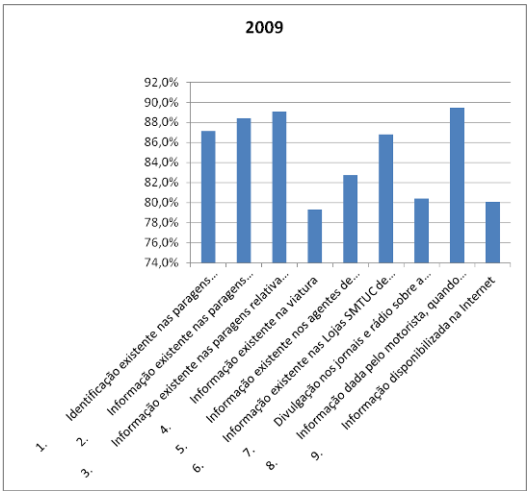
The quality management auditors considered 500 interviews as (a minimum) suitable to assess quality evaluation by PT passengers in Coimbra. However, SMTUC volunteered to go above this number. Thus, the following number of interviews and valid answers were achieved:

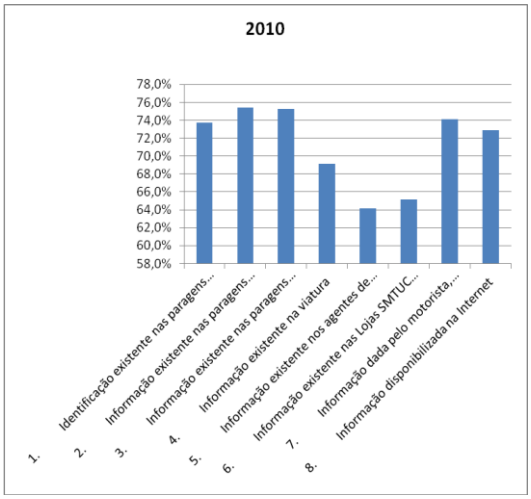
In 2009 it was obtained 1000 valid answers

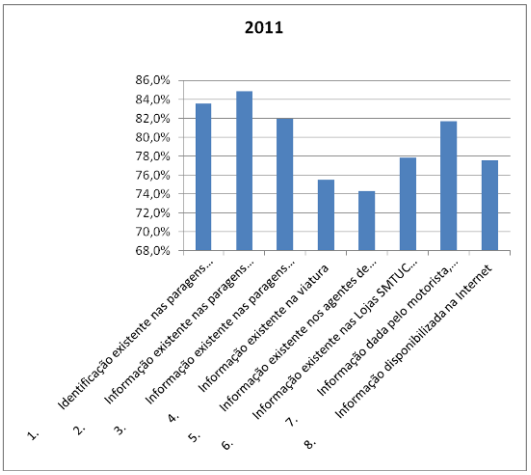
In 2010 it was obtained 750 valid answers

In 2011 it was obtained 750 valid answers

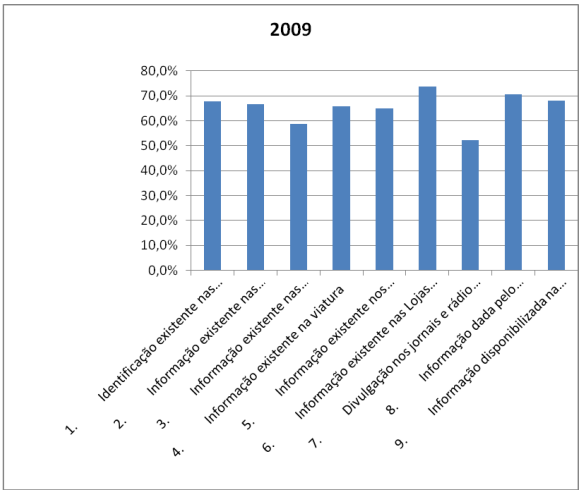
Importance given to the Available Information

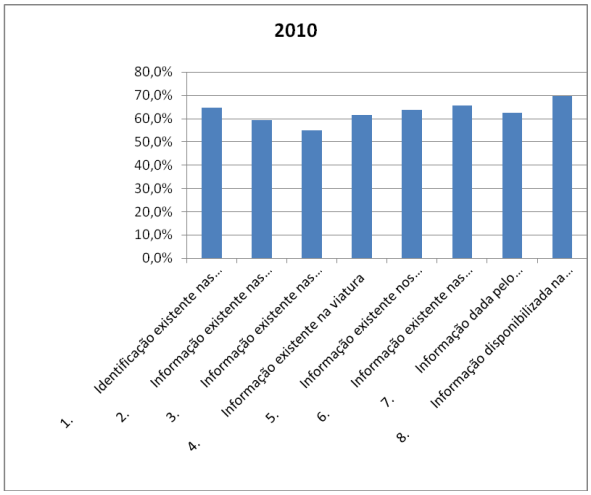


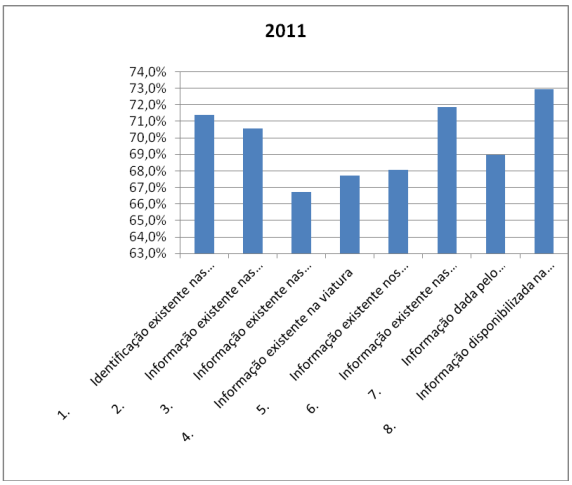


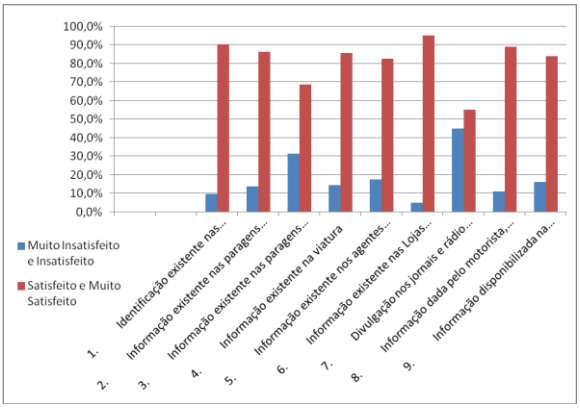


Level of satisfaction in relation to the Available Information






2011
74,0%
73,0%
72,0%
71,0%
70,0%
69,0%
68,0%
67,0%
66,0%
65,0%
64,0%
63,0%
1. Identificação existente nas...
2. Informação existente nas...
3. Informação existente nas...
4. Informação existente na viatura
5. Informação existente nos...
6. Informação existente nas...
7. Informação dada pelo...
8. Informação disponibilizada na...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40,0%
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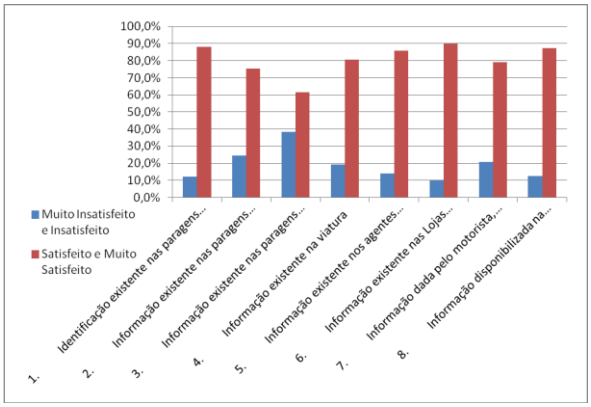
Muito Insatisfeito e Insatisfeito
Satisfeito e Muito Satisfeito
1. Identificação existente nas...
2. Informação existente nas paragens...
3. Informação existente nas paragens...
4. Informação existente na viatura
5. Informação existente nos agentes...
6. Informação existente nas Lojas...
7. Divulgação nos jornais e rádio...
8. Informação dada pelo motorista...
9. Informação disponibilizada na...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Muito Insatisfeito e Insatisfeito
Satisfeito e Muito Satisfeito
1. Identificação existente nas paragens...
2. Informação existente nas paragens...
3. Informação existente nas paragens...
4. Informação existente na viatura
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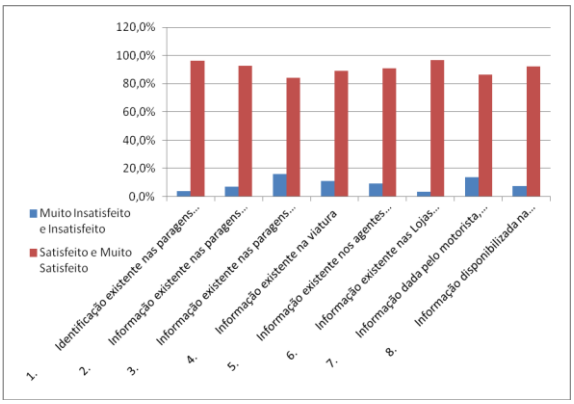
6. Informação existente nas Lojas...
7. Informação dada pelo motorista...
8. Informação disponibilizada na...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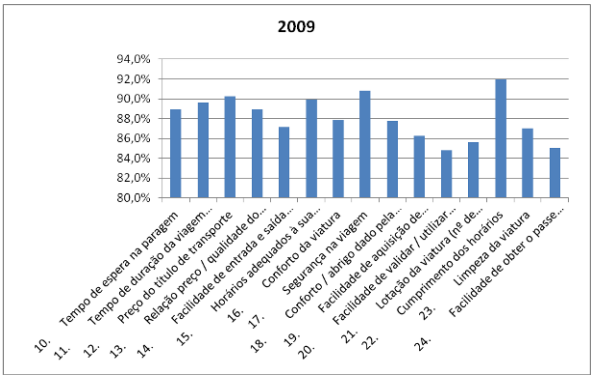
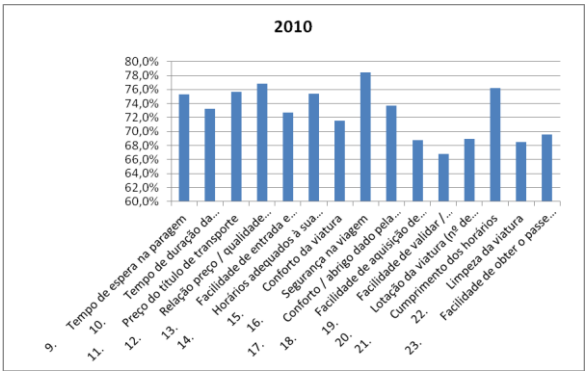
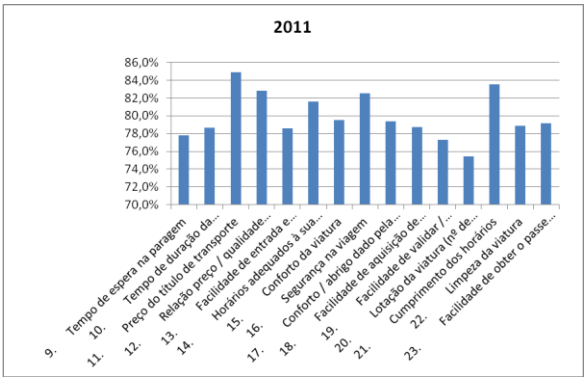
Muito Insatisfeito e Insatisfeito
Satisfeito e Muito Satisfeito
1. Identificação existente nas paragens...
2. Informação existente nas paragens...
3. Informação existente nas paragens...
4. Informação existente na viatura
5. Informação existente nos agentes...
6. Informação existente nas Lojas...
7. Informação dada pelo motorista...
8. Informação disponibilizada na...

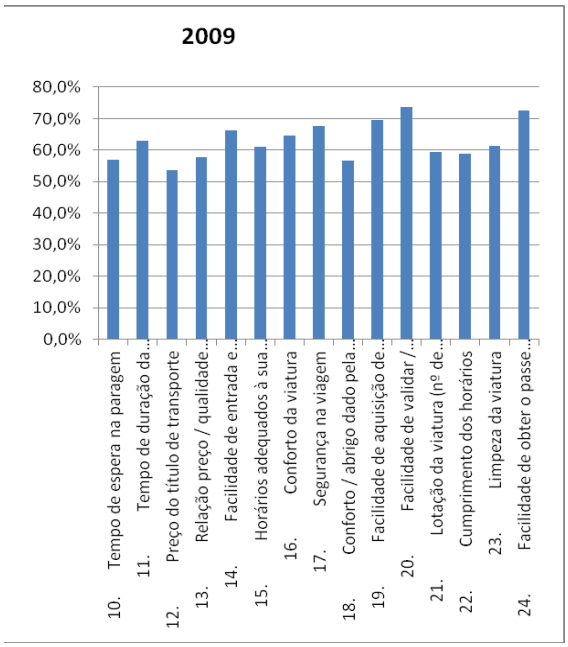
Importance given to the Quality of Service

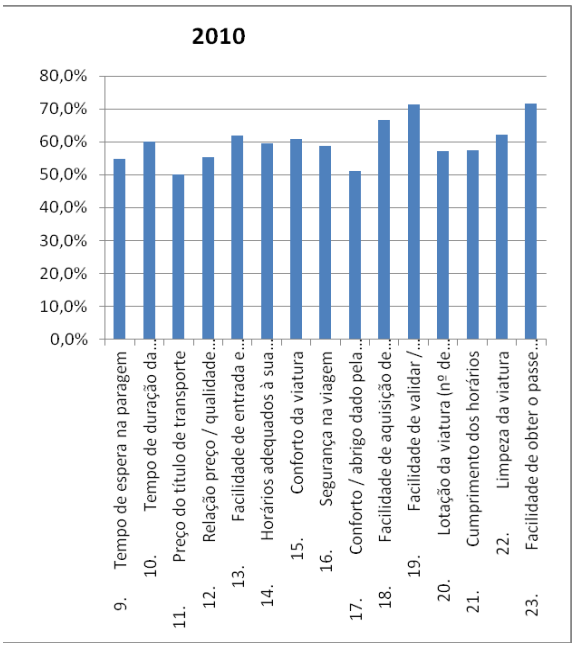


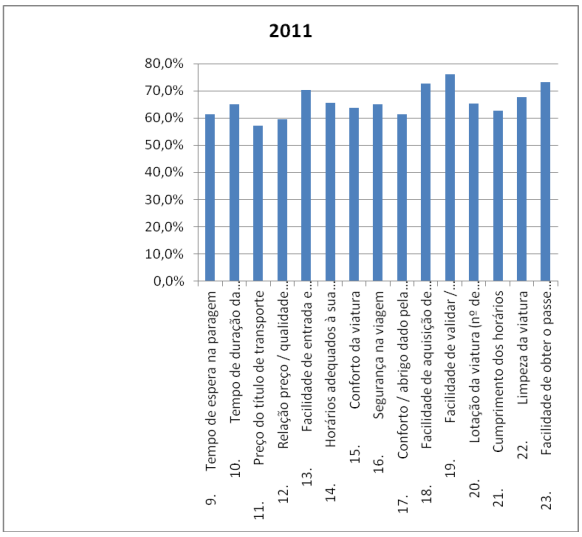




Level of satisfaction in relation to the Quality of Service






2011
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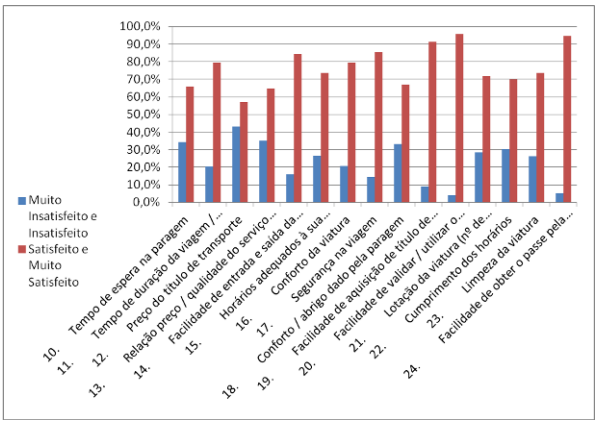
9. Tempo de espera na paragem
10. Tempo de duração da...
11. Preço do título de transporte
12. Relação preço / qualidade...
13. Facilidade de entrada e...
14. Horários adequados à sua...
15. Conforto da viatura
16. Segurança na viagem
17. Conforto / abrigo dado pela...
18. Facilidade de aquisição de...
19. Facilidade de validar /...
20. Lotação da viatura (nº de...
21. Cumprimento dos horários
22. Limpeza da viatura
23. Facilidade de obter o passe...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Muito Insatisfeito e Insatisfeito
Satisfeito e Muito Satisfeito
10. Tempo de espera na paragem
11. Tempo de duração da viagem / ...
12. Preço do título de transporte
13. Relação preço / qualidade do serviço...
14. Facilidade de entrada e saída da...
15. Horários adequados à sua...
16. Conforto da viatura
17. Segurança na viagem
18. Conforto / abrigo dado pela paragem
19. Facilidade de aquisição de título de...
20. Facilidade de validar / utilizar o...
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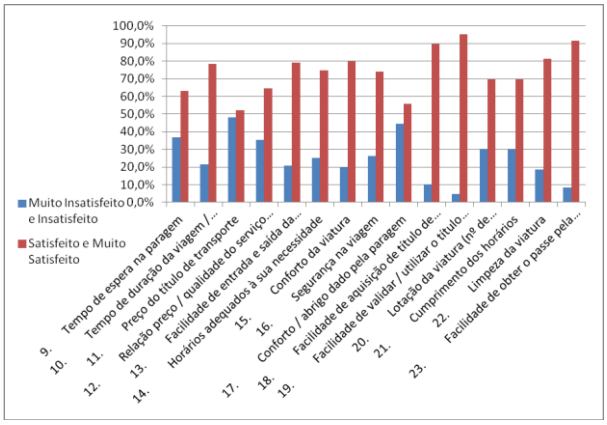
22. Cumprimento dos horários
23. Limpeza da viatura
24. Facilidade de obter o passe pela...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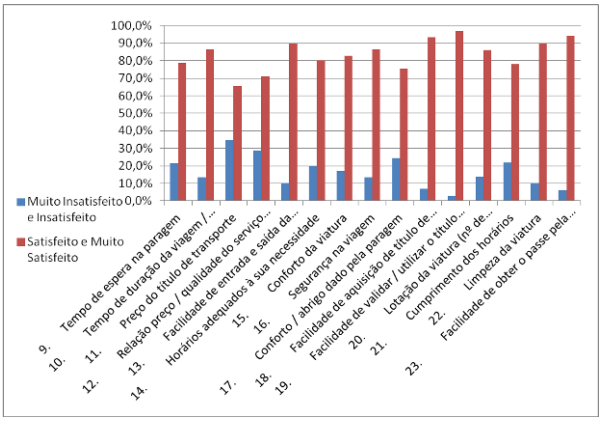
Muito Insatisfeito e Insatisfeito
Satisfeito e Muito Satisfeito
9. Tempo de espera na paragem
10. Tempo de duração da viagem / ...
11. Preço do título de transporte
12. Relação preço / qualidade do serviço...
13. Facilidade de entrada e saída da...
14. Horários adequados à sua necessidade
15. Conforto da viatura
16. Segurança na viagem
17. Conforto / abrigo dado pela paragem
18. Facilidade de aquisição de título de...
19. Facilidade de validar / utilizar o título...
20. Lotação da viatura (nº de...
21. Cumprimento dos horários
22. Limpeza da viatura
23. Facilidade de obter o passe pela...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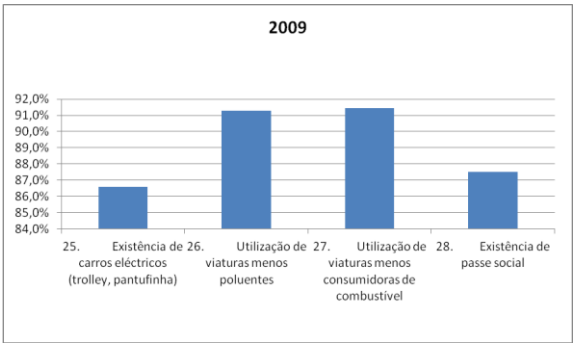
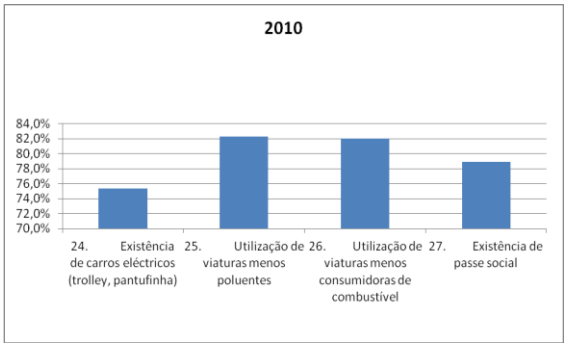
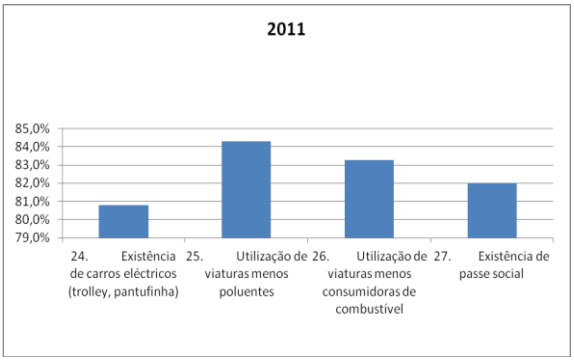
Muito Insatisfeito e Insatisfeito
Satisfeito e Muito Satisfeito
9. Tempo de espera na paragem
10. Tempo de duração da viagem / ...
11. Preço do título de transporte
12. Relação preço / qualidade do serviço...
13. Facilidade de entrada e saída da...
14. Horários adequados à sua necessidade
15. Conforto da viatura
16. Segurança na viagem
17. Conforto / abrigo dado pela paragem
18. Facilidade de aquisição de título de...
19. Facilidade de validar / utilizar o título...
20. Lotação da viatura (nº de...
21. Cumprimento dos horários
22. Limpeza da viatura
23. Facilidade de obter o passe pela...

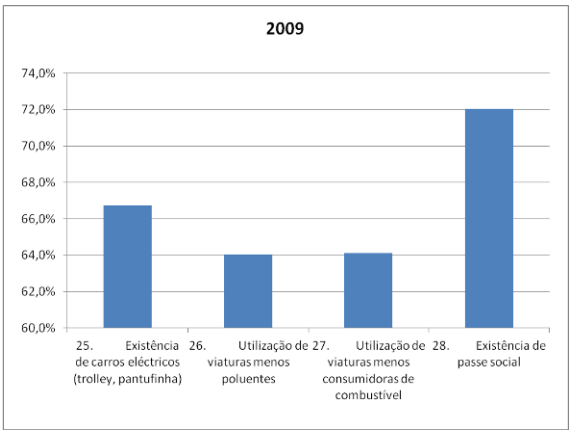
Importance given to the Contribution to Society

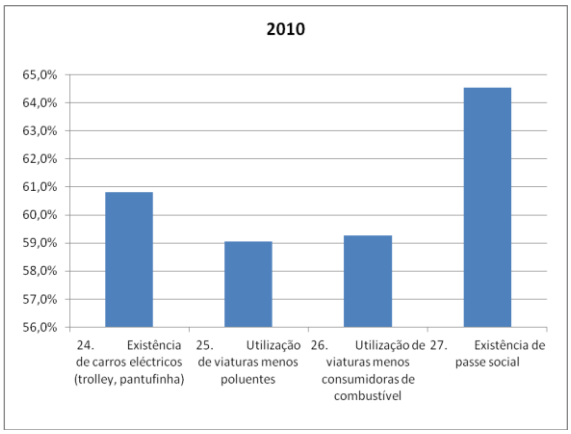


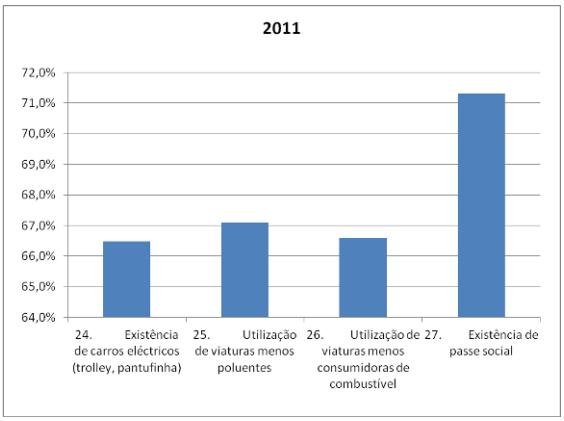


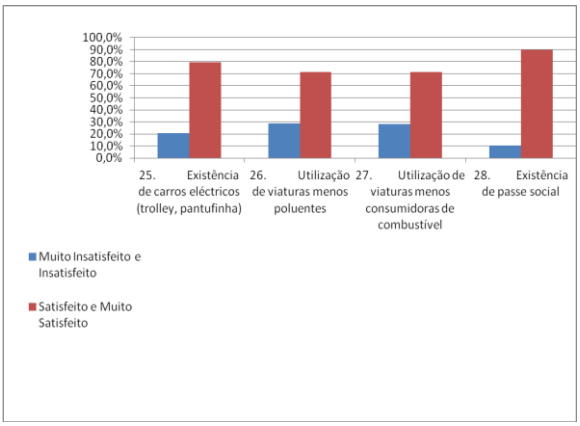


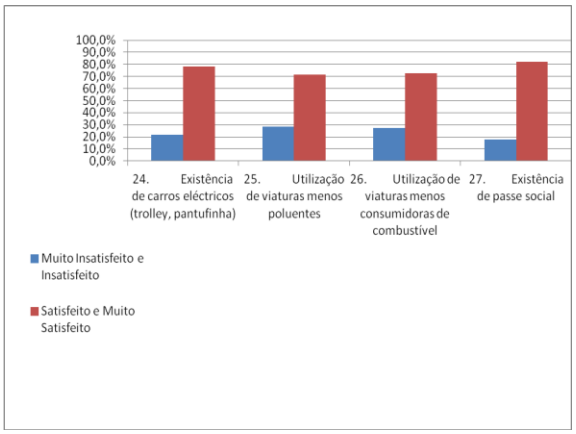
Level of satisfaction in relation to the Contribution to Society

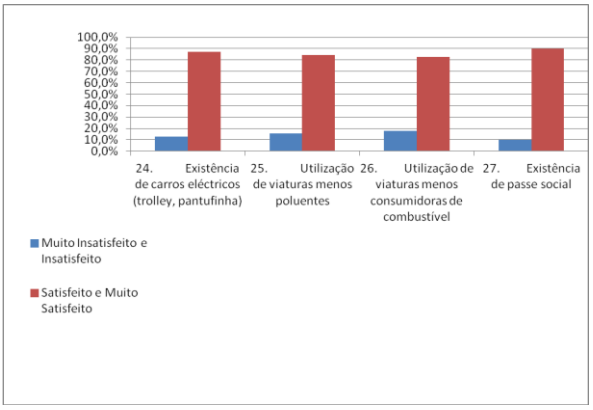




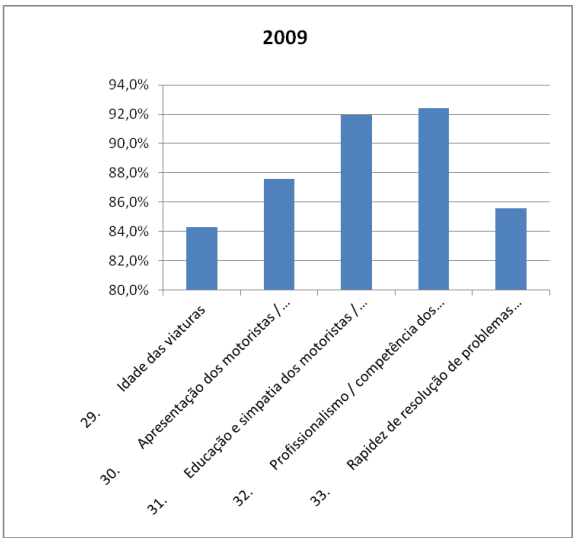


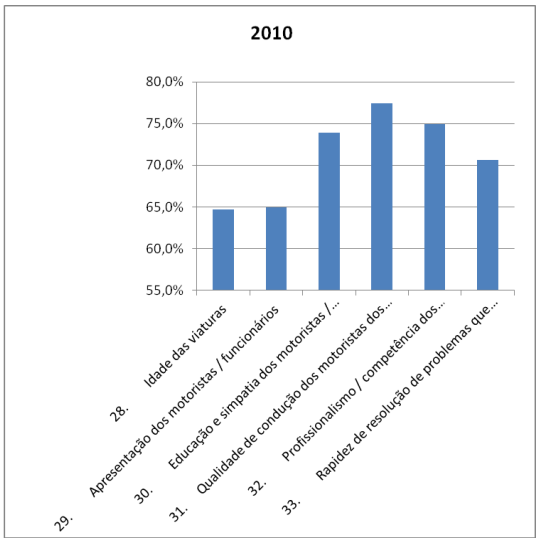


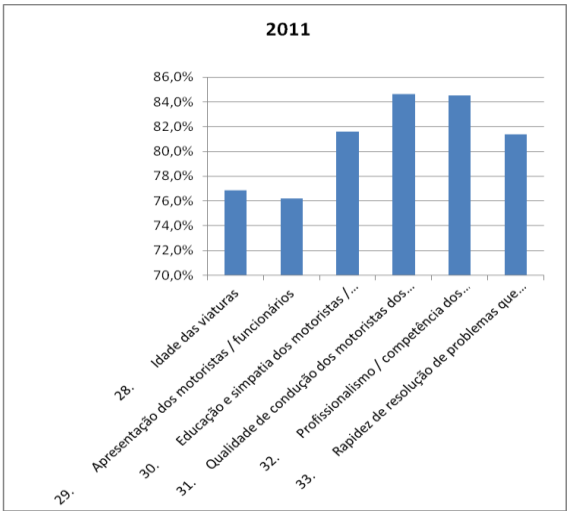




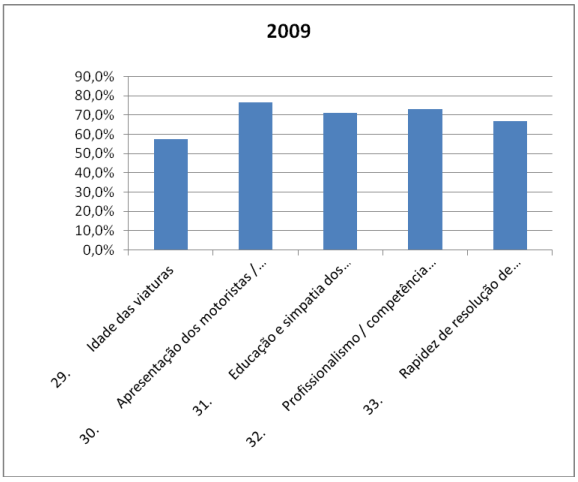
Importance given to the Image of the Company

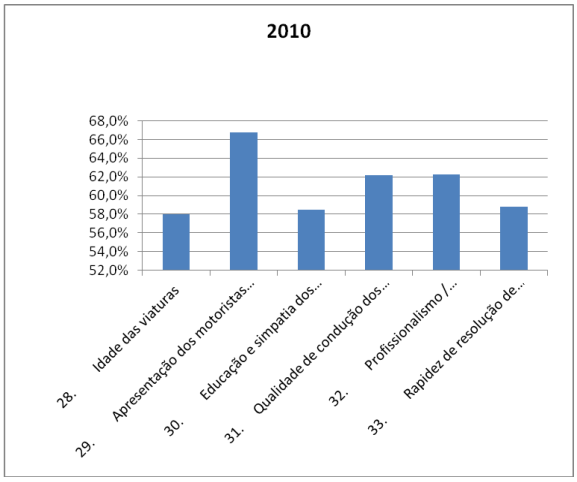


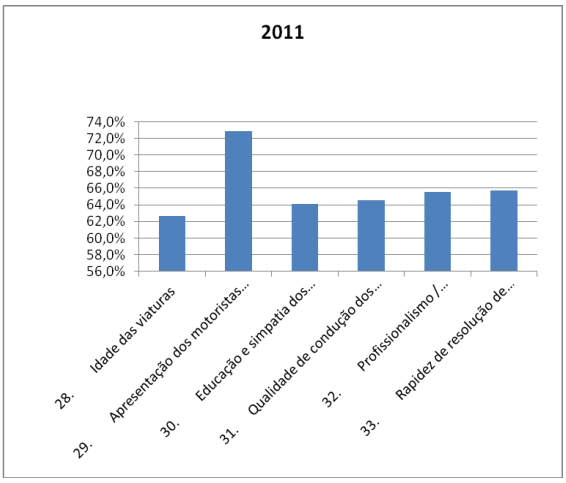


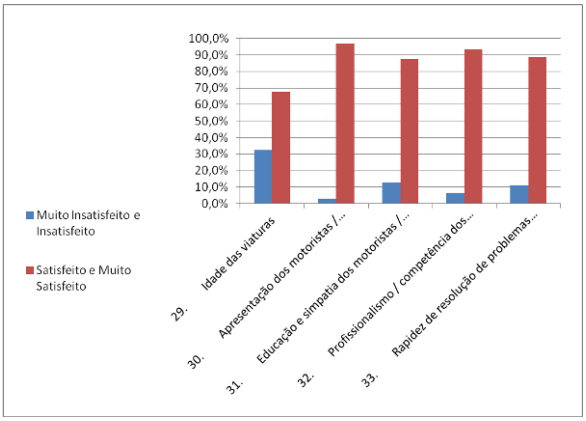


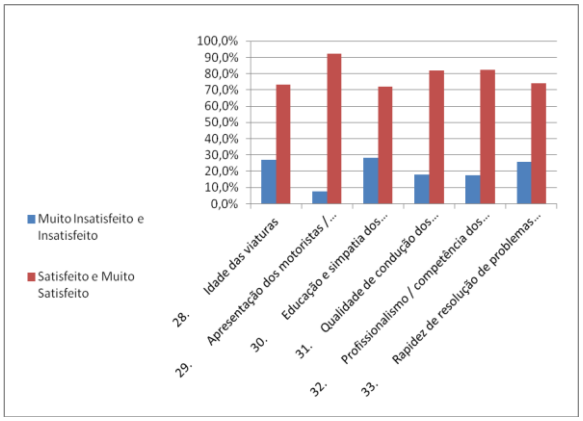
Level of satisfaction in relation to the Image of the Company

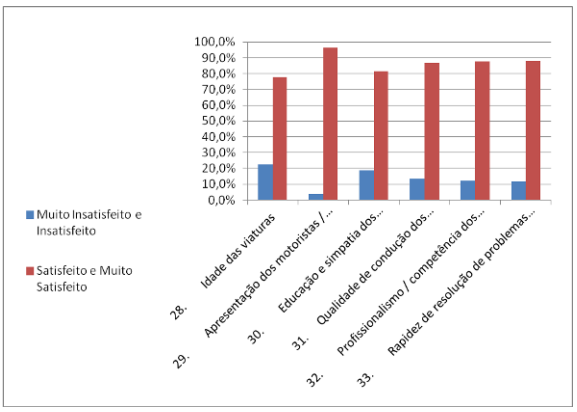




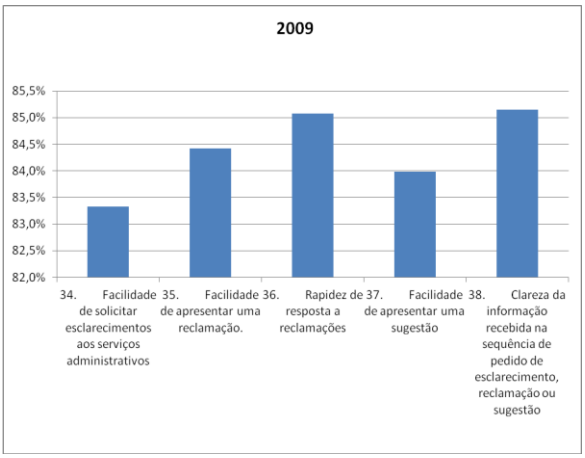


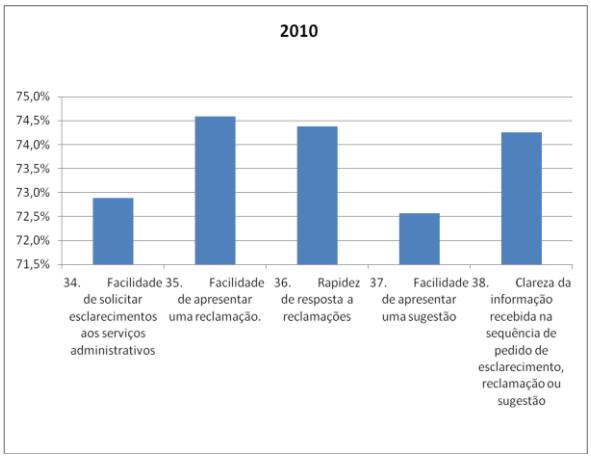


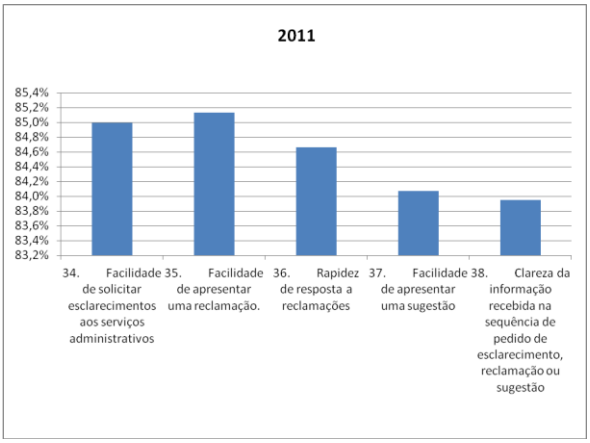




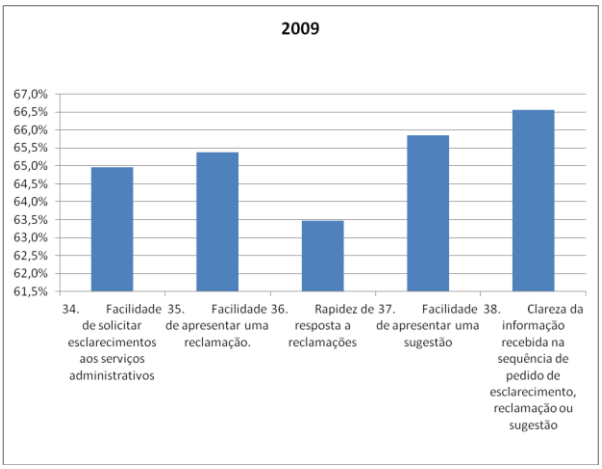
Importance given in relation to the Communication with the Administrative Services

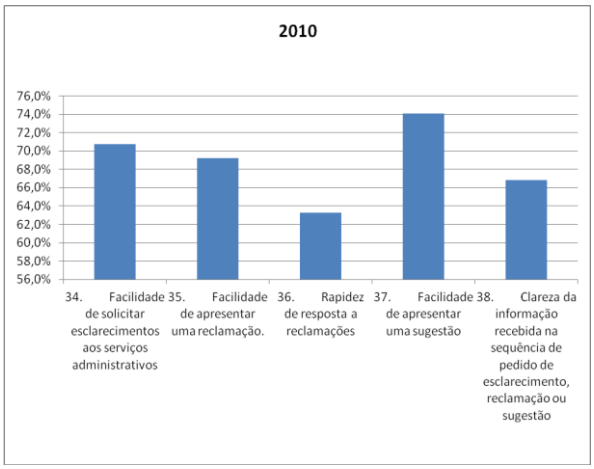


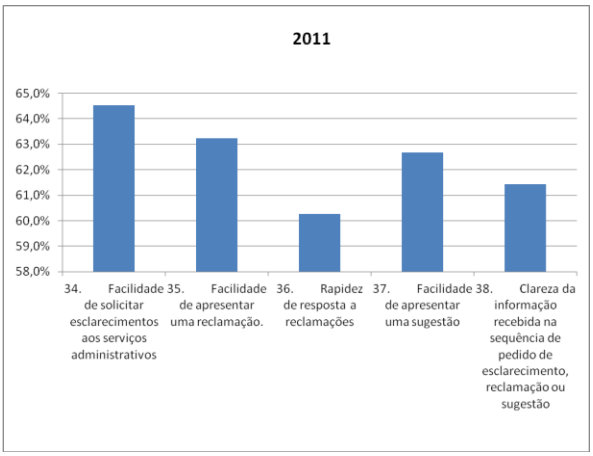


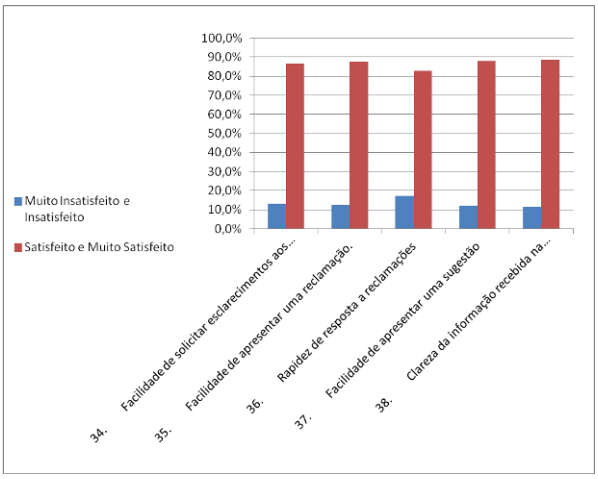


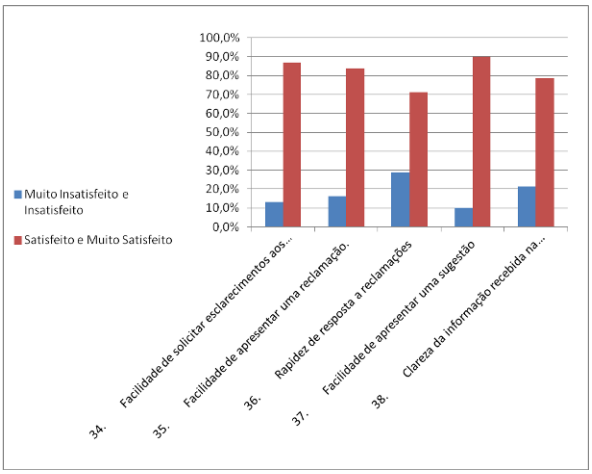
Level of satisfaction in relation to the Communication with the Administrative Services

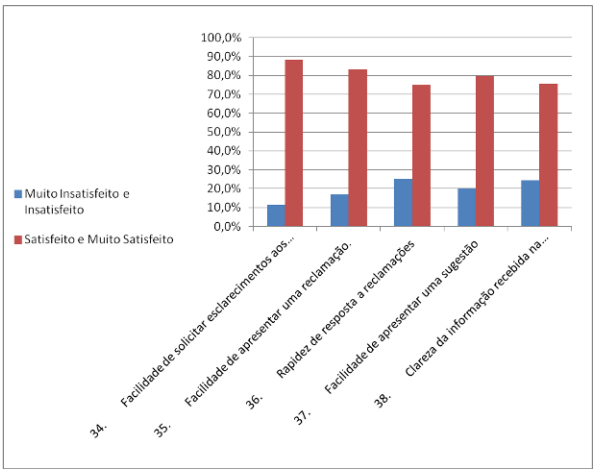






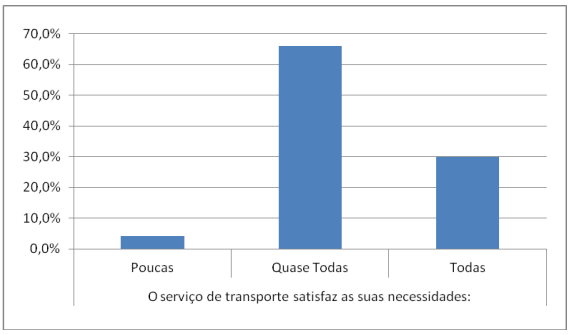


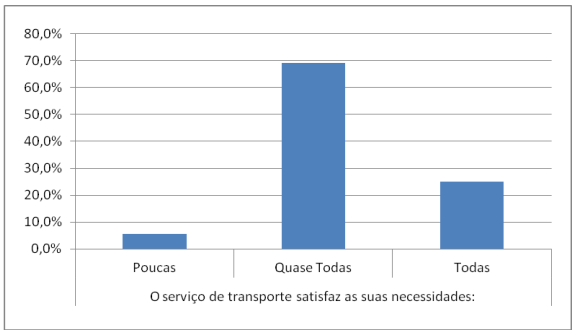




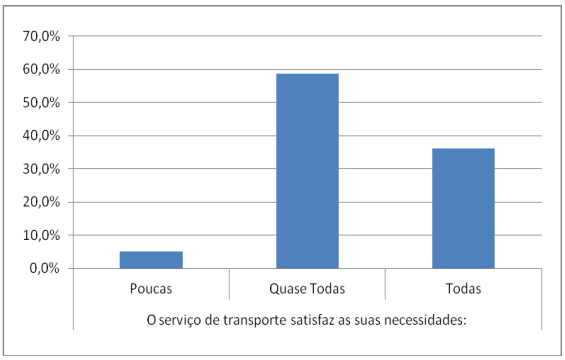
Results of the question “The transportation service meets your needs?”

2009 2010



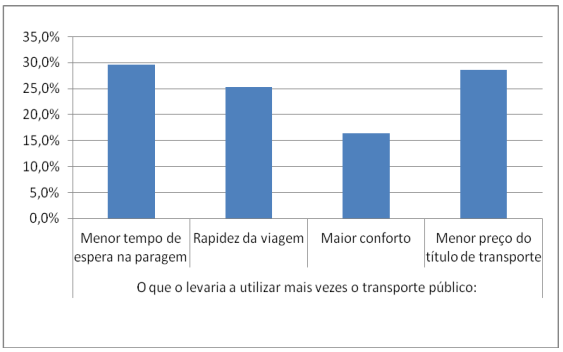


2011

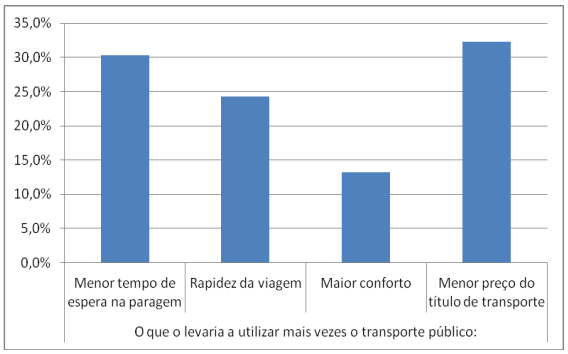


Results of the question "What would make you consider using public transportation more often?"

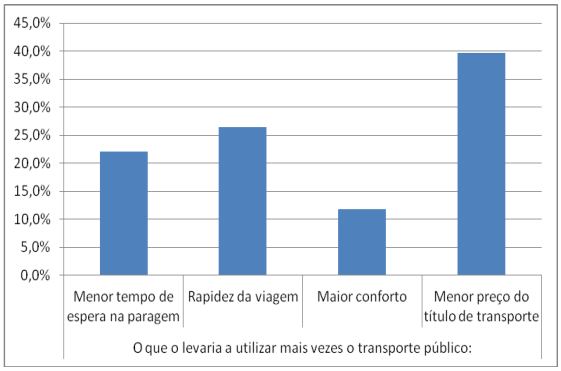
2009



2010



2011



M04.05 – Executive summary

In an effort to solve some of its mobility problems, the city of Coimbra decided to adopt a mobility management approach by developing and implementing site-based travel plans. With the guidance of the Municipality, the local public transport company SMTUC developed and implemented a travel plan for local oncological hospital (934 workers), as well as carried out several mobility management actions, particularly in the University Hospital and Paediatric Hospital (including campaigns, PT, carpooling, ticket discounts, etc.). Partnerships have also been established with some private companies to share part of the trips costs.

Accordingly, the city developed and implemented a travel plan at the Coimbra Oncological Hospital and implemented several mobility management actions in the adjacent University Hospital and Paediatric Hospital. In the initial stage the travel plan was focused on hospital employees. The main objective of the travel plan and mobility management actions was to contribute to a modal shift to emphasise other means of transportation besides the private car.

The key results of the measure have been the following:

- A modal shift of 10,3% from private cars to public transport at the Oncological Hospital, resulting from the implementation of the travel plan.
- An increase of operating revenues (+0,007 €/pkm). The measure induced a 28% increase of the average operating revenues related to the employees of the hospital that transferred to public transport.
- A positive contribution to energy efficiency in the city, resulting in significant energy savings in the displacement of the hospital staff (-15,1%) due to the assessed significant reduction of the energy consumption per passenger (-0,31 MJ/pkm).
- A mitigation of CO2 emissions leading to savings (-12,89 g/pkm) equal to 273 ton of CO2 during the first year of mobility plan implementation.

Also several informative campaigns have been carried out and as a results 1.154 children and 116 teachers and chaperones from 52 elementary schools have visited SMTUC offices.

The development and implementation of travel plans and mobility management actions in Coimbra catalysed a change in mentalities in planning technicians and local decision-makers. The participation of technicians from Municipality and SMTUC in 4 VANGUARD/EPOMM training sessions on mobility management issues also helped to transfer knowledge for the referred behaviour changes. After many decades focused on traffic management activities, Coimbra now acknowledges that mobility management solutions, especially travel plans, is a practical and valuable way of dealing with the city's mobility challenges.

The board of Administration of the University hospital has recently authorized the development of a travel plan to implement in the upcoming year. The city of Coimbra will also continue pressing the Paediatric hospital to implement a travel plan in the near future, rather than just implement isolated initiatives and actions. Also, there is a commitment from the majority of stakeholders to follow-up the existing travel plan, namely by developing a plan for hospital out patients and logistic services.

Additionally, city officials have indicated that the development and implementation of site-based travel plans is a very viable option in the future for being applied to the University campuses and local secondary schools.

A Introduction

A1 Objectives

The measure objectives are:

(M) High level / longer term:

- To improve the city air quality;
- To decrease city traffic levels;

(N) Strategic level:

- To increase the number of trips made in a sustainable way over the use of private car, in particular through a better information and the promotion about new mobility services and PT, with a special attention to young public.

(O) Measure level:

(1) To provide at least 1 mobility plan for 1 Hospital and mobility actions for other 2 hospitals, as well as 1 partnership with 1 enterprise.

(2) To make mobility campaigns, with special attention to the young students, including organising a "Bus-Paper" and visits to SMTUC by students from municipality primary schools.

(3) To improve 1% the municipality PT passengers that were workers at the hospital in Coimbra where the mobility plan has been implemented.

(4) To decrease by 5% to 10% the use of private cars of the workers at the Hospital in Coimbra where the mobility plan has been implemented.

(5) To improve the cooperation between SMTUC and Hospitals, University and Municipality.

A2 Description

The marketing on mobility suggested in this measure for the time of the CIVITAS MODERN project was part of a global integrated strategic plan for sustainable urban mobility that the Municipality of Coimbra has been studying and developing for the coming years. This plan aims to identify the most recent evolutions in urban mobility and develop more adequate policies which can be more successful in solving the mobility challenges affecting every modern town.

The analysis included the needs of a number of entities in terms of mobility, the planning of mobility actions and the development of a site-based travel plan to be produced by the Municipality.

With the guidance of the Municipality, the local public transport company SMTUC developed and implemented a travel plan for local oncological hospital (934 workers), as well as carried out several mobility management actions, particularly in the University Hospital and Paediatric Hospital (including campaigns, PT, carpooling, ticket discounts, etc), during CIVITAS. Partnerships were also established with some private companies and contracts were carried out in which some of these

entities assumed part of the trips costs (though the pass already has a reduction in its cost sustained by SMTUC and the municipality).

The travel plan and mobility actions were namely based on the following activities:

- A survey to investigate the needs of the hospital staff (according to the research conducted by the municipality).
- The promotion, among hospital employees, of the use of alternative transports – i.e., from individual private car to public transport, carpooling and others modes, including direct promotional campaigns and publishing / distribution of information – dedicated timetables, local maps with bus stop localisation, etc.
- Establishment of the hospital travel plan for the most important journeys.
- Installation in the hospitals lobbies of real time information e-panels related to the buses passage in the nearby bus stops.
- Public Transport adaptation to the needs of the hospital employees.
- Establishment of a car pooling service using the car pooling web page of the city of Porto created in the scope of the CIVITAS ELAN project.
- Yearly surveys to assess the changes in the mobility behaviour have been carried out, with focus in the modal shift.

Training of mobility coordinators has been carried out, with emphasis to 4 VANGUARD /EPOMM training sessions and dedicated training of the mobility manager was carried out in the hospital that implemented the travel plan.

Others campaigns and mobility actions were carried out in the University Hospital and Paediatric Hospital (as well as other entities such as primary schools) emphasising PT use and environmental protection promotion, through:

- Publicity/advertisement on buses and outdoors, specially dedicated to drivers.
- Visits to SMTUC by 1.154 students from schools - bus trips to demonstrate the advantages of PT were carried out.
- Organization of a “Bus-paper” (a rally-paper on a bus and other alternative transport modes) for young people and their parents.
- The SMTUC internet site.

The Municipality and SMTUC co-organised with VANGUARD a training on Social Inclusion with 66 participants from 21 cities and 12 countries.

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **New Conceptual Approach, Nationally** – The development and implementation of Mobility and Site-based Travel Plans are not a common practice in Portuguese planning. In fact, with the exception of one or two studies regarding the state-of-the-art, Portugal does not have any Mobility Plan approved and implemented. In Portugal the plans usually designated as "mobility plans" are centred on traffic solutions.
- **Targeting Specific User Groups, Nationally** – In Portugal, social marketing in the transportation and mobility sector is non-existent. As a result, the travel plans specified various campaigns designed to target specific employee populations in Hospitals – e.g., doctors, nurses, and other high-level officials – in order to try to alter the present behaviour regarding urban mobility.
- **New Organizational Relationships, Nationally** – The development of the travel plans and the implementation of mobility actions implies bringing the various hospital administrations into the planning process. In this sense, the planning and implementation processes involved various organizations working together to find a consensual solution to the problems – besides the hospitals, other stakeholders such as the municipality, the local police, etc, were also brought into the process. This multiparty approach to planning and implementing solutions to mobility problems is highly uncommon in Portugal.

B2 Research and Technology Development

The main initiatives regarding the research and technology development were:

- The definition and integration of several of the mobility management actions into the general mobility strategy of the city of Coimbra;
- Planning of the mobility management actions and the design of pilot travel plans.
- Research on the state of the art on travel plans in public institutions;
- Staff survey development and analysis;
- Geocoding and geo-referencing of staff information and mobility patterns;
- Development of dedicated schematic maps and destination matrixes for the hospitals;
- Development of indoor real time information panels for Hospital lobbies;
- Analysis and implementation of carpooling system in the Oncological hospital;
- Analysis and implementation of personalised travel plans for hospital employees.

B3 Situation before CIVITAS

In general, there is no tradition in developing and implementing travel plans in Portugal.

In Coimbra, mobility management has been a constant concern for the municipal authorities despite all the practical limitations that mobility management has undergone throughout the years. Although all the efforts developed to motivate the use of the public transport, the usage of private vehicles has been growing at a constant rate.

Coimbra is characterised by a strong concentration of health services (with two central hospitals which extend their influence to the whole central region of the country) and teaching services, mainly at the University level (the University of Coimbra is the oldest Portuguese University and one of oldest in Europe). Accordingly, appealing to the use of the public transport and discouraging private vehicles has been addressed to the working population and students of these areas, unfortunately with limited results.

It is vital to stimulate, to innovate, and to insist on the sensitisation of the population to the improvement of the quality of urban life, while simultaneously managing the evolution of urban growth and the correspondent definition of policies and measures regarding a sustainable urban mobility.

The implementation of travel plans for the health cluster in Coimbra in the scope of the CIVITAS MODERN project will contribute mainly for a change in the mentalities and for the involvement of several stakeholders in this problematic, as well as the opportunity to increase the knowledge on mobility management and take advantage of the experience offer by the implementation of the first site-based travel plans in Portugal.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Definition and planning of the mobility actions *(October 2008 – July 2010) – The planning of the actions by the Municipality, concerning the mobility management, was scheduled for a 2nd phase in order to consider the release of some definitions and specifications for a series of important projects which would imply changes in traffic and the mobility practices of people - i.e., in great part due the implementation of the tram project in Coimbra. This option has also allowed more time for training the personnel involved in this planning and in the implementation of the mobility plans and travel plans (mobility coordinators and mobility managers). For this reason the first phase was dedicated mainly to the campaigns, namely those that involve young people. Accordingly, the activities in each phase could be summarized by the following:*

- *Definitions of actions for the 1st phase:*
  - *It was decided to carry out campaigns aimed to sensitise families through their children, beginning with visits to SMTUC by students from schools, including local bus trips in order to demonstrate the advantages of PT.*
  - *Establish partnerships with some entities to create special services for the transportation of its employees / students (the partnership could be a division*

of costs between the entity, SMTUC and passenger or a simple guarantee of a minimum quantity of passengers to transport).

- *Planning the actions:*
  - *On the whole, 20 actions are expected, concerning the visit of 23 classes from 5 elementary schools, in a total of 466 children for the school year of 2009/2010. Similar quantity was expected for the next school years.*
  - *Partnerships with 2 entities (CSW and ESEnfC) were established for the transportation of its personnel on PT.*

- *Definitions of actions for the 2nd phase:*
  - *Knowledge acquisition on mobility management by researching the thematic literature and dedicated Internet websites.*
  - *Analysis of the heavily frequented sites (HFS) and selection of the principal entities to integrate and participate in the Mobility Management and Travel Plans.*
  - *In order to improve the knowledge on Mobility Management, 14 individuals involved in MODERN/Coimbra participated in the Conference "Land Use, Accessibility and Mobility Management" organized by the Portuguese Institute for Mobility and Inland Transport, with the involvement of EPOMM, in April 12-14, 2010.*
  - *Definition of the 3 hospitals and its surrounding area for the design of the travel plans for enterprises and a mobility plan for the area. Definition of the configuration for these mobility plans and foreseen measures.*
  - *Planning of campaigns with school children including the launching of a drawing contest focusing on the SMTUC transport.*

A working document with the design of pilot travel plans was delivered in July 2010.

Stage 2: Operability and accomplishment of the actions *(October 2009 – October 2011) – The first phase of actions, yet without the main part concerning the mobility plans, have consisted of:*

- *Contacts with schools and signatures of partnership agreements.*

- *Planning children transport.*

- *First visit to SMTUC site (24 children and 2 teachers).*
  - *Explanation about PT advantages for sustainable mobility.*
  - *Contact with maintenance area and several system control centres, like the new GPS – Operational Support System.*
  - *Explanation about specifications and advantages of trolleybuses, electric mini-buses and mini-buses for transport of physically impaired individuals, with trips in the first two kinds of buses.*

- *Planning the transport of employees / students concerning the partnership with CSW (Small-medium enterprise) and ESEnfC (Higher-education).*

Figure B4.1 – Visit of young students from a basic school to SMTUC site

- *Survey of the needs in the mobility area of the employees / students of CSW and ESEnfC.*
- *Promotion of PT use though employees / students of CSW and ESEnfC.*
- *Implementation of the transport system for employees / students.*

During the second phase the campaigns with the children have continued and the mobility actions for the 3 hospitals were initiated in accordance with the following:1

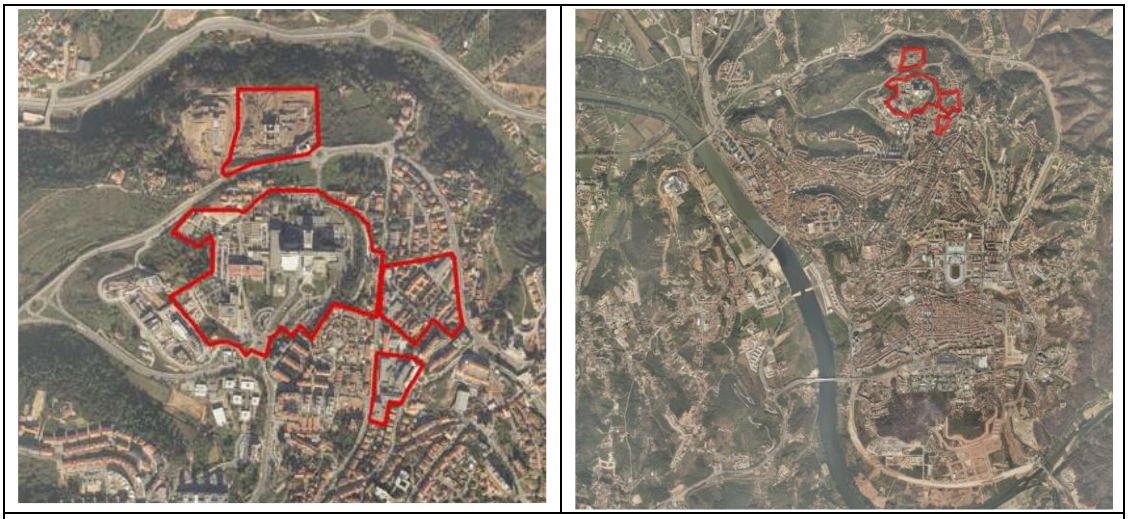
- *Continuation of the campaigns aimed at raising public awareness through the school children with student visits to the SMTUC site (1.130 children and 114 teachers and chaperones in this phase – until the end of the school year of 2010/2011).*

Children tooke a picture in a model of trolleybus. Later the photos was given to each child (left). Buspaper winners(right)

Figure B4.2 – SMTUC in schools I

- *Visit to SMTUC installations by the National Engineering Society, and Sport Training School for children.*
- *Launching in May 2010 of a drawing contest for school children focusing on the SMTUC transport under the theme of "SMTUC and the Environment".*

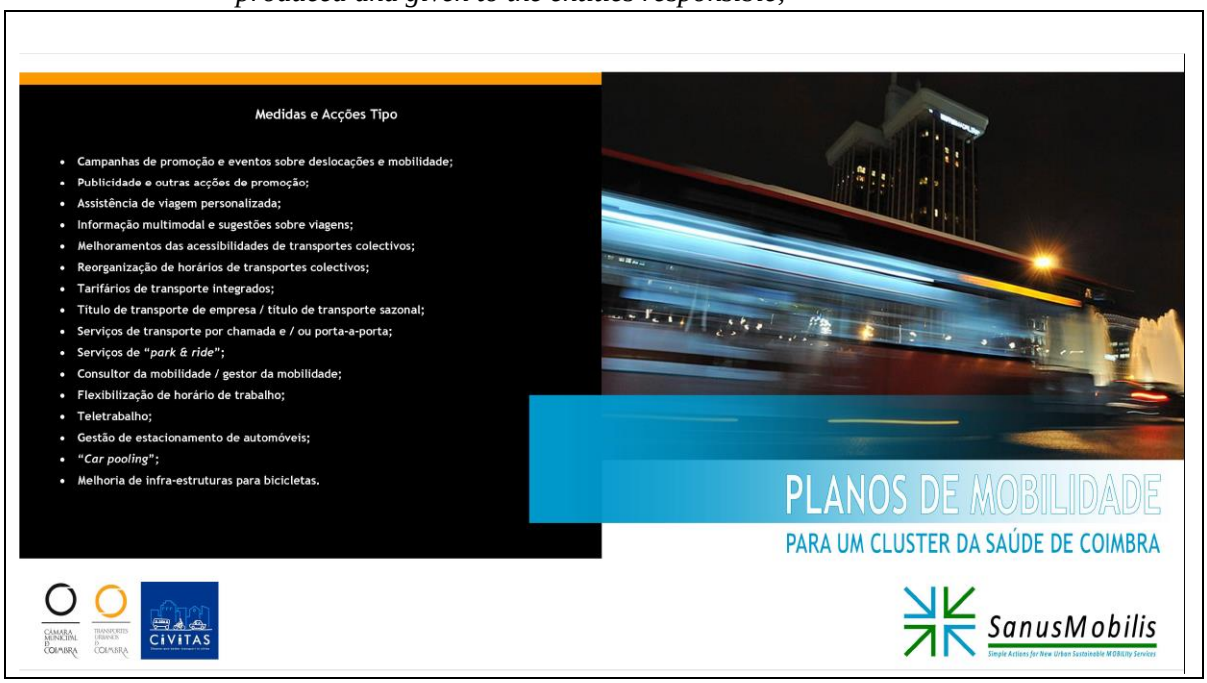
- *Beginning of the activities concerning company travel plans and mobility management actions for 3 hospitals and its integration in a mobility plan for the surrounding area:*



Geographical context of the Entities where Travel Plans and mobility management actions will be implemented (Left: detail of the entities; Right: localization of the entities in the surrounding urban area)

Figure B4.3 – Measure boundaries

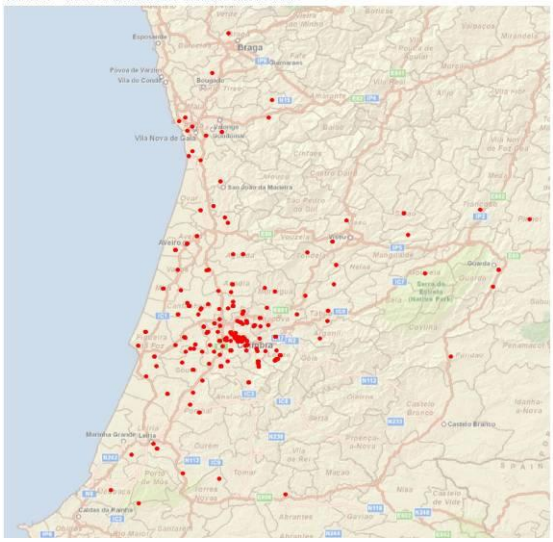
  - *Definition of the image for the mobility management actions for the health cluster with the creation of a logo and the trade mark "SanusMobilis" – **S**imple **A**ctions for **N**ew **U**rban **S**ustainable **MOBILI**ty **S**ervices.*
  - *Meetings with each CEO / President of the 3 hospitals in order to establish future partnerships regarding the "SanusMobilis" travel plans. A brochure with the advantages of the mobility plans and the foreseen actions was produced and given to the entities responsible;*

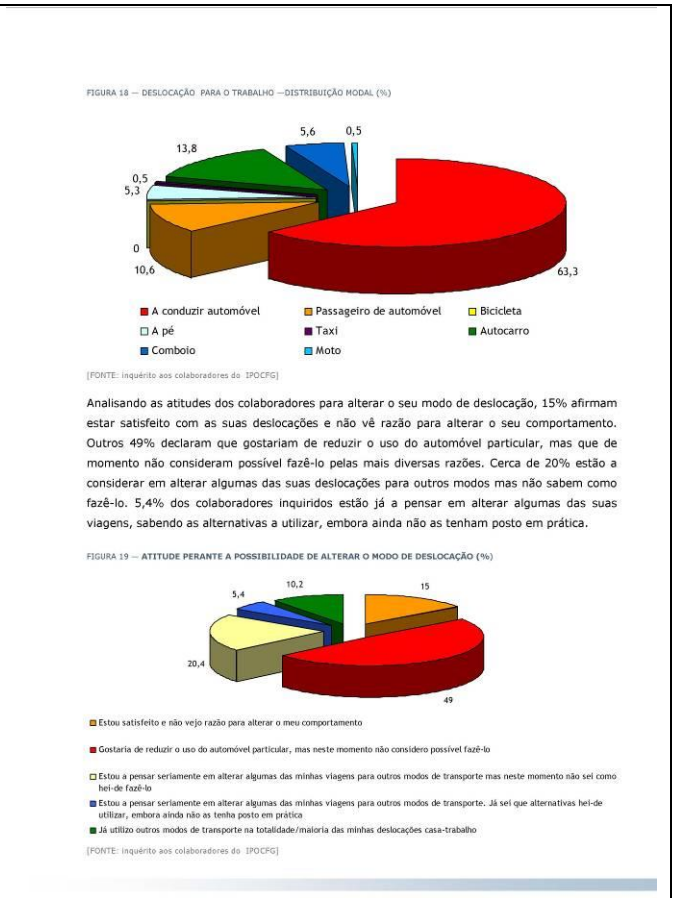


Brochure aimed to sensitize the entities involved in the mobility management actions with the SanusMobilis logo

Figure B4.3 – SMTUC SanusMobilis logo

- *Indication of the mobility manager by IPOC Hospital – This action was postponed for the other 2 hospitals because they were in a process of restructuration with the aim of having a joint Board of Directors.*
- *Development of survey model for collecting employee information;*
- *Data collection concerning IPOC Hospital, such as worker displacements, traffic volume, offer of Public transportation and parking, and number of traffic accidents.*
- *Design and production of large panels with dedicated PT maps for the 3 hospitals, containing the surrounding bus stops, the scheme of the PT lines that pass by these hospitals and the destination matrix for the respective PT lines.*
- *Installation of e-panels in the hospital lobbies with the real time information concerning the buses passage in the surrounding bus stops.*
- *Route adjustment of the 2 more frequented PT lines in order to directly serve the Paediatric Hospital with the implementation of a bus way and a bus stop with passenger shelter near the hospital.*
- *Initial data collection concerning the University Hospital, such as the offer of Public transportation and the parking system*
- *Elaboration and execution of a general mobility survey on the whole staff;*
- *The addresses of the whole hospital staff have been geo-referred and the subsequent analysis related to the local PT system has been carried out*





Geo-reference of all staff addresses (upper left) and general staff survey – roll-up in the IPOC Hospital announcing the survey (bottom left) and sample of graphics with survey results (right)

- *Analysis of the staff survey and of the mobility patterns of the hospital personnel.*
- *Implementation of the first measures at IPOC during the European Mobility Week – i.e., installation of real-time information e-panel in the hospital lobby, installation of schematic PT maps and destination matrix in the hospital lobby, 25% discount on SMTUC park & ride services for hospital staff.*

Real-time information e-panel and schematic PT maps and destination matrix in the hospital lobby(left), detail of e-panel with the real-time arrivals at the surrounding bus stops (centre) and signature ceremony of protocol for the 25% discount in the park & ride services with the participation of the mobility councillor of the Municipality and the CEO of the IPOC Hospital and SMTUC (right)

- *Execution of a promotional campaign of the RUMOS trip planner towards the IPOC staff.*
- *Execution of a promotional campaign promoting PT targeting the IPOC staff (highlighting the monetary savings in riding the bus).*
- *An information campaign has been carried out, informing the general public about the development and the implementation of the travel plans in the hospitals.*
- *Elaboration of a survey model for the "reference group" at the IPOC.*
- *Elaboration of the final version of the Mobility Plan for IPOC.*
- *Speech about "Planning and Communicating New Mobility Solutions in the City of Coimbra" during the CIVITAS Forum in Funchal.*
- *Presentation of the measure in a workshop on Mobility Management organised by the Portuguese Institute of Mobility and Inland Transportation in the Portuguese city of Évora.*
- *Meetings with the reference group of the IPOC hospital that included the attendance of the Chairman of the hospital. The meetings had the objectives to assess the monitoring of the mobility plan implementation and the collection of suggestions for future actions.*
- *Implementation of the car pooling service for the workers of the IPOC hospital. This implementation didn't have any capital costs. The IPOC workers used "Rota Partilhada", a web service for car pooling developed in Porto in the scope of the CIVITAS ELAN project. This web service allows the creation of closed groups and for the mobility plans in the Coimbra health cluster it was created the car pooling group "SanusMobilis".*
- *Release and analyse of the second survey for the workers of the IPOC hospital that included the modal split and modal shift assessment.*

Stage 3: Training of mobility coordinators and managers *(July 2010 – April 2012) – Training of local mobility coordinators was initiated, namely through their participation in various workshops and training seminars. The most significant event was their participation (3 SMTUC and Municipality members) in the Training on Mobility Management and Company Travel Planning organized by VANGUARD/EPOMM in Szentendre, Hungary in November 2010, as well as the participation of 2 SMTUC mobility coordinators on the VANGUARD training workshop on Social Marketing (Toulouse, 17-18 May 2011..*

On 22nd and 23rd March SMTUC and VANGUARD organized in Coimbra a training on Social Inclusion with 66 participants from 21 cities (5 Portuguese) and 12 European countries.

B5 Inter-relationships with other measures

The measures 02.05, 04.02, 04.05 and 08.03 were identified as a group of measures because each one of them had the potential to generate impacts on modal split. These measures also have potential to generate impacts on emissions. However, those impacts derive from modal split changes. Measure 04.05 was applied only to a health cluster that involves 3 hospitals and modal split impacts were measured with specific surveys for these hospitals, making it possible to determine separated impacts on modal split due to measure 04.05. For this reason, only measures 02.05, 04.02 and 08.03 are included in the modal shift bundle of measures.

Moreover, the measure is related to other measures as follows:

- **Measure no. 02.05** – The New Ticketing System in Coimbra will also have impacts on the modal shift and on the emissions in the Coimbra region. It is also been foreseen to use the system to provide new ticketing products for the entities involved in the mobility plans;

- **Measure no. 04.02** – The Infomobility Centre in Coimbra also had impacts on the modal shift and on the emissions of the Coimbra region. The Centre also promotes the mobility campaigns and travel plans concerning the entities involved in the mobility management actions;

- **Measure no. 08.03** – The Infomobility Tools for traffic data management in Coimbra will have also impacts on the modal shift and on the emissions, but in a greater area. At the functional level the e-panels of the GPS/GPSR – Operation Support System were integrated in the actions foreseen for the mobility plans for the 3 hospitals involved in this measure no. 04.05.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1: Impacts and Indicators for the measure

No.	Impact	Indicator	Data used	Comments
1	Operating Revenues	Average Operating Revenues	Total operating revenues; Total passenger-km	Operating revenues and passenger-km were computed by the data obtained by survey. Average revenues per passenger were provided by SMTUC.
2	Operating Costs	Average Operating Costs	Total operating costs; Total passenger-km	Operating costs were provided by SMTUC. The passenger-km was computed by the data obtained by survey
3	Costs	Capital Costs	Total capital costs expended in setting up the measure	Capital costs are provided by SMTUC
4	Fuel consumption	Vehicle fuel efficiency	Total energy consumed; Total passenger-km	Fuel consumption results of the displacements assessed by survey. Bibliographic sources "Study on internal and external costs from transport in Portugal, issued by University of Aveiro, March 2011"; the average consumption of each type of vehicles and surveys to the workers of the hospital involved in the mobility plan (2011/2012)
5	Emissions	CO Emissions	Fuel type; average consumption, Vehicle Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
6	Emissions	CO2 Emissions	Fuel type; average consumption; Vehicle Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
7	Emissions	NOx Emissions	Fuel type; average consumption; Vehicle Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
8	Emissions	Small Particulate Emissions	Fuel type; average consumption; Vehicle Type and passenger-km	Emissions factors of each type of fuel – "European Energy Agency, "the Emission Inventory Guidebook"
9	Modal Split	Average modal split passengers	Total passenger for the transport mode considered; Total passenger km	Surveys to workers of the hospital involved in the mobility plan (2011/2012)
10	Awareness	Awareness level	Total number of users with knowledge of the measure; Total number of respondents	Surveys to workers of the hospital involved in the mobility plan (2011/2012)
11	Acceptance	Acceptance level	Total number of users who favourably receive the measure; Total number of respondents	Surveys to workers of the hospital involved in the mobility plan (2011/2012)

The evaluation has been provided only for the assessment to the impacts in the hospital that applied the mobility plan and did not consider the impacts of other mobility actions and campaigns because in these cases the impacts were difficult or impossible to measure.

The mobility plan was only applied to the workers of the Oncological hospital (IPOC) and it was implemented in September 2011. A great part of the mobility actions implemented in the IPOC hospital focused in the promotion of the use of alternative transport modes and in the improvement of the public transport quality, accessibility and information channels. So, the shift of IPOC employees from the use of the private car to public transport provided by SMTUC has been the major expected impact of the measure implementation. This expected impact has been responsible for the selection of the major part of the indicators, because influenced the modal split, the savings in the energy consumption and emissions, as well as the operating revenues coming from the increase of the tickets sale in the SMTUC public transport service. The other selected indicators has been the operating costs and capital costs related to the implementation of the IPOC mobility plan and the society indicators selected to assess the impact of the mobility plan in the awareness and acceptance level of the IOPC staff about the measure implementation. For these reasons the information used for the evaluation is based mainly on the outputs of the surveys made to the workers of the IPOC hospital (the exceptions have been the indicators related to the costs).

Two surveys target to the hospital workers were carried out. The first survey (ex-ante) was carried out in 7-22 July 2011 before the implementation of the measure and the second (ex-post) was carried out 10-20 September 2012, after the implementation of the measure, but allowed also to assess the business-as-usual (BAU) scenario through specific questions. As agreed with the IPOC hospital administration the universe of the surveys has been all the 934 workers of the hospital since has been considered not recommended to select specific workers due the characteristic of some functions. The hospital didn't want to select and oblige appointed workers to fill the survey. The survey has been distributed to all workers by hospital intranet and during 2 days mobility coordinator and measure leader attended the hospital to provide explanation and ask to questions. The first survey had 159 respondents and the second survey had also the universe of the IPOC hospital workers but only with 54 respondents. The reason for the decrease in the respondents has been the complicated period that IPOC workers carried out together with the remaining Portuguese population due the financial crisis. Some austerity measure involving the health sector has been proclaimed and people were more concerned with their personal problems than with the mobility issues. Annex 6 show details of these surveys.

The source of the information has been the survey carried out in July 2011 (ex-ante) and it was possible to develop a methodology that allows analysing the evolution of the above indicators.

The input for the developed assessment was based on the results of the survey and it has as an objective to calculate the number of passenger-kilometres transferred from private car to urban public transport (it was verified that the other modes had internal variations but the total maintained constant). The premises for the development of the study were the following:

- The urban public transport operator (SMTUC) is the unique PT operator that serves directly the IPOC hospital;
- The IPOC hospital has a total of 934 workers. In the survey 13,8% stated that they used public transport (corresponding to 129 workers) and 63,3% stated that they used private car (corresponding to 591 workers). There were 720 workers in the 2 modes;
- From the survey it is possible to evaluate the average number of trips per passenger in these 2 modes. In 2011 the average number of trips is 3,5 per passenger per day;

- From the SMTUC management report it is possible to determine the average distance per passenger. The average distance per passenger is 3,56 km per day;
- In Portugal it was assumed that there are 240 days working days per year (source: National Statistics Institute);
- According to the SMTUC data the average revenue in 2011 is 0,3035 €/passenger;
- A load factor for PT (bus) of 16,4 passengers per bus (SMTUC data) and for private car a load factor of 1,3 passengers per car (IMTT – Portuguese Institute for Mobility and Inland Transportation) was considered.

For the above indicators 1, 2, 4, 5, 6, 7 and 8 the results from passenger-km are computed from the product of three factors: the average number of trips per passenger per day (3,5), the number of workers that had modal shift (private car to public transport – bus) and the average distance per passenger (3,56 km per trip - by the survey) – this data is obtained from the IPOC workers survey. The values of the passenger - kilometre (pkm) were calculated for the 2 modes (private car and SMTUC public transport). The total of daily workers that travel in these 2 modes were constant from the baseline to the ex-post assessment (720 workers). So for the total passenger km has been considered that the average number of displacements per day (3,5) has been also constant among the shift from private car to SMTUC public transport and the same consideration has been made for the average displacement extension per passenger (3,563 km). With the passenger-kilometres per day multiplying with the 240 working days the passenger-km per year is obtained - 720 workers x 3,5 average trips per day x 3,563 km per passengers x 240 days per year = 2.155.244 pkm per year (Annex 5).

For indicators 4, 5, 6, 7 and 8 the results from energy consumption from car and from PT bus vehicles used by the workers of the IPOC hospital are based on data about the total vehicle-kilometres performed on those vehicles. The average vehicle consumption (l/100km) is based on both bibliographic data and from real SMTUC fleet for private car and bus, respectively. For private car the source of data is the "study on internal and external costs from transport in Portugal, issued by University of Aveiro, March 2011" (9,2 l/100km). For public transport the source is the real data of the average fleet consumption (50,1 l/100km).

For private car, the average energy consumption in litres of Diesel per 100 km, is converted in energy (MJ) by a factor of 34,80 MJ/litre that is calculated by mixing 2 fuel types (Diesel -35,86 MJ/litre and Gasoline – 32,18 MJ/litre with the Portuguese 2007 fleet fuel mix 74,5% for Diesel and 25,2% gasoline. For public transport the average energy consumption (litres) is converted by a factor of 35,86 MJ/litre (Annex 1 and 2).

Detailed description of the indicator methodologies:

- **Indicator 1** (*Average Operating Revenues*) – Ratio of total income generated from fares and tickets resulting of the measure implementation in the IPOC hospital divided by the total passenger-km per year (€/passenger-km).

  A = B / C

  where: A = Average operational revenue for the service (€/passenger-km)

  B = Total operational revenue from the PT users that shifted from private cars(€)

  C = Total passenger-km

The revenues resulted by the modal shift from private car to SMTUC public transport multiplied by the average revenue per passenger (0,3035 €/passenger according with SMTUC 2011 management data). All data is related to the workers of the IPOC hospital.

- **Indicator 2** (*Average Operating Costs*) – Ratio of total operating costs incurred in the implementation of the measure divided by the total passenger-km per year (€/passenger-km).

  A = B / C

  where: A = Average operational costs for the service (€/passenger-km)

  B = Total operational costs incurred in the implementation of the measure, namely Personnel costs related with the mobility actions monitoring and mobility plans update (€)

  C = Total passenger-km

  Operating Costs corresponds to Personnel (mobility actions monitoring & mobility plans update).

- **Indicator 3** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

  Expenditures with the purchase and installation of the necessary equipment for the measure implementation in the IPOC hospital (real time information panels, roll-ups, study and assessment) (€)

- **Indicator 4** (*Vehicle fuel efficiency*) –Ratio between the energy consumed by private car and the SMTUC public transport used by the workers of the IPOC hospital divided by the total passenger-km performed per year (MJ/passenger-km).

  A = B / C

  where: A = Average vehicle fuel efficiency (MJ/passenger-km)

  B = Total energy consumed by the private car and by the SMTUC public transport used by the workers of the IPOC hospital (MJ)

  C = Total passenger-km performed by the private car and SMTUC public transport vehicles used by the workers of the IPOC hospital

- **Indicator 5** (*CO Emissions*) – Average CO emissions per vehicle-km (g/passenger-km)

  A = B / C

  where: A = Average CO emissions per passenger-km (g/passenger-km)

  B = Total CO emissions of the private car and public transport vehicles used by the workers of the IPOC hospital.(g)

  C = Total passenger-km performed by the private car and public transport vehicles used by the workers of the IPOC hospital.

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by the European Energy Agency, “the Emission Inventory Guidebook”, dated on 23rd August 2007. The emissions factors are

computed from the average fuel consumption for each type of vehicle were it was possible to have the final energy consumption (MJ) and the respective pollutant emissions.

- **Indicator 6** (*CO2 Emissions*) – Average CO2 emissions per passenger-km (g/ passenger-km)

  A = B / C

  where: A = Average CO2 emissions per vehicle-km (g/passenger-km)

  B = Total CO2 emissions of the private car and public transport vehicles used by the workers of the IPOC hospital (g)

  C = Total passenger-km performed by the private car and public transport vehicles used by the workers of the IPOC hospital.

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by the European Energy Agency, "the Emission Inventory Guidebook", dated on 23rd August 2007. The emissions factors are computed from the average fuel consumption for each type of vehicle were it was possible to have the final energy consumption (MJ) and the respective pollutant emissions.

- **Indicator 7** (*NOx Emissions*) – Average NOx emissions per passenger-km (g/ passenger-km)

  A = B / C

  where: A = Average NOx emissions per passenger-km (g/passenger-km)

  B = Total NOx emissions of the private car and public transport vehicles used by the workers of the IPOC hospital (g)

  C = Total passenger-km performed by the private car and public transport vehicles used by the workers of the IPOC hospital.

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by European Energy Agency, "the Emission Inventory Guidebook", dated on 23rd August 2007. The emissions factors are computed from the average fuel consumption for each type of vehicle were it was possible to have the final energy consumption (MJ) and the respective pollutant emissions.

- **Indicator 8** (*Small Particulate Emissions*) – Average Small Particulate emissions per passenger-km (g/ passenger-km)

  A = B / C

  where: A = Average Small Particulate emissions per passenger-km (g/passenger-km)

  B = Total Small Particulate emissions of the private car and public transport vehicles used by the workers of the IPOC hospital (g)

  C = Total passenger-km performed by the private car and public transport vehicles used by the workers of the IPOC hospital.

  The data about the Total CO emissions per vehicle-km by private car vehicles is based on emission factors (g/kg fuel), year 2005 for Portugal, given by the European Energy Agency,

"the Emission Inventory Guidebook", dated on 23rd August 2007. The emissions factors are computed from the average fuel consumption for each type of vehicle were it was possible to have the final energy consumption (MJ) and the respective pollutant emissions.

- **Indicator 9** (*Modal Split*) – Percentage of passenger km by transport mode over the year (%).

  A = B / C × 100

  where: A = Percentage of passenger km for the transport mode considered (%)

  B = Total passenger km for the transport mode considered

  C = Total passenger km

  The Total passenger km for the private and public transport modes and other modes considered are measured during IPOC workers survey set up to measure the Modal Split indicator.

  The questions are focused on the origin/destination, modes of transport used during trips performed by the respondents and number of passengers travelling together by private car. Furthermore, specific questions are carried out to assess changes in travel behaviour, such as the modes formerly used and the passenger.km made by the new users, before and after measure implementation.

  The survey was carried out on the 934 workers of the IPOC hospital in July 2011 (before the mobility actions implementation) and repeated in September 2012 (after the introduction of the mobility actions).

- **Indicator 10** (*Awareness level*) – Percentage of the workers of the IPOC hospital with knowledge of the measure on account of provided information (%).

  A = B / C × 100

  where: A = Percentage of workers of the IPOC hospital with knowledge of the measure (%)

  B = Total number of respondents with knowledge of the measure

  C = Total number of respondents

  The Awareness level of the measure was measured during the survey to the workers of the IPOC hospital that was perform in parallel to the IPOC workers survey for the modal split assessment. In this survey was introduced specific questions relative to the knowledge of the respondent about the measure.

- **Indicator 11** (*Acceptance level*) – Percentage of the users who favourably receive the measure (%).

  A = B / C

  where: A = Percentage of users who favourably receive the measure (%)

  B = Total number of respondents who favourably receive the measure

  C = Total number of respondents

The Acceptance level of the measure was measured during the survey to the workers of the IPOC hospital that was perform in parallel to the IPOC workers survey for the modal split assessment. In this survey was introduced specific questions relative to the knowledge of the respondent about the measure.

C1.2 Establishing a Baseline

The period from July 2010 to June 2011 was considered as the baseline, before the beginning of the measure implementation in July 2011 and the start-up of the mobility actions in September 2011. However, for the capital costs the baseline has been considered the period from September 2009 to August 2010, before the beginning of the measure preparation and implementation.

Indicators 1, 2 and 3 (Operating Revenues, Operating Costs and Capital Costs):

For indicator 1 the revenues of the system was calculated based on the product of the 129 IPOC workers that use the SMTUC PT – bus (13,8% of the 934 IPOC workers) by the average number of trips per day (3,5 per passenger per day), the number of days per year (240) and by the average revenue per passenger (0,3035 €/passenger).

The values of the passenger - kilometre (pkm) were calculated by using the considered trip scenario private car and the SMTUC public transport (720 workers x 3,5 average trips per day x 240 days per year x 3,563 km per passengers = 2.155.244 pkm).

For the indicators 2 (Average Operating Costs) and 3 (Capital Costs) the values were null because before the measure implementation no costs related with the measure occurred.

Accordingly, the results of the baseline for each indicator are indicated in the tables C1.2.1 to C1.2.3:

Table C1.2.1 – Indicator 1 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Revenues from the operation of the system	32.860 €
Total passenger-km	2.155.244 pkm
Average operating revenue	0,015 €/pkm

Table C1.2.2 – Indicator 2 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total Operating Costs	0 €
Total passenger –km	2.155.244 pkm
Average operating costs	0,00 €/pkm

Table C1.2.3 – Indicator 3 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total capital cost	0,00 €

Indicator 4 (Vehicle fuel efficiency):

In relation to the ex-ante scenario, it was established that all trips were performed using the initial ratio from the commuters that use the private car (591 workers) and SMTUC public transport (129 workers).

The fuel mix data source results from the share of the fuel consumption in Portugal in 2007 (source: DGEG – in Annex 1) and was calculated by the ratio of the each fuel type with all types of fuel commercialized in the road transport sector.

The vehicle fuel efficiency was calculated by the ratio between the total energy consumption considering the trips made by private car and public transport and the total vehicle-km estimated per year in the 2011 survey.

The energy consumption was, firstly based, on the passenger kilometres made by 591 IPO workers that uses private car and the 129 workers that uses PT. For both passengers, the p.km calculus were based on the number of workers transformed in passengers per year by multiplying the 129 or the 591 workers by the Average number of trips per day (3,5) with the working days per year (240) and with the average distance per passenger (3,563 km). Secondly, for both modes the p.km were transformed in vehicles kilometres (v.km) by the fraction of p.km with the load factor (16,4 passengers per PT vehicle and 1,3 passengers per private car).

The total passengers.km and v.km for private car and for SMTUC PT are the following.

Table C1.2.4 – Passenger kilometres and the v.km for Private Car and Public Transport – Ex-ante

	Private Car (PC)	SMTUC Public Transport (PT)
Passenger.km	1.769.480 pkm	385.763 pkm
Vehicles.km	1.361.139 vkm	23.522 vkm

These values will serve as input for computing the energy consumption by following formulas:

Table C1.2.5 – Energy Consumption for Private Car and Public Transport – Ex-ante

Energy consumption Private Car (PC)	**Energy consumption SMTUC Public Transport (PT)**
$\mathbf{A_{PC} = B_{PC} \times [(C1 \times D1 + C2 \times D2)/100] \times E_{PC}}$ A_{PC} = Energy consumption (MJ) B_{PC} = Estimated Average Fuel Consumption for private car (l/100km) – 9,15 l/100km C1 = Gasoline Fuel mix 2007 (%) – 25,2% D1 = Energy density for Gasoline (MJ/l) – 32,18 MJ/l C2 = Diesel Fuel mix 2007 (%) – 74,5% D2 = Energy density for Diesel (MJ/l) – 35,86 MJ/l E_{PC} = Distance travelled by passengers per year for private car (vkm)	$\mathbf{A_{PT} = B_{PT} \times (D2/100) \times E_{PT}}$ A_{PT} = Energy consumption (MJ) B_{PT} = Estimated Average Fuel Consumption for public transport (l/100km) – 50,5 l/100km D2 = Energy density for Diesel (MJ/l) – 35,86 MJ/l E_{PT} = Distance travelled by passengers per year for public transport (vkm)

The values of the energy density and fuel mix are displayed in Annex 1 and Annex 2. For detailed calculation of these values please consult Annex 5.

The table C1.2.6 shows the baseline for fuel efficiency.

Table C1.2.6 – Indicator 4 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total Energy Consumption [A]	4.760.329 MJ
A1 – Private Car	4.334.359 MJ
A1.1 – Private Car (Diesel)	3.324.385 MJ
A1.2 – Private Car (Gasoline)	1.009.974 MJ
A2 – Public Transport (Diesel)	425.970 MJ
Total passenger-km [B]	2.155.244 pkm
B1 – Private Car	1.769.480 pkm
B2 – Public Transport	385.763 pkm
Vehicle fuel efficiency [A]/[B]	2,21 MJ/pkm

Indicators 5, 6, 7 and 8 (CO, CO2, NOx, PT):

The source of the information has been the fuel emission factors for each pollutant given by bibliographic sources, as is displayed in Annex 4. The study considered the following emission factors (g/kg.fuel) and converted to g/MJ (by Annex 2) for the private car and public transport – bus (table 1.2.7).

Table C1.2.7 – Indicators 5, 6, 7 & 8 – Emissions Factors

POLLUTANT	**CO**	**NOx**	**CO2**	**PT**
Diesel Buses (g/kgfuel)	11,88	40,75	3 140	1,85
Diesel Passenger Car (g/kgfuel)	3,2	11,28	3 140	0,72
Gasoline Passenger Car (g/kgfuel)	61,56	9,18	3 180	0,03
Diesel Buses (g/MJ)	0,277	0,949	73,115	0,043
Diesel Passenger Car (g/MJ)	0,075	0,263	73,115	0,017
Gasoline Passenger Car (g/MJ)	1,430	0,213	73,867	0,001

With the emissions factors (g/MJ) calculated in the above table and the fuel consumption per mode and fuel type (Public transport – Diesel, Private Car – Diesel and Private Car – Gasoline) shown in the table C1.2.6 we obtain the overall fleet weighted emissions factors for each pollutant.

Table C1.2.8 – Indicators 5, 6, 7 & 8 – Emissions

Pollutant	**CO**	**NOx**	**CO2**	**PT**
Diesel Buses (g)	117.834	404.187	31.144.741	18.350

Private Car (g) - *weighted*	1.799.426	1.080.359	316.554.303	54.881
Total Emissions (g)	1.917.260	1.484.546	347.699.044	73.230

The indicators are displayed by the ratio between the emissions (g) and the distance travelled by the passengers per year (pkm) for public transport (385.763 pkm) and for private car (1.769.480pkm). The results of the baseline for each indicator are indicated in the table C1.2.9:

Table C1.2.9 – Indicators 5, 6, 7 & 8 – Ex-Ante

Indicators and respective parameters	Ex-Ante values
CO emissions	0,89 g/pkm
CO2 emissions	161,33 g/pkm
NOx emissions	0,69 g/pkm
PT emissions	0,03 g/pkm

Indicator 9 (Modal Split)

The modal split was assessed through the IPOC workers survey carried out in July 2011, before the beginning of the implementation of the mobility management actions. It was considered the modes private car, SMTUC public transport - bus and the other modes resulting of the survey (Annex 5).

Table C1.2.10 – Indicator n.9 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Modal split – Passenger.km	-
SMTUC Bus	16,4%
Private Car	75,4%
Other modes	8,2%

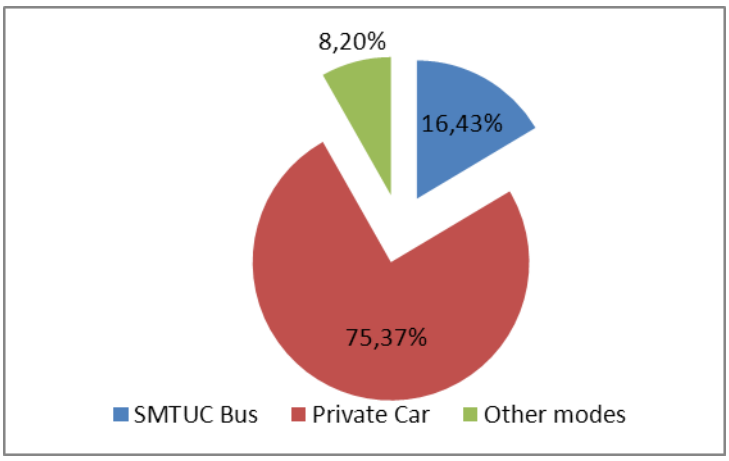


Figure C1.2.1 – Modal split – Ex-ante

Indicator 10 and 11 (Awareness level and Acceptance level)

The specific question if the respondent was favourable or not to the measure was performed in the survey was not applied before the launch of the "Mobility Management actions" because it was considered that it is not rational to ask people if they know about something which has not yet happened. So, it is considered that before something exists awareness is zero because it is impossible to know it (table C1.2.11).

A specific question about the IPOC workers acceptance of the mobility actions was carried out within the scope of the IPOC workers survey. The table C1.2.12 shows the result of the acceptance level.

Table C1.2.11 – Indicator n.10 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Awareness level	0 %

Table C1.2.12 – Indicator n.11 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Acceptance level	66,7 %

C1.3 Building the Business-as-Usual scenario

In the survey of September 2012, a query was made related to the modal shift of the IPOC workers since July 2011 (after the beginning of measure implementation). In this survey 9,3% of the respondents indicated that they changed to public transport without CIVITAS influence. Making the correspondence to all the 934 workers has been calculated the workers that changed in the BAU scenario – 86 workers. Taking into account this modal change the related indicators 1, 4, 5, 6, 7, 8 and 9 were assessed for the business-as-usual scenario (Annex 6 show details of the survey).

The BAU scenario reports to the period of September 2011 to August 2012, excepted for indicator 3 (Capital Costs). For this indicator the BAU scenario has been considered from September 2010 to August 2012, the same period considered for the ex-post results assessment related to the capital costs for the preparation and implementation of the measure.

Indicator 1 (Average Operating Revenues)

Without the implementation of the measure, the Operating Revenues are related to the increase of the 9,3% IPOC workers that transferred from private car to public transport (bus) without the effect of the measure. Adding these 86 workers with the 129 workers that usually uses the mode of transport gives a total of 215 workers. The passengers are calculated by using the average trips per day and the working days per year (215 workers x 3,5 trips per day x 240 days =180.600 IPOC passengers in SMTUC). These passengers generate revenues (it is considered that average revenue per passenger remains constant – 0,3035 €/passenger). For the total passengers-km (the 2 modes) is considered the total workers using private car and SMTUC public transport and that are equal to the baseline (720 passengers x 3,5 average trips per day x 3,563 km per passengers x 240 days per year = 2.155.244 pkm).

Therefore, the results of BAU scenario for this case are the following (table C1.3.1):

Table C1.3.1 – Indicator 1 – BAU

Indicators and respective parameters	BAU Values
Revenues from the workers that used SMTUC public transport	54.907 €
Total passenger-km	2.155.244 pkm
Average operating revenue (1 year / September 2011 – August 2012)	0,025 €/pkm

Indicator 2 (Average Operating Costs)

The change in the Operating Costs related to the operation of mobility management actions is obtained after setting up the measure. Therefore, without the implementation of the measure, the Operating Costs would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Therefore, the results of BAU scenario for this case are shown in the table C1.3.2.

Table C1.3.2 – Indicator 2 – BAU

Indicators and respective parameters	BAU Values
Operating costs	0 €
Total passenger-km	2.155.244 pkm

Average operating costs (1 year / September 2011 – August 2012)	0,00 €/pkm

Indicator 3 (Capital Costs)

Without the implementation of the measure, the capital costs would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Therefore, the table C1.3.3 shows the results of BAU scenario for this case.

Table C1.3.3 – Indicator 3 – BAU

Indicators and respective parameters	BAU values
Total capital cost (1 year / September 2010 – August 2011)	0,00 €
Total capital cost (1 year / September 2011 – August 2012)	0,00 €

Indicator 4 (Vehicle Fuel Efficiency)

Without the implementation of the measure, the energy consumption was related to the shift of the 9,3% IPOC workers (86 workers) from the private car to the SMTUC public transport (bus). With this premises it was assessed the impact of the increase in the public transport use and the related decrease of private car. For computing the energy consumptions for each mode it was considered the following, as already explained in baseline scenario:

- Total passengers in private car (591-86=505);
- Total passengers in SMTUC public transport - bus (129+86=215);
- The average number of trips is 3,5 per passenger per day;
- The average distance per passenger is 3,56 km per day;
- Working days per year is 240 days;
- Load factor for SMTUC PT (bus) of 16,4 passengers per bus and for private car a load factor of 1,3 passengers per car.

The energy consumption was, firstly based, on the passenger kilometres made by 505 IPO workers that uses private car and the 215 workers that uses PT in the BAU scenario. For both passengers, the p.km calculus were based on the number of workers transformed in passengers per year by multiplying the 215 or the 505 workers by the Average number of trips per day (3,5) with the working days per year (240) and with the average distance per passenger (3,563 km). Secondly, for both modes the p.km were transformed in vehicles kilometres (v.km) by the fraction of p.km with the load factor (16, 4 passengers per PT vehicle and 1,3 passengers per private car).

The total passengers.km and the v.km for private car and for PT are the following.

Table C1.3.4 – Passenger kilometres and v.km for Private Car and Public Transport – BAU

	Private Car (PC)	SMTUC Public Transport (PT)

Passenger.km	1.510.648 pkm	644.596 pkm
Vehicles.km	1.162.037 vkm	39.305 vkm

These values will serve as input for computing the energy consumption by the formulas expressed in Table C1.2.5 .

The calculation of this indicator is more detailed in Annex 5.

The table C1.3.5 shows the BAU for fuel efficiency.

Table C1.3.5 – Indicator 4 – BAU

Indicators and respective parameters	BAU values
Total Energy Consumption [A]	4.412.126 MJ
A1 – Private Car	3.700.347 MJ
A1.1 – Private Car (Diesel)	2.838.108 MJ
A1.2 – Private Car (Gasoline)	862.239 MJ
A2 – Public Transport	711.779 MJ
Total passenger-km [B]	2.155.244 pkm
B1 – Private Car	1.510.648 pkm
B2 – Public Transport	644.596 pkm
Vehicle fuel efficiency [A]/[B] (1 year / September 2011 – August 2012)	2,05 MJ/pkm

Indicators 5, 6, 7 and 8 (CO, CO2, NOx, PT):

The BAU scenario was established taking in account the emissions coming from the fuel consumption assessed for the indicator 5. The fuel consumption per mode and fuel type (Public transport – Diesel, Private Car – Diesel and Private Car – Gasoline) is shown in the table C1.3.5. The emissions factors are the same the one exposed in table 1.2.6. and the overall fleet weighted emissions factors for each pollutant were computed by the same methodology of the ex-ante scenario.

The next table show the emissions per pollutant during the BAU scenario:

Table C1.3.6 – Indicators 6, 7, 8, 9 & 10 – Emissions - BAU

POLLUTANT	**CO**	**NOx**	**CO2**	**PT**
Diesel Buses (g)	196.896	675.381	52.041.642	30.661
Private Car (g) - *weighted*	1.536.213	922.328	270.250.064	46.853
Total Emissions (g)	1.733.110	1.597.710	322.291.706	77.514

The indicators are displayed by the ratio between the emissions (g) and the distance travelled by the passengers per year (pkm) for SMTUC public transport - bus (644.590 pkm) and for private car (1.510.648 pkm). The results of BAU for each indicator are indicated in the table C1.3.7:

Table C1.3.7– Indicators 6, 7, 8, 9 & 10 – BAU

Indicators and respective parameters	BAU values
CO emissions (1 year / September 2011 – August 2012)	0,80 g/pkm
CO2 emissions (1 year / September 2011 – August 2012)	149,54 g/pkm
NOx emissions (1 year / September 2011 – August 2012)	0,74 g/pkm
PT emissions (1 year / September 2011 – August 2012)	0,04 g/pkm

Indicator 9 (Modal Split)

The modal split was assessed through the IPOC workers survey carried out in September 2012 related to the modal split (Annex 6 show details of the survey). It was considered the modes private car, SMTUC public transport - bus and the other modes resulting of the survey but analysing the impact of the measure. The survey showed that there has been an increase of PT use not related to the measure implementation. For this reason the BAU scenario for the modal split has been defined by reducing in the SMTUC public transport mode the passenger.km that changed from private car to SMTUC due the measure implementation, adding this value to the private car mode. It was verified that the other modes had internal changes but the total had no changes between the baseline and the BAU scenario.

Table C1.3.8 shows the modal split during the BAU scenario.

Table C1.3.8 – Indicator n.9 – BAU values

Indicators and respective parameters	BAU values
Modal split - Passenger.km	-
SMTUC Bus	27,5%
Private Car	64,3%
Other modes	8,2%

The next figure shows the modal split in the BAU scenario.

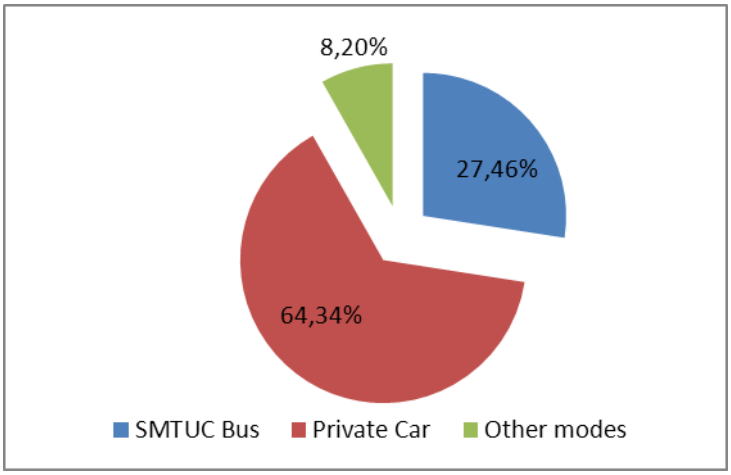


Figure C1.3.1 – Modal split – BAU values

Indicator 10 and 11 (Awareness level, acceptance level)

For awareness it was considered that before something occurs awareness is zero because it is impossible to know about something that not exist.

For the acceptance level it is considered that without the implementation of the measure, the acceptance would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Table C1.3.9 – Indicator n.10 – BAU values

Indicators and respective parameters	BAU values
Awareness level (1 year / September 2011 – August 2011)	0 %

Table C1.3.10 – Indicator n.11 – BAU values

Indicators and respective parameters	BAU values
Acceptance level (1 year / September 2011 – August 2011)	66,7 %

C2 Measure results

In the survey of September 2012, a query was made related to the modal shift of the IPOC workers since July 2011 (Annex 6 show details of the surveys). In this survey 14,8% of the respondents indicated that they changed from private car to SMTUC public transport. Making the correspondence to all the 934 workers has been calculated the workers that changed since measure implementation – 138 workers. Taking into account this modal change the next sub headings presented the measure results for the indicators – economy, energy, environment, transport and society.

The Ex-post scenario reports to the period of September 2011 to August 2012, excepted for indicator 3 (Capital Costs). For this indicator the BAU scenario has been considered from September 2010 to August 2012 to allow the assessment to all capital costs spent with the measure preparation and implementation.

As referenced before, the impacts has been considered only for the hospital involved in the implementation of the mobility plan (IPOC hospital).

C2.1 Economy

With the implementation of the measure, the Operating Revenues are related to the increase of the 14,8% IPOC workers that changed from private car to SMTUC public transport (bus).

Adding these 138 workers with the 129 workers that usually used SMTUC public transport before the implementation of the measure (ex-ante scenario) gives a total of 267 workers The passengers are calculated by using the average trips per day and the working days per year (267 workers x 3,5 trips per day x 240 days =224.280 IPOC passengers in SMTUC). These passengers generate revenues (it is considered that average revenue per passenger remains constant – 0,3035 €/passenger). For the total passengers-km (the 2 modes) is considered the total workers using private car and SMTUC public transport and that are equal to the baseline (720 passengers x 3,5 average trips per day x 3,563 km per passengers x 240 days per year = 2.155.244 pkm).

For indicator 2 the operating cost was given the SMTUC data and it corresponds to Personnel costs (mobility actions monitoring and mobility plans update). The annual operating cost was 779 €.

For indicator 3 the capital costs were related to the equipment installed in the IPOC hospital – real time information e-panels, PT network information boards, exhibitors, studies and mobility plan release.

Therefore, the following tables show the ex-post results for these cases.

Table C.2.1.1 – Indicator n.1 – Ex-post values

Indicators and respective parameters	Ex-Post values
Operating revenues (1 year /September 2011 to August 2012)	68.069 €
Passenger.km (1 year /September 2011 to August 2012)	2.155.244 pkm
Average operating revenues (1 year /September 2011 to August 2012)	0,032 €/pkm

Table C2.1.2 – Indicator n.2 – Ex-post values

Indicators and respective parameters	Ex-Post Values
Operating Costs (1 year /September 2011 to August 2012)	779 €

Passenger.km (1 year /September 2011 to August 2012)	2.155.244 pkm
Average operating costs (1 year /September 2011 to August 2012)	0,0004 €/pkm

Table C2.1.3 – Indicator n.3 – Ex-post values

Indicators and respective parameters	Ex-Post values
Total capital costs (1 year/September 2010 – August 2011)	18.670 €
Real time information e-panels	1.990 €
PT Network information boards	472 €
Exhibitors	208 €
Studies & Mobility Plan release	16.000 €
Total capital costs (1 year/September 2011 – August 2012)	0,00 €
Car-pooling service	0,00 €

Note: The implementation of the car pooling service for the workers of the IPOC hospital didn't have any capital costs. The IPOC workers used "Rota Partilhada", a web service for car-pooling developed in Porto in the scope of the CIVITAS ELAN project. This web service allows the creation of closed groups and for the mobility plans in the Coimbra health cluster it was created the car pooling group "SanusMobilis".

The following table summarise the comparison of the indicators 1, 2 and 3 after the implementation of the measure with the baseline and the BAU scenario.

Table C2.1.4 – Summary – Balance between economy indicators (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After – Before	Difference: After – B-a-U
4. Average Operating Revenues	0,015 €/passenger-km (1 year/Jul 10 – Jun 11)	0,025 €/passenger-km (1 year/Sept 11 – Aug 12)	0,032 €/passenger-km (1 year/Sept 11 – Aug 12)	0,017 €/passenger-km	0,007 €/passenger-km
5. Average Operating Costs	0,00 €/passenger-km (1 year/Jul 10 – Jun 11)	0,00 €/passenger-km (1 year/Sept 11 – Aug 12)	0,0004 €/passenger-km (1 year/Sept 11 – Aug 12)	0,0004 €/passenger-km	0,0004 €/passenger-km
6. Capital Costs	0,00 € (1 year/Sep 09 – Aug 10)	0,00 € (1 year/Sep 10 –Aug 11) 0,00 € (1 year/Sept 11 – Aug 12)	18.670 € (1 year/Sep 10l – Aug 11) 0,00 € (1 year/Sept 11 – Aug 12)	18.670 € 0,00 €	18.670 € 0,00 €

The following graph shows the evolution of average operating revenues (€/pkm) with CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

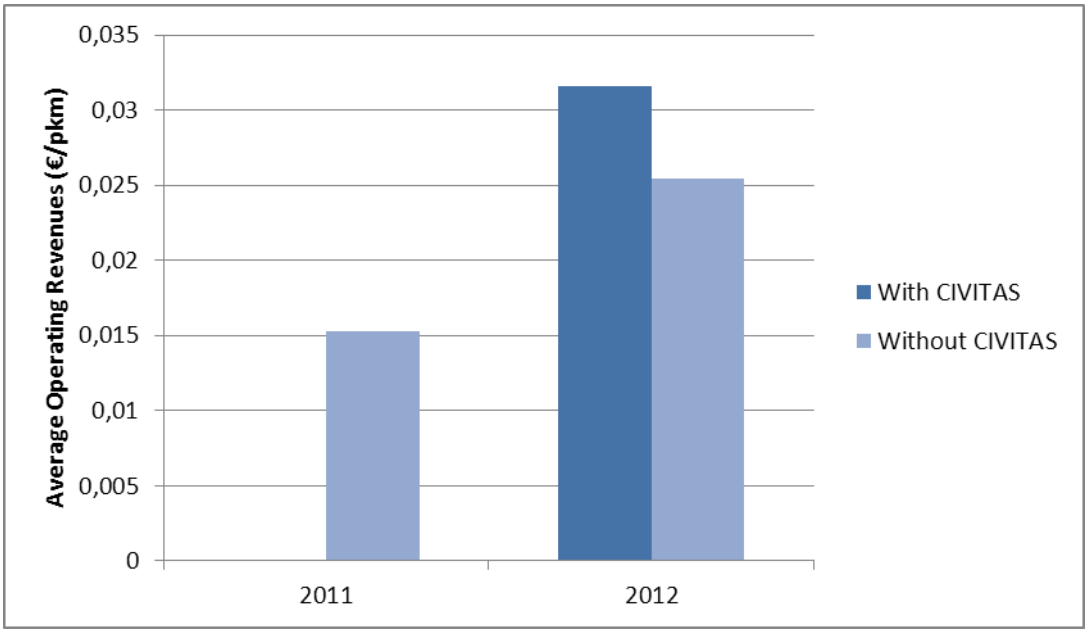


Figure C2.1.1 – Average operating revenues without/with CIVITAS

The following graph shows the evolution of average operating costs (€/pkm) with CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

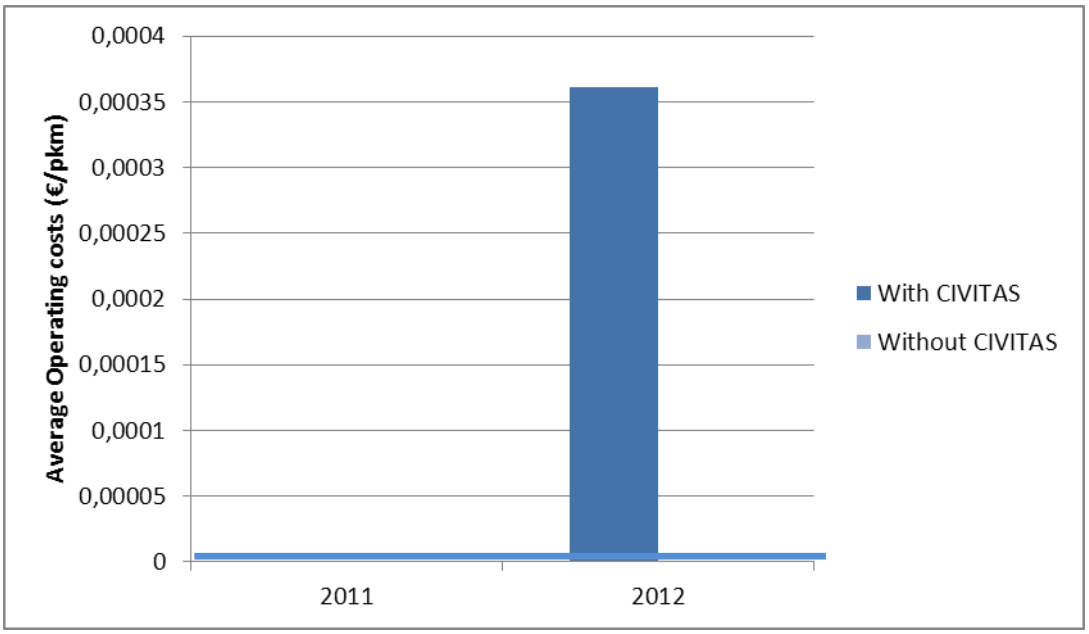


Figure C2.1.2 – Average operating costs without/with CIVITAS

The following graph shows the evolution of capital costs (€) with CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

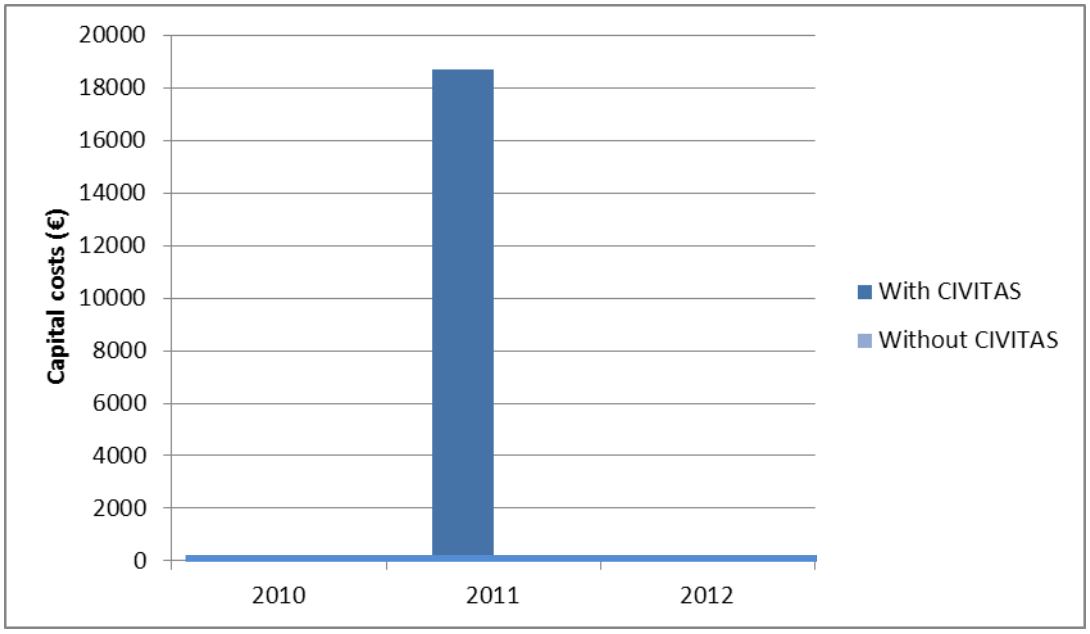


Figure C2.1.3 – Capital costs without/with CIVITAS

Analysing the economy indicators it is possible to conclude that the measure induced a 28% increase of the operating revenues related to the workers of the IPOC hospital that transferred to public transport from September 2011 to August 2012. In the same period the revenues coming from the total transfer of private car to public transport passengers increased 113,3% in the IPOC workers universe. With the CIVITAS measure the average operating costs increased 0,0004 €/pkm in comparison with the BAU and Ex-Post scenario), a value insignificant when compared with the increase in the average operating revenues (0,007 €/pkm). The increase of the operating revenues (ex-post – BAU) during the first year after measure implementation (13.162 €) were higher than the equivalent operating costs (779€) and almost all the costs incurred until this period, including the capital costs (779 € +18.670 € = 19.449 €). This fact indicates that the initial investment could be paid back in 2 years. .

C2.2 Energy

The source of information has been the surveys that allowed to estimated passenger-km per mode due to the transfer from private car to SMTUC public transport.

With the implementation of the measure, the energy consumption was related to the shift of the 14,8% IPOC workers (138 workers) from the private car to the SMTUC public transport (bus). With this premises it was assessed the impact of the increase in the public transport use and the related decrease of private car. For computing the energy consumptions for each mode it was considered the following, as already explained in baseline scenario:

- Total passengers in private car (591-138=453);
- Total passengers in SMTUC public transport - bus (129+138=267);
- The average number of trips is 3,5 per passenger per day;
- The average distance per passenger is 3,56 km per day;
- Working days per year is 240 days;

- Load factor for PT (bus) of 16,4 passengers per bus and for private car a load factor of 1,3 passengers per car.

The energy consumption was, firstly based, on the passenger kilometres made by 453 IPO workers that uses private car and the 267 workers that uses PT after the implementation of the measure. For both passengers, the p.km calculus were based on the number of workers transformed in passengers per year by multiplying the 267 or the 453 workers by the Average number of trips per day (3,5) with the working days per year (240) and with the average distance per passenger (3,563 km). Secondly, for both modes the p.km were transformed in vehicles kilometres (v.km) by the fraction of p.km with the load factor (16, 4 passengers per PT vehicle and 1,3 passengers per private car).

The total passengers.km and v.km for private car and for PT are the following:

- **Table C2.2.1 – Passenger kilometres and v.km for Private Car and Public Transport – Ex-post**

	Private Car (PC)	SMTUC Public Transport (PT)
Passenger.km	1.355.349 pkm	799.895 pkm
Vehicles.km	1.042.576 vkm	48.774 vkm

These values will serve as input for computing the energy consumption by the formulas expressed in Table C1.2.5.

The calculation of this indicator is more detailed in Annex 5

The Ex-post scenario of indicator 4 (Vehicle Fuel Efficiency) is calculated by the ratio of the energy consumption in litres, converted in MJ, of the private car and public transport use, with the passengers kilometres. The table C2.2.2 shows the energy consumption and the table C2.2.3 shows the Vehicle Fuel Efficiency indicator.

Table C2.2.2 – Indicator 4 – Ex Post

Indicators and respective parameters	Ex Post values
Total Energy Consumption [A]	4.203.205 MJ
A1 – Private Car	3.319.940 MJ
A1.1 – Private Car (Diesel)	2.546.342 MJ
A1.2 – Private Car (Gasoline)	773.598 MJ
A2 – Public Transport	883.264 MJ
Total passenger-km [B]	2.155.244 pkm
B1 – Private Car	1.355.349 pkm
B2 – Public Transport	799.895 pkm
Vehicle fuel efficiency [A]/[B] (1 year/September 2011 – August 2012)	1,95 MJ/pkm

Table C2.2.3 – Energy indicators – Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
4. Vehicle Fuel	2,21 MJ/pkm	2,05 MJ/pkm	1,95 MJ/pkm	-0,26 MJ/pkm	-0,10 MJ/pkm

Efficiency	(1 year/Jul 10 – Jun 11)	(1 year/Sept 11 – Aug 12)	(1 year/Sept 11 – Aug 12)		

The following graph shows the evolution of Vehicle fuel efficiency (MJ/pkm)With CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

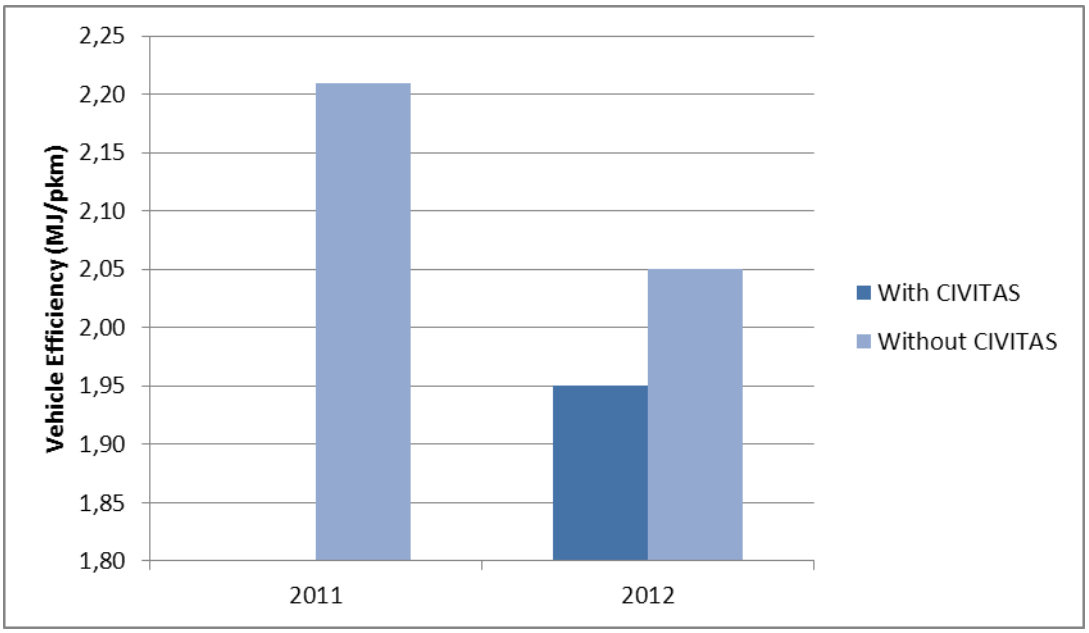


Figure C2.2.1 – Vehicle fuel efficiency without/with CIVITAS

This evolution shows that the shift from private car to SMTUC public transport – bus generates a positive impact to the vehicle efficiency (reducing 5% in relation to BAU scenario and 7% in relation to ex-ante scenario), meaning that the use of public transport in such conditions brings significant energy advantages.

This assessment was performed considering a modal shift inducing an increase of the PT offer that corresponds to the increase in the demand considering the load factor of SMTUC buses service (16,4 passengers per trip). But in reality this increase in demand did not affected the PT offer because this offer was enough to equilibrate the increase in the demand. Thus, was not verified a real increase in the fuel consumption concerning the public transport until now, but only a decrease in the consumption related to the private car. In this case the consumptions of the public transport mode for the ex-post and BAU scenario were equal to the baseline scenario and the tables C2.2.1 and C2.2.2 have the following modifications:

Table C2.2.4 – Indicator 4 – Ex Post

Indicators and respective parameters	Ex Post values
Total Energy Consumption [A]	3.745.910 MJ
A1 – Private Car	3.319.940 MJ
A2 – Public Transport	425.970 MJ
Total passenger-km [B]	2.155.244 pkm
Vehicle fuel efficiency [A]/[B] (1 year/September 2011 – August 2012)	1,74 MJ/pkm

Table C2.2.5 – Energy indicators – Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
4. Vehicle Fuel Efficiency	2,21 MJ/pkm (1 year/Jul 10 – Jun 11)	2,05 MJ/pkm (1 year/Sept 11 – Aug 12)	1,74 MJ/pkm (1 year/Sept 11 – Aug 12)	-0,47 MJ/pkm	-0,31 MJ/pkm

As expected, in this new (and actual) scenario the decrease in the fuel consumption was higher that the considered in the former scenario. In this case the vehicle fuel efficiency was 15,1% better due to the implementation of the mobility plan in the IPOC hospital and 21,3% better when comparing the global situation (before – after measure implementation).

C2.3 Environment

The source of information has been the surveys that allow estimating passenger-km per mode due to the transfer from private car to SMTUC public transport (2.155.244 pkm as shown in table C2.2.12) and the vehicle fuel consumption. The fuel consumption per each transport mode and fuel type (Private Car diesel, Private Car gasoline and Public Transport diesel) is the referenced in the table C2.2.12. The emission factors for each pollutant are given by bibliographic sources, as is displayed in Annex 4. The study considered the emission factors (g/kg.fuel) and converted to g/MJ (by Annex 2) for the private car (2 fuel types) and SMTUC public transport – bus (table 1.2.6).

The next table shows the results of the total emissions per pollutant and transport mode:.

Table C2.3.1 – Indicators 6, 7, 8, 9 & 10 – Emissions – Ex-post

POLLUTANT	**CO**	**NOx**	**CO2**	**PT**
Diesel Buses (g)	244.334	838.097	64.579.782	38.049
Private Car (g) - *weighted*	1.378.286	827.510	242.467.520	42.036
Total Emissions (g)	**1.622.620**	**1.665.608**	**307.047.302**	**80.085**

The indicators are displayed by the ratio between the emissions (g) and the distance travelled by the passengers per year (pkm) for SMTUC public transport - bus (799.895 pkm) and for private car (1.355.349 pkm).

The results of Ex-post for each indicator are indicated in the table C2.3.2 and the comparison with the baseline and the business-as-usual scenario in the table C2.3.3.

Table C2.3.2 – Indicators 6, 7, 8, 9, 10 – Ex Post

Indicators and respective parameters	Ex-Post values
CO emissions	0,75 g/pkm
CO2 emissions	142,47 g/pkm
NOx emissions	0,77 g/pkm
PT emissions	0,04 g/pkm

Table C2.3.3 – Environmental indicators - Summary– Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
6. CO emissions	0,89 g/pkm (1 year / Jul 10 – Jun 11)	0,80g/pkm (1 year / Sept 11 – Aug 12)	0,75 g/pkm (1 year / Sept 11 – Aug 12)	-0,14 g/pkm	-0,05 g/pkm
7. CO2 emissions	161,33 g/pkm (1 year / Jul 10 – Jun 11)	149,54 g/pkm (1 year / Sept 11 – Aug 12)	142,47 g/pkm (1 year / Sept 11 – Aug 12)	-11,79 g/pkm	-7,07 g/pkm
8. NOx emissions	0,69 g/pkm (1 year / Jul 10 – Jun 11)	0,74 g/pkm (1 year / Sept 11 – Aug 12)	0,77 g/pkm (1 year / Sept 11 – Aug 12)	0,08 g/pkm	0,03 g/pkm
9. PT emissions	0,034 g/pkm (1 year / Jul 10 – Jun 11)	0,036 g/pkm (1 year / Sept 11 – Aug 12)	0,037 g/pkm (1 year / Sept 11 – Aug 12)	0,003 g/pkm	-0,001 g/pkm

The following graph shows the evolution of CO emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the BAU scenario (Without CIVITAS).

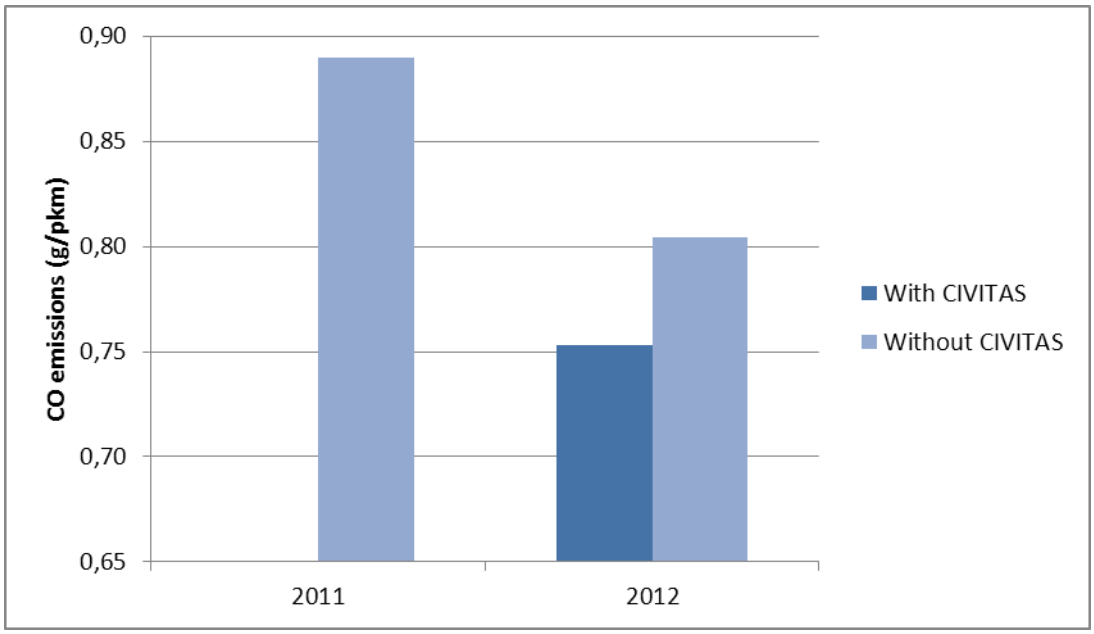


Figure C2.3.1 - CO emissions (with/without CIVITAS)

The following graph shows the evolution of CO2 emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

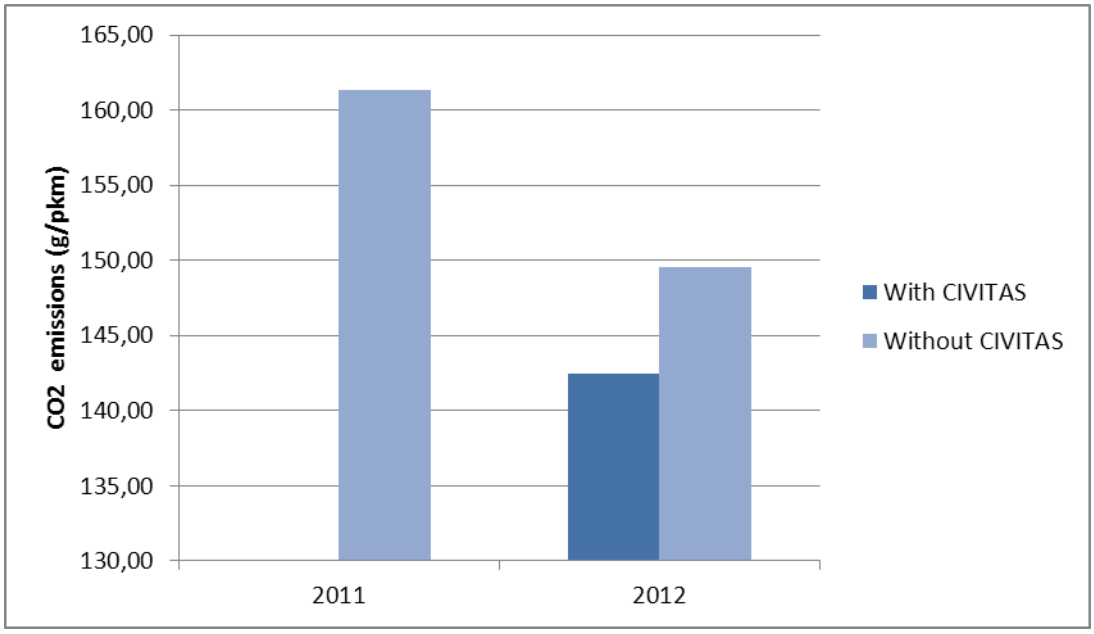


Figure C2.3.2 – CO2 emissions (with/without CIVITAS)

The following graph shows the evolution of NOx emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the BAU scenario (without CIVITAS).

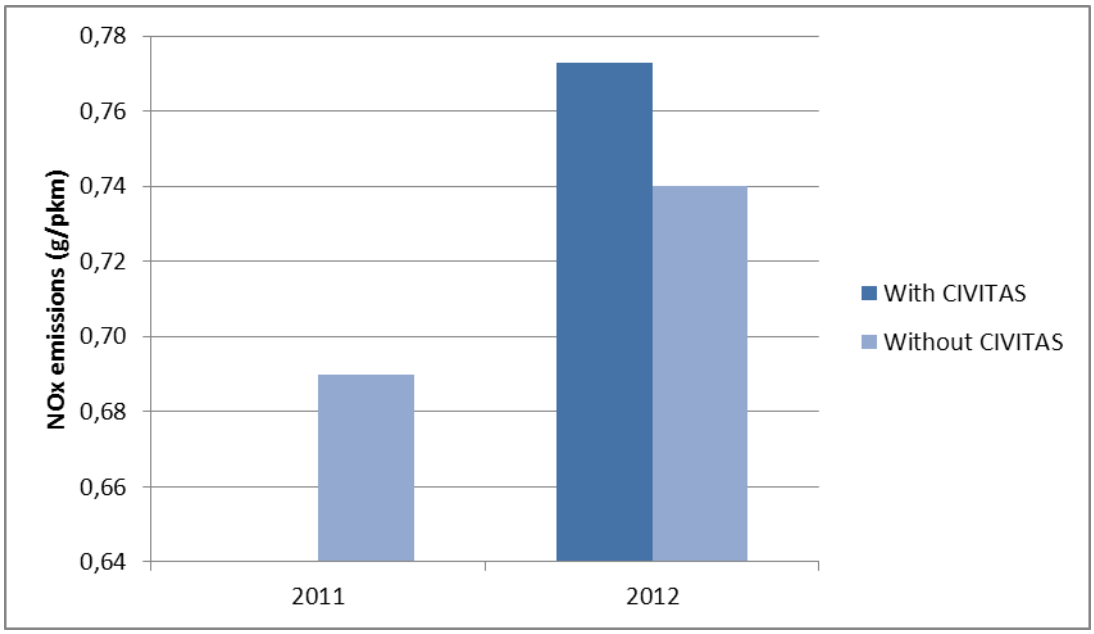


Figure C2.3.3 – NOx emissions (with/without CIVITAS)

The following graph shows the evolution of PT emissions (g/pkm) With CIVITAS and the evolution of this indicator according to the BAU scenario (without CIVITAS).

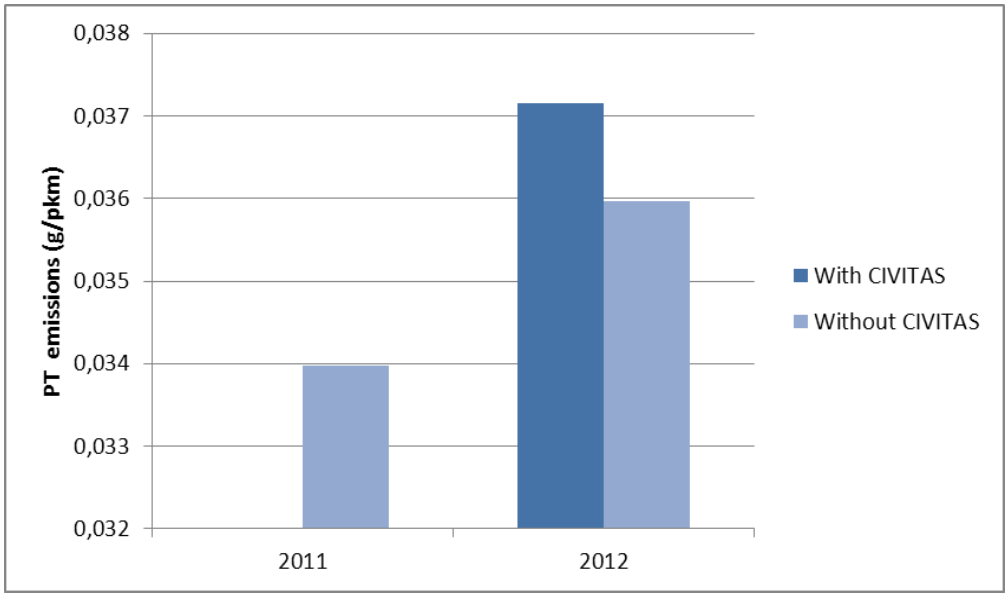


Figure C2.3.4 – PT emissions (with/without CIVITAS)

As expected, with a modal shift from private car to public transport using 100% diesel fuel, instead of using a share of gasoline / diesel vehicles, had impacts on the emissions. In the first year of the mobility plan implementation, the measure had positive impacts on the mitigation CO and CO2 emissions, but generates a negative impacts in terms of particles and NOx. In terms of emissions the CIVITAS measure had a positive impact of CO , CO2 with 0,05 g/pkm, 7,07 g/pkm, respectively, and a increase of 0,03 g/pkm in NOx emissions. The PT emissions had a little impact (0,003 g/pkm Ex-post for ex-ante and -0,001 g/pkm Ex-post for BAU).

As referenced for the fuel efficiency, this assessment was performed considering a modal shift inducing an increase of the PT offer that corresponds to the increase in the demand considering the load factor of SMTUC buses service (16,4 passengers per trip). But in reality this increase in demand did not affected the PT offer because this offer was enough to equilibrate the increase in the demand. Thus, was not verified a real increase in the emissions of pollutants concerning the public transport until now, but only a decrease in the emissions related to the private car. In this case the emissions of the public transport mode for the ex-post and BAU scenario were equal to the baseline scenario and the tables C2.3.1, C2.3.2 and C2.3.3 have the following modifications:

Table C2.3.4 – Indicators 6, 7, 8, 9 & 10 – Emissions – Ex-post scenario 2

POLLUTANT	**CO**	**NOx**	**CO2**	**PT**
Diesel Buses (g)	117.834	404.187	31.144.741	18.350
Private Car (g) - *weighted*	1.378.286	827.510	242.467.520	42.036
Total Emissions (g)	**1.496.120**	**1.231.697**	**273.612.261**	**60.386**

Table C2.3.5 – Indicators 6, 7, 8, 9, 10 – Ex Post scenario 2

Indicators and respective parameters	Ex-Post values
CO emissions	0,69 g/pkm
CO2 emissions	126,95 g/pkm
NOx emissions	0,57 g/pkm
PT emissions	0,03 g/pkm

Table C2.3.6 – Environmental indicators – Summary – Ex Post scenario 2, BAU scenario 2 and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
6. CO emissions	0,89 g/pkm (1 year / Jul 10 – Jun 11)	0,77g/pkm (1 year / Sept 11 – Aug 12)	0,69 g/pkm (1 year / Sept 11 – Aug 12)	-0,20 g/pkm	-0,08 g/pkm
7. CO2 emissions	161,33 g/pkm (1 year / Jul 10 – Jun 11)	139,84 g/pkm (1 year / Sept 11 – Aug 12)	126,95 g/pkm (1 year / Sept 11 – Aug 12)	-34,38 g/pkm	-12,89 g/pkm
8. NOx emissions	0,69 g/pkm (1 year / Jul 10 – Jun 11)	0,62 g/pkm (1 year / Sept 11 – Aug 12)	0,57 g/pkm (1 year / Sept 11 – Aug 12)	-0,12 g/pkm	-0,05 g/pkm
9. PT emissions	0,034 g/pkm (1 year / Jul 10 – Jun 11)	0,030 g/pkm (1 year / Sept 11 – Aug 12)	0,028 g/pkm (1 year / Sept 11 – Aug 12)	-0,006 g/pkm	-0,002 g/pkm

The following graphs show the emissions (g/pkm) With CIVITAS and the evolution of this indicator without CIVITAS (Scenario 2).

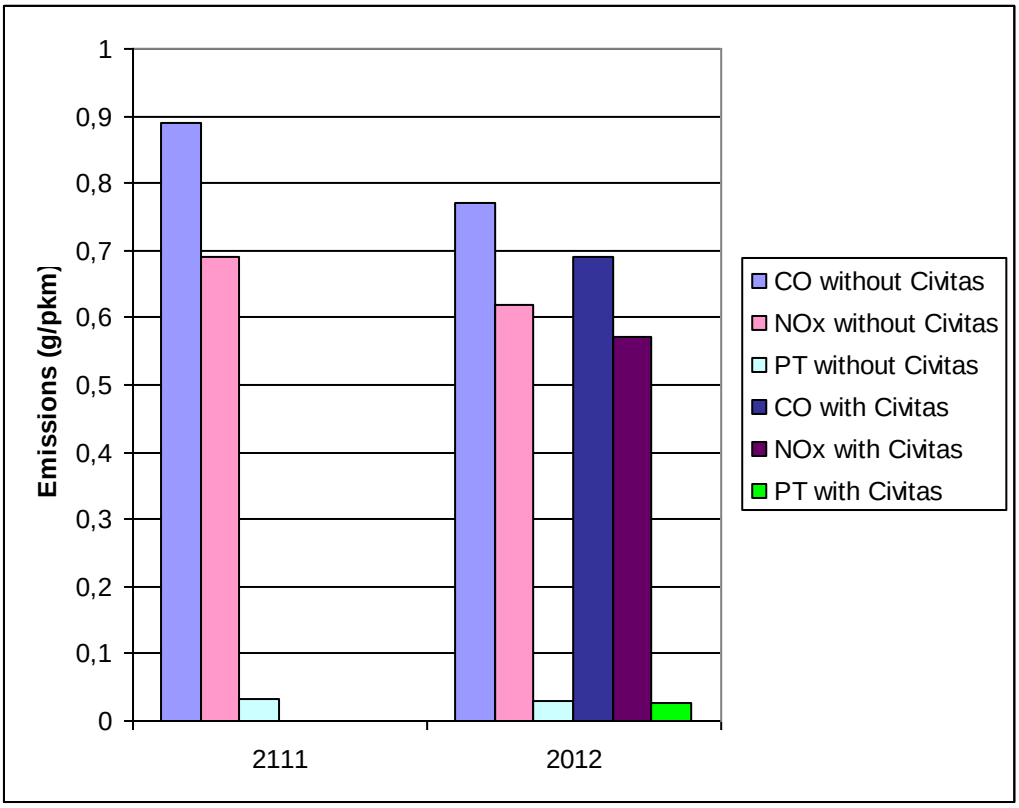


Figure C2.3.5 – CO, NOx and PT emissions according scenario 2 (with/without CIVITAS)

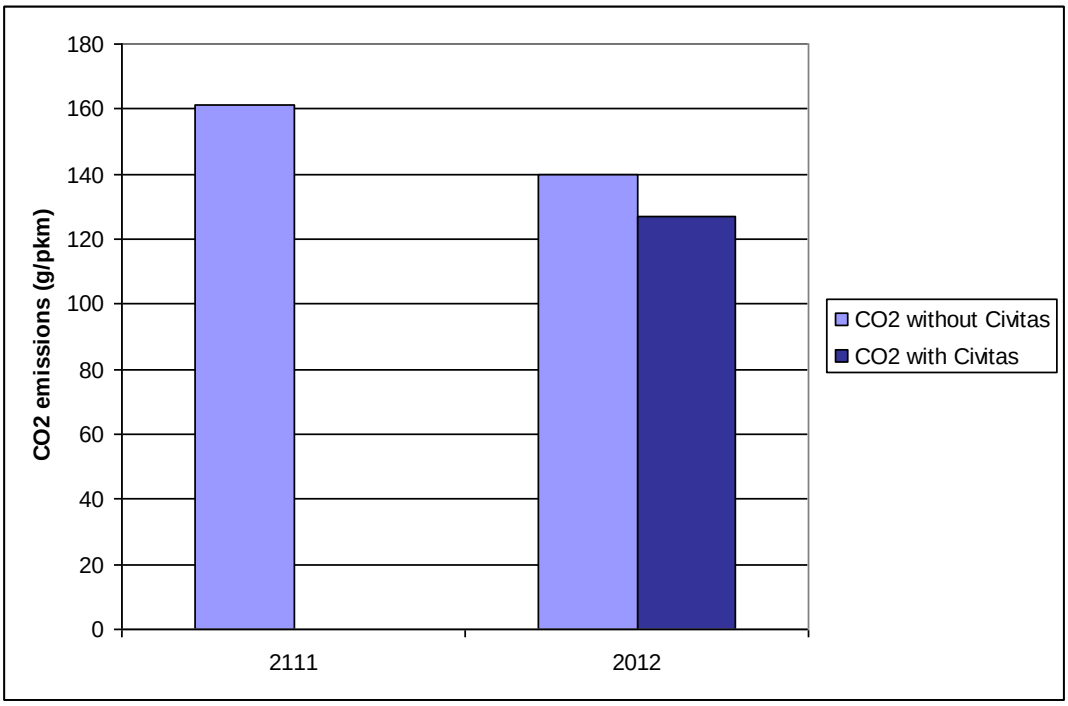


Figure C2.3.6 – CO2 emissions according scenario 2 (with/without CIVITAS)

As expected, in the new (and actual) scenario the emissions reduction was higher and occurred for all the pollutants. The decrease due to the measure effect was between 7% (PT emissions) and 10% (CO emissions) and concerning the global situation (Ex-post – baseline) the decrease had a variation from 17% (NOx emissions) to 22% (CO emissions). Only concerning the CO2 emissions, the measure allowed 273 ton of savings in the first year of the mobility plan implementation.

C2.4 Transport

The modal split was assessed through the IPO workers survey carried out in September 2012 (Annex 6 show details of the surveys).

Table C2.4.1 – Indicator n.9 – Ex-Post values

Indicators and respective parameters	Ex-Post values
Modal split – Passenger.km	-
SMTUC Bus	34,1%
Private Car	57,7%
Other modes	8,2%

The next figure shows the modal split in the Ex-post scenario.

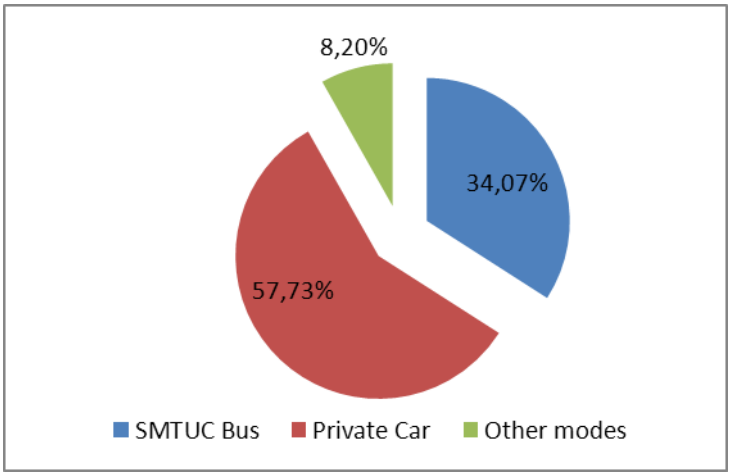


Figure C2.4.1 – Modal split – Ex-post values

The table of results of the indicators is as follows:

Table C2.4.2 – Summary – Balance between transport indicator (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
9. Modal split (p.km) - %	SMTUC Bus 16,4% Private Car 75,4% Other modes 8,2% (1 year / Jul 10 – Jun 11)	SMTUC Bus 27,5% Private Car 64,3% Other modes 8,2% (1 year / Sept 11 – Aug 12)	SMTUC Bus 34,1% Private Car 57,7% Other modes 8,2% (1 year / Sept 11 – Aug 12)	SMTUC Bus +17,6% Private Car -17,6% Other modes 0%	SMTUC Bus +6,61% Private Car -6,610% Other modes0%

For the workers who changed mode from driving to PT, the reasons behind the decision are related with the implementation of the real time PT schedules at the IPO facilities (about 30% of the answers) and because of the improvement in the quality of the public transport fleet and services (over 30% of the responses).

On the other and, the main reasons behind the attitude towards the change can be analyzed on the graphic below. There are 15% of responses for whom the actual situation is comfortable and with no reason to change the behaviour as we can see on the graphic.

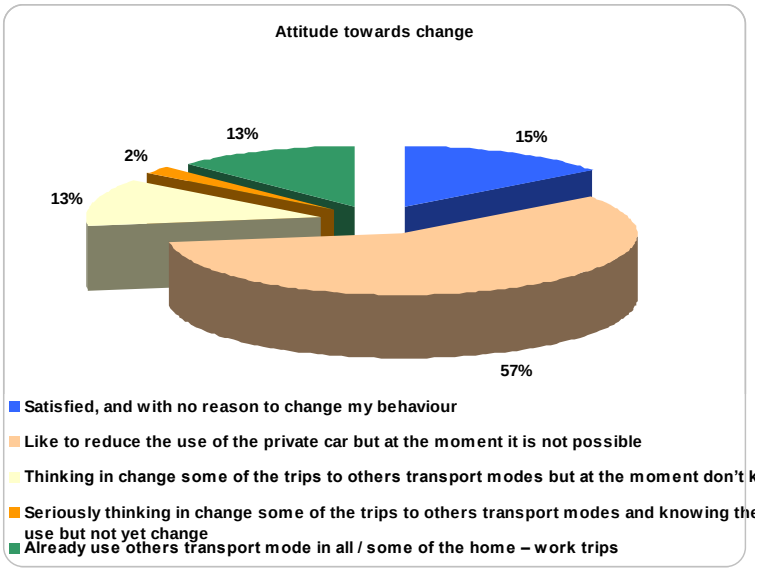


Figure C2.4.2 – Attitude toward change of the IPOC staff

C2.5 Society

To get an assessment about the acceptance and awareness – users towards the changes occurring due to the measure, specific questions was settled in the surveys to the workers of the IPO.

Table C2.5.1 – Indicator n.10 – ex-post values

Indicators and respective parameters	Ex-post values
Awareness (1 year/ Sept 11 – Aug 12)	96,3 %

Table C2.5.2 – Indicator n.11 – ex-post values

Indicators and respective parameters	Ex-post values
Acceptance – users (1 year /Sept 11 – Aug 12)	90,7 %

The table of results of the indicators is as follows:

Table 2.5.3 – Summary – Balance between society indicator (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
10. Awareness	0% (1 year / Jul 10 – Jun 11)	0% (1 year / Sept 11 – Aug 12)	96,3 % (1 year / Sept 11 – Aug 12)	96,3 %	96,3 %
11. Acceptance - users	0% (Sept 11 – Aug 12)	66,7 (1 year / Sept 11 – Aug 12)	90,7 % (1 year / Sept 11 – Aug 12)	90,7 %	24 %

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To provide at least 1 mobility plan for 1 Hospital and mobility actions for other 2 hospitals, as well as 1 partnership with 1 enterprise. A mobility plan for the IPOC hospital in Coimbra has been provided and mobility actions continue to be implemented in the other 2 hospitals involved in the measure. Two partnership for PT special services has been implemented, exceeding in this part the initial objectives.	**
2	To make mobility campaigns, with special attention to the young students, including organising a "Bus-Paper" and visits to SMTUC by students from municipality primary schools. Several mobility campaigns took place, including 3 campaigns directed to the IPOC hospital, 3 public presentations of the measure and an international workshop focused in this area organised in Coimbra. A "Bus-Paper", a kind of Pedi-paper but also travelling by public transport, has been organised for the children, as well as 52 visits of young students to SMTUC (61 classes from 17 elementary schools, in a total of 1.154 children and 116 teachers and chaperones.	**
3	To improve 1% the municipality PT passengers that were workers at the hospital in Coimbra where the mobility plan has been implemented. The PT passengers that were workers at the IPOC hospital increased 24,0% due the measure implementation.	***
4	To decrease by 5% to 10% the use of private cars of the workers at the Hospital in Coimbra where the mobility plan has been implemented. The private car use of the workers of IPOC hospital decreased 10,3% due the measure implementation.	**
5	To improve the cooperation between SMTUC and Hospitals, University and Municipality. The cooperation has been improved namely by the support of the Municipality in the release of the mobility plan, the implementation of the mobility plan and mobility management action in hospitals, as well as the partnership with University workers for tickets discounts in the Park & Ride system and with the Nursing School for the special prices and dedicated transport for the students.	**
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

This measure was implemented for the 934 workers of the IPO hospital and it induced a 6,6% modal shift from private car to public transport – bus (Ex-post – BAU scenario) in the first year, creating a positive impact in the balance between the operating revenues and costs (+12.383 €) and economies in terms of reductions of energy use (-380.407 MJ) and emissions(-273 ton CO2 emissions).

If the measure was applied to a larger scale, namely the 2 other hospital of the health cluster (Children's and University Hospital) the impacts will be more important taking into attention that the number of workers to be involved in the mobility plans will be higher (5.100). So for instance the up-scaling for the 5.100 workers of these hospitals will represent an expected gain of 67.616 € per year and savings per year of 2.077.169 MJ in the energy consumption and 1.491 ton in the CO2 emissions.

C5 Appraisal of evaluation approach

The evaluation strategy of this measure sought to focus on a number of indicators across the areas of economy, energy, environment, transport and society, which were to be measured in different ways.

The evaluation strategy that based the Local Evaluation Plan (LEP) was defined a long time before the final definition of the measure and during the LEP elaboration the hypothesis considered in relation to the foreseen evaluation approach of the measure was very different from the approach that actually was taken.

The evaluation strategy of the indicators in the area of Energy and Environment and the definition of relevant data to the indicators in the area of Economy and Transport was based on both the revenues and costs given by the SMTUC management and the information obtained in two surveys focused to the IPO hospital workers. These surveys were taken in different periods: before the implementation of the measure - July 2011 and after the implementation of the measure - September 2012. The surveys allowed the assessment to the evolution of the modal split and the subsequent transfer between modes.

Thus, the referred change in the modal split (private car to public transport – SMTUC bus) induces benefits in terms economy, energy use and related emissions of Green House Gases.

The elimination of the indicator related to the Acceptance level of the PT operators has been decided due the change of the entities involved in the mobility plans implementation. In the final plan for the measure implementation has been decided to apply the mobility plans in 3 hospitals located in a health cluster that is served only by SMTUC, that is the responsible for the measure implementation. So didn't made sense to carry out a survey on measure acceptance by interviewing the measure responsible himself.

C6 Summary of evaluation results

The key results are as follows:

- **Modal shift from private car to public transport** – As a result of the measure implementation it was verified an increase of 10,3% in the transport public use by the workers of the hospital where the mobility plan has been implemented. The private car usage of these workers decreased 24% due to the passengers transfer from private car to public transport.
- **Increase of operating revenues** –The measure induced a 28% increase of the average operating revenues related to the workers of the hospital that transferred to public transport (+0,007 €/pkm), The increase of the operating revenues (ex-post – BAU) during the first year after measure implementation (13.162 €) were higher than the equivalent operating costs (779€) and the initial investment (18.670 €) could be paid back in 2 years.
- **Contribution to energy efficiency in the city** – The implementation of the measure would result in significant energy savings (-15,1%) due to the assessed significant reduction of the energy consumption per passenger (-0,31 MJ/pkm).
- **Mitigation of CO2 emissions** – As result of the increase of public transport usage, the implementation of the measure would result in relevant CO2 emission savings (-12,89 g/pkm) that corresponded to 273 ton CO2 savings during the first year of mobility plan implementation.

C7 Future activities relating to the measure

The development and implementation of travel plans and mobility management actions in Coimbra has catalysed a change in mentalities in planning technicians and local decision-makers. After many decades focused on traffic management activities, Coimbra now acknowledges that mobility management solutions, especially travel plans, is a practical and valuable way of dealing with the city mobility challenges.

The board of Administration of the University hospital has recently sanctioned the development of a travel plan to implement in the upcoming year. The city of Coimbra will also continue pressing the Paediatric hospital to implement a travel plan in the near future, rather than just implement isolated initiatives and actions. Also, there is a commitment on the part of the major stakeholders to follow-up the existing travel plan, namely by developing a plan for hospital out patients and logistic services. The travel plan has a four year implementation period which guarantees the involvement of the different partners in the upcoming years.

Also, city officials have indicated that the development and implementation of site-based travel plans is a very viable option in the future for applying in the University campuses and local secondary schools. Other mobility management actions will also be applied in the future in managing mobility during large events, such as sports and entertainment events.

D Process Evaluation Findings

D.1 Deviations from the original plan

The deviations from the original plan comprised:

- **Development and implementation of only one of the foreseen mobility plans**– Initially the city of Coimbra intended to develop three mobility plans (i.e., travel plans). The municipality had indicated three different sites – 2 hospitals and 1 university campus. However, do to the distance between these three facilities and to the different functions they carried out, SMTUC proposed the development of three plans for the city's health cluster. This would allow for the optimisation of the work by developing travel plans for three hospitals which are all located in the northern part of the city – University Hospital, Oncological Hospital and Paediatric Hospital. The three hospitals were contacted and agreed to participate with SMTUC in the development and implementation of the travel plans. However, after several meeting with the Hospital Administrations the process only went forward in the Oncological Hospital. The other two hospitals delayed their participation due to the newly instituted national legislation that merged the Administration of the two entities. The merger process was prolonged throughout several months and accordingly the Board members did not want to commit with the plans while the issue was not totally resolved. On April 2011 a new Chairman for the joint hospitals was appointed but the resignation of the Portuguese Government delayed again this process. After the conclusion of the merger process on final December 2011 the hospitals finally acquiesced to developing and implementing the travel plans. Nevertheless, in the formers months the attention of the decision makers of the joint hospitals has been centred in the hospitals restructuration tasks and in the management of the financial constraints imposed on the Portuguese public sector, pushing the mobility issues to a less priority level. These problems have delayed again the development and implementation of the travel plans in these two hospitals. For these reasons the measure is required to be extended to have a longer period for the evaluation of the impacts of the mobility plan implemented in the 1st Hospital involved in the measure and to have time to launch additional mobility management actions in the other 2 hospitals that delayed their involvement.

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Barrier 1.1 – Political / Strategic Barrier** – Lack of know-how and experience in Mobility Management at the National level required key measures personnel to spend more time in training and knowledge acquisition that initially foreseen for the preparation phase, delaying the start of the measure implementation;

- **Barrier 1.2 – Institutional Barrier –** There is no legal requirement in Portugal for public entities to develop travel plans, namely entities which are large traffic-generators. The lack of a legislative framework contributes to the lack of appreciation of the importance of mobility management actions.

Implementation phase

- **Barrier 2.1 – Technological Barrier** – The lack of a planning culture focused on mobility management hindered the process in the initial stages. Key stakeholders and decision-makers revealed some hesitation in developing travel plans as a means of dealing with the mobility problems in the city.

- **Barrier 2.2 – Problem Related Barriers** – A lack of a culture focusing on mobility management and a long process of junction and restructuration on 2 of the 3 hospitals involved in the mobility plans occurred. This fact contributed significantly to the delay in the development and implementation of the travel plans.

Operation phase

- **Barrier 3.1 – Financial Barrier -** Due to the financial crisis, many of the measures and actions foreseen in the mobility plans have been delayed. The fact that the travel plans involve three public entities (i.e., Hospitals, Municipality, and Municipal PT Operator) has led to a substantial decrease in the budget allocations for the travel plans, since the national government has severely curtailed funding and tender procedures.

- **Barrier 3.1 – Organisational Barrier –** The staff at the hospitals was also unaware of the implications of implementing travel plans and were not prepared to assume many of the activities involved, such as being mobility managers.

D.2.2 Drivers

Preparation phase

- **Driver 1.1 – Institutional Driver** – Availability of training sessions on mobility management and of mobility managing planning tools allowed for the surpassing the lack of knowledge of the personnel involved in the managing of the measure and the experience acquired with the mobility actions in the first hospital will allow for quicker implementation in the next hospitals involved in this measure.

Implementation phase

- **Driver 2.1 – Cultural Driver** – The team involved in the mobility management actions was highly motivated and interested, especially in the training tasks, and allowed for the recovery of the delay verified.

Operation phase

- **Driver 3.1 – Political / strategic Driver** – The great success of the initial mobility actions in the first hospital served as a catalyst for augmenting the interest for these activities in other entities.

D.2.3 Activities

Preparation phase

- **Activities 1 – Technological Activities** – Taking into consideration the lack of knowledge of SMTUC technicians about mobility management (barrier 1.1) and the availability of training sessions (driver 1.1), SMTUC sent its technicians to several training sessions and workshops to consolidate their knowledge on developing mobility plans.

- **Activity 2 – Involvement activities –** To combat the lack of a legal requirement in Portugal for entities large traffic-generators to develop travel plans (barrier 1.2) and with the objective to provide the legislative framework for the effect, SMTUC technicians (and other experts involved in the CIVITAS MODERN project) participated in meetings and work sessions with IMTT, the Portuguese Institute of Mobility and Inland Transport. A guidebook on mobility management and documents with the proposals for the legal requirement has been released by IMTT.

Implementation phase

- **Activities 3 – Institutional Activities** – In order to convince the hospital administrations that implementing a travel plan would be beneficial to the institution (barrier 2.1) , SMTUC carried out a series of promotional campaign in the hospital and organised several meeting with the hospital administration (especially at the Oncological Hospital) to demonstrate the numerous advantages of having a travel plan.

- **Activity 4 – Involvement activities –** Also the great motivation of the team responsible for the mobility management (driver 2.2) allowed a constant pressing to demand replies and decisions from 2 of 3 hospitals involved in the mobility plans implementation and that was delaying the participation due to a complicated process of junction and restructuration of these hospitals (barrier 2.2).

Operation phase

- **Activities 5 – Political / Strategic** – The implementation of the travel plan at the Oncological Hospital of Coimbra marked the implementation of the first travel plan officially implemented in a Portuguese public hospital (driver 3.1). The social and media coverage the initiative has received, especially at the local level, has led to an increased interest in site-based travel plans, particularly on the part of the municipality, helping to make the entities more aware of the advantages of the mobility plans despite the financial crisis (barrier 3.1). The presentation of the Coimbra case at national level, namely in initiatives with IMTT, also contributed to a gradual change of mentalities.

- **Activity 6 – Involvement activities –** Great part of the activities that usually could be appointed to the mobility managers in the entities has been carried out by the SMTUC team involved in the mobility management, to avoid risks caused by the less preparation or motivation to assume these functions by some of them (barrier3.2).

D.3 Participation

D.3.1 Measure partners

- **Measure partner 1 – Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Leading role**

  SMTUC was responsible for the coordination of the activities of the measure, the work of research, knowledge acquisition, planning, and development of the travel plans. SMTUC is also an equal partner in the implementation of the plans (throughout their four year implementation period).

  Besides developing the plans and coordinating its activities, SMTUC has invested in the Hospital by placing real time information panels in the hospital lobbies, developing and introducing tailor-made travel information for hospital staff and outpatients implemented a car-pooling system for hospital employees, etc.

  The data collection regarding the evaluation was also carried out by SMTUC.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC); City; Principle participant**

  The Municipality carried out the initial State of the art study and terms of reference for the development of the different travel plans.

  Since October 2011 the Municipality has also been responsible for the dissemination of the CIVITAS MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

  PRODESO was responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

  PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

D.3.2 Stakeholders

- **Stakeholder 1 – General Public –** The general public will benefit from the implementation of the travel plans for two main reasons. The first will be due to the improvement in general mobility of the northern part of the city when all the hospitals have totally implemented the travel plans. The second major benefit results from the introduction of a new paradigm in approaching mobility issues in Coimbra, namely through mobility management techniques and methods.

- **Stakeholder 2 – Public Hospital in Coimbra** – The successful implementation of the travel plans will contribute to improving the hospital corporate image and resolve some of the severe traffic problems caused by these institutions in the Cities overall mobility.

- **Stakeholder 3 – Hospital Employees** – These professionals will be the ones who benefit the most from the travel plans since they are now aware of the different options available to them for the daily trips.

- **Stakeholder 4 – Municipality of Coimbra** – The participation in the development of Travel Plans opened up a new opportunity for the municipality to try to implement a new approach to solving its mobility problems – i.e., mobility management.

- **Stakeholder 5 – SMTUC** – The participation in the development of Travel Plans opened up a new opportunity for SMTUC to implement a new approach to solving its mobility issues and improve the PT services of the city – i.e., mobility management.

- **Stakeholder 6 – National mobility entities** – The official implementation of a travel plan in a large public institution is in the interest of national institutions, such as the Portuguese Institute for Mobility and Inland Transportation, because it allows for the incremental introduction of mobility management approaches.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **Cultural resistance to travel plans –** The resistance to travel plans results from a culture heavily focused on traffic management. The implementation of travel plans in countries with this type of culture implies intensive promotional campaigns to demonstrate the advantages of implementing mobility plans.

- **Commit stakeholders –** To achieve the desired results, the principal stakeholders must be committed with the development and implementation of the travel plans. Technical and financial issues should be perfectly explained to all the agents involved so that they know what to expect throughout the whole period of development and implementation.

- **Involve target group –** To involve people on the acceptance of the mobility management actions and avoid its indifference related to these issues it is important to have a relatively short gap between the announcement of the intentions and the beginning of the implementation. Case contrary people will have doubts about the really implementation of the plan. A good approach, that has been used in Coimbra case, could be the anticipated launch of the more simple measures (but identified as having important impact in the target group).

D.4.2 Recommendations: process

- **Communicate clearly and constantly –** The success of the travel plan depends on efficient communication activities, which involve stakeholders in every stage of the process. If people are nor informed and do not feel they are part of the process the results may not be satisfactory.

ANNEX 1: Fuel Mix Data

The next table shows the data obtained in relation to the evolution of the Share of different fuels (diesel, gasoline) in the Fuel consumption in Portugal since 2004:

Year	2004	2005	2006	2007
% Diesel	71,1%	72,2%	73,0%	74,5%
% Gasoline	28,6%	27,4%	26,6%	25,2%
% GPL	0,3%	0,3%	0,3%	0,4%

ANNEX 2: Energy Density and Conversion Factors

Energy Density				
1 litre Diesel	35,86 MJ	1 litre Diesel	0,835	kg
1 litre Gasoline	32,18 MJ	1 litre Gasoline	0,7475	kg

ANNEX 3: Load Factors in Transport

Unit: passengers per vehicle or tonnes per vehicle

Load factors (road)	Car (passengers)	Bus (passengers)	LDV (tonnes)	HDV (tonnes)
Austria	1.48	30.0	0.30	9.8
Belgium	1.46	11.6	0.30	5.0
Denmark	1.86	20.0	0.30	8.9
Finland	1.40	12.9	0.30	6.2
France	1.86	18.5	0.30	4.6
Germany	1.44	18.5	0.30	4.6
Greece	1.98	10.7	0.30	7.4
Ireland	1.71	8.5	0.30	7.3
Italy	1.88	16.9	0.30	5.5
Luxembourg	1.60	17.7	0.30	6.8
Netherlands	1.63	22.2	0.30	7.5
Norway	1.81	11.3	0.30	5.6
Portugal	2.46	27.7	0.30	3.9
Spain	2.02	25.2	0.30	5.6
Sweden	1.64	13.2	0.30	4.7
Switzerland	1.67	18.7	0.30	5.6
UK	1.66	8.9	0.30	6.9
Total	**1.74**	**17.2**	**0.30**	**5.62**

Source: Infras, 2000.

ANNEX 4: Emission Factors

Table 4-18: Bulk emission factors (g/kg fuel) for Portugal, year 2005.

Category	Portugal					
	CO	NO_x	NMVOC	CH_4	PM	CO_2 [kg/kg fuel]
Gasoline PC	61.56	9.18	8.50	0.71	0.03	3.18
Diesel PC	3.20	11.28	0.57	0.04	0.72	3.14
Gasoline LDV						
Diesel LDV	9.39	17.91	1.72	0.11	2.05	3.14
Diesel HDV	7.14	34.09	1.14	0.24	1.04	3.14
Buses	11.88	40.75	4.18	0.31	1.85	3.14
Mopeds	403.89	3.62	360.25	6.55	6.32	3.18
Motorcycles	590.71	5.89	128.94	4.57	2.80	3.18

ANNEX 5: Calculus

GENERAL DATA			
1. Average number of trips per day	3,5	Year 2007 - Details : Annex 1	
2. Average distance per passenger (km)	3,563	Fuel Mix - Gasoline	25% FMG
3. Working days per year	240	Fuel Mix - Diesel	74% FMD
4. Calorific Power Gasoline (MJ/l)	32,18		
5. Calorific Power Diesel (MJ/l)	35,86		

	Notes	Scenario		Ex-Ante	BAU	EX-Post
A BUS (SMTUC) Baseline - 13,8%	A1	Average Consumption (l/100km)	-	50,5	50,5	50,5
	B1	Workers (per day)	-	129	215	267
	C1	Passengers per year	C1 = 1. x 3. x B1	108.269	180.914	224.500
	D1	Load Factor (passengers per vehicle)	-	**16,4**	**16,4**	**16,4**
	E1	Passenger. km (p.km)	E1 = C1 x 2.	385.763	644.596	799.895
	F1	Distance (km)	F1 = E/D	23.522	39.305	48.774
	G1	Consumption per year (litres)	G1 = A x F1 / 100	11.879	19.849	24.631
	H1	Energy Consumption (MJ)	H1 = G x 4.	425.970	711.779	883.264
B PRIVATE CAR Baseline - 63,3%	A2	Average Consumption (l/100km)	-	9,2	9,2	9,2
	B2	Workers (per day)	-	591	505	453
	C2	Passengers per year	C2 = 1. x 3. x B2	496.626	423.982	380.395
	D2	Load Factor (passengers per vehicle)	-	**1,3**	**1,3**	**1,3**
	E2	Passenger. km (p.km)	E2 = C2 x 2.	1.769.480	1.510.648	1.355.349
	F2	Distance (km)	F2 = E2/D2	1.361.139	1.162.037	1.042.576
	G2	Consumption per year (litres)	G2 = A2 x F2 / 100	124.544	106.326	95.396
	H2	Energy Consumption (MJ)	H2 = G2 x (4.xFMG + 5.xFMD	4.334.359	3.700.347	3.319.940
TOTAL (A+B) BUS + PRIVATE CAR	B3	Workers (per day)	B3 = B1+B2	720	720	720
	C3	Passengers per year	C3 = C1+C2	2069	1767	1585
	E3	Passenger. km (p.km)	E3 = E1 + E2	1769480	1510648	1355349
	F3	Distance (km)	F3 = F1 + F2	1.361.139	1.162.037	1.042.576
	G3	Consumption per year (litres)	G3 = G1 + G2	124.544	106.326	95.396
	H3	Energy Consumption (MJ)	H3 = H1 + H2	4.334.359	3.700.347	3.319.940
		Consumption (MJ/pkm)		**2,21**	**2,05**	**1,95**

MODAL SPLIT CALCULUS

	Scenario	Ex-Ante	BAU	EX-Post
Passengers.km	Total Passengers.km	2.347.744	2.347.744	2.347.744
	BUS SMTUC	385.763	644.596	799.895
	Private Car	1.769.480	1.510.648	1.355.349
	Other modes	192.501	192.501	192.501
Modal split passengers.km	Total Passengers			
	BUS SMTUC	16,4%	27,5%	34,1%
	Private Car	75,4%	64,3%	57,7%
	Other modes	8,2%	8,2%	8,2%

ANNEX 6: Structure and questions of the IPOC Hospital Workers Survey

As agreed with the IPOC hospital administration the universe of the surveys has been all the 934 workers of the hospital since has been considered not recommended to select specific workers due the characteristic of some functions. The hospital didn't want to select and oblige appointed workers to fill the survey. The survey has been distributed to all workers by hospital intranet and during 2 days mobility coordinator and measure leader attended the hospital to provide explanation and ask to questions.

1st SURVEY - 7 – 22 July 2011

This first survey was made before the implementation of the measure and the main objective was to evaluate the mobility of their workers before the implementation of the measure.

The survey is structured in two mains sections. The section A includes 9 questions related with personal data of the worker , namely the questions related to the residence local, sex, age (<25, 25-34, 35-44, 45-55, >55), function/category, health problem or physique constraint that condition the choice of displacement to the work and what kind of constraint, working timetable, day of the week that usually work and timetable period of the day.

The section B includes 5 questions concerning the characteristics of the trips to work mainly the distance, the time of the voyage, the transport mode, the number of transfer and reasons of use the private car in the home-work trips.

SECCTION A – PERSONAL DATA
A1. Local of residence
A2. Sex
A3. Age (<25, 25-34, 35-44, 45-55, >55)
A4. Function /Category (leader , doctor, technician, nurse, diagnostic an therapeutic, technical assistant, operational assistant, other)
A5. Health problem or physique constraint that condition the choice of trip to the work (Yes / No)
A6. Type of handicap (blind, reduce mobility, other)
A7. Working time table (full time, part – time, flexible timetable, fix timetable, working shifts, weekend, nights)
A8. Working days of the week (Monday, Thursday, Wednesday, Tuesday, Friday , Saturday, Sunday)
A9. Normal working timetable (from /to)
SECTION B – TRIP TO WORK
B10. Distance to go to work (till 1 km, 1-2 km, 2-4 km, 4- 10 km , more than 10 km)
B11. Actually time of trip to go to work in minutes (0-15, 16-30, 31-45, 46-60, more than 60)
B12. Usual mode of transport to go to work (private car conductor, passenger private car, bicycle, walking, taxi, bus, train, motorcycle, other)

B13. Number of transfer
B14. Reasons of use the private car in the home-work trips (satisfied, and with no reason to change my behaviour, like to reduce the use of the private car but at the moment it is not possible, thinking in change some of the trips to others transport modes but at the moment don't know how to do it, seriously thinking in change some of the trips to others transport modes and knowing the alternatives to use but not yet change) Already use others transport mode in all / some of the home – work trips

Regarding the questionnaires, the gender is divided into 14,5% of men and 85,5% of women.

In terms of demographics, the main results have been achieved in the age intervals of 25-34 and 35-44 with results of 27,7% and 36,1%, respectively. Under 25 years of age, only 3% have responded affirmatively. In the other intervals, the results obtained are near 20% for the 45-55 and over 10% for the >55.

Concerning respondents occupation, the assistant technician (15.6%) and the technical operational (22.5%) categories provided over 35% of all the answers. On the other hand, the results of the senior technicians and doctors were the lowest of all, registering under 10%. In the other categories the results shows around 10% of the responses, namely the nurses (14.4%) and lab technician staff (8%). The leadership categorie registered the smallest contribution with only 4%.

2nd SURVEY - 10 – 20 Set 2012

The second survey was also addressed to the workers of the IPOC hospital and the main objective was to evaluate the Mobility Plan and the mobility behaviour of their workers.

The survey was equal to the first survey, to allow comparison of data. Only has been added some specific questions to assess the modal shift between the 2 stages (ex-ante – ex-post) and the reasons for these changes (allowing also the assess to the BAU values and the sequent impacts of the measure).

The survey was also structured in two main sections, like the first survey.

The section A includes the same 9 questions related with personal data of the worker , namely the questions related to the residence local, sex, age (<25, 25-34, 35-44, 45-55, >55), function/category, health problem or physique constraint that condition the choice of displacement to the work and what kind of constraint, working timetable, day of the week that usually work and timetable period of the day.

The section B includes 8 questions concerning the characteristics of the displacement to work mainly the distance, the time of the voyage, the transport mode, the number of transfer, if using private car share with another passenger, if after July 2011 had change the mode of transport and what was the mode used.

The last two questions of this section are related with the measures implemented in the SanusMobilis Mobility Plan and with the reasons of using the private car in the home – work trips.

SECTION A – PERSONAL DATA
A1. Local of residence
A2. Sex
A3. Age (<25, 25-34, 35-44, 45-55, >55)
A4. Function /Category (leader , doctor, technician, nurse, diagnostic a therapeutic, technical assistant, operational assistant, other)
A5. Health problem or physique constraint that condition the choice of trip to the work (Yes / No)
A6. Type of handicap (blind, reduce mobility, other)
A7. Working time table (full time, part – time, flexible timetable, fix timetable, working shifts, weekend, nights)
A8. Working days of the week (Monday, Thursday, Wednesday, Tuesday, Friday , Saturday, Sunday)
A9. Normal working timetable (from /to)
SECCTION B – TRIP TO WORK
B10. Distance to go to work (till 1 km, 1-2 km, 2-4 km, 4- 10 km , more than 10 km)
B11. Actually time of trip to go to work in minutes (0-15, 16-30, 31-45, 46-60, more than 60)
B12. Usual mode of transport to go to work (private car conductor, passenger private car, bicycle, walking, taxi, bus, train, motorcycle, other)
B13. Number of transfer
B14. Share of private car (Yes/ No)
B15. Mode of transport used till July 2011 if changed after that date (driving private car alone, driving private car with an occupant, private car passenger, bicycle, walking, taxi, bus, train, motorcycle, other)
B16. Measures of the SanusMobilis Plan that had influence in the change of the used transport mode (installation in hospital of the public transport real time information, improve of quality of the public transport, development of carpooling programme to the workers, signature of the discount protocol in the park & ride services to the collaborators, campaigns of public transport promotion and other alternative modes of sustainable mobility, support of the mobility management, other actions))
B17. Reasons of use the private car in the home-work trips (satisfied, and with no reason to change my behaviour, like to reduce the use of the private car but at the moment it is not possible, thinking in change some of the trips to other transport modes but at the moment don't know how to do it, seriously thinking in change some of the trips to others transport modes and knowing the alternatives to use but not yet change). Already use others transport mode in all / some of the home – work trips

Regarding the questionnaires, the gender is divided into 41% of men and 59% of women.

In terms of demographics, the main results have been achieved in the age intervals of 35-44 and 45-55 with results of 31% and 30%, respectively. Under 25 years of age, only 4% have responded affirmatively. In the other intervals, the results obtained are near 20%.

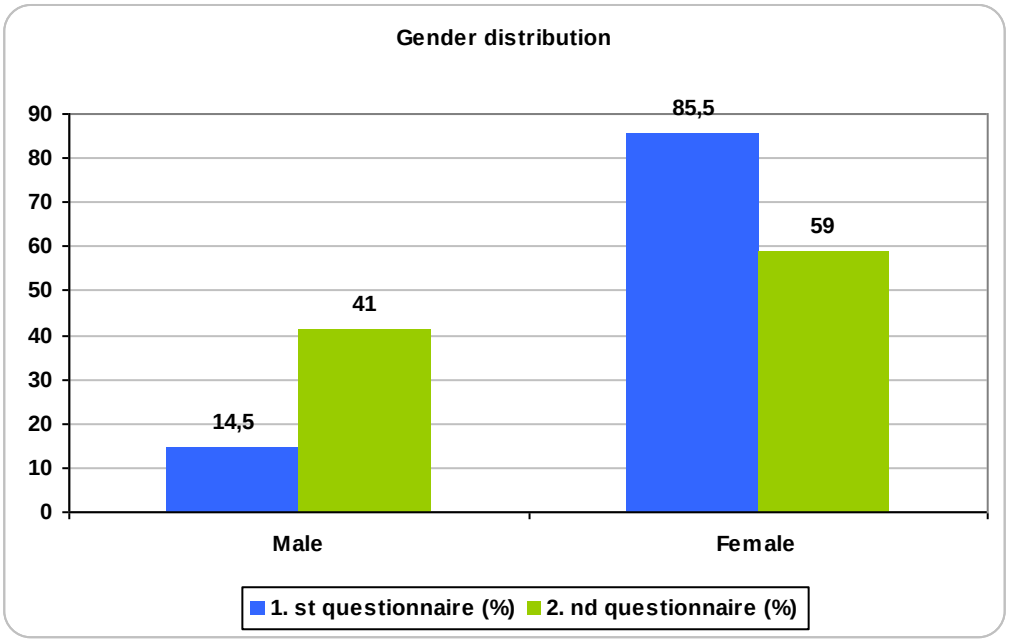
Concerning respondents occupation, the assistant technician and the technical operational categories provided 25% and 20% of the answers. On the other hand, the results of the senior technicians and doctors were the lowest of all, registering under 10%. In the other categories the results shows around 10% of the responses, namely the nurses and lab technician staff.

SURVEYS CAMPARISON

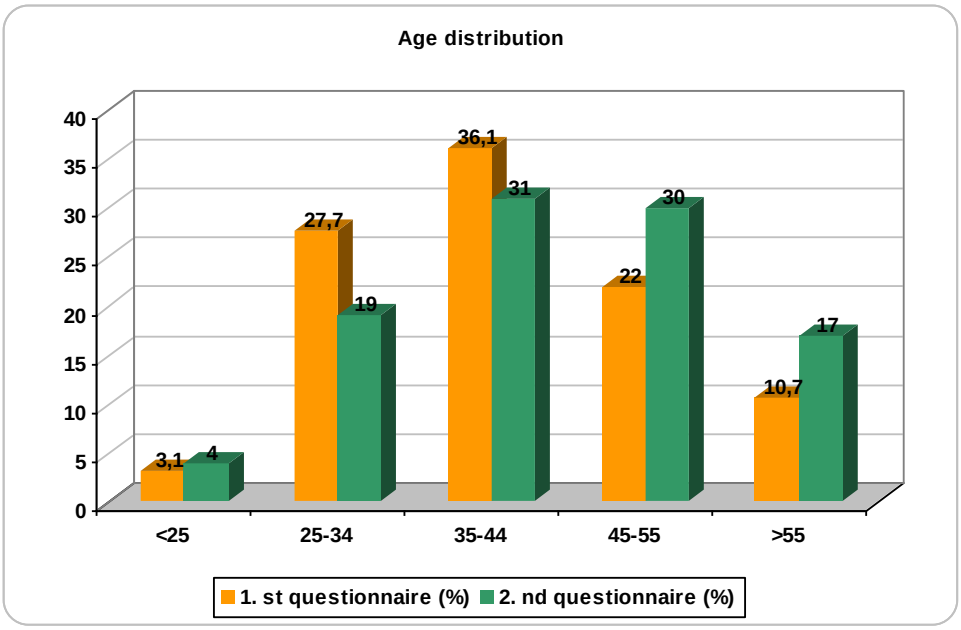
The first survey had 159 respondents and the second survey had also the universe of the IPOC hospital workers but only with 54 respondents.

The reason for the decrease in the respondents has been the complicated period that IPOC workers carried out together with the remaining Portuguese population due the financial crisis. Some austerity measure involving the health sector has been proclaimed and people were more concerned with their personal problems than with the mobility issues.

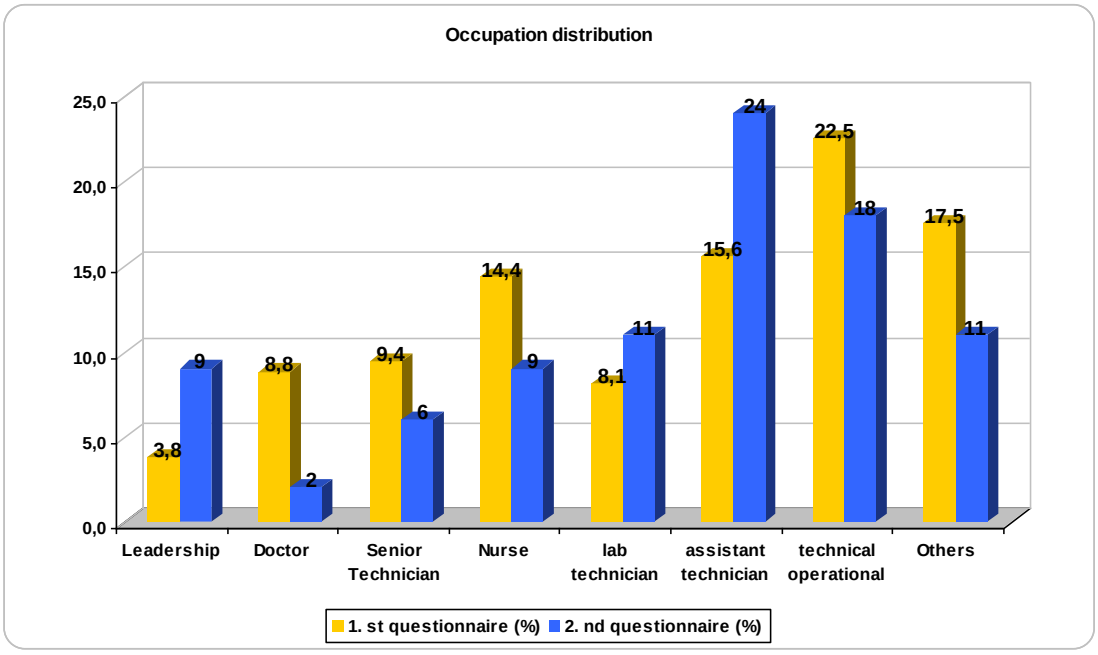
Regarding the gender distribution, highlight for increase with over 20% male, in the responses from first to the second questionnaire. On the other and, the results for the female responses decreased over 25%. Thus, in the second survey there was a more balanced distribution of answers.



Concerning the age distribution, the level of respondents was very similar, with only minor variations in the age group of 25-34 and 45-55, with more than 8% variation between surveys. Meanwhile, in the age groups of 35-44 and < 55 the variation was about 5% and finally at the age group of >25 it registered the smallest variation. So, this characteristic has not registered a significant variation between the two surveys.



In terms of occupation, it has been registered a response enlargement in the leadership class and the assistant technician with over 5% and 95, respectively. In the other groups there was a slight decrease in the responses of about 4%, highlighting the doctor groups with 6% decrease.



M05.07 – Executive summary

The measure consists of the implementation of a Driving Centre at the Municipal Public Transportation Services of Coimbra (SMTUC) equipped with a high tech driving simulator tailored to the specific public transport vehicle requirements and in accordance with the European Directive 2003/59 - which establishes continuous driver education (35 hours every 5 years).

The Driving Centre has been implemented in new and dedicated facilities at the SMTUC installations and the simulator has been purchased through an international public tender with the following specific features:

- Real and dynamic cabin that reacts to the driving and movement conditions, three external film screens permitting "all around simulation" and a complete trainee monitoring system with external control and intervention capabilities.
- Virtual reproduction of real driving conditions with high quality graphics, including the simulation of trolleybuses and the possibility of changing traffic and environmental conditions at any time by the trainer, as well as the creation of unexpected occurrences.
- Simulation of the interaction with the passengers, including the passenger entry and their behaviour in the buses during the journey.
- Data storage of driver/trainee performances, including drivers' behaviour and virtual fuel consumption, as well as .pre-programmed lessons or the possibility to program and record new lessons.

A reference group of 25 SMTUC drivers has been set up and trained using the simulator in order to have time to evaluate the impacts of the driving training sessions. As key results it has been obtained that:

- The training using driving simulators led to a 15% reduction in the average operating costs when compared with the training using real buses (from 3,41 €/vkm to 2,90 €/vkm).
- During the driving training sessions using the simulator, a substantial improvement of the average fuel efficiency in mixed circuit was observed, corresponding to a 15% reduction in terms of energy consumption per vkm.
- Using a driving training simulator instead of diesel vehicles in real operational conditions has a significant impact on the average emissions per vkm (-19% of CO2, -85% of NOx and -93% of CO).
- The driving training simulator can help improve transport safety in terms of accident risk. By considering the same circuit and travelling distance covered during two driving sessions in the simulator made respectively before and after the training resulted to have a 33% reduction of the total number of incidents.

The functioning of the Driving Centre will continue in the future. A process of licensing the driving centre for the training of PT drivers from other companies is in course and partnerships with some specialised organisations are presently under consideration.

Due to the lower cost that the driver training would have and the increase in available resources (buses not used for training) that the simulator allows for, a significant raise in the number of training courses and trainees is expected to happen. The European Directive 2003/59 seems also to be a good driver to increase the driving training activity. There would be fuel savings, pollution reduction, increase of safety, and higher levels of diving quality which would increase passenger comfort.

A Introduction

A1 Objectives

The measure objectives are:

(P) High level / longer term:

- To increase the safety in city and regional transports
- To reduce the fuel expenditures linked to transportation in the city and region
- To improve the air quality in the city and region

(Q) Strategic level:

- To improve the quantity and quality of the training of heavy duty vehicles drivers at municipal and regional level (both for PT and freight transport).

(R) Measure level:

(1) To implement a training centre for heavy duty vehicles drivers, equipped with a dynamic driving simulator, that could allow reduce both the accidents rate (at least 5% in SMTUC drivers), as the fuel expenditures (at least 3% in the SMTUC fleet);

(2) To improve 10% the driving training sessions;.

(3) To perform at least 500 training actions during CIVITAS;

(4) To improve the cooperation between SMTUC and others fleet operators (PT operators, Municipality, Driving Schools, etc.).

A2 Description

The measure consists of the implementation of a Driving Centre at the Municipal Public Transportation Services of Coimbra (SMTUC) equipped with a high tech driving simulator tailored to the specificities of public transport vehicles and in accordance with the European Directive 2003/59 - which establishes continuous driver education (35 hours every 5 years) and recommended the use of driving simulators for this effect.

Due the technical complexity of the driving simulator, namely its technical innovation, special attention has been given to the models conception and the definition of technical specifications of the driving simulator as well as to the design of the Driving Centre.

The Driving Centre has been implemented in new and dedicated facilities at the SMTUC installations and the simulator was purchased in an international public tender with the following specific features:,

- Real, dynamic cabin, three external film screens permitting “all around simulation” and a complete trainee monitoring system with external control and intervention capabilities.
- Real dimensions and customisation of the cockpit.
- Real time dynamic cockpit reaction to the driving and movement conditions.
- Virtual reproduction of real driving conditions with high quality graphics, including the simulation of trolleybuses.

- Simulation of the interaction with the passengers, including the passenger entry and their behaviour in the buses during the journey.
- Possibility of changing traffic and environmental conditions at any time by the trainer.
- Simulation of unexpected occurrences.
- Data storage of driver / trainee performances, including drivers' behaviour and virtual fuel consumption.
- Pre-programmed lessons for the initial training of new drivers or continuous training for the others (recycling courses) or the possibility to program and record new lessons.

However, the lack of funding from the Portuguese government for the driving simulator purchase obliged SMTUC to carry out a long administrative process to assure self-financing through a loan contract. This process delayed the measure implementation obliging to use recovery actions. So, taking into consideration that the training in the driving simulator is being assured by SMTUC trainers, they have been previously trained in the simulators of the driving centre of EMT (Transport Enterprise of Madrid), allowing them to be prepared for the start-up of the new simulator.

Also a reference group of 25 of the 280 SMTUC drivers was set up to have the time to evaluate the impacts of the driving training sessions that began on 26th June 2012. This methodology allowed for more intensive training sessions in the driving simulator and assess the drivers' behaviour modifications in a shorter time span. Other training sessions in the simulator occurred during the measure operation in a total of 262 until November 2012.

In addition, promotional campaigns directed to other fleet operators have been carried out to enlarge the target group of drivers that can benefit from safety and eco-driving training. Several news items were published in newspapers, magazines and websites, as well as several visits were conducted to the driving simulator, with emphasis being given to the Study Tour co-organised with VANGUARD.

The visit made by ANTROP (the Portuguese Association of Public Transport Operators), with the objective of establishing a partnerships for the large scale training of other companies and institutions has been also very important.

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **Innovative aspect 1 – Use of new technology/ITS**
  - There is no driver simulator available in the Centre Region of Portugal, of which Coimbra is the capital, and the 2 simulators existing in Portugal (Lisbon and Porto) are not targeted to passenger transportation because they don't simulate passenger interaction. Also important is the innovation at the international level with the simulation of trolleybuses driving.
  - Increase of the driver training hours in bus driving of public transport, decreasing the energy consumption and the number of accidents.
  - Quicker and better training monitoring due to the fact that the corrections can be more efficiently pointed out to the trainees.
  - Advantage given by the possibility to simulate unpredictable or emergency situations that aren't possible to realize unless using a simulator.
- **Innovative aspect 2 – Targeting specific user groups**
  - We consider that this is the best way to stimulate the continuous education of professional drivers of large vehicles, extendable to private fleet drivers, namely the younger ones that are satisfied with new technologies.

B2 Research and Technology Development

The research and technology development consisted mainly by the following:

- Online and literature research for the state-of-the-art on driving simulators technologies and functionalities with the objective of defining the simulator specifications.
- Development of a state-of-the-art driving simulator with real dynamic reactions in the driver's cockpit and "all around" simulation of the scenario and simulated objects.
- Simulation of the interaction with the passengers, including their reactions to the driving conditions.
- Innovative simulation of graphics and physical level of trolleybuses driving, including the model conception of streets with trolleybus feed lines.

The driving simulator allows for organising training sessions tailored to the specific need of public transportation. These training sessions permit public transportation professionals to respond more resourcefully to real life situations. Some of the specificities that the simulator provide are: different atmospheric conditions; types of roads; traffic levels; 180º visual field with streets, buildings, sign posts; environmental and interior sounds; driving and accident/failure simulation; etc.

From an operational point of view the simulator has numerous aptitudes and functions such as the faithful reproduction of environmental conditions, as well as the simulation of different bus models and existing trolleybuses. This is possible due to the quick and straightforward exchange of real bus components (e.g., instrument panel, steering wheel, pedals), which gives SMTUC the possibility of providing training to drivers from other companies and which use other models.

The new simulator offers a real qualitative enhancement to the level of instruction provided to public transportation drivers because it allows for safely simulating risk situations – for instance, adverse weather or traffic conditions. It also increases the teaching flexibility since SMTUC is no longer reliant on available vehicles or external conditions for organising training sessions. Also, the new training centre allows for establishing an evaluation process cased on objective and measureable criteria.

Using the simulator to carry out the driver training also offers SMTUC greater leverage in controlling fuel consumption. Moreover, the use of the simulator allows for reproducing extreme scenarios (e.g., accidents and break downs) without putting the trainees in jeopardy.

The trainees' evolution can be assessed throughout the multiple sessions due to the automatic production of reports which are indexed to the different drivers. Some of the indicators whose progression can be monitored are fuel and brakes consumption and number of accidents / incidents.

This type of training can contribute to an effective reduction of traffic accidents and a real cutback in fuel consumption in the SMTUC bus fleet, leading to significant fiscal savings and improved environmental conditions.

Despite the authenticity of the simulation experience, the only drawback is the fact that it can never replicate exactly all the features of real life driving. In effect, the absence of any real peril and consequences can undermine the training, leading to indifference and a nonchalant attitude to the risk, especially when trainees are not reminded of the need to act as if they were in real life settings.

However, even though this seems to be a disadvantage, the absence of risk and the requirement of an initial period of adaptation to the simulated environment – the first session should not exceed three minutes in order to avoid nausea and a subsequent trainee negative response – it can be considered that the adaptation to driving in real conditions would be much longer. Therefore, simulator training can lead to quicker results than training in real life conditions, especially in the case of more inexperienced drivers.

The advantages and disadvantages can be summarised as:

- Advantages:
  - Savings in energy consumption and reduction in emissions due to the fact the training sessions are conducted in a simulator rather than a real vehicle;
  - Training sessions are not reliant on the availability of vehicles, nor imply their stoppage;
  - Greater quality of the training provided due to the fact that it is possible to simulate different driving conditions instantaneously (weather conditions, traffic level, driver aggressiveness, passenger volume and behaviour, bus failures, etc.), as well as the consultation of automatic reports on the trainees performance (road accidents, passenger accidents, fuel consumption, breakage, etc.);
  - Improved trainnee evaluation due to the above factors related to the training reports;
  - Contribution to the increase in the driving training quality and quantity resulting in a reduction in road accidents and pollution levels;

- Allows for training sessions for begginers without having the risks inherent in real driving sessions.

- Disadvantages:
  - Driving in simulated settings is never an authentic reproduction of real life conditions;
  - Simulator training requires an initial period of adaptation.

B3 Situation before CIVITAS

In Coimbra, the training of the public transport drivers of the different companies was mainly constituted by initial training, concerning bus brands and specifications and the network and routes, essentially those existing in the urban area.

There was little continuous training and the one occurring is conducted involving the driving of real buses (the major part of the other professional drivers of large motor vehicles do not have continuous education).

Therefore there was need to provide continuous education for professional drivers. The education given so far had high costs because it involved the use of a vehicle that it is, during training periods, unavailable for public service. This also implies fuel consumption and human resource costs, not only in the practical courses but also in the attribution of vehicles for that purpose. There is also the aspect of pollution involved in using real buses.

Generally there is a lack of good professionals among the driver population for recruiting for training.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Model's conception and definition of technical specifications for the driving simulator *(October 2009 – February 2010) – Knowledge acquisition on training centres for heavy vehicle drivers and driving simulators, including technical visits to Driving Centres equipped with advanced simulators similar to the desired by SMTUC (Porto and Madrid) .*

Conceptualization of the model envisioned for the SMTUC Driving Centre, including the spatial distribution and organization, and the simulator technical specifications that also includes a description of the formative capabilities of the simulator and the requirements for its installation (Fig. B1). The simulator should allow the instructors to plan and manage the various types of exercises, namely defining the initial vehicle conditions, environmental conditions, program line, traffic conditions, and different incidents throughout the exercise. Equally it should provide adequate vehicle simulation behaviour, in accordance with the parameters selected by the instructor in the edition mode, including the boarding and exiting of passengers, as well as their reactions to the different driving conditions. The simulation of driving a trolleybus is one of the innovative aspects that was assumed in the technical specifications of the simulator despite this additional feature was not included in the original work-plan.

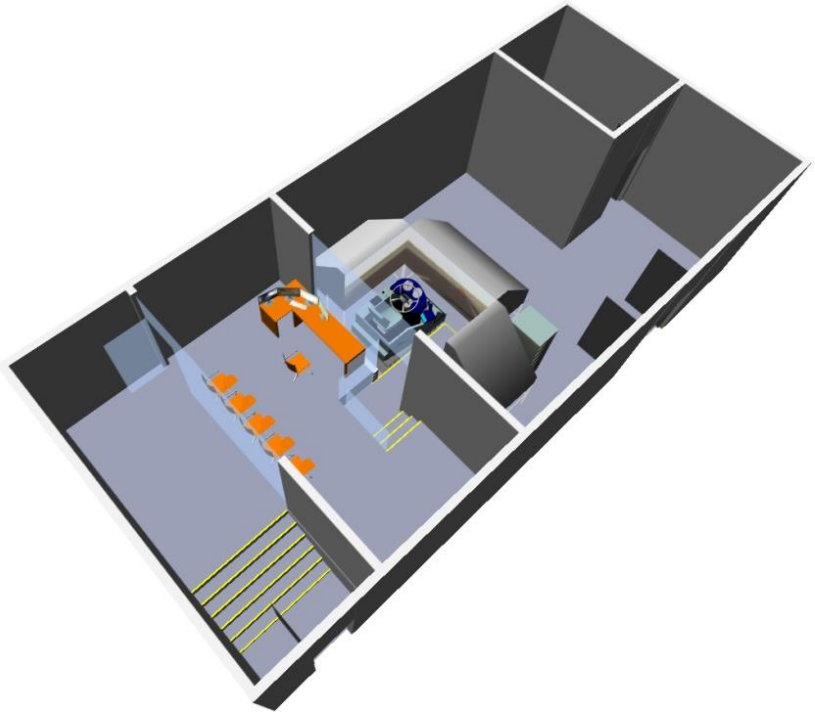


Fig. B.1 - Design of the Driving Centre – Building for the driving simulator installation

Release of the technical specifications and the preliminary version of the tender documents at internal level, including the driving centre facility.

Stage 2: Simulator's purchase and installation process *(November 2009 – June 2012) – Despite the first positive informal contacts with the Portuguese Institute for Mobility and Inland Transport (IMTT) since July 2007, for demanding the national co-financing for the purchase of the driving simulator, it was during the end of 2009 that several working meetings with the Chairman of the IMTT took place to point out the importance of installing this equipment in Coimbra (in the centre of the country). Due to a change of opinion concerning national financing, these initiatives and others during 2010 had no positive results, reason for which the Municipality and SMTUC opted for establishing a loan contract to cover the remaining part of the simulator financing not supported by CIVITAS.*

The loan process had the following phases: The adjudication took place on 14th June 2010 and the validation by the Municipal Assembly on 29th June. The loan contract was signed on 9th August 2010. The validation of the loan contract by the National Court of Accounting was foreseen until 28th October 2010 (or 15 days afterwards if the Court demand any additional explanations). Without any valid explanation the validation only took place in the end of December 2010.

SMTUC and the Municipality sped up the process to release the final version of the tender process for the purchase and installation of the driving simulator, demanding in the specifications that the installation should be divided into 2 phase;, the first allowing for the start of the driving training 4 month after the beginning of the installation (October 2011), the 2nd phase foresaw the development of the simulation of trolleybus driving.

Procedure authorization by the SMTUC Board of Directors for the simulator purchase occurred in 25th February 2011.

During this period the market research and architectural project for the building of the Training Centre took place., It had been decided to install the simulator in a new building instead of adapting an already existing facility. This building has been a soft construction (pre-building pavilion) with the design already defined. In June 2011 the first pavilion of the Training Centre was concluded (the facility for the theoretical training) and the works for the installation of the pavilion for the driving simulator began.

An excessively long period between the adjudication of the driving simulator purchase (21st June 2011) and the contract signature (11th October 2011) resulted from administrative reasons, producing a new delay, aggravated by the fact that the validation of the purchase procedure by the National Court of Accounts only took place on 10th January 2012.

At this date the process of development and construction of the driving simulator began.

Additionally, to speed up the installation process and have more time available for evaluation, the division of the implementation process in 2 phases was demanded: the first allowing for the start of the driving training 4 month after the beginning of the installation; , the 2nd for the development of the trolleybuses driving simulation tool.

The development of the driving simulator for standard buses and the installation of the main pavilion for the driving centre finished on May 2012. Subsequently the process of the driving simulator installation began.

During the 3rd week of June 2012 the installation of the driving simulator and the tests of the equipment were concluded (Fig. B3).

Fig. B3 – Driving simulator tests at SMTUC site

Stage 3: Training of the trainers and technical personnel *(October 2011 – June 2012) – The initial training for trainers and technical personnel took place on 11th October 2011 with*

the theoretical presentation of the simulator and its functionalities, with special attention given to the aspects related to the planning of the training sessions.

Another theoretical session took place on 3rd November and one practical session using a similar driving simulator took place in Spain (EMT - Transportation Enterprise of Madrid) from 28th to 30th November. So, with respect to the original schedule, this activity was anticipated and carried out in parallel with the implementation phase. The training in EMT included the measure leader and technical personnel of the training centre that also had a 1 day meeting to visit the supplier site and see the progress of the simulator development, as well as to plan the following activities, including recovery actions. New training sessions for the trainers and technical personnel were carried out in June 2012.

Stage 4: Training of the public transport drivers *(July 2011 – February 2013) – Taking into consideration that an important objective for the implementation in Coimbra of a Training Centre devoted to PT is to apply European Directive 2003/59, and that SMTUC has drivers subject to this law since mid-2011, when the driver simulator wasn't yet operational, a different planning was considered. It was decided that a complete set of training sessions according to the directive (35 hours) involving 5 SMTUC drivers on July 2011 and 15 on November 2011 was to be provided by an external company.*

But the training in the SMTUC driving simulator began on 26th June 2012.

A reference group of 25 of the 280 SMTUC drivers was set up to have the time to evaluate the impacts of the driving training sessions. This methodology allowed for having more intensive training sessions in the driving simulator and assess the drivers' behaviour modifications in a shorter time span.

In this matter, the driving training activities in the simulator consisted in two different tests, conducted in July and repeated in September 2012. The first test was performed in a mixed circuit, with negligible traffic in order to promote the adaptation of the drivers to the driving simulator and to the first concepts of eco-driving. The second test was performed in an urban circuit with traffic, with the main objective of introducing the drivers to the principles of defensive driving.

An assessment was made by comparing the results achieved in the first set of the 2 tests, with the results achieved by the drivers in the second set of the same 2 tests, which gives an overview of the progress and results achieved by the reference group of drivers.

Stage 5: Promotion towards potential users *(October 2011 – February 2013) – A first set of promotional actions has been launched with the contract signature in October 2011, namely through a press release and technical information sent to all Portuguese media and several stakeholders.*

After the installation of the driving simulator a public presentation was made in June 2012 with media coverage. Also during the European Mobility Week the Mayor of Coimbra visited the Driving Centre and other visits have been carried out, with emphasis on the Study Tour co-organised with VANGUARD.

The visit made by ANTROP, the Portuguese Association of Public Transport Operators, with the objective of establishing of partnerships for the large scale training of other entities, has been also very important.

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

- **Measure no. 01.03 - Alternative fuels in Coimbra** – Alternative fuels in Coimbra could be related with measure 05.07, given the eco-driving dimension of the new Safety Oriented Driving Training, so it also has the potential to generate impacts on SMTUC fuel consumption and, therefore, on SMTUC emissions. Thus, measures 01.03 and 05.07 could be identified as a group of measures. However, while measure 05.07 is focused on every SMTUC drivers, measure 01.03, during CIVITAS period, it is only focused on a small part of SMTUC bus fleet. Therefore, the effects of the implementation of these measures will be easily separated from each other (this is why these measures were also not identified as a bundling of measures for impact evaluation purpose, although they have a strong interrelationship).

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1: Indicators.

No.	Impact	Indicator	Data used	Comments
1	Operating Costs	Average Operating Costs	Total operating costs incurred by SMTUC driving training system; Total vehicle-km	SMTUC Data
2	Costs	Capital Costs	Total capital costs expended in setting up the measure	SMTUC Data
3	Fuel consumption	Vehicle fuel efficiency – Training Effect	Energy consumed by the driving training buses and simulator system; Total vehicle-km	SMTUC Data
4	Fuel consumption	Vehicle fuel efficiency – Eco-driving Effect	Energy consumed by the virtual buses during the driving simulator training sessions; Total vehicle-km	SMTUC Data
5	Quality of Service	Driving Service Quality	Driving service quality Index	SMTUC Data
6	Transport Safety	Accident Risk	Total number of recorded transport injury accidents and casualties; total vehicle-km	SMTUC Data
7	Emissions	CO Emissions	Fuel/Electricity consumption; Type of buses; Vehicle-km;	SMTUC Data EMEP/European Environment Agency (EEA)
8	Emissions	CO_2 Emissions	Fuel/Electricity consumption; Type of buses; Vehicle-km;	SMTUC Data EMEP/European Environment Agency (EEA)
9	Emissions	NOx Emissions	Fuel/Electricity consumption; Type of buses; Vehicle-km;	SMTUC Data EMEP/European Environment Agency (EEA)
10	Emissions	Small Particulate Emissions	Fuel/Electricity consumption; Type of buses; Vehicle-km;	SMTUC Data EMEP/European Environment Agency (EEA)
11	Awareness	Awareness level –	Total number of	SMTUC Data

		drivers	drivers with knowledge of the measure; Total number of respondents	
12	Acceptance	Acceptance level – drivers	Total number of drivers who favourably receive the measure; Total number of respondents	SMTUC Data

A lack of funding from the Portuguese government for the driving simulator purchase delayed the measure implementation because a long administrative process occurred to assure alternative funds. A reference group of 25 of the 280 SMTUC drivers was set up to have the time to evaluate the impacts of the driving training sessions that began on 26th June 2012. This methodology allowed to for more intensive training sessions in the driving simulator and to assess the drivers' behaviour modifications in a shorter time period.

Has been selected 25 drivers to represent almost 10% of the entire SMTUC drivers and to allow providing each set of driving sessions during a week (each daily session has been attended by 5 drivers – the recommended number to participate in the driving training at the same time).

The driving selection has been based in the average number of accidents per driver during 2011 for the total of SMTUC driver (288/280=1,03) and for the reference group (26/25=1,04). Also the average age of the group has been balanced with the total average age (43,3 years in 2011).

So, it must be referred that for some of the indicators mentioned above (3 to 10), the evaluation methodology was mostly based on the assessment of the results achieved by this reference group of 25 SMTUC drivers, as a result of the driving training activities conducted in the simulator.

In this matter, the driving training activities in the simulator consisted in two different tests, conducted in July and repeated in September 2012. The first test was performed in a mixed circuit, with negligible traffic in order to promote the adaptation of the drivers to the driving simulator and to the first concepts of eco-driving. The second test was performed in an urban circuit with traffic, with the main objective of introduction the drivers to defensive driving principles.

The assessment was made by comparing the results achieved in the first set of the 2 tests, with the results achieved by the drivers in the second set of the same 2 tests, which gives an overview of the progress and results achieved by the reference group of drivers during the 100 training sessions carried out in 2 months.

Detailed description of the indicator methodologies:

- **Indicator 1** (*Average Operating Costs*) – Ratio of total operating costs incurred by the SMTUC driving training sessions, divided by the total vehicle-km performed during the driving training sessions (€/vehicle-km).

  A = B / C, where:

  - ✓ A = Average operational costs of the driving training sessions (€/vehicle-km)
  - ✓ B = Total operational costs of the SMTUC driving training session, including fuel/energy costs directly related to the implementation of the driving training sessions, both in buses and simulator system, human and hardware maintenance costs, personnel costs necessary to the operation of the driving training sessions, all expressed in €.

- ✓ C = Total vehicle-km performed during the driving training sessions (vkm).

The collected data is related to the SMTUC driving training system and to the buses allocated to driving training activities. Results of vehicle-kilometres, vehicle and simulator training activities, have origin in SMTUC records and on driving training system software report. The data reliability is maximised due to an objective data collection among SMTUC records on performed trips on training activities, which in turn are recorded following reliable procedures and due to an objective data collection on the simulator reporting system.

- **Indicator 2** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

Expenditures with the purchase and installation of the necessary equipment and software for the SMTUC driving training system (including the financing costs, i.e., interests paid due to the loan contracted to the purchase of the simulator) and with the preparation of the facilities where the simulator driving activities take place (€).

All data are related to the overall SMTUC driving training system. The data reliability is maximised due to an objective data collection.

- **Indicator 3** (*Vehicle fuel efficiency- Training Effect*) – Ratio of energy consumed in the driving training sessions, divided by the total vehicle-km (MJ/vehicle-km).

A = B / C, where:

- ✓ A = Average vehicle efficiency of the driving training sessions (MJ/vkm)
- ✓ B = Total energy consumed in the driving training sessions (MJ)
- ✓ C = Total vehicle-km performed during the driving training sessions

All data are related to the SMTUC driving training sessions. Results from energy consumption by the SMTUC vehicles used in driving training activities are quantified by means of SMTUC regular procedure of registering fuel consumption by these vehicles every time each vehicle is fuelled after being used in these activities. The equivalent energy consumption is calculated with conversion factors. The data reliability is maximised due to an objective data collection among SMTUC records on performed trips on training activities. The energy consumption in the driving simulator training sessions is estimated using SMTUC regular procedure of registering total electricity consumed by the simulator.

- **Indicator 4** (*Vehicle fuel efficiency- Eco-driving Effect*) – Ratio of energy consumed by the buses in the driving training sessions using the driving training simulator, divided by the total vehicle-km performed by this virtual buses (MJ/vehicle-km).

A = B / C, where:

- ✓ A = Average vehicle efficiency of the driving training sessions using the driving training simulator (MJ/vkm)
- ✓ B = Total energy consumed by the virtual buses in the driving training sessions (MJ)
- ✓ C = Total vehicle-km performed by the virtual buses during the driving training sessions.

All data are related to the SMTUC driving training activities of the reference group in the driving simulator. Results from energy consumption and vehicle-kilometres performed on simulator come from simulator software report. The data reliability is maximised due to an objective data collection among SMTUC records on performed trips on training activities, which in turn are recorded following reliable procedures and due to an objective data collection on the simulator reporting system.

- **Indicator 5** (*Driving Service Quality*) – Measured as the average rating given by the driving training instructor to the drivers, in each training session. The driving service quality index is based on the average of 5 parameters:

  1. Signalling the change of direction manoeuvre;
  2. Reckless invasion of another route;
  3. Traffic signals compliance;
  4. Driving sudden;
  5. Use of mirrors.

- **Indicator 6** (*Accident Risk*) – Ratio of total number of recorded transport injury accidents and casualties recorded, divided by the total vehicle-km (number of accidents or casualties/vehicle-km).

  A = B / C, where:

  - ✓ A = Transport Safety Operation (number of accidents + casualties/vkm)
  - ✓ B = Number of recorded accidents or casualties recorded
  - ✓ C = Total vehicle-km performed during the driving training sessions

  Results from accidents/casualties and number of vehicle-kilometres, have origin in SMTUC data.

- **Indicator 6** (*CO Emissions*) – Average CO emissions per vehicle-km of driving training sessions (g/vehicle-km).

  A = B / C, where:

  - ✓ A = Average CO emissions per vehicle-km (g/vkm)
  - ✓ B = Total CO emissions resulting from driving training sessions, namely electricity/fuel consumption associated to vehicles and driving training simulator, (g)
  - ✓ C = Total vehicle-km performed in driving training sessions (vkm)

  For driving training vehicles, the CO emissions calculation is based on average European emission factors, for pollutant and type of vehicle technology (e.g. Conventional, Euro 1, ...), according to the EMEP/European Environment Agency (EEA) emission inventory guidebook

2009, updated May 2012, on exhaust emissions from road transport[13]. These average European emission factors were determined using the Tier 3 methodology (based model with COPERT) which follows in using typical values for driving speeds, ambient, temperatures, highway-rural-urban mode mix, trip length.

The CO emissions resulting from electricity consumption of the driving training simulator, are estimated by means of implied emission factors, expressed in tons of CO per GWh of electricity consumed, and are based on country data given by the Portuguese Environment Agency (Portuguese National Inventory Report on Greenhouse Gases).

Results from vehicle-kilometres coming from SMTUC records . The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 7** (*CO_2 Emissions*) – Average CO_2 emissions per vehicle-km of driving training sessions (g/vehicle-km).

  A = B / C, where:

  - ✓ A = Average CO_2 emissions per vehicle-km (g/vkm)
  - ✓ B = Total CO_2 emissions resulting from driving training session, namely electricity/fuel consumption associated to vehicles and driving training simulator, (g)
  - ✓ C = Total vehicle-km performed in driving training sessions (vkm)

  The calculation of total CO_2 emissions from driving training vehicles is based on country data given by the Portuguese Environment Agency (Portuguese National Inventory Report on Greenhouse Gases), more precisely, a historical series (1990-2009) of CO_2 implied emission factors expressed in grams per kilometre. These emission factors were determined using the Tier 3 methodology (based model with COPERT).

  The CO_2 emissions resulting from electricity consumption of the driving training simulator, are estimated by means of implied emission factors, expressed in tons of CO_2 per GWh of electricity consumed, and are based on country data given by the Portuguese Environment Agency (Portuguese National Inventory Report on Greenhouse Gases).

  Results from vehicle-kilometres coming from SMTUC records. The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 8** (NOx *Emissions*) – Average NOx emissions per vehicle-km of driving training sessions (g/vehicle-km).

  A = B / C, where:

  - ✓ A = Average NOx emissions per vehicle-km (g/vkm)
  - ✓ B = Total NOx emissions resulting from driving training sessions, namely electricity/fuel consumption associated to vehicles and driving training simulator, (g)

[13] http://eea.europa.eu/emep-eea guidebook

- ✓ C = Total vehicle-km performed in driving training sessions (vkm)

For driving training vehicles, the NOx emissions calculation is based on average European emission factors, for pollutant and type of vehicle technology (e.g. Conventional, Euro 1, ...), according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[14]. These average European emission factors were determined using the Tier 3 methodology (based model with COPERT) which follows in using typical values for driving speeds, ambient, temperatures, highway-rural-urban mode mix, trip length.

The NOx emissions resulting from electricity consumption of the driving training simulator, are estimated by means of implied emission factors, expressed in tons of NOx per GWh of electricity consumed, and are based on country data given by the Portuguese Environment Agency (Portuguese National Inventory Report on Greenhouse Gases).

Results from vehicle-kilometres coming from SMTUC records . The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

- **Indicator 9** (PM *Emissions*) – Average PM emissions per vehicle-km of driving training sessions (g/vehicle-km).

A = B / C, where:

- ✓ A = Average PM emissions per vehicle-km (g/vkm)
- ✓ B = Total PM emissions resulting from driving training sessions, namely electricity/fuel consumption associated to vehicles and driving training simulator, (g)
- ✓ C = Total vehicle-km performed in driving training sessions (vkm)

For driving training vehicles, the PM emissions calculation is based on average European emission factors, for pollutant and type of vehicle technology (e.g. Conventional, Euro 1, ...), according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[15]. These average European emission factors were determined using the Tier 3 methodology (based model with COPERT) which follows in using typical values for driving speeds, ambient, temperatures, highway-rural-urban mode mix, trip length.

The PM emissions resulting from electricity consumption of the driving training simulator, are estimated by means of implied emission factors, expressed in tons of PM per GWh of electricity consumed, and are based on country data given by the Portuguese Environment Agency (Portuguese National Inventory Report on Greenhouse Gases).

Results from vehicle-kilometres coming from SMTUC records . The data reliability is maximised due to an objective data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures.

[14] http://eea.europa.eu/emep-eea guidebook

[15] http://eea.europa.eu/emep-eea guidebook

- **Indicator 10** (*Awareness level*) – Percentage of the users with knowledge of the measure on account of provided information (%).

  A = B / C × 100, where:

  - ✓ A = Percentage of users with knowledge of the measure (%)
  - ✓ B = Total number of respondents with knowledge of the measure
  - ✓ C = Total number of respondents

  The Awareness level of the measure will be measured by carrying out specific questionnaires to SMTUC drivers including questions relative to the knowledge of the respondent about the measure (see Annex).

  The so called driver's survey is composed of specific questions related to the driving training sessions and methods used. The drivers interviewed express a judgement on several various items choosing between very satisfied – satisfied – indifferent – unsatisfied – very unsatisfied.

- **Indicator 11** (*Acceptance level*) – Percentage of the users who favourably receive the measure (%).

  A = B / C × 100, where:

  - ✓ A = Percentage of users who favourably receive the measure (%)
  - ✓ B = Total number of respondents who favourably receive the measure
  - ✓ C = Total number of respondents

  The acceptance level of the measure will be measured by carrying out specific questionnaires to SMTUC drivers including questions relative to the respondent's attitude towards the measure (see Annex).

  The so called driver's survey is composed of specific questions related to the driving training sessions and methods used. The drivers interviewed express a judgement on several various items choosing between very satisfied – satisfied – unsatisfied – very unsatisfied.

C1.2 Establishing a Baseline

Indicator 1: Average Operating Costs

The average operating costs of the baseline, Table C1.2.1, are based on the costs of running driving training sessions in real operational conditions, using buses. The data is based on SMTUC records.

Table C1.2.1: Average Operating Costs (€/vkm), Ex-Ante.

Indicator and Data Used	Ex-Ante Oct 2010-Sep 2011
Fuel Costs (€)	913,53
Maintenance personnel costs (€)	72,18
Hardware maintenance costs (€)	175,67
Personnel costs (€)	4.669,46
Total Costs (€)	**5.830,84**
Total vehicle-km (vkm)	1.710,73
Average operating costs (€/vkm)	**3,41**

Indicator 2: Capital Costs

This indicator takes into account the total capital costs, such as equipement and software, necessary to implement the measure, in other words, expenditures associated with the purchase and installation of the necessary equipment and software for SMTUC driving training simulator system. Considering that in the baseline, the measure had not yet been implemented, the capital costs are considered to be null.

Indicator 3: Vehicle Fuel Efficiency – Training Effect

The baseline takes into account the energy that is consumed in driving training sessions in real operational conditions, using buses. The data is based on SMTUC records, Table C1.2.2.

Table C1.2.2: Vehicle Fuel Efficiency (MJ/vkm), Ex-Ante.

Indicator and Data Used	Ex-Ante Oct 2010-Sep 2011
Total fuel consumed in the drive training sessions (MJ)	31.550,45
Total vehicle-km (vkm)	1.710,73
Average Fuel Efficiency (MJ/vkm)	**18,44**

Indicator 4: Vehicle Fuel Efficiency – Ecodriving Effect

The vehicle fuel efficiency in the baseline takes into account the results achieved on the first session of driving training activities of the reference group using the driving simulator, conducted in July 2012. It`s considered that at this stage the measure effects are negligible. Table C1.2.3, shows the results for the baseline.

For fuel efficiency purposes, the driving training sessions were performed in a mixed circuit, with negligible traffic in order to promote the adaptation of the 25 PT drivers to the driving simulator and to the first concepts of eco-driving.

Table C1.2.3: Average Fuel Efficiency (MJ/vkm), Ex-Ante.

Indicator and Data Used	Ex-Ante July 2012
Total fuel consumed in the first drive training session using the simulator (l)	34,87
Total fuel consumed in the first drive training session using the simulator (MJ)	1.250,37
Total vehicle-km (vkm)	57,50
Average Fuel Efficiency (MJ/vkm)	**21,75**

Note: 1litre of diesel=35,86 MJ

Indicator 4: Quality of Driving Service

The quality of driving service is measured as the average rating given by the driving training instructor to the 25 drivers of the reference group, in each training session. The rating is based on the average of five different parameters:

1. Signalling the change of direction manoeuvre;
2. Reckless invasion of another route;
3. Traffic signals compliance;
4. Driving sudden;
5. Use of mirrors.

For the baseline it will be considered the ratings achieved on the first session of driving training activities using the driving simulator, conducted in July 2012. In Table C1.2.4 are presented the baseline results.

Table C1.2.4: Quality of Driving Service Index, Ex-Ante.

Indicator and Data Used	Ex-Ante July 2012
Quality of Service	8

Note: Scale 1-10

Indicator 5: Accident Risk

The transport safety is measured by taking into account the number of recorded transport injury accidents and causalities, more precisely the number of times that the driving training system registers kerbs rises and trampling during the driving training session period of the reference group of 25 SMTUC public transportation drivers.

The baseline considers the numbers of occurrences registered on the first session of driving training activities using the driving training simulator, conducted in July 2012. In Table C1.2.5, are presented the baseline results.

For transport safety purposes, the driving training sessions were performed in an urban circuit with traffic, with the main objective of introduction the drivers to defensive driving principles.

Table C1.2.5: Transport safety/vkm, Ex-Ante.

Indicator and Data Used	Ex-Ante July 2012
Number of Kerb Rises and Trampling	53+5=58
Total vehicle-km (vkm)	122,50
Accident Risk (number of incidents /vkm)	**0,473**

Indicator 6: CO emissions

The baseline CO emissions were estimated by taking into account the total number of km performed on the driving training sessions in real operational conditions using buses.

The CO emission factor is based on average European emission factors, for pollutant and type of vehicle technology, in this case Euro 3, according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[16], Table C1.2.6.

The results of the measure, will be assessed by comparing the average emissions of conducting driving training sessions in buses versus driving training sessions in the simulator (considering electricity consumption of driving training simulator and associated emissions).

Table C1.2.6:CO emissions, Ex-Ante.

Indicator and Data Used	Ex-Ante Oct 2010-Sep 2011
Total vehicle-km (vkm)	1.710,73
Total CO emissions (gCO)	4.567,65
Average CO emissions per vehicle-km (gCO/vkm)	**2,67**

Indicator 7: CO_2 emissions

The baseline CO_2 emissions were estimated by taking into account the total number of km performed on the driving trainning sessions in real operational conditions using buses, Table C1.2.7.

The results of the measure, will be assessed by comparing the average emissions of conducting driving training sessions in buses versus driving training sessions in the simulator (considering electricity consumption of driving training simulator and associated emissions).

Table C1.2.7:CO_2 emissions, Ex-Ante.

Indicator and Data Used	Ex-Ante Oct 2010-Sep 2011
Total vehicle-km (vkm)	1.710,73
Total CO_2 emissions (gCO_2)	1.356.999,62
Average CO_2 emissions per vehicle-km (gCO_2/vkm)	**793,23**

Indicator 8: NOx emissions

[16] http://eea.europa.eu/emep-eea guidebook

The baseline NOx emissions were estimated by taking into account the total number of km performed on the driving training sessions in real operational conditions using buses.

The NOx emission factor is based on average European emission factors, for pollutant and type of vehicle technology, in this case Euro 3, according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[17], Table C1.2.8.

The results of the measure, will be assessed by comparing the average emissions of conducting driving training sessions in buses versus driving training sessions in the simulator (considering electricity consumption of driving training simulator and associated emissions).

Table C1.2.8:NOx emissions, Ex-Ante.

Indicator and Data Used	Ex-Ante Oct 2010-Sep 2011
Total vehicle-km (vkm)	1.710,73
Total NOx emissions (g NOx)	16.046,65
Average NOx emissions per vehicle-km: (g NOx/vkm)	**9,38**

Indicator 9: PM emissions

The baseline PM emissions were estimated by taking into account the total number of km performed on the driving training sessions in real operational conditions using buses.

The PM emission factor is based on average European emission factors, for pollutant and type of vehicle technology, in this case Euro 3, according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[18], Table C1.2.9.

The results of the measure, will be assessed by comparing the average emissions of conducting driving training sessions in buses versus driving training sessions in the simulator (considering electricity consumption of driving training simulator and associated emissions).

Table C1.2.9: **PM emissions, Ex-Ante.**

Indicator and Data Used	Ex-Ante Oct 2010-Sep 2011
Total vehicle-km (vkm)	1.710,73
Total PM emissions (g PM)	354,12
Average PM emissions per vehicle-km: (g PM/vkm)	**0,21**

Indicator 10: Awareness Level

To get a qualitative assessment of knowledge and attitude towards changes, 193 surveys (see Annex) to SMTUC drivers chose to attend driving training activities were conducted between the months of January and February 2012.

The representativeness of the sample is presented in Table C1.2.10.

[17] http://eea.europa.eu/emep-eea guidebook

[18] http://eea.europa.eu/emep-eea guidebook

Table C1.2.10: Awareness: representativeness of the sample.

Statistical Universe (SMTUC drivers chose to attend driving training activities)	193 (2012-01-23 to 2012-02-02)
Surveys	193
Statistical confidence interval	95%
	% error p = 0,5 % error p = 0,25

The baseline results are presented in Table C1.2.11.

Table C1.2.11: Awareness level, Ex-Ante.

Indicator and Data Used	Time Period	Ex-Ante
Number of positive answers	2012-01-23 to 2012-02-02	164
Total Number of respondents		193
Awareness level of the drivers (%)		**84,97**

<u>Indicator 11: Acceptance Level</u>

The acceptance level of the measure was measured by carrying out specific questionnaires (see Annex) to SMTUC drivers including questions relative to the respondent's attitude towards the measure. In total, 183 questionnaires were made, Table C1.2.12.

Table C1.2.12: Acceptance level, Ex-Ante.

Indicator and Data Used	Time Period	Ex-Ante Values
Number of positive answers	2012-01-23 to 2012-02-02	167
Total Number of respondents		193
Acceptance level of the drivers (%)		**86,52**

C1.3 Building the Business-as-Usual scenario

As mentioned in the Final Evaluation Plan document, the business as usual (BAU) scenario should consider the possible autonomous city development if a certain measure is not going to be implemented.

In general the change in the measure indicators due to the to the training activities making use of the driving simulator is obtained after implementing the measure. Therefore, if the measure wasn't implemented, it`s considered that the indicators results would be similar to those registered for the baseline scenario. It is considered that there are no effects of other factors that have any influence in the indicators. For this specific measure, the business as usual (BAU) scenario is considered to be similar to the baseline situation.

Indicator 1: Average Operating Costs

Table C1.3.1: Average Operating Costs (€/vkm), BAU.

Indicator	BAU=Ex-ante
Average operating costs (€/vkm)	3,41

Indicator 2: Capital Costs

The change in the Capital Costs due to the to the training activities making use of the driving simulator is obtained after setting up the measure. Therefore, if this measure wasn't implemented, the capital costs would be null.

Indicator 3: Vehicle Fuel Efficiency – Training Effect

Table C1.3.2: Vehicle Fuel Efficiency (MJ/vkm), BAU.

Indicator	BAU=Ex-Ante
Average Fuel Efficiency (MJ/vkm)	18,44

Indicator 4: Vehicle Fuel Efficiency – Eco-driving Effect

Table C1.3.3: Vehicle Fuel Efficiency (MJ/vkm), BAU.

Indicator	BAU=Ex-Ante
Average Fuel Efficiency (MJ/vkm)	21,75

Indicator 5: Quality of Driving Service

Table C1.3.3: Quality of Service, BAU.

Indicator	BAU=Ex-Ante
Quality of Service	8

Note: Scale 1-10

Indicator 6: Accident Risk

Table C1.3.4: Accident risk/vkm, BAU.

Indicator and Data Used	BAU=Ex-Ante

Accident Risk (number of incidents /vkm)	0,473

Indicator 6 to 9 (Emissions)

Table C1.3.5: Average emissions/vkm, BAU.

Indicator and Data Used	BAU=Ex-Ante
Average CO emissions per vehicle-km (gCO/vkm)	2,67
Average CO_2 emissions per vehicle-km (gCO_2/vkm)	793,23
Average NOx emissions per vehicle-km: (g NOx/vkm)	9,38
Average PM emissions per vehicle-km: (g PM/vkm)	0,21

Indicator 10: Awareness Level

Table C1.3.6: Awareness level, BAU.

Indicator	BAU=Ex-Ante
Awareness level of the drivers (%)	84,97

Indicator 11: Acceptance Level

Table C1.3.7: Acceptance level, BAU.

Indicator and Data Used	BAU=Ex-Ante
Acceptance level of the drivers (%)	86,52

C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

C2.1 Economy

Indicator 1: Average Operating Costs

For the ex-post period, the average operating costs are in fact, the costs of running the driving training simulator system along the training sessions. In total personnel costs, maintenance costs and electricity consumption costs, costs are considered, Table C2.1.1.

Table C2.1.1: Average Operating Costs (€/vkm), Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Energy Costs (€)[19]	83,14
Maintenance personnel costs (€)	4,72
Hardware maintenance costs (€)	2,84
Personnel costs (€)	1.303,35
Total Costs (€)	**1.394,05**
Total vehicle-km (vkm)	480
Average operating costs (€/vkm)	**2,90**

In Table C2.1.2, the measure results for this indicator are presented, resulting from the comparison between the average operating costs of the driving training simulator system (Ex-post) with the average operating costs of a driving training session in real operational conditions, using a vehicle (Ex-ante).

Table C2.1.2: Economy: Indicator 1, Average Operating Costs.

Indicator	Ex-Ante Baseline Oct 2010-Sep 2011	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average operating costs (€/vkm)	3,41	3,41	2,90	-0,51	

According to this results, after the measure implementation, the average operating costs of SMTUC driving training activities, decreased about 15%, from 3,41 €/vkm to 2,90 €/vkm, essentially due to lower energy and personnel costs.

Indicator 2: Capital Costs

The capital costs are all considered in the Ex-post period, Table C2.1.3.

Table C2.1.3: Economy: Indicator 2, Capital Costs.

Indicator	Ex-Ante Baseline	BAU	Ex-Post September	Difference Ex Post – Ex	Difference: Ex Post – BAU

[19] Electricity consumed in the driving training simulator.

	Oct 2010-Sep 2011		2012	Ante	
Capital Costs (€)	0	0	500.913,24	500.913,24	

C2.2 Energy

Indicator 3: Vehicle Fuel Efficiency – Training Effect

The results of the ex-post period, corresponding to the tests in the driving training simulator, are presented in Table C2.2.1.

Table C2.2.1: Average Fuel Efficiency (MJ/vkm), Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Total Electricity Consumption (kWh)	196,64
Total energy consumed in the drive training activities: (MJ)	707,89
Total vehicle-km (vkm)	115
Average Fuel Efficiency (MJ/vkm)	**6,16**

In Table C2.2.2, the measure results for this indicator are presented, resulting from the comparison between the average fuel efficiency of the driving training simulator system (Ex-post) with the average operating costs of a driving training session in real operational conditions, using a vehicle (Ex-ante).

Table C2.2.2: Energy: Indicator 3, Vehicle Fuel Efficiency.

Indicator	Ex-Ante Baseline Oct 2010-Sep 2011	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average Fuel Efficiency (MJ/vkm)	18,44	18,44	6,16	-12,29	

Compared to the BAU scenario, the average fuel efficiency in the ex-post period has improved significantly, a reduction of about 66% in terms of energy consumption per vkm, in result of switching from diesel to electricity.

Indicator 4: Vehicle Fuel Efficiency – Eco-driving Effect

Table C2.2.3: Average Fuel Efficiency (MJ/vkm), Ex-Post.

Indicator and Data Used	Ex-Ante July 2012
Total fuel consumed in the first drive training session using the simulator (l)	29,49
Total fuel consumed in the first drive training session using the simulator (MJ)	1.057,37
Total vehicle-km (vkm)	57,50
Average Fuel Efficiency (MJ/vkm)	**18,39**

Note: 1litre of diesel=35,86 MJ

Comparing the results achieved in the two driving sessions using the simulator in same conditions (bus, routes, distance, …), it`s possible to conclude that the drivers achieved an increase of about 15% in terms of average fuel efficiency, probably as a result of eco driving principles assimilation.

Table C2.2.4: Energy: Indicator 3, Vehicle Fuel Efficiency.

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average Fuel Efficiency (MJ/vkm)	21,75	21,75	18,39	-3,36	

C2.3 Environment

Indicator 6: CO emissions

The CO emissions in the ex-post period are associated to the electricity consumption of the driving training simulator, and were estimated using national emission factor for electricity production. The total vehicle-km are an output of the driving training simulator software report, Table C2.3.1.

Table C2.3.1:CO emissions, Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Total vehicle-km (vkm)	115
Driving training system electricity consumption (kWh)	196,64
Electricity Emission Factor (t CO/GWh)	0,11
Total CO emissions (gCO)	21,26
Average CO emissions per vehicle-km (gCO/vkm)	**0,18**

The average CO emissions in the ex-post period are significantly lower in comparison with the ex-ante and BAU scenario (-93%) due to the fact that emissions result from electricity consumption of the driving training simulator instead of diesel consumption of driving training vehicles in the ex-ante and BAU scenario, Table C2.3.2.

Table C2.3.2: Environment : Indicator 6, Average CO emissions per vehicle-km (gCO/vkm).

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average CO emissions per vehicle-km (gCO/vkm)	2,67	2,67	0,18	-2,49	

Indicator 7: CO_2 emissions

The CO_2 emissions in the ex-post period are associated to the electricity consumption of the driving training simulator, and were estimated using national emission factor for electricity production. The total vehicle-km are an output of the driving training simulator software report, Table C2.3.3.

Table C2.3.3:CO_2 emissions, Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Total vehicle-km (vkm)	115
Driving training system electricity consumption (kWh)	196,64

Electricity Emission Factor (t CO_2/GWh)	375
Total CO_2 emissions (gCO_2)	73.805,36
Average CO emissions per vehicle-km (gCO/vkm)	**641,79**

The average CO_2 emissions in the ex-post period are significantly lower in comparison with the ex-ante and BAU scenario (-19%) due to the fact that emissions result from electricity consumption of the driving training simulator instead of diesel consumption of driving training vehicles in the ex-ante and BAU scenario, Table C2.3.4.

Table C2.3.4: Environment : Indicator 7, Average CO_2 emissions per vehicle-km (gCO_2/vkm).

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average CO_2 emissions per vehicle-km (gCO_2/vkm)	793,23	793,23	641,79	-151,44	

Indicator 8: NOx emissions

The NOx emissions in the ex-post period are associated to the electricity consumption of the driving training simulator, and were estimated using national emission factor for electricity production. The total vehicle-km are an output of the driving training simulator software report, Table 2.3.5.

Table C2.3.5:NOx emissions, Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Total vehicle-km (vkm)	115
Driving training system electricity consumption (kWh)	196,64
Electricity Emission Factor (t NO_x/GWh)	0,94
Total NOx emissions (g NOx)	185,29
Average NOx emissions per vehicle-km (gNOx/vkm)	**1,61**

The average NOx emissions in the ex-post period are significantly lower in comparison with the ex-ante and BAU scenario (-83%) due to the fact that emissions result from electricity consumption of the driving training simulator instead of diesel consumption of driving training vehicles in the ex-ante and BAU scenario, Table 2.3.6.

Table C2.3.6: Environment : Indicator 7, Average NOx emissions per vehicle-km (gNOx/vkm).

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average NOx emissions per vehicle-km (gNOx/vkm)	9,38	9,38	1,61	- 7,77	

Indicator 9: PM emissions

The PM emissions in the ex-post period are associated to the electricity consumption of the driving training simulator, and were estimated using national emission factor for electricity production. The total vehicle-km are an output of the driving training simulator software report, Table C2.3.7.

Table C2.3.7:PM emissions, Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Total vehicle-km (vkm)	115
Driving training system electricity consumption (kWh)	196,64
Electricity Emission Factor (t PM/GWh)	0,15
Total PM emissions (g PM)	29,57
Average PM emissions per vehicle-km (g PM/vkm)	**0,26**

The average PM emissions in the ex-post period are slightly higher in comparison with the ex-ante and BAU scenario (+22%) due to the fact that emissions result from electricity consumption of the driving training simulator instead of diesel consumption of driving training vehicles in the ex-ante and BAU scenario, Table C2.3.8.

Table C2.3.8: Environment : Indicator 7, Average PM emissions per vehicle-km (g PM/vkm).

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average PM emissions per vehicle-km (g PM/vkm)	0,21	0,21	0,26	0,05	

C2.4 Transport

Indicator 4: Quality of Driving Service

Table C2.4.1: Quality of Driving Service, Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Quality of Service	8

Table C2.4.2: Transport: Indicator 4, Quality of Driving Service Index.

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Quality of Driving	8	8	8	0	

Based on the average rating given by the driving training instructor in each training session, it`s possible to observe the maintenance in the driving quality level.

Indicator 5: Accident Risk

Table C2.4.3 presents the number of times that the driving training system registered kerbs rises and trampling during the driving training session ex-post period. The total vehicle-km are an output of the driving training simulator software report.

Table C2.4.3: Accident risk/vkm, Ex-Post.

Indicator and Data Used	Ex-Post September 2012
Number of Kerb Rises and Trampling : (number of incidents)	39+0=39
Total vehicle-km (vkm)	122,50
Accident Risk (number of incidents /vkm)	**0,318**

The transport safety has increased, as a result of the lower number of registered occurrences in the ex post period, Table C2.4.4.

Table C2.4.4: Transport: Indicator 5, Accident Risk.

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Transport safety (number of incidents /vkm)	0,473	0,473	0,318	-0,155	

Based on these results it`s possible to conclude that between the two driving training sessions, the accident risk as decreased 33%. The results are explained by a lower number of incidents registered in the second session (39) in comparison with the ones registered in the first session (58), both for the same travelled distance of 122,50 km. This is an important added value of the driving training system.

C2.5 Society

Indicator 10: Awareness Level

Table C2.5.1: Awareness level, Ex-post.

Indicator and Data Used	Time Period	Ex-Ante
Number of positive answers	2012-10-26 to 2012-11-20	174
Total Number of respondents		187
Awareness level of the drivers (%)		**93,05**

The awareness level of the drivers have increased about 8% in comparison with the ex-ante period, Table C2.5.2.

Table C2.5.2: Society: Indicator 10, Awareness level.

Indicator	Ex-Ante Baseline Jan-Feb 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Awareness level of the drivers (%)	84,97	84,97	93,05	8,07	

Indicator 11: Acceptance Level

Table C2.5.3: Acceptance level, Ex-Post.

Indicator and Data Used	Time Period	Ex-Ante Values
Number of positive answers	2012-10-26 to 2012-11-20	168
Total Number of respondents		187
Acceptance level of the drivers (%)		**89,84**

The acceptance level of the drivers have increased about 3% in comparison with the ex-ante period, Table C2.5.4.

Table C2.5.4: Society: Indicator 11, Acceptance level.

Indicator	Ex-Ante Baseline Jan-Feb 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Acceptance level of the drivers (%)	86,52	86,52	89,84	3,32	

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To implement a training centre for heavy duty vehicles drivers, equipped with a dynamic driving simulator, that could allow both the reduction of accident rates (at least 5% in SMTUC drivers), and fuel expenditures (at least 3% in the SMTUC fleet). The driving simulator has been purchased and installed in a new pavilion built for the creation of the driving centre in SMTUC site. The accident risk assessed in simulation conditions decreased 33% with the driving training in the simulator, indicating that the objectives concerning the accident rates will be exceeded in real situation. The same for the fuel consumption, taking into consideration the 15% decrease with the driver training.	***
2	To improve 10% the driving training sessions. During a year of driving simulator training (November 2011 – October 2012) 259 driving training sessions on simulator and 17 on real buses and trolleybuses have been carried out. In the 1 year period prior to the measure implementation (2010) only 85 driving training sessions occurred (on real buses). This represents an increase of 225% with the measure implementation.	***
3	To perform at least 500 training actions during CIVITAS. During CIVITAS, considering only the period after the implementation of the new Driving Centre, 518 training sessions have been carried out, 262 on the driving simulator.	**
4	To improve the cooperation between SMTUC and others fleet operators (PT operators, Municipality, Driving Schools, etc.) Technicians of the Municipality, Carristour (PT Driving School) and ANTROP (Portuguese Association of Public Transport Operators) visited the driving simulator centre and partnerships with these entities for future training actions for PT drivers of all the centre Portuguese region under consideration.	**
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

As described in detail in the previous points of the report, the measure was implemented in a reference group of SMTUC drivers, more precisely 25 drivers, who were involved in different training sessions, using the driver training simulator.

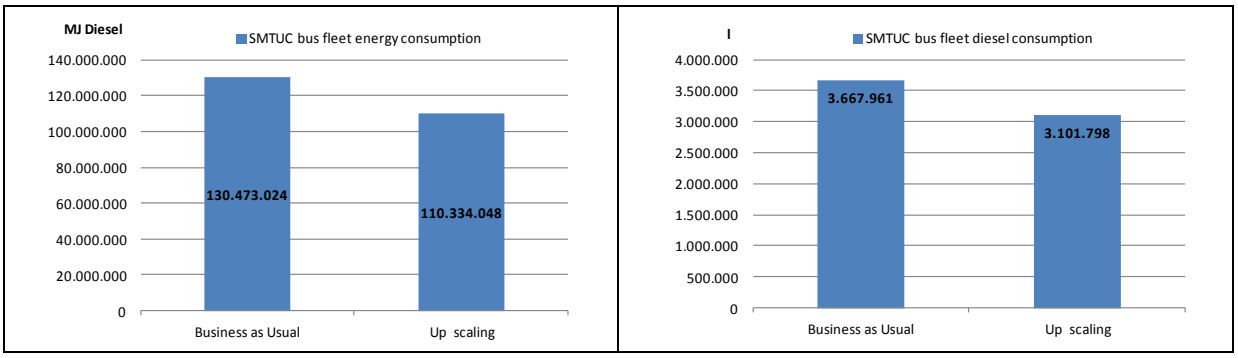
Considering that SMTUC has a global universe of about 280 drivers, it`s important to assess the potential impacts of up scaling the measure to the entire SMTUC universe, particularly in terms of the possible improvement of vehicle fuel efficiency/fuel consumption, as a result of the driving training simulator activities and eco driving principles.

Taking into consideration the indicator, average fuel efficiency on a mixed circuit, expressed in terms of energy per vehicle kilometre, it was possible to conclude that the measure resulted in a improvement of the fuel efficiency because in the ex post scenario, after the measure implementation, the 25 drivers recorded an improvement in fuel efficiency ratios, which means a lower fuel consumption for the same driving course, Table C4.1.

Table C4.1: Energy: Indicator 3, Vehicle Fuel Efficiency.

Indicator	Ex-Ante Baseline July 2012	BAU	Ex-Post September 2012	Difference Ex Post – Ex Ante	Difference: Ex Post – BAU
Average Fuel Efficiency – Driving Training Simulator Effect (MJ/vkm)	21,75	21,75	18,39	-3,36	

Assuming the extrapolation of these results to the entire SMTUC universe and considering that based on historical data, the entire SMTUC fleet has an annual value of approximately 6.000.000 vkm, it is possible to estimate the impact that the measure could have in an upscale scenario, Graph C4.1 and C4.2.

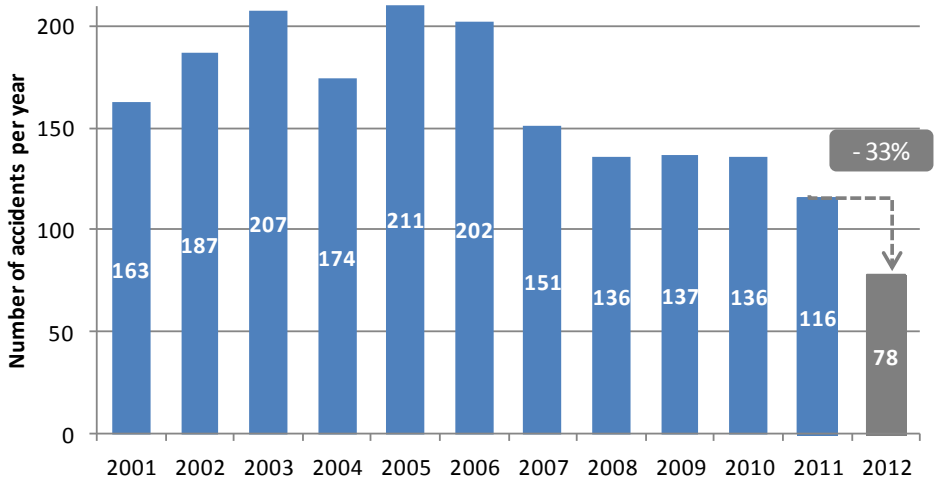


Graph C4.1and C4.2: Measure up scaling potential results in terms of possible fuel economy.

If the measure could be up scaled to all SMTUC drivers, and assuming that the 15% decrease of the average fuel efficiency achieved in the driving simulator could be maintained in real operational conditions, the total SMTUC bus fleet diesel consumption could be reduced in about 500.000 litres per year. Considering a reference price for the diesel of about 1,0395 €/l, this number could represent an annual saving of 519.750€ in terms of fuel costs.

The potential reduction of fuel consumption as a result of eco driving principles could also have an important impact in terms of emissions avoided. In fact, assuming the average CO_2 emission factor for diesel, 2,60 $kgCO_2/l$ diesel (Portuguese National Inventory Report on GHG, 1990-2009. Submitted Under the UN Framework Convention in Climate Change and the Kyoto Protocol. April 2011) the potential emissions avoided will be about 1.300 tCO_2.

In terms of accident risk, it was possible to observe that the number of accidents decreased 33% between the two driving training sessions conducted in the simulator, probably as a result of the defensive driving principles acquired by the 25 drivers during the sessions. Assuming that this trend can be transposed to the whole SMTUC universe, it is possible to estimate the impact of the measure in terms of total number of accidents per year, taking into consideration the historical SMTUC data in this field, Graph C4.3. This would lead to a historically low number of accidents registered in a given year in the SMTUC universe.



Graph C4.3: Measure up scaling potential results in terms of number of accidents.

C5 Appraisal of evaluation approach

The evaluation process was based on different approaches, depending on the indicators within the areas of economy, energy, environment and society.

Initially an additional indicator was considered, more precisely "Percentage of female drivers in the universe of SMTUC drivers". However, considering the measure objectives it was decided that this indicator does not have a direct relation with the measure implementation and does not add any gain to measure evaluation. For these two motives the indicator was not considered for evaluation purposes.

In terms of emissions calculation, the approach was based on emission factors, specific for pollutant and type of vehicle technology (in this case an Euro 3 vehicle), according to the EMEP/European Environment Agency (EEA) emission inventory guidebook 2009, updated May 2012, on exhaust emissions from road transport[20]. These average European emission factors were determined using the Tier 3 methodology (based model with COPERT) which follows in using typical values for driving speeds, ambient, temperatures, highway-rural-urban mode mix, trip length.

A lack of funding from the Portuguese government for the driving simulator purchase delayed the measure implementation because a long administrative process occurred in order to assure alternative funds. As the demonstration period (4 months) didn't allow an assessment of the real behaviour of the drivers after a correct period of driving simulator training, a reference group of 25 SMTUC drivers was set up to have the time to evaluate the impacts of the driving training sessions that began on 26th June 2012. This methodology allowed for more intensive training sessions in the driving simulator and assess the drivers' behaviour modifications in a shorter time period.

So, for the indicators 3 to 10 the evaluation methodology was mostly based on the assessment of the results achieved by the reference group of 25 SMTUC drivers, as a result of the 4 driving training sessions conducted in the simulator (two different tests, conducted in July and repeated in September 2012)

[20] http://eea.europa.eu/emep-eea guidebook

Without the possibility of measuring the real impacts of the training in the drivers behaviour during an acceptable time frame, the indicator in the safety field has been the Accident risk derived from the simulator outputs in spite of the assessment to the real evolution of the number of accidents of SMTUC drivers. A similar approach has been made for the fuel consumption and the related emissions, while the driving quality has been also assessed during the driving simulator trainings, but from the trainers' perception on driver behaviour.

C6 Summary of evaluation results

The key results are as follows:

- **Reduction of the Average Operating Costs** – The measure led to a reduction in the average operating costs (€/vkm) of the driving training activities. In fact, the driving training simulator has lower energy, maintenance, and personnel costs in comparison with driving training sessions in real operational conditions, using diesel vehicles. Overall, the average operating costs decreased about 15%, from 3,41 €/vkm to 2,90 €/vkm, essentially due to much lower energy costs.

- **Improvement of Fuel Efficiency**– The measure has the potential to improve the average fuel efficiency of SMTUC services. During the driving training sessions using the simulator, a substantial improvement of the average fuel efficiency in mixed circuit was observed, corresponding to a 15% reduction in terms of energy consumption per vkm (about 500.000 litres per year of fuel savings when the training is eventually applied to all SMTUC drivers).

- **Reduction of Emissions** – Using a driving training simulator instead of diesel vehicles in real operational conditions has a significant impact on the average emissions per vkm. The replacement of the diesel consumed in the driving training vehicles for electricity consumed in the driving training system simulator, leads to reductions in the average emissions per vehicle-km between 19% and 93%, depending on the pollutant under consideration.

- **Lower Accident Risk** - The driving training simulator can help improve transport safety. Between driving training sessions in the simulator and considering the same circuit and travelling distance, a reduction of the total number of occurrences was registered, namely curb jumping and trampling in about 33%.

C7 Future activities relating to the measure

The functioning of the Driving Centre will continue in the future. A process of licensing the driving centre for the training of PT drivers from other companies is in course and partnerships with some specialised organisations are presently under consideration.

Due to the lower cost that the driver training would have and the increase in available resources (buses not used for training) that the simulator allows for, a significant raise in the number of training courses and trainees is expected. There would be fuel savings, pollution reduction, increase of safety, and higher levels of diving quality which would increase passenger comfort.

D Process Evaluation Findings

D.1 Deviations from the original plan

The deviations from the original plan comprised:

- **Delay in the measure implementation due a prolonged administrative and bureaucratic process related to the lack of co-financing from the national government** – Despite the first positive informal contacts with the Portuguese Institute for Mobility and Inland Transport (IMTT) beginning in July 2007, for demanding the national co-financing for the purchase of the driving simulator, it was at the end of 2009 that several working meetings with the Chairman of the IMTT took place to point out the importance of installing this equipment in Coimbra (in the centre of the country). Due a change of opinion concerning the national financing, these initiatives and others during 2010 had no positive results, reason for which the Municipality and SMTUC[21] opted to establish a loan contract to cover the remaining part of the simulator financing not supported by CIVITAS. This resulted in a prolonged administrative and bureaucratic process, due in large part to the greater control carried out by the National Court of Accounting due the national financial crisis. The consequent delay and the need to carry out a correct evaluation obliged the extension of the measure for another 4 months despite the recovery actions undertaken.

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Barrier 1.1 – Technological Barrier** – The lack of know-how and experience about state-of-the-art on driving simulators for public transport vehicles, due the reduced number of this type of equipment installed at European level, made the work for the specifications and for the design of the driving simulator, as well as the tender procedures, more difficult.

- **Barrier 2.1 – Financial Barrier** – The lack of co-financing by the national government for the driving simulator purchase obliged SMTUC and Municipality to carry out a loan contract to assure the needed funds for the driving simulator purchase. The already prolonged time-expensive administrative and bureaucratic procedures for this effect and for the international tender have been aggravated by the financial national crisis. In fact the time lost with the process for the 2 stages of validation by the National Court of Account have been too much and added to aggravate important delays, despite the recovery actions undertaken.

Implementation phase

[21] Urban Public Transport Operator owned by the Municipality of Coimbra

- **Barrier 2.1 – Technological Barrier** – SMTUC opted for the construction of new buildings for the Driving Centre and for the installation of the driving simulator because the existing facilities did not have the conditions to support the technical requirements that the high technology imposed. SMTUC opted for the installation of pavilions to allow a simpler and more cost-effective process, But the initial company responsible for the installation of the main pavilion abandoned the process, obliging SMTUC to carry out a new procedure for the effect. This problem caused some delays that didn't have an influence in the driving simulator installation because SMTUC carried out recovery actions.

Operation phase

- **Barrier 3.1 – Problem related Barrier** – The driving training sessions on the SMTUC driving simulator began with a great delay (26th June 2012) due to the accumulated problems referenced in the formers barriers. Despite the extension of the measure duration, the remaining time for the evaluation of the measure impacts (less than 4 months) was too short to allow a correct assessment to the change in the SMTUC drivers behaviour.

- **Barrier 3.1 – Technological Barrier** – The driving condition in this kind of simulators implied some time of adaptation, otherwise the trainees could become sick. If this phenomenon occurs all the future training activities for these drivers could be put in risk, as well as the image of the training activities with driving simulator.

D.2.2 Drivers

Preparation phase

- **Driver 1.1 – Technological Driver** – The possibility of visiting other driving simulators in this phase, namely due to the good relationship between SMTUC and the Transport Public Operator of Madrid (EMT) or the Portuguese Association of Public transport Operators (ANTROP), both owners of this kind of equipment.

- **Driver 2.1 – Financial Driver** – Despite the financial crisis in Portugal and the lack of national co-financing, SMTUC and Municipality decided to assume alone the financing of the major part of the driving simulator purchase, establishing a loan contract for this effect. The availability of CIVITAS funds and the desire of SMTUC to respect their commitments with the MODERN project also helped the decision. Also important could be the availability of income in the future coming from the training of drivers from other companies that need to comply with the European Directive 2003/59.

Implementation phase

- **Driver 2.1 – Involvement Driver** – The involvement and motivation of the SMTUC technicians and the great cooperation between SMTUC and the driving simulator supplier has been a great aid for the recovery actions needed during the implementation process.

Operation phase

- **Driver 3.1 – Organisational Driver** – Despite the difficulty of having drivers available for the training activities, in great part due the economical crisis in Portugal that didn't allow the reinforcement of more drivers, SMTUC made all the efforts to grant some drivers to the referred activity.

- **Driver 3.2 – Technological Driver** – During the visits to the Driving Centre of EMT SMTUC technicians also had training in the planning of the training sessions in driving simulator, as well as the risks that could appear and the best way to solve them.

D.2.3 Activities

Preparation phase

- **Activities 1 – Technological Activities** – Taking into consideration the lack of knowledge of the SMTUC technicians on driving simulators technology (barrier 1.1) and the possibility of visiting other driving simulators (driver 1.1), visits were carried out to the driving simulator for heavy vehicles in Porto (ANTROP) and the driving simulators for public transport buses in the Transport Public enterprise of Madrid (EMT), helping SMTUC technicians to acquire experience in this equipment, as well as to better set-up the measure implementation and the specifications for the driving simulator.

- **Activities 2 – Financial Activities** – To combat the lack of co-financing by the national government (driver 1.2) and taking advantage of the good involvement in the measure of the Municipality and SMTUC (driver 1.2), it was decided to carry out a loan contract to grant the remaining funds that were needed for the purchase of the driving simulator. For this decision also contributed the fact that in the future this investment could be covered by income from the training of drivers of other companies that need to comply with European Directive 2003/59 (that binds the continuous driver education - 35 hours each 5 years - recommending that this should be made by state-of-the-art simulators). For this reason partnership with several stakeholders are being analysed.

Implementation phase

- **Activities 3 – Involvement Activities** – Taking advantage of the good involvement and motivation of the SMTUC technicians (driver 2.1), a rigorous planning and monitoring of the installation of the pavilions for the Driving Centre has been carried out, avoiding that some of the delays in the beginning of this process (barrier 2.1) could affect the installation of driving simulator. Also the good cooperation with INDRA, the developer of the driving simulator (driver 2.1), contributed to the success of this issue, because great part of the work of equipment assemblage has been made in the manufacturer site, instead of the final place in the SMTUC Driving Centre.

Operation phase

- **Activities 4 – Problem related Activities** – The remaining time for the evaluation of the measure impacts (less than 4 months) was too short to allow a correct assessment to the change in the SMTUC drivers behaviour (barrier 3.1). Taking advantage of the SMTUC willingness to comply with their commitments, putting available drivers for the training activities (driver 3.1), it was decided to set-up a reference group of 25 of the 280 SMTUC drivers to have the time to evaluate the impacts of the driving training sessions that began on 26th June 2012. This methodology allowed to have more intensive training sessions in the driving simulator and assess the drivers' behaviour modifications in a shorter time span.

- **Activities 5 – Planning Activities** – Taking into consideration that the driving conditions in the simulator obliged to have some time of adaptation to avoid risks of less acceptance from the trainees (barrier 3.2), SMTUC used the experience acquired in the training activities during the visits to the Driving Centre of Madrid (driver 3.2) and made a rigorous planning of the training activities, namely by stipulating that the first session for each driver must be inferior to 3 minutes and in favourable driving conditions (without passengers, less traffic, large streets and good weather conditions).

D.3 Participation

D.3.1 Measure partners

- **Measure partner 1 - Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Leading role**

SMTUC was responsible for the coordination of the activities of the measure, the work of research, knowledge acquisition and planning of the measure implementation. Also SMTUC conducted the setup of the measure and it implementation, namely by the purchase of the driving simulator and the accomplishment of it installation in SMTUC site.

The training activities, including the ones related to the reference group of 25 drivers, has been also carried out by SMTUC.

The data collection regarding the evaluation was also collected and provided by SMTUC.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC); City; Principle participant**

The Municipality together with SMTUC assumed a loan contract for the financing of the driving Simulator purchase.

Also the Mayor, the Councillor for Mobility, and technicians from the Municipality visited the driving simulator together with the media, helping SMTUC to promote the driving simulator.

Since October 2011 the Municipality has been also responsible for the dissemination of the CIVITAS MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

  PRODESO was responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

  PE was the partner responsible for the evaluation of this measure, namely analysing data and results, as well as providing the related reports.

D.3.2 Stakeholders

- **Stakeholder 1 – General Public –** The general public will benefit from more safety and economic driving behaviour of the transport public drivers after the training sessions in the driving simulator.

- **Stakeholder 2 – INDRA** – This company was the responsible for the development and installation of the driving simulator, as well as the initial training for the trainers and maintenance personnel of SMTUC **(**www.indracompany.com).

- **Stakeholder 3 – Associação Nacional dos Transportadores Rodoviários de Pesados de Passageiros (ANTROP)** – The National Association of the Road Public Transport Operators allowed SMTUC to visit their driving simulator and is analysing the possibility to establish a partnership with SMTUC with the objective of licensing and provide training in the SMTUC driving simulator (www.antrop.pt).

- **Stakeholder 4 – CarrisTur** – Carristur, that is owned by Carris, the Urban Public transport of Lisbon, is also responsible for a training service. Carristur provide to SMTUC a proposal for a partnership with the objective of licensing and provide training in the SMTUC driving simulator (www.carristur.pt).

- **Stakeholder 5 – Empresa Municipal de Transportes de Madrid (EMT)** – The Municipal Public Transport operator of Madrid allowed SMTUC to visit its Driving Centre and experienced the driving simulators, as well as provided training to the SMTUC trainers and important information to all the participants, including the measure leader. (www.emtmadrid.es).

- **Stakeholder 6 – Public Transport Operators** – The drivers of the public transport operators were a target group for the training activities in the SMTUC driving simulator.

- **Stakeholder 7 – Media** – Media has been a channel for the dissemination and promotion of the measure and all the events organized had the participation at least of the local media.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **Preparation of Drivers –** The use of the high tech simulator implies a period of physical habituation in order for drivers to take complete advantage of its potential. Accordingly, the first sessions should be limited to periods under three minutes so that the drivers can get used

to the simulation environment. The length of time that drivers use the simulator can be gradually augmented as the various sessions progress.

- **Adapt the physical space to the specifications of the simulator -** The simulator is high powered equipment which generates a high amount of heat. The physical space were the simulator is located should be prepared with air conditioning systems which can contribute to creating the best possible training environment.

- **Visits to already implemented driving simulators –** Visiting already implemented driving simulators and changing experiences with training Centres equipped with this tools is recommended because many times the idea predefined about this equipment is very different of the reality and with important technological complexity.

- **Taking advantage of the European Directive 2003/59 –** The European Directive 2003/59, which establishes continuous driver education (35 hours every 5 years), recommending the use of high-tech driving simulators, could be an important driver for the profitability of the investment.

D.4.2 Recommendations: process

- **Plan and integrate potential partners at the earliest stage possible –** The creation of a training centre which envisions the participation of other companies and partners demands that contacts and negotiations begin at the earliest stage possible. In order to reap the benefits of the investment the company which owns the simulator should begin involving other companies and partners from the start-up of the simulator, otherwise it will lose valuable time afterwards.

- **Guarantee funding before beginning the acquisition process –** The high investments involved in the acquisition of a high tech simulator such as the one purchased in Coimbra demands that all the financial funding be sorted out and defined from the beginning of the decision process in order to avoid delays in securing the financial resources while the process is on-going.

Annex 1: (Survey Form)

Driving Center | Questionnaire to SMTUC drivers

Question 1: Do you know that SMTUC has the intention to implement a Driving Training Center equipped with a high technology driving simulator (with a real and dynamic driving seat and capable of simulating passengers interaction)?

☐ Yes ☐ No

Question 2: What is your opinion about the use of high technology driving simulator for the purpose of training bus drivers?

☐ Favorable ☐ Unfavorable

M06.03 – Executive summary

This measure comprises the elaboration of a technical and economic feasibility study to set up a car sharing service in Coimbra, including the development a state of the art report and technical and economic feasibility study to set up a car sharing service. This study will assess the "acceptability" among stakeholders and potential users, develop a business plan for implementing a car sharing service, as well as compromise the Planning and Implementation of a communication campaign and dissemination of the end results.

The innovation of this measure is very relevant because will contribute to a greater sustainability of local and regional of PT. More precisely, the study proposes the introduction of an innovative transport solution (electric vehicles) that is unique in the region (car-sharing) and which will imply the direct involvement of the Municipality and the Urban public PT operator (SMTUC) thus promoting the integration with the rest of the public transport services and products and improving the use of the Municipal PT fleet.

The feasibility study prepared within the CIVITAS MODERN period concluded that this measure is feasible at a relatively low cost and has the potential to generate revenues that support the operation and permit the gradual recovery of the investment.

The results of the measure indicate that in a short period of time the operational car-sharing system could generate positive impacts over the balance between the operating revenues and the operating costs (+ 0.04 €/vkm), the vehicle fuel efficiency (-0,84 MJ/vkm), and vehicle fuel emissions (-10 ton CO2 per year).

The development of the study demonstrated that:

- car sharing services are very important in cities that want to have an integrated mobility system, being an important complement to the public transport network.
- If institutional fleets are to be used in supplying the system, a previous assessment of the car usage by the current users of the fleet is strongly recommended.
- launching the service with the use of a reduced fleet, based on comparisons with the usage of similar services in other cities, is a good alternative to launching of a large scale service based on expensive and unrealistic demand potential assessments through surveys.
- The involvement or commitment of the key decision-makers in the implementation of a new system, especially in certain cultural settings or where there is a general lack of knowledge, is very important in order to identify problems and anticipate recovery actions, e.g., to avoid delays or irreversible consequences.

A Introduction

A1 Objectives

The measure objectives are:

(S) High level / longer term:

- To decrease the city traffic levels in the city;
- To improve the city air quality;
- To reduce dependence on fossil fuels.

(T) Strategic level:

- To increase the number of trips made in a sustainable way over the use of private car.

(U) Measure level:

(1) To release a feasibility study of new mobility services, mainly that concerns car sharing exploited by "clean" fleets and pre-existent cars from the municipality;

(2) To reduce the emission of greenhouse gases in Coimbra in case of real implementation of the measure.

A2 Description

This measure is a technical and economic feasibility study made in order to set up a car sharing service in Coimbra as a pilot case in Portugal. Similar services are only beginning to be implemented in Lisbon and Oporto.

The proposed action fully complies with the strategy of the City of Coimbra which seeks to improve the public transport system. The strategy aims not only at improving the more traditional mobility modes and methods, but also to offer citizens new forms of complementary public transport such as can be car sharing, car pooling, and DTR services.

The study was carried out to evaluate the feasibility of a car sharing service in Coimbra, but simultaneously several dissemination activities have been developed to test the acceptability of this concept amongst stakeholders and potential users in Coimbra, as well as to test its implementation in other cities in Portugal.

The innovative features of this service in the Portuguese context justified the need of a brief review of state of art, in order to understand how the existing car sharing schemes in other countries can be applied to Coimbra and other Portuguese cities with minimal adaptations, since the basic technology, know-how, software and experience exist in several EU countries and have been applied through several EU projects, such as MOSES, and is part of the CIVITAS projects. This aspect constituted the first part of the measure development.

However, this study has not simply adapted other pre-existent concepts and policies. It has created its own innovation by directly involving the municipality to implement a special type of 'mixed' car sharing service that includes cars from the municipality in the fleet, significantly reducing therefore the initial cost of the implementation of the service. These municipal cars will be available not only to the car sharing customers during working days after working hours, and during weekends and

holidays, but also they will be available during working hours, which will oblige the civil servants to use the car sharing service as a fleet management service of the municipality. This study forecasts that the car sharing service can be initiated with the introduction of 5 vehicles from the municipality, with an average age of 12 years. Four of the vehicles are diesel motors (2 + 2 compact urban dwellers) and one is a gasoline motor (urban).

Moreover, in terms of the car sharing fleet, the study - besides the proposal of procurement procedure and selection of suitable fleets - considers the car sharing fleet to be partly composed by clean vehicles (5 electric cars urban type), requiring in this case an initial investment to implement the service. So the entire car-sharing fleet in a first phase will be constituted by 10 vehicles, 5 from the municipality fleet and 5 new electric cars (175000 € of investment, including equipment associated with the service). These vehicles will be placed in 5 car-sharing parking stands (Fig. A.2.1), whose location in the city was chosen using the combination of several criteria.

Fig. A.2.1 – The 5 car sharing parking locations

The study comprises all relevant elements for contracting, procurement, implementation, and monitoring the car sharing service.

The study also presents the analysis of several scenarios for the service implementation, concluding that the most recommended for the initial phase would be the scenario that considers 25 member per vehicle with 3 average bookings/monthly trips. In this scenario an average monthly offer of 11250 v/km, which implies an annual consumption of 152618 MJ, is expected. Concerning the economic impact per year, the operating costs of the service will be 99590 € and the operating revenues are expected are 105296 €. In terms of the environmental impact the CO2 and particle emissions is expected to decrease from 10,3 ton to 7,8 ton.

The articulation with other public transport supply (public and private, including taxi services and fare integration possibilities) was also analysed. The new e-ticketing system, implemented in the scope of

the CIVITAS MODERN measure 02.05, already has the capability to integrate a future car-sharing service in the existing e-cards.

Promotional and communication campaigns were organized, namely the setting-up of meetings with other car sharing operators and experts. A workshop was organized on 7th June 2011 during the 3rd CIVITAS MODERN Official Event in Coimbra, with the participation of the Director of Iniziativa Car Sharing of the Environmental Ministry of Italy (Marco Mastretta) and with presentations from other experts from the University of Coimbra and car-sharing services from Lisbon and Brescia as well as the communication of the Municipality expectations by the Councillor for Mobility of the City of Coimbra. Several technicians from the Municipality and SMTUC participated in this workshop.

Also relevant for the evaluation of the "acceptability" of the service among stakeholders and potential users, a demonstration activity of a car-sharing service was organized on 22nd September 2011, during the European Car Free Day in Coimbra. This activity had the attendance of the Mayor of Coimbra, stakeholders, media and public in general. The event included explanations about the system, trips in a hybrid car of the "MOB Car-Sharing" Service of Lisbon, presentation of the study and an opinion survey about the system. A stakeholder survey about the activities during the European Mobility Week was also carried out by the Municipality and the car-sharing demonstration had the note 4,0 in a scale from 1 to 5.

The success of this measure (a feasibility study) can be judged by the results of the "acceptability" test among stakeholders and potential users in Coimbra and selected other cities in Portugal and through the monitoring of the dissemination activities and the seminar series at university and other educational institutions. The ultimate success of the measure would be if Coimbra or another Portuguese city, as a result this feasibility study and of the dissemination efforts, would undertake a pilot demonstration project.

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **New mode of transport exploited, regionally**
    - The car sharing service represents by itself an innovative mobility service for the Coimbra region because in Portugal only Lisbon and Oporto are implementing a car sharing system,.
- **New policy instrument, regionally**
    - The study considered the car sharing fleet to be partly composed by clean vehicles (electric), which is in line with the municipality policy for improving city air quality and reducing the dependence on fossil fuels.
- **New conceptual approach and targeting specific user groups, nationally**
    - The development of a of mixed car sharing service directly involving the Municipality and Municipal services like SMTUC –: foresees the exclusive availability of part of the Car Sharing fleet during working hours for the Municipality services. These cars will be available to other car sharing customers for the remaining hours of the day (the major part of the rush

hours) and during weekends and holidays. In case of success, the idea could be extended to other entities;

- As a service implemented by the public transport operator, it is integrated with the rest of the public transport products, namely smart cards, monthly passes, etc.

B2 Research and Technology Development

Being a feasibility study no demonstration was expected in the measure, despite the possibility of future implementation of car sharing. Accordingly, all the work developed was focused on research and technology development, according to the measure description, with the exception of the parts concerning the dissemination and evaluation activities.

B3 Situation before CIVITAS

Until 2008, no **car sharing** study was ever undertaken in Portugal, and the concept is sparsely known, even among professionals and municipal managers and employees. Car sharing services exist in Lisbon and Porto, but they have limited dissemination. Only the Public Transport provider of Porto (STCP) is member of the UITP car-sharing platform.

Even **car pooling** is not practised in an organized way. The EU project Mobils (DGTren, 6th FP) tested car pooling in Lisbon hospitals (and some in the partner cities Barcelona and Toulouse). Some trials are presently occurring in the Lisbon region in an INTERREG project (MARE).

Even **flexible public transport** services are exceptional, the municipality of Beja (In the Southern region of Portugal) being one of the exceptions, with a shared taxi service in the rural areas of the municipality (since 2000).

With the measure, both the results of the study, as well as the results of the dissemination campaigns, will contribute to a change of mentalities and to greater involvement of the stakeholders, increasing the acceptance level for this new mobility service. The Municipality became more participative in this issue. Accordingly, one of the objectives that the measure aims to achieve is make people aware about the benefits of using an innovative model for mobility, i.e., using electric vehicles, that should take advantage of the electric charging infrastructure that is already implemented in Coimbra.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: State of the art report and technical and economic feasibility study to set up a car sharing service *(April 2011-October 2011) – During this stage the research activity to access the state-of-the-art of new mobility services was carried out, with special attention paid to car sharing, and developed of a technical and economic feasibility study to set up this last kind of service. The work undertaken consisted mainly in:*

- *Knowledge acquisition on new mobility services, mainly those linked to the car-sharing and the bike-sharing, by researching the thematic literature and dedicated Internet websites;*
- *Meetings with other car sharing operators and experts;*

- *Participation of technicians from the Municipality and SMTUC in workshops, namely on 7th June 2011 during the 3rd CIVITAS MODERN Official Event in Coimbra, performed by the Director of Iniziativa Car Sharing of the Environmental Ministry of Italy and with the intervention of experts from the University of Coimbra and car-sharing services from Lisbon and Brescia as well as the communication of the Municipality expectations by the Councillor for Mobility of the City of Coimbra (Fig. B4.1)*;

Workshop on Car-Sharing performed in Coimbra by Marco Mastretta, Director of ICS (left) and with the speech of experts from the University of Coimbra and car-sharing services from Lisbon and Brescia and the Councillor for Mobility of Coimbra City (right)

Figure B4.1 - Workshop in Coimbra

- *Data research and collection for the development of the study;*
- *Analysis of some opinions received from experts;*
- *Site visits to other car-sharing operators;*
- *On July 2011 the working document reporting the state-of-the-art research was released at internally. Later this document was integrated with the feasibility study.*
- *Development and release of a study and implementation plan for a bike-sharing service in Coimbra (this issue was an additional achievement taking in attention that it wasn't foreseen in the DoW of CIVITAS MODERN);*
- *Visit of the Councillor for Mobility of the City of Coimbra and technicians from the Municipality and SMTUC to the "MOB Car-Sharing" of Carristour - Lisbon, that also included a work meeting with the Board of Directors and technicians of Carristour;*

In September 2011 a document integrating the state-of-the-art report and the technical and economical feasibility study was also delivered.

Stage 2: Results of the "acceptability" test among stakeholders and potential users *(September 2011 – April 2012) – The "acceptability" of the service among stakeholders and potential users was assessed through the following steps:*

- *First internal analysis of a draft of the study in SMTUC between the end of August and the first week of September 2011.*
- *On 22nd September 2011, during the European Car Free Day in Coimbra, a demonstration activity of a car-sharing service with the attendance of the Mayor of Coimbra, stakeholders, media and public in general was carried out (Fig. B4.2). The event included an explanation about*

the system, travel in a hybrid car of the "MOB Car-Sharing" Service of Lisbon, presentation of the feasibility study and collection of the opinion about the system. A stakeholder survey about the activities during the European Mobility Week was carried out by the Municipality and the car-sharing demonstration received a grade of 4,0 in a scale from 1 to 5. The event also included a bike-sharing demonstration.

Mayor of the City of Coimbra promotes new mobility services during the European Mobility Week – Press conference over the river in the middle of the pedestrian bridge (top), experiencing bike-sharing from the Infomobility Centre to the Municipal Market (bottom left) to assists the car-sharing demonstration (bottom right).

Figure B4.2 - Mobility services promotion

- *Other dissemination activities about car sharing had important feed back, namely from the municipalities or public transport operators.*

Stage 3: Development of a business plan for a car sharing service (*October 2011 – June 2012) –a business plan to set up a car sharing service in Coimbra was developed that consisted mainly in the following:*

- *Literature review focusing on the features of other (existing) car sharing services, in order to identify key indicators of these systems, such as number of cars, number of members, number of stations, and relations between these indicators, e.g. number of cars per station, members per car, etc.*

- *Analysis of the Portuguese car sharing services, namely in Lisbon and Oporto, in order to identify the key features of the systems and the actual awareness.*

- *Identification of the key features of a car sharing system, namely its objectives, roles, limitation, and principal market.*
- *Brief characterization of the demographic features of Coimbra, to identify the potential users of the system.*
- *Brief characterization of the land use and mobility features of the city of Coimbra, in order to identify the key places for the location of the stations.*
- *Analysis of the existent public transport systems and their major features (extension, number of passengers, etc.)*
- *Identification of key places for the location of the stations.*
- *Determination of the fleet dimension and characteristics.*
- *Determination of the proposed fees.*
- *Technical issues regarding the proposed management system, on-board hardware, reservation processes.*
- *Indication of the strategy to be followed in order to implement the system in Coimbra, if the municipality decides to do it.*
- *Identification of potential partners for the system.*
- *SWOT analysis.*

Stage 4: Planning of the promotional and communication campaigns (*September 2011 – April 2012) –Initial planning for the activities of the European Car Free Day in Coimbra reported in stage 2 was carried out. Another campaign to present the business plan for a car sharing service to the stakeholders was planned, with emphasis on the municipalities, universities, car sharing operators and public transport operators. During the planning phase 2 methodologies were foreseen. The first was to integrate the campaign in the Annual Meeting of Cities with Public Transportation Services. Later this annual Meeting was postponed, making it impossible to carry out this methodology for the campaigns. Therefore the other solution was the delivery of a presentation of the business plan to the stakeholders. The organization of a webinar or teleconference in September 2012 are in discussion, but it will be an additional achievement to the project.*

Stage 5: Promotional and communication campaign and dissemination of the results (*June 2012) – In June 2012 the presentation of the business plan to set up a car sharing service in Coimbra was delivered by e-mail to the stakeholders. The target group consisted mainly of the municipalities, universities, car sharing operators and public transport operators. contacts with some PT operators and Municipalities to assess results about their opinion and acceptability was carried out and the results were later sent to the stakeholders. A deliverable with the final report, including the business plan and the results of the acceptability and promotional and communication campaigns, was released. A press release was also delivered to the media with the main outputs of the measure. The study was placed on-line on the site of the National Institute of Mobility and Inland Transportation.*

B5 Inter-relationships with other measures

Taking into account that the measure is a feasibility study, no inter-relationship with other measures are foreseen during CIVITAS MODERN implementation, especially in terms of measurable impacts.

If the measure would come to be implemented it could generate impacts at modal split level as well as Measures 02.05, 04.02, 04.05 and 08.03.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.4.1 – Impacts and Indicators for the measure

No.	Impact	Indicator	Data used	Comments
1	Operating Revenues	Average Operating Revenues	Total operational revenues from the operation of the car sharing service; Total vehicle-km	Feasibility study scenario
2	Operating Costs	Average Operating Costs	Total operational costs expended with operation of the car sharing service; Total vehicle-km	Feasibility study scenario
3	Costs	Capital Costs	Total capital costs expended in setting up the measure	Feasibility study scenario
4	Fuel consumption	Fuel Mix	Energy consumption for the fuel considered; Total energy consumed	DGEG – General Directorate for Energy and Geology
5	Fuel consumption	Vehicle fuel efficiency	Total energy consumed; Total vehicle-km	DGEG and Manufacturer information about the average consumption of each type of vehicles and feasibility study scenario for the usage
6	Emissions	CO Emissions	Fuel type; Annual consumption; Type and number of vehicles; Vehicle-km	Manufacturer information about the emissions of each type of vehicles and feasibility study scenario for the usage
7	Emissions	CO2 Emissions	Fuel type; Annual consumption; Type and number of vehicles; Vehicle-km	Manufacturer information about the emissions of each type of vehicles and feasibility study scenario for the usage
8	Emissions	NOx Emissions	Fuel type; Annual consumption; Type and number of vehicles; Vehicle-km	Manufacturer information about the emissions of each type of vehicles and feasibility study scenario for the usage
9	Emissions	PT Emissions	Fuel type; Annual consumption; Type and number of vehicles; Vehicle-km	Manufacturer information about the emissions of each type of vehicles and feasibility study scenario

				for the usage
10	Emissions	HC Emissions	Fuel type; Annual consumption; Type and number of vehicles; Vehicle-km	Manufacturer information about the emissions of each type of vehicles and feasibility study scenario for the usage

This measure consists in the elaboration of a feasibility study for the setup of a car sharing service in Coimbra. The implementation of the measure includes the definition of the methodology to determine the potential costs and benefits concerning the "Feasibility Study of New Mobility Services in Coimbra" and the estimation of those costs and benefits according to the defined methodology. No practical action will result from this measure during the CIVITAS project. Therefore, the concept of impact evaluation is not straightforward resulting in the fact that only potential impacts of the measure may be derived from the study.

In relation to the scenario to set up the car sharing service, in the feasibility study, and related evaluation effects, a fleet composed by 10 vehicles in 2 groups (conventional plus electrics) has been considered. For the conventional vehicles 5 vehicles will be available: 4 diesel (2 urban + 2 compact) and 1 gasoline (urban). For the electric group, 5 vehicles would be purchased for the service.

In relation to the trips, the feasibility study considers an average extension of 15 km with duration of 2 hours. The scenario chosen to perform the impact evaluation corresponds to the situation in which the car sharing system would have 25 members/vehicle with each of its users performing an average of 3 Reservations / Trips per Month.

Detailed description of the indicator methodologies:

- **Indicator 1** (*Average Operating Revenues*) – Ratio of total income generated from car sharing service divided by the total vehicle-km per year (€/vehicle-km).

  A = B / C

  where: A = Average operational revenue for the service (€/vehicle-km)

  B = Total operational revenue, coming from the sales of the car sharing service (€)

  C = Total vehicle-km

  All data is related to the car sharing service and fleet. The vehicle-kilometres and the operational revenues for the car sharing service are based on the hypothesis considered in the feasibility study.

- **Indicator 2** (*Average Operating Costs*) – Ratio of total operating costs incurred in the operation of the car-sharing system divided by the total vehicle-km per year (€/vehicle-km).

  A = B / C

  where: A = Average operational costs for the service (€/vehicle-km)

  B = Total operational costs incurred in the operation of the car sharing service, including expenditures with the fuel/energy and the maintenance of the vehicles used in the operation of the car sharing service, costs with the personnel necessary for the operation and

management of the service, and rent space necessary for management and administrative activities (€)

C = Total vehicle-km

All data is related to the car sharing service and fleet. The vehicle-kilometres and the operating costs are based on the hypothesis considered in the feasibility study.

- **Indicator 3** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

  Expenditures with the purchase and installation of the equipment (vehicles and infrastructure) that support the operation of the car sharing service and with the development and research related to the planning of the new service (€)

  All data is related to the car sharing service and fleet. The capital costs of the service are based on the hypothesis considered in the feasibility study.

- **Indicator 4** (*Fuel Mix*) – Percentage of the market share of transport fuel for each type of fuel used in a given period (%).

  $A = B / C \times 100$

  where: A = Fuel mix, or percentage for the fuel considered (%)

  B = Total energy consumption for the fuel considered (MJ)

  C = Total energy consumed for all vehicles (MJ)

  All data is related to the trips made by the users of the car sharing service. The energy consumption for these trips is based on the hypothesis considered in the feasibility study.

- **Indicator 5** (*Vehicle fuel efficiency*) – Ratio of energy consumed by the private car and public transport vehicles in the Coimbra metropolitan area divided by the total vehicle-km performed by these vehicles per year (MJ/vehicle-km).

  $A = B / C$

  where: A = Average vehicle efficiency (MJ/vehicle-km)

  B = Total energy consumed in the car sharing service and private car vehicles used on the trips made by the users of the car sharing service (MJ)

  C = Total vehicle-km performed on the trips made by the users of the car sharing service

  All data is related to the trips made by the users of the car sharing service. The vehicle-kilometres and the energy consumption for these trips are based on the hypothesis considered in the feasibility study.

- **Indicator 6** (*CO Emissions*) – Average CO emissions per vehicle-km (g/vehicle-km)

  $A = B / C$

  where: A = Average CO emissions per vehicle-km (g/vehicle-km)

B = Total CO emissions for the vehicles considered (g)

C = Total vehicle-km performed by the vehicles considered

All data is related to the trips made by the users of the car sharing service. The vehicle-kilometres and the emission factors for these trips are based on the hypothesis considered in the feasibility study.

- **Indicator 7** (*CO2 Emissions*) – Average CO2 emissions per vehicle-km (g/vehicle-km)

  A = B / C

  where: A = Average CO2 emissions per vehicle-km (g/vehicle-km)

  B = Total CO2 emissions for the vehicles considered (g)

  C = Total vehicle-km performed by the vehicles considered

  All data is related to the trips made by the users of the car sharing service. The vehicle-kilometres and the emission factors for these trips are based on the hypothesis considered in the feasibility study.

- **Indicator 8** (*NOx Emissions*) – Average NOx emissions per vehicle-km (g/vehicle-km)

  A = B / C

  where: A = Average NOx emissions per vehicle-km (g/vehicle-km)

  B = Total NOx emissions for the vehicles considered (g)

  C = Total vehicle-km performed by the vehicles considered

- All data is related to the trips made by the users of the car sharing service. The vehicle-kilometres and the emission factors for these trips are based on the hypothesis considered in the feasibility study.

- **Indicator 9** (*PT Emissions*) – Average PT emissions per vehicle-km (g/vehicle-km)

  A = B / C

  where: A = Average PT emissions per vehicle-km (g/vehicle-km)

  B = Total PT emissions for the vehicles considered (g)

  C = Total vehicle-km performed by the vehicles considered

  All data is related to the trips made by the users of the car sharing service. The vehicle-kilometres and the emission factors for these trips are based on the hypothesis considered in the feasibility study.

- **Indicator 10** (*HC Emissions*) – Average HC emissions per vehicle-km (g/vehicle-km)

  A = B / C

  where: A = Average HC emissions per vehicle-km (g/vehicle-km)

B = Total HC emissions for the vehicles considered (g)

C = Total vehicle-km performed by the vehicles considered

All data is related to the trips made by the users of the car sharing service. The vehicle-kilometres and the emission factors for these trips are based on the hypothesis considered in the feasibility study.

C1.2 Establishing a Baseline

The year 2007 is considered as the baseline, before the "start of the study" in April 2011.

The measure results are obtained taking into consideration the feasibility study scenario on indicators 4, 5, 6, 7, 8, 9 and 10.

Indicators 1, 2 and 3 (Operating Revenues, Operating Costs and Capital Costs):

The source of the information has been the feasibility study on both the estimated costs and revenues of operating the car sharing system, as well as on the vehicle-km performed by those services

In relation to the ex-ante situation it was considered that before the existence of the service all costs and revenues are equal to zero.

Accordingly, the results of the baseline for each indicator are indicated in the tables C1.2.1 to C1.2.3:

Table C1.5.1 – Indicator 1 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Revenues from the operation of the system	0,00 €
Total vechicle-km	n.a.
Average operating revenue	0,00 €/vkm

Table C1.2.2 – Indicator 2 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total Operational Costs	0,00 €
Total vechicle-km	n.a.
Average operating costs	0,00 €/vkm

Table C1.2.3 – Indicator 3 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total capital cost	0,00 €

Indicators 4 and 5 (Fuel Mix and Vehicle fuel efficiency):

The feasibility study provides information on both the estimated energy consumption related to the car sharing system and the respective vehicle-km.

In relation to the ex-ante situation, it was established that all trips (with potential to be shifted to the car sharing before the implementation of the service) were performed using of the private car.

The fuel mix data source results from the share of the fuel consumption in Portugal in 2007 (source: DGEG – in Annex 1) and was calculated by the ratio of the each fuel type with all types of fuel commercialized in the road transport sector.

The table C1.2.4 shows the baseline for fuel mix.

Table C1.2.4 – Indicator 4 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Fuel Mix – Diesel	74,5%
Fuel Mix – Gasoline	25,2%
Fuel Mix – GPL	0,4%
Fuel Mix – Electricity	0,0%

The vehicle fuel efficiency was calculated by the ratio between the energy consumption considering the trips made by private car and the total vehicle-km estimated per year in the feasibility study scenario.

The energy consumption was calculated by a weighted average given by the following expression:

A = B x C1 x D1 + B x C2 x D2

where,

A = Energy consumption (MJ)

B = Estimated Annual Fuel Consumption (l)

C1 = Gasoline Fuel mix (%)

D1 = Energy density for Gasoline (MJ/l)

C2 = Diesel Fuel mix (%)

D2 = Energy density for Diesel (MJ/l)

The values of Fuel Mix are in table C1.2.4 and the values of the energy density are displayed in Annex 3.

The estimated annual fuel consumption (A) is calculated in accordance with the following expression:

A = B1 X C1+ B2 X C2

A = Estimated Annual Fuel Consumption (l)

B1 = Distance (vehicle-km) driven by private cars with potential to be shifted with the car sharing implementation according the feasibility study scenario for the city cars (vkm)

C1 = Fuel consumption of urban cars (l/100 km)

B2 = Vehicles-Km made by private cars with potential to be shifted with the car sharing implementation according the feasibility study scenario for the compact cars (vkm)

C2 = Fuel consumption of compact cars (l/100 Km)

The values of the distance (vkm) were calculated by using the considered trip scenario (15 vkm X 25 members per vehicle X 3 Average trips per month X 12 months = 13.500 vkm) multiplied by the number of each car type (5 urban cars and 5 compact cars in the baseline);

The values of the Fuel consumptions per car types are considered in table C2.1.4, that is the urban combustion is 6,0 l/100km, the compact combustion is 7,0 l/100km and the urban electric is 15 kWh/100km.

The results of the baseline for each indicator are shown in the table C1.2.5.

Table C1.2.5 – Indicator 5 – Ex-ante

Indicators and respective parameters	Ex-Ante values
Total Energy Consumption	289.435 MJ
Total vechicle-km	135.000
Vehicle fuel efficiency	2,14 MJ/vkm

Indicators 6, 7, 8, 9 and 10 (CO, CO2, NOx, PT, and HC emissions):

The source of the information has been the feasibility study on the estimated emissions related to the car sharing system and the respective vehicle-km. The study considered the following emission factors (g/vkm) for each type of vehicle based on the manufacturers information about each type of vehicle (table 1.2.6).

Table C1.2.6 – Indicators 6, 7, 8, 9 & 10 – Emissions Factor

Emission Factor (g/km)	Urban	Compact
NOx	0.08	0.09
HC	0.10	0.12
CO	1.00	1.17
PT	100.00	125.00
CO2	139.00	162.1

In relation to the ex-ante situation it was considered that all trips (with potential to be shifted to the car sharing before the implementation of the service) were performed using private cars.

The ex-ante emissions scenario per vkm results from the balance of the emissions per vehicle type, taking into consideration the vkm foreseen for each car type in the feasibility study scenario (15 vkm x 25 members per vehicle x 3 Average trips per month x 12 months = 13.500 vkm) multiplied by the number of each car type (5 urban cars and 5 compact cars in the baseline).

The results of baseline for each indicator are indicated in the table C1.2.7:

Table C1.2.7 – Indicators 6, 7, 8, 9 & 10 – Ex-Ante

Indicators and respective parameters	Ex-Ante values
CO emissions	1,08 g/vkm
CO2 emissions	150,57 g/vkm
NOx emissions	0,09 g/vkm
PT emissions	112,50 g/vkm
HC emissions	0,11 g/vkm

C1.3 Building the Business-as-Usual scenario

Indicator 1 (Average Operating Revenues)

The change in the Operating Revenues related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the Operating Revenues would be as before. It was established that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The next graph (Fig. C1.3.1) shows the evolution of the Average Operating Revenues (€/vKm) obtained for the B-a-U scenario:

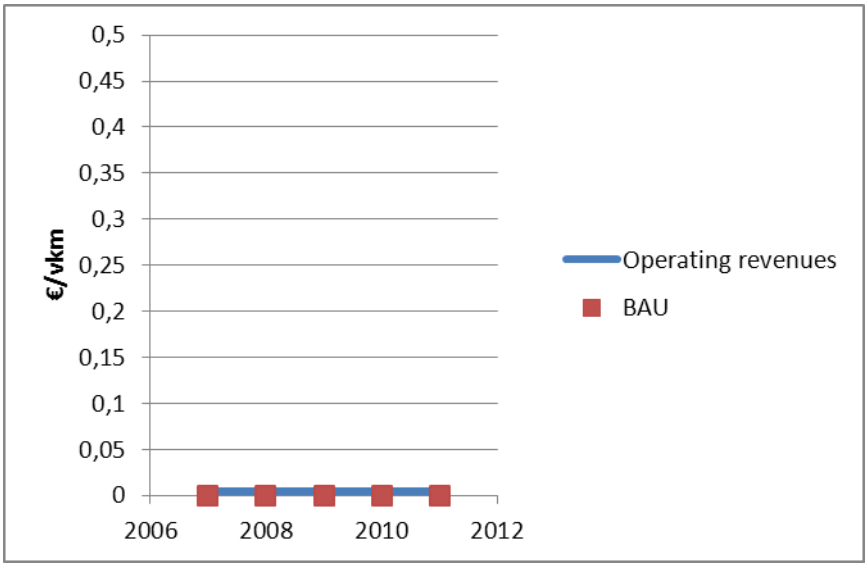


Figure C1.3.1 - Operating revenues

Therefore, the results of BAU scenario for this case are the folowing (table C1.3.1):

Table C1.3.1 – Indicators 1 – BAU

Indicators and respective parameters	BAU Values
Average operating revenue (2008)	0,00 €/vkm

Average operating revenue (2009)	0,00 €/vkm
Average operating revenue (2010)	0,00 €/vkm
Average operating revenue (2011)	0,00 €/vkm

Indicator 2 (Average Operating Costs)

The change in the Operating Costs related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the Operating Costs would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The following graph (Fig.C1.3.2) shows the evolution of the of the Average Operating Costs (€/vkm) obtained for the B-a-U scenario:

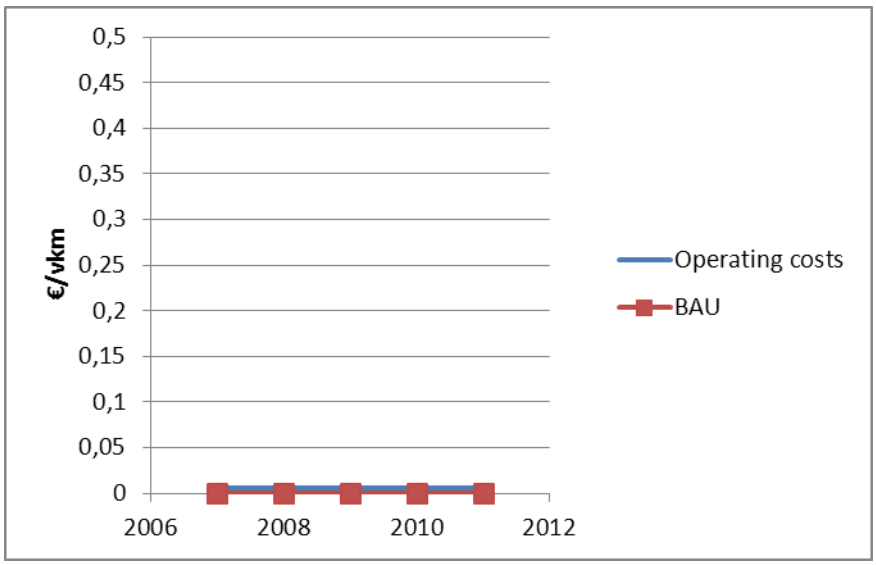


Figure C1.3.2 - Operating costs

Therefore, the results of BAU scenario for this case are shown in the table C1.3.2.

Table C1.3.2 – Indicators 2 – BAU

Indicators and respective parameters	BAU Values
Average operating costs (2008)	0,00 €/vkm
Average operating costs (2009)	0,00 €/vkm
Average operating costs (2010)	0,00 €/vkm
Average operating costs (2011)	0,00 €/vkm

Indicator 3 (Capital Costs)

The change in the capital costs related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the capital costs would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The following graph (Fig. C1.3.3) shows the evolution of the Capital Costs (€) obtained for the B-a-U scenario.

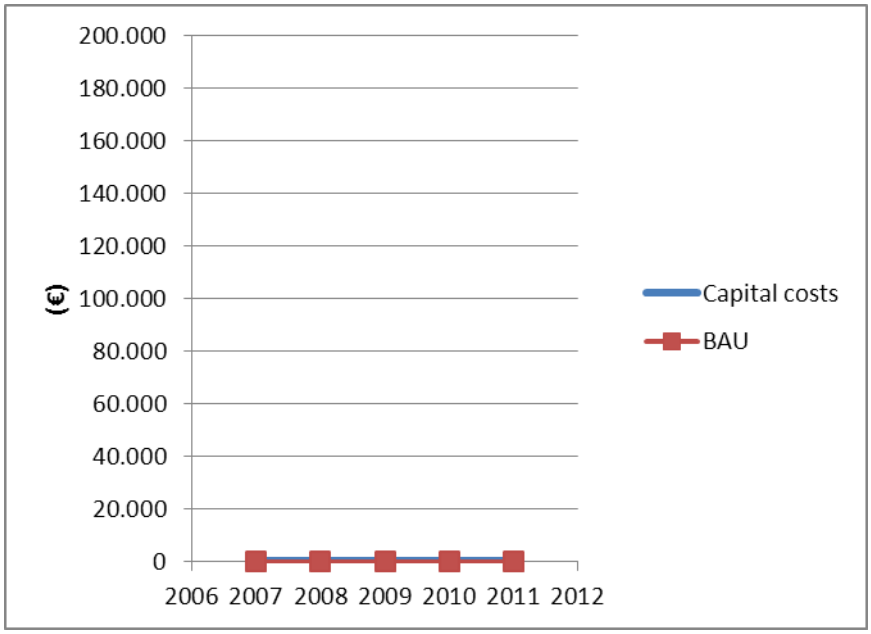


Figure C1.3.3 - Capital costs

Therefore, the table C1.3.3 shows the results of BAU scenario for this case.

Table C1.3.3 – Indicators 3 – BAU

Indicators and respective parameters	BAU values
Total capital cost (2008)	0,00 €
Total capital cost (2009)	0,00 €
Total capital cost (2010)	0,00 €
Total capital cost (2011)	0,00 €

Indicator 4 (Fuel Mix)

In order to determine the B-a-U scenario for this indicator, the available data about the evolution of the Share of different fuels (diesel, gasoline) in the Fuel consumption in Portugal has been used because there is no data available at local level and because it was possible to obtain data at the national level since 2004 (for further details, read Annex 1 Fuel Mix Data). Thus, it is possibile to extrapolate for the next few years (BAU 1).

Considering that the evolution of the series obtained is independent from the measure and considering that this measure had no real implementation, in order to determine the B-a-U scenario for this indicator for the period 2008-2011 the actual data about the fuel mix has been used (BAU 2 that is equal to BAU1).

The B-a-U scenario for the indicator Fuel Mix (%) is presented in the following graph (ex-ante untill 2007 and BAU2 from 2008 to 2011):

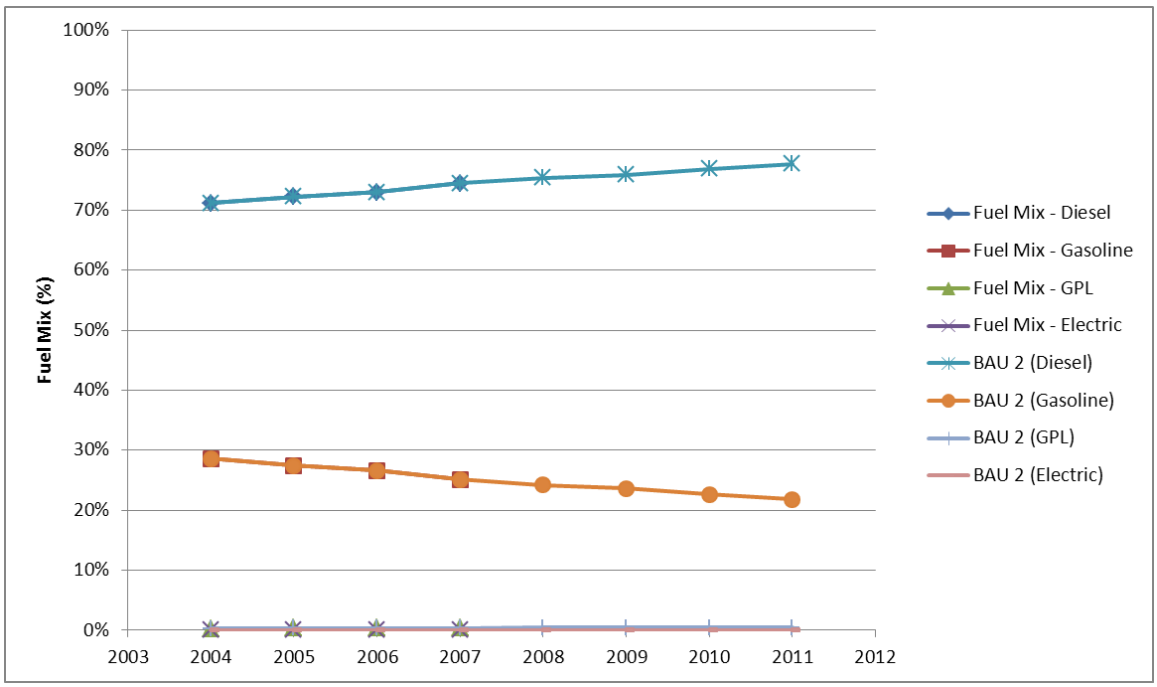


Figure C1.3.3 - Fuel Mix

Therefore, the table C1.3.4 shows the results of BAU scenario for this case (BAU 2).

Table C1.3.4 – Indicators 4 – BAU

Indicators and respective parameters	BAU Values			
	Diesel	Gasoline	GPL	Electricity
Fuel Mix (2008)	75,4%	24,2%	0,4%	0,0%
Fuel Mix (2009)	75,9%	23,6%	0,5%	0,0%
Fuel Mix (2010)	76,9%	22,7%	0,4%	0,0%
Fuel Mix (2011)	77,7%	21,8%	0,5%	0,0%

Indicator 5 (Vehicle Fuel Efficiency)

In order to determine the B-a-U scenario for this indicator the approach used was the evolution of energy consumption (MJ) and the distance vehicle-km (passenger cars - pkm). With this ratio value the vehicle fuel efficiency (MJ/vkm) is calculated. The energy consumption data source is the evolution of fuel consumption in Portugal (2007-2011) because there is no data available at local level and because it was possible to obtain data at national level since 2006 (for further details, read Annex 2 Vehicle Fuel Efficiency Data). Since there are only historic series for the distance pkm for the period 2007-2009 it facilitated a forecast for the years 2010 and 2011, i.e.,considering that the average occupancy of the car mantains stable (table C1.3.5).

Table C1.3.5 – Energy consumption and pkm – BAU

Year	2007 (base year)	2008	2009	2010	2011
Energy Consumption (GJ)	279.401.131	271.853.161	272.458.842	270.955.163	253.870.585
Passanger-cars (mio pkm)	86.600	87.000	86.000	n.a.	n.a.
Δ Energy Consumption	100%	97%	98%	97%	91%
Δ pkm	100%	100%	99%	n.a.	n.a.
Δ pkm (trend)	***100,00%***	***100,46%***	***99,31%***	***99,23%***	***98,88%***
Δ MJ/pkm (vkm)	**100,00%**	**96,85%**	**98,20%**	**97,73%**	**91,89%**

The following graph (Fig. C1.3.4) presents a comparison between the evolution of fuel energy consumption (MJ) and passenger cars (pkm), considering 2007 as the base year (100%).

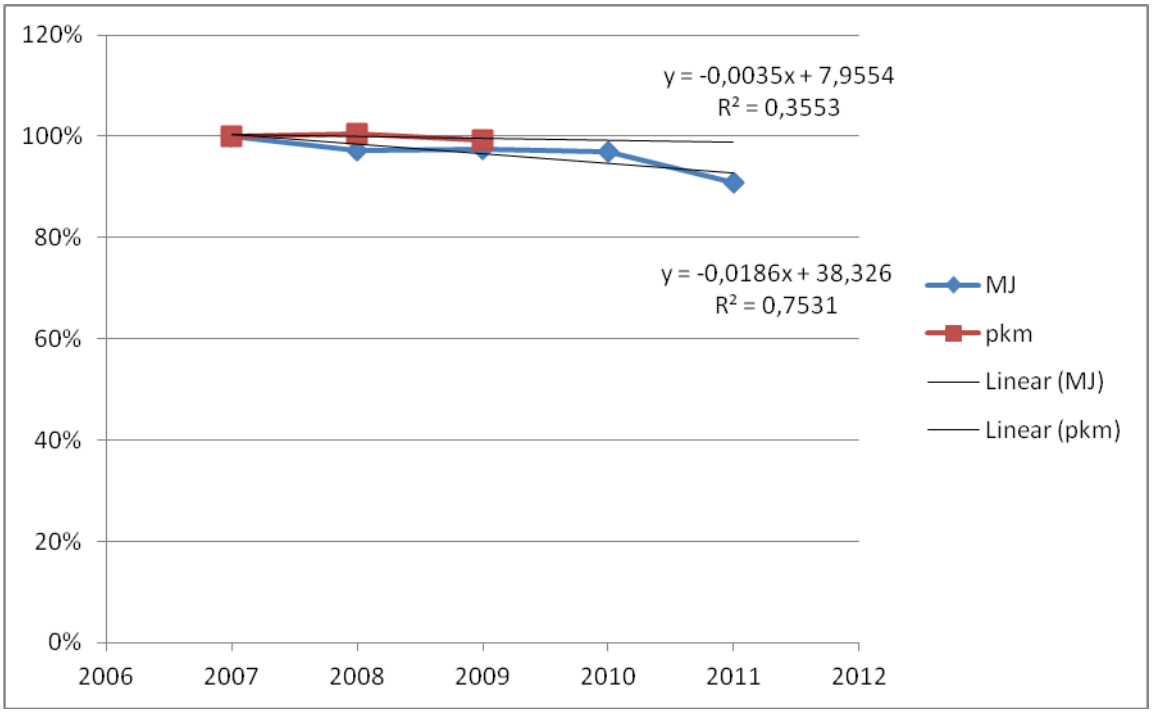


Figure C1.3.4 - Fuel Mix and pkm forecast

The graph reveals a trend for a decrease in fuel energy consumption that is steeper than the one registerd on passenger cars, thus, meaning that vehicle fuel efficiency (MJ/pkm and thus MJ/vkm) tends to decrease. The trend used for forecasting passanger kilometres (pkm) has as low correlation

coeficient (0,3535) that shows a low degree of linear relationship between the variables. To analyse it more carefuly, other types of trends were tested (exponencial, logaritmic,…) but at all of them showed similar correlation coeficients. This is also reinforced by the fact that the financial crises in Portugal also induced a low demand for PT, and it will have an impact both for the passangers kilometres and for the energy consumption in the coming years.

Considering that the evolution of the series obtained is independent from the measure and considering that this measure had no real implementation, in order to determine the B-a-U scenario for this indicator for the period 2008-2011, the actual data about the fuel energy consumption, actual data about pkm from 2008-2009 and the data trend from 2010-2011 have been used. Thus, it is possibile to extrapolate for the next few years (BAU 2).

The B-a-U scenario for the indicator Vehicle Fuel Efficiency (MJ/vkm) is presented in the following graph (BAU 2):

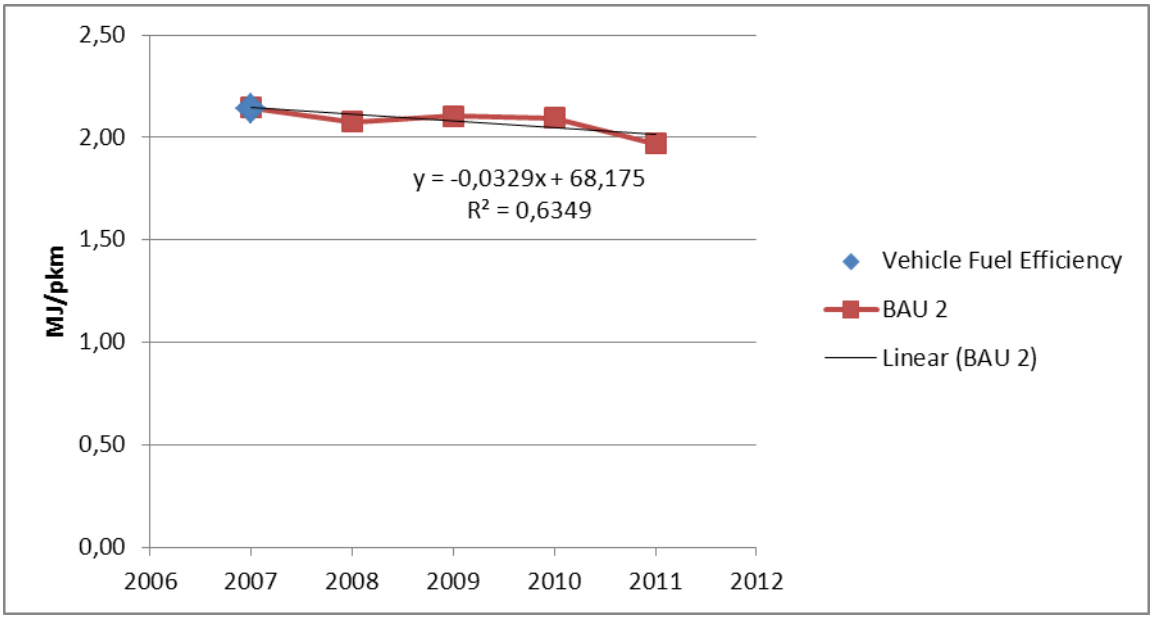


Figure C1.3.5 - Vehicle efficiency pkm forecast

Therefore, the table C1.3.6 shows the results of BAU scenario for this case (BAU 2).

Table C1.3.6 – Indicator 5 – BAU

Indicators and respective parameters	BAU values
Vehicle fuel efficiency (2008)	2,08 MJ/vkm
Vehicle fuel efficiency (2009)	2,11 MJ/vkm
Vehicle fuel efficiency (2010)	2,10 MJ/vkm
Vehicle fuel efficiency (2011)	1,97 MJ/vkm

Indicator 6 (CO emissions)

The change in the CO emissions related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the CO emissions would be as before. It was established that there are no effects of other factors that have any influence in this indicator. In this, case the Business-as-usual is equal to the baseline situation.

The following graph (Fig. C1.3.6) shows the evolution of the CO emissions (g/vkm) obtained for the B-a-U scenario.

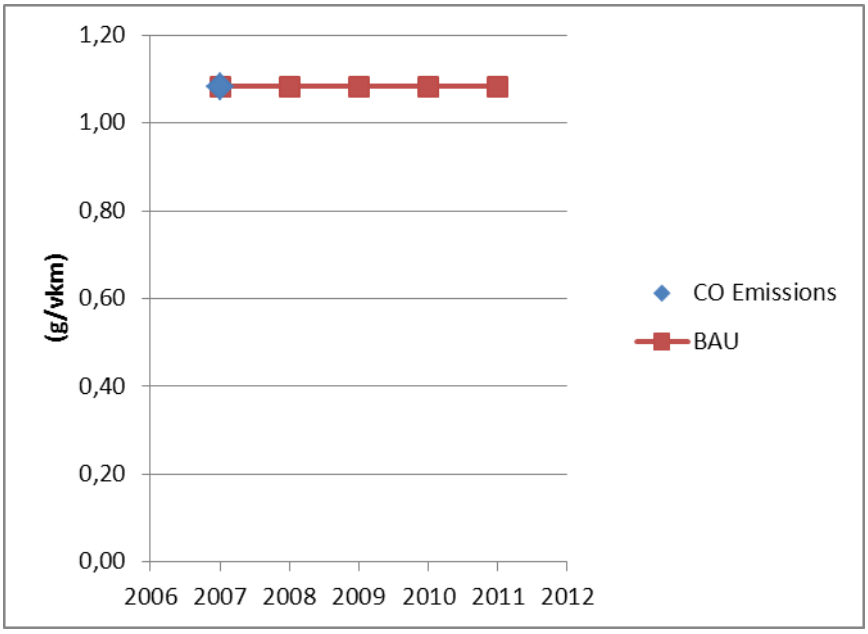


Figure C1.3.6 - CO emissions

Therefore, the table C1.3.7 shows the results of BAU scenario for this case:

Table C1.3.7 – Indicator 6 – BAU

Indicators and respective parameters	BAU values
CO emissions (2008)	1,08 g/vkm
CO emissions (2009)	1,08 g/vkm
CO emissions (2010)	1,08 g/vkm
CO emissions (2011)	1,08 g/vkm

Indicator 7 (CO2 emissions)

The change in the CO2 emissions related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the CO2 emissions would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The following graph (Fig. C1.3.7) shows the evolution of the CO2 emissions (g/vkm) obtained for the B-a-U scenario.

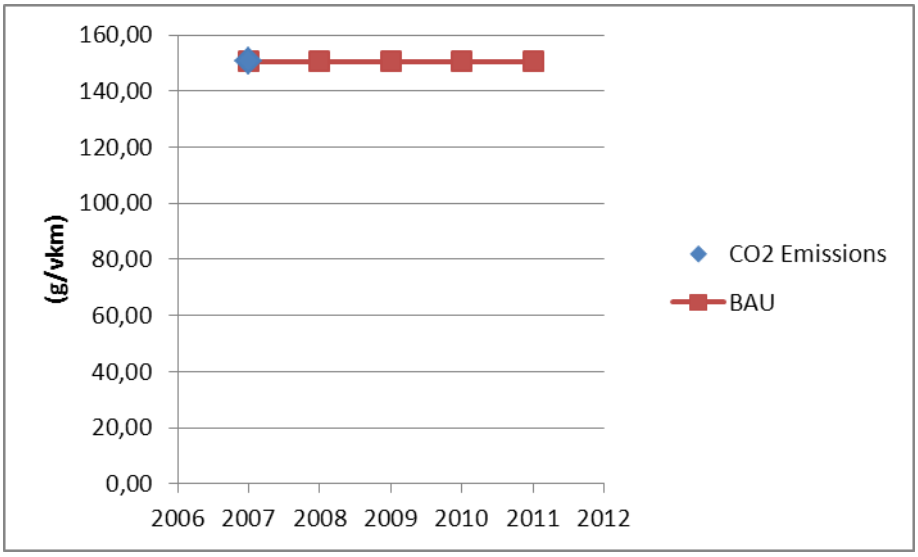


Figure C1.3.7 - CO2 emissions

Therefore, the table C1.3.8 shows the results of BAU scenario for this case.

Table C1.3.8 – Indicator 7 – BAU

Indicators and respective parameters	BAU values
CO2 emissions (2008)	150,57 g/vkm
CO2 emissions (2009)	150,57 g/vkm
CO2 emissions (2010)	150,57 g/vkm
CO2 emissions (2011)	150,57 g/vkm

Indicator 8 (NOx emissions)

The change in the NOx emissions related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the NOx emissions would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The following graph (Fig. C1.3.8) shows the evolution of the NOx emissions (g/vkm) obtained for the B-a-U scenario.

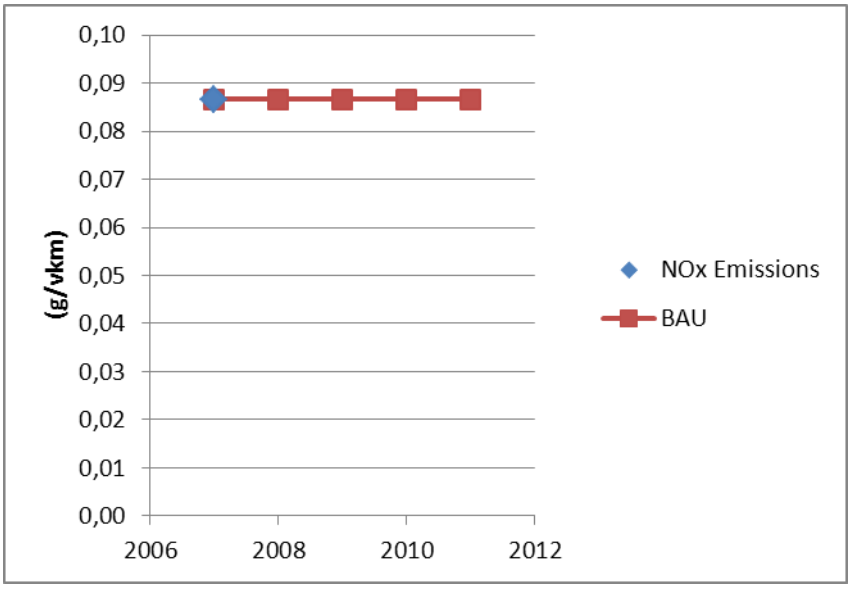


Figure C1.3.8 - NOx emissions

Therefore, the table C1.3.9 shows the results of BAU scenario for this case.

Table C1.3.9 – Indicator 8 – BAU

Indicators and respective parameters	BAU values
NOx emissions (2008)	0,09 g/vkm
NOx emissions (2009)	0,09 g/vkm
NOx emissions (2010)	0,09 g/vkm
NOx emissions (2011)	0,09 g/vkm

Indicator 9 (PT emissions)

The change in the PT emissions related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the PT emissions would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The following graph (Fig.C1.3.9) shows the evolution of the PT emissions (g/vkm) obtained for the B-a-U scenario.

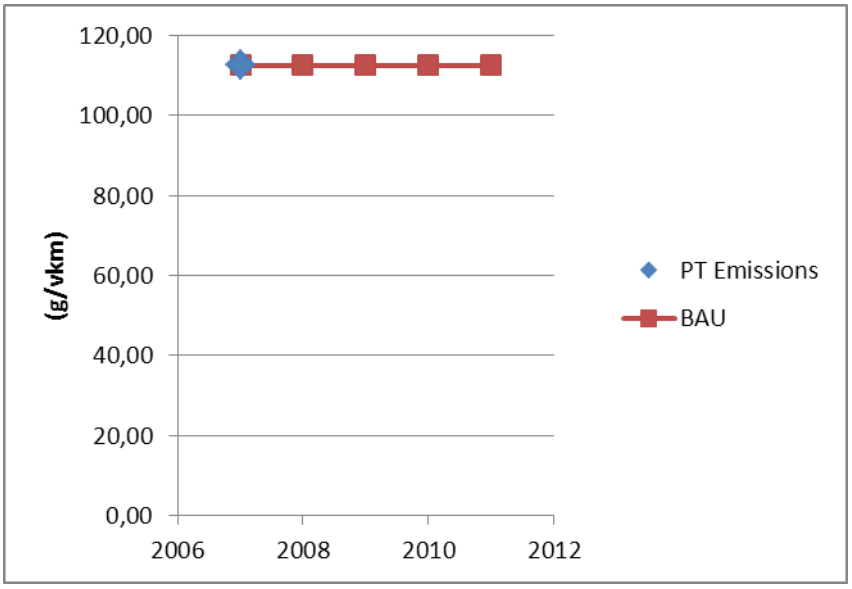


Figure C1.3.9 - PT emissions

Therefore, the table C1.3.10 shows the results of BAU scenario for this case.

Table C1.3.10 – Indicators 9 – BAU

Indicators and respective parameters	BAU values
PT emissions (2008)	112,5 g/vkm
PT emissions (2009)	112,5 g/vkm
PT emissions (2010)	112,5 g/vkm
PT emissions (2011)	112,5 g/vkm

Indicator 10 (HC emissions)

The change in the HC emissions related to the operation of the carsharing service is obtained after setting up the measure. Therefore, without the implementation of the measure, the HC emissions would be as before. It was established that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

The following graph (Fig. C1.3.10) shows the evolution of the HC emissions (g/vkm) obtained for the B-a-U scenario.

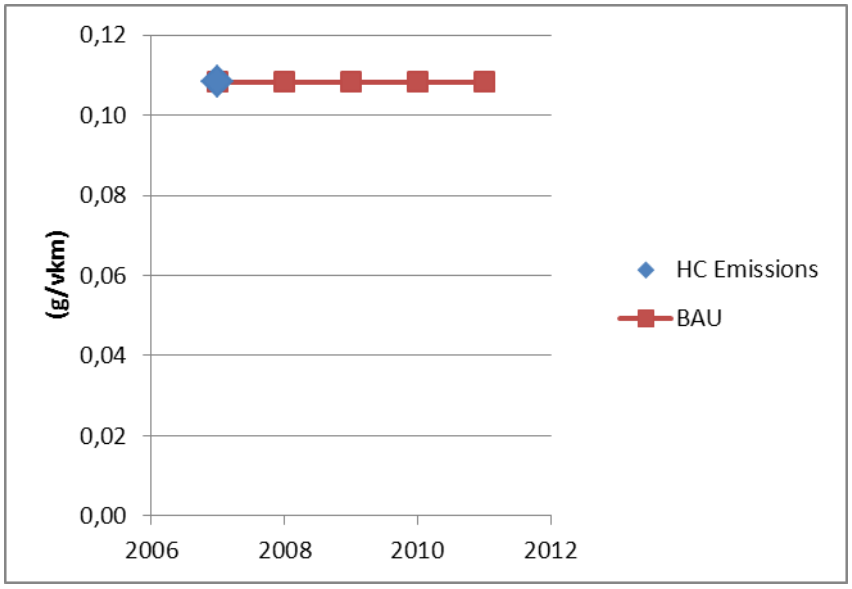


Figure C1.3.10 - HC emissions

Therefore, the table C1.3.11 shows the results of BAU scenario for this case.

Table C1.3.11 – Indicator 10 – BAU

Indicators and respective parameters	BAU values
HC emissions (2008)	0,11 g/vkm
HC emissions (2009)	0,11 g/vkm
HC emissions (2010)	0,11 g/vkm
HC emissions (2011)	0,11 g/vkm

C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

The evaluation of the measure reports to a Feasibility Study of New Mobility Services in Coimbra.To be more comprehensive all key aspects are expressed and related in the study.

C2.1 Economy

In the same way as for the baseline, the results of the indicators for the situation after implementing the measure were obtained. Indicators 1 - Average Operating Revenues, 2 - Average Operating Costs and 3 Capital Costs were evaluated considering a scenario of real implementation of the measure during CIVITAS MODERN. The table C2.1.1 shows the Car-sharing implementation scenario considered:

Table C2.1.1 – Measure implementation stages

Year	Stage
2008	Purchase of the vehicles, installation of the necessary equipment and Operation
2009	Operation
2010	Operation
2011	Operation

The source of information has been the feasibility study on both, the estimated costs and revenues of operating the carsharing system and revenues, as well as on the vehicle-km performed by those services.

The revenues were calculated for car-sharing system profitability result from the fee associated with the usage of vehicles index with the unit prices of the tariff (€/hour and €/km) for a standard trip – 15 Km extension and 2h duration (Table C2.1.2).

Table C2.1.2 – Car sharing fees and values for a standard trip

Vehicles		**8:00 a.m. to 7:59 p.m.**		**Standard Trip**		**Total**
Motor	**Type**	**€/vh**	**€/vkm**	**2h**	**15km**	**€**
Combustion	**Urban**	2.50	0.25	5.00	3.75	8.75
	Compact	3.00	0.30	6.00	4.50	10.50
Electric	**City**	4.00	0.40	8.00	6.00	14.00

For example, for one a city car with 25 members/ vehicle usage and with an average booking of 3 monthly trips has a monthly revenue of 23.625 €, i.e, a revenue of 7.875 €/city car. For the compact

car and for urban electric the revenues are calculated with the same methodology as illustrated in following figures.

The overall revenues are calculated by the sum of the 3 typologies of vehicle, that is 105.525€ per year, as is expressed in the table C2.1.3.

Table C2.1.3 – Annual Renevues

Type of vehicle	N.º vehicles	N.º Users	N.º Reservations	Daily Distance (km)	Hour Fee €/vh	Usage (h)	Distance Fee €/vkm	Revenues (€)
Combustion urban vehicle	3	25	3	15	2,50	2	0,25	23.625
Combustion compact vehicle	2	25	3	15	3,00	2	0,30	18.900
Electric vehicle	5	25	3	15	4,00	2	0,40	63.000
Total	**10**	**25**	**3**	**15**	**-**	**-**	**-**	**105.525**

The table C2.1.4 shows the indicative values of the costs "Vehicle x hour" and "vehicle x km", associated with the different types of vehicles and that allow to obtain an operation cost per vehicle.

The methodology used for calculation considered the staff, the training, fuel, maintenance (cleaning + tires), insurance, parking, booking of the vehicle, Call Centre operationalization and Communication costs.

Table C2.1.4 – Costs of the service operation

Vehicles		COSTS (€)																	
		Constant Annual				Constant / hour (7.5km/h)				Variable / Km					Total / km				Operation
						Annual Usage				Maintenance + Tyres									
Engine	Type	Acquisition Costs	Amortization	Insurance	Management (1)	5000km/year	7500km/year	10000km/year	12500km/year	5000km/year	7500km/year	10000km/year	12500km/year	Fuel	5000km/year	7500km/year	10000km/year	12500km/year	per vkm (10000km/year x vehic)
Combustion	City	10000	1250	600	1750	5,40	3,60	2,70	2,16	0,11	0,09	0,08	0,07	0,10	0,21	0,19	0,18	0,17	0,54
	Compact	15000	1875	900	1750	6,79	4,53	3,39	2,72	0,14	0,11	0,10	0,09	0,11	0,25	0,22	0,21	0,20	0,66
	Family	25000	3125	1500	1750	9,56	6,38	4,78	3,83	0,20	0,15	0,13	0,11	0,13	0,33	0,28	0,25	0,24	0,89
Electric	City	29500	3688	1770	1750	10,81	7,21	5,41	4,32	0,23	0,17	0,14	0,12	0,03	0,26	0,20	0,17	0,15	0,89

(1) 1 employee per 10 vehicles fleet

The feasibility study considered an analysis of the emissions, energy, costs and revenues and are build up in the following table. The analisys is based in the 3 types of cars (3 combustion urban, 2 combustion compact and 5 electric urban) based in a usage profile of 25 users per vehicle, 15 km for an average trip and an average of 3 reservations per month. The analisys are summarized in the table C2.1.5.

Table C2.1.5 – Car-sharing service anaysis summary

N.º users/ vehicle		
25		
Average N.º Reservations		
3		
Average Trip (km)		
15		
N.º of Cars		
3	**2**	**5**
Combustion City	Combustion Compact	Electric City
Average consumption (l/100 km) - Electric in kWh/100km		
6	7	15
NOx (g) / year		
3.240	2.520	5.400
HC (g) / year		
4.050	3.150	6.750
CO (g) / year		
40.500	31.496	67.500
PT (g) / year		
4.050.000	3.375.000	6.750.000
CO2 (g) / year		
5.629.500	4.377.875	9.382.500
Average Monthly Offer - vkm		
3.375	2.250	5.625
Estimated Annual Fuel Consumption (litres)		
2.430	1.890	1.125
Estimated ENERGY(MJ)		
84.159	67.775	36.450
Capital Costs (€)		
7.500	5.000	162.500
Operating Costs (€)		
21.708	17.807	60.750
Operating Revenues(€)		
23.625	18.900	63.000
Rendibility (%)		
8%	**6%**	**4%**

Taking into consideration the Average Montly Offer shown in the previous table and the operation costs obtained in the table C2.1.4 results the annnual costs (table C2.1.6)

The overall costs are determinated by the sum of the typologies of urban car, compact car and electric urban (partial costs expressed on above figures) of vehicles, that is 100.265 € per year, as ilustrated in the table.

Table C2.1.6 – Annual Costs

Type of vehicle	A Average Monthly Offer (vkm)	B Operation Costs €/vkm	C = (A x 12) x B Costs (€)
Combustion urban vehicle	3.375	0,54	21.708
Combustion compact vehicle	2.250	0,66	17.807
Electric vehicle	5.625	0,89	60.750
Total	**-**	**-**	**100.265**

Taking into account the implementation scenario above, the tables C2.1.7 and C2.1.8 shows the results of indicators 1and 2, respectively.

Table C2.1.7 – Indicator 1 – Ex Post

Indicators and respective parameters	Ex-Post values
Revenues from the operation of the system	105.525,00 €
Total vechicle-km	135.000 vkm
Average operating revenue (2008)	0,78 €/vkm
Average operating revenue (2009)	0,78 €/vkm
Average operating revenue (2010)	0,78 €/vkm
Average operating revenue (2011)	0,78 €/vkm

Table C2.1.8 – Indicator 2 – Ex Post

Indicators and respective parameters	Ex-Post values
Total Operational Costs	100.265 €
Total vechicle-km	135.000 vkm
Average operating costs (2008)	0,74 €/vkm
Average operating costs (2009)	0,74 €/vkm
Average operating costs (2010)	0,74 €/vkm
Average operating costs (2011)	0,74 €/vkm

The capital costs are related with the sum of the initial investiment for the vehicles, the embedded devices, the system and software operational management, assembly, branding and promotional campaign, and the "start-up" of the service.

In relation to the capital costs, it has been considered a cost of 30.000,00 € to purchase each 5 electric vehicle and a cost of 2.500,00 € to purchase and install the equipment and software necessary to the integration of the vehicles in the fleet of the car-sharing system, as well as the other costs above mentioned. The other 5 cars from the Municipality already purchased and depreciated were not considered. The overall capital cost is expressed in the table C2.1.9.

Table C2.1.9 – Indicator 3 – Ex Post

Indicators and respective parameters	Ex-Post values
Total capital cost (2008)	175.000,00 €
Total capital cost (2009)	0,00 €
Total capital cost (2009)	0,00 €
Total capital cost (2011)	0,00 €

The table C2.1.10 sumarize the Economy indicators.

Table C2.1.10 – Economy indicators summary – Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
1. Average Operating Revenues	0,00 €/vkm (2007)	0,00 €/vkm (2008) 0,00 €/vkm (2009) 0,00 €/vkm (2010) 0,00 €/vkm (2011)	0,78 €/vkm (2008) 0, 78 €/vkm (2009) 0, 78 €/vkm (2010) 0, 78 €/vkm (2011)	0, 78 €/vkm (2008) 0, 78 €/vkm (2009) 0, 78 €/vkm (2010) 0, 78 €/vkm (2011)	0, 78 €/vkm (2008) 0, 78 €/vkm (2009) 0, 78 €/vkm (2010) 0, 78 €/vkm (2011)
2. Average Operating Costs	0,00 €/vkm (2007)	0,00 €/vkm (2008) 0,00 €/vkm (2009) 0,00 €/vkm (2010) 0,00 €/vkm (2011)	0,74 €/vkm (2008) 0,74 €/vkm (2009) 0,74 €/vkm (2010) 0,74 €/vkm (2011)	0,74 €/vkm (2008) 0,74 €/vkm (2009) 0,74 €/vkm (2010) 0,74 €/vkm (2011)	0,74 €/vkm (2008) 0,74 €/vkm (2009) 0,74 €/vkm (2010) 0,74 €/vkm (2011)
3. Capital Costs	0,00 € (2007)	0,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	175.000,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	175.000,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)	175.000,00 € (2008) 0,00 € (2009) 0,00 € (2010) 0,00 € (2011)

The following graph shows the evolution of average operating revenues (€/vkm) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (without CIVITAS).

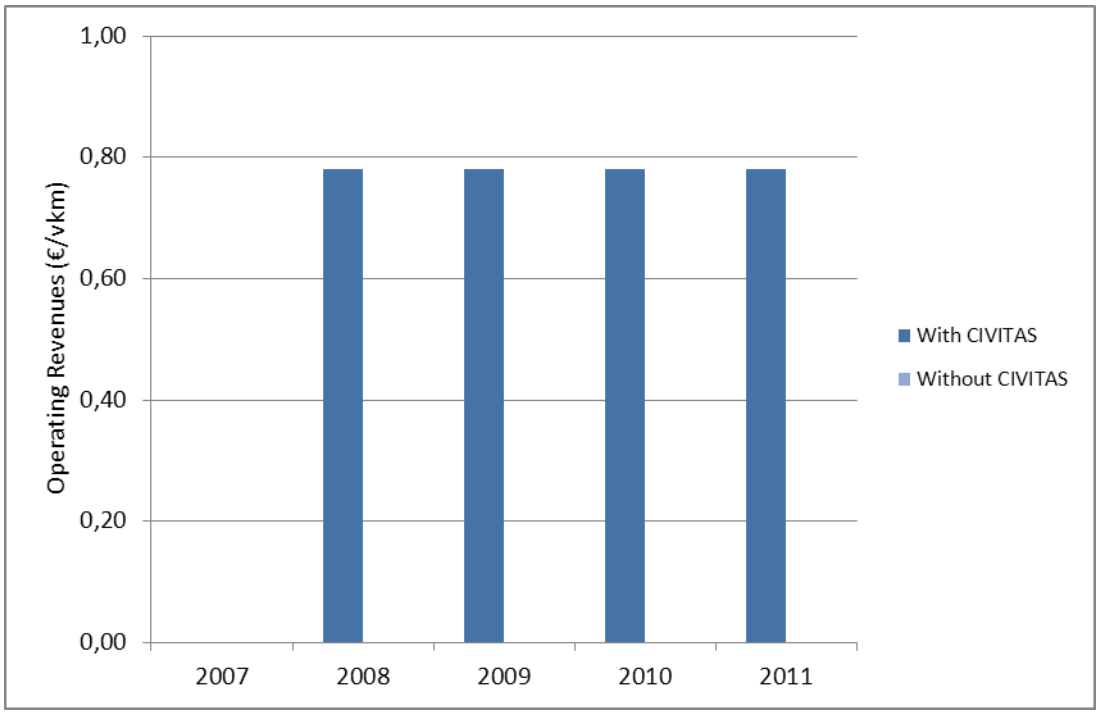


Figure C2.1.1 - Operating revenues (with/without CIVITAS)

The following graph shows the evolution of average operating costs (€/vkm) with CIVITAS MODERN and the evolution of this indicator according to the B-a-U scenario (without CIVITAS MODERN).

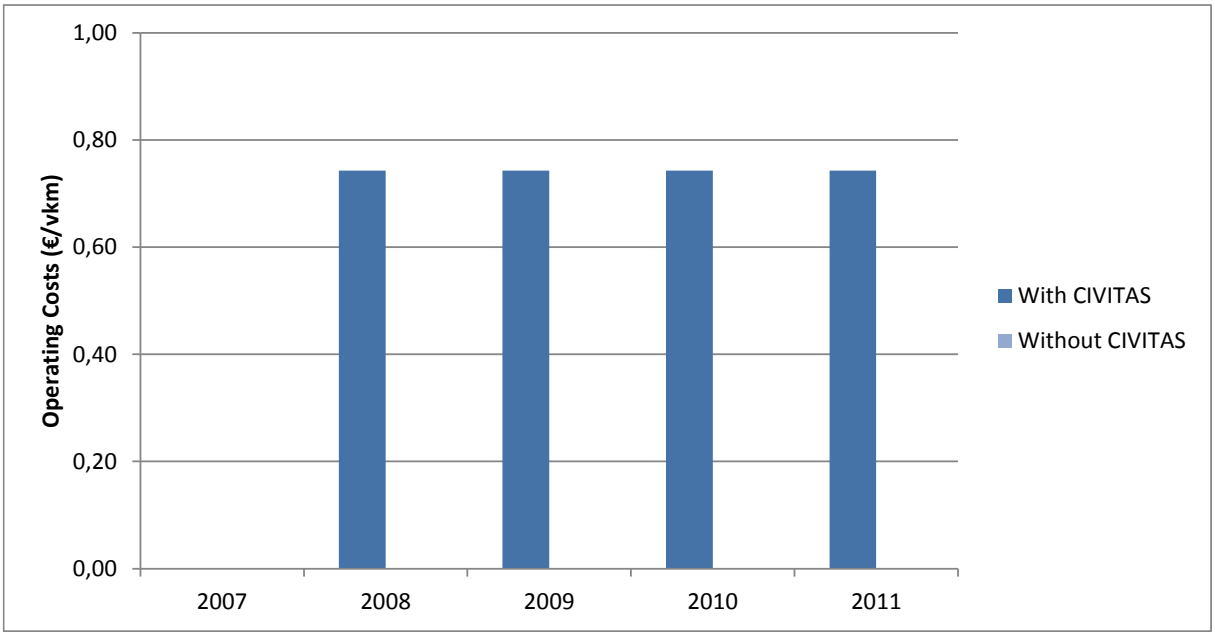


Figure C2.1.2 - Operating costs (with/without CIVITAS)

The following graph shows the evolution of capital costs (€) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (without CIVITAS).

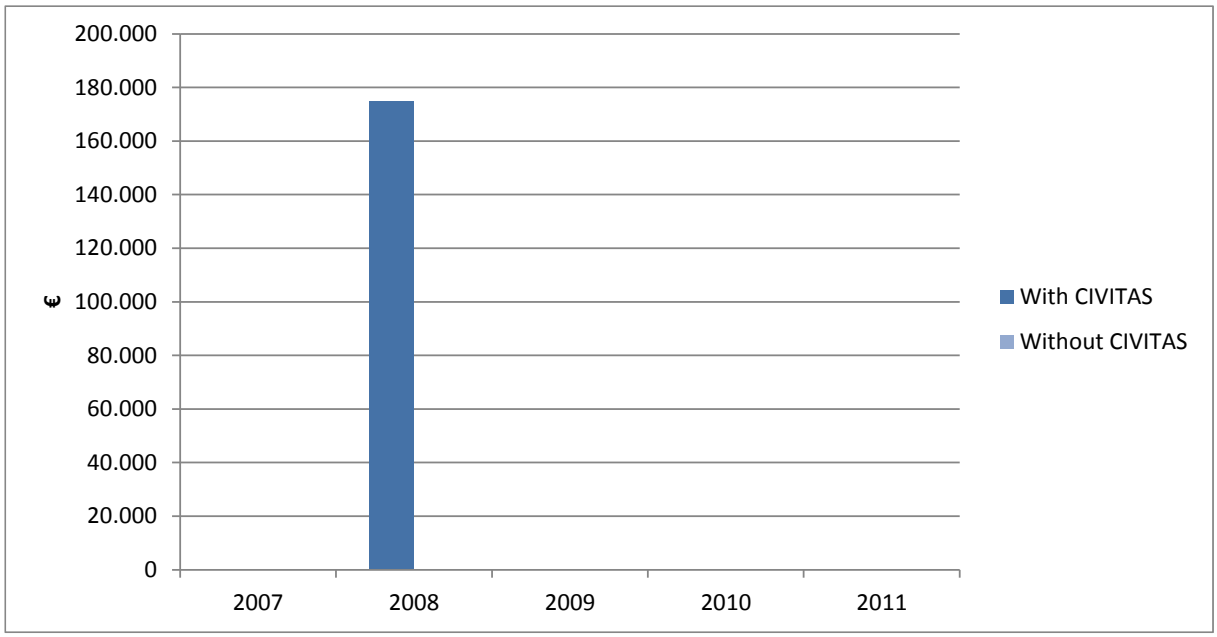


Figure C2.1.3 - Capital costs (with/without CIVITAS)

As expected, capital and average operating revenues and costs experienced an increase as a result of the implementation of the measure. However, as expected, capital costs return to zero after the installation of the power station. In relation to operating costs and revenues.The measure revealed to be efficient by contributing to a greater increase in average operating revenues in comparison with costs, generating a surplus of 0,04 €/vkm.

C2.2 Energy

The source of information has been the feasibility study on both the estimated energy consumption related to the car-sharing system and the respective vehicle-km.

In relation to the ex-post situation it was considered that all trips (with potential to be shifted to the car-sharing before the implementation of the service) were performed using private cars. The fuel mix data is determined by the share of the Portuguese fuel consumption (litres) based on the average yearly statistics given by the Portuguese Directorate for Energy and the conversion factors of litres to MJ are in Annex 3.

The results of the Ex-post values for indicator 4. (fuel Mix) is determinated by the ratio of the consumption in litres of each type of fuel (diesel, gasoline) introduced in the car-sharing service and the overall consumption of the vehicles introduced in the service. The values and the relative weight of each type of fuel are calculated in the following table.

Table C2.2.1 – Fuel Mix calculation – Ex Post

Vehicles			Energy Consumption		
Motor	**Type**	**N.º**	**(l/100km) / kWh/100km***	**MJ**	**%**
Diesel	Combustion Urban	2	6	58.093	66,8%
Diesel	Combustion Compact	2	7	67.775	
Gasoline	Combustion Urban	1	6	26.066	13,8%
Electric	Electric Urban	5	15*	36.450	19,3%
TOTAL		10	-	188.384	

Please note that for the above calculations the annual distance considered a daily trip of 15 km, with 25 users and 3 reservations per month for each car. With this profile and considering its stablisation in the 4 years, the fuel mix indicator is expressed in the following table.

Table C2.2.2 – Indicator 4 – Ex Post

Indicators and respective parameters	Ex-Post values
Fuel Mix – Diesel (2008 / 2009 / 2010 / 2011)	66,8%
Fuel Mix – Gasoline (2008 / 2009 / 2010 / 2011)	13,8%
Fuel Mix – GPL (2008 / 2009 / 2010 / 2011)	0,0 %
Fuel Mix – Electricity (2008 / 2009 / 2010 / 2011)	19,3%

The Ex-post scenario of indicator 5 (Vehicle Fuel Efficiency) is calculated by the ratio of the energy consumption in litres (table C2.1.5), converted in MJ, of the vehicles assigned to the car sharing service with the vehicle kilometres. The table C2.2.3 shows the Vehicle Fuel Efficiency indicator.

Table C2.2.3 – Indicator 5 – Ex Post

Indicators and respective parameters	Ex-Post values
Vehicle fuel efficiency (2008)	1,13 MJ/vkm
Vehicle fuel efficiency (2009)	1,13 MJ/vkm
Vehicle fuel efficiency (2010)	1,13 MJ/vkm
Vehicle fuel efficiency (2011)	1,13 MJ/vkm

Table C2.2.4 – Energy indicators – Ex Post, BAU and Ex-ante

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
4. Fuel Mix (Diesel/ Gasoline/ GPL/ Electricity)	74,5% /25,2% / 0,4% / 0,0% (2007)	75,4% /24,2% / 0,4% / 0,0% (2008)	66,8% /13,8% / 0,0% / 19,3% (2008)	-8,6% / -10,4% / -0,4% / -19,3% (2008)	-11,4% / -0,4% / +19,3% (2008)
		75,9% /23,6% /	66,8% /13,8% /	-8,6% / -10,4% /	-9,1% / -9,8% /

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
		0,5% / 0,0% (2009) 76,9% /22,7% / 0,4% / 0,0% (2010) 77,7% /21,8% / 0,5% / 0,0% (2011)	0,0% / 19,3% (2009) 66,8% /13,8% / 0,0% / 19,3% (2010) 66,8% /13,8% / 0,0% / 19,3% (2011)	-0,4% / -19,3% (2009) -8,6% / -10,4% / -0,4% / -19,3% (2010) -8,6% / -10,4% / -0,4% / -19,3% (2011)	-0,5% / -19,3% (2009) -10,1% / -8,9% / -0,4% / -19,3% (2010) -10,9% / -8,0% / -0,5% / -19,3% (2011)
5. Vehicle Fuel Efficiency	2,14 MJ/vkm (2007)	2,14 MJ/vkm (2008) 2,14 MJ/vkm (2009) 2,14 MJ/vkm (2010) 2,14 MJ/vkm (2011)	1,13 MJ/vkm (2008) 1,13 MJ/vkm (2009) 1,13 MJ/vkm (2010) 1,13 MJ/vkm (2011)	-1,01 MJ/vkm (2008) -1,01 MJ/vkm (2009) -1,01 MJ/vkm (2010) -1,01 MJ/vkm (2011)	-1,01 MJ/vkm (2008) -1,01 MJ/vkm (2009) -1,01 MJ/vkm (2010) -1,01 MJ/vkm (2011)

The next graph shows the evolution of the Fuel Mix (%) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

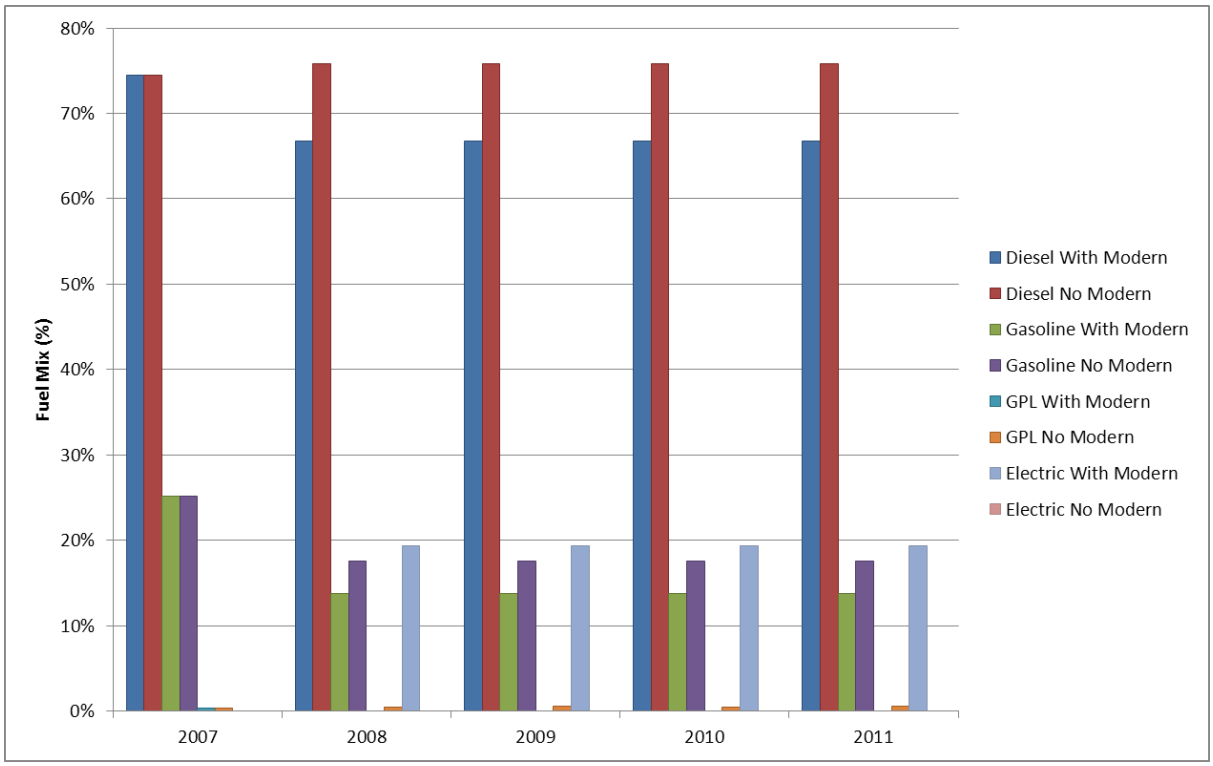


Figure C2.2.1 - Fuel Mix evolution (with/without CIVITAS)

This evolution shows that the most relevant influence of the measure on fuel mix is the increase of the share in the consumption of the electric vehicles together with the decrease in the share of the consumption of the gasoline ones (pushing the decrease beyond the trend downwards). However, since 2008, the share in the consumption of the gasoline vehicles without the measure keeps the trend downwards while the share in the consumption of these vehicles with the measure keeps stable. Thus, the gap in the consumption of the gasoline vehicles with the implementation of the measure in relation to the BAU scenario tends to decrease.

In relation to the share of the consumption of diesel vehicles, initially, the measure contributes to a slight increase in relation to the BAU scenario but after 2010 with the measure the consumption of diesel vehicles keeps stable and below the trend upwards of the consumption of diesel vehicles on BAU scenario. The main reason for these changes are related with the transference of conventional combustion vehicle to electric vehicle that induces a reduction of final energy consumption. Note that in Portugal the national electrical energy production benefits electric vehicles, because there are a good share (e.g 48,9% in 2011[22]) of renewables energy sources, mainly wind and hydro.

The following graph shows the evolution of Vehicle fuel efficiency (MJ/vkm)With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

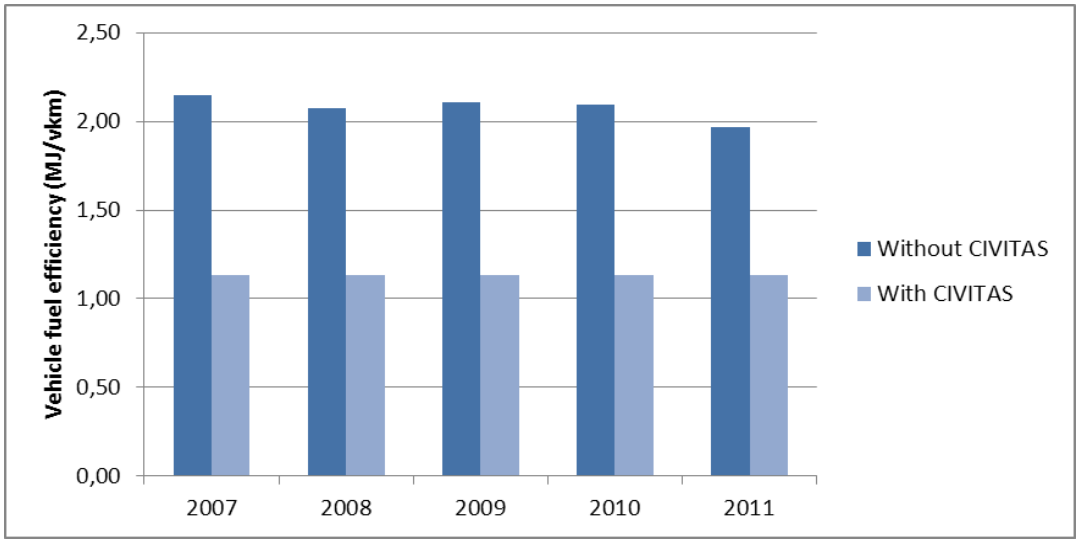


Figure C2.2.2 - Fuel efficiency (with/without CIVITAS)

This evolution shows that from the use of smaller vehicles together with the use of electric vehicles results a significant reduction in vehicle fuel efficiency (MJ/vkm), meaning that the operation of the carsharing system in such conditions brings significant energy advantages. However, considering the trend in the a reduction in vehicle fuel efficiency with no measure, the significant energy savings obtained from the operation of the carsharing system (as result of the use of a fleet with an important share of small electric vehicles) tend to slowly decrease.

C2.3 Environment

The source of information has been the feasibility study on the estimated polluent emissions related to the carsharing system (Emission factor in table C1.2.6) and the respective vehicle-km.

[22] Source: Portuguese Association of Renewable Energy Producers

In relation to the ex-post situation it was considered that all trips (with potential to be shifted to the carsharing before the implementation of the service) were performed using private car.

The results of for each indicator are:

Table C2.3.1 – Indicators 6, 7, 8, 9, 10 – Ex Post

Indicators and respective parameters	Ex-Post values
CO emissions (2008 / 2009 / 2010 / 2011)	0,53 g/vkm
CO2 emissions (2008 / 2009 / 2010 / 2011)	74,13 g/vkm
NOx emissions (2008 / 2009 / 2010 / 2011)	0,04 g/vkm
PT emissions (2008 / 2009 / 2010 / 2011)	55,00 g/vkm
HC emissions (2008 / 2009 / 2010 / 2011)	0,05 g/vkm

Table C2.3.2 – Environmental indicators - Summary– Ex Post, BAU and Ex-ante

Indicator	**Before (date)**	**B-a-U (date)**	**After (date)**	**Difference: After –Before**	**Difference: After – B-a-U**
6. CO emissions	1,08 g/vkm (2007)	1,08 g/vkm (2008) 1,08 g/vkm (2009) 1,08 g/vkm (2010) 1,08 g/vkm (2011)	0,53 g/vkm (2008) 0,53 g/vkm (2009) 0,53 g/vkm (2010) 0,53 g/vkm (2011)	-0,55 g/vkm (2008) -0,55 g/vkm (2009) -0,55 g/vkm (2010) -0,55 g/vkm (2011)	-0,55 g/vkm (2008) -0,55 g/vkm (2009) -0,55 g/vkm (2010) -0,55 g/vkm (2011)
7. CO2 emissions	150,57 g/vkm (2007)	150,57 g/vkm (2008) 150,57 g/vkm (2009) 150,57 g/vkm (2010) 150,57 g/vkm (2011)	74,13 g/vkm (2008) 74,13 g/vkm (2009) 74,13 g/vkm (2010) 74,13 g/vkm (2011)	-76,44 g/vkm (2008) -76,44 g/vkm (2009) -76,44 g/vkm (2010) -76,44 g/vkm (2011)	-76,44 g/vkm (2008) -76,44 g/vkm (2009) -76,44 g/vkm (2010) -76,44 g/vkm (2011)
8. NOx emissions	0,09 g/vkm (2007)	0,09 g/vkm (2008) 0,09 g/vkm (2009)	0,04 g/vkm (2008) 0,04 g/vkm (2009)	- 0,04 g/vkm (2008) - 0,04 g/vkm (2009)	- 0,04 g/vkm (2008) - 0,04 g/vkm (2009)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
		0,09 g/vkm (2010) 0,09 g/vkm (2011)	0,04 g/vkm (2010) 0,04 g/vkm (2011)	- 0,04 g/vkm (2010) - 0,04 g/vkm (2011)	- 0,04 g/vkm (2010) - 0,04 g/vkm (2011)
9. PT emissions	112,5 g/vkm (2007)	112,5 g/vkm (2008) 112,5 g/vkm (2009) 112,5 g/vkm (2010) 112,5 g/vkm (2011)	55,0 g/vkm (2008) 55,0 g/vkm (2009) 55,0 g/vkm (2010) 55,0 g/vkm (2011)	- 57,5 g/vkm (2008) - 57,5 g/vkm (2009) - 57,5 g/vkm (2010) - 57,5 g/vkm (2011)	- 57,5 g/vkm (2008) - 57,5 g/vkm (2009) - 57,5 g/vkm (2010) - 57,5 g/vkm (2011)
10. HC emissions	0,11 g/vkm (2007)	0,11 g/vkm (2007)	0,05 g/vkm (2008) 0,05 g/vkm (2009) 0,05 g/vkm (2010) 0,05 g/vkm (2011)	-0,05 g/vkm (2008) -0,05 g/vkm (2009) -0,05 g/vkm (2010) -0,05 g/vkm (2011)	-0,05 g/vkm (2008) -0,05 g/vkm (2009) -0,05 g/vkm (2010) -0,05 g/vkm (2011)

The following graph shows the evolution of CO emissions (g/vkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

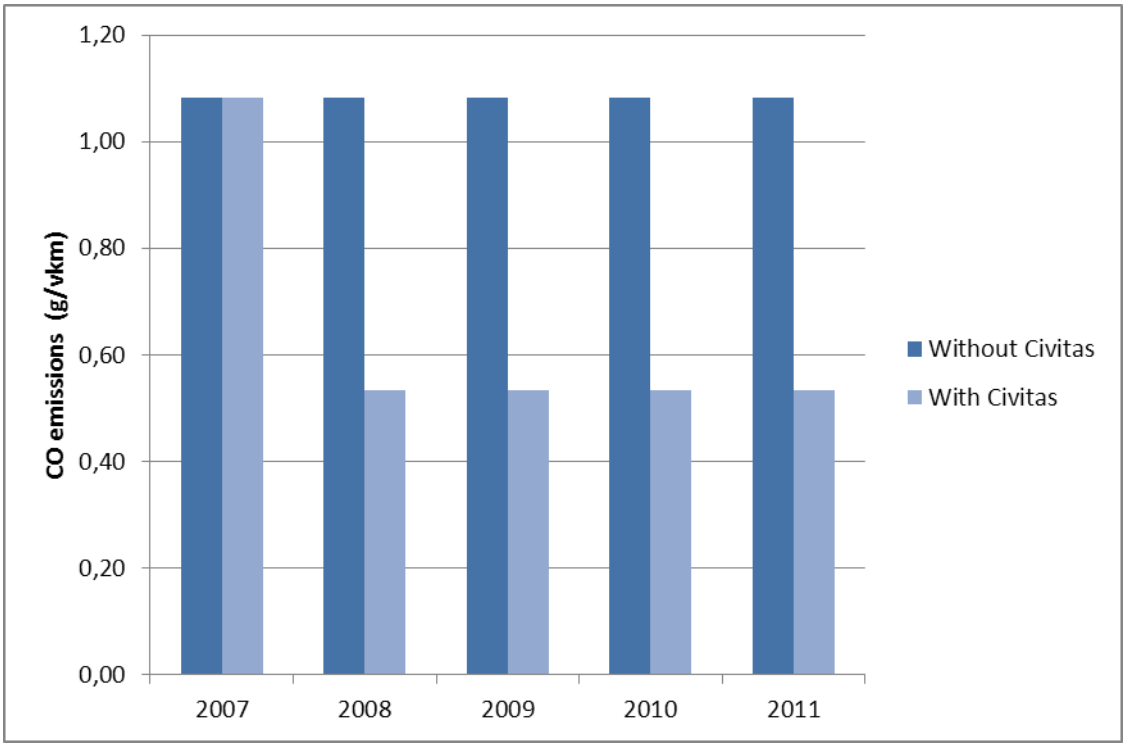


Figure C2.2.3 - CO emissions (with/without CIVITAS)

The following graph shows the evolution of CO2 emissions (g/vkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

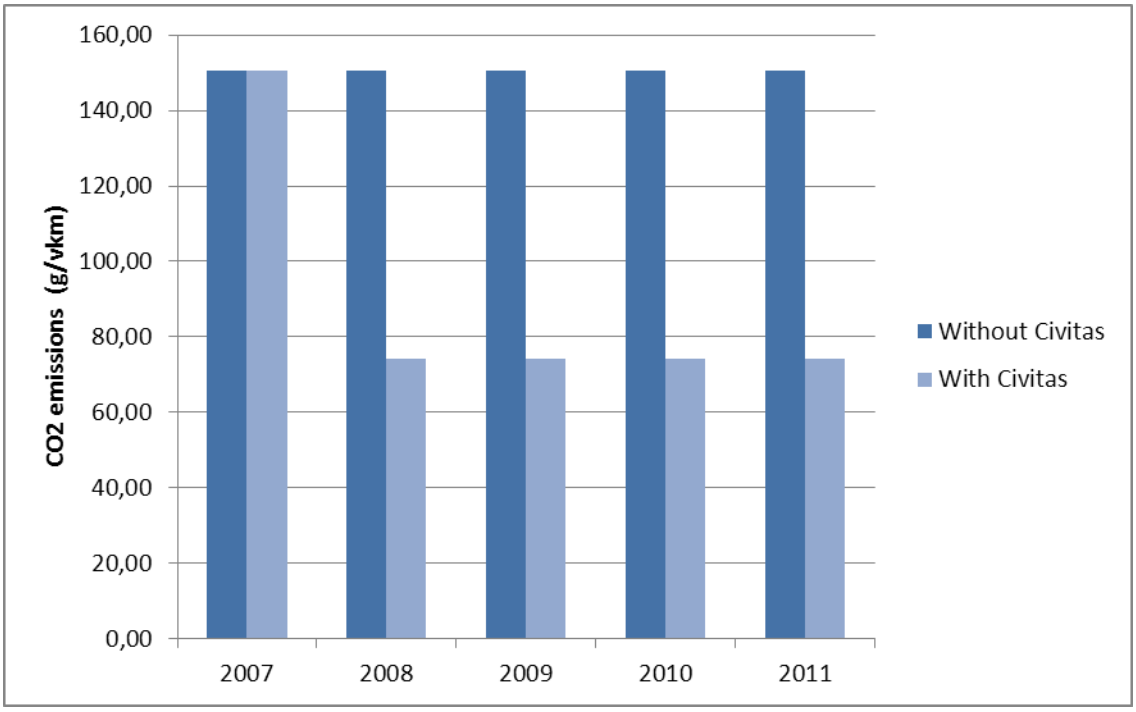


Figure C2.2.4 – CO2 emissions (with/without CIVITAS)

The following graph shows the evolution of NOx emissions (g/vkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

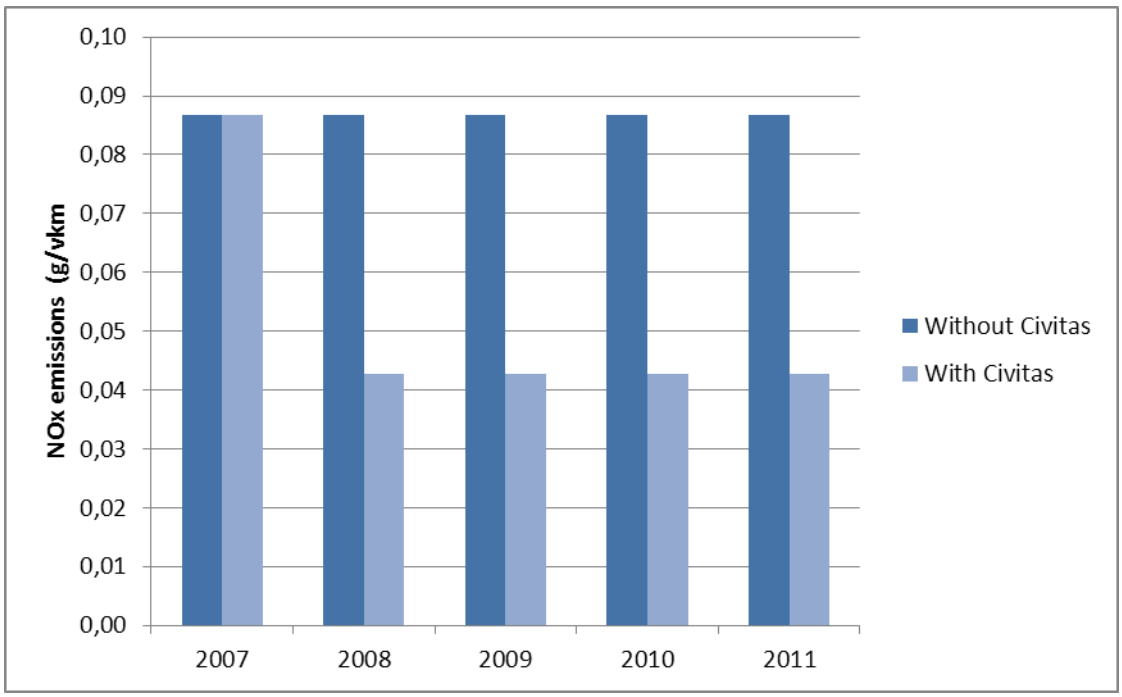


Figure C2.2.5 – NOx emissions (with/without CIVITAS)

The following graph shows the evolution of PT emissions (g/vkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

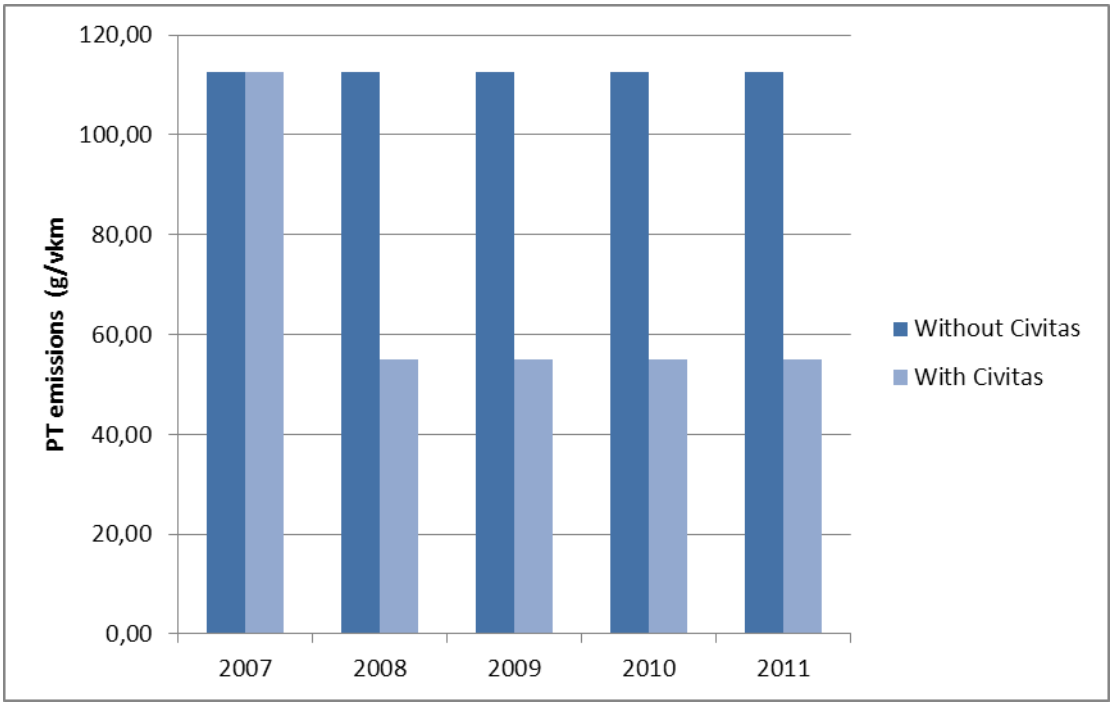


Figure C2.2.6 – PT emissions (with/without CIVITAS)

The following graph shows the evolution of HC emissions (g/vkm) With CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

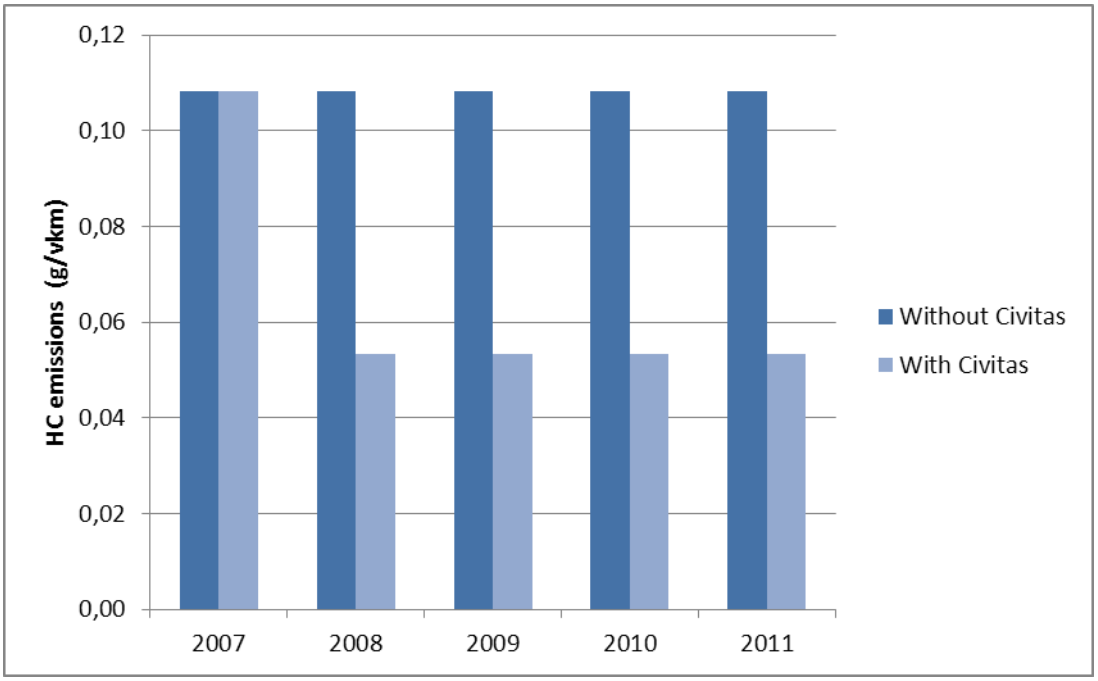


Figure C2.2.7 – HC emissions (with/without CIVITAS)

As expected, with an increased share of (smaller) urban vehicles and specially with the utilization of electric vehicles (whose emissions were considered to be equal to zero given that they have no emissions at local level), the emissions dropped significantly.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To release a feasibility study of new mobility services, mainly that concerns car sharing exploited by "clean" fleets and pre-existent cars from the municipality; The feasibility study of new mobility services has been released	**
2	To reduce the emission of greenhouse gases in Coimbra in case of real implementation of the measure. The study forecast a reduction in the emissions of -0,55, -76,44, -0,04, -0,05 and -57,5 g/vkm in CO, CO2, NOx and HC emissions, respectively).	**
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

The hypothesis undertaken in the feasibility study considered that the carsharing system would be implemented for the whole city, so there is no similar plan to expand this kind of measure to other areas of Coimbra. This measure includes 10 vehicles and covers the entire city. If the measure was applied to a larger scale the impacts will be greater since in the indicators will have an expected substancial decrease. For instance, by upscalling the 10 tested vehicles to 30 potential vehicles the reductions of final energy will be 3,03 MJ/vkm (a reduction of 1,01 MJ/vkm (2010) for 10 vehicles

induces a reduction of 3,03 MJ/vkm in a universe of 30 vehicles). With this potencial reduction it will also affect the local emissions (CO, CO2, NOx, PT, HC) in similar proportions.

C5 Appraisal of evaluation approach

The evaluation strategy of this measure sought to focus on a number of indicators accross the areas of economy, transport, energy, environment and society, which were to be measured in different ways.

The evaluation strategy that based the Local Evaluation Plan (LEP) was defined a long time before the final definition of the measure and during the LEP elaboration the hypothesis considered in relation to the foreseen evaluation approach of the measure was very different from the approach that actually was taken.

In relation to Modal Split (at city level) it was considered that the measure would have little influence and therefore this indicator could be eliminated.

Inspite of the possible meaningfulness of the impact of the measure on the modal split, the evaluation strategy of the indicators in the area of Energy and Environment and the definition of revelant data to the indicators in the area of economy (vehicle-km) was based on the information related to the modal split (data/assumptions about potential modal shift) – not at the city level but on the scope of the trips made by the potential users of the service (in order to determine the corresponding abattement in emissions and energy consumption due to the measure).

Thus, the referred change in the approach of the feasibility study together with the elimination of the above mentioned indicators implied also the redefinition of the evaluation approach of the other indicators.

Taking into consideration that this measure is a study no ex-ante data was avalable for the Awareness level, Acceptance level – users and Acceptance level – operators, resulting in the elimination of these indicators.

C6 Summary of evaluation results

The key results are as follows:

- **Good balance between operating revenues and costs** – The increase in the average operating revenues (+0,78 €/vkm) is more significant than the increase in the average operating costs (-0,74 €/vkm), the balance is 0,04 €/vkm.
- **Increase of penetration electric mobility in the city organics** – Folowing the assumptions established by the feasibility study, the measure would result an increase in the share of the electric vehicles (+19,3 %), mainly, through a decrease in the share of Diesel vehicles (+8,6% / -10,4% being neglectible the impact in the share of the diesel vehicles.
- **Contribution to energy efficiency in the city** – The implementation of the measure would result in significant energy savings due to the expected significant reduction of the energy consumption in each trip (-0,84 MJ/vkm).
- **Improvement of ecological footprint** – As result of the use of a fleet with an important share of small electric vehicles, the implementation of the measure would result in relevant emission savings at local level, given that from the operation of the electric vehicles result no emissions at local level (-0,55, -76,44, -0,04, -0,05 and -57,5 g/vkm in CO, CO2, NOx and HC emissions, respectively).

C7 Future activities relating to the measure

After the end of measure it is foreseen to continue efforts to sensitize decision makers in Coimbra for the real implementation of the car sharing service in this city as well as to disseminate the study to other cities and other stakeholders, with the scope to enlarge the car sharing network in Portugal.

The Municipality became more participative in this issue and made a preliminary agreement for the use of 5 cars of its fleet in case of the car sharing implementation. Also the Mobility Councillor requested that the study consider the possibility of using of electric cars and integrate it in the national electric mobility project (Mobi.e).

Finally during the Mobility Week 2012 the Municipality announced that it wants to launch a municipal service of car pooling.

The seminars, workshops and demonstration events, organized in the scope of this measure, also contributed to increment the knowledge about this kind of service for academics and operators of PT and car sharing services.

D Process Evaluation Findings

D.1 Deviations from the original plan

The deviations from the original plan comprised:

- **The responsibility to carry out the study changed from Municipality to the public transport operator** – In the beginning of the CIVITAS MODERN project there was no experience about car-sharing in Portugal and only some months after was the first service launched, so there was a lack of know-how in this area. This lack of expertise was extended also to the Municipal technicians, worsened by the fact that the mobility issues were frequently a responsibility of SMTUC, the urban public transportation service dependent of the municipality and functioning as the municipal mobility entity. For this reason the municipal technicians had great difficulty in gaining expertise in this domain, while SMTUC technicians increased their knowledge, due the involvement in other CIVITAS MODERN measures and benefiting from the international networking allowed by the project. Taking into consideration that the difficulties experienced by the municipality could have delayed the measure, it was decided that SMTUC would support the municipality in this task and after June 2011 all the responsibility was assumed by SMTUC, a decision that allowed the achievement of all the measure goals foreseen .

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Barrier 1.1 – Organizational Barrier** – A lack of expertise about car sharing in the Municipality technicians, worsened by the fact that at the Portuguese level the circumstances were not very different, caused difficulties in involving municipal technicians in the measure.

Implementation phase

The measure was only a study, so no implementation phase has been foreseen during CIVITAS. Anyway the following barriers could have been the reason for the initial decision to carry out only a feasibility study during CIVITAS instead to implementing the measure:

- **Barrier 2.1 – Cultural Barrier** – The lack of a culture in car sharing in Portugal contributed to the fact that the Municipality of Coimbra and SMTUC didn't believe in the success of such initiative and to made the decision of providing only a study during CIVITAS (it is also important to retain that the first experiences in Portugal with car sharing only began at the same time that MODERN project started)
- **Barrier 2.2 – Financial Barrier** – In addition to the above mentioned barriers other financial priorities were on the Municipality and SMTUC agenda, which involved great investments in the mobility area, namely to recover the lack of national funding to other CIVITAS measures also contributed the final decision to proceed with only a study.

Operation phase

The measure was only a study, so no operation phase has been foreseen during CIVITAS.

D.2.2 Drivers

Preparation phase

- **Driver 1.1 – Organizational Driver** –SMTUC technicians were motivated to solve mobility issues and increase their knowledge about car sharing, due to their involvement in other CIVITAS MODERN measures and the benefits coming from international networking and exchange of experiences. These factors has been used for their involvement in the measure instead the technicians of the Municipality.

- **Driver 1.2 – Involvement Driver** – The Director of *Iniziativa Car Sharing* of the Environmental Ministry of Italy offered to help people involved in the measure and other stakeholders to increase their knowledge and involvement in this area. For the same effect the CEO of *Carris Tour*, the entity for the Car sharing service in Lisbon, invited the Municipality representatives and SMTUC technicians for a technical visit to his service.

Implementation phase

The measure was only a study, so any implementation phase has been foreseen during CIVITAS. Nevertheless, the following driver was essential in catalysing the possibility of implementing the measure:

- **Driver 2.1 – Planning Driver** – The study foresees the possibility of using the Municipal fleet in the car sharing service. This innovative aspect was well received by municipal decision-makers for 2 reasons: the first reason was the possibility of managing the municipal fleet by the car sharing operator (probably SMTUC); the second was the profitability of the fleet for other uses.

Operation phase

The measure was only a study, so no operation phase has been foreseen during CIVITAS.

D.2.3 Activities

Preparation phase

- **Activities 1 – Organizational Activities** – Taking into consideration the lack of knowledge of Municipal technicians about car sharing services (barrier 1.1) and the fact that SMTUC technicians are motivated and more skilled for this issue (driver 1.1), it was decided to change the responsibility for carrying out the study from the Municipality to SMTUC. It was also decided to have the support of consultants used as a training and methodological driver to the SMTUC personnel.

- **Activities 2 – Organizational Activities** – To take advantage of the expertise of the Director of *Iniziativa Car Sharing* of the Environmental Ministry of Italy (driver 1.2), during the 3rd Official CIVITAS MODERN Event, Coimbra hosted an international workshop on car sharing services performed by the referred expert and with the participation of other experts, allowing for SMTUC technicians to increase their knowledge in new mobility services. For the same reason the Councillor for Mobility of Coimbra Municipality and SMTUC technicians visited the car sharing service in Lisbon.

Implementation phase

The measure was only a study, so no implementation phase has been foreseen during CIVITAS. Anyway meetings with Municipality and SMTUC responsible took place, as well as the launching of

promotional campaigns to increase the interest in the measure, avoiding the problems related to barriers 2.1 and 2.2 and taking advantage of the driver 2.1.

Operation phase

The measure was only a study, so no operation phase has been foreseen during CIVITAS

D.3 Participation

D.3.1 Measure partners

- **Measure partner 1 - Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC);** Public transport company; Leading role

  SMTUC was responsible for the coordination of the activities of the measure, the collection of part of the data needed for the feasibility study to set up a car sharing service in Coimbra, as well as its conception and the release of the business plan.

  Additionally, SMTUC together with Municipality played an important role in the planning and implementation of the promotional campaigns carried out to disseminate the measure and test it acceptability.

  Some of the data collection regarding the evaluation were also carried out by SMTUC.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC);** City; Principle participant

  CMC supported SMTUC in the feasibility study, namely in the data collection and in the planning and implementation of the promotional campaigns to disseminate the measure. Since October 2011 the Municipality has been also responsible for the dissemination of the CIVITAS MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO);** High school; Principle participant

  While responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA, PRODESO gave some support in the 3rd Official CIVITAS MODERN Event in Coimbra, which included the international workshop about car sharing.

- **Measure partner 4 – Perform Energia, Lda (PE);** Private company; Principle participant

  PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

D.3.2 Stakeholders

- **Stakeholder 1 – Car Drivers –** The measure was targeted to the car driver that wants to avoid to be owning a car (or another car for the family), offering him an alternative when he has particular mobility needs .

- **Stakeholder 2 – CarrisTour** – This enterprise was the responsible for the car sharing service in Lisbon and provided technicians to make a presentation of the service in the international workshop of the 3rd Official CIVITAS MODERN Event in Coimbra and in the car sharing

demonstration during the European Free Car Day. The CEO of *Carris Tour* also received Municipality representatives and SMTUC technicians for a technical visit to the Lisbon car sharing service.

- **Stakeholder 3 – "Iniziativa Car Sharing Italy"** – The Director of *Iniziativa Car Sharing* of the Environmental Ministry of Italy coordinated and performed the main part of the international workshop during the 3rd Official CIVITAS MODERN Event in Coimbra.

- **Stakeholder 4 – Media** – Media has been a channel for the dissemination and promotion of the measure and all the events organized had the participation at least of the local media.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **Car sharing services are very important for establishing an integrated transport system** – Car sharing services are very important in the cities that want to have an integrated mobility system, being an important complement to the public transport network, creating alternatives for the special mobility needs of drivers that want to avoid have their own car. Cities that have a good public transport network could have advantages in the implementation of these services because each driver that leaves his car could be a potential public transport user. So, as the case of Coimbra and the other 2 Portuguese cities with car sharing systems, the public transport operator could be responsible for this system. Coimbra has a public transport operator that belongs to the Municipality and in a such case this could be an advantage since that the system could be in accordance with the Municipality objectives and allow for better management of all available resources. This driver allowed that the feasibility study to set up a car sharing service could take in consideration the use of the municipal fleet for the service. Also the use of electric cars was chosen in order to take advantage of the *Mobi.e* project (a national project that installed a network of battery chargers in the major part of Portuguese cities). In any way all these conditions are difficult to congregate together in many cities, so the best recommendation is to give great importance to the specification phase and to allow the complete analyse of each case. It is important not to forget any possibility to find the best solution.

- **The share of already existing municipal or private company fleet could face constraints caused by the normal users** – If the share of the Municipal fleet (or the share of other fleets) is foreseen, it must be retained that constraints caused by the usual users of the fleet could appear. These users could overestimate the importance and the time of their car use, so a previous and impartial assessment of the car usage is strongly recommended. This strategy will allow for a correct planning of the fleet to be used in the future service and to have arguments that could justify the choices. During the study a tendency to appoint the oldest cars of the Municipality for the car sharing service was also detected. It is important that everyone understands that the quality of the fleet will be crucial for the services success, so it is recommended to sensitize the decision makers to this problem and also take this issue in consideration during planning.

- **The assessment of potential users could be difficult** – The assessment of potential users of the car sharing service through surveys is very expensive. Another less expensive approach could be to compare the usage in similar services in other cities and propose the beginning of the service with a compromise between the quality given by a great offer (but more expensive) and the use of a smaller fleet that will be cheaper (in the condition that the quality of the offer don't decrease drastically). As previously referred, in Coimbra the increment in the car sharing fleet will be done by the share of cars already used by personnel of the Municipality.

D.4.2 Recommendations: process

- **Potential constraints must be assessed as soon as possible to allow timely recovery actions–** A cultural lack of knowledge about car sharing services was detected in the former contacts with the personnel of the Municipality that were designated to perform the feasibility study. When a lack of knowledge occurs, involvement or commitment of designated people to carry out a task it is very important to have the perception of the problem sooner and anticipate the recovery actions to avoid delays or irreversible consequences. A permanent and rigorous monitoring and coordination of tasks are crucial for this purpose. In Coimbra's case the problem was solved by the involvement in the measure of personnel from SMTUC, the urban public transportation service dependent of the municipality and functioning as municipal mobility entity. These personnel were highly motivated by their involvement in other CIVITAS measures. This involvement and the exchange of experience with other CIVITAS cities also allowed this personnel to have more knowledge about these issues.

- **Knowledge acquisition is very important as is taking advantage of all the available drivers –** Complementary to the previous recommendation it can be affirmed that the increase in the knowledge about car sharing issues was also made possible in Coimbra thanks to the training actions, the attendance of workshops and demonstrations, as well as by visiting other car sharing services. These activities have been possible thanks to the offer of some car sharing operators and experts in this area, but also due to the contacts carried out with these kinds of entities. So it is recommended to put all the efforts when it is needed to solve any problem and it is very important to take advantage of all the drivers and opportunities that are offered.

ANNEX 1: Fuel Mix Data

The next table shows the data obtained in relation to the evolution of the Share of different fuels (diesel, gasoline) in the Fuel consumption in Portugal since 2004:

Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
% Diesel	71,1%	72,2%	73,0%	74,5%	75,4%	75,9%	76,9%	77,7%
% Gasoline	28,6%	27,4%	26,6%	25,2%	24,2%	23,6%	22,7%	21,8%
% GPL	0,3%	0,3%	0,3%	0,4%	0,4%	0,5%	0,4%	0,5%

Source: DGEG - General Directorate for Energy and Geology, Statistics

ANNEX 2: Vehicle Fuel Efficiency Data

The next table shows the data obtained in relation to the evolution of the fuels sales (diesel, gasoline) in Portugal since 2006:

Year	2006	2007	2008	2009	2010	2011
Diesel (ton)	4.764.738	4.864.374	4.791.541	4.831.597	4.870.663	4.607.986
Gasoline 98 (ton)	277.004	225.386	168.600	152.474	137.734	104.341
Gasoline 95 (ton	1.398.446	1.362.922	1.318.223	1.308.281	1.249.228	1.150.735
Total	**6.440.188**	**6.452.682**	**6.278.364**	**6.292.352**	**6.257.625**	**5.863.062**

Source: DGEG - General Directorate for Energy and Geology, Statistics

The following table shows the evolution of energy consumption (MJ) of different fuels (diesel, gasoline). These values are obtained from the evolution of fuel sales (above) with a conversion factor of 43,3 MJ/kg:

Year	Diesel	Gasoline 98	Gasoline 95	Total
2006	206.313.155.400	11.994.273.200	60.552.711.800	278.860.140.400
2007	210.627.394.200	9.759.213.800	59.014.522.600	279.401.130.600
2008	207.473.725.300	7.300.380.000	57.079.055.900	271.853.161.200
2009	209.208.150.100	6.602.124.200	56.648.567.300	272.458.841.600
2010	210.899.707.900	5.963.882.200	54.091.572.400	270.955.162.500
2011	199.525.793.800	4.517.965.300	49.826.825.500	253.870.584.600

Considering that no historic series has been obtained for passenger cars vehicle-km, the historic series for passenger cars passenger-km has been used with the assumption that the average occupancy of the car is stable.

The following table the data obtained in relation to the evolution of Passenger Cars (pkm) in Portugal since 1990 (source: European Commission, EU transport in figures - Statistical Pocketbook, 2011).:

Year	Passenger Cars (10^9 pkm)
1990	40
1995	52,7
2000	71
2005	85
2007	86,6
2008	87
2009	86

ANNEX 3: Energy Density and conversion factors

Energy Density	
1kWh	3,6 MJ
1 litre Diesel	35,86 MJ
1 litre Gasoline	32,18 MJ
1 litre GPL	23 MJ

M08.03 – Executive summary

This measure comprises the implementation of an updated GPS/GPRS Operation Support System in all the Municipal Public Transportation Services of Coimbra (SMTUC) bus fleet and the installation of new generation real time passenger information panels in order to improve PT commercial speed and guarantee more accuracy in the real time information.

The innovative aspects of this measure are very relevant because they have a positive impact in the quality and accessibility of PT. More precisely, the use of GPRS data transmission system allows for improving the quality and efficiency in the real time operational management of the urban PT network and opens up the possibility of implementing in the future an integrated management system of the city traffic lights (giving priority to the PT fleet). Also it permits an optimisation electronic real-time information panels at bus stops (that are accessible to all users and that are supplied with renewable energy) –

The demonstration of the measure within the CIVITAS MODERN period showed that this measure is feasible at a relatively low cost in comparison to those of PT operation.

The demonstration of the measure achieved positive impacts over (passenger numbers and therefore in) the average operating revenues, operating costs, the percentage of trips lost due to traffic problems, the average network speed, and the awareness level of the PT users in a relatively short period of time.

The results obtained in relation to the Cost Benefits Analysis (CBA) suggest that the measure is both effective and efficient in achieving positive results in terms of cumulated costs not only in lifetime of the measure (11,7M € in 10 years) but since the year of its implementation. Also, more than half of the investment will be covered in 10 years only with the decrease of the costs.

The implementation of the measure shows that:

- The upgrade of the Operation Support System to GPRS technology is a cost-effective way to improve the quality of the PT operation management and of the information to the public (including travel planning real-time information on mobile phones) in transport companies that possess more obsolete technologies, namely with investment requirements that are substantially inferior to the costs of acquiring a new system.
- The installation of e-panels in the lobbies and waiting rooms of hospitals with the real time information about the bus arrivals at the nearby bus stops is a good option to improve the information given to the public considering the high visibility and attendance of such places and the reduced costs of the these e-panels in comparison to those usually applied at bus stops.
- Stakeholders should be involved in the specification and launching of the products.
- To preserve the credibility of the information systems among the public it is indispensable to maintain a rigorous and frequent control of the information supplied to users. Accompanying the installation process and monitoring the early stages of operational management of the GPRS / GPS Operation Support System was very important for detecting and characterising the diverse problems that came up and to find rapid solutions for them.

Measure title: **Infomobility Tools for Traffic Data Management in Coimbra**

City: **Coimbra** *Project:* **MODERN** *Measure number:* **08.03**

A Introduction

A1 Objectives

The measure objectives are:

(V) High level / longer term:

- To reduce city traffic levels
- To increase the quality of the urban Public Transportation (PT)

(W) Strategic level:

- To guarantee an accurate real time management of the urban PT network, with special attention to the reliability and image of the service, including the information to the public.

(X) Measure level:

(1) To implement an updated GPS/GPRS Operation Support System[23], with new equipment on board 125 buses and to renew 12 existing real time passenger information panels in order to allow more accurate real time information – reducing the information update gap to less than 1 minute - and improve commercial speed – increasing it by 0,5% in the SMTUC[24] PT network.

(2) To install 6 new generation real time passenger information panels

(3) To develop 1 mobile phone application for passenger information (PT timetable consultation)

(4) The improved real time transport network management also could allow to surpass the 99,5% supply of trips (i.e., the number of trips made in comparison to the ones programmed).

A2 Description

The city of Coimbra is serviced by SMTUC, the public transport operator which covers the majority of the area of the municipality of Coimbra

In order to guarantee the operational management of its PT network, SMTUC has an Automatic Vehicle Management (AMV) system at its disposal. This system is based on GPS technology for establishing SMTUC fleet location and routing. SMTUC possessed an analogical communication and data transfer system from the year 2000 up to the beginning of the CIVITAS MODERN project. However, this system became obsolete and began to reveal some problem regarding its feasibility.

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[23] Automatic Vehicle Management (AVM) System

[24] Municipal PT operator that cover all the urban area of Coimbra City and the major part of Coimbra Municipality

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To improve information quality and the management of the urban public transport fleet, SMTUC was to transfer to a GPS/GPRS technology system.

The updating for the GPS/GPRS – Operation Support System occurred in 2008, just before the start of the CIVITAS MODERN Project and consisted mainly in the following:

- Purchase of 125 new single board computers and command consoles for SMTUC public transport fleet, which could support the GPS/GPRS technology and offer more functionalities and lessen maintenance costs.
- Installation of the new software in the control centre and in the 12 existing real time public information e-panels at bus stops.

The system covers the entire SMTUC PT network, i.e., the entire urban area of the city of Coimbra and the major part of the Municipality..

This updated AVM system has been used in the measure to allow improved real time information for the PT network management and for the infomobility tools. The data actualization in the control centre and in the other devices, namely the e-panels, became more frequent, allowing for more accurate real time information.

Taking advantage of the enhanced system, to increase the information provided to the Coimbra inhabitants and visitors, in the scope of the CIVITAS MODERN project a public information system for mobile phones was developed and 6 new generation electronic panels with real time information about bus schedule (1 for bus stops and 5 for interiors) were designed and installed with the following characteristics:

- The mobile phone application "SMTUC Mobile" provides the Urban public transport time tables on mobile phones, with the possibility of filtering travel period, lines, bus stops, etc. (allowing the automatic information to the user about the travel time more suitable) free of charge.

- The electronic panel at bus stops is powered by solar energy and is equipped with a second display closer to the users that provides the same information as the main display, but which is more adequate for the visually impaired..

- The e-panel for interiors were placed in hospital lobbies to provide real time information about PT bus trips in the nearest bus stops. This activity supported the mobility actions of the CIVITAS MODERN measure 04.05 – Mobility Management Actions.

The GPS/GPRS – Operation Support System is managed at the SMTUC control centre that monitors the public transport network, including the real time information provided to the users (the centre functions every day from 5:30 a.m. to 1:30 a.m. with, at least, 3 employees/day).

The control centre is also responsible for the supply of data for other systems, such as the new e-ticketing system (passenger entry is geo-referenced, lines and bus stops and the PT schedule are coded), the "trip planner RUMOS" (PT routes, bus stops and schedule) and the Geographic Information System of SMTUC (passenger entry, PT routes, bus stops and schedules are geo-referenced). On the other hand the e-ticketing console in the buses also command the GPS/GPRS – Operation Support System, to avoid duplication of operations for the bus drivers and the redundancy of equipment(which is very useful in case of failures).

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A feasibility study was also carried out in order to assess the technical, economical and quality impact of implementing an integrated management system of city traffic lights on the public transport network (with priority for public transport fleet at the cross roads). Two solutions were identified and analysed:

- At each individual cross road the priority is stipulated only by the approach of each individual bus, which sets-off the beginning of the green cycle.
- The GPS/GPRS – Operation Support System automatically manages the priority system.

The second solution was identified as being better and several tests with the GPS/GPRS – Operation Support System and the traffic lights control system were carried out in order to assess the compatibility of the 2 systems and the possibility of implementing it in the in a short time period (despite that during CIVITAS only the technical study was foreseen).

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure were:

- **Innovative aspect 1** – Use of new technology/ITS
    - Use of GPRS data transmission system that allows for more reliable high-speed information transmission, with better quality in the real time updating of all devices on all usable levels.
    - Electronic panels at bus stops supplied by solar energy and equipped with a second display closer to the users that provides the same information of the main display (aiding the visually impaired), , and allows for the loading of the transport e-tickets and the consultation of its balance.
    - Opportunity of using the GPS/GPRS – Operation Support System to provide information for the integrated management of the city traffic lights allowing for the priority to PT fleet at the cross roads in the future (this system is not yet used in Portugal).
- **Innovative aspect 2** – Targeting specific user groups
    - The implementation of applications, such as "SMTUC Mobile" could increment the use of PT by more a demanding public which is more receptive to new technologies, namely young people.
    - The above mentioned e-panels, allows for the visually impaired and other segments of the population with physical limitations (such as the elderly) to have access to the information about the PT system.

B2 Research and Technology Development

The major part of the research and technology development activities in this measure occurred before the start of the CIVITAS MODERN project and was linked to the specifications and development of new software for the GPS – Operation Support System which would replace the analogical (trunking) data transmission technology by GPRS technology. On the other hand, the development of the new e-panels (for bus stops and for interiors) and of the "SMTUC Mobile" application took place during the project, as well as all the tasks linked to the feasibility study on the traffic lights priority for the TP fleet.

These activities are explained below:

Starting in 1999, the urban public transport services of the city of Coimbra (SMTUC) purchased and installed the first GPS - Operation Support System - which was the basis for the system upgrade conducted in 2008.

With this initial system the following elements were installed:

- Infrastructure for radio communications with a Station Base running in Trunking System (System architecture in Fig. B2.1.1).
- Network Control Centre, that consists of a server, a supervision workstation and two posts to control the entire SMTUC PT network.
- On-board equipment, including a radio for voice communication and data, a computer connected to the radio, an antenna for communications, and a GPS receptor, various sensors of bus surveillance, and audio equipment for the automatic passenger information audio system.
- Real time information e-panels for passengers at 12 bus stops.

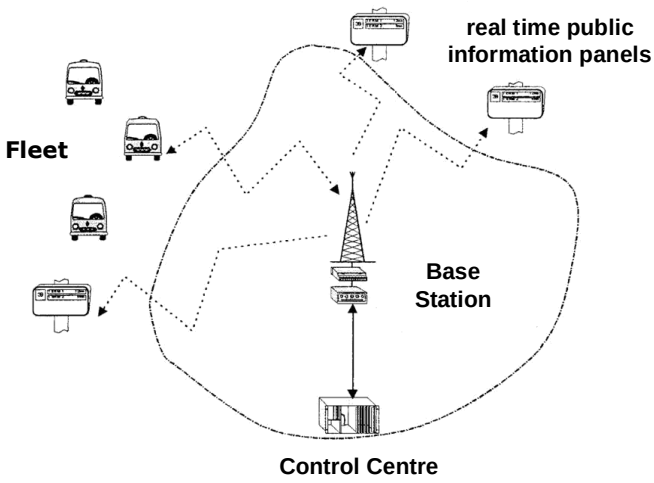

Figure B2.1.1 – System Architecture

The initial system already contemplated the following features:

- Operational management of the vehicles in real time, including the reliability of timetables and the status of the buses (on time, delayed, ahead of time) ;
- Knowledge of real-time location of vehicles;
- Establishment of voice communications between the Control Centre and the vehicles;
- Real time automatic information to passengers at stops on the conditions of supply of transport with time of arrival of the next buses;
- Automatic sound information for passengers in the vehicles indicating the next stop and the notice of the approaching stop;
- Analysis of the performance of the Network;
- Real-time transmission of irregularities in the operation of vehicles and traffic in general;

The second phase began in 2007. This phase comprehended the research and specification work for identifying the required improvements needed for running the initial system with greater accuracy.

The main problem, which was urgently addressed, was that the communications system, via Trunking technology, only provided information of the status of vehicles at intervals of about 2

minutes or more. This raised questions about the accuracy of the real time information at the bus stops e-panels and the real time data for the management of the public transport network.

The fact that the e-panels only allowed information for bus 4 lines of the SMTUC PT network at once (one for each row of the display designed for the purpose) hindered the possibility of a alternation among the various lines that serve each stop. This limitation affected the quantity and quality of the information provided, especially in the City's central stops supplied by a large number of PT lines.

Accordingly the upgrade of the GPS – Operation Support System sought to achieve the following results:

- Improve the efficiency and precision of the real time data transmission / fleet management system, namely allowing for the transmission of a greater quantity of data, with a greater transmission frequency, and a reduction in the system's failures;
- Replace the existing equipment for more modern equipment with reduced maintenance;
- Improve the production of real-time information for the general public and information for system planning and management;
- Improve the voice communication with the buses.

Therefore, a migration to data transmission system based on GPRS technology was carried out and the main modifications to the hardware were linked to the communication system. The SMTUC Base Station's analogical antennas were abandoned and communications were guaranteed through the use of an operator.

With regards to the Control Centre, the modifications centred essentially in changing the software and the communication equipment – GPRS for data transmission and GSM for voice communication

The main modifications resulted in the installation of new on-board computers on the buses. These new devices have touch screen technology which gives drivers' greater ease in using the system, as well as better quality in the information available. The new equipment also has new software and are split in 2 parts: The on-board concentrator that has the capacity to process information autonomously and concentrates the interactions with the rest of the bus's equipment (ignition, odometer, and assorted telemetric); The on-board computer that has a touch screen and houses all the relevant data (routes, timetables, etc.), processes data, and interfaces with the driver..

Also, new GPRS data transmission equipment and software were placed in the existing 12 e-panels

The software main modifications are:

The previous system used an analogical trunking radio network for data and voice communications. This technology did not permit the simultaneous transmission of voice and data. In addition, the minimum period for relaying position information was never under one and a half minutes (usually it was higher);

The substitution of data communication through GPRS technology has allowed for greater efficiency and data transfer capacity.

Position information communication is now done in one minute intervals. Also, the commands effectuated by the drivers are delivered immediately (contrary to the previous system)

The adaptation of the software to the new data communication system was carried out on the system's server, the buses, and the e-panels;

Voice communication is now established through GSM (cell phones were distributed to all SMTUC bus drivers). Therefore, it does not interfere with data communication and has substantially improved the overall quality of communications. Also, communication with the driver is now possible even when he is outside the bus;

The shorter and improved bus position information relay period makes the system more efficient in all aspects – real time information for the public, in the e-panels, and for the operators at the Operation Support System;

Inside the bus the driver now possess information about the journeys, such as start and finish points, bus schedule, eventual route delay time, and indication of the next stop;

In the previous system, timetables were introduced into the on-board computer through a memory card which the driver had to retrieve daily at the control centre. This process had numerous inconveniences: card damage or malfunctions were frequent; cards were many times lost or left on the bus; in routes with high frequency rates two cards were required due to the card memory limits.

In the current system all the information is in the on-board computer where it is updated using a pen-drive in a first phase and now automatically by WiFi (taking advantage of the integration with the new e-ticketing system – CIVITAS MODERN measure 02.05). The integration with the new system also allows the driver to use only one of the consoles for introducing data for both systems (the e-ticketing system module is used by default).

The 2nd generation of e-panels was designed with the participation of SMTUC technicians. As specified, they are supplied by solar energy and have a secondary module that allows for the consultation of the e-tickets by users and also have a screen with the same real time information that is displayed in the main screen – for visually impaired and elderly citizens – as well as sound system for the blind.

The accuracy of the information provided by the system upgrade also allowed for an improvement of the information channels and processes. In other words the upgrade fostered better tools for the management and integration with other systems, as well as allowed for the use of this information to launch a new system supplied by this data e.g., Geographic Information System, the mobile phone application "SMTUC Mobile", the "RUMOS" trip planner and the new e-ticketing system.

A mobile phone application in which the data base is updated with the data provided by the GPS / GPRS Operation Support System was also developed (Initially it was foreseen only a feasibility study for a SMS application). The application – "SMTUC Mobile" – consists of the following:

The application could be downloaded from the SMTUC webpage and run in Java systems for mobile phones, so a "Smartphone" is not necessary for this application (an Android application has been released and is in tests).

The users only need to download the application to their mobile phones and don't have additional costs to access the bus timetables.

The application suggests the best trip time for the PT line chosen by the user, according the actual hour or the period chosen.

A feasibility study was also carried out in order to assess the technical, economical and quality impact of implementing an integrated management system of city traffic lights on the public transport network (with priority for public transport fleet at the cross roads). 2 technical solutions that were compared:

- At each cross road the priority is stipulated only by the approach of each bus. In this case it is the arrival of a bus that commands the beginning of the green cycle, without intervention of the control centre of the GPS/GPRS – Operation Support System. This solution is cheaper but less efficient because all the buses have the same treatment and buses with delays don't have priority. Also it increases the risk of a negative impact in the city's global traffic;
- The GPS/GPRS – Operation Support System is responsible for the management of the priority system and the start of a green cycle for buses only begins for buses with delays that are approaching a cross road. This system is more expensive, because it implies costs in software development for the control centre of the GPS/GPRS – Operation Support System. However it allows for more quality in the PT network and for a decrease in the risk of the negative impact in the overall traffic.

B3 Situation before CIVITAS

Coimbra Municipality has had a strong concern about the citizens' information on mobility issues. Inclusively, to deal with these concerns it has installed some multimedia offices in some strategic city spots.

In the case of SMTUC, real time public information panels on the bus trips were installed in some of its bus stops..

All the SMTUC information came from a GPS – Operation Support System in which communications were based in a radio system. The system allowed also for the management of the SMTUC PT network from a control centre, giving real time information about the fleet localization and its delays or advances in comparison to the foreseen buses schedules, as well as the communication with the drivers trough data or voice messages, and a real time sound system on board buses providing the information about the next bus stop.

This analogical communication system had some limitations in the quantity, frequency and precision of the data transmitted to the PT fleet and the first generation of electronic panels..

The main problems of the analogical system are the communication frequency (the excessive time needed to update the data in each bus or e-panels), the lower quantity of data provided in each data transfer, and the lack of reliability of the single computers on board the buses. Mainly, the first and last issue cause difficulties in the management of the PT network and less quality in the real time information provided for the e-panels and on-board buses (sound messages about next bus stop), while the lower quantity of data provided hindered the development of new functionalities.

Also the lack of reliability and precision contributed to the achievement of contrary results compared to those expected. The system did not satisfy all the users expectations.

Accordingly, there was the need for a more accurate and quicker system and with improved data communication frequency. For these reasons, in the scope of the CIVITAS MODERN project it was be decided to upgrade the GPS – Operation Support System by migrating to GPRS communication and the development of new software. That was the only way to achieve a satisfactory level in the real time information quality at the bus stops. In addition, there were gains in the global and integrated management of the transport network functioning that can improve even more with the desired extension of this to the integrated management of the city traffic lights allowing the priority to PT fleet at the cross roads.

With the improvements described above, particularly the gains in the real time operational management of the PT network, during CIVITAS the accuracy and reliability of the PT schedules, was increased, raising the PT commercial speed by 2% (more then the 0,5% initially expected).

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Model's conception and definition of technical specifications for the Operation Support System upgrade *(October 2008-February 2009) – The major part of the specifications and development were made before CIVTAS start-up and were used by the Project. This initial work consisted of the development of new GPS / GPRS – Operation Support System software in Coimbra to replace the previous analogical radio system, so that it can support the data communication technology by GPS/GPRS and new functionalities.*

During CIVITAS the design of the new e-panels that could be feed by solar energy and with a module in the base of the mast with a 2nd display for real time information and reading and loading of the e-tickets was carried out..

A document concerning the "Report on design and implementation of the System" was also delivered.

Stage 2: Purchase and installation of the GPS / GPRS – Operation Support System *(October 2008) – The lack of feasibility and precision of the existing analogical system and the difficulty in finding suppliers for the damaged equipment of the existing system forced the need to hasten the purchase process and avoiding the start of the CIVITAS Plus project (which was postponed). The purchase and installation process were concluded with success before CIVITAS start-up and the system was used by the project. This phase included mainly the installation of the 125 new single board computers (that support the GPS/GPRS technology) for the totality of the SMTUC public transport fleet, the installation of the new software in the control centre and in the 12 existing real time public information e-panels at bus stops and the substitution of the voice communication equipment. The data actualization in the control centre and in the other devices, namely the e-panels, became more frequent, allowing for more accurate real time information.*

The on-board equipment installed in the entire SMTUC fleet has the following characteristics:

On-board concentrator

The equipment has the capacity to process information autonomously and concentrates the interactions with the rest of the bus's equipment (ignition, odometer, and assorted telemetric). It also posses a GPS (Sirfill) and a GPRS modem. This equipment interacts with the on-board computer and has the following characteristics:

On board computer

The computer has a touch screen and houses all the relevant data (routes, timetables, etc.), processes data, and interfaces with the driver. It has the following characteristics:

Due to voice communications having passed to GSM technology, cell phones were distributed to all 284 SMTUC bus drivers.

The entire SMTUC PT network was covered with the new GPS/GPRS Operation Support System (82 bus-lines and a network extension of 556 Km)

Stage 3: Training of the System users *(October 2008 – February 2010) – Before the beginning of the CIVITAS MODERN project the initial training concerning the operations with the equipment on board buses for the drivers and their trainers and training for the control centre personnel on the system management was carried out (315 participants during 472 hours). This phase also comprised the training of maintenance personnel trainers (5 participants during 70 hours).*

In 2010 new training actions for the drivers about the 2nd model of mobile phones for the voice communications and to the control centre users about new functionalities, such as the "SMTUC Mobile" System took place (327 participants during 344 hours).

Stage 4: Operational management and monitoring of the updated GPS / GPRS – Operation Support System *(October 2008 – October 2012) – The start-up of the updated system was in March 2008, before CIVITAS beginning. During CIVITAS this stage consisted of the monitoring of the public transport network, functioning every day from 5:30 a.m. to 1:30 a.m. with at least on staff member in permanence, reinforced by more personnel, mainly at rush hours. Some of the activities are:*

- *Monitoring the real time trip of the buses to avoid gaps in comparison to the schedule, trying to ensure the reliability and quality of the service provided.*
- *Monitoring the real time information displayed on electronic panels at bus stops to avoid inconsistencies with reality.*
- *Establish communications with the bus drivers when necessary.*
- *Real time security survey of PT users and bus drivers.*
- *Real time maintenance survey of buses and other equipment, like panels at bus stops and audio real time user information in the interior of the buses.*
- *Delivery of the information received and stored on the server of the system, including the data needed for other systems, such as the "trip planner RUMOS" and the "SMTUC Mobile".*
- *Data collection for evaluation purposes.*

The control centre is also responsible supplying of data for other systems, such as the new e-ticketing system (passenger entry is geo-referenced, lines and bus stops and the PT schedule are coded), the "trip planner RUMOS" (PT routes, bus stops and schedule) and the Geographic Information System of SMTUC (passenger entry geo-referencing, PT routes, bus stops and schedule). On the other hand the e-ticketing console on the buses also command the GPS/GPRS – Operation Support System, in order to avoid the duplication of operations for bus drivers and to allow redundancy of equipment, which is very useful in case of failures.

Stage 5: Development launching of the "SMTUC Mobile" System *(October 2008 – September 2009) – Development of an application (SMTUC Mobile) to be allocated in PT WebPages, that supplies PT timetables on mobile phones when uploaded to this equipment (fig B4.1). The application suggests the best trip time for the PT line chosen by the user, according the actual hour or the period chosen. Between April and September 2009 the tests phases were carried out and there was the improvement of the different software versions until the successful final version was delivered.*

The public transport service of the Portuguese City of Braga has also implemented this system, taking into consideration the great success of this application in Coimbra and its advantages, namely to be free for users.

Figure B4.1 – Overview of the "SMTUC Mobile" application

Stage 6: Technical study for preferential traffic light regulation for PT *(September 2009 – January 2010)* –A feasibility study was also carried out in order to assess the technical, economical and quality impact of implementing an integrated management system of city traffic lights on the public transport network (with priority for public transport fleet at the cross roads).. *The study took in consideration, namely, the following:*

- *Survey of Urban PT routes and road intersections to chose priority sites for implementation of the system;*
- *Survey of traffic light controls to analyse which control device models could receive the system;*

- *Contacts with suppliers to choose the best solutions to apply;*
- *Study performed to analyze various solutions for the conflict between regular traffic and public transport in traffic light controlled intersections;*
- *Traffic counts at the designated axis, for an established period of time, allowing for an estimation of the losses and concentration of volume of public transport that needs to proceed with priority passage in a specific trip and during the period of highest traffic intensity;*
- *Study of the traffic lanes with the most congestion during the period of highest traffic intensity (rush hour);*

Two solutions were identified, studied and estimated costs for each one:

- *In each cross road the priority is stipulated only by the approach of each individual bus, which initiates the beginning of the green cycle;*
- *The GPS/GPRS – Operation Support System manages the priority system and only initiates the start of a green cycle for buses that approach a cross road with a delay in its schedule.*

A report that schematizes the two identified solutions, highlighting the advantages and disadvantages of each one, was released. The report highlights that the second solution is better for enhancing the quality of the PT service.

The future implementation of this system namely aims to increase the Average PT Network speed.

Despite that during CIVITAS only the technical study for preferential traffic light regulation for PT was foreseen, the Municipality and SMTUC conducted several tests with the GPS/GPRS – Operation Support System and the traffic lights control system in order to evaluate the possibility of implementing the preferential traffic light regulation in a short period.

The tests were confined to the city centre, which is the area of the city that could receive this system in the future (fig B4.2).

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Figure B4.2 – Centre City areas appointed for the implementation of the preferential traffic light regulation for PT

Stage 7: Purchase and installation of the 2nd generation e-panel that allows real time public information for the passengers *(March 2009 – October 2012) –The first new model of the 2nd generation e-panel, which allows for real time public information at bus stops was installed (fig. B4.3). . The tests have been successful and it was decided to purchase more e-panels.*

Main screen of the panel with real time information

Real time information panel at bus stops powered by solar energy (left) and detail of the secondary module with second information screen and "contact less" reader (right)	about buses arrivals time

Figure B4.2 – Overview of the real time information panel

In the last trimester of 2011 SMTUC purchased another 5 e-panels with real time information, that are similar to the e-panels installed at bus stops, but are designed for interiors (Fig.B4.4).

The first e-panel for interiors has been installed at the lobby of the IPOC hospital on the 22nd September 2011, integrated in the mobility actions of CIVITAS measure 04.05.

This kind of e-panels allows users to be comfortable in the hospital lobby while they wait for the arrival of the bus. The possibility to rest in the lobby until the last moment is very important taking in attention that the majority of these users have problems of accessibility (patients, elderly, handicapped, ...)

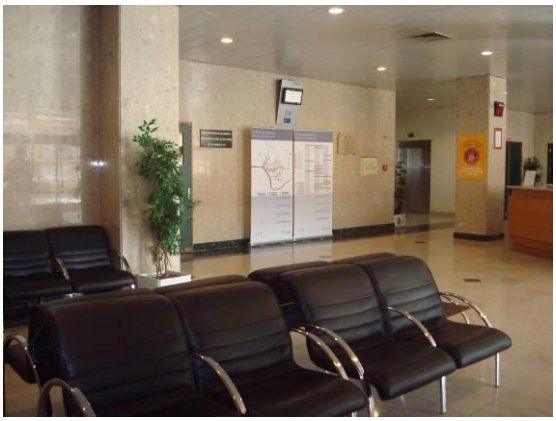	
E-panel in the lobby of the IPOC hospital.	The e-panel gives real time information about bus arrivals at the bus stops near the hospital

Figure B4.3 – Overview of the real time information panel in the IPOC Hospital

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

- **Measure no. 02.05** –At a functional aspect the e-panels of the GPS/GPSR – Operation Support System will have capabilities linked to this system (module that display the contents of e-tickets and could load e-cards in the future);

- **Measure no. 04.02** – At a functional aspect the static data provided by the GPS/GPSR – Operation Support System will have capabilities linked to the "RUMOS trip planer", integrated in this measure no. 04.02;

- **Measure no. 04.05** – At a functional aspect the e-panels of the GPS/GPSR – Operation Support System was integrated in the actions foreseen for the mobility plans for the hospitals involved in this measure no. 04.05.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1: Indicators.

No.	Impact	Indicator	Data used	Comments
1	Operating Revenues	Average Operating Revenues	Total income generated from fares and tickets; total vehicle-km	Operating revenues are provided by SMTUC
2	Operating Costs	Average Operating Costs	Total operating costs incurred by the management and information systems; total vehicle-km	Operating costs are provided by SMTUC
3	Costs	Capital Costs	Total capital costs expended in setting up the measure	Capital costs are provided by SMTUC
4	Service Reliability	Percentage of lost trips due to traffic problems	Total number of performed trips; Total number of scheduled trips	% lost tripe are provided by SMTUC
5	Vehicle Speed	Average PT Network Speed	Total PT vehicle-km; Total vehicle-h	PT network speed are provided by SMTUC
6	Awareness	Awareness level – users	Total number of respondents with knowledge of the measure; Total number of respondents	Awareness level are by the SMTUC satisfaction survey

Detailed description of the indicator methodologies:

- **Indicator 1** (*Average Operating Revenues*) – Ratio of total income generated from fares and tickets, divided by the total vehicle-km per year (€/vehicle-km).

  A = B / C

  where: A = Average operational revenue for the SMTUC PT service (€/vehicle-km)

  B = Total operational revenue coming from tickets/fares sales (€)

  C = Total vehicle-km

  All data is related to the overall SMTUC services and fleet. Results from vehicle-kilometres coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded every day. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the GPS/GPRS Operation Support System.

- **Indicator 2** (*Average Operating Costs*) – Ratio of total operating costs incurred by the service divided by the total vehicle-km per year (€/vehicle-km).

  A = B / C

  where: A = Average operational costs for the service (€/vehicle-km)

  B = Total operational costs of the service, including Personnel Costs, Fuel Costs, Maintenance Costs and Other Operational Costs related to the SMTUC PT service (€)

  C = Total vehicle-km

  All data are related to the overall SMTUC services and fleet. Results from vehicle-kilometres coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded every day. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the GPS/GPRS Operation Support System.

- **Indicator 3** (*Capital Costs*) – Total capital costs expended in setting up the measure (€).

  Expenditures with the purchase and installation of the necessary equipment (single board computers for buses and information panels, new GPS receptors, real time information panels for bus stops), software for the management and information systems and with the development and research for new GPRS software for control centre, single board computers and information panels (€)

  All data is related to the overall SMTUC management and information systems and fleet. The data reliability is maximised due to an objective data collection.

- **Indicator 4** (*Percentage of lost trips due to traffic problems*) – Percentage of trips lost due to traffic problems by the SMTUC fleet during regular operation in comparison to the scheduled trips (%).

  A = B / C × 100

  where: A = Percentage of lost trips (%)

  B = Total number of lost trips due to traffic problems

  C = Total number of scheduled trips

  All data is related to the overall SMTUC regular operation. Results from lost trips and their respective loss motive are registered monthly. The source is the Excel file where the trips are recorded every day by the SMTUC operator. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedures: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the GPS/GPRS Operation Support System.

- **Indicator 5** (*Average PT Network Speed*) – Ratio of total vehicle-km performed by the SMTUC fleet during regular operation divided by the total vehicle-h spent on performing the respective services (km/h)

  A = B / C

  where: A = Average PT Network Speed (km/h)

  B = Total vehicle-km

  C = Total vehicle-h

  All data is related to the overall SMTUC fleet. Results from vehicle-kilometres and vehicle-h coming from the subtraction of non performed trips data to the scheduled ones. The source is the Excel file where the trips are recorded everyday. The data reliability is maximised due to an accurate data collection among SMTUC records on performed and scheduled trips, which in turn are recorded following reliable procedure: each driver records the corresponding performed/non performed trips; the extension of each trip is known; the number of performed trips recorded by the drivers is validated by the GPS/GPRS Operation Support System.

- **Indicator 6** (*Awareness level*) – Percentage of the users with knowledge of the measure on account of provided information (%).

  A = B / C × 100

  where: A = Percentage of users with knowledge of the measure (%)

  B = Total number of respondents with knowledge of the measure

  C = Total number of respondents

  The Awareness level of the measure is measured during customer satisfaction surveys (for more details, see annex dedicated to the customer satisfaction survey) by introducing the following specific question relative to the knowledge of the respondent about the measure – Are you aware about the SMTUC timetable information service for mobile phones?

C1.2 Establishing a Baseline

The year 2007 is considered as the baseline, before the start of the "operational management and monitoring of the updated GPS / GPRS – Operation Support System" in March 2008.

The measure results are obtained from SMTUC records on indicators 1, 2, 3, 4 and 5 and from the customer satisfaction survey periodically carried out by SMTUC on indicator 6 – Awareness level of users.

Indicators 1, 2, 3, 4, and 5 (Operating Revenues, Operating Costs, Capital Costs, Percentage of lost trips due to traffic problems and Average Network Speed):

The transport company SMTUC provided information on both the costs of operating the SMTUC PT system and revenues coming from ticket sales to passengers in relation to the operation of SMTUC transport services. Similarly, it is provided information on the Average PT network speed, on the Percentage of lost trips due to traffic problems in comparison to the scheduled trips along SMTUC regular operation and on capital costs in setting up the measure

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The results of baseline for each indicator are:

Table 6 – Indicator n.1 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Revenues from tickets (€)	7.951.000,00
Total vehicle-km	5.887.000
Average operating revenues	1,35 €/vkm

Table 7 – Indicator n.2 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Total Operational Costs	14.171.776,57 €
Total vehicle-km	5.887.000 (vkm)
Average operating costs	2,41 €/vkm

Table 8 – Indicator n.3 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Investment in the purchase of the equipment	0,00 €
Total capital costs	0,00 €

Table 9 – Indicator n.4 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Total scheduled trips	382 232
Total trips lost due to traffic problems	1 062
Trips lost due to traffic problems	0,28 (%)

Table 10 – Indicator n.5 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Average Network Speed	16,67 (km/h)

Indicator 6 (Awareness):

This question was not applied before the launch of the "SMTUC Mobile" because it was considered that it is not rational to ask people if they know about something which has not yet happened. Thus, it is considered that before something exists awareness is zero because it is impossible to know it.

Table 11 – Indicator n.6 – ex-ante values

Indicators and respective parameters	Ex-Ante values
Awareness level – users	0 %

C1.3 Building the Business-as-Usual scenario

The CIVITAS MODERN accelerated the implementation of the GPS / GPRS – Operation Support System, the acquisition of more real time information e-panels, and the provision of the mobile phone application to users. Without CIVITAS these improvements would not have taken place within a 4 or 5 years (certainly not within the period of the project).

Without the implementation of the measure (business-as-usual scenario) no changes were likely to occur in any of the following indicators: 3 - Capital Costs, and , 6 - Awareness level – users. Therefore, the B-a-U scenario for these indicators equals to the respective Ex-Ante value.

The available historical data about the indicators 1 - Average Operating Revenues, 2 - Average Operating Costs, 4 - Percentage of lost trips due to traffic problems and 5 - Average Network Speed may help to detect trends for these indicators. The B-a-U scenario for these indicators is based on trend lines resulting from historical data about them over the last years of SMTUC operation.

Indicator 1 (Average Operating Revenues)

In order to determine the B-a-U scenario for this indicator, the available data about revenues from tickets has been used because the annual series data over the last years are available (in relation to vehicle-km it is considered that making extrapolations is non sense because it is a parameter that is controlled by the operator and not related to the measure). Thus, it is possible to extrapolate for the next few years.

Revenues from tickets are a product of the number of passengers and of the tariff requested to each passenger. In order to extrapolate on revenues from tickets the available data about the number of passengers has been used because the annual series data over the recent years is available (in relation to the tariff requested to each passenger it is considered that making extrapolations is non sense because it is a parameter that is controlled by the operator and not related to the measure).The following graph illustrates the real number of passengers of SMUTC until 2007 and the indexed projection from 2008 to 2012.

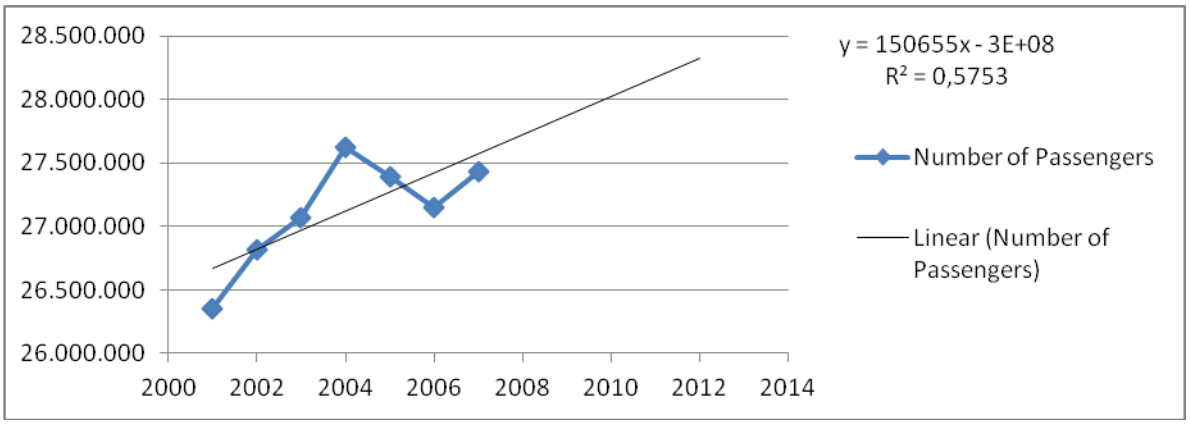

Figure 4 – Number of passagers until 2007 and linear projection for 2008-2012

However, with the financial crisis deeply affecting the Portuguese economy, extensive social changes occurred in Coimbra, with unforeseeable impacts over SMTUC PT demand.

The significant increase in the unemployment rate in Portugal (from 7,5% in the last trimester of 2008 to the actual rate over 15%), caused a decrease of the PT demand. However, the influence of the purchasing power in the demand for public transportation also needs to be known, in order to verify if this factor is enough to invert the tendency.

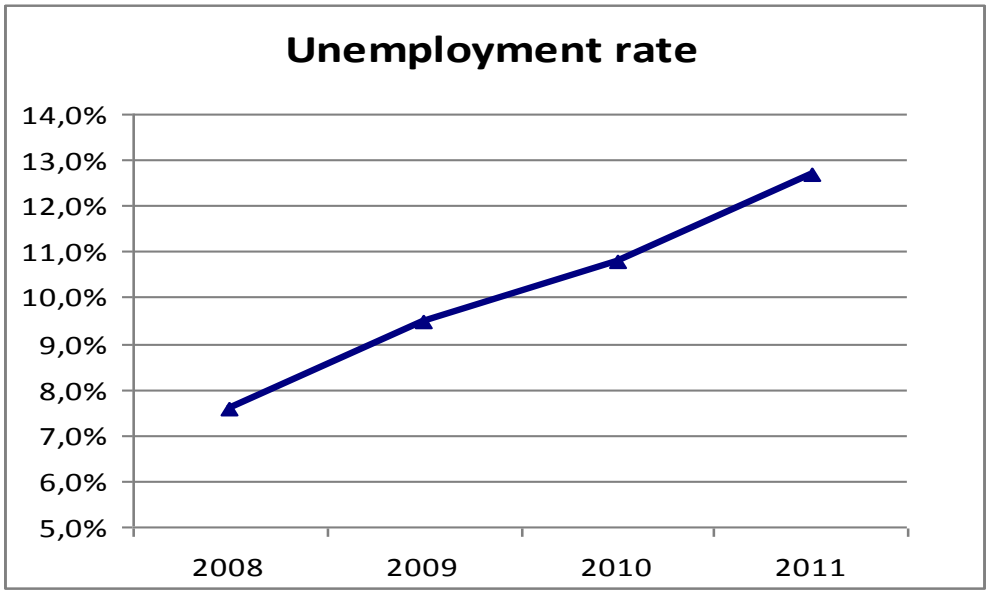

Figure 5A – Unemployment rate

Figure 6B – Salary per capita

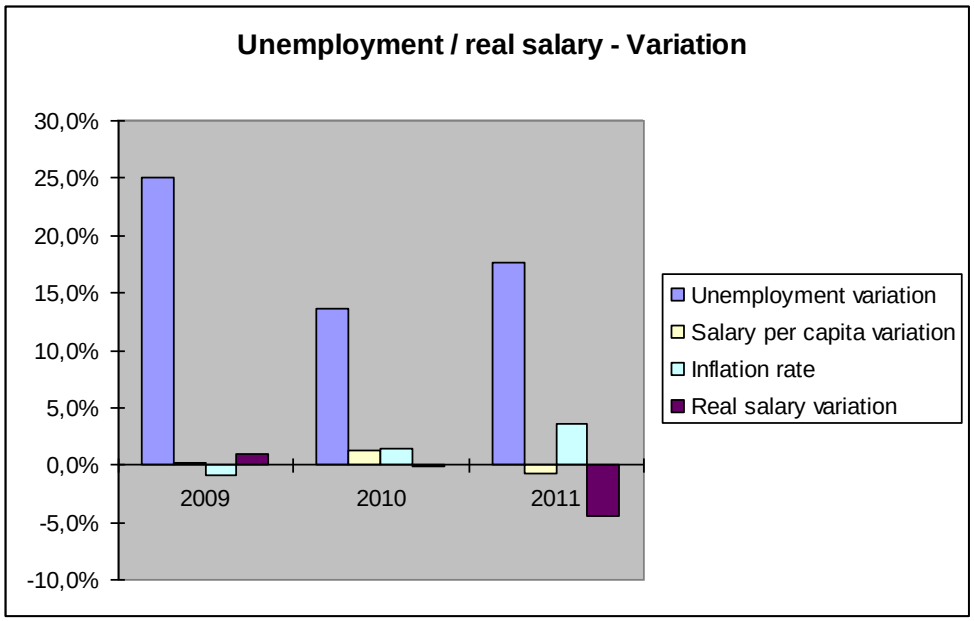

Figure 7C – Variation Unemployment rate/ real Salary

The unemployment rate has increased 25% in 2009 in comparison to 2008 and more than 13% in the other years (fig. 2A), while the real salary per capita has not witnessed comparable variations (maximum variation – decrease of 4,4% between 2010 and 2011 as shown in the fig.2B).

Accordingly, it seems that without CIVITAS the trend would be a drop in the SMTUC passengers due to the financial crisis and the fact that the influence of the augment in the unemployment rate was greater then the decrease in the purchasing power (fig.2C).

Thus, it has been considered that in this context extrapolation is no longer suitable and using available data from sites would be better to determine the evolution of the number of passengers.

The next graph shows the evolution of road based Public Transport passenger-km in Portugal (source: European Commission, EU transport in figures - Statistical Pocketbook, 2011).

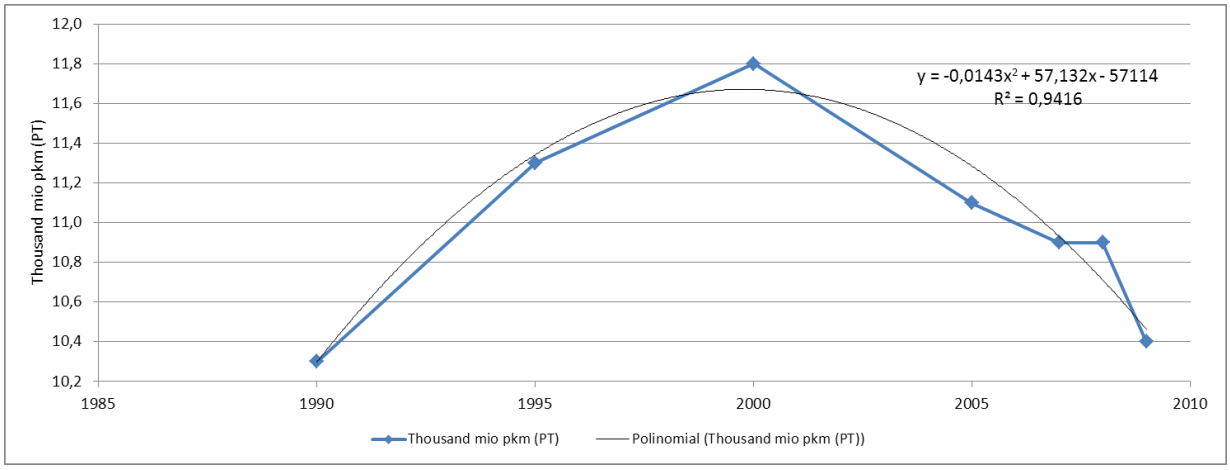

Figure 8 – Passanger kilometer forecasting

The above graph shows a 2 phase trend. During 1990-1999 an increase is identifiable in pkm and in 2000-2009 there was a decrease of Public Transport in Portugal.

The next graph shows the evolution of road based number of Public Transport passengers in Portugal from 2000-2003.(Source: GPERI-MOPTC (2009), Obras Públicas, Transportes e Comunicações - Alguns Números - 2000-2007, Transporte Rodoviário, Portugal (Source: INE)

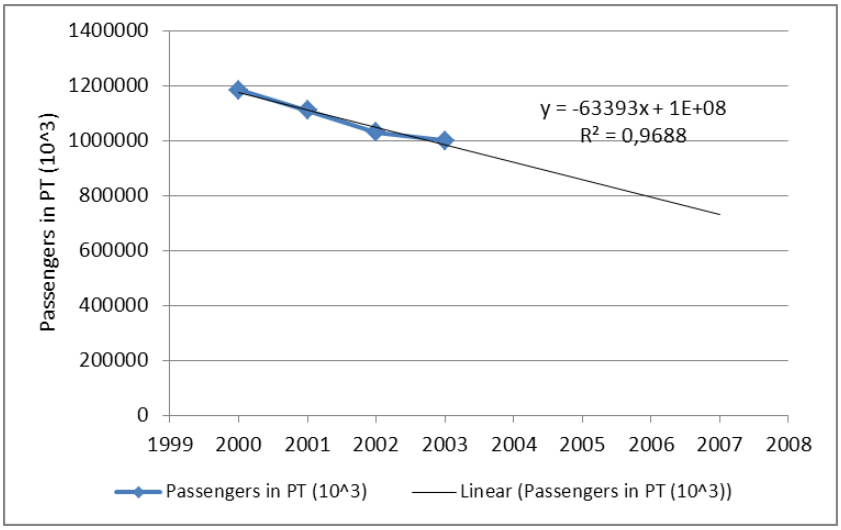

Figure 9 – Passanger in PT forecasting

The graph shows a decreasing trend in the number of passengers of PT in Portugal from 2000-2003, which confirms the general trend over the last decade of a general decrease in the use of PT in Portugal.

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Considering that Braga is the Portuguese city most comparable to Coimbra in terms of population and transport supply, the available data relative to the road based urban PT operator of the city of Braga (TUB) has been chosen to extrapolate about the number of PT passengers in Coimbra.

The next graph shows a comparison between the evolution of passenger numbers in the SMTUC network with the evolution of passenger numbers in TUB network according to the data obtained:

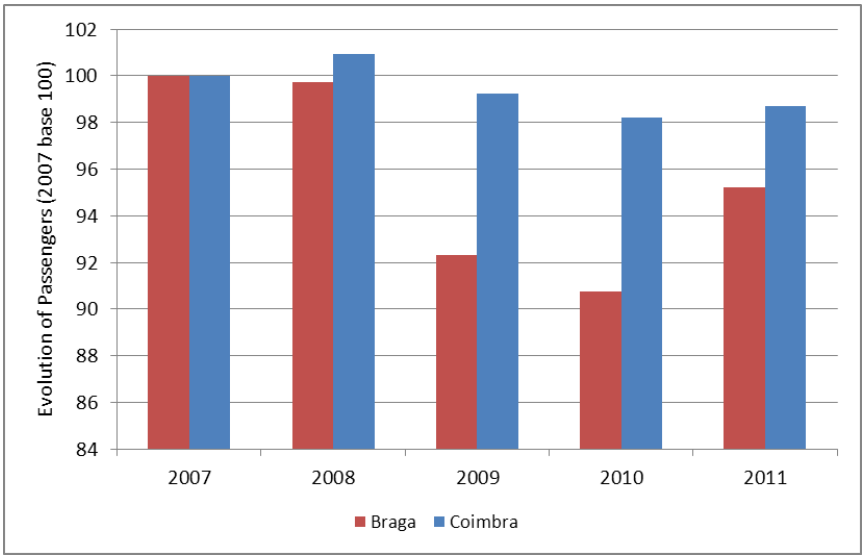

Figure 10 – Evolution of passangers (2007 base)

The graph shows that SMTUC experienced a smaller reduction in the number of passengers than TUB. Hence, the assumption is that MODERN is the reason for the lower reduction and that in case of no MODERN in Coimbra the drop would have followed the drop in the number of passengers experienced by TUB.

The next graph shows the evolution of passengers in TUB network according to the data obtained (see annex):

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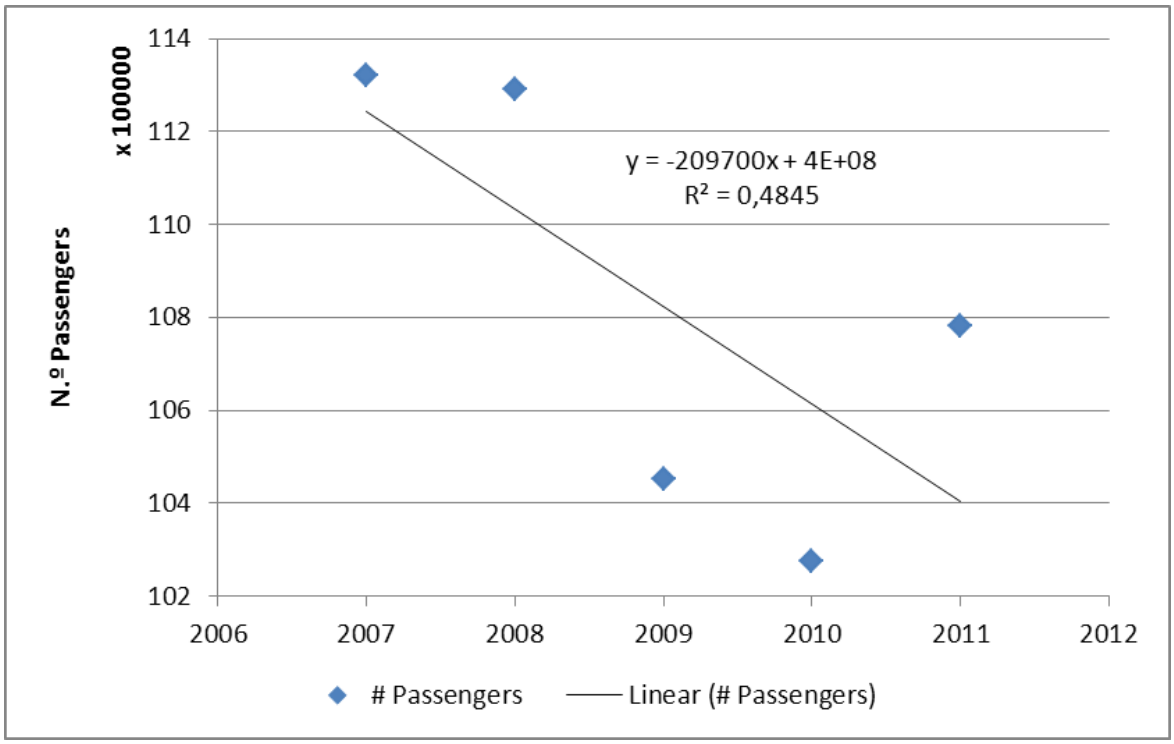

Figure 11 – Passengers in TUB network

By using the trend in the above graph, it was possible to extrapolate the number of passenger in Coimbra from the baseline (2007) until 2012 (BAU 2). The trend used for forecasting the evolution of passengers shows a low correlation coeficient (0,4845), i.e, a low degree of linear relationship between the two variables.

To analyse more pecisley, other types of trends (exponential, logarithmic, polynomial, …) were tested but at all of them show similar correlation coeficients. Due to this fact the linear trend was choosen as the the one that forecast the next period.

The following graph illustrates the passenger numbers in Coimbra from 2001-2007 (pax/year), the scenario resulting from the extrapolation of that data (BAU 1), and the scenario resulting from the use of the data concerning the Braga operator (TUB) to extrapolate about the number of passengers in the SMTUC network (BAU 2):

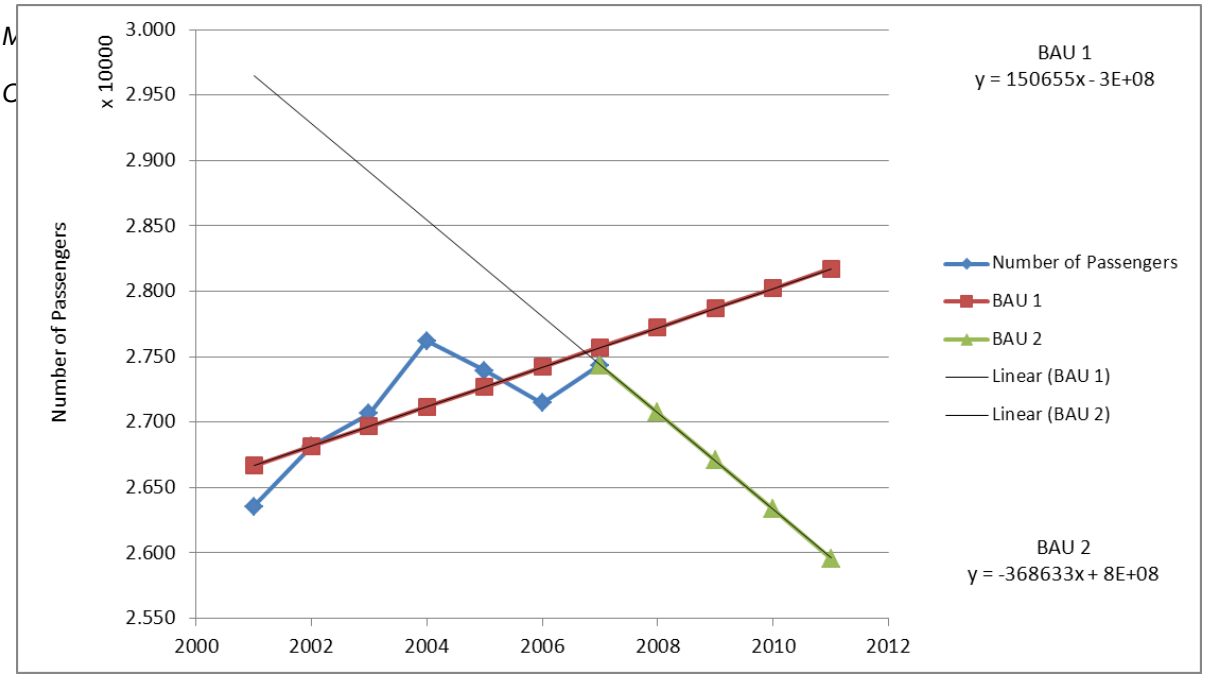

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Figure 12 – Passengers in SMTUC network forecasting

The next graph shows the evolution of the tariff requested to each passenger from 2001-2011.

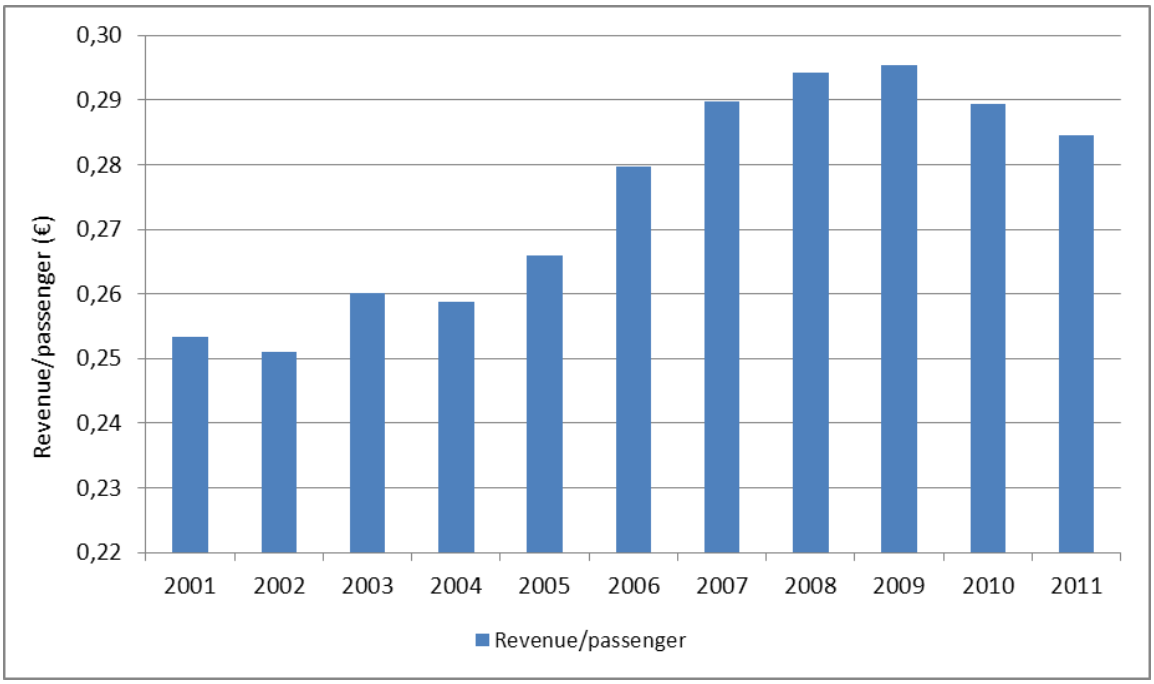


Figure 13 – Renevues per passenger in SMTUC

With the values from the tariff requested to each passenger, with the values available from the number of passengers 2001-2007, together with the BAU scenario for the number of SMTUC passengers (BAU 2) from 2007-2011, and with the values available from the number of vehicle-km, the B-a-U scenario was obtained for the indicator (BAU 2) presented in the next graph:

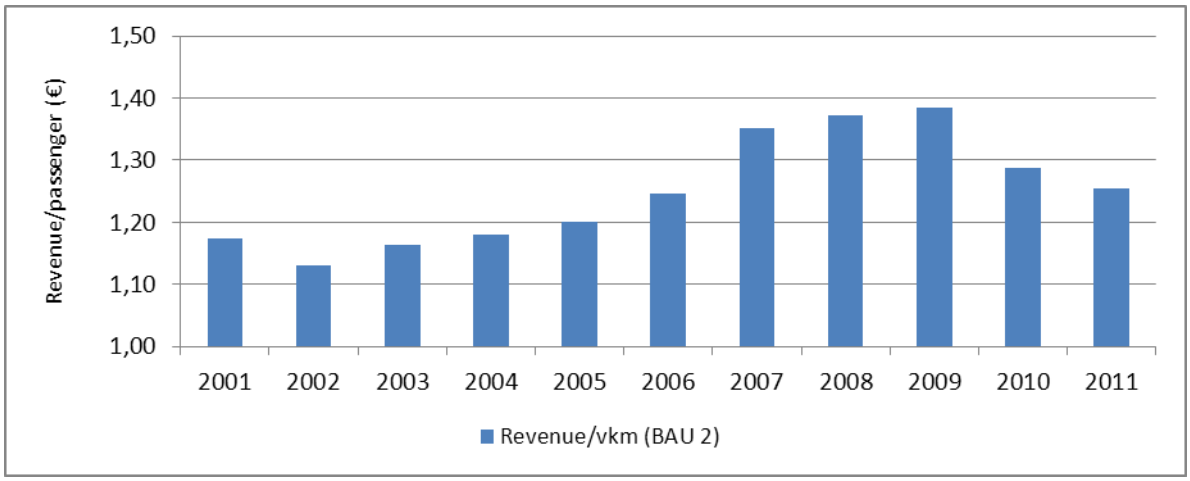


Figure 14 – Renevues per vkm in SMTUC

Therefore, the results of BAU scenario for this case are:

Table 7 – Indicator n.1 – BAU values

Indicators and respective parameters	BAU Values
Average operating revenues (2008)	1,37 €/vkm
Average operating revenues (2009)	1,38 €/vkm
Average operating revenues (2010)	1,29 €/vkm
Average operating revenues (2011)	1,25 €/vkm

Indicator 2 (Average Operating Costs)

In order to determine the B-a-U scenario for this indicator, it was calculated using the available data about total operational cost because the annual series data over the last years is available (in relation to vehicle-km it is considered that extrapolations are not adequate because it is a parameter that is controlled by the operator and not related to the measure). Thus, it is possible to extrapolate for the next few years.

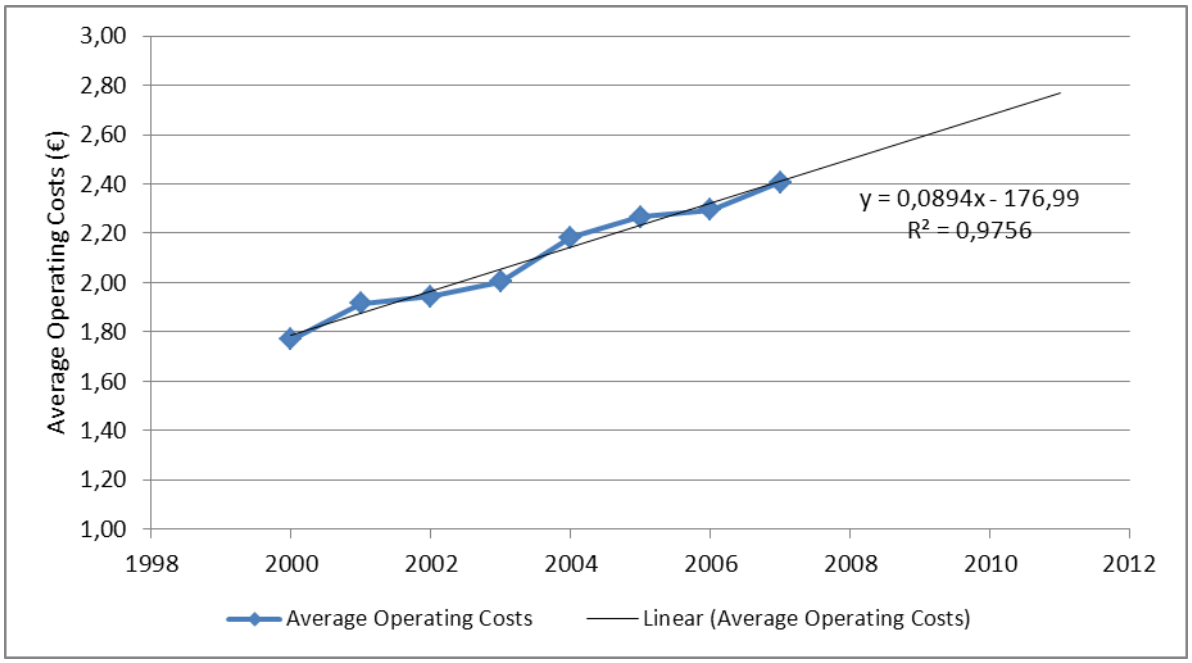


Figure 15 – Operating costs in SMTUC

However,

a) considering the relative low cost of the measure in comparison to the total SMTUC operating costs,

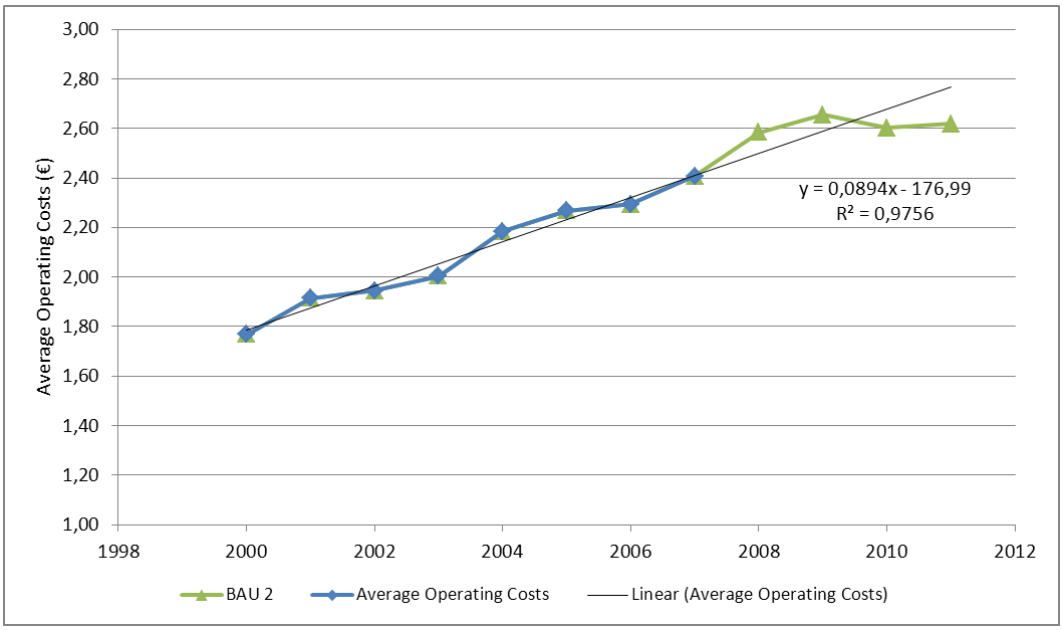
b) considering the increasingly volatile conditions in which SMTUC is operating (including strong variations in fuel prices, labour market regulation reforms, and budget cuts, including salaries related to the public response to the financial crisis) resulting in an increasing variability of costs in time in comparison to the extrapolation of the cost values from the past,

The B-a-U scenario has been redefined (in relation to vehicle-km, again, it was considered that extrapolations are not adequate because it is a parameter that is controlled by the operator and not related to the measure). Therefore, a new approach has been defined to set the B-a-U scenario for this indicator.

One basic consideration in the definition of the new B-a-U scenario is that this measure has no impacts in the total costs of the SMTUC operation beyond, obviously, the added operating cost resulting from the implementation of the measure itself.

Thus, in order to determine the B-a-U scenario, it was considered more adequate to use the already known operating costs resulting from the implementation of the measure itself (upgraded AVM system) and compare with the expected evolution of the operating costs due the former system. This calculation has been made for the Cost Benefit Analyse and is explained in the item C2.6. In the CBA the operating costs balance between the ex-post and the B-a-U scenario results in a decrease of the operating costs (-6.063 €, -6.993 € and -13.353 € in 2009, 2010 and 2011, respectively – see table 31). So de B-a-U is obtained by subtracting these negative values from the total operating costs of the SMTUC operation and then dividing the results by the total vehicle-km.

The following graph shows the evolution obtained for the B-a-U scenario of the Average Operating



Costs – €/vkm (considering the above assumptions the B-a-U scenario coincides with the ex-ante values on the ex-ante period from 2000-2007) and table 8 shows the BAU values.

Figure 16 – Operating costs forecast

Table 8 – Indicator n.2 – BAU values

Indicators and respective parameters	BAU Values
Average operating costs (2008)	2,59 €/vkm
Average operating costs (2009)	2,66 €/vkm
Average operating costs (2010)	2,61 €/vkm
Average operating costs (2011)	2,63 €/vkm

Indicator 3 (Capital Costs)

The change in the capital related to the management and information systems is obtained after setting up the measure. Therefore, if this measure was not implemented, the capital costs would be as before. It was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-Usual is equal to the baseline situation.

The next graph shows the evolution obtained for the B-a-U scenario.

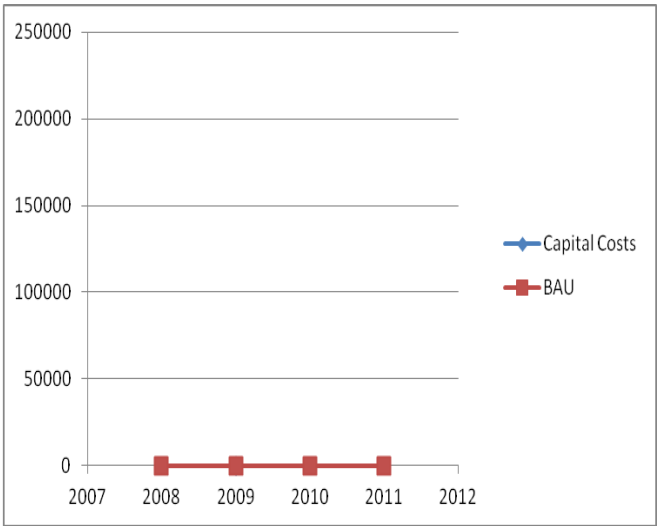


Figure 17 – Capital costs

Therefore, the results of BAU scenario for this case are:

Table 9 – Indicator n.3 – BAU values

Indicators and respective parameters	BAU values
Total capital cost (2008)	0,00 €
Total capital cost (2009)	0,00 €
Total capital cost (2010)	0,00 €
Total capital cost (2011)	0,00 €

Indicator 4 (Percentage of lost trips due to traffic problems)

In order to determine the B-a-U scenario for this indicator, the available historical data has been used.

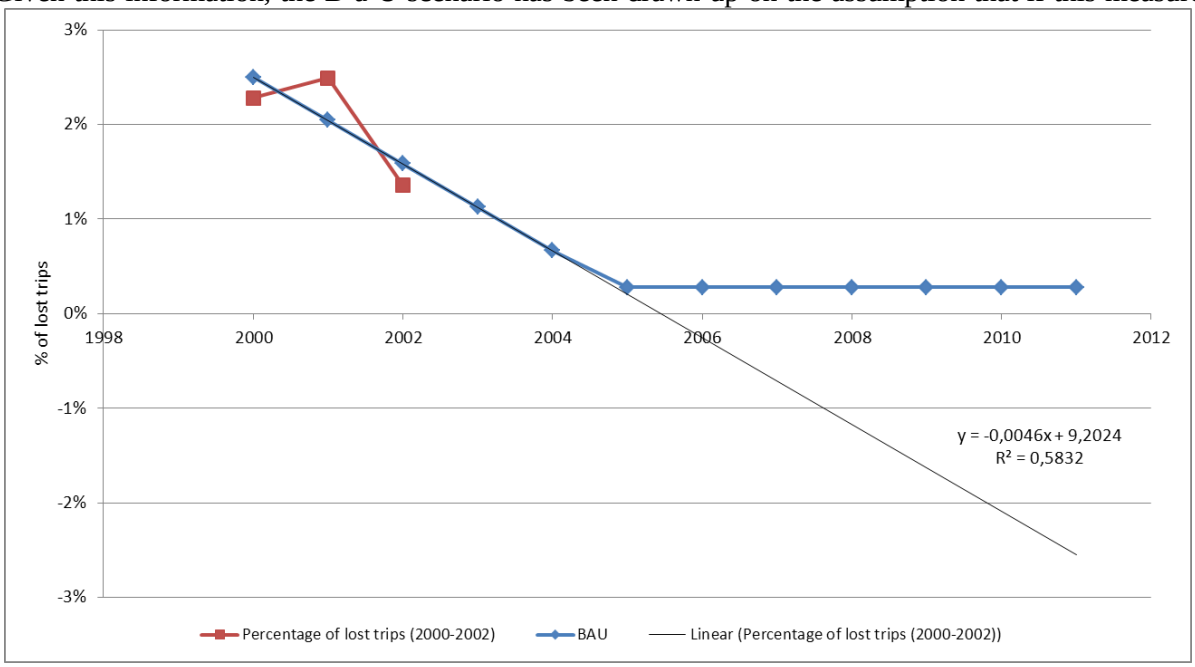
Year	2000	2001	2002	2007
Total scheduled trips (n.)	313061	313061	384794	382232
Total trips lost due to traffic problems (n.)	7133	7800	5236	1062
Trips lost due to traffic problems (%)	2,28	2,49	1,36	0,28

The annual series data is unknown from 2003 to 2006, because during this period only the number total of lost trips has been registered and the reasons for this fact are missing.

For this reason any available information about the evolution of the number of lost trips due to traffic problems in that period was requested from SMTUC. According to the obtained information, in the beginning of this period several modifications were carried out on the operation of the network which

led to a reduction in the number of lost trips due to traffic congestion. According to the same source, the number of lost trips due to traffic problems could be considered as stable before the start of the measure, in accordance with the evolution of the global value of lost trips.

Given this information, the B-a-U scenario has been drawn-up on the assumption that if this measure



was not implemented, the percentage of lost trips due to traffic problems from 2000-2005 would follow a linear trend (based on the ex-ante values from 2000-2002) and from 2005-2008 would be constant and equal to the ex-ante value obtained for 2007, according to the following graphs:

Figure 18 – Lost trips forecast

Thus, the percentage of lost trips due to traffic problems after 2007 would be as before. In this period it was considered that there are no effects of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Table 10 – Indicator n.4 – BAU values

Indicators and respective parameters	BAU Values
Percentage of trips lost due to traffic problems (2008)	0,28 %
Percentage of trips lost due to traffic problems (2009)	0,28 %
Percentage of trips lost due to traffic problems (2010)	0,28 %
Percentage of trips lost due to traffic problems (2011)	0,28 %

Indicator 5 (Average Network Speed)

In order to determine the B-a-U scenario for this indicator, the available historical data has been used because the annual series data of the last few years is available. Thus, it is easy to extrapolate for the next few years.

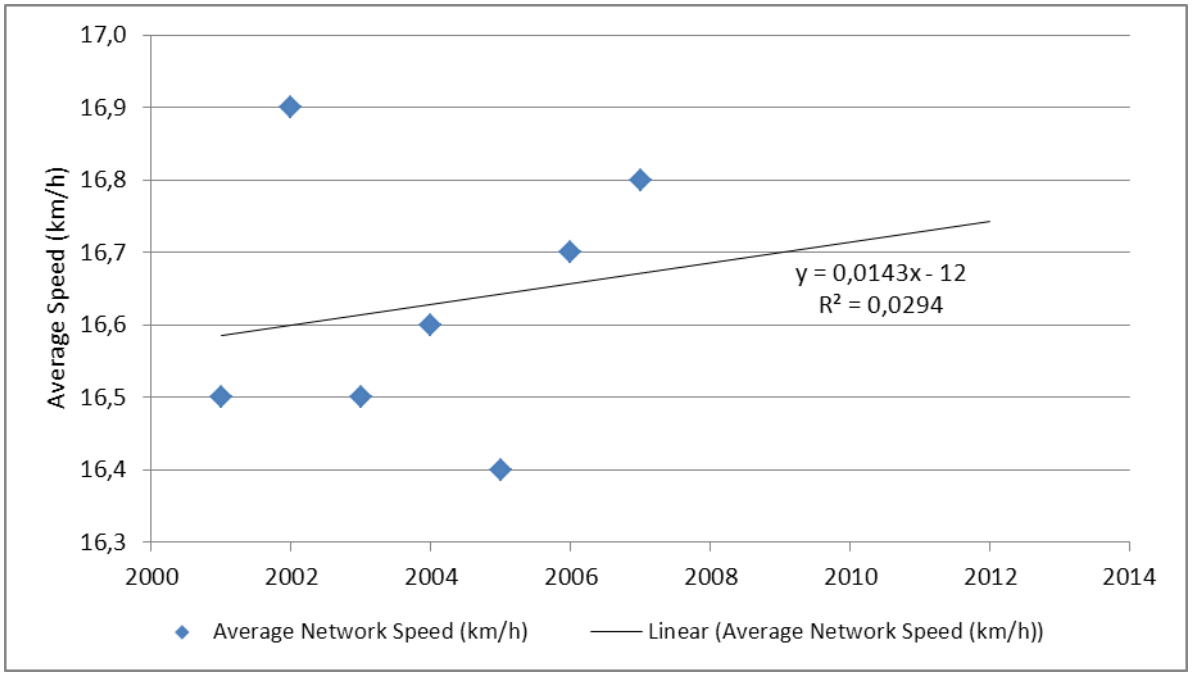


Figure 19 – Average speed forecast

The trend \for forecasting the evolution of passengers shows a low correlation coeficient (0,0294), i.e, a low degree of linear relationship between the two variables. To analyse it more precisley, other types of trends (exponential, logarithmic, polynomial, …) were tested, but at all of them show similar correlation coeficients. Due to this fact the linear trend was choosen as the the one that forecasts the next period.

Therefore, the results of BAU scenario for this case are:

Table 11 – Indicator n.5 – BAU values

Indicators and respective parameters	BAU Values
Average Network Speed (2008)	16,69 km/h
Average Network Speed (2009)	16,70 km/h
Average Network Speed (2010)	16,71 km/h
Average Network Speed (2011)	16,73 km/h

Indicator 7 (Awareness level – users)

The change in the Awareness level – users related to the management and information systems is obtained after setting up the measure. Therefore, if this measure was nor implemented, the Awareness level – users would be as before, i.e equal to zero. Besides this, it is considered that there are no effects

of other factors that have any influence in this indicator. In this case the Business-as-usual is equal to the baseline situation.

Therefore, the results of BAU scenario for this case are:

Table 21 – Indicator n.6 – BAU values

Indicators and respective parameters	BAU values
Awareness level – users (2008)	0 %
Awareness level – users (2009)	0 %
Awareness level – users (2010)	0 %
Awareness level – users (2011)	0 %

C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

C2.1 Economy

In the same way as for the baseline, the results of the indicators have been obtained after the complete implementation of the measure in 2008 for the capital costs resulting of the installation of the upgraded AVM system and in 2009 ("operational management and monitoring of the updated GPS / GPRS – Operation Support System" and launch of the "SMTUC Mobile"). :

The total revenues of the SMTUC PT service were accounted for and then divided by the vehicle-km performed. The total operating costs were also calculated and then divided by the vehicle-km performed. Also the total capital costs were accounted for.

Therefore, the tables 22 to 23 show the ex-post results for these cases.

Table 22 – Indicator n.1 – Ex-post values

Indicators and respective parameters	Ex-Post values
Average operating revenues (2008)	1,40 €/vkm
Average operating revenues (2009)	1,41 €/vkm
Average operating revenues (2010)	1,32 €/vkm
Average operating revenues (2011)	1,31 €/vkm

Table 23 – Indicator n.2 – Ex-post values

Indicators and respective parameters	Ex-Post Values
Average operating costs (2008)	2,59 €/vkm
Average operating costs (2009)	2,66 €/vkm
Average operating costs (2010)	2,61 €/vkm
Average operating costs (2011)	2,63 €/vkm

Table 24 – Indicator n.3 – Ex-post values

Indicators and respective parameters	Ex-Post values
Total capital costs (2008)	241.542,00 €
Total capital costs (2009)	0,00 €
Total capital costs (2010)	0,00 €

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Total capital costs (2011)	0,00 €

The table 25 summarise the comparison of the indicators 1, 2 and 3 after the implementation of the measure with the baseline and the BAU scenario.

Table 25 – Summary – Balance between economy indicators (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
6. Average Operating Revenues	1,35 €/vehicle-km (2007)	1,37 €/ vehicle-km (2008)	1,40 €/ vehicle-km (2008)	0,05 €/ vehicle-km (2008)	0,03 €/ vehicle-km (2008)
		1,38 €/ vehicle-km (2009)	1,41 €/ vehicle-km (2009)	0,06 €/ vehicle-km (2009)	0,03 €/ vehicle-km (2009)
		1,29 €/ vehicle-km (2010)	1,32 €/ vehicle-km (2010)	-0,03 €/ vehicle-km (2010)	0,03 €/ vehicle-km (2010)
		1,25 €/ vehicle-km (2011)	1,31 €/ vehicle-km (2011)	-0,04 €/ vehicle-km (2011)	0,05 €/ vehicle-km (2011)
7. Average Operating Costs	2,41 €/vehicle-km (2007)	2,59 €/ vehicle-km (2008)	2,59 €/ vehicle-km (2008)	0,18 €/ vehicle-km (2008)	0,00 €/ vehicle-km (2008)
		2,66 €/ vehicle-km (2009)	2,66 €/ vehicle-km (2009)	0,25 €/ vehicle-km (2009)	0,00 €/ vehicle-km (2009)
		2,61 €/ vehicle-km (2010)	2,61 €/ vehicle-km (2010)	0,20 €/ vehicle-km (2010)	0,00 €/ vehicle-km (2010)
		2,63 €/ vehicle-km (2011)	2,63 €/ vehicle-km (2011)	0,22 €/ vehicle-km (2011)	0,00 €/ vehicle-km (2011)
8. Capital Costs	0,00 € (2007)	0,00 € (2008)	241542,00 € (2008)	241542,00 € (2008)	241542,00 € (2008)
		0,00 € (2009)	0,00€ (2009)	0,00€ (2009)	0,00€ (2009)
		0,00 €	0,00 €	0,00 €	0,00 €

		(2010) 0,00 € (2011)	(2010) 0,00 € (2011)	(2010) 0,00 € (2011)	(2010) 0,00 € (2011)

The following graph shows the evolution of average operating revenues (€/vkm) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

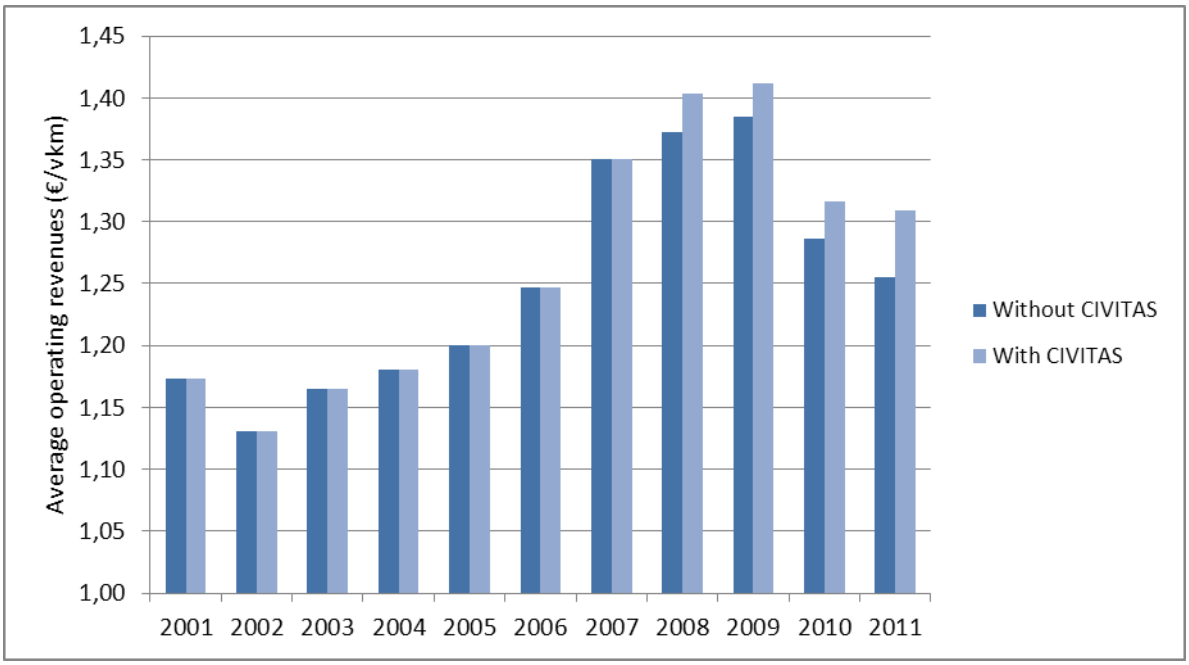

Figure 20 – Average operating revenues without/with Civitas

The following graph shows the evolution of average operating costs (€/vkm) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

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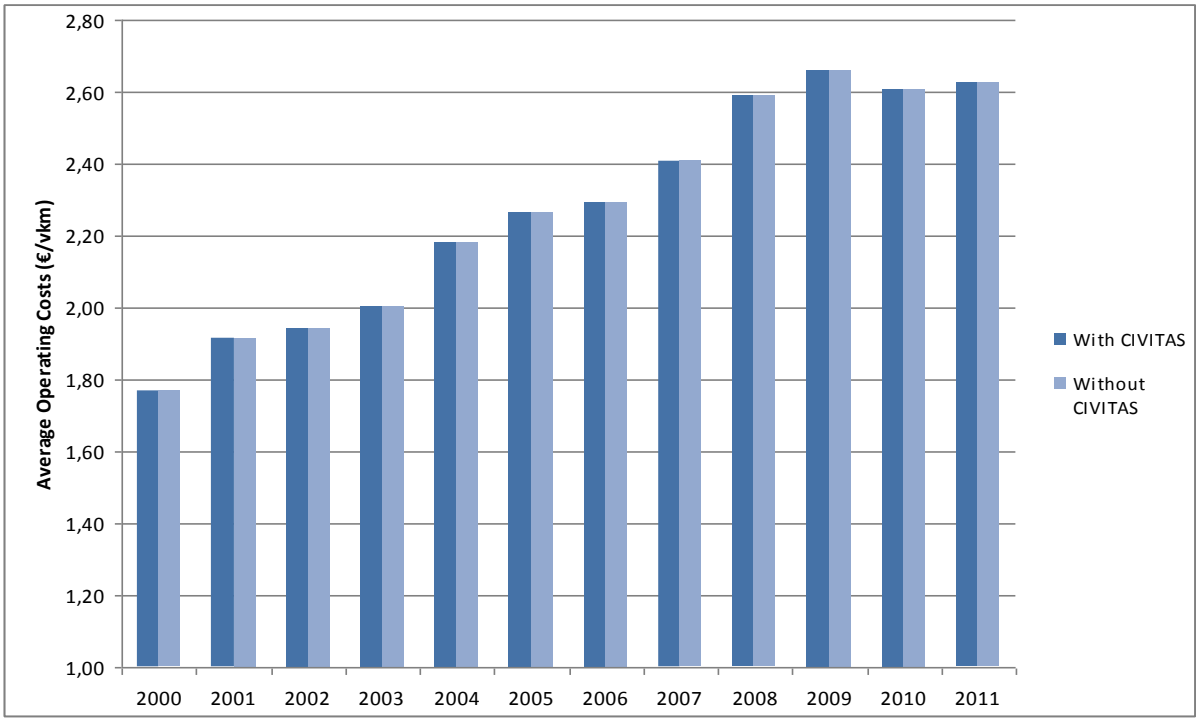

Figure 21 – Average operating costs without/with Civitas

The following graph shows the evolution of capital costs (€) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

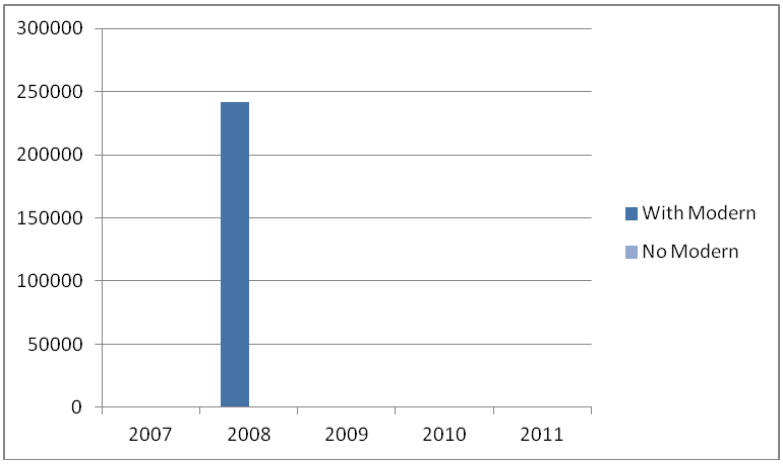

Figure 22 – Capital costs without/with Civitas

The improvements introduced along with the measure implementation were not enough to avoid the reduction of the number of passengers and, thus, in revenues in this period. However, together with other measures, they avoided an even greater drop and revealed to be efficient by contributing to a greater increase in average operating revenues in comparison to the B-a-U scenario

The balance of the average operating costs between the results and the B-a-U is null, despite the reduction of the operating costs with the measure implementation. The motive is the low value of this

decrease comparatively to the total amount of the operating costs of all SMTUC PT service. Anyway the increase in the operating costs comparatively the baseline results of exogenous factors (mainly the great increase in the fuel costs) and not of the measure impacts.

As expected, capital costs experienced an increase as a result of the implementation of the measure in comparison to the B-a-U scenario,, but only a Cost-Benefit Analysis could conclude if the gains in the average operating revenues and the decrese in the operating costs added to the evolution in the external costs are enough for the payback of the investiment.

C2.4 Transport

In the same way as for the baseline, the results of the indicators have been obtained after the complete implementation of the measure in 2009 ("operational management and monitoring of the updated GPS / GPRS – Operation Support System" and launch of the "SMTUC Mobile"). These are the results of indicators 4 and 5 (tables 25 to 27):

Indicator 4 (Percentage of lost trips due to traffic problems)

Table 25 – Indicator n.4 – Ex-post values

Indicators and respective parameters	Ex-Post Values
Percentage of trips lost due to traffic problems (2008)	0,28 %
Percentage of trips lost due to traffic problems (2009)	0,21 %
Percentage of trips lost due to traffic problems (2010)	0,15 %
Percentage of trips lost due to traffic problems (2011)	0,23 %

Indicator 5 (Average Network Speed)

Table 26 – Indicator n.5 – Ex-post values

Indicators and respective parameters	Ex-Post Values
Average Network Speed (2008)	17,0 km/h
Average Network Speed (2009)	17,0 km/h
Average Network Speed (2010)	17,1 km/h
Average Network Speed (2011)	17,1 km/h

These results show that the measure had a positive impact both in terms of the reduction of the percentage of trips lost due to traffic problems (thus contributing to the increase of Accuracy of PT timekeeping) and in terms of the increase in the Average Network Speed.

Table 27 – Summary – Balance between transport indicators (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U

9. Percentage of lost trips due to traffic problems	0,28 % (2007)	0,28% (2008) 0,28% (2009) 0,28% (2010) 0,28% (2011)	0,28 % (2008) 0,21 % (2009) 0,15 % (2010) 0,23% (2011)	0,00 % (2008) - 0,07 % (2009) - 0,13 % (2010) - 0,05 % (2011)	0,00 % (2008) - 0,07 % (2009) - 0,13 % (2010) - 0,05 % (2011)
10. Average Network Speed	16,8 km/h (2007)	16,7 km/h (2008) 16,7 km/h (2009) 16,7 km/h (2010) 16,7 km/h (2011)	17,0 km/h (2008) 17,0 km/h (2009) 17,1 km/h (2010) 17,1 km/h (2011)	0,2 km/h (2008) 0,2 km/h (2009) 0,3 km/h (2010) 0,3 km/h (2011)	0,3 km/h (2008) 0,3 km/h (2009) 0,4 km/h (2010) 0,4 km/h (2011)

The following graph shows the evolution of the percentage of lost trips with CIVITAS and the evolution of this indicator according to the B-a-U scenario (without CIVITAS).

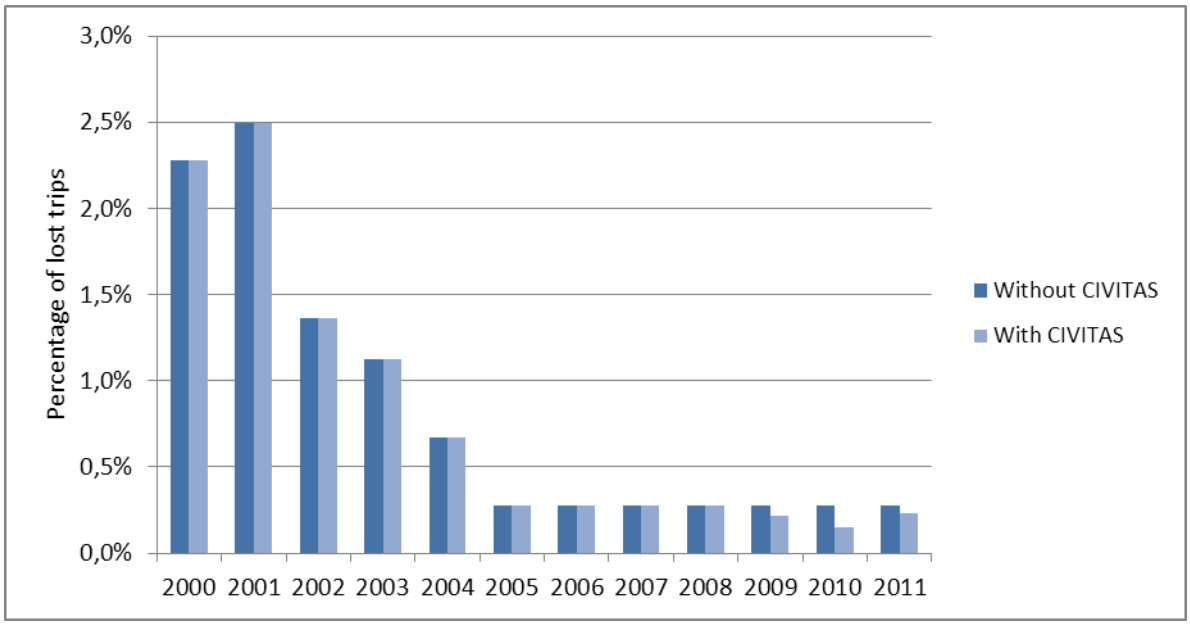

Figure 23 – Percentage of lost trips Without/With Civitas

Observing the previous graph, it can be concluded that the measure had a positive impact in the percentage of lost trips. It can be observed that with the CIVITAS measure the percentage of lost trips has decreased in comparison to the B-a-U scenario 0,07%, 0,13% and 0,05% between 2009, 2010 and 2011, respectively.

But contrary the trend, in 2011 the lost trips had a little increase in relation to 2010 because the traffic conditions worsened very much due to works on the dam-bridge during several months of 2011 and 2012.

Although this positive impact seems of little importance in terms of percentage, it should be noted that the baseline position was already quite low due to the implementation of other measures that contributed to improve the performance of the service before CIVITAS.

In fact, the level was so good that achieving improvements seems to be quite challenging. However, the implemented system helped in achieving the referred to improvement.

Finally, it should be noted that, in spite of a moderate impact from the quantitative point of view, the reduction of the number of lost trips is very relevant from the qualitative point of view and, as such, regardless of the small quantitative impact, investing in improving this aspect of the service seems to be worthwhile.

The following graph shows the evolution of the Average Network Speed (vkm/h) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

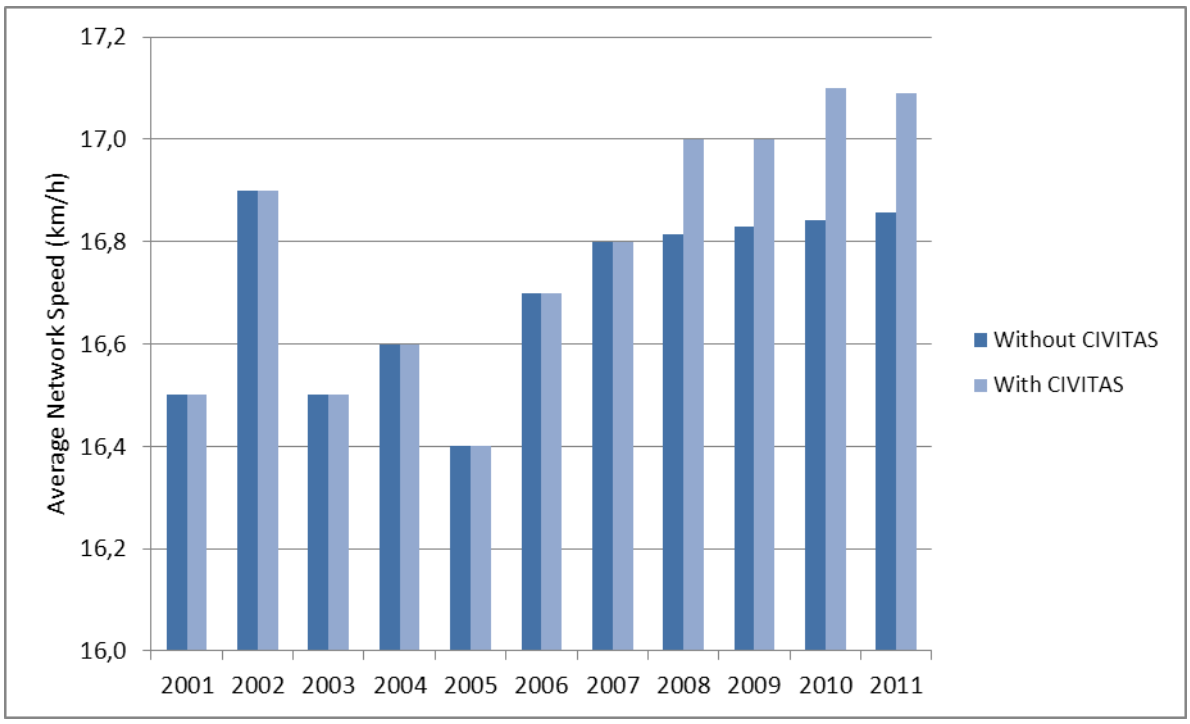

Figure 24 – Average Network Speed Without/With Civitas

The measure had a positive impact in the average network speed. Comparing the results with CIVITAS and without CIVITAS it is possible to observe that the average network speed has increased 1,0%, 1,5%, 1,4%, between 2009, 2010 and 2011, respectively.

It can be difficult to understand the influence of the GPS/GPRS – Operation Support System in the augmentation of the average network speed. According to the measure leader this fact could result from to 2 main factors – 1) a better control of the drivers' service, avoiding superfluous time loss; and 2) a better use of the offer, taking advantage of the greater quantity and accuracy of the data recorded with the real time information about the operations, including the former cases of excessive time loss. With this data it was possible to assess the trips that also had an over-extended travel time and proceed with the adaptation of the time tables with trips that were conducted more quickly. This contributed particularity to increase the transport quality and the economy of resources (buses, fuel, and drivers).

As an example of several other already implemented the measure leader described the changes in the 2 PT lines with more demand (with greater trip offer and frequency) – by shortening the trip time as a result of the analysis of the data provided by the upgraded system it was possible to save 18 operation hours (more than 1 bus and 2 drivers**).**

Another indicator of improvement in the Quality of the PT Service is the decrease in the number of failures of the GPS / GPRS Operation Support System (the major problems assessed were failures in the communication system of the buses).

The following table shows the evolution of the number of average daily failures of the GPS / GPRS Operation Support System per year between 2007 and 2012.

Table 28 – Average daily filures of GPS / GPRS Operation Support System

Year	2007	2008	2009	2010	2011	2012
Daily failures	14,20	9,52	10,50	11,51	9,85	10,91

Source: SMTUC data

The number of average daily failures after the implementation of the measure has been consistently below the 2007 value. This indicates that the measure has been effective in increasing the reliability of the Operation Support System. This system is a critical tool for improving PT operation, being determinant in reducing service disturbances, reducing the number of lost trips, and to increasing the average network speed.

The GPS / GPRS Operation Support System is a critical tool in improving PT operations, being determinant in reducing service disturbance, reducing the number of lost trips, and to increasing the average network speed.

C2.5 Society

To get an assessment about the knowledge towards the changes occuring, specific questions were added to the customer satisfaction survey to PT users carried out in the scope of the Quality Management System of SMTUC (according to the indicator definition above). Thus, the results of the indicators have been obtained after implementing the measure in 2009 (after the conclusion of the "tests phases of the SMTUC Mobile System"). The results of indicator 6 are the following:

Table 29 – Indicator n.6 – Ex-post values

Indicators and respective parameters	Ex-Post values
Awareness level users (2010-03-23 a 2010-03-29)	27%
Awareness level users (2011-03-29 to 2011-04-04)	34%

The table of results of the indicators is as follows:

Table 27 – Summary – Balance between societyindicator (after/before and after/BAU)

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
11. Awareness level – users	0 (2009)	0 % (2010) 0 % (2011)	27 % (2010) 34 % (2011)	27 % (2010) 34 % (2011)	27 % (2010) 34 % (2011)

The following graph shows the evolution of the Awareness Level (%) with CIVITAS and the evolution of this indicator according to the B-a-U scenario (Without CIVITAS).

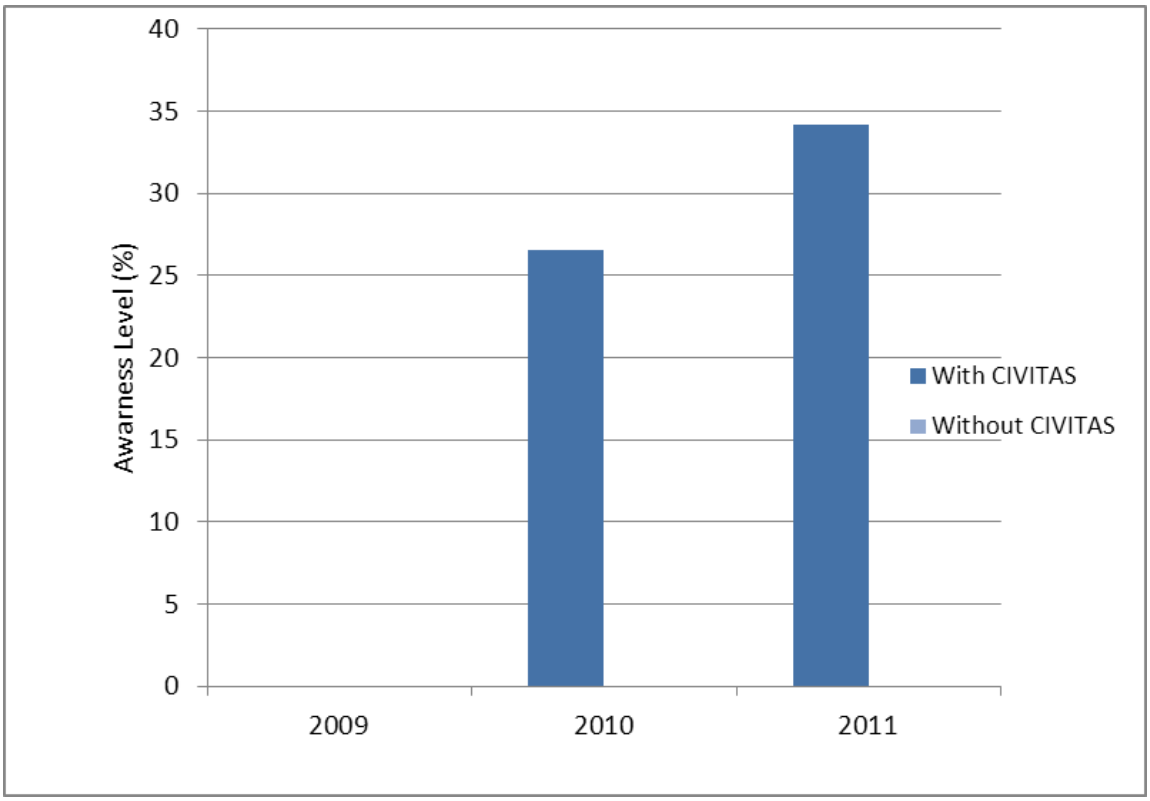

Figure 25 – Awarness level Without/With Civitas

This evolution shows that the awareness level increased steadily along with the implementation of the measure (more rapidly from 2009-2010 than from 2010-2011).

Final remarks:

For several reasons, the achieved results must be considered carefully.

The update of the GPS / GPRS – Operation Support System is of strategic importance not only because of the direct impact in the SMTUC operation but also because it provides the integration with other systems, the majority launched with CIVITAS MODERN (new e-ticketing system, "RUMOS trip planner", "SMTUC Mobile;…).

Nevertheless, it also offers other future opportunities for integration with other systems (e.g. articulation with preferential traffic light regulation). Indeed, some of the possible benefits of the measure could be augmented in the future, after the integration with other systems is implemented and made operational.

Therefore, future evaluation could be carried out extra CIVITAS MODERN to assess those future benefits.

So far, the direct impact of the operation of the GPS / GPRS – Operation Support System resulted as expected in benefits on the percentage of lost trips due to traffic problems and on the average network speed.

However, the improvements achieved with the corresponding limited investment are of course limited and, as such, probably not easily perceived by the users and even less by those not commonly using PT. Besides that, the percentage of lost trips due to traffic problems and the average network speed are just two factors among many others that the users take into account when making their judgments about the quality of the PT service as a whole.

There is a trend for an increasing use of mobile phones to access information. However, the number of people using mobile phones for that purpose was not evaluated, but the awareness level about "SMTUC Mobile" aplication increased from 2010 to 2011. The fact that this application does not need a "smatphone" to run could allow for an increase in its use.

C2.6 Cost benefit analysis

C2.6.1 Evaluation period for CBA

Cost-benefit analysis was conducted using the CBA Guideline for CIVITAS Plus Evaluation (Draft 1.0) document developed by Transportation Research Group (TRG), School of Civil Engineering and the Environment, University of Southampton, UK. The output of the CBA was the Net Present Value (NPV) of the measure, which computes the changes of economic costs and benefits, discounted over the 10 years expected lifetime of the measure, which matches the evaluation period of CBA (2008-2018).

The analysis was performed by comparing the costs and benefits of the GPS/GPRS Operation Support System (CIVITAS Case) with a radio system (BAU Case).

The generated benefit of the technological change is due to the increase of the average PT network speed.

In terms of costs the main beneficiaries were the Control Centre personnel, the maintenance, the communication, and energy of the control centre. The main benefits were the augment in the average PT network speed.

The balance between costs and benefits was computed using the NPV by discounting the aggregated annual cash flow (sum of the 10 year annual cash flows). The discount rate considered is 3% per year.

C2.6.2 Method and values for monetisation

Capital cost for the year 2008 is monetised considering the investment of the new GPS/GPRS Operation Support System.

Operating costs for the years 2009-2018 is monetised considering the value of SMTUC Operating Costs related to the measure. The enrolled costs are the (A.) Control Centre Personnel, the (B.) Maintenance, the (C.) Communication and (D.) Energy of the control centre.

These costs were also updated in the analysis period by considering the following:

Table 28 – Explanation of source and assumptions for construction the CBA analysis

Operating Cost	BAU Case	CIVITAS Case	OBS.
B. Control Centre Personnel	Real value of 2009 and a reduction of 14% in 2012.Stable in 2013-2018 Period	Real value of 2009 and a reduction of 14% in 2012.Stable in 2013-2018 Period	Till reduction of personnel costs is due to the financial crisis with the reduction of salary. Expected stability in 2013-2018 Period
B. Maintenance	Real values in 2009. Expected an increase of 3% per year (2010-2018)	Real values in 2009-2012. In 2010-2018 period is expected a stability in the cost	Estimated by SMTUC
C. Communication	2009 real value. 2010-2018 is expected an increase of 1% per	2009 real value. 2010-2018 is expected an increase of 1% per year	Estimated by SMTUC
D. Energy of the control centre	2009 real value. 2010-2018 is expected an increase of 2,8% per	2009 real value. 2010-2018 is expected an increase of 2,8% per year	2012 Forecast of the Portuguese energy regulator

Time savings from journey time reductions result from the measure. Thus, time savings for BAU situation are monetised considering the value 0 and only exist for CIVITAS measure situations. Time savings from journey time reductions (CIVITAS Measure) are monetised considering the following expression:

$A = B \times C \times (D - E)/(D \times E) \times F$

Where

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A – Saving from journey time reduction (€)

B – Average value of time (€/h)

C – Average length of trip per passenger (km)

D – Ex-post values for the Average Network Speed (km/h). The Ex-post values for Average Network Speed (km/h) were used for years 2008-2012, considering that the positive effect of the measure has a limited effect over the Average Network Speed, the value relative to 2012 has been used for analysis period.

E – B-a-U values for indicator 5 Average Network Speed (km/h). The B-a-U values for Average Network Speed (km/h) were used for years 2008-2012; considering that there would be a limit increase trend in the Average Network Speed, the B-a-U value in comparison to 2012 has been used for years 2013-2018.

F – Number of passengers; The Passenger Numbers obtained from SMTUC were used for years 2008-2012; Considering the financial crisis deeply affecting the Portuguese economy and the extensive social changes occurring in Coimbra, with unforeseeable impacts over SMTUC PT demand, the value of the Number of Passengers for 2012 has been used for predicting years 2013-2018.

Considering the unavailability of data about modal shift to PT as result of the measure and admitting that the improvements introduced along with the measure implementation had little influence in the modal split, it has been assumed that during the evaluation period the reductions of environmental emissions would be null. Therefore, savings from reductions of environmental emissions for years 2008-2018 are monetised considering the value 0 both for CIVITAS measure and BAU.

It should be acknowledged that between 2008-2011 other measures with potential impacts over passenger numbers (and therefore, over revenue and benefits from time savings) were implemented in Coimbra. In this period, the most relevant external change (in relation to this measure) over the SMTUC service is the start of the start-up of the Infomobility Centre (on 15th September 2009) and of the RUMOS system (October 2009), on the scope of CIVITAS MODERN Measure 04.02 – Infomobility Centre and Mobility Marketing in Coimbra. However, considering the potential limited impact over passenger numbers resulting from those changes, the assumption is that the CBA results are not (significantly) affected.

The values for the benefit are showed in the following table.

Table 29 –Determinations of the benefit in the CBA analysis

Year	Time Savings (€/h)	Average length of trip (km)	Average Speed – BAU (km/h)	Average Speed – CIVITAS (km/h)	Number of passengers (N.)	Benefit (€)
2008	11,53	3,56	16,7	17,0	27.689.418	1.260.673,09
2009	11,53	3,56	16,7	17,0	27.220.764	1.181.990,29
2010	11,53	3,56	16,7	17,1	26.937.520	1.493.816,11
2011	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22
2012	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22
2013	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22
2014	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22
2015	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22
2016	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22

2017	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22
2018	11,53	3,56	16,7	17,1	27.077.853	1.406.674,22

References of values used - Time Savings

The average length of trip per passenger considered is of 3,563 km – This value is obtained by dividing the value of passenger-km on the SMTUC network in comparison to 2008 (Source: IMTT, Barómetro da Mobilidade, 2009) by the total number of passengers in comparison to 2008 obtained from SMTUC (see annex 1 Average Revenues Data).

The pondered Average value of time (€/h) is obtained considering the following:

B = (H × I + J × K) / (H + J) where:

H – Proportion of passengers travelling for work related motives (47%)

I – Average value of time for passengers travelling for work related motives (18,19 €/h)

J – Proportion of passengers travelling for non-work related motives (53%)

K – Average value of time for passengers travelling for non-work related motives (5,64 €/h)

This implies that the value of time is **11,53€/h** (for more detail consult ANNEX 8 Cost-Benefit Analysis Data).

C2.6.3 Life time cost and benefit

Tables 30 to 33 shows the economic data used for the Cost Benefit Analyse.

Table 30 – Capital cost in the evaluation period (not discounted)

Year	CIVITAS measure	BAU
2008	241.542,00	0,00
2009	0,00	0,00
2010	0,00	0,00
2011	0,00	0,00
2012	0,00	0,00
2013	0,00	0,00
2014	0,00	0,00
2015	0,00	0,00
2016	0,00	0,00
2017	0,00	0,00

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Table 31 –Costs in the evaluation period (not discounted)

		0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018
A. Control Centre Personnel	CIVITAS Case	0	127.605	127.605	127.605	109.740	109.740	109.740	110.837	111.946	113.065	114.196
	BAU Case	0	127.605	127.605	127.605	109.740	109.740	109.740	110.837	111.946	113.065	114.196
B. Maintenance	CIVITAS Case	0	21.600	21.600	16.200	18.000	18.000	18.000	18.000	18.000	18.000	18.000
	BAU Case	0	30.040	30.941	31.870	32.826	33.811	34.825	35.870	36.946	38.054	39.196
C. Communication	CIVITAS Case	0	11.287	11.400	11.514	11.629	11.745	11.863	11.982	12.101	12.222	12.345
	BAU Case	0	7.596	7.672	7.749	7.826	7.905	7.984	8.064	8.144	8.226	8.308
E. Energy (Control Centre)	CIVITAS Case	0	4.830	5.071	5.325	5.591	5.871	6.164	6.473	6.796	7.136	7.493
	BAU Case	0	6.144	6.451	6.774	7.112	7.468	7.841	8.233	8.645	9.077	9.531
TOTAL (€)	CIVITAS Case	0	165.322	165.676	160.644	144.960	145.356	145.767	147.291	148.843	150.424	152.033
	BAU Case	0	171.385	172.669	173.997	157.505	158.923	160.390	163.004	165.681	168.422	171.231
Changes (€)		**0**	**-6.063**	**-6.993**	**-13.353**	**-12.544**	**-13.567**	**-14.623**	**-15.713**	**-16.838**	**-17.999**	**-19.198**

Note: The decrease in the maintenance costs since 2011 was due to a renegotiation of the maintenance contract with the system supplier, due the greater reliability of the new system. In the other hand the costs in the communications increased with the new system caused by the change between a proprietary communication system (analogical) by a service contractualised with an operator.

Table 32 - Savings for the evaluation period (not discounted)

		0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018
Vehicle Speed	CIVITAS Case	1.260.673	1.181.990	1.493.816	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674
	BAU Case	0	0	0	0	0	0	0	0	0	0	0
TOTAL (€)	CIVITAS Case	1.260.673	1.181.990	1.493.816	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674
	BAU Case	0	0	0	0	0	0	0	0	0	0	0
Changes (€)		**1.260.673**	**1.181.990**	**1.493.816**	**1.406.674**	**1.406.674**	**1.406.674**	**1.406.674**	**1.406.674**	**1.406.674**	**1.406.674**	**1.406.674**

Table 33 – Balance between costs and benefits due to measure (lifetime period)

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018
Undiscounted Cash Flow (€)											
Changes in total costs	241.542	-6.063	-6.993	-13.353	-12.544	-13.567	-14.623	-15.713	-16.838	-17.999	-19.198
Changes in total benefits	0	1.181.990	1.493.816	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674	1.406.674
Net Cash Flow	-241.542	1.188.054	1.500.810	1.420.028	1.419.218	1.420.241	1.421.297	1.422.387	1.423.512	1.424.673	1.425.872
Discounted Cash Flow (€)											
Changes in total costs	241.542	-5.887	-6.592	-12.220	-11.145	-11.703	-12.246	-12.776	-13.292	-13.795	-14.285
Changes in total benefits	0	1.147.563	1.408.065	1.287.306	1.249.812	1.213.410	1.178.068	1.143.755	1.110.442	1.078.099	1.046.698
Net Cash Flow	-241.542	1.153.450	1.414.657	1.299.526	1.260.957	1.225.113	1.190.314	1.156.531	1.123.733	1.091.893	1.060.983
Cumulative cash flow	-241.542	911.908	2.326.565	3.626.092	4.887.049	6.112.161	7.302.475	8.459.006	9.582.739	10.674.633	11.735.615
Changes in NPV (€)	**11.735.615**										

C2.6.5 Summary of CBA results

The results of CBA demonstrate that the measure produces a NPV of 11,6 M € over a 10 year period analysis, based on the updated balance of costs and benefits of the GPS/GPRS Operation Support System (CIVITAS Case) with a radio system (BAU Case).

In order to evaluate the sensitivity due to the discount rate an analyses will be carried out (table 34). A 3% rate per year was assumed and 2 scenarios will analyse a high discount rate with 5,5% and a low discount rate (2,5%)

Table 34 – Sensivity analysis (low and high scenario)

Analysis	NPV (M€)
Low (discount rate 2,5%)	12,05
Current (discount rate 3%)	11,74
High (discount rate 5%)	10,58

By analysing the sensitivity, the analysis demonstrated that the discount rate has a small impact in the NPV and it always remains positive.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To implement an updated GPS/GPRS Operation Support System, with new equipment on board 125 buses and to renewal 12 existing real time passenger information panels in order to allow more accuracy in real time information - less than 1 minute gap to update the information - and better commercial speed - increase by 0,5% in the SMTUC PT network. An updated GPS/GPRS Operation Support System with new equipment was installed on board 125 buses and 12 existing real time passenger information panels were renewed, resulting in more accuracy in real time information - less than 1 minute gap to update the information - and better commercial speed - increase by 2,4% in the SMTUC PT network	***
2	To install 6 new generation real time passenger information panels 6 new generation real time passenger information panels were installed	**
3	To develop 1 mobile phone application for passenger information (PT timetables consult). 1 mobile phone application for passenger information (PT timetables consult) was developed	**
4	The better real time transport network management also could allow to surpass the 99,5% real supply relatively to the one programmed. The improved real time transport network management allowed to largely surpass the 99,5% real supply (in comparison with the programmed trips) – from 2008 to 2011 this value ranged between 99,72% and 99,85%.	***
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%) ** = Achieved in full * = Exceeded**		

C4 Up-scaling of results

The GPS / GPRS – Operation Support System and the SMTUC Mobile System were implemented on the whole SMTUC network which covers the entire city of Coimbra, so there is no need to expand this kind of measure to other areas of the city.

Concerning the measure replication, we can highlight that the Portuguese City of Braga has also implemented the application "SMTUC Mobile" after the success of this product in Coimbra. Also, the fact that SMTUC and the application developer didn't have any revenues coming from this implementation facilitated the transfer of technology.

C5 Appraisal of evaluation approach

The evaluation strategy of this measure sought to focus on a number of indicators across the areas of economy, transport and society, which were to be measured in different ways.

The unavailability of information about modal split in Coimbra and the fact that a survey to assess this impact concerning all the inhabitants of Coimbra would be very expensive determined the exclusion of the indicator modal split. Due to the fact that the first yearly Customer Satisfaction Survey integrated in the Quality Management System of SMTUC has been carried out between December 2008 and January 2009, it was impossible to assess the ex-ante data of the Quality of PT Service and Acceptance Level – Users and the exclusion of these indicators was determined.

The unavailability of ex-ante data about modal split also determined the exclusion of any energy or environment related indicator on this measure.

The final phase of the evaluation process determined the redefinition of the indicators Average Operating Revenues and Average Operating Costs. These were limited to those directly related to the measure and in the final version are related to the overall SMTUC PT service because it was considered the best solution for allowing for the comparison of results.

Also the indicator Accuracy of PT Timekeeping was redefined and changed to "Percentage of lost trips due to traffic problems" because it has been considered the best way to evaluate this impact.

These redefinitions resulted necessarily in the redefinition of the B-a-U scenario for these indicators.

The relative low cost of the measure in comparison to the total SMTUC operating costs, the increasingly volatile conditions in which SMTUC is operating (including strong variations in fuel prices, labour market regulation reforms and budget cuts including salaries related to the public response to the financial crisis) resulting in increasing variability of costs throughout time in comparison to the extrapolation of the cost values from the past, made it impossible to follow the initial approach and determined the option to define other approach, in which the added operating cost resulting from the implementation of the measure itself are subtracted to the total operating costs of the SMTUC operation.

C6 Summary of evaluation results

The key results are as follows:

- **Low average operating costs** – As expected, capital and average operating cost increased as the result of the implementation of the measure, although the contribution of the measure to the increase in the average operating cost has been insignificant (0,01 €/ vehicle-km).

- **Decrease of lost trips** – The implementation of the measure resulted in the decrease of the percentage of lost trips due to traffic problems (which was already quite low in the baseline position due to the implementation of other measures that contributed to improve the performance of the service before CIVITAS) and in spite of a moderate impact from the quantitative point of view, the reduction of the number of lost trips is very relevant from the qualitative point of view. The reduction of lost trips was 0,07 %, 0,13 %, 0,05 % in 2009, 2010, 2011, respectively.

- **Increase of average PT network speed** – The implementation of the measure resulted in the increase of the average network speed, bringing time savings to current passengers and increasing the attractiveness of PT and thus contributing to a modal shift favouring PT service and an increase in revenues. The increase of average PT network speed was 0,3 km/h (2009) and 0,4 km/h (2010, 2011).

- **Increase of awareness level** – The awareness level increased steadily along with the implementation of the measure (more rapidly from 2010-2011 than from 2009-2010); this reveals the importance of measure implementation to raise awareness. The awareness level increases 27 % in 2010 and 34 % in 2011.

- **GPS/GPRS – Operation Support System generates an economic value–** The results of CBA show a NPV of 11,74 €. This means that the savings from journey time reduction and increase in operating revenues are enough to compensate the increase in operating costs and the capital costs due to the implementation of the measure. Furthermore a sensitivity analysis was performed and showed that the discount rate had a small influence on NPV.

- **Tailored monitoring should be developed** – Considering the expectable time necessary for the measure to enter in everyday life of the general population of the city (e.g., time necessary for the population to know and get used with the new information panels) and the overlapping with other measures meanwhile implemented, future monitoring could be made extra CIVITAS project to fully assess the evolution in the (direct) impact of the measure in terms of ridership, revenue, emissions reduction, and energy savings.

C7 Future activities relating to the measure

It is expected that the system will keep in full operation, maintaining the same standards with which it currently works.. The PT SMTUC operator is preparing the acquisition of at least 3 additional panels during 2012. The SMTUC operator is preparing also for the implementation during this year of another mobile phone application with real time information.

SMTUC will complete the feasibility study by adding an assessment of the economic and environmental benefits related to the integrated management of the city traffic lights.

D Lessons learned

D0 Measure / focussed measure

1	The measure fits into the EU policy towards clean urban transport (five pillars of the EU Green Paper)
2	The measure fits into the city policy towards sustainable urban transport and / or towards sustainability in general
3	The expected impact on the transport system, environment, economy and/ or society / people is very high
4	The high level of innovativeness of the measure with respect to technique, consortium, process, learning etc
5	The measure is typical for a group of measures or a specific context
6	The possibility of carrying out a good Cost Benefit Analysis
7	Participation of a range of different actors
8	The high degree of complexity of managing the measure
9	The measure is regarded as an example measure
10	Other, *please describe????*

Which are the three most important reasons for selecting this measure as a focused measure?

2 The measure fits into the city policy towards sustainable urban transport and sustainability in general	1	Most important reason
1 The measure fits into the EU policy towards clean urban transport (five pillars of the EU Green Paper)	2	Second most important reason
5 The measure is typical for a group of measures	3	Third most important reason

D1 Deviations from the original plan

The deviations from the original plan comprised:

- **Implementation of a mobile phone application instead of the feasibility study for its implementation** – Despite that in the original work plan it was only foreseen developing a feasibility study to implement an application that supplies PT timetables on mobile phones, it was decided to develop and implement this application during CIVITAS.
- **Purchase of 6 new generation e-panels with real time information for PT passengers instead of the 12 initially foreseen** – The financial crisis in Portugal caused all national funding for this area to be reduced and, accordingly, national funding has been not available and SMTUC will have to assume alone the financial compromises for the major part of the large investments in the CIVITAS measures. This fact delayed the rhythm of purchase of new e-panels, contributing to the fact that until May 2012 only 6 of the 12 e-panels foreseen were purchased (despite that the purchase of 3 more are planned until the end of CIVITAS).
- **The feasibility study for the application of Galileo System wasn't produced** – Due to the fact that the Galileo system was not yet available and there was little technical information about its operating method at the preparation phase of the measure, the GPS/GPRS – Operation Support System was implemented with the standard procedure, but with the possibility of applying this technology in the future.
- **The technical study about traffic light priority for PT was made with delay** – External factors, like traffic modifications and tram implementation studies that have implications with traffic light systems in Coimbra, delayed the production of the technical study about traffic light priority for PT. Nevertheless, this delay did not have any implication in the other tasks or measures of CIVITAS MODERN project.

D2 Barriers and drivers

D2.1 Barriers

Preparation phase

The preparation phase occurred before CIVITAS start-up – Regardless, during this period the following barrier was detected:

- **Barrier 1.1 – Technological Barrier:** Due to the fact that the Galileo system was not yet available and there was little technical information about its operating method at the preparation phase of the measure, the GPS/GPRS – Operation Support System was implemented with the standard technology. For this external reason the initial objective of applying the Galileo technology was not achieved

Implementation phase

Great part of the implementation phase occurred before CIVITAS start-up – During this period was detected the following barriers (after CIVITAS start-up):

- **Barrier 2.1 – Financial Barrier:** The financial crisis in Portugal didn't allow any national funding for the major part of the investments in the CIVITAS measures. For this reason SMTUC assumed by itself these investments. However, the rate of purchase of new e-panels decreased, leading to the fact that until May 2012 only 6 of the 12 e-panels foreseen had been purchased.

- **Barrier 2.2 – Technological Barrier:** External factors, like traffic modifications and tram implementation studies that have implications with traffic light systems in Coimbra, delayed the production of the technical study about traffic light priority for PT. Nevertheless, this delay did not have any implication in the other tasks or measures of CIVITAS MODERN project

Operation phase

- **Barrier 3.1 – Technological Barrier:** In the beginning some technical failures that compromised the GPS / GPRS – Operational Support System reliability occurred.

D2.2 Drivers

Preparation phase

The preparation phase occurred before CIVITAS start-up – Regardless of this fact, this period detected the following drive:

- **Driver 1.1 – Problem related Driver:** The lack of reliability and accuracy of the previous analogical Operation Support System forced the decision to carry out the upgrade to a GPRS system as soon as possible.

Implementation phase

- **Driver 2.1 – Technological Driver:** The presentation by a student of a beta version of an application that supplies PT timetables on mobile phones (that he wanted to offer to SMTUC) allowed SMTUC to carry on the final development of the application.

Operation phase

- **Driver 3.1 – Financial Driver:** Availability of CIVITAS for the management and monitoring of the GPS/GPRS Operation Support System.

D.2.3. Activities

Preparation phase

- **Activities 1 – Planning Activities:** To mitigate the effects of the impossibility of waiting for the release of the Galileo System (barrier 1.1), the suppliers of the upgrade for the GPS/GPRS Operation Support System analysed the specifications and designed the referred update to allow for a migration to Galileo System in the future.

- **Activities 2 – Problem related Activities:** Due the urgency in the migration to the GPRS Operation Support System caused by the problems referred in the driver 1.1, it was decided to begin with the migration without waiting for the beginning of the CIVITAS MODERN project.

Implementation phase

- **Activities 1 – Planning Activities:** Due the financial problems reported in barrier 2.1, the acquisition in the first phase of only 1 e-panel for the bus stops and 5 e-panels for interiors was carried out so as to avoid ending the CIVITAS MODERN project without any purchase of e-panels, . The e-panels for interiors are cheaper, but are also very useful.

- **Activities 2 – Technological Activity:** Despite in the original work plan it was only foreseen to develop a feasibility study to implement an application that supplies PT timetables on mobile phones, the opportunity given by a proposal for the development of the application with low costs (driver 2.1), caused SMTUC develop and implement this application during CIVITAS.

Operation phase

- **Activities 1 – Technological Activities:** To avoid the problems of reliability of the system related in the barrier 3.1, a rigorous monitoring of the system failures has been carried out with the control centre personnel supported by SMTUC and CIVITAS (drive 3.1) and a new version of the system software was launched, allowing for the system to run in better conditions and with few failures.

- **Activities 2 – Financial Activities:** The involvement of SMTUC concerning the guarantee of the infrastructure maintenance and the personnel costs of the Centre, aided by CIVITAS during the first 3 years (driver 3.1), also contributed to the maintenance of all public transport operators in the Centre and for the achievement of the objectives defined, helping to reduce the effects of the barrier 3.1.

D3 Participation of stakeholders

D.3.1 Measure partners

- **Measure partner 1 - Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC); Public transport company; Leading role**

  SMTUC was responsible for the specification, acquisition and installation process of the GPS / GPRS Operation Support System upgrade, as well as the training of the system users (drivers, controllers, and maintenance staff). Also, SMTUC has carried out the management of operational and monitoring activities.

  Integrated in this system are 6 new real-time public information e-panels which SMTUC has purchased and is responsible for installing.

  SMTUC was also involved in the development and implementation of the mobile phone application "SMTUC Mobile" and supported the Municipality (CMC) in the development of the technical study on traffic light priority for PT, as well as on the compatibility tests between the traffic light management system and the GPS/GPRS Operation Support System.

- **Measure partner 2 – Câmara Municipal de Coimbra (CMC); City; Principle participant**

  CMC was responsible for carrying out the technical study on traffic light priority for PT and the compatibility tests between the traffic light management system and the GPS/GPRS Operation Support System.

  Since October 2011, CMC assumed the responsibility for the dissemination of the MODERN project of Coimbra.

- **Measure partner 3 – Prodeso Ensino Profissional, Lda (PRODESO); High school; Principle participant**

  While responsible for the dissemination activities for the first three years of the MODERN project of COIMBRA, PRODESO gave some support in the promotion of this measure.

- **Measure partner 4 – Perform Energia, Lda (PE); Private company; Principle participant**

  PE was the partner responsible for the evaluation of this measure, namely analysing data and results.

D.3.2 Stakeholders

- **Stakeholder 1 – Public transport users**

  SMTUC passengers are the main beneficiaries of this measure since it has allowed for an enhancement of the quality and feasibility of the real-time management of the PT network and the information provided to the general public.

- **Stakeholder 2 – Supplier of the GPS / GPRS Operation Support System**

BCCM was the supplier of the GPS / GPRS Operation Support System and the e-panels for real time information to the passengers, as well as being co-responsible for its integration with other systems.

- **Stakeholder 3 – Supplier of the new e-ticketing system**

  NOVA BASE was the supplier of the new e-ticketing that was integrated with the GPS / GPRS Operation Support System, namely allowing a single console to command both systems and to receive information about the coordinates of the bus stops for the geo-referencing of passenger entrances.

- **Stakeholder 4 – Associação de invisuais e ambliopes**

  The association for the visually impaired participated in several working sessions with SMTUC during the specification and implementation stage of the GPS/GPRS Operation Support System, in order to assist in optimising the audible information in the interior of the buses and in the e-panels placed at the bus stops.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **The upgrade of Operation Support Systems with analogical communication technology could be a good solution and an alternative to the implementation of an entire new system –** The upgrade of the Operation Support System to GPRS technology is recommended for transport companies that possess more obsolete technologies (i.e., analogical communication systems in large fleets) which hinder the quality of the fleet management and the public information offered to their customers. SMTUC has verified that intervals equal to/superior to 2 minutes in the updating of the information results in imprecise information for the control centre operators and for the general public through the e-panels. When there is a break in communications that interval may reach 4 minutes, aggravating this phenomenon. The investment needed for the system upgrade is not very significant and is substantially inferior to the costs of acquiring a new system. And in the case of Coimbra, the upgrade solved the operational needs perfectly. The improvement of the information update interval is also essential in case there is the need for integration with the traffic light priority system.

- **Analogical systems are not recommended in case of implementation of real time infomobility tools –** The migration to a GPRS system is also important is case of wanting to offer on-line travel planning services in real-time, namely on mobile phones. The reliability of the service depends on the quantity and the quality of the available information – a fact which is not possible with the maintenance of analogical systems.

- **Stakeholders must be involved in the launch of new products –** Stakeholder should be involved in the specification and launching of the products, namely through the participation of associations and other representative organisations (such as the case of the association of the visually impaired in Coimbra, which helped plan and implement in the best possible fashion the audible information in the bus and bus stops).

- **Quality control and monitoring of the information provided to the public is very important –** Since the quality and reliability of the information are essential to the credibility of the information systems offered to the public it is indispensable to maintain a

rigorous and frequent control of the information offered. In the case of Coimbra, the access to the information was conducted through the GPS / GPRS Operation Support System control centre, including the replication of the information provided via the real-time information e-panels.

D.4.2 Recommendations: process

- **Despite the financial crisis alternative solutions must be find to overcome this problem –** The financial crisis in Portugal causes a lack of national funding for the major part of the large-scale investments in the CIVITAS measures and made SMTUC assume the financial compromises on its own. This fact delayed the rate of purchase of the new e-panels with real time information for passengers (namely in bus stops). But to avoid finishing the CIVITAS MODERN project without any purchase of e-panels, it was decided to buy in the first phase only 1 e-panel for the bus stops and 5 e-panels with the same functions but for interiors. This kind of e-panel is cheaper, but very useful as in the case of Coimbra which installed these e-panels in the lobbies and waiting rooms of hospitals.

- **Installation process of the system must be carefully monitored –** Supporting and monitoring the installation process at the early stages of the GPRS / GPS Operation Support System was very important for detecting and characterising the diverse problems that came up and to find rapid solutions for them.

ANNEX 1: Average Revenues Data

The next table shows the data obtained relative to operating revenue, passenger numbers and vechicle-km in SMTUC network:

Year	Operating Revenue (€)	Number of Passengers	Vehicle-km
2001	6.675.000,00	26.355.409	5.689.000
2002	6.730.000,00	26.815.583	5.954.000
2003	7.038.000,00	27.065.496	6.043.000
2004	7.148.000,00	27.621.417	6.053.000
2005	7.287.000,00	27.393.744	6.071.000
2006	7.590.000,00	27.145.712	6.089.000
2007	7.951.000,00	27.432.020	5.887.000
2008	8.148.000,00	27.689.418	5.806.000
2009	8.043.000,00	27.220.764	5.698.000
2010	7.797.000,00	26.937.520	5.924.000
2011	7.704.514,90	27.077.853	5.886.000

Source: SMTUC

The following table shows the data obtained related to passenger numbers in the urban PT of Braga (TUB) network:

Year	Number of passengers
2007	11.321.000
2008	11.292.000
2009	10.452.000
2010	10.275.000
2011	10.781.000

Source: TUB

ANNEX 2: Average Operating Costs Data

The following table shows the data obtained concerning the operating costs in the SMTUC network divided by four cost categories (Personnel Costs, Fuel Costs, Maintenance Costs and Other Operational Costs), obtained from SMTUC PT operator:

Year	Personnel Costs (€)	Fuel Costs (€)	Maintenance Costs (€)	Other Operational Costs (€)
2000	6.211.276,14	1.197.056,24	455.196,74	1.991.545,35
2001	6.667.741,24	1.333.845,61	520.198,97	2.373.431,80
2002	7.398.532,70	1.458.151,45	591.124,78	2.127.700,05
2003	7.441.994,83	1.561.723,50	606.400,18	2.503.095,84
2004	7.621.411,45	1.809.821,20	759.229,61	3.028.831,96
2005	7.913.630,41	2.192.124,07	762.153,41	2.895.859,05
2006	8.135.630,49	2.426.966,60	781.505,97	2.621.444,52
2007	8.369.273,36	2.476.741,77	784.174,64	2.541.586,80
2008	8.355.722,54	2.977.081,11	900.721,81	2.807.772,14
2009	8.982.836,77	2.261.365,92	955.504,79	2.974.657,30
2010	8.953.220,48	2.701.160,84	884.608,00	2.925.517,37
2011	8.586.244,59	3.144.380,01	898.442,65	2.822.488,84

Source: SMTUC

The folowing table shows the data obtained relative to the Total Operational Costs and Vechicle-km in SMTUC network, obtained from SMTUC PT operator:

Year	Total Operational Costs (€)	Vehicle-km
2000	9.855.074,47	5.571.000
2001	10.895.217,62	5.689.000
2002	11.575.508,98	5.954.000
2003	12.113.214,35	6.043.000
2004	13.219.294,22	6.053.000
2005	13.763.766,94	6.071.000
2006	13.965.547,58	6.089.000
2007	14.171.776,57	5.887.000
2008	15.041.297,60	5.806.000
2009	15.174.364,78	5.698.000
2010	15.464.506,69	5.924.000
2011	15.451.556,09	5.886.000

Source: SMTUC

The following table shows the data obtained relating to the management and information systems (i.e., directly related to the implementation of the measure) and from which the additional operating cost resulting from the implementation of the measure has been obtained over one year:

Operational Cost of the management and information systems	Old System	New System	Difference 2009
Personnel	116.587,15 €	127.604,60 €	11.017,45 €
Energy	4.339,94 €	4.829,96 €	490,02 €
Communication services	7.596,28 €	11.287,13 €	3.690,85 €
Maintenance personnel	10.712,37 €	19.258,42 €	8.546,05 €
Software maintenance	0,00 €	21.600,00 €	21.600,00 €
Hardware maintenance	40,28 €	170,17 €	129,89 €
Total	139.276,02 €	184.750,28 €	45.474,26 €

Source: SMTUC

The data collection has been carried out from 2007-03-01 to 2008-02-29 for the old system and from 2009-01-01 to 2009-12-31 for the new system

The additional operating cost resulting from the implementation of the measure for 2008, 2010 and 2011 has been determined on the basis of the value obtained for 2009.

The value for 2008 considers that the system only has been implemented from March onwards and the values for 2010 and 2011 consider the inflation rate of the previous year, given the fact that the contracts of supplying the necessary resources for the measure are defined according to the inflation rate of the previous year.

Operational Cost of the management and information systems	Difference 2008	Difference 2009	Difference 2010	Difference 2011
Personnel	9.181,21 €	11.017,45 €	10.929,31 €	11.082,32 €
Energy	408,35 €	490,02 €	486,10 €	492,91 €
Communication services	3.075,71 €	3.690,85 €	3.661,32 €	3.712,58 €
Maintenance personnel	7.121,71 €	8.546,05 €	8.477,68 €	8.596,37 €
Software maintenance	18.000,00 €	21.600,00 €	21.427,20 €	21.727,18 €
Hardware maintenance	108,24 €	129,89 €	128,85 €	130,65 €
Total	37.895,22 €	45.474,26 €	45.110,47 €	45.742,01 €

The next table shows the inflation rate from 2009-2010:

Year	2008	2009	2010	2011
Inflation Rate (%)	2,60%	-0,80%	1,40%	3,80%

Source: Bank of Portugal, National Institute of Statistics

ANNEX 3: Capital Costs Data

Year	Capital cost values(€)
2007	0,00
2008 (Investment in the purchase of the equipment25)	241.542,00
2009	0,00
2010	0,00
2011	0,00
Total	241.542,00

Source: SMTUC

ANNEX 4: Lost Trips Data

Data relative to lost trips during 2000, obtained from SMTUC PT operator:

VIAGENS PERDIDAS										QUILOMETROS PERDIDOS									
MÊS	A	B	C	D	E	F	G	H	TOTAL	MÊS	A	B	C	D	E	F	G	H	TOTAL
Jan-00	680	1	0	0	0	206	0	0	**887**	*Jan-00*	6365	16	0	0	0	2026	0	0	**8407**
Fev-00	641	6	12	0	0	82	0	0	**741**	*Fev-00*	5576	85	90	0	0	822	0	0	**6573**
Mar-00	775	4	0	0	0	166	0	1171	**2116**	*Mar-00*	6815	70	0	0	0	1620	0	15675	**24180**
Abr-00	602	3	4	0	1	130	0	13	**753**	*Abr-00*	5063	33	31	0	9	1262	0	121	**6519**
Mai-00	773	9	0	0	0	190	0	383	**1355**	*Mai-00*	6802	92	0	0	0	1911	0	4503	**13308**
Jun-00	738	9	0	0	32	350	0	0	**1129**	*Jun-00*	6512	124	0	0	251	3128	0	0	**10015**
Jul-00	267	6	0	0	0	132	0	0	**405**	*Jul-00*	2713	102	0	0	0	1326	0	0	**4141**
Ago-00	22	2	0	0	0	30	0	0	**54**	*Ago-00*	199	17	0	0	0	484	0	0	**700**
Set-00	425	15	15	0	1	645	0	0	**1101**	*Set-00*	3889	143	118	0	13	5833	0	0	**9996**
Out-00	719	18	1	0	9	424	4	0	**1175**	*Out-00*	6406	196	9	0	91	3525	45	0	**10272**
Nov-00	725	33	3	1	0	360	0	157	**1279**	*Nov-00*	7074	312	20	8	0	3002	0	1478	**11894**
Dez-00	766	12	11	14	1	389	1	0	**1194**	*Dez-00*	7639	172	82	110	20	3387	12	0	**11422**

LEGENDA:

A	Não cumprimento de horário
B	Avaria na viatura
C	Avaria na rede de tracção ou falta de corrente
D	Interrupção de rua ou estrada
E	Acidente
F	Falta de motorista
G	Falta de viatura
H	Outros motivos

[25] The purchase of the necessary equipment for the management and information systems occurred in 2007-12-2007. However, considering that this purchase occurred only few days before the start of the year in which the operation started (which started during March 2008),on scope of this document, the capital costs related to the purchase of the necessary equipment for the management and information systems are accounted on year 2008.

Data concerning lost trips during 2001, obtained from SMTUC PT operator:

VIAGENS PERDIDAS										QUILOMETROS PERDIDOS									
MÊS	A	B	C	D	E	F	G	H	TOTAL	MÊS	A	B	C	D	E	F	G	H	TOTAL
Jan-01	1054	18	46	2	13	406		1	**1540**	*Jan-01*	10618	210	341	17	130	3578		10	**14904**
Fev-01	840	6			43	398			**1287**	*Fev-01*	7860	58			339	3463			**11720**
Mar-01	835	35			2	299		2448	**3619**	*Mar-01*	7396	348			17	2579		33898	**44238**
1.º Trim	2729	59	46	2	58	1103		2449	**6446**	1.º Trim	25874	616	341	17	486	9620		33908	**70862**
Abr-01	546	13		1	1	200		82	**843**	*Abr-01*	4697	115		12	28	1739		963	**7554**
Mai-01	836	13		7	29	609		2662	**4156**	*Mai-01*	7616	164		104	242	5445		35927	**49498**
Jun-01	754	2				619			**1375**	*Jun-01*	6389	20				5567			**11976**
2.º Trim	2136	28		8	30	1428		2744	**6374**	2.º Trim	18702	299		116	270	12751		36890	**69028**
Jul-01	658	7	6		6	349		47	**1073**	*Jul-01*	5433	84	126		72	3116		611	**9442**
Ago-01	61	15			2	221			**299**	*Ago-01*	691	201			39	2218			**3149**
Set-01	624	29	10			449			**1112**	*Set-01*	5693	363	85			4272			**10413**
3.º Trim	1343	51	16		8	1019		47	**2484**	3.º Trim	11817	648	211		111	9606		611	**23004**
Out-01	1592	55	21	11	19	219	15	278	**2210**	*Out-01*	15999	703	147	72	195	2208	184	3287	**22795**
Nov-01										*Nov-01*									
Dez-01										*Dez-01*									
4.º Trim	1592	55	21	11	19	219	15	278	**2210**	4.º Trim	15999	703	147	72	195	2208	184	3287	**22795**
ANO	7800	193	83	21	115	3769	15	5518	17514	ANO	72392	2266	699	205	1062	34185	184	74696	185689

LEGENDA:

A	Não cumprimento de horário
B	Avaria na viatura
C	Avaria na rede de tracção ou falta de corrente
D	Interrupção de rua ou estrada
E	Acidente
F	Falta de motorista
G	Falta de viatura
H	Outros motivos

Data concerning lost trips during 2002, obtained from SMTUC PT operator:

VIAGENS PERDIDAS										QUILOMETROS PERDIDOS									
MÊS	A	B	C	D	E	F	G	H	TOTAL	MÊS	A	B	C	D	E	F	G	H	TOTAL
Jan-02	735	91	19	20	19	336	4	3	**1227**	*Jan-02*	6454	937	113	161	173	3183	53	39	**11113**
Fev-02	480	52	3	4	8	195	0	6	**748**	*Fev-02*	5636	669	27	34	115	1683	0	58	**8222**
Mar-02	451	67	16	19	12	59	3	4	**631**	*Mar-02*	6368	1158	196	293	237	525	56	50	**8883**
	1666	**210**	**38**	**43**	**39**	**590**	**7**	**13**											
Abr-02	399	67	29	3	23	25	0	9	**555**	*Abr-02*	6848	1484	361	62	511	264	0	163	**9693**
Mai-02	521	64	14	19	18	65	0	11	**712**	*Mai-02*	9828	1317	211	387	378	386	0	117	**12624**
Jun-02	282	45	10	18	21	16	28	1	**421**	*Jun-02*	6895	1016	184	501	438	135	235	8	**9412**
	1202	**176**	**53**	**40**	**62**	**106**	**28**	**21**											
Jul-02	59	39	2	4	17	116	0	0	**237**	*Jul-02*	1446	1022	20	77	498	1111	0	0	**4174**
Ago-02	37	25	0	7	6	1	0	0	**76**	*Ago-02*	513	366	0	73	77	4	0	0	**1033**
Set-02	437	74	32	4	25	25	0	9	**606**	*Set-02*	10331	2221	540	92	764	264	0	163	**14375**
	533	**138**	**34**	**15**	**48**	**142**	**0**	**9**											
Out-02	605	68	8	6	21	1	0	329	**1038**	*Out-02*	16937	1776	87	155	606	20	0	4536	**24117**
Nov-02	592	50	1	17	23	9	1	4	**697**	*Nov-02*	15109	1425	23	488	810	76	18	44	**17993**
Dez-02	638	56	3	3	14	0	0	77	**791**	*Dez-02*	6841	737	20	41	201	0	0	947	**8787**
	1835	**174**	**12**	**26**	**58**	**10**	**1**	**410**											

LEGENDA:

A	Não cumprimento de horário
B	Avaria na viatura
C	Avaria na rede de tracção ou falta de corrente
D	Interrupção de rua ou estrada
E	Acidente
F	Falta de motorista
G	Falta de viatura
H	Outros motivos

Data concerning lost trips during 2007, obtained from SMTUC PT operator:

3120 - SES (Estatística)

VIAGENS PERDIDAS / 2007

	MOTIVOS								
	Não cumprimento de horário	Avaria na viatura	Avaria na rede de tração/falta corrente	Interrupção de rua ou estrada	Acidente	Falta de motorista	Falta de viatura	Outros motivos	
	A	B	C	D	E	F	G	H	TOTAL / Mês
JAN	45	29	2	11	10	0	2	2	101
FEV	54	43	6	4	15	0	1	3	126
MAR	163	52	7	8	15	0	0	5	250
ABR	118	57	3	4	5	0	3	10	200
MAI	73	56	25	6	20	0	4	13	197
JUN	112	36	2	4	8	4	0	23	189
JUL	34	37	2	8	8	1	0	1	91
AGO	13	32	0	0	2	1	0	1	49
SET	60	61	1	1	6	0	0	4	133
OUT	113	62	6	4	13	0	0	7	205
NOV	135	42	0	7	8	0	0	5	197
DEZ	142	24	8	3	25	0	0	3	205
Total /									1.943
Motivo	1.062	531	62	60	135	6	10	77	

Data concerning lost trips during 2008, obtained from SMTUC PT operator:

3120 - SES (Estatística)

VIAGENS PERDIDAS / 2008

	MOTIVOS								
	Não cumprimento de horário	Avaria na viatura	Avaria na rede de tração/falta corrente	Interrupção de rua ou estrada	Acidente	Falta de motorista	Falta de viatura	Outros motivos	
	A	B	C	D	E	F	G	H	TOTAL / Mês
JAN	44	60	9	11	7	0	0	11	142
FEV	17	45	6	1	8	1	0	8	86
MAR	19	32	14	0	6	0	0	4	75
ABR	83	51	5	14	9	0	0	19	181
MAI	64	50	4	27	5	1	3	9	163
JUN	37	64	15	7	13	0	1	2	139
JUL	41	44	0	0	2	0	1	4	92
AGO	3	16	0	0	3	0	0	3	25
SET	43	56	3	4	8	0	0	4	118
OUT	125	70	7	25	13	0	0	7	247
NOV	136	41	6	8	7	0	0	3	201
DEZ	177	48	10	2	10	2	0	0	249
Total /									1.718
Motivo	789	577	79	99	91	4	5	74	

Data concerning lost trips during 2009, obtained from SMTUC PT operator:

3120 - SES (Estatística)

VIAGENS PERDIDAS / 2009

	MOTIVOS								
	Não cumprimento de horário	Avaria na viatura	Avaria na rede de tracção/falta corrente	Interrupção de rua ou estrada	Acidente	Falta de motorista	Falta de viatura	Outros motivos	
	A	B	C	D	E	F	G	H	TOTAL / Mês
JAN	40	59	5	1	6	0	4	4	119
FEV	45	81	0	3	7	0	0	4	140
MAR	47	55	1	0	3	0	0	8	114
ABR	66	58	4	33	6	0	0	6	173
MAI	44	118	7	50	3	0	0	2	224
JUN	16	59	3	2	7	0	0	5	92
JUL	7	29	2	3	8	0	1	1	51
AGO	6	23	0	0	6	0	0	1	36
SET	29	55	0	0	6	0	0	2	92
OUT	157	74	1	4	10	1	0	15	262
NOV	91	66	0	13	12	5	0	6	193
DEZ	33	33	1	16	8	0	1	2	94
Total / Motivo	581	710	24	125	82	6	6	56	1.590

Data concerning lost trips during 2010, obtained from SMTUC PT operator:

3100 - SEE

VIAGENS PERDIDAS / 2010

	MOTIVOS									
	Não cumprimento DE HORÁRIO	Avaria na VIATURA	Avaria na rede de TRACÇÃO	Interrupção de RUA	ACIDENTE	Falta de VIATURA	Falta de MOTORISTA	Queda no interior VIATURA	Outros MOTIVOS	
Mês	A	B	C	D	E	F	G	H	I	Total /Mês
JAN	52	71	13	18	12	0	1	0	0	167
FEV	49	49	1	7	10	2	0	0	2	120
MAR	60	68	4	32	16	0	0	0	20	200
ABR	24	84	15	13	11	0	0	1	5	153
MAI	77	117	5	3	12	0	0	0	8	222
JUN	8	70	3	7	8	0	1	0	2	99
JUL	35	75	5	29	6	0	0	0	2	152
AGO	5	19	0	2	2	0	0	0	0	28
SET	40	34	4	11	4	0	0	1	4	98
OUT	375	93	1	39	8	0	0	1	0	517
NOV	79	55	10	17	14	0	1	2	1	179
DEZ	60	71	1	22	17	0	0	3	0	174
Total / Motivo	864	886	62	200	120	2	3	8	44	2.109

Data concerning lost trips during 2011, obtained from SMTUC PT operator:

3100 - SEE

TRANSPORTES URBANOS DE COIMBRA

VIAGENS PERDIDAS / 2011

MOTIVOS

Mês	Não cumprimento DE HORÁRIO A	Avaria na VIATURA B	Avaria na rede de TRACÇÃO C	Interrupção de RUA D	ACIDENTE E	Falta de VIATURA F	Falta de MOTORISTA G	Queda no interior VIATURA H	GREVE /PLENÁRIO I	Outros MOTIVOS J	Total	Viagens Programadas
JAN	27	57	2	9	6			1			**102**	33,531
FEV	27	49	5	1	7						**89**	31,465
MAR	49	68		46	12						**175**	34,368
ABR	30	100	1	14	7			3		14	**169**	30,073
MAI	34	120	20	6	9		137		312	34	**672**	34,358
JUN	16	72		9	12			1	187	1	**298**	31,338
JUL	7	62	2	1	3					4	**79**	30,196
AGO	2	31		2	4					1	**40**	26,535
SET	30	78	4	12	6	8					**138**	32,890
OUT	122	121	9	13	19		48	1	310	3	**646**	31,856
NOV	131	73	6	10	14		3		1,263	1	**1,501**	31,220
DEZ	146	52	3	6	9		4	2		1	**223**	29,583
Total / Motivo	**621**	**883**	**52**	**129**	**108**	**8**	**192**	**8**	**2,072**	**59**	4,132	**377,413**

Synthesis of the total scheduled trips, of the total trips lost due to traffic problems, and determination of the percentage of trips lost due to traffic problems:

Year	2000	2001	2002	2007	2008	2009	2010	2011
Total scheduled trips	313.061	313.061	384.794	382.232	383.244	370.891	382.160	377.413
Total trips lost due to traffic problems	7.133	7.800	5.236	1.062	1.062	789	581	864
Trips lost due to traffic problems (%)	2,28	2,49	1,36	0,28	0,28	0,21	0,15	0,23

Source: SMTUC

ANNEX 5: Average Network Speed data

The following table shows the data obtained concerning the Average Network Speed in the SMTUC network obtained from SMTUC PT operator, obtained from SMTUC PT operator:

Year	Average Network Speed (km/h)
2001	16,5
2002	16,9
2003	16,5
2004	16,6
2005	16,4
2006	16,7
2007	16,8
2008	17,0
2009	17,0
2010	17,1
2011	17,1

Source: SMTUC

ANNEX 6: Awareness data

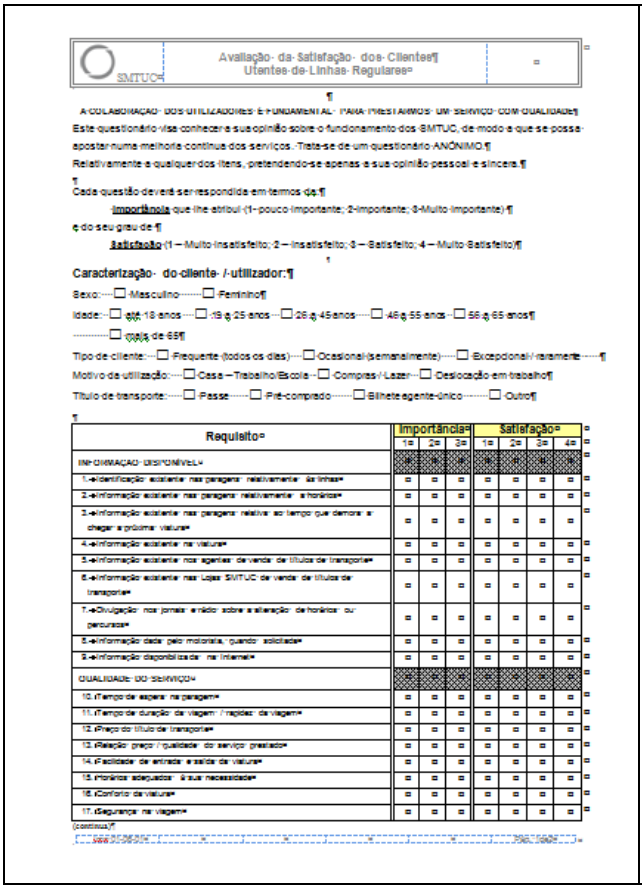
Question: Are you aware about the SMTUC timetable information service for mobile phones?

Year of the survey (period of data collection)	Positive answers – Yes (Nr.)	Negative answers – No (Nr).	Positive answers – Yes (%)
2009 (2008-12-04 a 2009-01-09)	0	0	0
2010 (2010-03-23 a 2010-03-29)	192	532	27
2011 (2011-03-29 a 2011-04-04)	250	482	34

Source: SMTUC

ANNEX 7: Quality Survey

ANNEX 7.1 Questionnaire model



SMTUC

Avaliação da Satisfação dos Clientes
Utentes de Linhas Regulares

A COLABORAÇÃO DOS UTILIZADORES É FUNDAMENTAL PARA PRESTARMOS UM SERVIÇO COM QUALIDADE

Este questionário visa conhecer a sua opinião sobre o funcionamento dos SMTUC, de modo a que se possa apostar numa melhoria contínua dos serviços. Trata-se de um questionário ANÓNIMO.

Relativamente a qualquer dos itens, pretendendo-se apenas a sua opinião pessoal e sincera.

Cada questão deverá ser respondida em termos da:

Importância que lhe atribui (1- pouco importante; 2-importante; 3-Muito importante)

e do seu grau de:

Satisfação (1 – Muito Insatisfeito; 2 – Insatisfeito; 3 – Satisfeito; 4 – Muito Satisfeito)

Caracterização do cliente / utilizador:

Sexo: ☐ Masculino ☐ Feminino

Idade: ☐ até 18 anos ☐ 19 a 25 anos ☐ 26 a 45 anos ☐ 46 a 55 anos ☐ 56 a 65 anos ☐ mais de 65

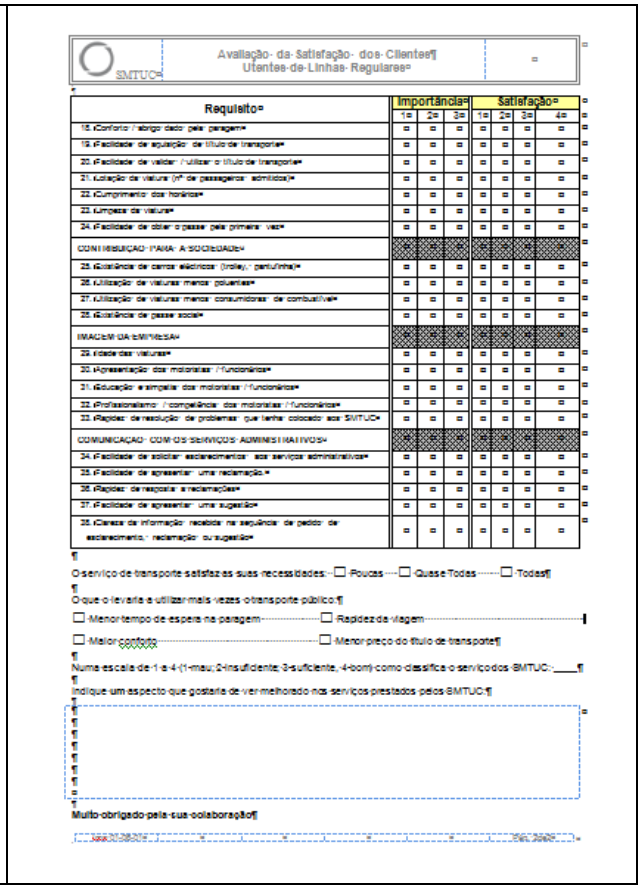
Tipo de cliente: ☐ Frequente (todos os dias) ☐ Ocasional (semanalmente) ☐ Excepcional/raramente

Motivo da utilização: ☐ Casa – Trabalho/Escola ☐ Compras/Lazer ☐ Deslocação em trabalho

Título de transporte: ☐ Passe ☐ Pré-comprado ☐ Bilhete avulso ☐ Outro

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
INFORMAÇÃO DISPONÍVEL							
1. Identificação existente nas paragens relativamente às linhas	☐	☐	☐	☐	☐	☐	☐
2. Informação existente nas paragens relativamente aos horários	☐	☐	☐	☐	☐	☐	☐
3. Informação existente nas paragens relativa ao tempo que demora a chegar a próxima viatura	☐	☐	☐	☐	☐	☐	☐
4. Informação existente na viatura	☐	☐	☐	☐	☐	☐	☐
5. Informação existente nos agentes de venda de títulos de transporte	☐	☐	☐	☐	☐	☐	☐
6. Informação existente nas Lojas SMTUC de venda de títulos de transporte	☐	☐	☐	☐	☐	☐	☐
7. Divulgação nos jornais e rádio sobre a alteração de horários ou percursos	☐	☐	☐	☐	☐	☐	☐
8. Informação dada pelo motorista, quando solicitada	☐	☐	☐	☐	☐	☐	☐
9. Informação disponibilizada na Internet	☐	☐	☐	☐	☐	☐	☐
QUALIDADE DO SERVIÇO							
10. Tempo de espera na paragem	☐	☐	☐	☐	☐	☐	☐
11. Tempo de duração da viagem / rapidez da viagem	☐	☐	☐	☐	☐	☐	☐
12. Preço do título de transporte	☐	☐	☐	☐	☐	☐	☐
13. Relação preço / qualidade do serviço prestado	☐	☐	☐	☐	☐	☐	☐
14. Facilidade de entrada e saída da viatura	☐	☐	☐	☐	☐	☐	☐
15. Horários adequados à sua necessidade	☐	☐	☐	☐	☐	☐	☐
16. Conforto da viatura	☐	☐	☐	☐	☐	☐	☐
17. Segurança na viagem	☐	☐	☐	☐	☐	☐	☐

(continua)



SMTUC

Avaliação da Satisfação dos Clientes
Utentes de Linhas Regulares

Requisito	Importância 1	Importância 2	Importância 3	Satisfação 1	Satisfação 2	Satisfação 3	Satisfação 4
18. Conforto / abrigo dado pela paragem	☐	☐	☐	☐	☐	☐	☐
19. Facilidade de aquisição de título de transporte	☐	☐	☐	☐	☐	☐	☐
20. Facilidade de validar / utilizar o título de transporte	☐	☐	☐	☐	☐	☐	☐
21. Lotação da viatura (nº de passageiros admitidos)	☐	☐	☐	☐	☐	☐	☐
22. Cumprimento dos horários	☐	☐	☐	☐	☐	☐	☐
23. Limpeza da viatura	☐	☐	☐	☐	☐	☐	☐
24. Facilidade de obter o passe pela primeira vez	☐	☐	☐	☐	☐	☐	☐
CONTRIBUIÇÃO PARA A SOCIEDADE							
25. Existência de carros eléctricos (trolley, pentolinha)	☐	☐	☐	☐	☐	☐	☐
26. Utilização de viaturas menos poluentes	☐	☐	☐	☐	☐	☐	☐
27. Utilização de viaturas menos consumidoras de combustível	☐	☐	☐	☐	☐	☐	☐
28. Existência de passe social	☐	☐	☐	☐	☐	☐	☐
IMAGEM DA EMPRESA							
29. Idade das viaturas	☐	☐	☐	☐	☐	☐	☐
30. Apresentação dos motoristas / funcionários	☐	☐	☐	☐	☐	☐	☐
31. Educação e simpatia dos motoristas / funcionários	☐	☐	☐	☐	☐	☐	☐
32. Profissionalismo / competência dos motoristas / funcionários	☐	☐	☐	☐	☐	☐	☐
33. Rapidez de resolução de problemas que tenha colocado aos SMTUC	☐	☐	☐	☐	☐	☐	☐
COMUNICAÇÃO COM OS SERVIÇOS ADMINISTRATIVOS							
34. Facilidade de solicitar esclarecimentos aos serviços administrativos	☐	☐	☐	☐	☐	☐	☐
35. Facilidade de apresentar uma reclamação	☐	☐	☐	☐	☐	☐	☐
36. Rapidez de resposta a reclamações	☐	☐	☐	☐	☐	☐	☐
37. Facilidade de apresentar uma sugestão	☐	☐	☐	☐	☐	☐	☐
38. Clareza da informação recebida na sequência de pedido de esclarecimento, reclamação ou sugestão	☐	☐	☐	☐	☐	☐	☐

O serviço de transporte satisfaz as suas necessidades: ☐ Poucas ☐ Quase Todas ☐ Todas

O que o levaria a utilizar mais vezes o transporte público:

☐ Menor tempo de espera na paragem ☐ Rapidez da viagem

☐ Maior conforto ☐ Menor preço do título de transporte

Numa escala de 1 a 4 (1-mau; 2-insuficiente; 3-suficiente; 4-bom) como classifica o serviço dos SMTUC: ____

Indique um aspecto que gostaria de ver melhorado nos serviços prestados pelos SMTUC:

Muito obrigado pela sua colaboração!

ANNEX 7.2 Structure and questions

The questionnaire starts with 4 questions related to the interviewee – Sex, Age (<18, 19-25, 26-45, 56-65, >65), type of client (frequent, occasional, exceptional/rare use), motive of the trip (home-work/school, shopping/leisure, in service), and type of ticket (pass, single ticket bought on the selling point, single ticket bought on the vehicle, other).

The main part of the questionnaire is composed of 38 specific questions related to various items related to 5 areas of the service (1-Available information, 2-Quality of service, 3-Contribution to society, 4-Image of the company, 5-Communication with the administrative services) and a specific global customer satisfaction question that summerises the quality of service. In each question the people interviewed express a judgement choosing between very satisfied – satisfied – unsatisfied – very unsatisfied and about the importance of each of the 38 items choosing between very important – important – low importance.

Each question is assessed in terms of the importance given (1-Not important, 2-Important, 3-Very Important) and level of satisfaction (1-Very Dissatisfied 2-Dissatisfied 3-Satisfied 4-Very Satisfied) of the user concerning the respective item.

AVAILABLE INFORMATION
1. Identification of existing lines at stops
2. Information at stops about timetables
3. Information at stops about the waiting time until the next vehicle
4. Information inside the vehicle
5. Information at ticket selling points
6. Information at SMTUC ticket selling shops
7. Disclosure of information in the newspapers and radio about timetable or routes changing[26]
8. Information given by the driver, upon request
9. Information available on the Internet
QUALITY OF SERVICE
10. Waiting time at stop
11. Trip duration / speed of travel
12. Price of the ticket
13. Relation Price / Quality of the service
14. Ease of entry and exit of the vehicle
15. Adjustment of the timetable to your needs
16. Comfort of the vehicle
17. Safety during the trip
18. Comfort / protection given by the stop shelter
19. Ease of ticket purchase
20. Ease of ticket validation / utilization
21. Capacity of the vehicle (nr. of passengers allowed)
22. Compliance with the timetable
23. Cleanliness of the vehicle
24. Facility in obtaining the travelcard for the first time
CONTRIBUTION TO SOCIETY
25. Existence of electric vehicles (trolleybuses, electric mini-buses)

[26] This question was eliminated on the 2010 and 2011 surveys.

26. Utilization of less polluting vehicles
27. Utilization of less fuel consumming vehicles
28. Existence of social travelcard
IMAGE OF THE COMPANY
29. Age of the vehicles
30. Presentation of drivers / staff
31. Education and friendliness of the drivers / staff
32. Quality of driving performance of SMTUC drivers[27]
33. Professionalism / competence of the drivers / staff
34. Quickness in the resolution of problems you may have submited to SMTUC
COMMUNICATION WITH THE ADMINISTRATIVE SERVICES
35. Facility in requesting clarifications to the administrative services
36. Facility in submmiting a complaint.
37. Response quickness in respect to complaints
38. Facility in presenting a suggestion
39. Clarity of the information obtained in response to a request for information, complaint or suggestion

The questionnaire concludes with 5 questions related to the respondent's general attitude towards the service supplied by SMTUC:

1. The transportation service meets your needs (1-Few, 2-Nearly all, 3-All)

2. What would make you consider using public transportation more often (1-Shorter waiting time at stops, 2-Higher speeds, 3-Increased comfort, 4-Lower price of the ticket)

3. How do you rate the SMTUC service on a scale of 1 to 4 (1-bad, 2-poor, 3-sufficient, 4-good)

4. Indicate a point you would like to see improved in the SMTUC service:

[27] This question was not included on the 2009 survey.

ANNEX 7.3 Customer satisfaction survey results

Quality of service is measured by means of a customer satisfaction survey periodically carried out by SMTUC:

The survey is repeated once a year and is carried out to customers in face to face interviews on board of the SMTUC busses.

The sample is selected on the basis of the lines used by the passengers, i.e., the number of interviwees choosen in each line is defined according to the demand of the line in relation to the overall SMTUC demand.

The size of the sample is defined according to the specifications of the quality management auditors which supervise the entire process in line with the ISO9001 standard.

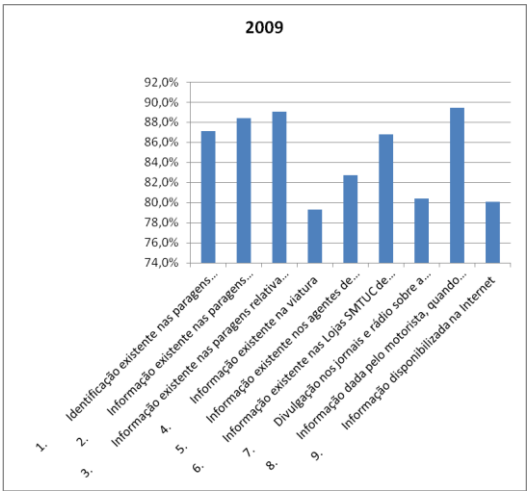
The quality management auditors considered 500 interviews as (a minimum) suitable to assess the quality evaluation by PT passengers in Coimbra. However, SMTUC voluntered to surpass this number. Thus, the following number of interviews and valid answers were achieved:

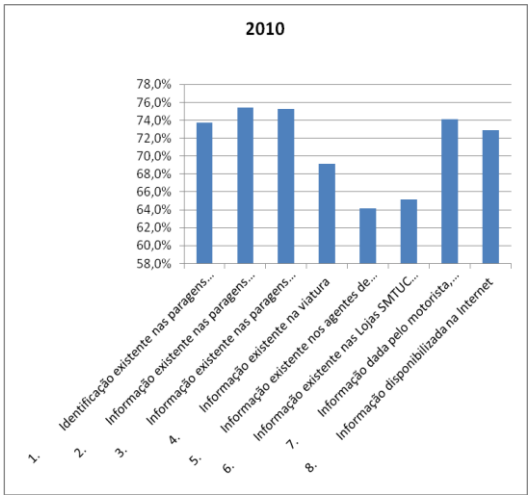
In 2009 a sample of 1000 interviews was defined and 984 valid answers were obtained.

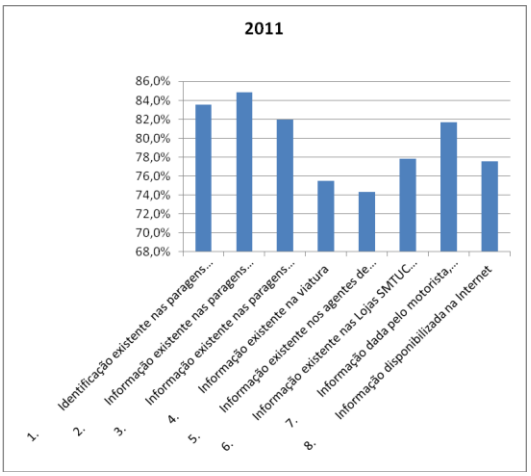
In 2010 a sample of 750 interviews was defined and 734 valid answers were obtained

In 2011 a sample of 750 interviews was defined and 736 valid answers were obtained

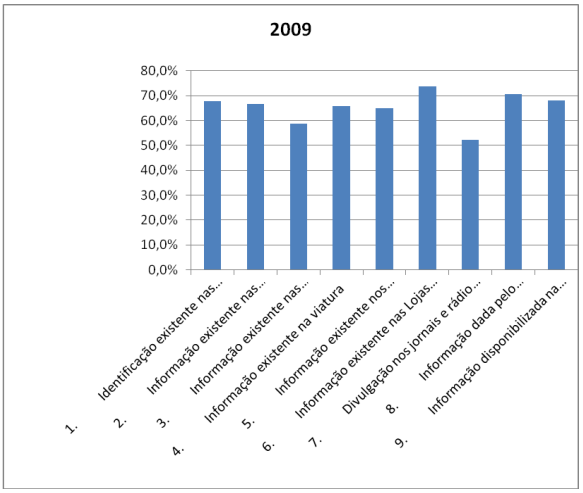
Importance given to the Available Information

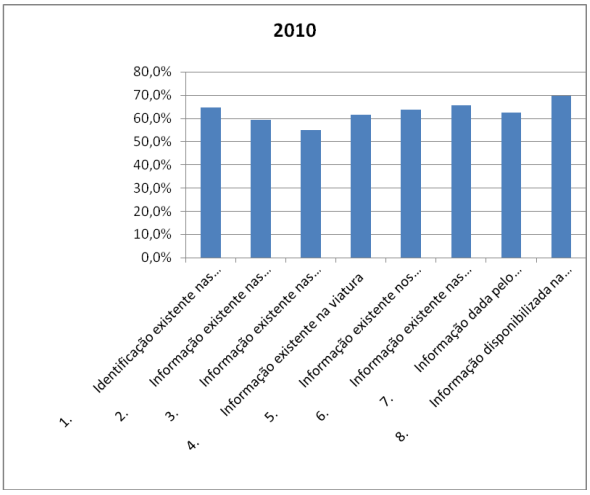


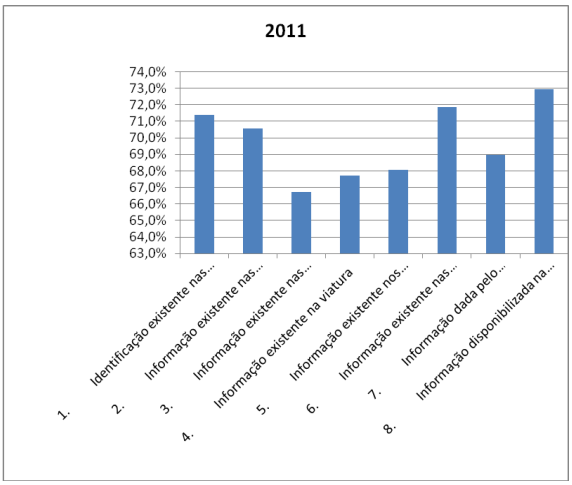


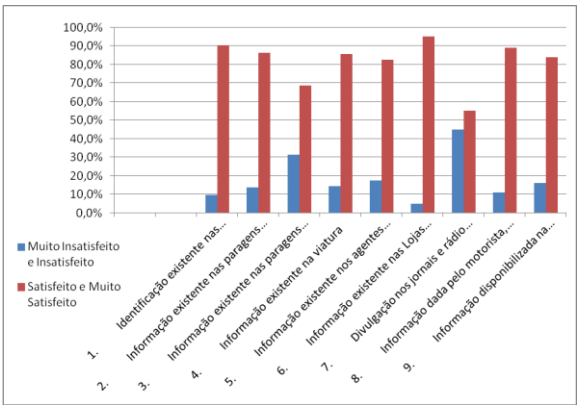


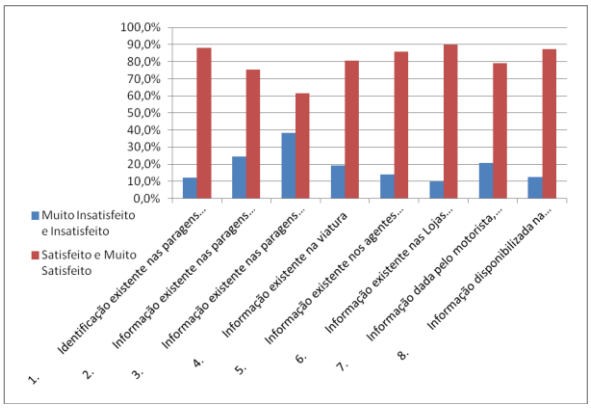
Level of satisfaction in accordance with the Available Information

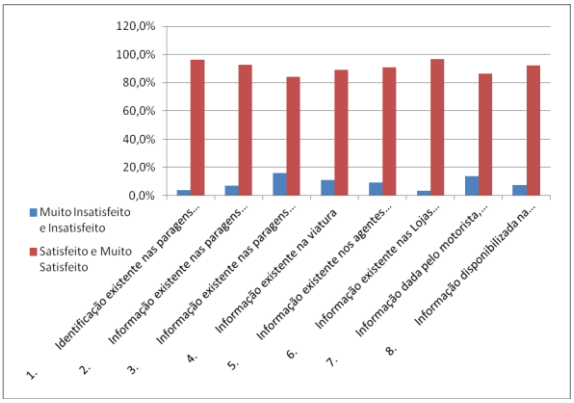




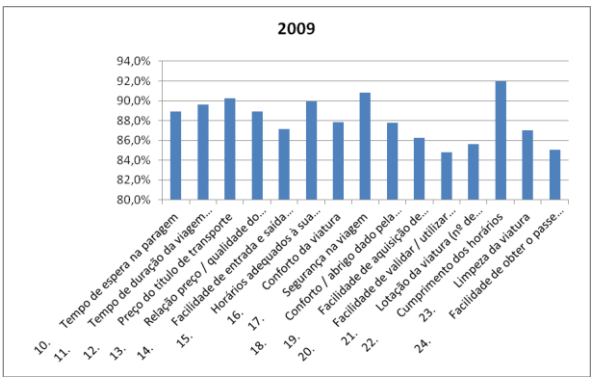


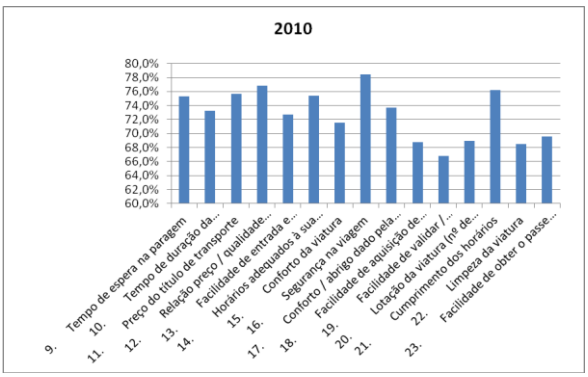


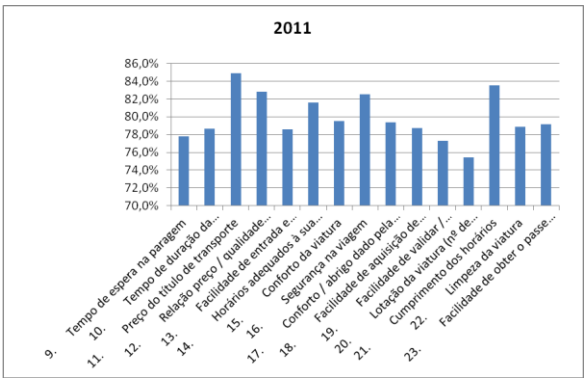




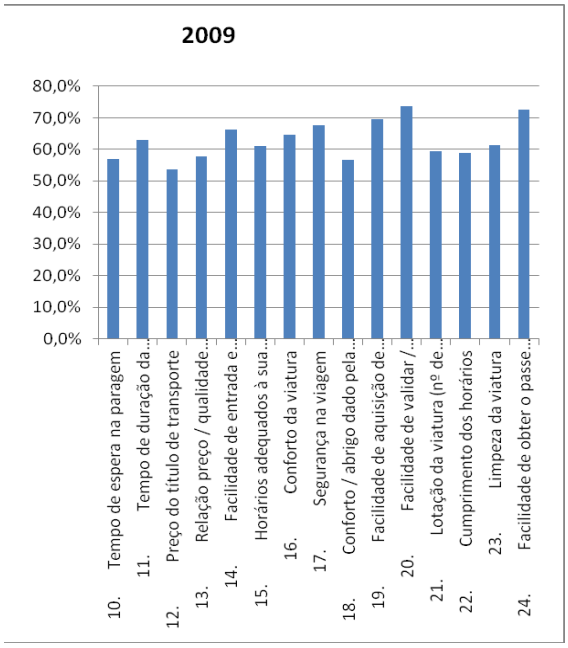
Importance given to the Quality of Service

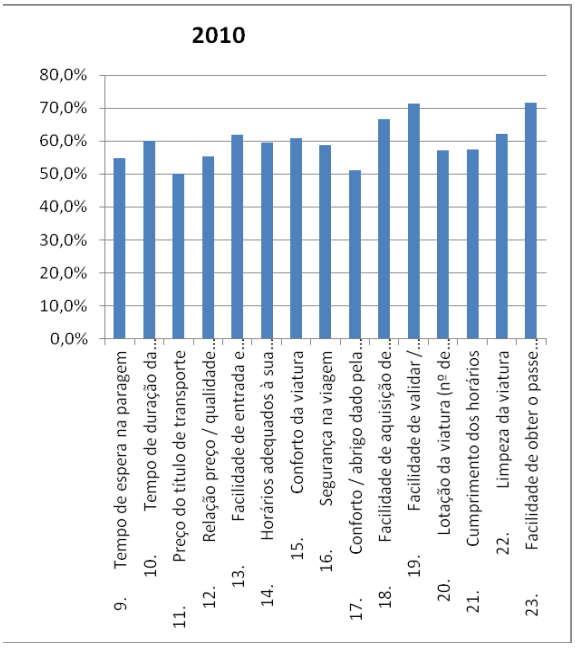


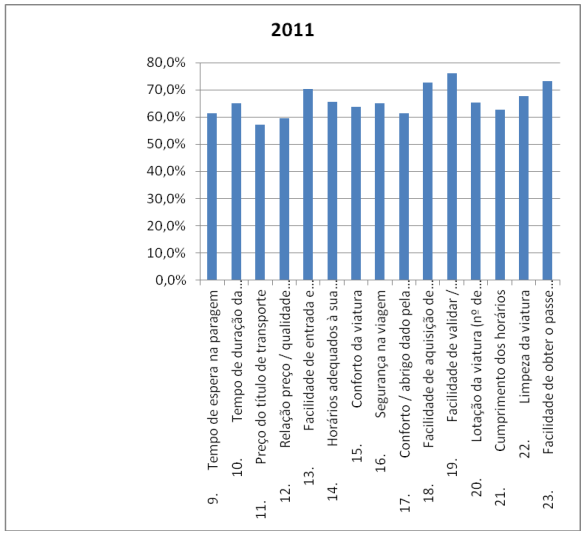


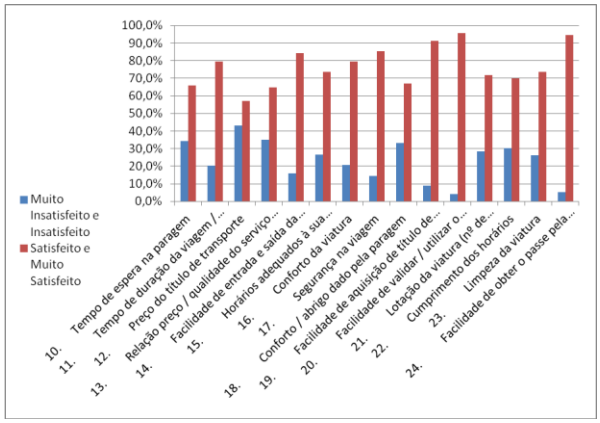


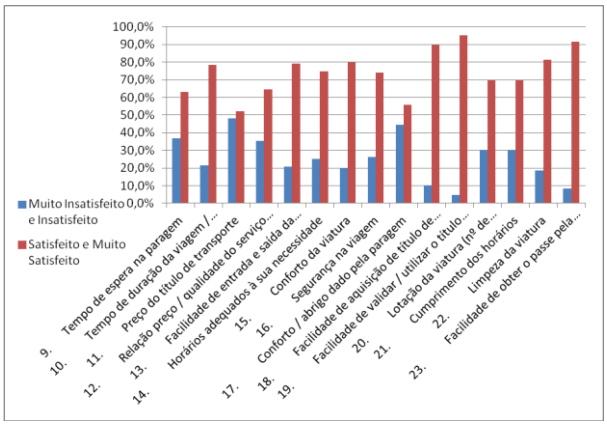
Level of satisfaction concerning the Quality of Service

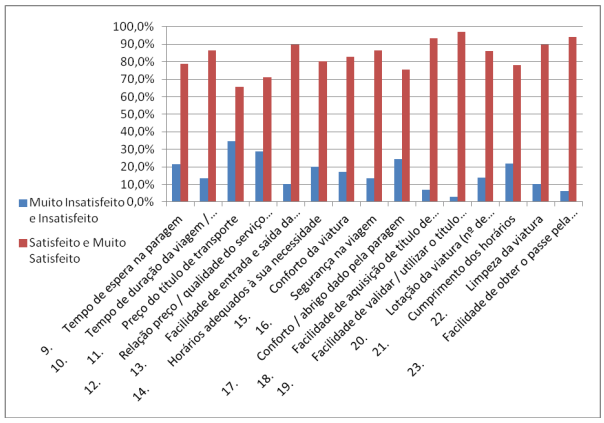




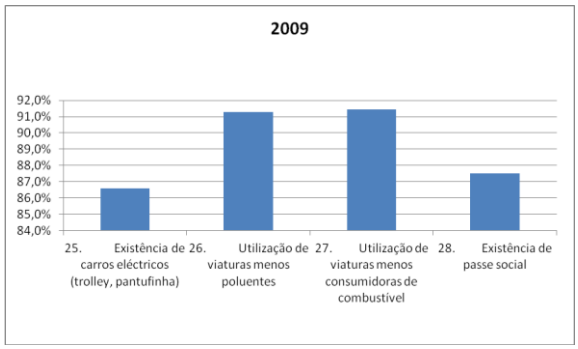


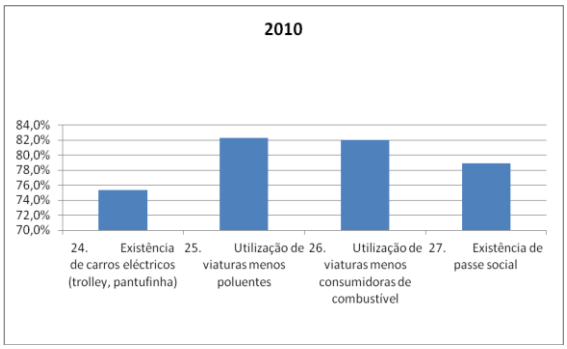


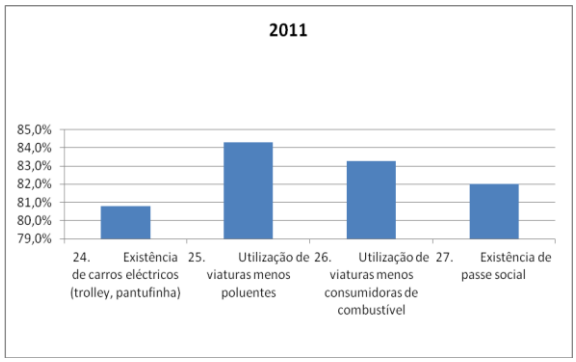




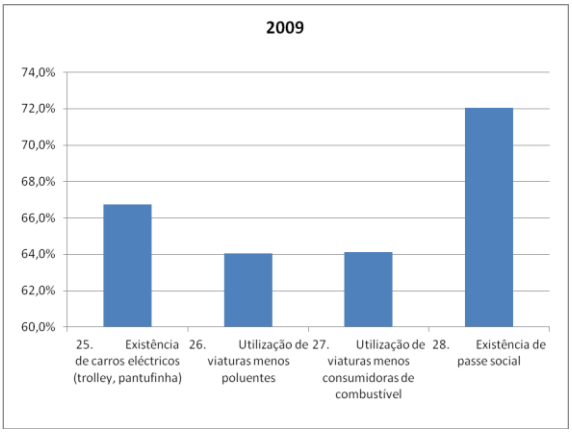
Importance given to the Contribution to Society

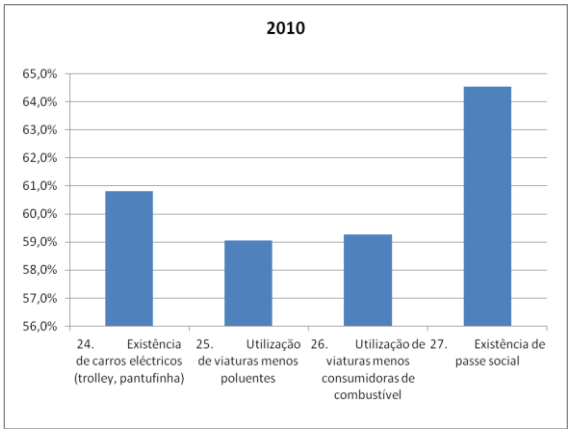


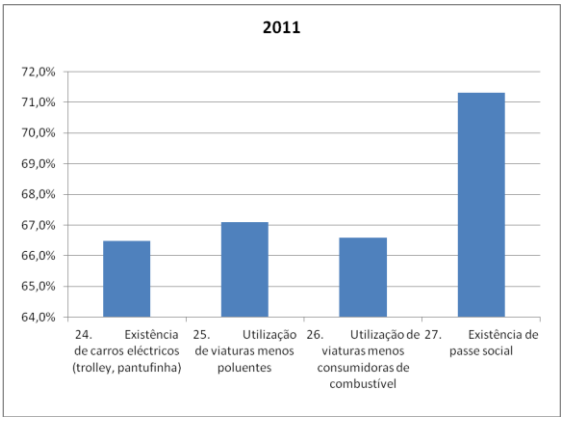


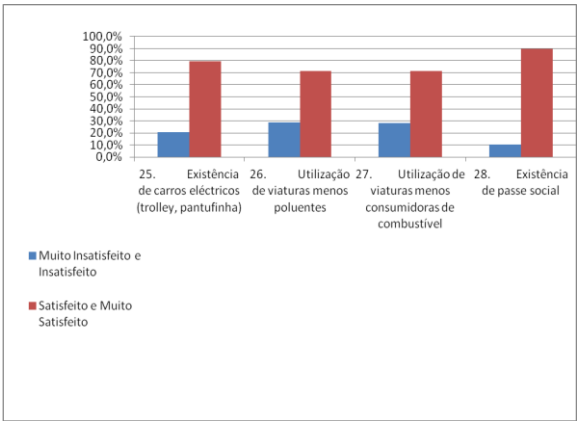


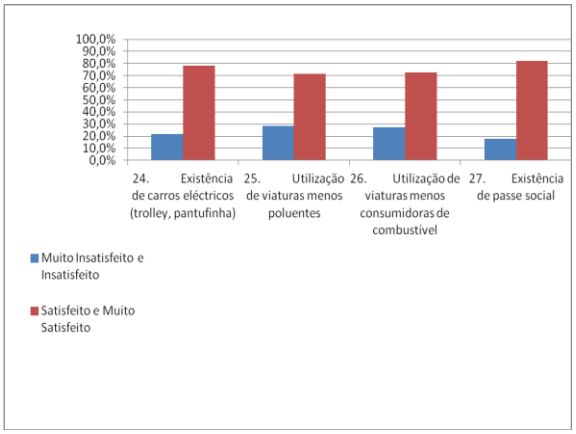
Level of satisfaction in relation to the Contribution to Society

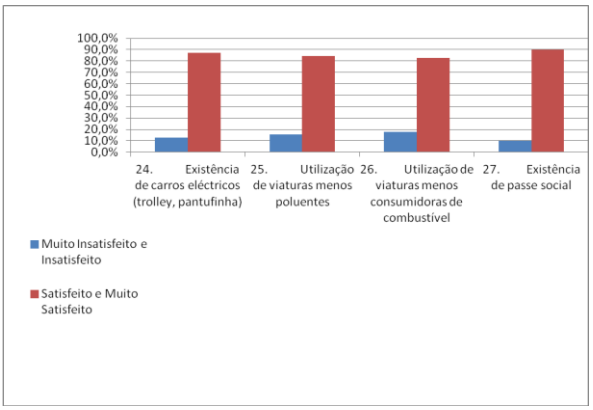




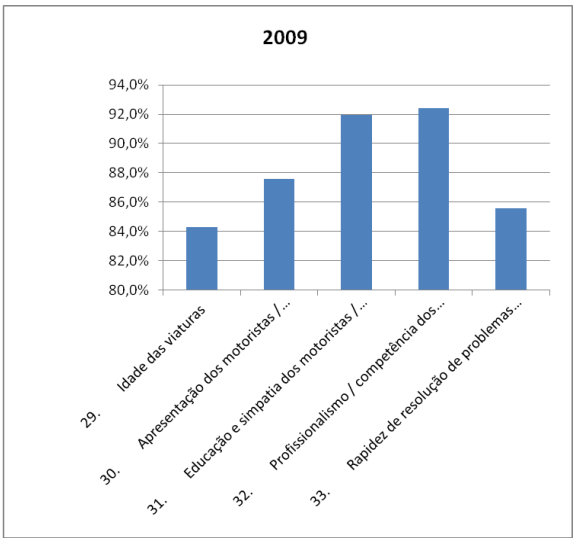


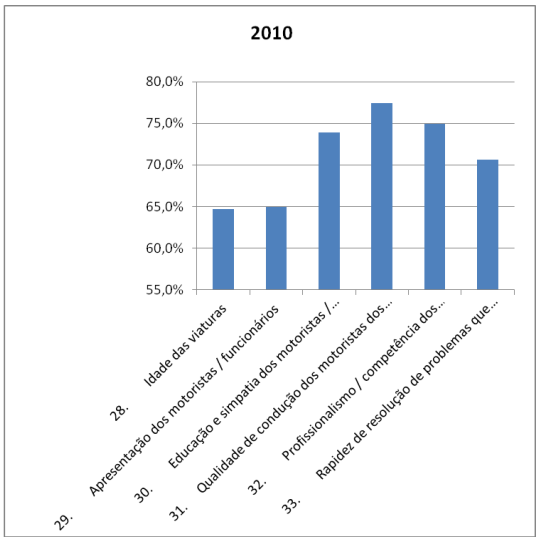


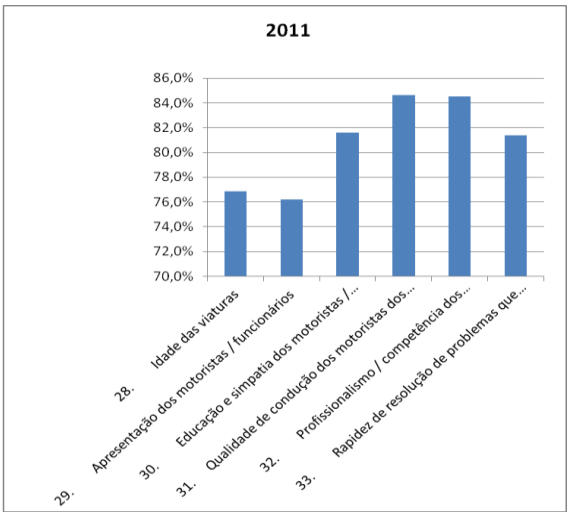




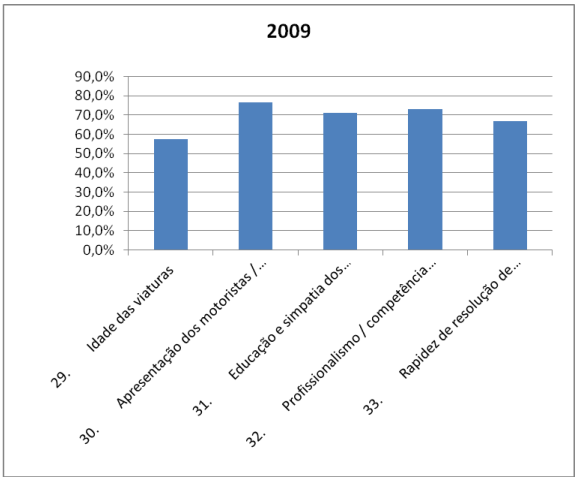
Importance given to the Image of the Company

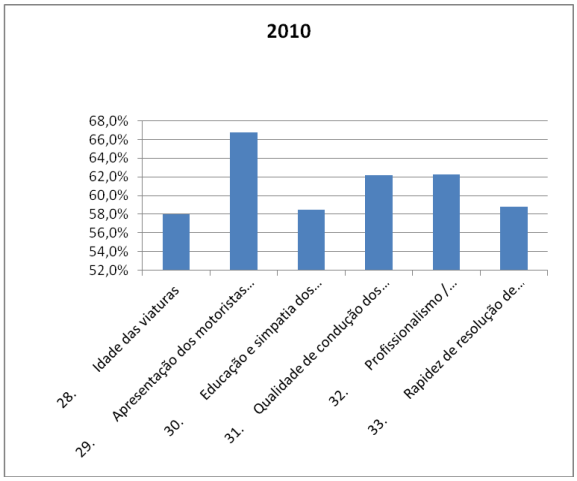


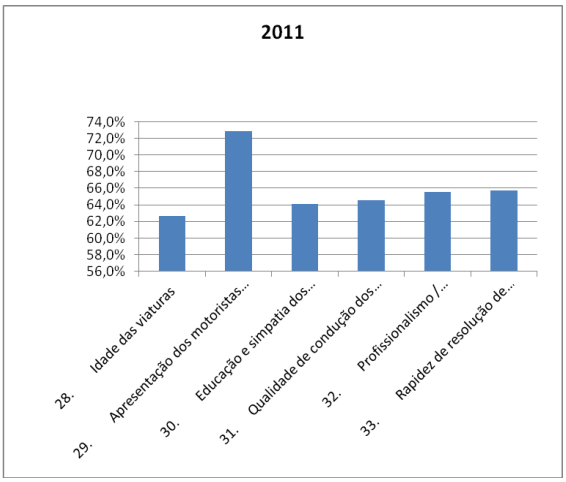


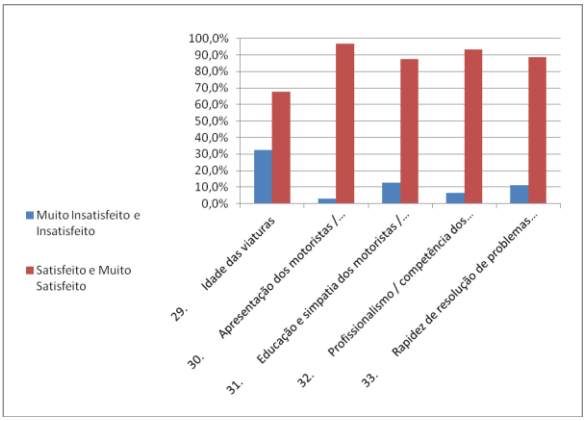


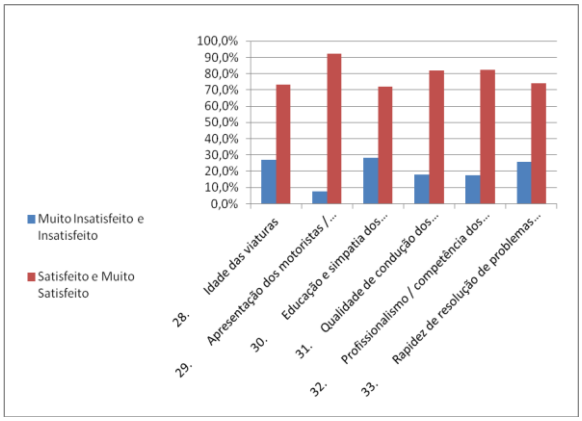
Level of satisfaction concerning the Image of the Company

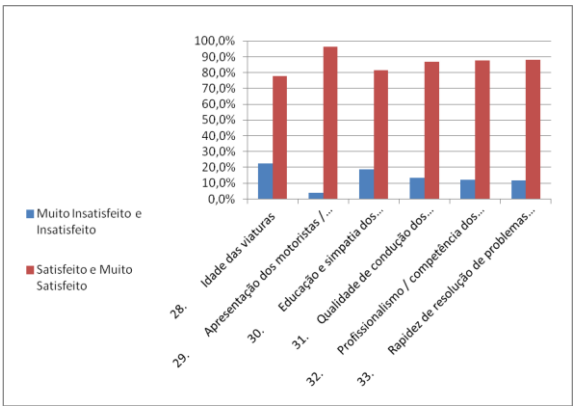




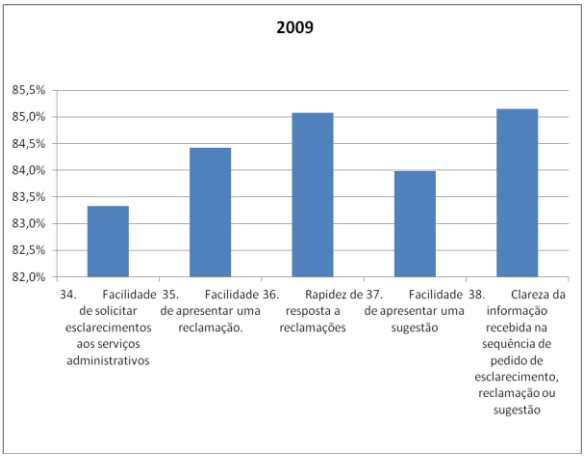


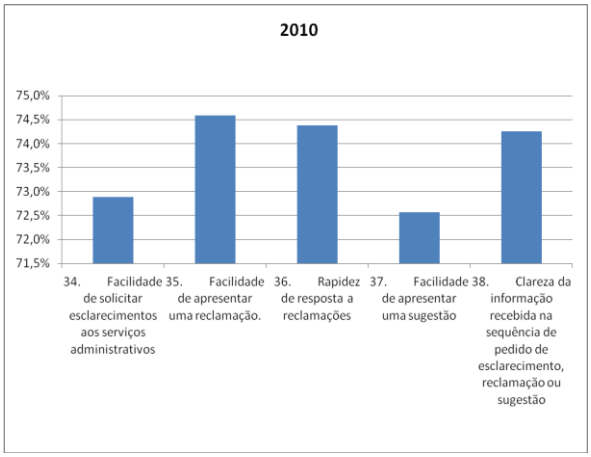


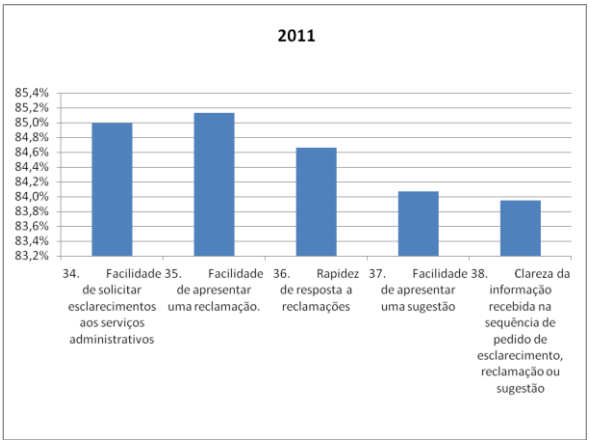




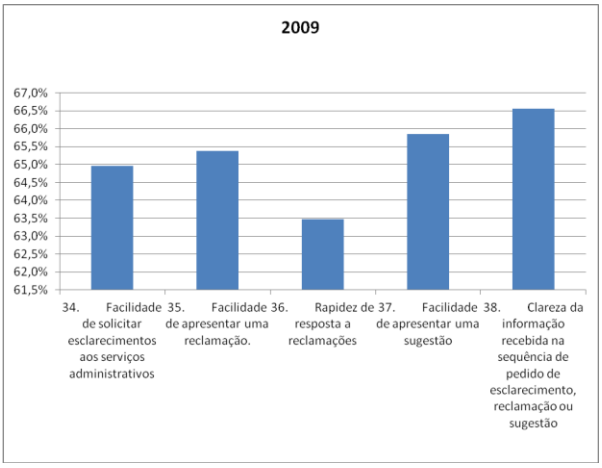
Importance given to the Communication with the Administrative Sevices

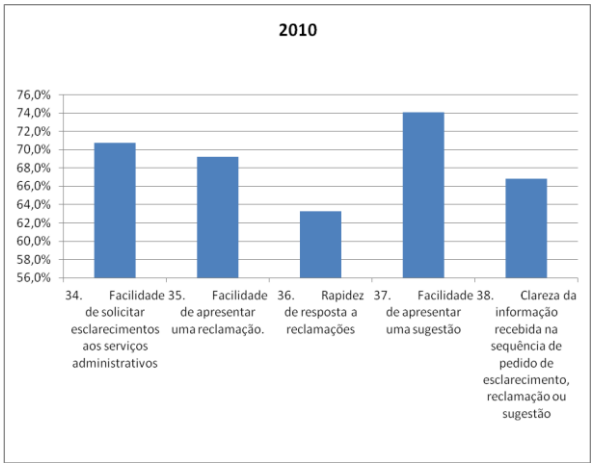


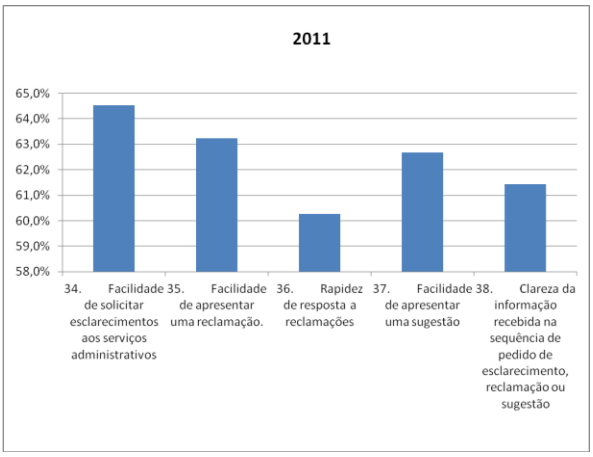


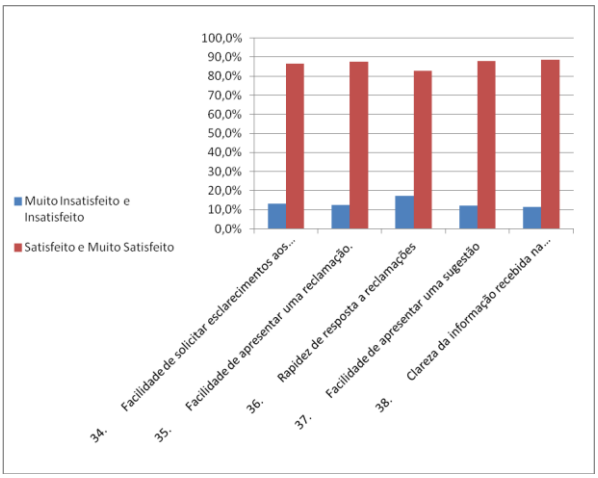


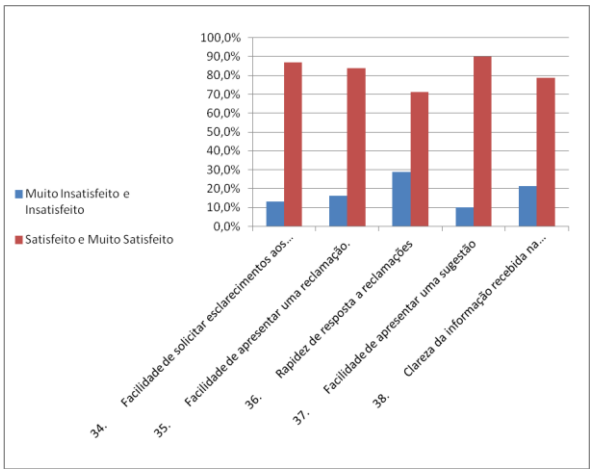
Level of satisfaction concerning the Communication with the Administrative Sevices

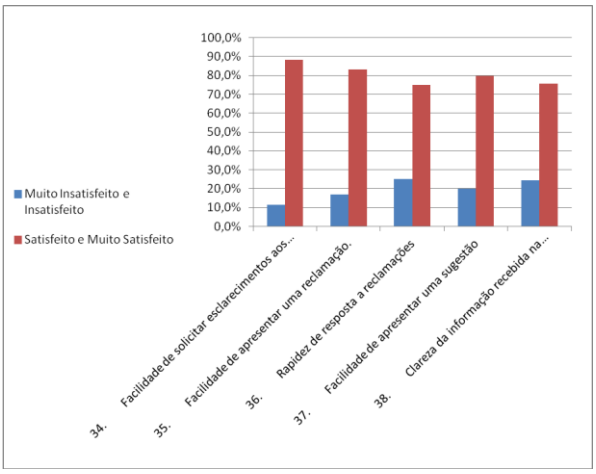






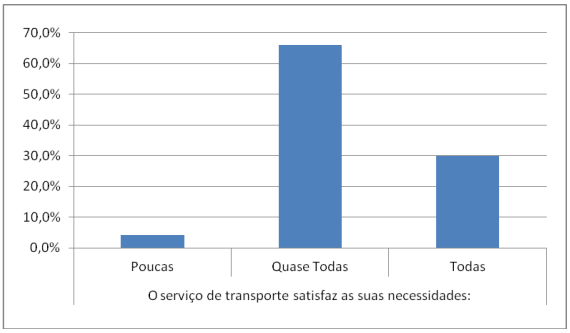




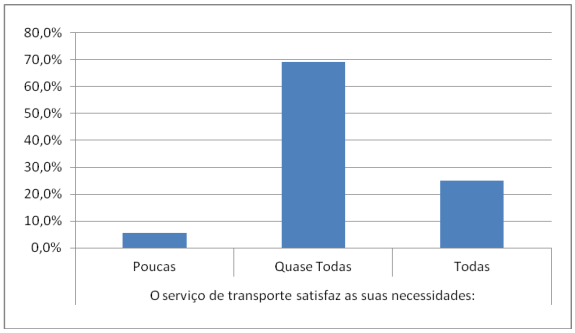


Results of the question "The transportation service meets your needs?"

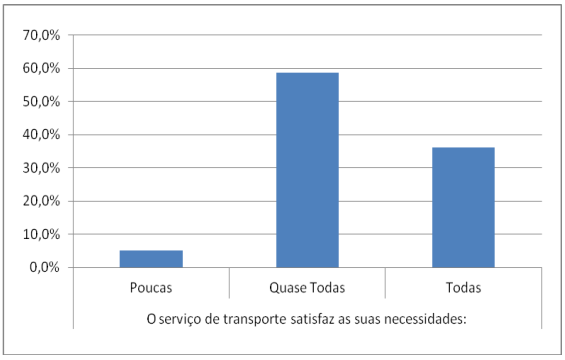
2009



2010

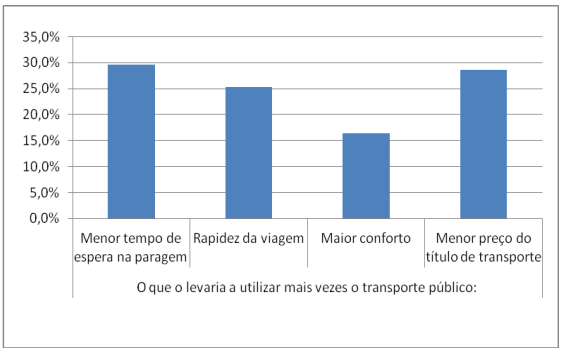


2011

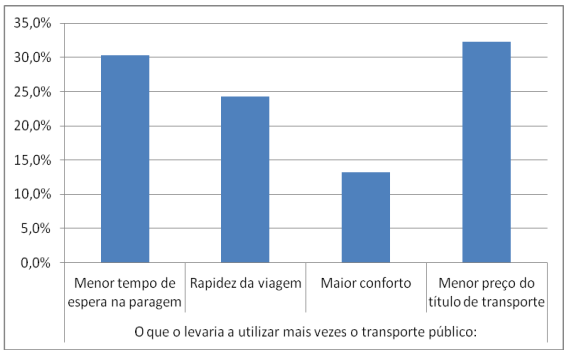


Results of the question "What would make you consider using public transportation more often?"

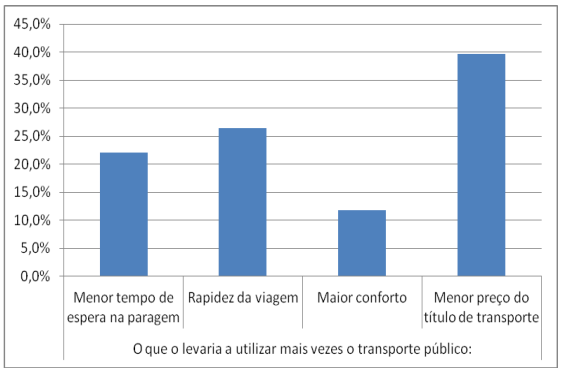
2009



2010



2011



ANNEX 8: Cost-Benefit Analysis Data

The next table shows the values obtained for travel time savings:

Year: 2002	Time savings (€/h)
Work related trips (Bus, Portugal)	15,52
Non-work related trips (Bus, Portugal)	4,81

Source: HEATCO Project. Deliverable D5 Proposal for Harmonised Guidelines (2006) (URL: http://heatco.ier.uni-stuttgart.de/), taken from J. Piao and J. Preston, CBA Recommendations for CIVITAS Evaluation, Transportation Research Group, Southampton University, UK

The following table shows the evolution of inflation rates from 2001-2007:

Year	2002	2003	2004	2005	2006	2007
Inflation Rate (%) since 2000	3,62%	3,29%	2,36%	2,28%	3,09%	2,45%

Source: Bank of Portugal, National institute of Statistics

The following table shows the estimated values of travel time savings:

Year: 2008	Time savings (€/h)
Work related trips (Bus, Portugal)	18,19
Non-work related trips (Bus, Portugal)	5,64
AVERAGE	**11,53**

The estimation of these values is based on the values of travel time savings obtained from POINTER and on the evolution of inflation rates from 2001-2007.

The next table shows the age of SMTUC passengers:

Age (%)	2009	2010	2011
<18	12,6	12,5	6,1
19-25	28,3	32,4	41,2
26-45	23,9	19,6	23,6
46-55	15,2	13,5	15,2
56-65	13,2	10,3	7,9
>62	6,8	11,7	6

Source: SMTUC – Customer satisfaction Survey

The following table shows the motive of the trips of SMTUC passengers

Motive (%)	2009	2010	2011
Home-Work/School	66,8	63,9	70,2
Shopping/Leisure	29,6	31,4	25,5
Work trip	3,6	4,7	4,3

Source: SMTUC – Customer satisfaction Survey

The following table shows the percentage of work related trips and non-work related trips among SMUC passengers:

Motive (%)	2009	2010	2011	Average
Work related trips	47,8	45,1	48,5	47,1
Non-work related trips	52,2	54,9	51,5	52,9

The assumption in this table is that Home-Work/School trips among passengers <18 are 100% Non-work related trips, that Home-Work/School trips among passengers 19-25 are 75% Non-work related trips and that Home-Work/School performed by each age group is proportional to the percentage of SMTUC passengers belonging to that group.