Potentials and Effects of a European-wide CO_2-Certificate Trading Scheme upon Road Traffic in Austria (MACZE)

1 Introduction

In Austria, car traffic is responsible for about 28% of all greenhouse gas emissions. At present, no effective instruments are available to reduce the greenhouse gas emissions caused by car traffic. In future, one can expect a further increase of both traffic volume and CO_2 emissions. The use of financial measures to curb such emissions is unpopular but highly promising; therefore one must ask which potentials, risks and effects CO_2 certificate trading might have upon car traffic. At present, no satisfactory answers can be given to these intriguing questions.

For example, it has to be determined how best to organize the emission certificate market. In this context, design and form of the trade model and the decision who should be obliged to obtain a certificate are important. In addition, the overall acceptance of such a trade scheme is crucial. It is advisable to find out how the different groups, i.e. car users, companies, stakeholder, etc. would react to such measures. As far as the effects of an emission trading scheme on traffic are concerned, possible changes of the mobility behaviour are most important, particularly a shift in the mode of transport or the deduced travel demand. By how much might CO_2 emissions caused by car traffic be potentially reduced by such measures? In the long run, the organisation of the CO_2 certificate trading scheme is likely to have an impact upon the Austrian economy and vehicle technology (incentives to innovate).

The research project MACZE "**M**öglichkeiten und **A**uswirkungen eines EU-weiten **C**O_2-**Z**ertifikathandels für den Straßenv**e**rkehr in Österreich" [potentials and effects of an EU-wide CO_2 certificate trading scheme upon road traffic in Austria] addresses this question. The project is funded by the Climate and Energy Funds of the Austrian federal government and conducted by the University of Natural Resources and Applied Life Sciences – Department for Spatial, Landscape and Infrastructure Science, Institute for Transport Studies (IVe) – in cooperation with the Vienna University of Economics and Business – Department of Social Sciences, Institute for Regional Development and Environment (RUW). The project's main objective is the development of a quantitative model to estimate effects and impact of CO_2 certificate trading upon car traffic in different scenarios which have to be clearly defined. Design and development of the model are based on the assumption that the EU will introduce CO_2 certificate trading for the traffic sector.

This paper is meant as a status report of the research project MACZE. An analysis of the possibilities of integrating road traffic in an EU-wide CO_2 certificate trading scheme requires an investigation of this (road) traffic and its specific characteristics. This aspect is covered at the beginning of this paper. Then advantages and disadvantages of different market models or ways of organizing the certificate trading are discussed. The MACZE model is described in chapter 4. This chapter also provides information about the methodology used for this research project. The main focus is upon the stated-preference analysis. The last part of the paper indicates the next steps to be taken within the research project.

2 Traffic

2.1 Number of trips and degree of motorization in Austria

The average number of trips of mobile people in Austria is 3.7 trips per day; roughly 70 minutes are needed every day to be mobile (Herry Consult Gmbh 2007, p. 87). In total, people in Austria cover about 120 bn kilometres per year. Nearly 70% of these are travelled by car (Figure 1).

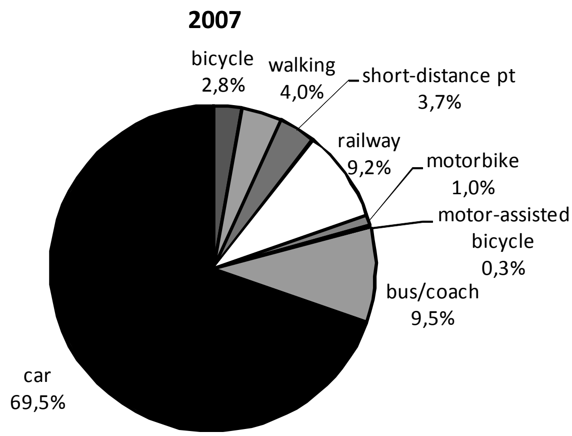

Figure 1: Modal choice in passenger traffic (Modal Split) in Austria in 2007 [Federal Environment Agency 2009b, p. 111]

Over the last years an increase in the amount of passenger traffic could be observed. For the transport of goods, road transport is also the preferred mode; about two thirds of goods are transported by heavy goods vehicles. For the remaining 30% rail transport is used, within Europe a comparatively high share (Umweltbundesamt n.d.). The internal traffic is strongly dominated by heavy goods vehicles; trips are comparatively short and frequently it does not make sense to use any other mode of transport.
For the whole of Austria the degree of motorization of the population was 507 cars per 1,000 inhabitants in the year 2005. Due to the availability of alternative modes of transport (public transport), the degree of motorization is lower in central locations than in peripheral areas (Herry Consult Gmbh 2007, p. 71). In the Burgenland region in eastern Austria with a low population density the degree of motorization is the highest in Austria with 575 cars per 1,000 inhabitants while the degree of motorization in the Vienna region is comparatively low with only 403 cars per 1,000 inhabitants.
The number of newly registered cars has remained fairly constant at about 300,000 per year. Since 1995 most newly registered cars have had a Diesel engine which means that the share of Diesel vehicles (about 54% of all cars) in Austria is rather high compared to other countries.

2.2 CO_2-emissions caused by road traffic

The development of CO_2 is a linear function of the fuel consumption of vehicles. The combustion of one litre of petrol leads to the emission of about 2.35 kg CO_2. In this respect the performance of Diesel engines is even worse with about 2.65 kg CO_2 per litre. Despite this chemical advantage of petrol, a Diesel engine is more efficient as far as fuel consumption and thus CO_2 emission are concerned, especially with increasing weight of the vehicle and/or higher engine performance. As far as the transport of goods is concern, the CO_2 emissions are not only influenced by the vehicle and its traction power but also by its cargo. As for passenger traffic we find on the one hand that vehicles with a higher (unladen) weight and a stronger engine emit more CO_2 per vehicle kilometre; on the other hand, if one considers the CO_2 emission per tonne-kilometre, the performance of truck-trailer combinations is considerably better than that of small lorries. All trucks use nothing but Diesel fuel.
As far as road transport is concerned, greenhouse gas emissions due to passenger traffic are about twice as high as those caused by the transport of goods. In total, transport accounts for a high 28% of greenhouse gas emissions in Austria (Umweltbundesamt 2007). Moreover, this is the sector with the highest growth rate (Figure 2). To a large degree this increase is due to fuel tourism, but also to the overall increase of the traffic volume since 1990 and the change of the modal split in favour of cars and trucks. The highest increase of

CO_2 emissions is due to the truck traffic (increase since 1990 +129%, for cars +45% (Federal Environment Agency 2009a, p. 83).

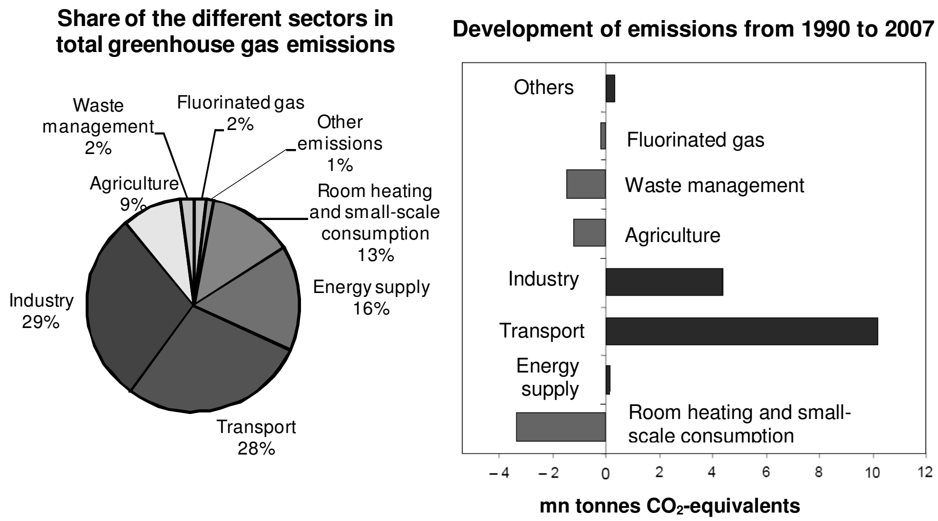

Figure 2: Share of the different sectors in the national greenhouse gas emission in 2007 and change of the emissions per sector from 1990 to 2005 in absolute figures (mn tonnes CO_2-equivalents) [Federal Environment Agency 2009b, p. 32]

2.3 Fuel prices

On all fuels used for road traffic which are based on mineral oil a tax on oil is levied. In Austria, this tax is 0.347 EUR/litre for Diesel fuel and thus lower than the respective tax for petrol products (0.447 EUR/litre). VAT (20%) is levied on the retail price including the tax on oil which means that on average about 50% of the sum paid by a driver at a petrol station are taxes.

In Europe, different retail prices for fuels in different countries lead to considerable fuel tourism. Reasons for this phenomenon are high taxes (as in Austria, but depending on the type of fuel) but also varying net prices. In general, Austrian fuel prices (both Diesel and petrol) are somewhat lower than the EU average. More foreign vehicles have their tanks filled in Austria than Austrian vehicles in foreign countries. Fuel tourism means higher tax revenues (disregarding possible future CO_2 penalties!), but it has a negative impact upon the Austrian CO_2 balance, because nobody differentiates where the fuel bought in Austria is actually used.

3 Definition and design of an emission trading scheme for the traffic sector

In order to analyse the consequences of a certificate scheme for road traffic, this scheme must be clearly defined. Taking the specific characteristics of traffic into account, the following aspects are particularly relevant:

- *Trade model:* Regarding the trade model one has to decide whether to create an emission trading scheme per sector of the economy or some trans-sectoral scheme.
- *Certification approach:* This determines which economic agents are obliged to obtain a certificate; one has to differentiate between upstream, midstream and downstream approaches.
- *Emission objectives:* The determination of reduction objectives (absolute or relative values) has an impact upon the economic and particularly ecological efficiency of the trading scheme.

- *Initial allocation:* The efficiency of the trading scheme is significantly influenced by the kind of allocation of certificates of carbon offset (e.g. auction vs. charge-free allocation to participants in the scheme on the basis of their last consumption).
- *Reporting, control and sanctioning system:* An effective control and sanctioning system needs to be developed to guarantee the effective functioning of the certificate scheme.

The following paragraphs deal in more detail with the design of an emission trading scheme for the specific trade model to be used (trans-sectoral vs. sectoral) und the type of certification (upstream vs. midstream vs. downstream approach).

3.1 Trans-sectoral vs. sectoral trading

The trade with certificates of carbon offset can either be trans-sectoral (open trade model) or limited to individual sectors of the economy (closed trade model). An open trade model would mean linking a certificate scheme for road traffic to the existing "EU Emission Trading Scheme" for large stationary pollution sources. In the latter case certificates of carbon offset would be freely transferable between the sectors energy, industry, and (road) traffic. A closed trade model would mean that several schemes would run in parallel and that no trans-sectoral trade with certificates of carbon offset would be permitted.
The economic advantage of a trade with certificates of carbon offset is based on the fact that the desired reductions of emissions are achieved by those pollution sources whose marginal avoidance cost is the lowest. The more heterogeneous the cost structure the bigger the efficiency potential; this leads to the conclusion that as many sectors as possible should be involved in the emission certificate trading. This would mean that a trans-sectoral optimization of the reduction efforts could be achieved and thus the full economic advantage of the certificate trading realized.
Assuming that the marginal avoidance cost in the traffic sector is considerably higher than in the sectors industry and energy, then emission trading which is limited to road traffic does not seem cost-efficient. In this regard, a combination of the two schemes would lead to efficiency gains. But one has to take into account that in a situation where the marginal avoidance costs of all sectors become rather similar the pressure to innovate will be lower in the traffic sector than compared to the situation where the emission trading scheme is restricted to the traffic sector alone. But some authors assume that the innovation potential of the traffic sector is particularly high (Birnbaum et al. 2007).
To give an example: A price of EUR 25 per tonne of CO_2 (possibly for cyclical reasons, in July 2009 trade prices are less than EUR 15) would mean a surcharge of Eurocents 6.6 per litre of Diesel. Due to comparatively low price elasticities (see chapter 4.1) such a price difference would have virtually no impact upon transport demand. Therefore one can assume that in an open trading scheme CO_2 emissions would be primarily reduced in other sectors. On the other hand, this means that in a closed system with fixed sector-related objectives for emission reductions the price per tonne of CO_2 would have to rise dramatically. To determine which price level would be high enough to achieve a change in behaviour and thus the ecological objectives is one of the major research issues the project MACZE wants to address (see chapter 4).

3.2 Various certification approaches

The certification approach determines who would be obliged to obtain a certificate. The obligation to obtain a certificate is based on the polluter pays principle. Therefore in the traffic sector both vehicle users (downstream approach) and vehicle manufacturers (midstream approach) might be included in the certification scheme. Moreover, there is the possibility to oblige both producers and importers of fossil fuels to obtain a certificate (upstream approach).

Downstream approach

The downstream approach addresses the problem at the level where the "decision to pollute" is made. As far as road traffic is concerned, this is the individual vehicle user. If this approach is used every vehicle user must have a sufficient number of certificates to compensate for his traffic-related pollutant emission. Raux and Marlot (Raux & Marlot 2005) recommend an annual fuel quota or certificate quota. If more than the allocated amount of fuel is needed, additional certificates must be bought; fuel savings mean that unused certificates can be sold. Since the vehicle user determines the choice of vehicle and his driving behaviour, the downstream approach creates a direct incentive to reduce pollutant emissions. Given the high number of vehicle users, this approach is connected with a correspondingly high monitoring effort. Moreover, the issue of a suitable allocation formula has to be taken into account (Michaelis 2006, p. 482).

Upstream approach

At present most discussions focus on an upstream approach in the form of a traditional cap-and-trade scheme. In this case individual fuel producers would need to obtain a number of certificates in accordance with the amount of fuel they sell. The upstream approach is in line with the polluter pays principle since there is a direct correlation between the sold amount of fossil fuels and the pollutant emission (see chapter 2.2); moreover the cost caused by the obligation to obtain certificates is passed on to the vehicle users via the price. Compared to the downstream approach an upstream approach would cause lower measurement and monitoring cost, because of the low number of actors that have to be involved. With either approach it is possible to target the desired reduction in emissions effectively.

Midstream approach

In contrast to the upstream or downstream approach the midstream approach is based on relative emission objectives. This means that a baseline-and-credit scheme would be used with a fleet emission standard for vehicle manufacturers and importers. By multiplying the specific emissions in grams of CO_2 per km with the estimated total number of vehicles sold such a scheme would be linked to absolute emission objectives. So far concepts of this nature have only been developed for passenger traffic. Deuber (2002, p. 81) suggests a total mileage of 200,000 km. Undesirable deviations of the actual emissions from the forecast emissions could be limited by using vehicle size classes with a different total mileage per class and by differentiating between petrol and Diesel engines (Michaelis 2006). One assumes that similar to the upstream approach a midstream approach would cause comparatively low measurement and monitoring costs (Ewringmann et al. 2005). The advantage of the midstream approach compared to the upstream approach is the generation of direct incentives to innovate; its disadvantage is the fact that the mobility or driving behaviour will not be directly influenced and that the emission capping is limited to new cars, i.e. the emissions of pre-existing cars are not taken into account.

Because of the weaknesses of each approach integrated concepts are gaining in importance. In order to create direct incentives for car users within the midstream approach, one might adjust the monthly taxes (e.g. use an emission-related basis of assessment for the motor vehicle tax) and/or the variable operating costs (e.g. an increase of the tax on oil) accordingly. On the other hand, the emission standards for new cars which will be implemented from 2012 onward, would be a meaningful addition to an upstream approach (Kampman, Davidson & Faber 2008), to offer directly manufacturers incentives to invest.
With the help of these emission standards for new cars suitable structures for an emission trading scheme in combination with a midstream approach are generated; vehicle manufacturers might even welcome a replacement of emission standards by certificate trading, because this would offer them more flexibility. It seems more difficult to implement an upstream approach, because neither the mineral oil industry nor vehicle users are likely to show great interest in emission trading, therefore one can assume a high degree of

resistance to such a scheme. Vehicle users would reject any rise of the tax on oil as vehemently as a rise in prices due to emission trading, but it would be much cheaper to adjust the tax rate than to introduce a completely new scheme. The ecological implications are the major disadvantage of a change in taxes compared to certificate trading because only a sufficiently substantial increase of the tax rate would help to meet the emission objectives completely. Any tax rate must be fixed at the introduction of the respective tax, while the price of a certificate within a trading scheme could be determined quite flexibly according to (suitably limited) supply and demand. Certificate trading is ecological effective; but the total economic costs are difficult to assess, because the price of certificates is not controllable – in comparison to a tax rate.

4 The MACZE model

4.1 Structure and parameters of the model

As part of the research project an econometric travel demand model and an econometric fuel consumption model are developed and combined to show the connection between travel demand, fuel consumption, fuel costs, and the availability or price of CO_2 certificates (Figure 3):

- The travel demand model for the transport of passengers and goods is meant to describe – depending on some important influential factors – the connection between travel demand and fuel prices from the users' point of view. Among other factors, socio-demographic aspects, travel purposes, type of region, and the availability of alternatives are taken into account. The model is based on a discrete-choice model and the theory of individual utility maximization, which has proved useful to describe travel behaviour.

- The econometric fuel consumption model is used to show the connection between fuel consumption, fuel price and the availability or price of CO_2 certificates. The parameters of the model are based on the analysis of the European market for CO_2 certificates during the last few years. One important parameter is the demand for fuel which depends on travel demand, the metrics for the fuel consumption of pre-existing vehicles and the prices for the users.

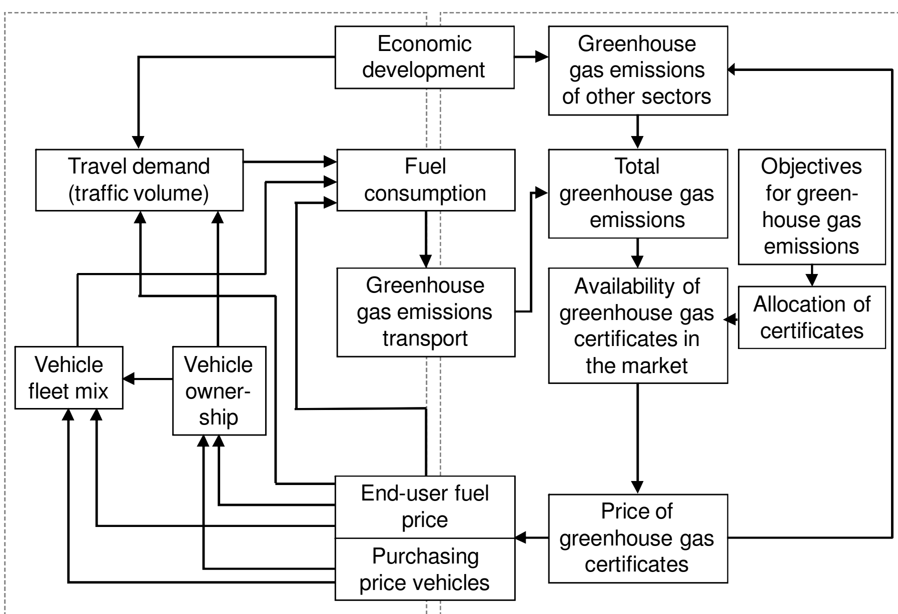

Figure 3: MACZE model (developed by the authors)

Within the framework of the MACZE model concept and structure of an EU-wide (partly) open emission trading scheme for the traffic sector are analysed.
A comparison of the advantages and disadvantages of the various certification approaches shows that the downstream approach can be ruled out because in real life it does not seem manageable. Moreover, the discussion points to the fact that neither a midstream nor an upstream approach are obvious favourites. Therefore the quantitative analysis looks at the effects of both midstream and upstream approaches. Among other reasons this is done to allow comparisons on the basis of quantitative models for the first time and thus fill a current gap in scientific knowledge.
The design of the model requires estimates of the demand of all industry sectors included in the model. As far as the traffic sector is concerned, the following indicators are essential parameters:

It is important for the upstream approach to investigate the impact of an increase of the fuel price upon the vehicle mileage in passenger traffic. For various fuel price scenarios the demand behaviour is determined with the help of a stated-preference analysis (chapter 4.2).
In the case of the midstream approach, the price elasticity of the demand for energy-efficient vehicles is particularly crucial. This means that the prices of new cars and new registrations but also emission-relevant characteristics of the cars are of importance. A survey of the preferences of the vehicle users provides insights into the demand behaviour. The impact of changing vehicle prices upon the fleet mix is shown as part of the modelling.
Scientific publications show different outcomes for the connection between a fuel price increase and demand. Unfortunately, studies are difficult to compare because they are based on different models, different observation periods, and different regions. Moreover, elasticities do not necessarily indicate linear connections. This means that the size of the price increase might have a considerable impact; while a price increase by 10 cents per litre might not lead to a noticeable reaction of the transport users, an increase by 50 cents per litre might quickly lead to a change in their way of thinking or a search for alternatives to their previous mobility behaviour. Moreover, short-term and long-term reactions are not necessarily the same.
The demand data used for the modelling of the transport of goods are all taken from scientific publications. One can expect lower elasticities than in passenger traffic, because as far as the transport of goods is concerned, the share of the fuel price in the overall operating costs is lower than in passenger traffic (e.g. due to personnel costs). But if one takes all cost components into account, then the share of the fuel price in the transport of goods sector is higher (14% in short-range transport and 23% in long-distance transport compared to 11% in passenger traffic), since one assumes that on average the loss of value alone accounts for about 43% of the cost of a passenger car, while the average depreciation in the transport of goods sector is less than 10% (Herry Consult Gmbh 2007, p. 216).
The analysis of the connection between fuel price and traffic volume is made more difficult by the fact that other factors may well have an impact, and that impact might be bigger than the effect of a change in fuel prices. This is particularly true for the transport of goods: despite the fact that at the beginning of 2009 fuel prices went down compared to the previous year, the first statistics available for the year 2009 indicate a decrease of motorway traffic in Austria by more than 10%; the current recession is the most likely reason for this decrease.
For passenger traffic household income is highly relevant. Within the framework of the stated-preference analysis the impact of fuel prices upon the (monthly) budget of a private household is discussed in all interviews to obtain plausible reactions. Moreover, long-term economic forecasts are used for the model.
Needless to say, the offer of certificates and their price are also important parameters of the model. For our project, various scenarios will be considered. The project team has to agree upon them. Suggestions made by the EU Commission might be the starting point for the offer of certificates; current trade prices are the basis for the prices used in the model.

4.2 Stated-preference analysis

As part of the project, a stated-preference analysis is conducted to determine the metrics for the travel behaviour in passenger traffic within the econometric traffic demand model. The main feature of this technique is the quantification of the interdependencies which cannot be determined by other qualitative and quantitative methods; the technique provides a good estimate of reactions to hypothetical measures (FGSV 2006; Axhausen & Sammer 2001). A multi-stage survey is planned: Firstly, a telephone survey will help to identify relevant target persons or households willing to participate in an interactive survey. Target groups are Austrian households with car trips at three specific dates (working day and weekend). Secondly, in-depth household interviews are conducted, with on-going quality control. While taking the specific dates into account and on the basis of their previous travel behaviour and income situation, members of a household are faced with various hypothetical fuel price and car price scenarios. Then the respondents have to decide how they would react in the hypothetical situations (discrete-choice process). The plausibility of these reactions is checked. All members of the household should participate in the interview and their reactions should be analysed and documented with the help of parameters for travel behaviour and purchasing behaviour. As part of the stated-preference interview reactions to two or three scenarios are collected. These scenarios which take various basic conditions for the trading of CO_2 certificates into account, for example the development of fuel prices, are defined with the help of the project team and cover a timespan of 20 years.

4.3 The analysis of focus groups

In the last phase of the project focus groups with all relevant types of participants in the trading of CO_2 certificates within the traffic sector are conducted and analysed. In sociology, focus groups are a tried and tested method to discuss issues related to a specific subject and their potential solutions in small groups, thus benefiting from group-dynamic effects. This method is particularly recommended if "complex behaviour and motivation aspects should be revealed or a high number of new ideas should be generated, because synergies in the group make it possible to use a bigger pool of ideas than that available in an isolated interview with one person." (Henseling et al. 2006, p. 11, quoted after Hoppe 2003; Krueger & Casey 2000). A moderator with a semi-structured discussion guide leads the discussion. The participants make their comments on the basis of their own subjective experience (Sammer et al. 2006). Within the framework of the MACZE project the main task of focus groups is the collection of insider information regarding the effects, problems, difficulties, success factors etc. and a feedback to the results of the interviews. On the one hand, participants in these discussions are representatives of oil companies, of companies with experience in the trading of CO_2 certificates, of government authorities, stake holders etc. On the other hand, car drivers, as well as company and consumer representatives have to be involved to ascertain their attitudes and acceptance and to get an idea of potential problems.

4.4 Areas included in the survey

Since the volume of passenger traffic depends, among other things, on the location of a region, different types of regions were selected for the survey. These regions were created with the help of the Österreichische Bundesverkehrswegeplan [Austrian plan for federal traffic routes] (Herry & Sammer 1996) and on the basis of the population forecast provided by ÖROK (ÖROK 1990). The following types of regions were selected: big city (Vienna), medium-sized towns, central districts, and peripheral districts. A total of 30 districts were selected for the survey (Figure 4), they cover more than 50% of the total Austrian population. It is planned to achieve a representative number of interviews for each type of region. The grossing-up of the car trips can be done on the basis of the Austrian plan for federal traffic routes.

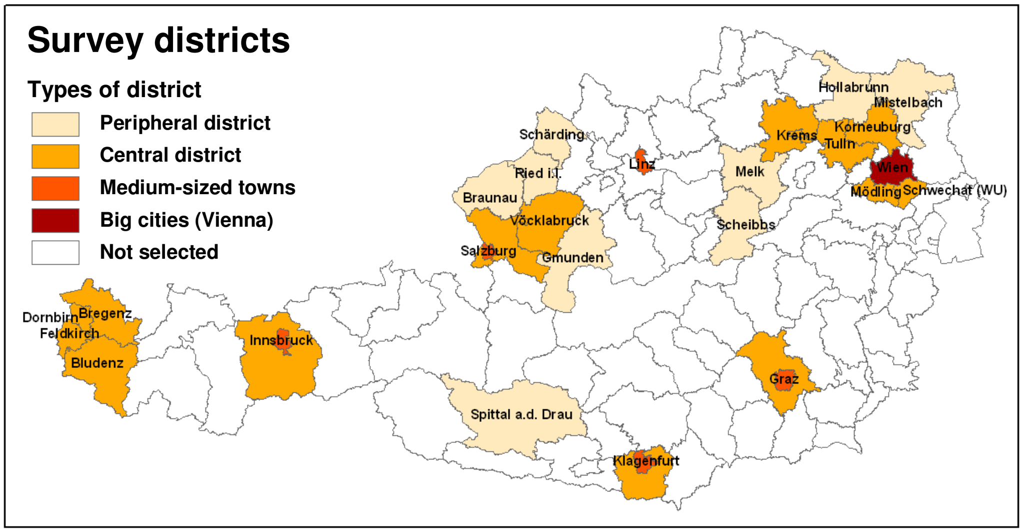

Figure 4: Districts selected for the survey – various types of regions [developed by the authors]

The clustering shown above was selected because mobility surveys have shown that the modal choice and travel demand in passenger traffic differ considerably by location. They depend on the available transport supply. In Vienna, the only big city in Austria, public transport trips account for 35% of all trips (UITP 2008). Due to the dense public transport network (5 underground lines, 32 tram lines, 83 bus lines, and additional railway lines), the inhabitants of Vienna have quite attractive and comparatively cheap alternatives to the use of their own car as far as urban trips are concerned. Austria's medium-sized towns (Graz, Linz, Salzburg, Innsbruck, Klagenfurt) also offer a bus and in some places tram network; to close gaps in the public transport network, people frequently use a bicycle (share in the total number of trips: up to 20%). The region with the highest share of bicycle trips is Vorarlberg in western Austria (Districts Bregenz, Dornbirn, Feldkirch, Bludenz); this is also the region with the highest population density (after Vienna). In general, the availability of public transport is rather limited in rural or small-town districts. With the exception of people living in places which are close to main railway stations, most people must use their cars for at least some of their trips. Far away from the main railway lines, travel time, timetable intervals, and service times of secondary railway lines and regional coaches make the use of the public transport system far less attractive than the use of one's own car.

In contrast to pollutants with local effects, from an ecological point of view it is not relevant where CO_2 is generated; for the grossing-up of the Austria-wide saving potentials a clustering by region makes sense. One would expect fuel price elasticities to be comparatively low in peripheral areas due to the lack of alternatives to cars, while in more densely populated areas rising fuel prices make people look for more environmentally friendly alternatives (public transport, bicycle, walking). At least in Vienna and to some degree also in medium-sized towns higher fuel prices might make some people completely abandon the use of cars. Therefore towns and cities have a far higher CO_2 saving potential than rural areas. In very peripheral regions a significant increase in fuel prices might further increase the already existing migration and thus intensify the shrinking of the population.

5 Preview

In the next phase of the project interviews will be conducted and analysed. The data collected are used in the MACZE model. With the help of the model possible effects of an emission trading scheme upon the transport sector can be shown. In the discussions about the form of the model only a trade model (downstream approach) was excluded; this means that it will be possible to say which kind of scheme might lead to the highest CO_2 savings in

Austria. The main objective is not to recommend the ideal way of introducing such an emission trading scheme for the traffic sector; the project just wants to show the potential but also the risks of an inclusion of the traffic sector in any such scheme, to answer some of the open research questions concerning this subject.

6 Literature

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