Measure title: **Policy Options for Access Restrictions**

City: **Stuttgart** *Project:* **CARAVEL** *Measure number:* **06.03**

A Introduction

A1 Objectives

The main target of the project is:

- Design and implementation of a policy to reduce pollution in different areas of human activities through the strategies of restrictions and management of transport.

The measure objectives are:

- Fulfil the requirements on pollution in line with the European Clean Air Directive.
- Analysis of the data of air pollution due to transport in different places.
- Proposal of strategies of access restrictions and for other traffic restrictions in areas where the concentration of emissions exceed the allowed levels (esp. particles, etc.).
- Design of strategies of restrictions and management of transport according to the activities developed.
- Reduction of the pollution levels due to transport with the aim to permanently fall below the limit values in the restricted areas proposed.

A2 Descriptions

Clean Air Programmes have to be released for cities or quarters of cities with exceedances of the limit values according to the EU. The responsible authority for this task is the local government of the State of Baden-Wuerttemberg, not the municipality. The Clean Air Programmes are restricted to cities or quarters of cites with exceedances. Based on the Clean Air Programme and the action plan published at the end of December 2005 the measures of different types of access restrictions and transport management were defined:

Access restrictions for specific areas (e.g. depending on type of vehicles, emission category of vehicles, trip purpose, etc.):

Action 1 – A1: Ban for heavy through traffic for Stuttgart was introduced on January 2006 (for all heavy duty vehicles – HDV - with more than 3.5 tons of total weight).

Action 2 – A2: Introduction of environmental zone (LEZ – low emission zone) for Stuttgart.

- Level 1 introduced on March 2008 (planned for July 2007)
- Level 2 will be introduced on January 2012

Action 3 – A3: Implementation of two pedestrian crossings to make traffic more fluent at a highly polluted site in the course of the “city highway B14”.

- Consequence: Reduction of speed limit from 60 to 50 km/h on the “city highway B14”.
- Model simulation to investigate the flow system and the air pollution situation at this highly polluted site in Stuttgart to improve the knowledge about the processes leading to the high concentrations of air pollutants and high number of exceedances of valid European limit values for PM_{10} and NO_2.

- Management/supply of public transport, support of car-pooling and parking management.

To achieve wide acceptance of the measures the implementation process has been supported by:

- comprehensive PR activities to communicate the necessity of the measures and to raise awareness for their acceptance and, as e.g. a public-opinion poll programme among the citizens of Stuttgart to the implementation of the Clean Air Programme
- the installation of a "round table on clean air and noise reduction" with responsible and other stakeholders concerned, which facilitates the easy and quick implementation of the measures and helps to avoid critical situations in advance.

Maps

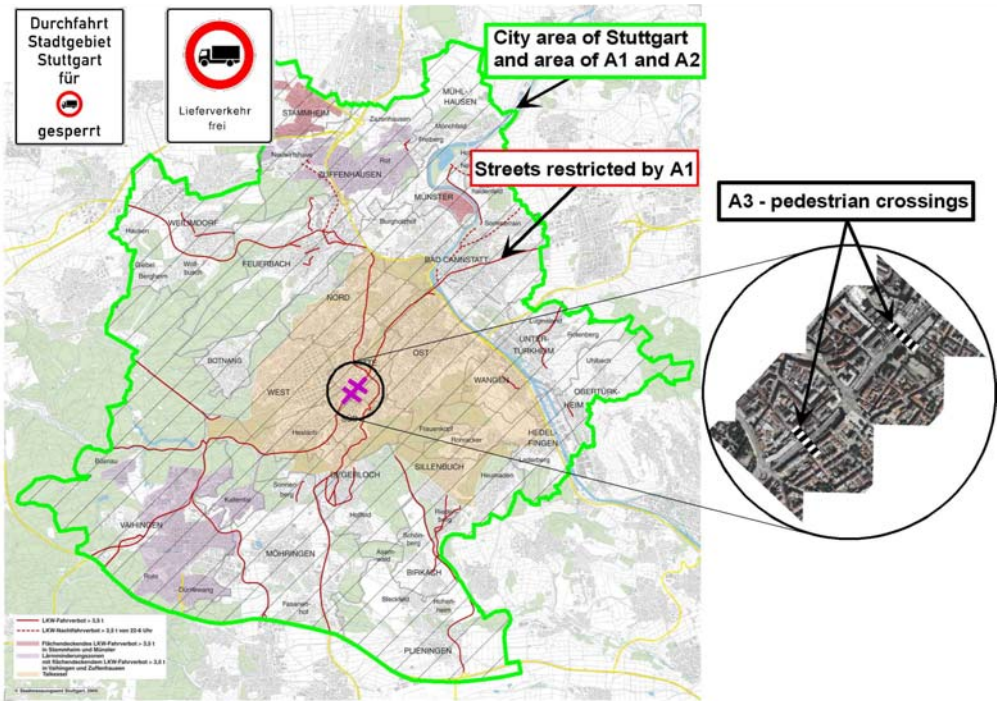


Fig. 1: Map of Stuttgart with measures:
A1 - Ban for heavy through traffic,
A2 - Environmental zone (LEZ – low emission zone) and
A3 - Pedestrian crossings (source: Clean Air Programme for Stuttgart 2005, modified by LHS 2008).

The city of Stuttgart covers an area of 207 km² (area within the green line in Fig. 1). A1 (with two exceptions) and A2 are valid for the total city area. A3 is a local measure in one heavy traffic road in the city centre.

Definition

Light duty vehicles – LDV – passenger cars and vans up to 3.5 t (<= 3.5 t) of total weight.

Heavy duty vehicles – HDV – vans, lorries and busses with more than 3.5 t (> 3.5 t) of total weight.

B Measure implementation

B1 Innovative aspects

- New conceptual approach
- Use of new technology / ITS
- New mode of transport exploited
- Targeting specific user groups
- New economic instrument
- New policy instrument
- New organisational arrangements or relationships
- New physical infrastructure solutions

The innovative aspects of the measure are:

- **Innovative aspect 1: New conceptual approach/new policy instrument** – Design of strategies, taking into account data of air quality, aiming at reducing the pollution levels in different urban zones by means of access strategies and management of transport. Implementation of 2 pedestrian crossings as a traffic calming measure.
- **Innovative aspect 2: Targeting specific user groups** - Installation of a Round Table on clean air and noise reduction to establish an expert committee supporting the decision makers on measure acceptance and implementation and involving a broad spectrum of local stakeholders:

B2 Situation before CIVITAS

component	valid from	limit value	remarks
PM10	01.01.2005	**50 µg/m³**	**24 hour average value** 35 exceedences per year allowed
PM10	01.01.2005	**40 µg/m³**	**yearly mean value**
NO_2	2002 to 31.12.2009	**200 µg/m³**	**1 hour mean value** (98 percentile) -> 175 exceedances per year allowed
NO_2	01.01.2010	**200 µg/m³**	**1 hour mean value** 18 exceedances per year allowed
NO_2	01.01.2010	**40 µg/m³**	**yearly mean value**

Fig. 2: Limit values for PM_{10} and NO_2 according German guideline 22. BImSchV resp. European Air Quality Directives 1996/62/EG and 1999/30/EG.

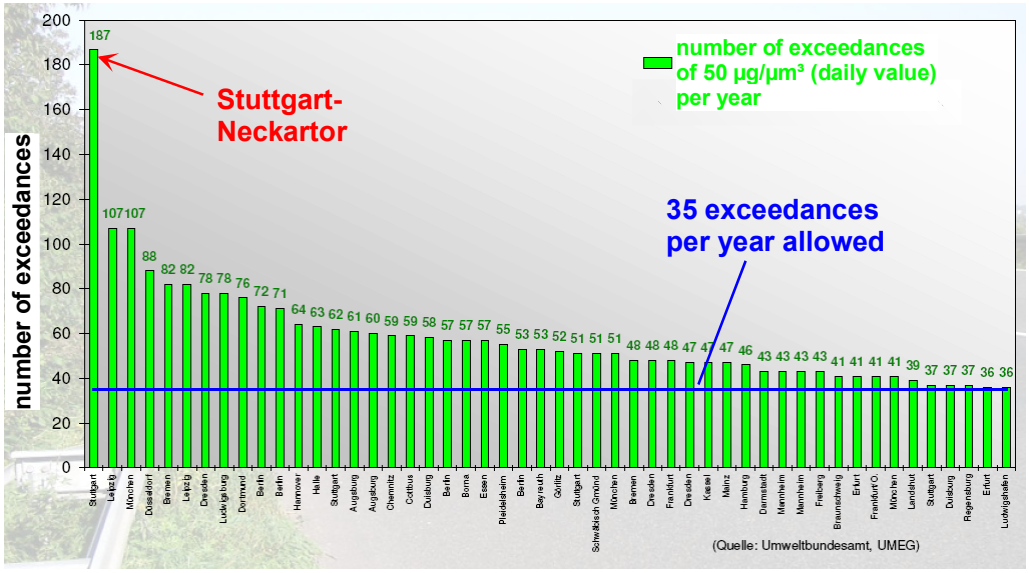
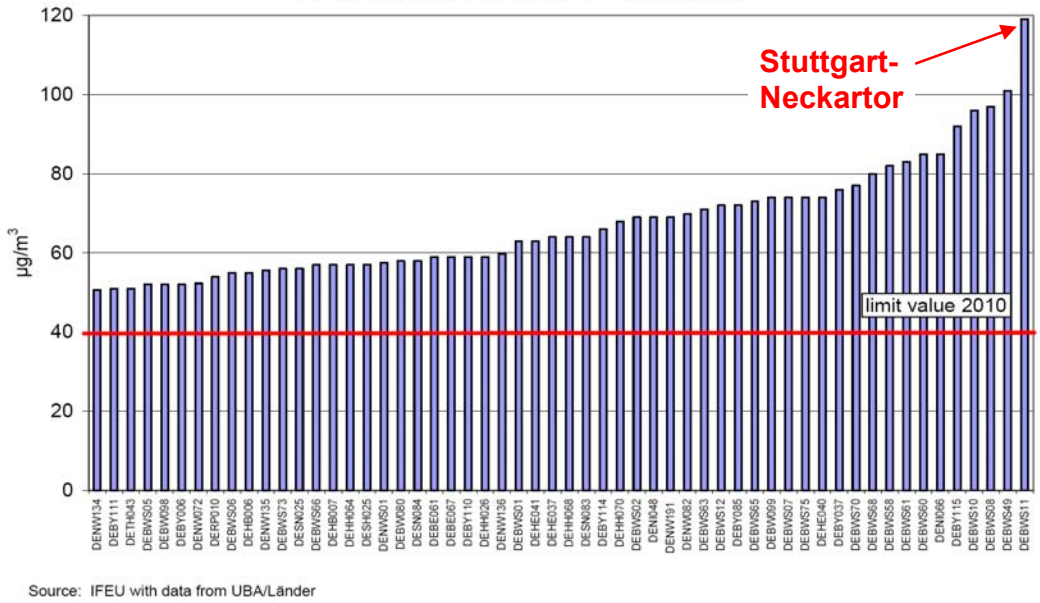


Fig 3: Number of exceedances per year of the limit value for PM_{10} of 50 µg/m³ in different German cities for the year 2005. Up to 35 exceedances per year are permitted.

The European Commission has set new definitions and limits for pollution in cities (European Air Quality Directive), see Fig. 2. Within a strict time schedule cities have to check whether and how to meet these requirements as well as to set up plans and measures to reduce pollution. This will mainly lead to measures in the transport sector where air pollutants are exceeding the given limit values. This concerns presently the limit value for NO_2 (98-percentile for all 1-hour mean values -> 175 allowed exceedances per year), which is massively exceeded in Stuttgart with 555 exceedances in 2004 and even 848 in 2005 (see Fig. 6). The same is the case for the annual limit value for NO_2 of 40 µg/m³ which will be valid from 2010 on. About 30 road sections of different lengths are concerned in Stuttgart, where the mean NO_2 concentration amounts to partially about 100 µg/m³ and more (see Fig. 16). In the year 2005 the highest yearly mean value in Germany was measured at Stuttgart-Neckartor (see Fig. 4) with 119 µg/m³. According to the limit values of the European Air Quality Directive, the short-term value for particulate matter (PM_{10}) is 50 µg/m³ (24 h value) from 2005, which is allowed to be exceeded by 35 times per year. The 24-hours limit value for PM_{10} causes problems in various German cities mainly in high traffic areas, because of massive exceedances. This can be seen in Fig. 3 where the number of exceedances of the 24 hour values of PM_{10} for the year 2005 is given. Stuttgart is "leading" this list of number of exceedances with the highest number of 187. At some sites even the annual limit value will be exceeded. In 2005 e.g. at the high polluted traffic site “Stuttgart-Neckartor” (see Fig. 5) the PM_{10} concentrations exceeded the annual limit value (40 µg/m³) with 55 µg/m³ (see Fig. 6). In Fig. 6 measured concentrations at different measurement sites in Stuttgart are summarised. It can be clearly seen that at Stuttgart-Neckartor the highest concentrations are measured in Stuttgart but the limit values are also exceeded at other sites in Stuttgart.

For the City of Stuttgart the air pollution reduction measures were published within the Clean Air Programme and the action plan for PM_{10} and for NO_2. The measures were under discussion and the plans were supplemented and finalized. Different measures in transport were designed, implemented, tested and assessed during CIVITAS II.



Source: IFEU with data from UBA/Länder

Fig 4: Yearly mean value for NO_2 in different German cities for the year 2005. The limit value will be 40 µg/m³ from the year 2010.

Fig. 5: Highly polluted traffic site "Neckartor" in Stuttgart.

The following figure shows the values exceeded at different measurement sites in Stuttgart in 2004 and 2005. Violet values show exceedances of valid limit values. Red values indicate exceedances of limit values valid from 2010.

	Stgt. Bad Cannstatt Seubert-straße	Stgt. Zentrum Eberhardt straße	Stgt. Zuffen-hausen Franken-straße	Stgt Mitte Strasse (Hbf)	Stgt. Bad Cannstatt Waiblinger Strasse	Stgt. Feuerbach Siemens-straße	Sgt. Mitte Hohen-heimer Straße.	Stgt. Am Neckartor
Number of exceedances of the 1 hour limit value for NO_2 > 200 µg/m³ (limit value since 2005: 175 hours per year; from 2010: 18 hours per year)								
2004	**0**	**0**	**0**	**5**	**5**	**293**	**143**	**555**
2005	**0**	**0**	**0**	**4**	**-**	**250**	**175**	**848**
Yearly limit value for NO_2 (limit value from 2010: 40µg/m³)								
2004	**33**	**43**	**40**	**77**	**66**	**97**	**89**	**106**
2005	**33**	**50**	**43**	**74**	**82**	**97**	**96**	**119**

Number of exeedances of the daily limit value for PM10 > 50µg/m³ (limit: 35 days per year) (limit value since 2005: max. 35 exceedences per year)								
2004	**14**	**7**	**29**	**42**	**65**	**63**	**58**	**160**
2005	**12**	**7**	**26**	**37**	**-**	**51**	**62**	**187**
Yearly limit value for PM_{10} (yearly limit value since 2005: 40µg/m³)								
2004	**23**	**22**	**27**	**34**	**36**	**37**	**36**	**51**
2005	**24**	**24**	**28**	**35**	**-**	**37**	**38**	**55**

Fig. 6: Measurement values of NO_2 and PM_{10} in Stuttgart for the years 2004 and 2005 at different measurement sites (source: LUBW and city of Stuttgart).

B3 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Set up of demonstration cases including selection of measures, areas, definition of criteria of success, definition of demonstration cases (01 Feb. 2005 – 31 Jan. 2006).

Selection of

- Stuttgart wide ban for heavy through traffic – A1
- Environmental zone – A2
- Pedestrian crossings – A3
- Round Table clean air and noise reduction
- Speed reduction from 60 to 50 km/h on arterial roads in Stuttgart

Stage 2: Test of specific measures (Phase 1) and detailed plan for improvements of tests in Phase 2 (1 February 2006 – 31 July 2007)

- Stuttgart wide ban for heavy through traffic: Jan. 2006 to February 2008
- Installation of Round Table on Clean Air and Noise. February 2006
- Installation of 2 pedestrian crossings: May - July 2006
  -> Speed reduction from 60 to 50 km/h on arterial roads in Stuttgart
- Launch of specific public campaigns ("Feinstaubbroschüre" etc.): November 2006
- Public opinion poll programme with Stuttgart citizens: April – June 2007

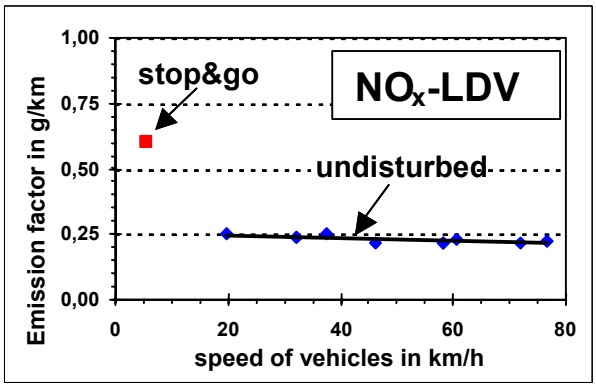
Stage 3: Test of specific measures (Phase 2), (1 August 2007 – 30 June 2008).

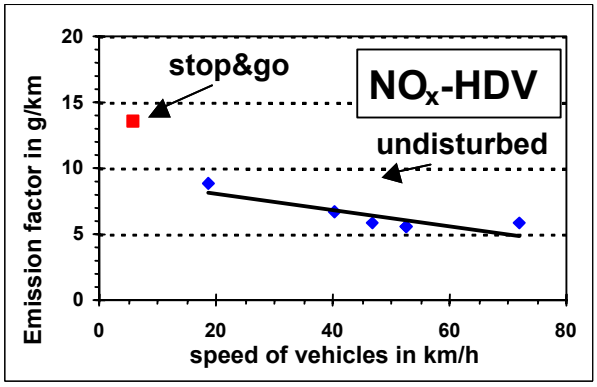
- Implementation of environmental zone: 1st Stage March 2008
  2nd Stage January 2012
- Conduction of various measurements, data collection, modelling etc in parallel to the implemented measures.
- Analysis and assessment of the various measures installed.

Stuttgart wide ban for heavy through traffic – A1:

One important measure of the Clean Air Programme for Stuttgart is the ban for heavy through traffic. It was introduced in Jan 2006 but limited to the introduction of measure A2, the environmental zone, which was introduced in March 2008. Thus the ban for heavy through traffic is suspended since March 2008. All vehicles with a weight of more than 3.5 tons, which wanted to pass the city area of Stuttgart (see Fig. 1), were not allowed to.

Exceptions were two national roads B10/B14 (partly). Traffic investigations proved that at different sites on heavy traffic roads in Stuttgart the reduction of heavy vehicles was different.





emission factor HDV/emission factor LDV	NO_x	PM_{10}	CO_2
undisturbed (blue dots)	27,8	21,4	3,5
stop & go (red dots)	22,5	29,4	2,0

Fig 7: Emission factors for HDV (heavy duty vehicles – all vehicles with more than 3.5 t of weight) and LDV (light duty vehicles – all vehicles, including passenger cars up to 3.5 t of weight) in dependency to the speed of the vehicles (blue dots) and for stop and go traffic (red dots).

Fig. 7 delivers the proof of the importance to reduce the number of HDVs. The emission factors for NO_x and PM_{10} for HDV are 20 to 30 times higher than for LDVs. Thus the reduction of one HDV vehicle has the same effect than the reduction of 20 to 30 LDVs vehicles.

Environmental zone – A2

Stage 1 was introduced in March 2008. Stage 2 will be introduced in Jan 2012. The area of the environmental zone can be seen in Fig. 1, covering the entire city of Stuttgart (with some small exceptions). Due to the Clean Air Programme for Stuttgart diesel vehicles with an emission standard Euro 1 or lower and ignition vehicles without a three-way catalytic converter are banned from the municipal area. Up to 9,000 vehicles out of approx. 300,000 vehicles in Stuttgart are affected by this measure. The vehicle owners either have to upgrade the emission standard of their cars by installing a suitable diesel soot filter or to sell their cars. With Stage 2, EURO 2 diesel vehicles will be affected and banned from the city area.

Fig. 8: Public awareness campaign for the introduction of the environmental zone (source: Stuttgarter Zeitung)

Pedestrian crossings – A3

Fig. 9: Pedestrian crossings on arterial road B14 in Stuttgart (Leonhardskirche, Hauptstätter Straße; LHS).

In July 2006 two pedestrian crossings were installed over the heavy traffic national road B14 which is an eight lane road around this area (Fig 1 and Fig. 9). The background of the measure was, to get a progressive signal system together with other traffic lights in the neighbourhood of the recently installed traffic lights for the pedestrian crossings. In this way the traffic could be regulated much better. Additionally the maximum speed was reduced from 60 to 50 km on the entire course of this national road within the city. The theory behind the efficiency of this measure is that the traffic flows more fluently, when the traffic lights are regulated by a progressive signal system and the maximum speed is lower. The emission factors for stop & go traffic are much higher than for fluent traffic – approx. factor 2 to factor 4 (see Fig. 7). Thus the traffic has to be kept fluent in order to reduce emissions of air pollutants. The speed also influences the emission behaviour. There is a slight increase of the emission factors with lower speed of the vehicles. For HDV the dependency of the emission factors on the speed is more pronounced.

Installation of Round Table on Clean Air and Noise Reduction

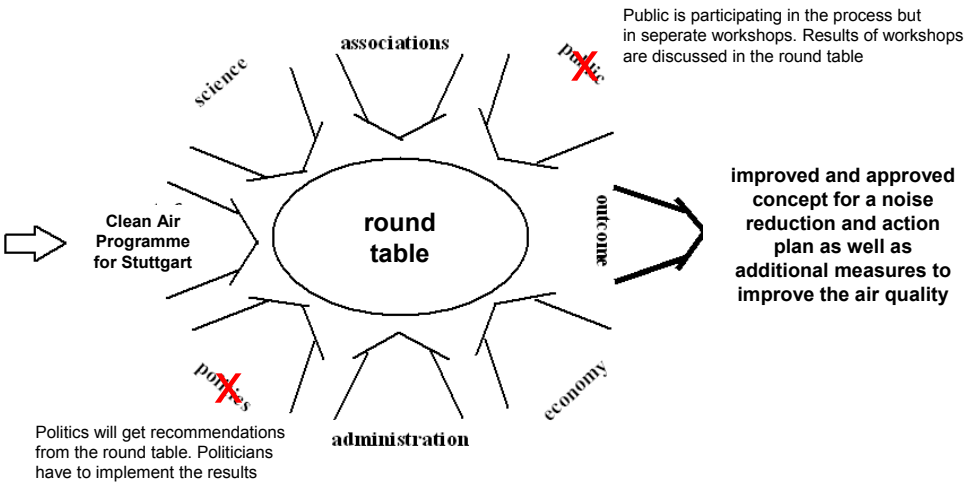


Fig. 10: Concept of the round table introduced in Stuttgart to improve the air quality and to reduce noise.

Design of a new innovative concept for a common *Round Table* for the *Clean Air Programme* and the *Noise Reduction Plan*: End of 2004 the *Round Table* for the *Noise Reduction Plan* was established in Stuttgart. In several sessions first valuable results in noise reduction were

achieved. This Round Table was extended for the implementation of the measures of the *Clean Air Programme* for Stuttgart. In former times noise reduction and air quality were managed separately, but recently experts proposed a common strategy because many measures in both areas go along with each other. Thus Stuttgart is among the first cities to apply this innovative concept within the CIVITAS CARAVEL Project.

Public opinion poll programme with Stuttgart citizens

Fig. 11: Interviewer during a telephone interview.

The citizen poll was carried out form March to May 2007. The study was realized by the Institute for Social Science at Stuttgart University and dealing with the topic of air monitoring. 409 citizens were polled. Fig. 11 gives the impression of an interviewer during a telephone interview.

Launch of specific public campaigns ("Feinstaubbroschüre" etc.)

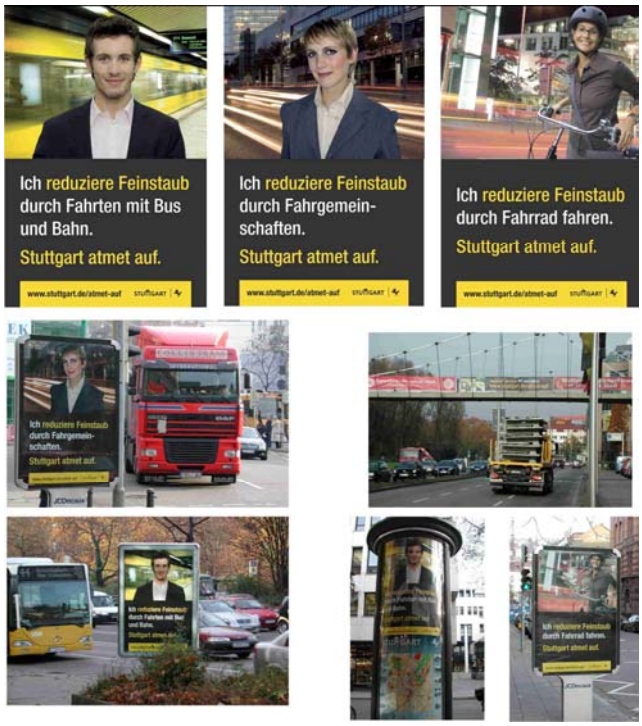


Fig. 12: Public awareness campaign with different posters distributed in the city.

In 2006 a public awareness campaign was carried out to raise awareness of the topic of PM_{10} and the possibilities to reduce it by environmentally-friendly transport modes like cycling, public transport and carpooling. Fig. 12 shows some of the posters and banners, which were placed on highly frequented places in the city for two weeks to make people aware of the air pollution problems in the city and in order to suggest some measures to reduce air pollution.

B4 Deviations from the original plan

The deviations from the original plan comprised:

- **Clean Air Programme** – Due to the delayed introduction of the Clean Air Programme for Stuttgart that was originally planned for January 2005 but finally introduced in January 2006 with a delay of one year.
- **Environmental Zone** – Introduction was originally planned for 1 July 2007, but was finally implemented 1 March 2008 due to legal reasons.

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

- **M9.3 Carpooling System in Stuttgart.** – Recommendation and support are given to create car-pools (esp. for commuters and events).
- **M11.4 Sustainable mobility marketing in Stuttgart.** Marketing of car-pooling and car-sharing, mobility management for companies, courses for drivers on energy-saving driving
- **M12.7 Event-oriented traffic management in Stuttgart**. Linkage and presentation of actual traffic information; influence on traffic control and route guidance.

The linking is actually indirectly, success in the mentioned measures helps to reduce particulate emissions.

C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Evaluation Category	N°	Indicator	Units	Source of data	Methodology for indicator construction (survey, modelling, etc)	Baseline date
Environment	7	Particulate matter level (PM_{10})	µg/m³	Environmental Protection Office	Ban for heavy through traffic and pedestrian crossings: Measurement results of PM_{10}, traffic census and dispersion modelling	12/2005
Environment	6	NO_2 level	µg/m³	Environmental Protection Office	Ban for heavy through traffic and pedestrian crossings: Measurement results of NO_2, traffic census and dispersion modelling	12/2005
Environment	11	Particulate matter (PM_{10}) emissions	kg/h	Environmental Protection Office	Ban for heavy through traffic and pedestrian crossings: traffic census/ emission modelling Environmental zone: emission modelling	12/2005 06/2007
Environment	10	NO_x emissions	kg/h	Environmental Protection Office	Ban for heavy through traffic and pedestrian crossings: traffic census/ emission modelling Environmental zone: emission modelling	12/2005 06/2007
Society	13	Awareness level		Environmental Protection Office	Survey (questionnaire), Round Table "Clean Air", press/local council publications	06/2007
Society	14	Acceptance level	controlled vehicles (trucks)/day	Environmental Protection Office	Survey (questionnaire) Traffic counts, measurements (speed)	04/2007
Transport		Number of trucks	Vehicle/day	City of Stuttgart	Traffic counts	01/2005
Transport		Number of infringements	Number of vehicles (trucks)	City of Stuttgart	Police control	05/2006

Fig. 13: Summary of the impacts and indicators applied to Measure 6.3.

Detailed description of the indicator methodologies:

- **Particulate matter level (PM_{10})** – Measurements (continuous) of PM_{10}, traffic census and dispersion modelling: The emission data from the emission inventory are used to simulate the ambient air concentrations. Comparison of actual data with the data of 2004.
- **NO_2 level –** Measurements (continuous of NO_2), traffic census and dispersion modelling: The emission data from the emission inventory are used to simulate the ambient air concentrations. Comparison of actual data with the data of 2004.
- **Particulate matter emissions** - Emission inventories: data for 2004 are available since 6/2007, modelling; problem: modelled data for 2006 will be surveyed in 2009 only (available after the project only).
  Ban for heavy through traffic : survey / calculations: before / after introduction of ban for heavy through traffic (traffic survey before (2005) and after (in 2007

available) for the whole city, available in 2008. Emission data are important input data for dispersion modelling.
Pedestrian crossings: survey / calculations (before and after introduction (2005/2006 and 6/2007). These emission data are important input data for dispersion modelling.
Environmental zone: survey / calculations: before / after introduction of the measure (traffic survey before (2007) and after (in 2008 available) for the whole city. Emission data are important input data for dispersion modelling.

- **NO_x emissions -** Emission inventories via emission modelling.
- **Awareness level -** Survey: Questionnaire campaign: (telephone interviews of Stuttgart citizens, target: 400 successfully conducted interviews, duration: February – May 2007).
  Comments in newspapers, public discussion, web site.
  Round Table on clean air / noise, statements of interest groups / stakeholders.
- **Acceptance level -** Survey: Questionnaire campaign (see above);
  Measurements (traffic counts) concerning compliance rate of ban for heavy through traffic through Stuttgart (regularly) on several days since 1 Jan 2006).
  Traffic counts and traffic speed measurements before and after introduction (Dec 05) of new pedestrian crossings (during Oct 06 – April 07).
- **Number of trucks -** Traffic counts.
- **Number of infringements -** Vehicle controls by police (compliance rate of ban for heavy through traffic by police controls at several locations/roads in Stuttgart).

C1.2 Establishing a baseline

Measurement values of air pollutants: The local government of Baden-Wuerttemberg - the Ministry of Environment - established a network of around 45 permanent monitoring stations a long time ago (some years ago 70 stations were in use, nowadays the number has been decreased, due to a new measurement strategy). These stations are measuring a huge variety of air pollutants continuously. In 2004 this network was supplemented with a so-called spot measurement programme. Highly contaminated sites, where people are affected, were acquired and for a limited time period (at least one year) continuous and discontinuous measurements of the most relevant air pollutants have been performed. A number of additional 23 monitoring stations belong to this spot measurement network.

In Stuttgart alone 3 permanent monitoring stations and additional 3 stations within the spot measuring programme are installed. The municipality of Stuttgart is also running a monitoring station in the city. The results of these monitoring stations are used to determine the effect of the access restrictions and the other emission reduction measures.

Stuttgart municipality is running numerous automatic traffic counting devices. The evaluation of these traffic data gives direct information about the impact of the access restrictions on the number of cars and the effectiveness of the measures.

Emission inventories are sporadically generated by different organizations (LUBW[1]), the organization running the ambient air monitoring network in Baden-Wuerttemberg or the University of Stuttgart. Comparing a topical emission inventory with an earlier inventory gives information about the temporal variation of the air pollutants' emissions. These results alone or together with the results of atmospheric dispersion models deliver information about the impact of the access restrictions and the emission reducing measures.

[1] LUBW: Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg (formerly UMEG)

Modelling of emissions and ambient air concentrations:

HBEFA 2.1 (Version 2004)

One basic input data for dispersion models like PROKAS or MISKAM (see below) are emission data. These emission data are usually calculated using a data base containing the necessary information about the emissions. In our case the manual for emission factors (HBEFA 2.1), containing all necessary emission factors for different emission sources as well as for different air pollutants was used. The manual for emission factors is computer software. It also contains estimations for the development of the emission factors for the future, e.g. for 2010 and 2015. Therefore prognoses can be calculated as well.

Wind field and Dispersion Model MISKAM (micro-scale)

For the precise modelling of the dispersion of air pollutants the computer software MISKAM was used to determine the effect of the measures fixed in the Clean Air Programme for Stuttgart on the air quality. For the detailed computation of the near-surface wind field the model MISKAM (micro-scale climatic and dispersion model) is used. From its physical background MISKAM is a more sophisticated representative of a number of available computer models. The application of MISKAM is in the range of small-scale dispersion processes with typical model extensions of some 100 m and thus being suitable for examining the effects of the traffic-restricting measures of the Clean Air Programme on the air quality of specific areas in Stuttgart. MISKAM is a three-dimensional non-hydrostatic numeric flow and dispersion model to deliver prognosis of wind distributions and the distribution of air pollutants at roads up to quarters. It was conceived originally for the treatment of micro-climatic problems and makes the simulation of the air flows in the vicinity of buildings possible as far as rectangular block structure characteristics are chosen. Spatial resolutions of up to 1 - 2 meters can be achieved by this model.

Dispersion model PROKAS (meso-scale)

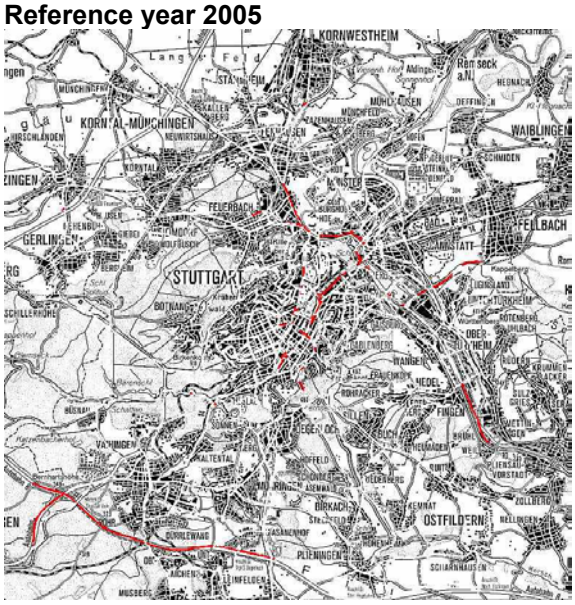
The dispersion model PROKAS is a meso-scale dispersion model. Compared to MISKAM, which is a micro scale model, PROKAS can be used for the modelling of the ambient air concentrations for the entire area of the city of Stuttgart. It is a simulation model for air pollutants originating from street traffic, like NO_2-, benzene, soot and PM_{10}. Air pollutants from long distance transport or from other sources like industry can be considered in the previous impact concentrations. The most important input data are the network of the streets, the number of cars and average speed (for the calculations of the emissions) and the category of the surrounding buildings.

C1.3 Building the business-as-usual scenario

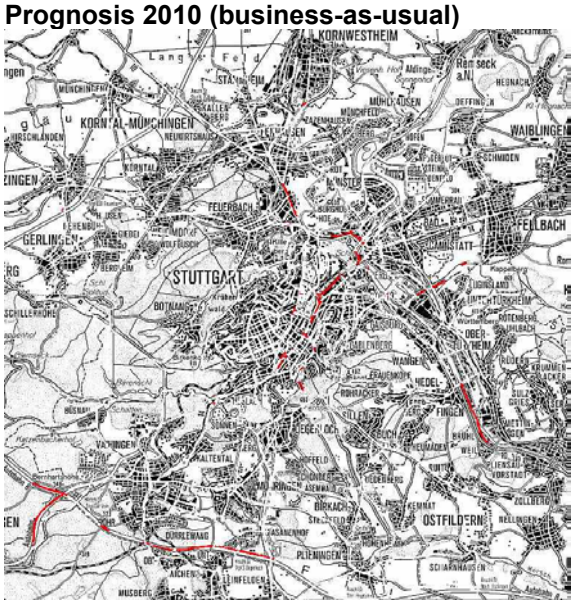
The information of this chapter is based on model simulations with the dispersion model PROKAS for the reference year 2005 and also for two prognosis cases for 2010 and 2015. The emissions were calculated on the basis of the manual for emission factors (HBEFA 2.1). For the reference year all available traffic data and information of the fleet composition were used. For the prognosis cases assumptions for the development of the traffic, the improvement of the emission technology (see Fig. 14) and for the composition of the vehicle fleet were considered. All relevant emission sources like industry, household burning and traffic were considered via the urban and overall background concentrations. Exceedances of the limit values are mostly recognised nearby the main emission source traffic, in the vicinity of heavy traffic roads. The roads with exceedances of the limit values are marked in red in the following figures.

Indicator: Particulate matter level (PM_{10}):

Reference year 2005



Prognosis 2010 (business-as-usual)



Prognosis 2015 (business-as-usual)

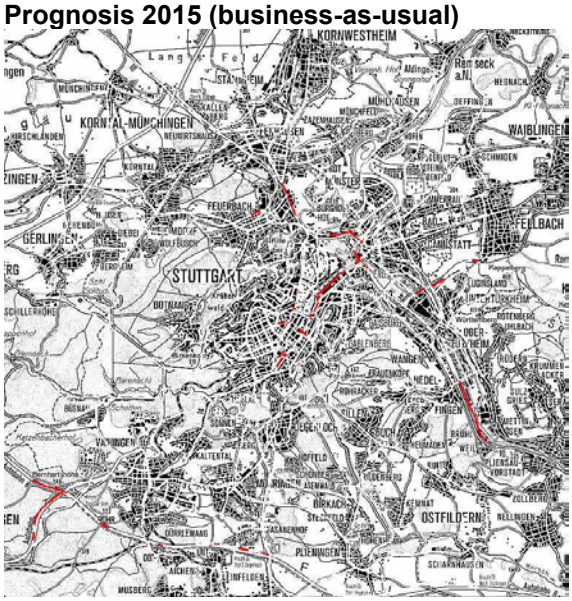
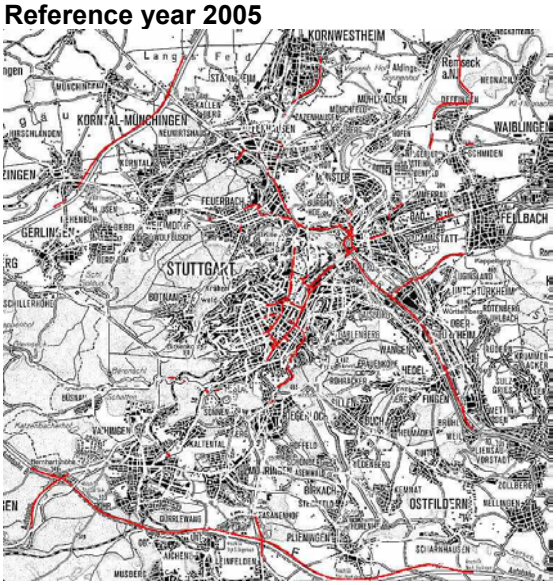


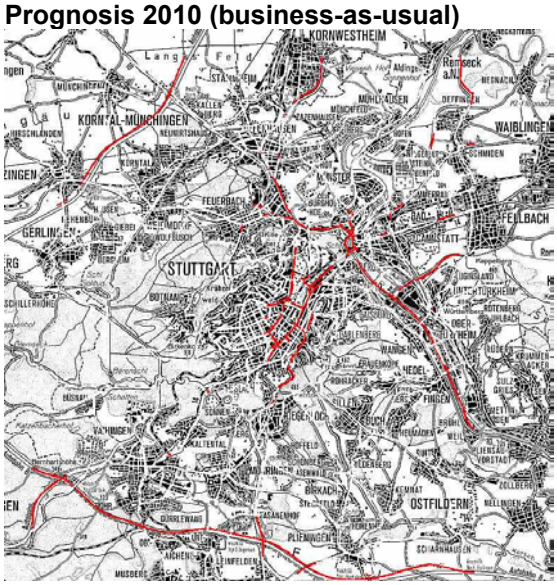
Fig. 14: Roads in Stuttgart exceeding the annual limit value for PM_{10} of 40 µg/m³ for the reference year 2005 and prognosis for 2010 and 2015.

In Fig. 14 roads in Stuttgart exceeding the annual limit for PM_{10} of 40 µg/m³ for the reference year 2005, prognoses for 2010 and 2015 for the business-as-usual scenario are marked in red. There are quite a lot of roads exceeding the EU limit value which is valid since 2005. Without any measure to reduce the emissions the number of roads or parts of roads with exceedances of the yearly limit value for PM_{10} will gradually decrease due to an increase of vehicles with lower emissions. But some hotspots with high concentrations, like the well-known Neckartor, will still suffer from high concentrations with exceedances due to the high number of vehicles passing these roads.

Reference year 2005



Prognosis 2010 (business-as-usual)



Prognosis 2015 (business-as-usual)

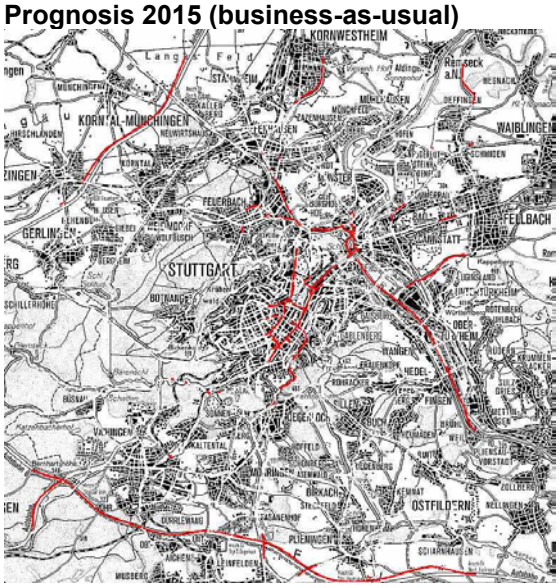
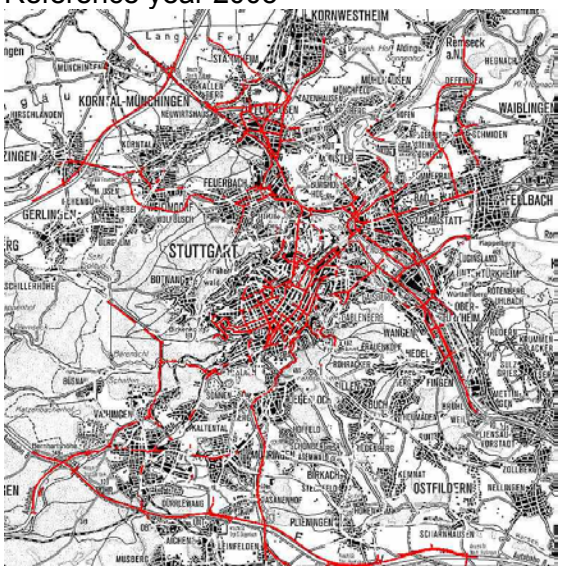


Fig. 15: Roads in Stuttgart exceeding the short time limit value (daily value) for PM_{10} of 50 µg/m³ (35 exceedances per year allowed) for the reference year 2005 and prognosis for 2010 and 2015.

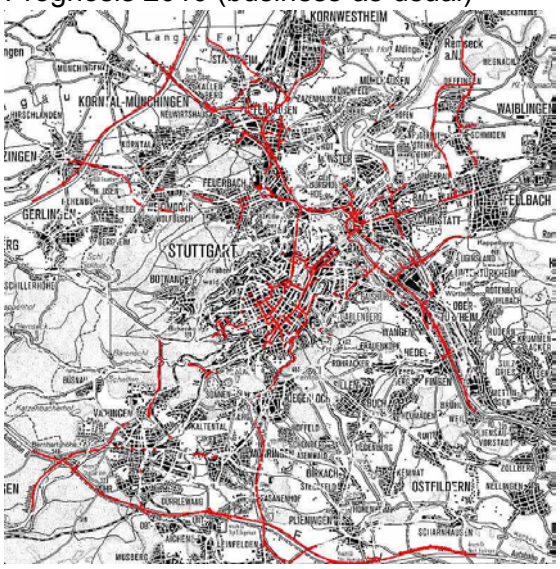
Fig. 15 shows the roads in Stuttgart exceeding the daily limit for PM_{10} of 50 µg/m³ for more than 35 times (35 exceedances per year are allowed) for the reference year 2005; prognoses for 2010 and 2015 for the business-as-usual scenario are marked in red. There are quite a lot of roads exceeding the EU limit value which is valid since 2005. There are more roads with exceedances for the daily limit value than for the yearly limit value in Figure 11. This proves that for PM_{10} the short time limit value (daily limit value) is stronger than the long time limit value (yearly limit value). Without any measure to reduce the emissions the number of roads or parts of roads with exceedances of the yearly limit value for PM_{10} will gradually decrease. But some hotspots with high concentrations, like the well-known Neckartor, will still suffer from high concentrations with exceedances due to the high number of vehicles passing these roads.

Indicator NO_2 level:
Roads in Stuttgart exceeding the annual threshold for NO_2 of 40 µg/m³ for the reference year 2005, prognoses for 2010, 2015:

Reference year 2005



Prognosis 2010 (business-as-usual)



Prognosis 2015 (business-as-usual)

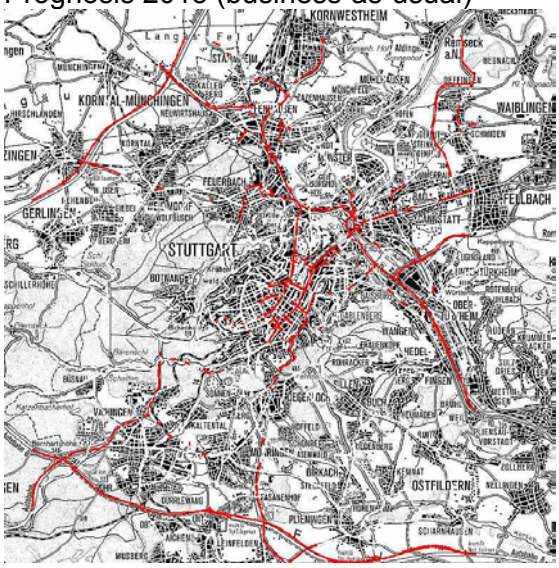


Fig. 16: Roads in Stuttgart exceeding the annual limit value for NO_2 of 40 µg/m³ for the reference year 2005 and prognosis for 2010 and 2015.

In Fig. 16 the reference situation of 2005 is compared to the situation in 2010 (yearly limit value = 40 µg/m³) and 2015, concerning the exceedances of the NO_2 limit values in Stuttgart, based on the assumption that no additional emission reduction measures will be achieved. The number of roads with exceedances is much higher for NO_2 than for PM_{10}. The prognosis shows that the situation will become worse first (2010) before it will become better again in 2015, due to the improvement of the vehicles' emission behaviour (see Fig. 17). The fact of increasing direct NO_2 emissions, which has been observed during the last few years, are not yet taken into account in the simulation results.

If the measures proposed in the Clean Air Program and action plan for the reduction of the ambient air pollutants are not efficient enough or even not implemented, the NO_2 limit values will not be achieved and a similar or even worse situation like today will occur for PM_{10}.

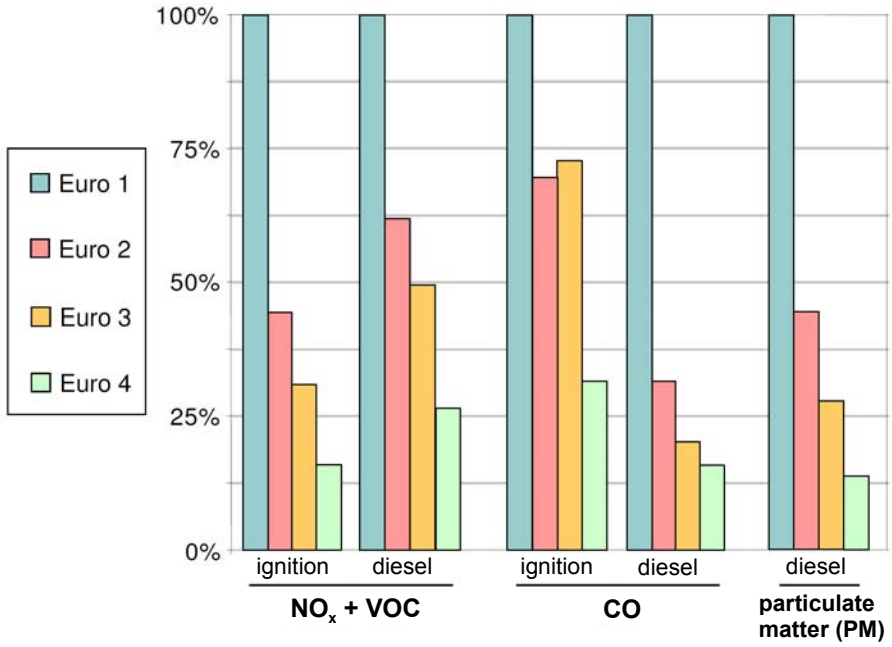


Fig. 17: Development of EURO norm exhaust emissions for NO_x+VOC (volatile organic compounds), CO and particulate matter (PM) for ignition and diesel passenger vehicles compared to the emissions of EURO 1 (100%).

Figure 17 shows the development of the emissions according to the different EURO norms for various air pollutants like NO_x+VOC (volatile organic compounds), CO and particulate matter (PM) for ignition and diesel passenger cars. The emissions of the EURO norms 2, 3, and 4 are related to the emissions of EURO norm 1 (100 %). It is evident that the emission factors are constantly decreasing with increasing EURO norm, resp. with the improvement of the emission behaviour of the vehicles. The emissions of EURO norm 4 compared to EURO norm 1 are 70 to 85% lower. This is the reason why the number of exceedances in Figures 14 to 16 decreases for the prognosis of 2010 or at least 2015, despite the fact that the assumed number of driven kilometres in the scenarios was increasing.

C2 Measure Results

C2.3 Environment

A1 - Ban for heavy through traffic

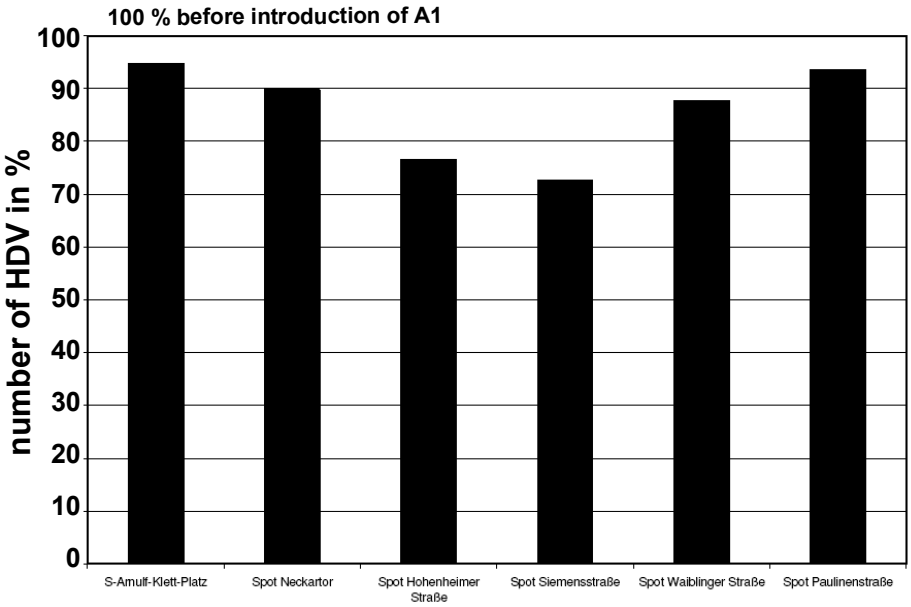


Fig. 18: Reduction of HDV (heavy duty vehicles > 3.5 tons) after introduction of A1 – the ban for heavy through traffic (source: Clean Air Programme for Stuttgart).

Fig. 18 delivers the results of investigations of the ban for heavy through traffic. The reduction varied between 5 to almost 30 % of the number of vehicles at different sites (air quality hotspots) in the city. On average there was a reduction of heavy traffic vehicles of approx. 10 % for the entire city area.

	LDV kilometers	HDV kilometers
Before introduction of A1	199 803	9 570
after introduction of A1	195 922	8 471
Difference: after minus before	**- 2 %**	**- 13 %**

Fig. 19: Results of traffic counts and model simulations according to driven kilometres for LDV (light goods vehicles - < 3.5 tons) and HDV (heavy duty vehicles - > 3.5 tons) before and after introduction of A1 on a 'test road'.

Before and after the introduction of Action A1 traffic counts and model simulations of the traffic on a 'test road' in Stuttgart were done. The test road was a 2 kilometre distance on the heavy traffic road B14 (see Fig. 1 – same 'test road' like A3). The results of the investigation are summarized in Fig. 19. It can clearly be seen that the number of driven kilometres per day for HDV on the 'test road' decreased from 9,570 to 8,471 kilometres. This is a reduction of 13 % despite the number of driven kilometres for LDV kept almost constant (less than 2 % reduction) at the same time. The calculated emission reduction caused by this measure was approx. 8 % for PM_{10} and NO_x. This is a further proof that the ban for heavy through traffic was an effective measure to keep traffic out of the city and to reduce air pollution.

The effect of A1 on the PM_{10} and NO_x emissions as well as on the PM_{10} and NO_2 ambient air concentrations for six different sites in Stuttgart can be seen in Fig. 20. The black bars indicate the baseline for 2005 (100 %) without the introduction of any action. The grey bars indicate the situation after the introduction of A1. At the six different sites the effect of the action and thus the reduction of the emissions and the ambient air concentrations is different. Due to the results of these model simulations PM_{10} emissions were reduced by about 2 to 3 %. NO_x emissions were reduced more effectively by about 8 %. The effect on the PM_{10} concentrations in the ambient air is approx. 4 to 5 % due to the fact that PM_{10} consists of direct PM_{10} emissions as well as of abrasion and re-suspension particles. The effect of A1 on the NO_2 concentration in the ambient air at the different sites was approx. 7 %.

A2 – Environmental zone

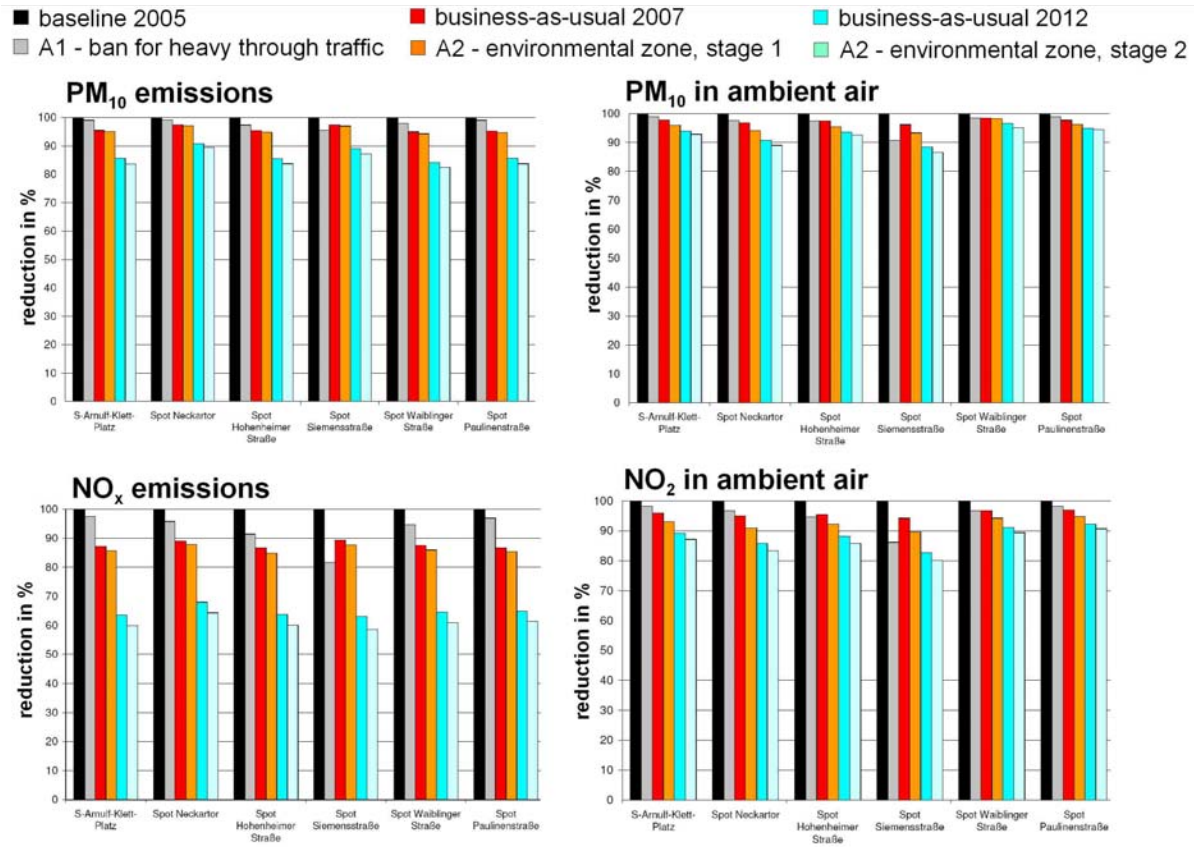


Fig. 20: Effect of three different measures (A1, A2 stage 1 and A2 stage2) on the emissions of PM_{10} and NO_x as well as on the ambient air concentrations of PM_{10} and NO_2 at six different sites in Stuttgart as a result of model simulations (source: Clean Air Programme for Stuttgart).

The effect of the environmental zone (Stage 1 – introduced in March 2008) on the PM_{10} and NO_x emissions as well as on the PM_{10} and NO_2 concentrations in ambient air can be seen in Fig. 20, by comparing the red bars (baseline 2007) with the orange bars (after introduction of A2 – Stage 1). The effect of the environmental zone (A2) on the emissions as well as on the ambient air concentrations is less then for A1 and amounts approx. 2 to 3 %. The effect of A2 – Stage 2 (comparison of the blue bars) ranges in the same order of magnitude. To reduce the air pollution more effectively even more measures with higher reduction potential will have to be implemented in future (see Chapter C4).

A3 - Pedestrian crossings with speed reduction

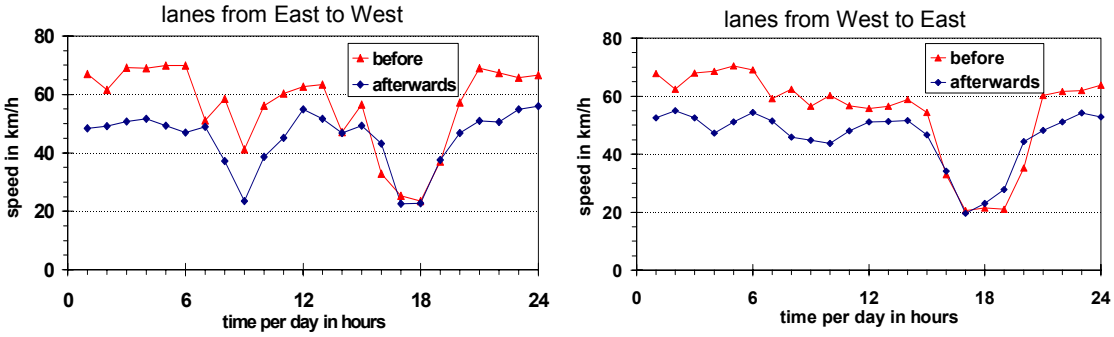


Fig. 21: Average speed of vehicle fleet on the 'test road' B14 before and after the introduction of A3 separated into lanes from East to West and lanes from West to East.

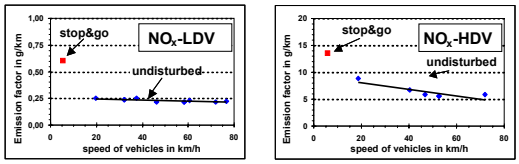
Fig. 21 gives the average speed of the vehicle fleet on the test road B14. On the left diagram the average speed on the four lanes from East to West are shown and on the right diagram the average speed on the four lanes from West to East are shown. Red lines indicate the values before the introduction of A3, the blue lines the situation after the introduction of A3. These mean daily time series show clearly that there is traffic jam with low average speed of approx. 20 km/h twice per day on the lanes from East to West - once in the morning hours from 7 a.m. to 9 a.m. and in the afternoon / evening hours from 4 p.m. to 7 p.m. In the opposite direction, on the lanes from West to East there is no traffic jam in the morning only in the afternoon / evening between 4 p.m. to 8 p.m. During the time of the traffic jam the average speed of the vehicle fleet does not differ a lot before and after the introduction of the measure. But for the rest of the day with a fluent traffic flow it can clearly be seen that the average speed of the fleet is 10 to 15 km/h lower after the introduction of the measure A3.

- **Number of vehicles:** **more vehicles** -> **more emissions**

	LDV kilometers	HDV kilometers
Before introduction of A1	199 803	9 570
after introduction of A1	195 922	8 471
Difference: after minus before	**- 2 %**	**- 13 %**

- 8 %

- **speed of vehicles:** **lower speed** -> **more emissions**
  (in the range of the investigation)



+ 2 %

- **ratio of traffic jam:** **more traffic jam** -> **more emissions**

± 0 %

total: - 6 %

Fig. 22: Factors influencing traffic emissions: number of vehicles, speed of the vehicles and ratio of traffic jam.

Fig. 22 shows the factors influencing traffic emissions and the achieved emission reduction of measure A3. The emissions are influenced by the number of vehicles. The more vehicles on the road the more emissions are set free. As a result of the traffic counting and the emission modelling a reduction of PM_{10} and NO_x emissions of 8 % was determined due to less HDVs after the introduction of A3 (it is more an effect of A1 than of A3!). The vehicle speed is also influencing the emissions. In the range between 20 and 70 km/h the emissions increase with lower speed. They increase only very

slightly for passenger cars, but more for HDVs. A slight increase by 2 % of the emissions due to lower vehicle speed could be determined after the introduction of Measure A3. Traffic jams have a great influence on emissions. In congested traffic flow the emissions are much higher (factor 2 to 4!) than for fluent traffic flow with constant vehicle fleet. Therefore traffic congestion has to be avoided. The results of the investigations show that there was no influence of Measure A3 with regard to the amount of traffic jams and therefore there was no influence on the emissions due to speed reduction. In total the emissions were approx. 6 % lower for the period after the introduction of Measure A3 than before, but this was due to the reduction of traffic volume of HDVs and not because of the effect of Measure A3. Without the simultaneous reduction of HDVs during the test period, the total effect of the measure on the air pollution situation would have been even negative -> increase of emissions by approx. 2 %!

	Stgt. Bad Cannstatt Seubert-straße	Stgt. Zentrum Eberhardt straße	Stgt. Zuffen-hausen Franken-straße	Stgt Mitte Strasse (Hbf)	Stgt. Bad Cannstatt Waiblinger Strasse	Stgt. Feuerbach Siemens-straße	Sgt. Mitte Hohen-heimer Straße	Stgt. Am Neckartor
Number of exceedances of the 1 hour limit value for NO_2 > 200 µg/m³ (limit value since 2005: 175 hours per year; from 2010: 18 hours per year)								
2006	**0**	**0**	**3**	**43**		**160**	**548**	**853**
2007	**0**	**0**	**0**	**8**		**120**	**283**	**481**
Number of exeedances of the daily limit value for PM10 > 50µg/m³ (limit: 35 days per year) (limit value since 2005: max. 35 exceedences per year)								
2006	**29**	**21**	**34**	**47**	**76**	**81**	**84**	**175**
2007	**11**	**6**	**15**	**32**	**40**	**60**	**52**	**110**

Fig. 23 Exceedances of PM_{10} and NO_2 limit values in Stuttgart in 2006 and 2007 (source: LUBW and city of Stuttgart).

Comparing the results of the measurements at different heavy traffic sites in Stuttgart in the years 2006 / 2007 (Fig. 23) after the introduction of the Clean Air Program with the baseline data of 2004 and 2005 (Fig. 6) before the introduction of the measures, the following can be concluded: The values of 2006 are comparable to the values of 2004 and 2005. In 2007 the values were much lower, e.g. number of PM_{10} exceedances of daily values was 110 at Stuttgart-Neckartor compared to 160, 187, and 175 in 2004, 2005, and 2006. But this was not the effect of the emission reduction measures, it was the effect of good meteorological conditions in 2007 compared to the previous years. This effect was observed at most monitoring stations in Germany. The possible emission reductions of the measures of the Clean Air Programme are only small (see Fig. 20). Therefore the effects can only be proved with emission and dispersion modelling but by comparing measurement results of different years.

C2.4 Transport

Indicator: Number of trucks

Light and medium weight goods vehicles - (< 12 t)	2003	2005	2006	Difference 2005 - 2006	
				Number	%
Direction of city centre	325	327	304	-23	-7.0
Direction Degerloch	295	346	261	-85	-24.6
Cross-section	620	673	565	-108	-16.0

Heavy goods vehicles (>= 12 t)	2003	2005	2006	Difference 2005 - 2006	
				Number	%
Direction of city centre	167	271	123	-148	54.6
Direction Degerloch	107	288	166	-122	42.4
Cross-section	274	559	289	-270	-48.3

Fig. 24: Traffic volume at the heavy vehicle census point B27 Weinsteige

Indicator: Number of infringements

Regular traffic controls took place to supervise the ban for heavy through traffic. In average 15 % of the HDVs were caught within the city area and which had no permission to pass through the city. This number is higher than the average percentage of vehicles which are not allowed to pass through Stuttgart, but within these controls only vehicles with registration plates from cities outside Stuttgart were controlled. Therefore the basis of these two figures is different and thus the figures cannot be compared directly.

C2.5 Society – Results of the public opinion poll

Indicator: Awareness level

409 citizens of Stuttgart were interviewed within the public opinion poll. 95 % of the people knew about the problem of air pollution concerning small particulate matter in their city. 65 % of the interview partners knew that as a consequence of the air pollution a Clean Air Programme for their city was established (Clean Air Programme was published in Jan 2006, interviews were performed from March to May 2007).

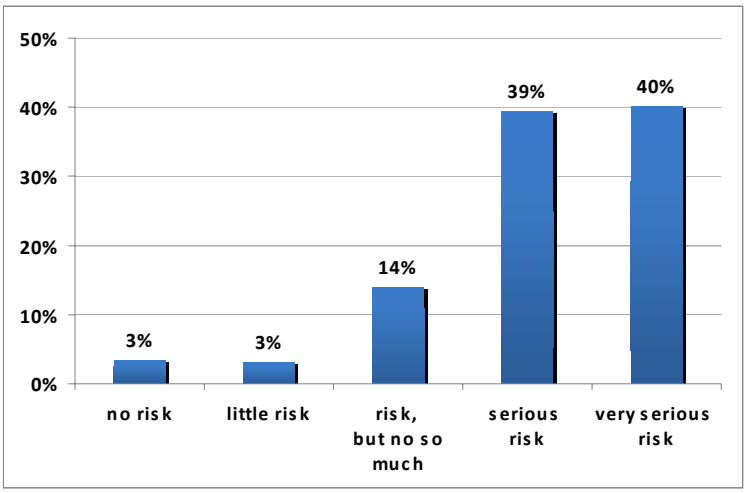


Fig. 25: Question: "Do you think that air pollution from fine particulate matter is a risk for your health"?

96 % of the interviewed citizens of Stuttgart are aware that air pollution from fine particulate matter is a risk for their health. Only 6 % think that there is no or only a little risk for their health (see Fig. 25).

Indicator: Acceptance level
Among others the citizens were asked how to improve the air pollution situation. High acceptance met the heavy through traffic ban with 79% approval. Also the upgrading of the bicycle network (66% approval) and the traffic ban in the new environmental zone (65% approval) were welcomed by the polled citizens.

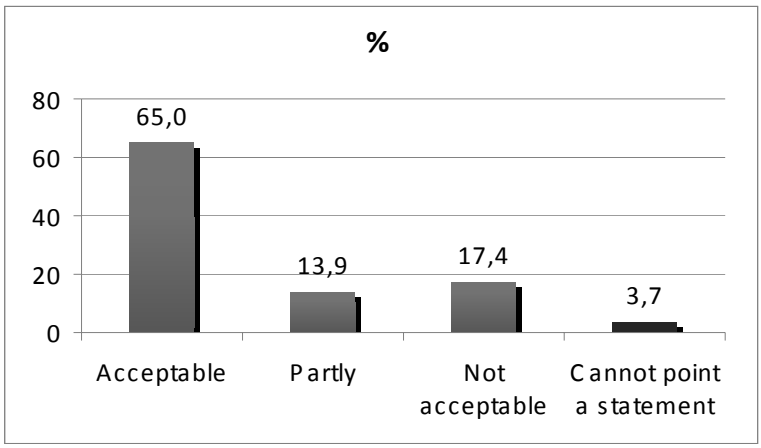


Fig. 26: Acceptance of the measure: General access restriction for vehicles of Emission Class 1 -> Action A2 – environmental zone Stage 1

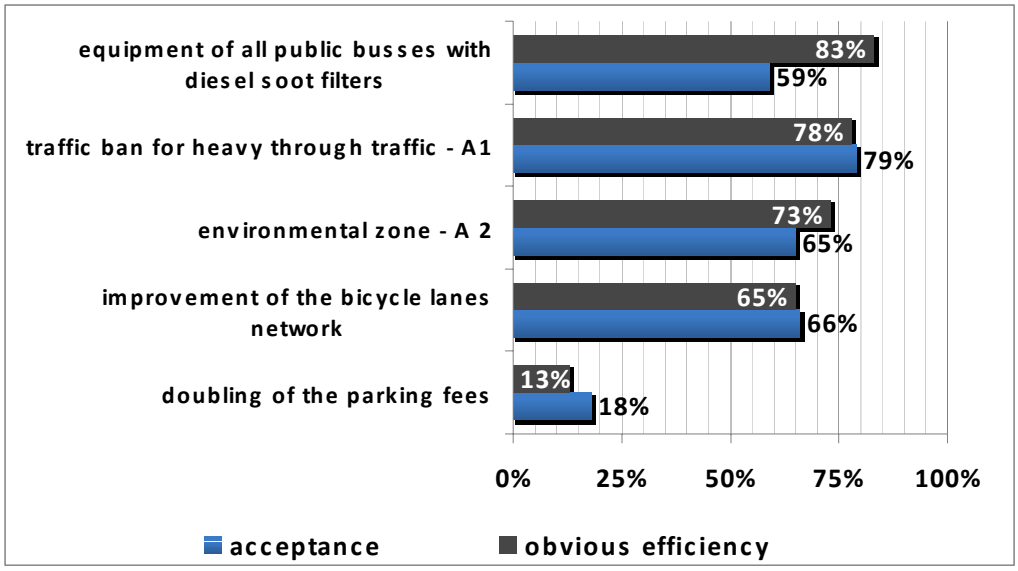


Fig. 27: Level of acceptance and context with obvious efficiency of different measures of the Clean Air Programme.

In Fig. 27 the results of the acceptance and the obvious efficiency of the proposed measures were summarized. Firstly there is a strong correlation between the level of acceptance and obvious efficiency. When people assume that a measure is efficient then they are ready to accept it (or vice versa?). Despite the measure "doubling of parking fees" with a level of acceptance and obvious efficiency of less than 20 %, all other measures, which were all measures of the Clean Air Programme, obtained a level of acceptance and obvious efficiency of more than 60 % up to 80 %.

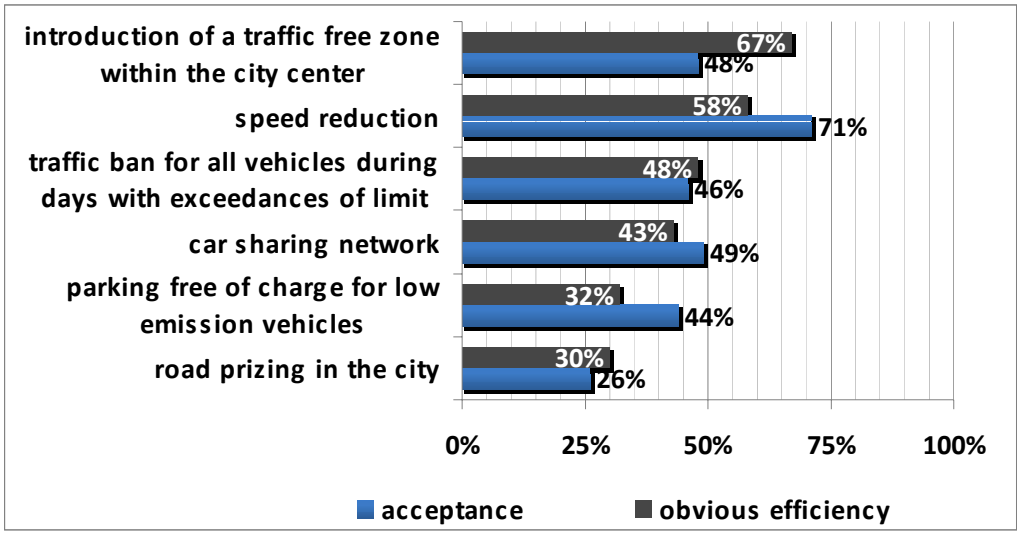


Fig. 28: Level of acceptance and context with obvious efficiency of different proposed measures beyond the measures of the Clean Air Programme.

Beyond the measures of the Clean Air Programme (Fig. 27) additional measures were proposed. Despite the measure road prizing with values of about 30 %, the measures obtained a good level of acceptance and obvious efficiency. Even very "hard" measures, like the introduction of a traffic-free zone within the city centre or a traffic ban for all vehicles during days with exceedances (every 2nd day in Stuttgart!) obtained high values of acceptance (Fig. 28).

C3 Achievement of quantifiable targets

No.	Target	Rating
1	Fulfil the requirements on pollution in line with the European Clean Air Directive.	*
2	Analysis of the data of air pollution due to transport in different places.	**
3	Proposal of strategies of access restrictions and for other traffic restrictions in areas where the concentration of emissions exceed the allowed levels (esp. particles, etc.).	**
4	Design of strategies of restrictions and management of transport according to the activities developed.	**
5	Reduction of the pollution levels due to transport with the aim to permanently fall below the limit values in the restricted areas proposed.	*
NA = Not Assessed	*** = Not achieved**	****= Achieved in full** *****= Exceeded**

C4 Up-scaling of results

- Efficiency of more effective measures:

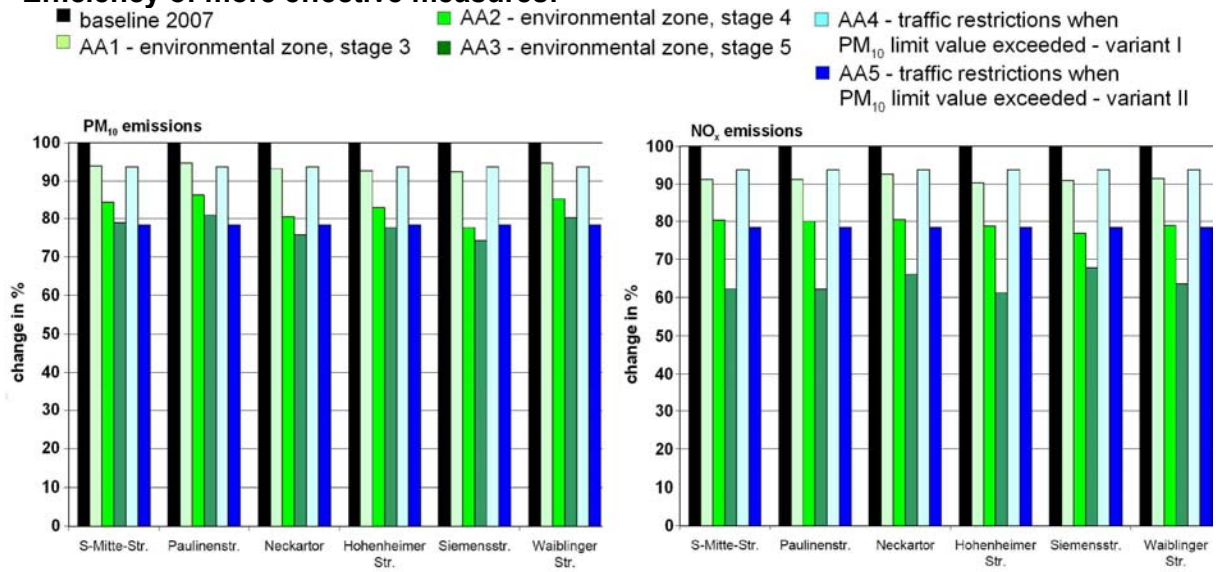


Fig. 29: Results of an investigation of more effective measures to reduce air pollution and to reach the limit values of the EU Directives.

In order to fall permanently below the limit values for PM_{10} and NO_2 more effective measures have to be considered. Fig. 29 shows the results of such a study. Three of the investigated measures (AA1 to AA3) included stricter emission standards for vehicles moving within the environmental zone. Only very strict measures like measure AA3 (only vehicles with EURO norm 4 or higher within the environmental zone, starting in 2007) can reduce the PM_{10} and NO_x emissions between 20 and 40 %. Measure AA4 (traffic ban for all vehicles within the city centre during days with exceedances of the limit values) can reduce the emissions of 10 to 20 %.

C5 Appraisal of evaluation approach

Some difficulties resulted during the evaluation process with regard to data sources and data availability of traffic data. Historical traffic data have not always been accessible (e.g. for certain time periods) as required due to data storing capacities in Stuttgart. There has been a lack of traffic measuring sites in the whole city area to have sufficient and reliable data sources (this is already being improved through increased measuring site network etc.).

During the evaluation process it became evident that the data available from the Clean Air Programme Stuttgart that relate to certain locations (spots) or measuring sites only is not suitable for an overall evaluation of the measure and that an area-wide modelling of the ambient air concentrations is necessary for this purpose.

C6 Summary of evaluation results

The key results are as follows:

- **Key result - Reduction of pollution levels** due to transport with the aim to permanently fall below the limit values in the restricted areas proposed.

  As a result of Measure A1 Ban for heavy duty vehicles passing through Stuttgart (Measure A1), the reduction varied between 5 to almost 30 % of vehicles at different sites (air quality hotspots) in the whole city. On average there was a

reduction of heavy duty vehicles amounting to approx. 10 % for the entire city area.

The emissions are influenced by the number of vehicles. The more vehicles on the road the more emissions are set free. As a result of the traffic counting and the emission modelling a reduction of PM_{10} and NO_x emissions by 8 % was determined due to less HDVs after the introduction of the Measure A1 Ban for heavy duty vehicles passing through Stuttgart. This measure was one of the most effective measures in terms of emission reduction. However with the introduction of the Environmental Zone the HDV ban was suspended (but has been under discussion for being reintroduced since then).

- **Key result – Environmental Zone (Measure A2).** The effect of the environmental zone (Stage 1 introduced in March 2008) on the PM_{10} and NO_x emissions as well as on the PM_{10} and NO_2 concentrations in ambient air can be seen in Fig. 20. The effect of the environmental zone (A2) on the emissions as well as on the ambient air concentrations is less then for A1 and amounts approx. 2 to 3 %. The effect of A2 – Stage 2 ranges in the same order of magnitude. To reduce the air pollution more effectively even more measures with higher reduction potential will have to be implemented in future (see Chapter C4).

- **Key result – Introduction of pedestrian crossings (Measure A3).** The vehicle speed is also influencing the emissions. In the range between 20 and 70 km/h the emissions increase with lower speed. They increase only very slightly for passenger cars, but more for HDVs. A slight increase by 2 % of the emissions due to lower vehicle speed could be determined after the introduction of Measure A3.

  Traffic jams have a great influence on emissions. In congested traffic flow the emissions are much higher (factor 2 to 4!) than for fluent traffic flow with constant vehicle fleet. Therefore traffic congestion has to be avoided. The results of the investigations show that there was no influence of Measure A3 with regard to the amount of traffic jams and therefore there was no influence on the emissions due to speed reduction. In total the emissions were approx. 6 % lower for the period after the introduction of Measure A3 than before, but this was due to the reduction of traffic volume of HDVs and not because of the effect of Measure A3. Without the simultaneous reduction of HDVs during the test period, the total effect of the measure on the air pollution situation would have been even negative, as emissions would have increased by approx. 2 %! There is, however, a positive effect in terms of traffic safety and more comfort for pedestrians (who no longer must use underground passage).

- **Key result - Awareness level among citizens**: 409 citizens of Stuttgart were interviewed within the public opinion poll. 95 % of the people knew about the problem of air pollution concerning small particulate matter in their city. 65 % of the interview partners knew that as a consequence of the air pollution a Clean Air Programme for their city was established (Clean Air Programme was published in January 2006, interviews were performed from March to May 2007). The acceptance survey was very successful and serves as a model for a similar study in connection with an action plan on noise reduction. Beyond the measures of the Clean Air Programme additional measures were surveyed. Despite the measure “road prizing” with values of about 30 %, the measures obtained a good level of acceptance and obvious efficiency. Even very "hard" measures, like the introduction of a traffic-free zone within the city centre or a traffic ban for all vehicles during days with exceedances (every 2nd day in Stuttgart!) obtained high acceptance values (see Fig. 28).

D Lessons learned

D1 Barriers and drivers

D1.1 Barriers

- Political barrier – The state of Baden-Wuerttemberg as the responsible authority (Land) for the Clean Air Programme set up adequate measures to fulfil European Directives on clean air. Regular meetings between the responsible authority (Land and Regierungspräsidium) and the local council (city of Stuttgart LHS) have been held to find agreements for the favoured measures and their implementation. To overcome problems a Round Table of experts was installed and several meetings with stakeholders were done to comment the critical factors, to define/modify measures and to contribute to acceptance and awareness of the measures.
- Financial barrier - Necessary means for investments. Not foreseeable delays due to high bureaucratic effort in the implementation of the measures. To prevent financial problems a resolution of the local council was necessary for the provision of financial means.
- Institutional barrier – Local Council does not agree to single the measures. In view of the potential importance of the measures an implementation without agreement of local council is very unlikely. Situation has partially been avoided with the issue of the final clean air programme.
- Technical barrier - Lack of official traffic sign to designate restricted areas. Special signs for the ban for heavy through traffic were needed (barrier was avoided).
- Legal barrier - New vehicle emission classification. Avoided: After European-wide classification of emission classes, introduction of national standards were possible, environmental zone could be finally implemented in March 2008.
- Acceptance barrier - Financially related imposements to realize access restrictions in the city centre, e.g. introduction of toll fees, raising parking fees (see also results of the citizen survey). Awareness raising measures/public campaigns were taken, opinion poll among citizens on various measures was conducted with the result of low acceptance of possible financial measures like toll fees, higher parking fees.

D1.2 Drivers

- European standards, e.g. Clean Air Directive – Set up of new European standards defining thresholds for PM10 highly supported the implementation of adequate measures in Stuttgart.

  The environmental zone was finally implemented on 1 March 2008. The initial date was planned for 1. July 2007, but had to be postponed due to open questions in the original version of the 35. BImSchV regulation. The entire area of Stuttgart is covered. Only two roads on the border of the city are excluded. Due to the Clean Air Programme for Stuttgart diesel vehicles with an emission standard Euro 1 or lower and ignition vehicles without a three way catalytic converter are banned from the municipal area. Up to 9,000 vehicles out of approx. 300,000 vehicles in Stuttgart are affected by this measure. The vehicle owners either have to upgrade the emission standard of their car by installing a suitable diesel soot filter or to sell it. The second phase of this measure will be introduced in 2012, where EURO 2 diesel vehicles will be affected and banned

from the municipal area. The environmental zone has been a permanent topic in the local media, especially in the newspapers.

Finally the new European standards on noise emissions ahead will, among others, very likely help to reintroduce the clean air measure "ban for heavy through traffic". With the introduction of the environmental zone a rather effective measure against urban air pollution, the ban for heavy through traffic, was suspended.

- Environmental/traffic situation, i.e. high pollution levels (PM_{10} and NO_2); high public awareness level. High traffic volumes on roads in/through the city centre (target area); set of standards for PM_{10} and NO_2 (and others) by the European Commission to be fulfilled have facilitated the introduction of several measures. Public campaigns (public opinion polls, round tables ...) helped to raise acceptance of the introduced measures among citizens, stakeholders and politicians, (ban for heavy through traffic, environmental zone, pedestrian crossings and speed reduction on all main city roads from 60 to 50 km/h).
- High public awareness of the topic: National/regional administrations and politicians were under higher pressure by e.g. single citizens taking proceedings against their city for not fulfilling valid EU thresholds (PM_{10}). The issue of particulate matters was a frequent topic in local and regional press supporting the public and the political debate.

D2 Participation of stakeholders

- Administration: Officers of the Stuttgart Region, officer of state government (Baden-Wuerttemberg) responsible for Clean Air Programme, officers of different departments of the municipality: Office for Environmental Protection,, Office for Public Affairs, Department for Traffic Planning, Department for City Planning, Department for Road Construction.
- Public transport sector – governmental: Verkehrs- und Tarif-Verbund Stuttgart (VVS), Stuttgarter Straßenbahnen AG (SSB).
- Industrial NGOs: Industrie- und Handelskammer, Handwerkskammer Region Stuttgart, City-Initiative Stuttgart e.V.
- NGOs with traffic background: Allgemeiner Deutscher Automobil Club (ADAC), Verkehrsclub Deutschland, Allgemeiner Deutscher Fahrrad-Club (ADFC).
- NGOs with environmental background: Bund für Umwelt und Naturschutz Deutschland e.V. (BUND), Naturschutzbund Deutschland (NABU), Landesnaturschutzverband, NaturFreunde Stuttgart.
- Scientists: Stuttgart Universitiy (Institut für Straßen- und Verkehrswesen).

D3 Recommendations

- **Recommendation 1** - Ban for heavy through traffic: Relatively easy to implement from the technical point of view (sign posts), but one of the most efficient measures of the Clean Air Plan in Stuttgart (- 18% HDVs, see results). Stuttgart had defined the term "delivery traffic" in a wider sense, why, for example, exceptions were not necessary (ban for vehicles >3.5t, but private delivery traffic, campers were not affected); therefore also the administrative efforts for implementing and operating the measure were not so high (no additional staff. Police controls also showed that the compliance rate was relatively high with 15% of infringements. Altogether the measure was very positively accepted among the population.

- **Recommendation 2** – Environmental zone: When introducing environmental zones, clear and standard legal regulations are necessary; and they are required on national (or even European) level to achieve a common standard that is valid, at least, for the whole national state. France and Poland, for example, do not have so-called emission classes to define all vehicles on a common basis.

In Germany, the regulations vary between the national states in terms of implementation stages. Moreover, the regulations should include not all PM_{10}, but also other emissions (not only Diesel vehicles, but all vehicles). High administrative efforts are needed for implementation so-called "environmental zones" as in Stuttgart (e.g. for treating exceptions: around 6,000 applied for exceptions, 3,000 received an exception, additional staff was requested to prepare all the labels and exceptional rules).

- **Recommendation 3** –Public transport

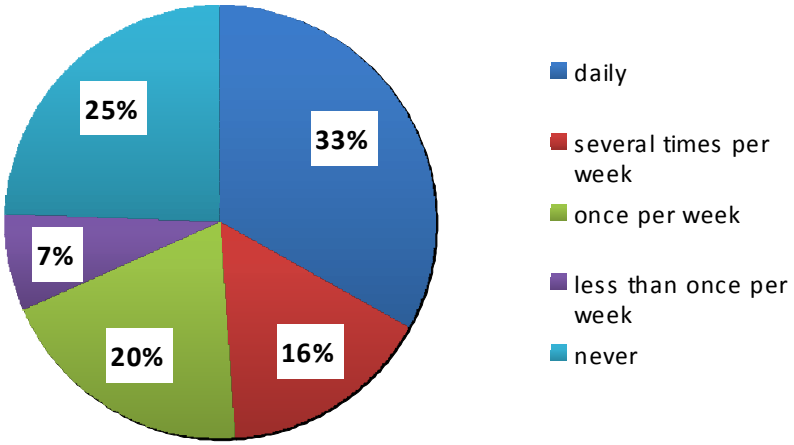


Fig 30: Results of public opinion poll. Answers to the question how often the interview partner uses public transport.

Fig. 30 shows results of the public opinion poll. The question of the interviewers was how often the interview partners use public transport to move within the city of Stuttgart. The statistic provides the information that there is a potential of 52 % (25 % never, 7 % less than once per week and 20% once per week) who have to be motivated to use public transport more often and to reduce individual transport to improve the air quality in the city.

D4 Future activities relating to the measure

Extension of the environmental zone is planned as follows:
Starting from the year 2012 stage 2 of the environmental zone will be introduced. Vehicles with EURO 2 norm and below will no longer be allowed to enter the city area of Stuttgart. The efficiency of this measure can be seen in Fig. 20.

Speed reduction of vehicles on highways around Stuttgart or national roads within the city area

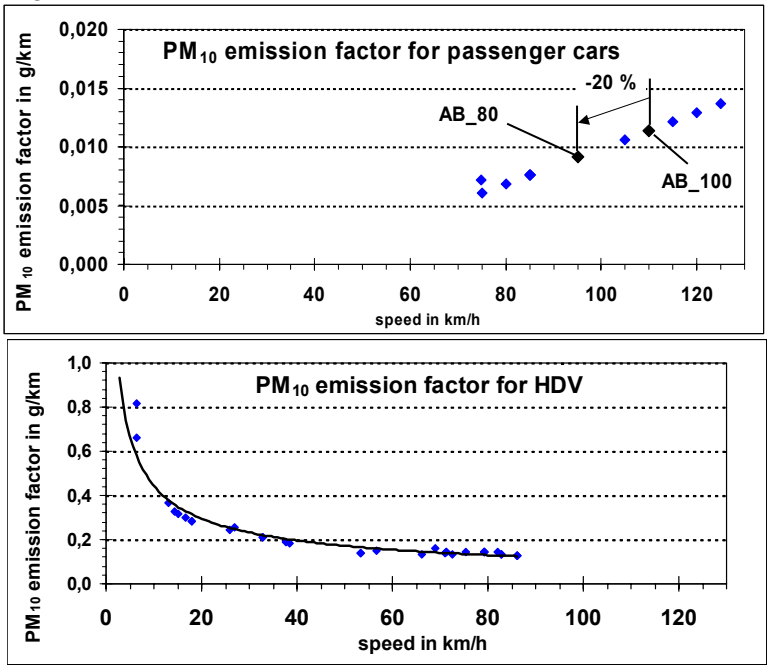


Fig. 31: Emission factors for PM_{10} separated for passenger cars (upper diagram) and HDV (lower diagram) dependant on the speed of the vehicles.

At present the possibility of speed reductions for vehicles on highways around Stuttgart or national roads within the city area are under discussion. Fig. 31 gives an overview of the effect of these measures. For passenger cars (upper diagram) a reduction of the allowed speed from 100 km/h to 80 km/h will reduce PM_{10} emissions by 20 %. Speed reductions for HDV (lower diagram) have not much influence on the PM_{10} emissions.

Traffic control according to exceedances of limit values:
Presently discussions are taking place to find ways to use the traffic control system (IVLZ) in case of exceedances of the limit values. Possible measures are speed reduction (in order to make the traffic more fluent), access restrictions for highly polluted areas, access restrictions for certain vehicle categories or certain time periods per day etc.