Think globally, act locally - reducing environmental impacts of transport

Regine Gerike[1*], Tina Gehlert[2], Falk Richter[1], Wolfram Schmidt[1]

[1] Chair of Transport Ecology - [2] Chair of Traffic and Transportation Psychology
Faculty of Transportation Sciences "Friedrich List"
Dresden Technical University

Abstract

This paper presents a pragmatic approach for reducing the environmental impacts of transport in the German Federal State Saxony. The aim is to use the potential of pricing measures for effectively reducing environmental impacts of transport. They are combined with less-effective but more accepted non-pricing measures in a policy package. The development of this approach starts with the calculation of the current external costs of transport in the case study area. Second, a policy package reducing these external costs is composed. Third, the development of the external costs is assessed and compared in two scenarios, a BAU-scenario and the policy scenario where measures reducing the environmental impacts of transport are implemented. Fourth, the public and political acceptability of this policy package are investigated. The results show that it is possible to develop a policy package that is effective for reducing the environmental impacts as well as acceptable to the public and politicians. Therefore, such a package approach is suitable to guide future political decisions and actions towards a more sustainable transport sector.

Keywords: Sustainability; Transport; Environmental impacts; External costs; Acceptability; Saxony.

1. Introduction

For several decades, European transport policy has sought to reduce the environmental impacts of transport and to support the concept of sustainability in the transport sector. Significant progress was made in different areas, especially in the development of new technology. However, the reductions in emission achieved by innovations were largely overcompensated by an increased transport performance.

Economic measures are regarded as a promising way for reducing the environmental impacts of transport. Such measures include not only direct operating (internal) costs but also costs resulting from environmental impacts, congestion, accidents etc. (the so-

---

* Corresponding author: regine.gerike@tu-dresden.de

called external costs). These external costs are not covered by travellers but are imposed on the whole society, other regions or future generations. As a result, current transport prices do not reflect the full costs caused by transport. However, these prices influence mobility behaviour by setting the financial scope in which people realise their travel. If they do not include the external cost components people will not include them into their travel decisions either. Thus, pricing measures for internalising the external costs, i.e. making the users pay for all the costs they cause, are a powerful instrument to change these decisions and reduce the environmental impacts of transport.

From a theoretical point of view the situation is clear. In practice, political initiatives to move forward with this approach are hardly implemented even though there are some notable exemptions, like the heavy good vehicle tax in Switzerland (Schade & Schlag, 2003). A reason could be that external costs, on which these internalisation measures are based, are highly variable and their calculation contains a number of uncertainties especially for long-term effects. Another and probably more important reason is the lack of acceptability. Politicians are reluctant to increase the costs for transport because they fear resistance from the public and the business community.

To overcome this problem a pragmatic approach was developed for reducing the environmental impacts of transport. The aim was to design a policy concept that is effective for reducing environmental effects as well as acceptable to the public and politicians. A package approach was used combining effective but less acceptable pricing measures with more acceptable non-pricing measures. These non-pricing measures do not directly internalise external costs but still contribute to the reduction of environmental effects of transport. Hence, we do not intend to stick to the internalisation principle in the classical economic sense but extend it and include non-pricing measures that support the reduction of environmental effects as well. This approach moves transport significantly towards sustainability as outlined in the national and international guidelines published for example by the ECMT/OECD and the European Commission (EC, 2006; ECMT 2004).[1]

This paper is based on a series of research projects that aimed at designing such a policy package for the German Federal State Saxony. The development process included the calculation of the current external costs of transport for the case study area. These costs can be seen as a mirror of the environmental impacts of transport which are transformed to monetary units. Second, a package of policy measures was designed to reduce these external costs and the environmental effects behind them. Third, the effectiveness of the policy package to reduce the environmental effects was assessed. This was done by modelling the impacts of the policy package and comparing them with a Business-As-Usual-scenario (BAU). The BAU-scenario is based on the assumption that no significant changes in transport policy will be implemented. The comparison between both scenarios also illustrates the savings for the economy if the policy package is implemented. Finally, the public and political acceptability of the policy package was assessed (see Becker, 2002; Gerike, 2000, 2004, 2006b).

The paper is organised in a similar way. The next section introduces the case study area which is the Free State of Saxony, its regional structure and local conditions. In section 3 the methodology to calculate the external costs is described, with special

---

[1] A sustainable transport development requires the consideration of further aspects besides the implementation of the polluter-pays-principle and the reduction of environmental effects of transport; see Gerike, 2007 for a comprehensive specification of the concept of sustainable transport development.

emphasis on the specifications for Saxony. Section 4 presents the current amount and spatial distribution of external costs of transport in Saxony. In section 5 the policy package composed to reduce these external costs and the environmental damages of transport is outlined. In section 6 the results of the modelling exercise are described. To illustrate the effectiveness of the policy package its impacts are compared with a BAU-scenario. In section 7 the methods and results for assessing the public and political acceptability of the policy scenario are presented. The paper finishes with a discussion of the results in section 8.

2. The regional structure of Saxony (Germany)

The Free State of Saxony is one of 16 Federal states of Germany situated in the eastern part of the country (see Figure 1). It covers an area of 18,415 km2 with approximately 4.3 million inhabitants.

Saxony, just as the other parts of Germany, is affected by serious demographic changes that affect passenger as well as freight transport (Scharfe, 2004; Saxon State Office of Statistics, 2003). Two main trends in the development of the population are observed.

First, the population is expected to decline due to low birth rates and employment migration to the western part of Germany. According to the population forecast of the Statistical Agency of Saxony, the number of inhabitants will decrease from 2000 to 2020 by 14 percent to approximately 3,786,000 inhabitants (Saxon State Office of Statistics, 2003). The differences in the density of the population will increase since sparsely populated rural areas will depopulate more strongly than the urban centres. Only for the biggest cities Leipzig and Dresden a slight increase in the population is predicted.

Second, the population is expected to grow older on average due to higher life-expectancy, as well as again low birth rates and migration (of mostly younger people). The mean age will increase from 43 years in 2000 to 49 years in 2020. In 2020 the share of people older than 65 years will be higher than 30 percent in almost one third of the Saxon municipalities.

Furthermore, Saxony is situated between various European centres and therefore used as transit route. In 2003 the share of foreign vehicles on Saxon motorways amounted to 20 percent and is expected to increase further (BASt, 2006).

These developments impose potential problems for the transport sector. There will be no significant decrease in transport volumes but fewer taxpayers covering the costs for the maintenance of transport infrastructure.
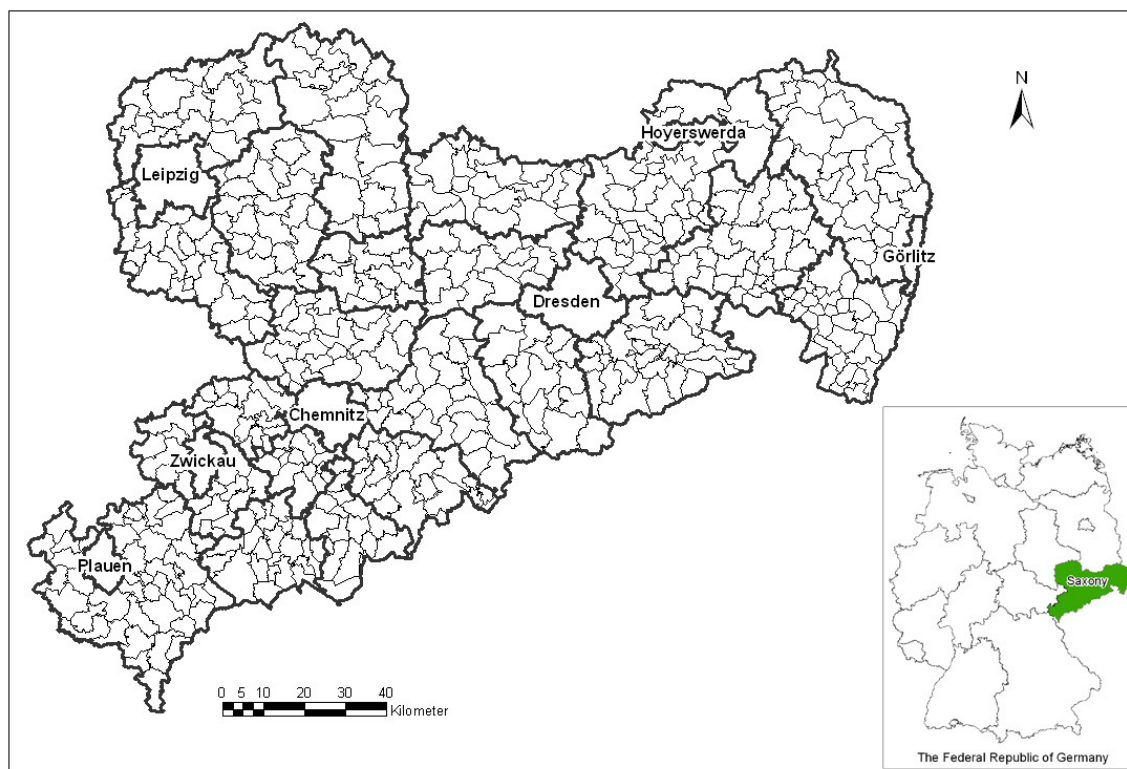
Figure 1: The Free State of Saxony: Regional administration.

3. Methodology for calculating external costs

The methodology used for calculating externals costs of transport in Saxony was based mainly on the studies carried out by Infras/IWW (Infras/IWW, 2000, 2004), the EU-projects UNITE (Nash, 2003) and ExternE (Bickel, 2005) as well as on Swiss projects (ARE, 2004 a-d; Ott, 2005). The methods chosen were modified to incorporate the more detailed data available for the case study area. Figure 2 gives an overview over the main input data, the methodology and the basic assumptions for quantifying the external costs of transport in Saxony.

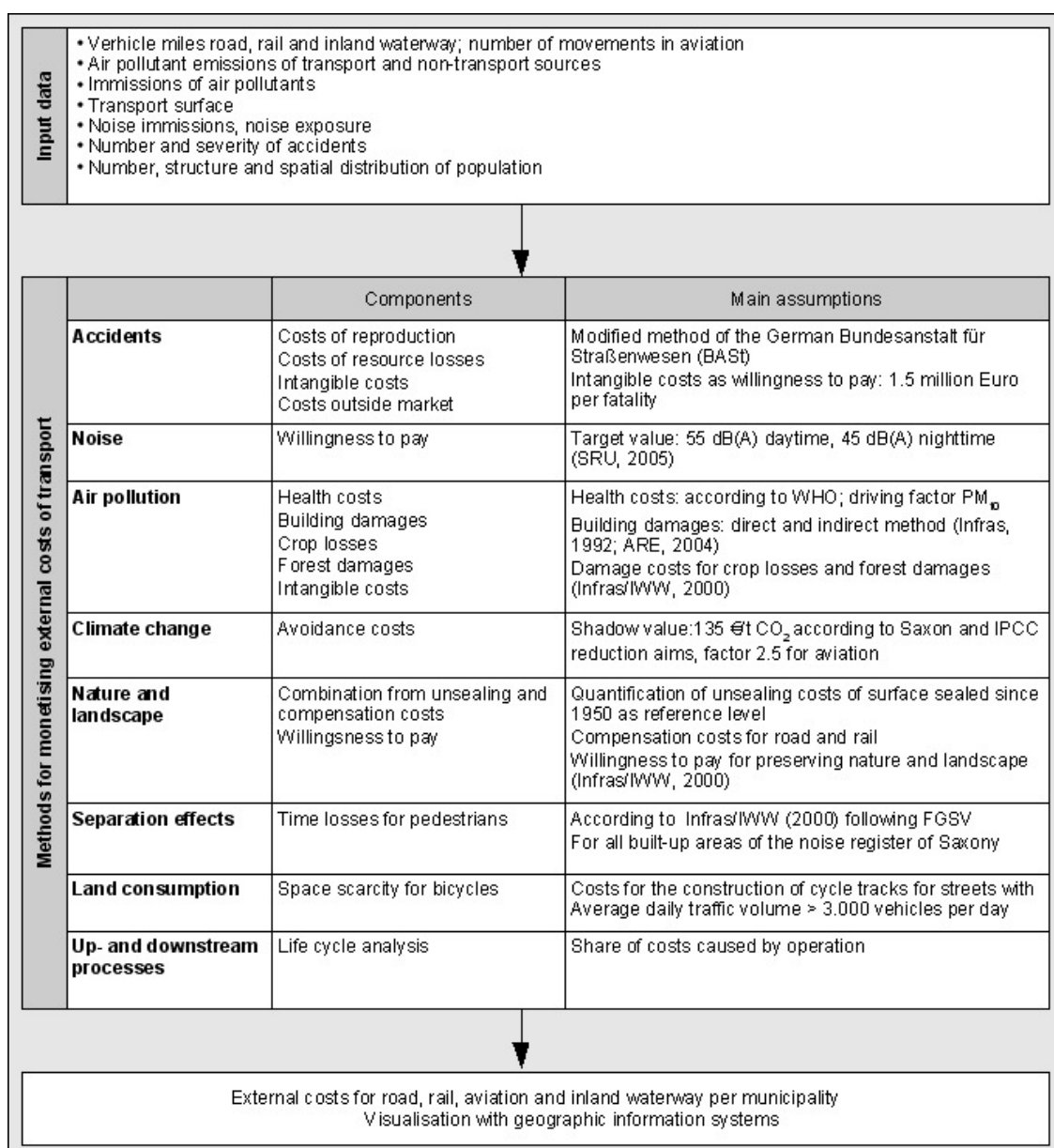|	Components	Main assumptions
Accidents	Costs of reproduction Costs of resource losses Intangible costs Costs outside market	Modified method of the German Bundesanstalt für Straßenwesen (BASt) Intangible costs as willingness to pay: 1.5 million Euro per fatality
Noise	Willingness to pay	Target value: 55 dB(A) daytime, 45 dB(A) nighttime (SRU, 2005)
Air pollution	Health costs Building damages Crop losses Forest damages Intangible costs	Health costs: according to WHO; driving factor PM_{10} Building damages: direct and indirect method (Infras, 1992; ARE, 2004) Damage costs for crop losses and forest damages (Infras/IWW, 2000)
Climate change	Avoidance costs	Shadow value:135 €/t CO_2 according to Saxon and IPCC reduction aims, factor 2.5 for aviation
Nature and landscape	Combination from unsealing and compensation costs Willingsness to pay	Quantification of unsealing costs of surface sealed since 1950 as reference level Compensation costs for road and rail Willingness to pay for preserving nature and landscape (Infras/IWW, 2000)
Separation effects	Time losses for pedestrians	According to Infras/IWW (2000) following FGSV For all built-up areas of the noise register of Saxony
Land consumption	Space scarcity for bicycles	Costs for the construction of cycle tracks for streets with Average daily traffic volume > 3.000 vehicles per day
Up- and downstream processes	Life cycle analysis	Share of costs caused by operation

Figure 2: Input data and methodology for quantifying external costs of transport in Saxony.
Source: Gerike, 2006b.

The following general approaches to monetise the environmental impacts of transport were applied:
- Damage costs: Environmental damages that are caused by the transport sector are directly converted into monetary units. This approach is the most suitable way of assessing the costs of the environmental damages. However, it can only be applied if dose-response-functions are known.
- Willingness to pay (WTP)/hedonic price methodology: People are willing to pay for measures to improve the environment. This WTP can be regarded as the price for this environment. The first option to quantify this price is to ask people how much they are willing to pay for e.g. a certain amount of noise reduction (WTP). The second option is to investigate the differences between prices e.g. for dwellings with more and less noise exposure (hedonic price methodology). These

differences can be interpreted as lost money due to noise pollution. Both approaches indicate upper limits of external costs and are used here e.g. for quantifying noise and intangible costs.

- Prevention costs: This method quantifies the costs that are necessary to avoid certain environmental damages. To assess prevention costs it is necessary to set goals for environmental protection. These goals could be the result of a political process or scientific consensus. This method is often used for estimating climate costs.

Based on these general approaches specific methods to calculate the different external costs have been used. The following paragraph describes them in more detail (see also Figure 2):

Accident costs: The first component was the costs of reproduction including costs of medical treatment, professional rehabilitation and judicial costs. The second cost component, the costs of resource losses, included societal production losses causes by death or temporary inability to work. Net-production losses were quantified as product of losses of future working time and average per-capita income minus future consumption. The third and very sensitive cost component was intangible costs of health damages. These costs are quantified by using a "risk value" of 1.5 million Euros per fatality. This risk value was applied only for non-causers of accidents. The assumption was that the causers know about the risks related to their driving behaviour and have included it into their personal cost-benefit-calculation. The fourth cost component, the costs outside the market, included the production of goods and services that are not included into the national account. All those costs were reduced by motor vehicle third party liability insurance contributions in order to get the external accident costs.

Noise costs: The noise costs were calculated by using the cost rates developed by Infras/IWW (Infras/IWW, 2000, 2004). These cost rates were applied for a combined target value of 55 dB(A) for daytime and 45 dB(A) for night-time. This assumption is based on the recommendations of the German Advisory Council on the Environment.[2]

Air pollution costs: The air pollution costs are composed of health costs, building damages, costs due to crop losses and forest damages. Health costs are by far the dominant component. They were calculated based on epidemiological results of the WHO (Infras/IWW, 2000, 2004; WHO, 1999). As with accident costs, the intangible costs are a very sensitive component also for the calculation of air pollution costs. These costs were quantified in the same way than the accident costs.

Climate change costs: For quantifying the climate change costs a shadow price of 135 Euros per ton CO_2 was used. This shadow price is based on calculations on avoidance costs related to the goal of reducing transport CO_2-emissions by 50 percent until 2030 compared to 1990 (Infras/IWW, 2004; Becker, 2002). The chosen value is much higher than the shadow price of 20 Euros per ton CO_2, which would result from using the Kyoto-aims (Nash, 2003). The decision for the higher value was based on the assumption, that the shadow price should reflect the apparent deviations from long-term, scientific goals. The Kyoto protocol is an important step to achieve reductions of CO_2 emissions, but it is a political compromise and in the long term not sufficient. Even

---

[2] See SRU, 2005; using the target values of 65 dB(A) daytime / 55 dB(A) night-time recommended by the Environmental Noise Directive (RL 2002/49/EG) would lower the external noise costs by about 60 percent, see Gerike, 2004 for an analysis of sensitivity.

if all Kyoto aims will be met, there will be costs of climate change that future generations have to bear and that were caused by today's transport. These costs should be reflected by the external climate costs.

Nature and landscape: A biocentric approach was used to monetise the effects of transport infrastructure on nature and landscape: Starting from a predefined carrying capacity it was analysed to what degree the current transport system exceeds this carrying capacity and what costs would be necessary to keep it. The following components were included: unsealing and repair costs, costs of contamination of soil and water and a flat-rate value to consider further effects like visual constraints.

Separation effects: These effects were monetised by time losses due to waiting times and detours which pedestrians face at transport infrastructure in built-up areas. They are based on FGSV (1997) and Infras/IWW (2000).

Land consumption: These costs were quantified by the costs of scarcity based on FGSV (1997) and Infras/IWW (2000): "The legitimisation of these costs is based on a fairness principle: The road sector is leading to space scarcity in cities, which causes additional cost especially for non-motorised transport." (Infras/IWW, 2000, p. 48). Thus, the costs for bike lanes which have to be built at highly frequented roads were quantified.

Up- and downstream effects: The external costs of up- and downstream effects comprise all effects that are caused by activities for the transport sector that go beyond moving goods or passengers. Examples for those activities are the provision of energy, the production of vehicles and infrastructure. Based on Infras/IWW (2000) costs of air pollution and costs of climate change were included here as main components of up- and downstream effects.

The resulting costs of the environmental damages that transport causes comprise a certain degree of uncertainty. It arises from the different degree of accuracy of the input data as well as the methods for calculating the costs. Two strategies were applied to cope with this uncertainty. First, different methods were used in parallel to monetise one effect. In this way an interval with upper and lower limits was determined. Second, the precautionary principle was used: In case of any uncertainty concerning methodology and / or quality of input data lower limits were calculated. That means the results rather underestimate the "true" external costs of transport.

Input data was available at different spatial level of disaggregation depending on the type of external cost and transport mode. Data on traffic volumes, air pollutant emissions and energy use was available per link for a very detailed network for all transport modes. The road noise register of Saxony provided detailed data on noise and population. Data on air pollutant immission was taken from the Saxon immission register with a spatial disaggregation of 2.5 x 2.5 km^2. Information on number and severity of accidents was available on municipal level. Land-use data was obtained from official Saxon statistics.

All environmental effects of transport were included into the analysis as well as external costs of accidents.[3] The calculation was carried out at different levels of spatial disaggregation. Depending on the input data and the methodology the most disaggregated level possible was used. Finally, the results per cost component were converted to municipal level so that data on external costs of transport is available for all of the 522 municipalities of Saxony.

---

[3] See Becker, 2002 for the discussion of congestion and infrastructure costs.

All external costs of transport were calculated according to the inland principle: All environmental effects within Saxony were considered no matter whether they were caused by Saxons or by other people. Therefore, only the LTO-cycle (Landing-Take-Off) was taken into consideration for aviation up to 915 m (3000 ft) (Gerike, 2000).

The methodology described above was applied to determine the status quo in Saxony and to forecast the external costs for the policy scenario as well as the BAU-scenario. For both forecast scenarios the following assumptions were made:

- Only real changes were calculated: No rate of price increase was included. Thus, the changes of external costs predicted only reflect the changes of real environmental effects. Consequently, the risk value and the shadow price for climate costs are not extrapolated by any interest rate.

- Accidents: The estimated number of unreported accidents was taken from the status quo based on the assumption that no relevant changes in regulation will come into effect. Furthermore, the share of causers compared to all casualties is an important input parameter. It differs between the vehicle categories: For accidents with two-wheeled vehicles involved, almost all injuries are causer (80% with motor bikes, 84% to 90% for mopeds). This share decreases to about 18 percent for duty vehicles and 33 percent for private cars (Gerike, 2006b). In the BAU-scenario it is assumed that the transport volume for two-wheeled vehicles and duty vehicles increases, while it decreases for private cars compared to the status quo. Since these trends are contrary to each other and the share of causers was stable in the years analysed for the status quo, the status quo share of causers to non-causers was applied to the BAU-scenario too.

- Air pollution, noise: For the air pollutant emissions it could be referred to the DAVUS-project and to the road noise register of Saxony (Scharfe, 2004). The immissions were predicted from the status quo based on the development of air pollutant emissions as well as of climatic conditions.[4]

4. External costs of transport in Saxony - the status quo

Table 1 shows the external costs of transport per cost component for all transport modes in the year 2002. This is the most recent year calculated in the status quo. The dominant transport mode is road transport which causes about 95 percent of all external costs of transport. Rail transport is responsible for about 4 percent of total external costs. Waterborne and aviation together cover 1 percent.

Table 2 gives an overview over the shares of the different vehicle categories within road transport. Here, the car is dominant causing 64 percent of all external costs. The most important cost component of cars is the accident component. That is, because of the risk value used to quantify intangible costs.[5] The risk value also influences the external health costs caused by air pollution as further important cost component. The climate costs are very sensitive to the shadow prices used. These costs are also very

---

[4] See LfUG, 2005 for a discussion of climate change problems for Saxony.
[5] See section 3 for the methodology used for quantifying intangible costs. See Gerike, 2000 for a sensitivity analysis for all cost components.

high since a shadow price of 135 Euros per ton CO_2 was taken as basis. The up- and downstream costs depend mainly on external costs of air pollution and climate change.

Table 1: External costs of transport modes in 2002.

[m Euros]	*Road*	*Rail*	*Aviation*	*Waterborne*	*Total*
Accidents	2,185	0	1	0	2,186
Air pollution	1,386	63	0	8	1,457
Climate change	1,061	43	14	5	1,123
Up- and downstream processes	547	42	2	3	594
Noise	406	102	2	n.c.	510
Nature and landscape	197	0	0	n.c.	197
Land consumption	97	n.c.	n.c.	n.c.	97
Separation effects	1	0	n.c.	n.c.	1
Total	5,880	250	19	16	6,165

Note: N.c. = not calculated.
Source: Gerike, 2006b.

Table 2: External costs of different vehicle categories in road transport in 2002.

[m Euros]	*Car*	*LDV/HDV*	*MC*	*Bus*	*Total*
Accidents	1,879	170	123	13	2,185
Air pollution	556	770	0	60	1,386
Climate change	659	370	9	23	1,061
Up- and downstream processes	324	208	3	12	547
Noise	125	260	16	5	406
Nature and landscape	133	60	2	2	197
Land consumption	78	17	2	1	98
Separation effects	1	0	0	0	1
Total	3,755	1,855	155	116	5,881

Note: LDV = Light Duty Vehicle; HDV = Heavy Duty Vehicle; MC = Motorcycle
Source: Gerike, 2006b.

Figure 3 shows the spatial distribution of external costs for all transport modes. Here the concentration of external costs in the main cities becomes apparent: The 10 biggest municipalities, where 37 percent of inhabitants live, cause 31 percent of total external costs. The three biggest cities Dresden, Leipzig and Chemnitz alone, covering 5 percent of the whole area of Saxony and 28 percent of inhabitants, generate a share of 24 percent of external costs of transport (Gerike, 2005).
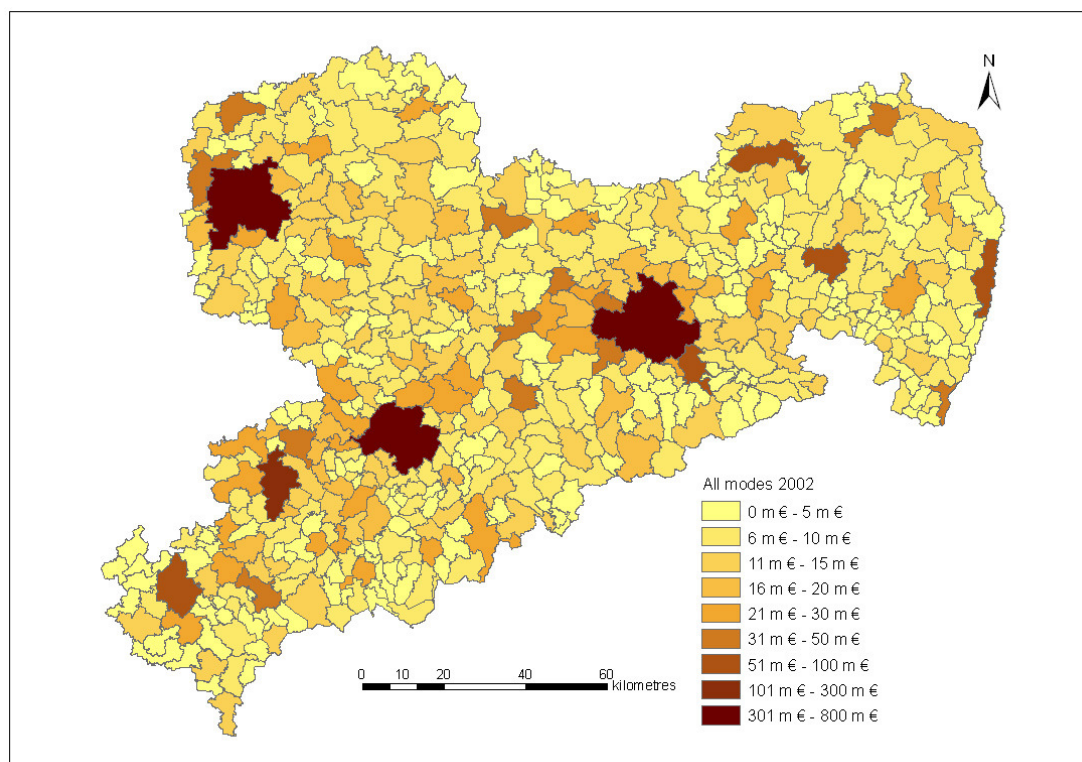
Figure 3: Total external costs of all transport modes in Saxony in 2002.
Source: Gerike, 2006b.

5. The policy package

The development of the policy package was guided by the following considerations (see Gerike, 2004, 2006b):

- The results so far have shown that external costs and thus the environmental effects in transport consist of several components which are each characterised by different qualities: Noise exposure depends for instance mainly on traffic volumes, road surface and technology of the vehicles, such as the engine performance. Number and severity of accidents, however, depend on driving behaviour and on road design. Because of these varying characteristics it is not possible to choose one single measure that effectively reduces all environmental effects. Different measures that target the different environmental impacts of transport are needed.
- Pricing and non-pricing measures differ in their degree of effectiveness and acceptability. Pricing measures are very effective for reducing environmental effects, but they are lacking public and political acceptability. Non-pricing measures are on the other hand well accepted, but not as effective. By combining pricing and non-pricing measures in a so-called package approach a reasonable degree of acceptability even for pricing measures can be achieved (Jones, 2001; Schade & Schlag, 2000; Goodwin, 1989).

- The results of section 4 and the knowledge about the characteristics of the external costs of transport in Saxony to date enabled us to identify the most relevant components and areas in order to set the priorities within the policy package accordingly.
- Furthermore, mainly measures were chosen which Saxony is responsible for the implementation. However, this requirement needed to be relaxed somewhat, because the legal responsibility to implement some of the most effective measures is assigned to the Federal or even European level. Thus, a compromise had to be made between the aim of effectiveness and the possible implementation by the Free State of Saxony.
- Finally, when specifying each measure current policy developments in Saxony were taken into consideration in order to facilitate the implementation of the policy package by using current and possible future windows of opportunity.

These considerations let us conclude, that a package of policy measures is necessary which focuses on different environmental effects and includes pricing as well as non-pricing measures. The aim was twofold. On the one hand the intention was to include the main effects that cause the highest amount of external costs (air pollution and climate costs, accident and noise costs). On the other hand the spatial distribution of external costs of transport in Saxony was considered. Here, a significant concentration in urban areas became apparent (see section 4).

Figure 4 describes the measures chosen and their specification for the modelling exercise and the acceptability study. Since the package became quite comprehensive, it was decided to divide it into four parts to keep it clear and manageable. The four parts of the package also represent the main foci of the policy package resulting from the Saxon conditions: urban transport, land consumption, climate change and safety.

The first part of the policy package focuses on urban transport. It contains measures which should be mainly implemented in the main Saxon cities (Chemnitz, Dresden, Leipzig). The focus was set on air pollution and noise that are above average in these urban areas. Furthermore, the measures are aimed at reducing traffic volume in the inner cities in general in order to achieve an overall reduction of environmental effects of transport. The two pricing measures in this part of the package are urban road pricing and parking management. The level of charge for urban road pricing was determined to correspond with a single ticket for public transport. Parking management is explicitly proposed for both, the city centre as well as shopping centres outside the city. That is, in order to prevent the distortion of the competition between the retail sector in the city centres and the shopping centres outside. Since a number of shopping centres outside the cities exist, this specification seems necessary not only to prevent negative side-effects but also to get support from the local business community. Thus, the level of both pricing measures was explicitly not based on marginal external costs but was chosen pragmatically. The aim was to move towards the polluter-pays-principle while simultaneously keeping the pricing measures comprehensible for the public.

The external costs of land consumption do not belong to the main costs mainly because of the methodological difficulties in monetising changes in soil and water quality caused by transport. However, this is a serious long-term problem from an environmental point of view that attracts increasingly attention especially in the discussion on sustainable development. Therefore, the problem of land consumption should be included in any policy package reducing the environmental impacts of

transport. Furthermore, the continuing migration of people to other parts of Germany in combination with the demographic change in Saxony will lead to declining tax revenues in the future. This makes investments in infrastructure and even the maintenance of the existing transport infrastructure an expensive endeavour (Ahrens, 2005). By linking new construction projects to existing public transport connections, developments in new areas will become less attractive which reduces land consumption considerably. Furthermore, if public transport access needs to be in place prior construction, the costs of building new transport infrastructure become part of the overall land development costs. That again makes areas that are closer to the existing public transport network more attractive.

The third part of the policy package deals with climate change. It is regarded as key to the effectiveness of the policy package as a whole. A reduction of external costs in that area will influence all other environmental effects in a positive direction and is therefore vital for environmental protection. Thus, the measures belonging to this part of the package have been included despite the fact that they mainly do not fall into the legal responsibility of Saxony. However, on the European and Federal level there is considerable progress in the discussion on climate change and the transport sector. Recently, the European ministers of environment decided to commit to reducing greenhouse gas emissions by 30 percent until 2020 in the frame of an international agreement on climate protection (compared to 1990). The EU intends to reduce their emissions at least by 20 percent until 2020 (compared to 1990) until a new agreement will be arranged and independent of their position in international negotiations. The German government announced even more ambitious targets. Thus it seemed reasonable to include these policy measures, even though they cannot be implemented by the Saxon authorities themselves.

The last part of the package was devoted to traffic safety. That is, because first accidents cause significant external costs (see section 4). Second, in previous years Saxony has invested considerable resources in improving traffic safety. For example, Saxony participated in a pilot project introducing the learner driver's license, which allows teenagers to drive already at the age of 17 (instead of 18), provided that they are accompanied by a licensed driver. Therefore, the positive political climate in Saxony may be used as window of opportunity to facilitate the implementation of these policy measures.

Policy measures	*Specification in the policy scenario*
Measures focusing on urban transport	
1: Urban road pricing	City centre cordon: flat rate for entry of 1.70 €/day
2: Parking management	In city centres as well as shopping centres outside cities: 1.00 €/hour
3: Pedestrian zones	Extension of existing pedestrian zones
4: Higher environmental standards in public transport	EEV for all public transport vehicles
5: Promotion of cycling	Extension of the cycle network, bicycle parking facilities
6: Promotion of car sharing	Centrally located parking facilities, co-operation of car sharing operators with public transport
7: Access restrictions	Access restrictions for high emission vehicles in sensitive areas such as city centres or nature reserves
Measures focusing on land consumption	
8: Sustainable transport planning	Public transport access must be in place prior new developments
Measures focusing on climate change	
9: CO_2-tax	To cover climate damages an additional tax on petrol: + 0.32 €/litre and diesel: + 0.36 €/litre will be levied
10: Promotion of fuel saving driving behaviour	Driver's education and training programmes emphasis and practice fuel saving driving behaviour
11: Promotion of alternative fuels	Biodiesel will be subsidised by lower prices, more petrol stations and research programmes
Measures focusing on safety	
12: Risk differentiation of driver's third party liability insurance	Bonus-Malus system according to accident risk
13: Speed reductions	Motorways: 120 km/hour , urban areas: 30 km/hour
14: Reform of driver's education	Pilot projects of learner driver's licenses, which allow a person to drive provided they are accompanied by a licensed driver
15: Higher safety standards	Legal alcohol limit for driving reduced to 0.00‰.

Figure 4: Package of policy measures.
Source: Gerike, 2006b.
Note: EEV = Enhanced environmentally friendly Vehicle (category used in European emission standards)

6. Effectiveness of the policy scenario

In this section the results of the modelling exercise analysing the effectiveness of the policy scenario are presented. The impacts of the policy scenario are compared to a BAU-scenario. The BAU-scenario was based on the assumption that there will be no significant changes in transport policy within the time span of modelling. The policy and BAU-scenario were modelled for the year 2020. This time span has been chosen because it is far enough into the future to capture not only short time but also long-time effects. On the other hand, the year 2020 is close enough to the status quo so that reliable results could be obtained by taking current transport trends into consideration. Furthermore, the project DAVUS (Scharfe, 2004) which was an important data base for

Vehicle Kilometres Travelled (VKT) and air pollutant emissions provided detailed data for the year 2020.

First, the expected development of key input data is described since these changes considerably influence the development of external costs. Second, the development of external costs itself will be presented. Table 3 shows the Vehicle Kilometres Travelled (VKT) in the policy scenario as well as in the BAU-scenario. Car traffic performance in the policy scenario is about 12 percent lower compared to the BAU-scenario. Bus traffic performance is significantly higher, about 10 percent.

Table 3: Differences in vehicle kilometres travelled in the policy scenario compared to the BAU-scenario.

[m vkm]	*2020 BAU*	*2020 Policy*	*Difference in %*
Car	26,047	22,843	-12%
MC	805	792	-2%
Bus	198	218	+10%
LDV/HDV	6,428	6,114	-5%

Source: Gerike, 2006b.

Figure 5 describes the results for the air pollutant emission. The total emissions are significantly lower in the policy scenario compared to the BAU-scenario. This holds true for the CO_2-emmissions, the PM10-emmissons as well as the NOx-emissions. The reasons for these reductions are a changed fleet mix and driving patterns as a consequence of the policy measures. However, the development of the emissions is partly compensated by the further increase in the traffic performance (see section 2).
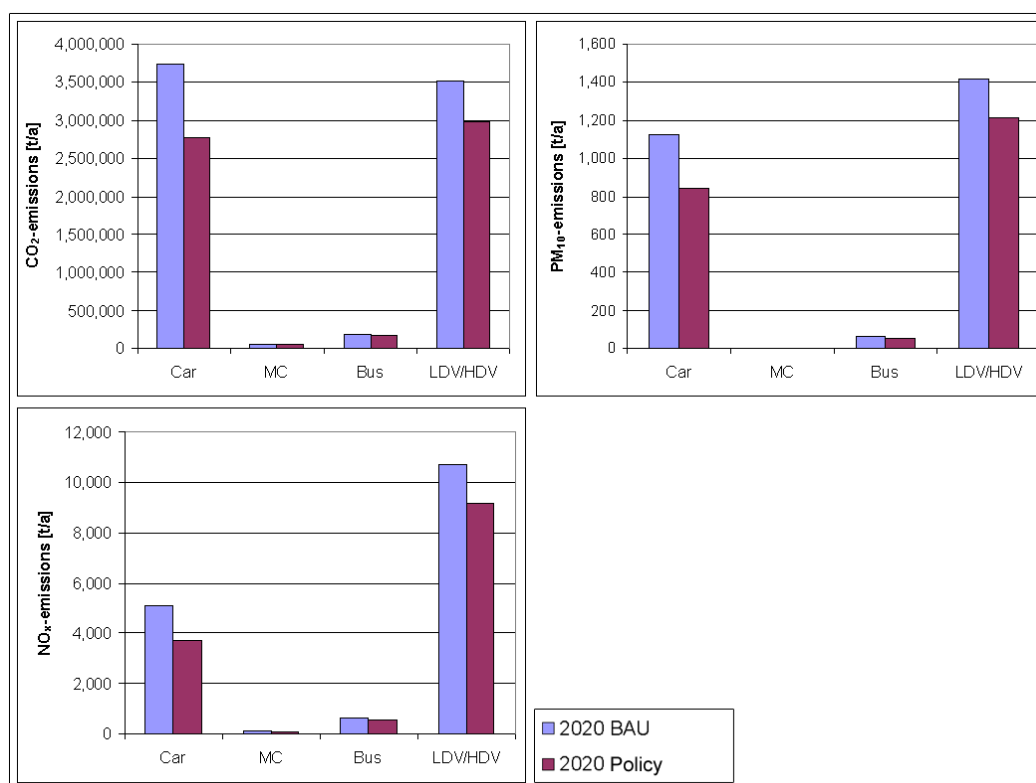

Figure 5: Reduction of air pollutant emission in the policy scenario compared to the BAU-scenario.
Source: Gerike, 2006b.

   The policy scenario furthermore results in reductions of accident rates by 23 percent compared to the BAU-scenario. That means that in the policy scenario there are 23 percent fewer injuries per vehicle mile travelled than in the BAU-scenario. Figure 6 shows how this affects the total accident figures. The number of injuries decreases by 31 percent. Hence, the reduction of accident rates is facilitated by decreasing transport performance achieved through the policy measures.
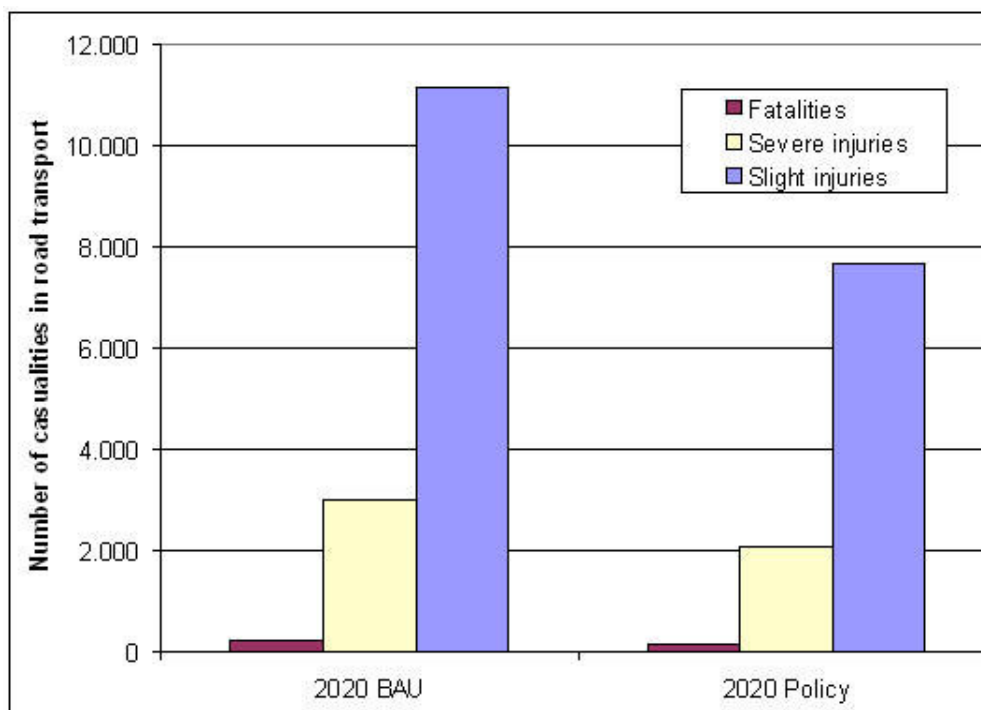

Figure 6: Number of causalities in road transport.
Source: Gerike, 2006b.

   Table 4 shows the external costs of road transport predicted for the year 2020 for the BAU-scenario and the policy scenario. The total external costs of road transport amount to nearly 4,000 million Euros in the policy scenario, which corresponds to 82 percent of the total external costs in the BAU-scenario. That is a reduction of 18 percent. The strongest reduction is observed for the accident costs that decline to 69 percent in the policy scenario. This effect is exclusively due to the lower number of injures in the policy scenario (cf. Figure 5). The noise costs decline to 94 percent due to decrease in traffic performance in some of the different vehicle categories. The costs of air pollution and climate change are reduced because of the reductions of air pollutant emissions and energy use. It is expected that the policy measures achieve improvements in the specific environmental performance per vehicle kilometre as well as in the total environmental impacts. The external costs of nature and landscape, land consumption and separation effects remain stable because it is assumed that the transport infrastructure remains unaffected by the policy package. Despite the fact that no changes were assumed for these effects, they are included in Table 4 and Figure 7 for making the absolute numbers comparable to the status quo presented in section 4.6.

---

[6]   Spatial effects were treated separately (Spiekermann, 2005).

Looking at the shares of the cost components the share of accidental costs declines from 26 percent in the BAU-scenario to 22 percent in the policy scenario. The share of all other components remains stable respectively goes up even if the absolute numbers decline. The share of air pollution costs for instance goes up from 27 percent to 30 percent, the share of noise costs increases from 7 percent to 9 percent.

Table 4: External costs of road transport: BAU- and policy scenario (in prices of 2000).

	2020 BAU	*2020 Policy*	*Difference in %*
Accidents	1192	819	-31%
Noise	337	318	-6%
Air pollution	1,235	1,093	-12%
Climate change	1,015	806	-21%
Nature and landscape	149	149	-
Usage of space	94	94	-
Separation effects	1	1	-
Up- and downstream processes	503	414	-18%
Total	4,528	3,694	-18%

Source: Gerike, 2006b.

Figure 7 gives an overview over the distribution of costs components within the road sector as dominant transport mode in the two scenarios. The strongest reduction of externals costs is achieved within cars. The external costs decline from 2,592 million Euros to 1,976 million Euros in the policy scenario. The main reason for this decrease is again the declining accident figures.
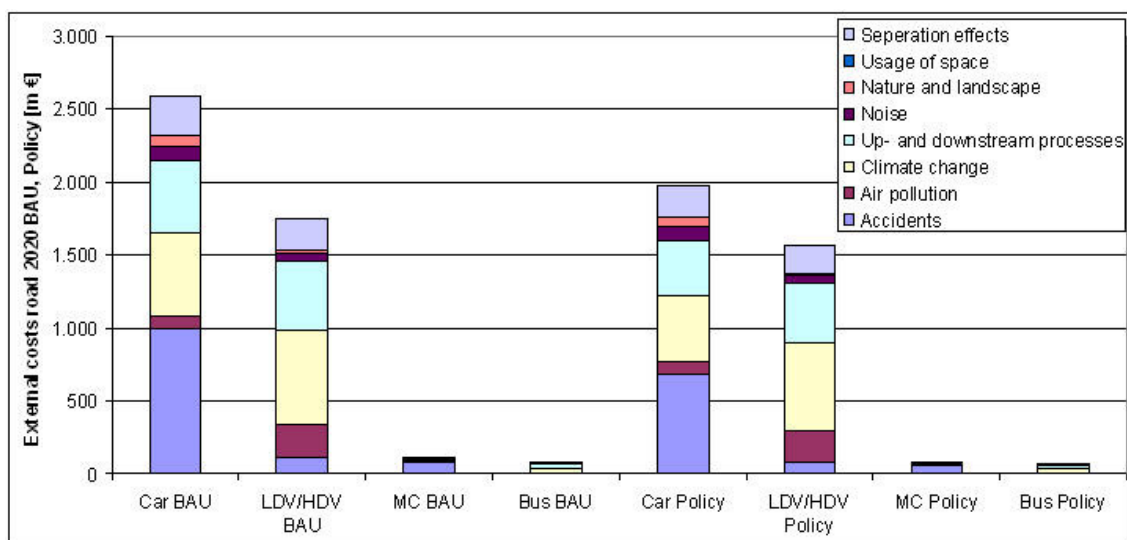

Figure 7: Total external costs of road transport in 2020: BAU-scenario and policy scenario.
Source: Gerike, 2006b.
Note: Car BAU = Car BAU-scenario, Car Intern. = Car Policy scenario

7. Acceptability of the policy package

A political and public acceptability survey was conducted to assess the acceptability of the policy package. A semi-standardised interview with Saxon citizens as well as politicians and decision-makers was designed and conducted. The policy package was presented to the participants using the card sorting technique. That means, the specification of each proposed policy measure was printed on a 15 cm x 21 cm card. Theses cards and the specifications of the policy measures respectively were presented to the participants one by one with no reference to the four parts of the package (see Figure 4). After the presentation participants were asked about their assessment of this particular policy measure. If participants did not understand the meaning of a policy measure further explanations were given prior to the assessment questions. These explanations were determined beforehand and in this way standardised for all participants. Each interview lasted approximately 60 minutes.

The citizen sample consisted of 40 participants, 19 male and 21 female participants. The average age was 42 years (SD = 16.45 years). 57.5 percent of the participants were living in Saxon cities and 42.5 percent were living in rural areas. 92.5 percent of the participants had a driving licence and 77.5 percent owned a private car. Those 77.5 percent also used their private cars as main mode of travel, only 22.5 percent used public transport.

The sample of politicians and decision-makers consisted of 15 participants, 13 male and 2 female participants. The average age was 46 years (SD = 7.29 years). All of them were working in the transport sector in Saxony at the time of the interview and therefore chosen as experts. However, this sample just as the citizen sample is not representative for the population of Saxon citizens and decision-makers. 3 participants belonged to the Federal state level, 1 participant to the district level, 9 participants to local authorities and 5 participants to relevant companies and associations. Every participant possessed a driver's licence. 53 percent of participants used their private car as the main travel mode followed by 40 percent using public transport.

After the presentation of each policy measure participants were asked to evaluate three aspects: the acceptability, the perceived effectiveness and the knowledge of each measure on a 4-point scale from 1 = not at all known/effective/acceptable to 4 = most well known/effective/acceptable. The politicians and decision makers were not asked about their knowledge. It was assumed that as experts in the transport sector they are familiar with these measures. Finally, the acceptability of the whole policy scenario was assessed using the 4-point scale again.

In contrast to the evaluation of the effectiveness of the policy scenario (see section 6) the acceptability was not only assessed for the whole scenario but also for each policy measure separately. Only after participants evaluated each policy measure they were asked about their acceptability of the whole scenario. The reason for this procedure was twofold. First, the composition of the policy package was based on a number of considerations (see section 5). For example, it was assumed that pricing measures are least accepted whereas non-pricing measures are well accepted. These considerations are mainly based on the results of international studies and have not been validated in the Saxon context. Thus, the results of the single measures were used to verify the considerations of the package composition. The second reason was to give participants enough time to get familiar with each policy measure before they are asked to evaluate the whole policy scenario.

The results of the public acceptability, the knowledge and the perceived effectiveness of each policy measure are presented in Table 5. In general most policy measures are rather unknown. The most well-known measures were the learner driver's license, the legal alcohol limit of 0.00‰ and car sharing. The least known measures were the reform of driver's third party liability insurance, parking management and the CO_2-tax. According to the participants their knowledge about the policy measures results mainly from the political discussions in the media. Against this background it is not surprising that for example the new learner driver's license is a rather well-known measure whereas the more established parking management did not receive a high knowledge score. At the time of the interviews a pilot project concerning the new learner driver's license has just started and pictured in the media.

The effectiveness of the measures is assessed somewhat more positive. On average 75 percent of the policy measures were regarded as effective or rather effective. The legal alcohol limit of 0.00‰ and the access restrictions in sensitive areas are assessed as most effective whereas the learner driver's license, the parking management and the promotion of alternative fuels were regarded as least effective measures. Hence, the theoretical assumption that more well-known measures are also regarded as more effective does not apply to all cases (Schade & Schlag, 2000).

The acceptability of the policy measures was quite mixed. As expected the pricing measures such as urban road pricing or the CO_2-tax were rather unacceptable. In contrast non-pricing measures such as the promotion of cycling and car sharing were more acceptable to the public. The promotion of cycling and fuel saving driving behaviour were regarded as most acceptable. Least acceptable were parking management and the CO_2-tax as well as the learner's driving licence.

Table 5: Public acceptability of the policy package (1=not at all to 4=most, mean values).

Policy measures	Knowledge	Perceived Effectiveness	Acceptability
Measures focusing on urban transport			
1: Urban road pricing	1.75	2.90	2.30
2: Parking management	**1.23**	**2.30**	**1.70**
3: Pedestrian zones	2.48	2.87	3.47
4: Higher environmental standards in public transport	2.00	3.22	3.35
5: Promotion of cycling	2.28	2.82	3.65
6: Promotion of car sharing	2.70	2.65	3.15
7: Access restrictions	2.35	3.35	3.45
Measures focusing on land consumption			
8: Sustainable transport planning	1.65	2.50	2.90
Measures focusing on climate change			
9: CO_2- tax	**1.40**	2.82	**1.60**
10: Promotion of fuel saving driving behaviour	2.10	3.10	3.57
11: Promotion of alternative fuels	2.05	**2.32**	2.25
Measures focusing on safety			
12: Risk differentiation of driver's third party liability insurance	**1.13**	3.02	3.45
13: Speed reductions	2.33	3.00	2.27
14: Reform of driver's education	2.95	**1.90**	**1.97**
15: Higher safety standards	3.53	3.50	3.40

Note: the highest mean values are indicated by white/grew numbers, the lowest mean values by black bold numbers

The aim of composing a package of policy measures was to achieve a reasonable degree of acceptability especially for the pricing measures. Thus, participants were asked to evaluate the acceptability of the whole policy scenario. With a mean value of 2.12 the acceptability of the policy scenario lies within the range of the lowest mean values (2: Parking management; 9: CO_2-tax) and the highest mean values of the single measures (5, 10: Promotion of cycling and fuel saving driving behaviour). Overall 37.5 percent of the participants stated that they agree at least somewhat with the policy scenario. Compared to the figures of 10 percent to 20 percent that are reported for pricing measures as single measure this can be regarded as a substantial improvement (see Schade & Schlag, 2000; Jones 2001; Lyons, Dudley, Slater & Parkhurst, 2004). That means that pricing measures received indeed a higher acceptability score within the policy package than as single measures. Only urban road pricing received a somewhat higher mean value as single measure.

The results for the political acceptability and the perceived effectiveness of politicians and decision-makers are presented in Table 6. Similar to the public the decision-makers assessed the effectiveness of the policy measures rather positive. All measures were assessed as at least rather effective with mean values higher 2.50. The only exemption is the learner driver's license which is regarded as rather ineffective. The positive

assessment of the effectiveness of the policy measures by the experts can be regarded as a tentative validation of the modelling exercise results which demonstrated that the policy package significantly reduces external costs in transport in Saxony.

For the politicians pricing measures were less acceptable than non-pricing measures as well. However, the level of support for pricing measures was higher compared to the citizens. Furthermore, the learner driver's license that was already assessed as not effective was rather unacceptable. Most acceptable to the politicians were the promotion of cycling and fuel saving driving behaviour and the reduction of the legal alcohol limit to 0.00‰.

Table 6: Political acceptability of the policy package (1=not at all to 4=most; mean values).

Policy measures	Perceived Effectiveness	Acceptability
Measures focusing on urban transport		
1: Urban road pricing	2.73	**2.47**
2: Parking management	2.60	2.60
3: Pedestrian zones	2.93	2.80
4: Higher environmental standards in public transport	2.73	3.13
5: Promotion of cycling	3.47	3.80
6: Promotion of car sharing	2.73	3.40
7: Access restrictions	3.29	3.36
Measures focusing on land consumption		
8: Sustainable transport planning	3.13	3.27
Measures focusing on climate change		
9: CO_2- tax	2.60	2.67
10: Promotion of fuel saving driving behaviour	2.67	3.53
11: Promotion of alternative fuels	2.73	2.73
Measures focusing on safety		
12: Risk differentiation of driver's third party liability insurance	3.07	3.33
13: Speed reductions	3.20	2.73
14: Reform of driver's education	**2.07**	**2.00**
15: Higher safety standards	3.27	3.60

Note: the highest mean values are indicated by white/grew numbers, the lowest mean values by black bold numbers

With a mean value of 2.67 the acceptability of the entire policy scenario lies within the range of the lowest mean values and the highest mean values of the single measures for the politicians and decision-makers as well (1: Urban road pricing vs. 5: Promotion of cycling). Overall 66.7 percent of this sample evaluated the entire policy scenario as suitable for reducing external costs of transport in Saxony. Even thought politicians accepted pricing measures as single measure to a higher degree compared to the citizens they also supported them more as part of a policy package.

Comparing public and political acceptability it seems that there are only minor differences. Both groups regarded the promotion of cycling and fuel saving driving behaviour as the most acceptable measures. Furthermore, the reduction of the legal alcohol limit of 0.00‰ and the access restrictions received high acceptability scores. The smallest mean difference between both groups was observed for the learner driver's license. Both groups did not accept this measure. They shared the view that teenagers are not mature and careful enough at that age. Furthermore, they do not agree with the imitation of American examples, with which this kind of driver's education is associated. Statistically significant differences between public and political acceptability were found for the CO_2-tax and the parking management which were accepted to a higher degree by the politicians. The reverse holds true for the access restrictions which were accepted to a higher degree by the public (Mann Whitney U-Test, $p < 0.05$).

Figure 8 compares the public acceptability with the public acceptability as it is perceived by politicians and decision-makers. The results show that the public acceptability is mostly underestimated. This replicates the results of a similar study by Schade and Schlag (2000). The closest correspondence was found for the CO_2-tax, the promotion of car sharing and the promotion of alternative fuels. The biggest discrepancy was found for urban road pricing, pedestrian zones and the risk differentiation of driver's third party liability insurance. The public acceptability of these measures was far higher than anticipated by decision-makers. And even though this acceptability study comprised only a small and not representative sample it suggests that not only the public acceptability of pricing measures but restrictive measures in general is underestimated by politicians and decision-makers. That may explain why the overall positive political acceptability of the proposed policy measures has not been translated into political actions so far.
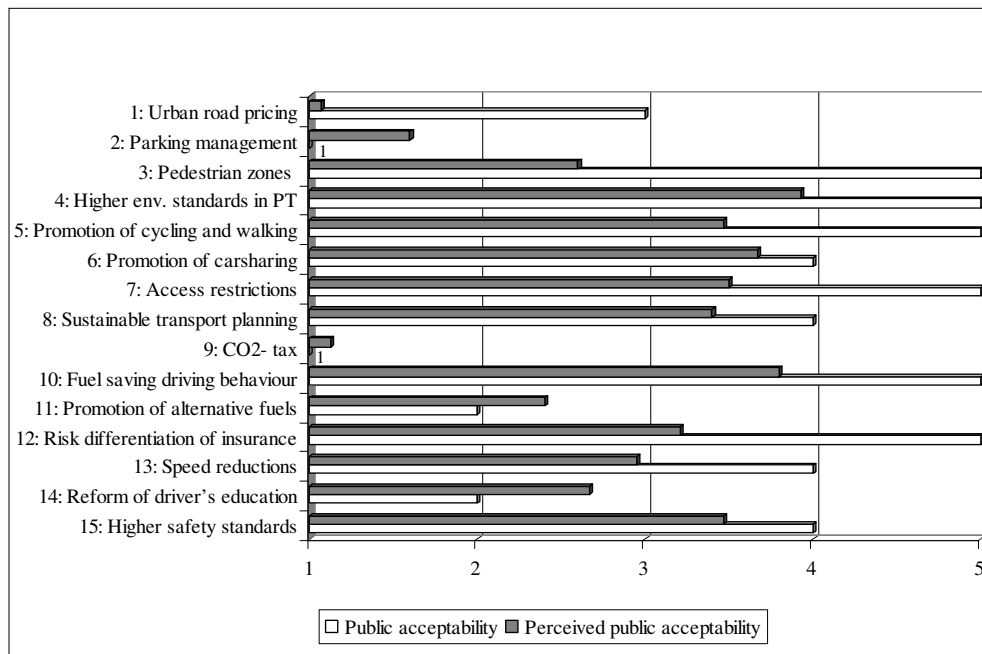

Figure 8: Comparison of public acceptability and the assumed public acceptability by politicians and decision-makers (mean values).
Note: Perceived public acceptability was measures on a percentage scale from 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% to 5 = 81-100%. The relative frequency of the public acceptability has been transformed into the percentage scale for comparison.

8. Summary and Conclusions

There is scientific consensus, that external costs cause inefficiencies in the transport sector. Their reduction is a vital condition for making transport more efficient and environmentally friendly. The situation is clear theoretically. However, political activities to move forward with this approach have only been undertaken tentatively.

Politicians are reluctant to increase the costs for transport because they fear resistance from the public and the business community. Pricing measures, which are very effective for reducing the environmental impacts of transport, lack public and political acceptability. Non-pricing measures on the other hand are well accepted, but not as effective. The combination of pricing and non-pricing measures in a so-called package approach is regarded as a promising solution to this dilemma. An increase in the costs of transport will probably always remain a controversial issue, but a policy package may gain sufficient public support to move forward with the implementation of the polluter-pays-principle reducing the environmental impacts of transport.

This paper presents such a package solution for the Free State of Saxony. Based on the current situation of external costs of transport in Saxony (the status quo) a package of policy measures was developed. The impact of this policy scenario was assessed and compared with a Business-As-Usual-scenario (BAU-scenario). Furthermore, the public and political acceptability of this policy package was analysed.

The main conclusions of this research are:

- The decline in population due to the demographic change does not solve the environmental problems of transport in Saxony. Even though a decrease by 14 percent is predicted from 2000 to 2020, road transport volumes will remain stable with car volumes decreasing by only 4 percent and freight transport even increasing by 15 percent. Therefore, political actions are necessary to significantly reduce the environmental impacts and thus the external costs of transport.

- The modelling results show that a package approach of pricing and non-pricing measures is effective for reducing the environmental impacts in transport. The policy package reduces the external costs by 18 percent compared to the BAU-scenario.

- The interviews revealed that citizens as well as politicians assessed the policy package as rather effective for solving the environmental problems of transport. As expected the acceptability of the single policy measures was mixed. Pricing measures such as urban road pricing or the CO_2-tax were rather unacceptable. Non-pricing measures such as the promotion of cycling and car sharing were more acceptable. But overall almost 40 percent of the citizens supported the entire policy package. This is a substantial improvement of the acceptability of pricing measures. Presented as single measures they typically gain public support of only 10 percent to 20 percent. However, the level of public acceptability especially of restrictive and pricing measures was clearly underestimated by politicians and decision-makers. That may explain why they hesitate to put forward effective pricing measures in the transport sector.

This paper has demonstrated that it is possible to design a package of policy measures for reducing environmental impacts in transport that is effective as well as acceptable on a local level. Even though it is certainly not realistic to assume that this package will fully be implemented in a short period of time, it can serve as a guideline for a sustainable transport policy in Saxony in a long-term perspective. Furthermore, the

process of designing such a policy package described here may serve as an example for other cities or regions how to initiate a process of reducing external costs of transport.

References

Ahrens, G.-A. (2005) Demographic changes - consequences for the transportation sector. *Journal for Public Health*, No. 1: 16-21.
Becker, U.; Gerike, R.; Rau, A.; Zimmermann, F. (2002) *Determination of external costs of transport for Saxony – main study.* Study on behalf of Saxon Department for Environment and Geology, Final report, Dresden,
http://hsss.slub-dresden.de/deds-access/hsss.urlmapping.MappingServlet?id=1173280083359-8184 – in German.
Bickel, P.; Friedrich, R. (Ed.) (2005) *ExternE. Externalities of Energy*. Methodology 2005 Update, Stuttgart,
http://www.externe.info/.
ECMT (2004) *Assessment and Decision Making for Sustainable Transport.* European Conference of Ministers of Transportation, Organization of Economic Coordination and Development (www.oecd.org)
European Commission (2006) *Keep Europe Moving - Mid-term review of the 2001 Transport White Paper*. Brussels,
http://ec.europa.eu/transport/transport_policy_review/index_en.htm.
Federal Office for Spatial Development (ARE) (2006) *External costs of road and rail transport 2000*. Bern. – in German.
Federal Office for Spatial Development (ARE) (Ed.) (2004a) *External costs of transport in the field of nature and landscape – monetising fragmentation*. Bern. – in German.
Federal Office for Spatial Development (ARE) (Ed.) (2004b) *External health costs caused by transport-related air pollution in Switzerland – Update for the year 2000*. Bern. – in German.
Federal Office for Spatial Development (ARE) (Ed.) (2004c) *External noise costs of road and rail transport in Switzerland – Update for the year 2000.* Bern. – in German.
Federal Office for Spatial Development (ARE) (Ed.) (2004d) *Damages to buildings caused by transport – Update of external costs fort the year 2000*. Bern. – in German.
Federal Highway Research Institute (BASt) (2006) *Counting foreign car traffic on federal motorways and European roads 2003*. BASt-report V 141,
http://www.bast.de/nn_42742/DE/Publikationen/Fachliche/Berichte/unterreihe-v/2006-2004/v141.html – in German.
Road and Transportation Research Association (FGSV) (1997) *Recommendations for economic feasibility studies on roads* (EWS), Update of RAS-W 86, FGSV-No. 132, Köln – in German.
Gerike, R. (2007) *How to make sustainable transportation a reality – the development of three constitutive task fields for transportation*. München: Oekom.
Gerike, R.; Seidel, T.; Becker, U.; Richter, F.; Schmidt, W. (2006b) *Consequences of an internalisation package for Transport in Saxony*. Study on behalf of Saxon Department for Environment and Geology, Final report, Dresden. – in German.
Gerike, R.; Seidel, T. (2005) Internalisation of external effects in transportation – chance or illusion? *Verkehrsforschung-online*, *2,* 1-20,
http://www.verkehrsforschung-online.de/ – in German.
Gerike, R. (2004) *Updating external costs of transport for Saxony*. Study on behalf of Saxon Department for Environment and Geology, Dresden. – in German.

Gerike, R.; Becker, U. (2000) *Determination of external costs of transport for Saxony – preliminary study*. Study on behalf of the Saxon Department for Environment and Geology, Final report and manual of arguments, Dresden. – in German.

Goodwin, P. (1989) The "Rule of the Three": a possible solution to the political problem of competing objectives for road pricing. *Traffic Engineering + Control* 30 (10) 1989: 495-497.

Infras, IWW (2000) *External Costs of Transport*. Study on behalf of International Union of Railways (UIC), Paris.

Infras/IWW (2004) *External Costs of Transport – Update Study*. Study on behalf of International Union of Railways (UIC), Final Report, Zürich.

Jones, P. (2001) Gaining public support for road pricing through a package approach. T*raffic Engineering + Control* 32 (4) 2001: 194-196.

Lyons, G., Dudley, G., Slater, E., Parkhurst, G. (2004). *Evidence-base review – attitudes to road pricing,* Final report to the Department for Transport, University of the West of England, Bristol.

Nash, C., with contributions from partners (2003) *UNITE (UNIfication of accounts and marginal costs for Transport Efficiency)*, Final Report for Publication, Leeds,
http://www.its.leeds.ac.uk/projects/unite/deliverables.html.

Ott, W., Baur, M., Iten, R., Vettori, A. (2005) Thorough implementation of the polluter-pays-principle. *Umwelt-Materialien*: Nr. 201. Federal Agency of Environment, Forest and Landscape (BUWAL), Bern. – in German.

German Advisory Council on the Environment (SRU) (2005) *Environment and Road Transport. High Mobility- Environmentally Sound Traffic.* special report, Berlin,
excerpt on http://www.umweltrat.de/english/eframe02.htm – in German.

Saxon Department for Environment and Geology (LfUG) (Ed.) (2005) *Climate change in Saxony – status quo and prospects*. Dresden,
http://www.umwelt.sachsen.de/lfug/ – in German.

Schade, J., Schlag, B. (2000) *Acceptability of Urban Transport Pricing*. VATT-Research Reports, Helsinki.

Schade, J., Schlag, B. (Eds.) (2003) *Acceptability of Transport Pricing Strategies*. Elsevier: Oxford.

Scharfe, S., Zimmermann, F. (2004) *Impacts of demography on future developments in the transport sector in Saxony*. Study on behalf of the Saxon Department for Environment and Geology, Dresden. – in German.

Saxon State Office of Statistics (Ed.) (2003) *Regionalised population forecast for Saxony by 2020.* Kamenz. – in German.

Spiekermann, K.; Wegener, M (2005) *Spatial impacts of measures for internalising external costs of transport in Saxony*. Final report, Dortmund. – in German.

WHO (1999) Health Costs Due to Road Traffic-Related Air Pollution, an impact assessment project of Austria, France and Switzerland, economic evaluation, technical report, London.