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ABSTRACT

The partial equilibrium model PRIMES-transport has been used for the evaluation of different transport policy measures which are on the table at EU or national level. The model covers the transport activity by transport mode and their associated energy consumption and air pollution in the EU, country by country. A full range of alternative technologies for each mode are considered and the choice of technologies is based on the generalised cost concept, inclusive the time cost and other not direct cost element. In a first part, the design of the model and the reference scenario specification are described.

Then in a second part the different transport policy measures are evaluated. The policy measures are the introduction of more fuel efficient road vehicles (furthering the ACEA agreement), the promotion of biofuels (EU proposal), the introduction of low-sulphur heavy fuel in navigation and finally the German LKW-Maut road-toll. Their impact are evaluated in terms of transport activity (overall and per mode), energy consumption, emissions and associated damage and technological choice.

Keywords: transport policy, transport modelling

1 INTRODUCTION

Energy security and environmental concern are driving forces in policy design for the transport sector. EU vehicle emission and fuel quality regulation has contributed to a reduction of air pollution from road transport and there are various policy proposals on the table at EU and national level to address some of the main issues linked to transport: pricing measures (e.g. road-pricing), vehicle technology improvements (e.g. increasing fuel-efficiency), ITS, etc. The use of biomass to produce liquid/gaseous fuels can also contribute to the EU target for the share of renewables in total energy consumption. Moreover this option is CO_2 neutral and is beneficial for energy security. In this paper we propose to evaluate some policy proposals with the applied partial equilibrium model of the EU transport sector, PRIMES-transport, which provides a framework for a cost-benefit analysis of transport policy scenarios. The objective is not to compare the impact of the different policies but to evaluate the contribution of each of them to some of the EU targets related to transport.

The policy scenarios considered are:

- Enhanced fuel efficiency improvement for road vehicles
- Implementation of bio-fuels directives
- Reduction of the sulphur content in fuels for navigation
- Introduction of a distance-based toll for heavy duty vehicles on all motorways in Germany

Though congestion is one of the main external cost in transport in the EU (Mayeres and Van Dender, 2001), policy related to congestion is not addressed here (though congestion is taken in the account in the calculation of transport activity and in the welfare evaluation), Primes-transport being not fully appropriate for analysing this type of issue. The PRIMES-transport model includes a representation of all transport markets (urban passenger, non-urban passenger, freight) and a vehicle technology choice submodel. The focus is on transport demand and the influence of policy measures on the evolution of that demand.

In the first section a brief description of the model and its database is given. In the second section, the reference scenario is briefly described. In the third section, the policy proposals and their model implementation are described. Finally, we compare the effects of the policy scenarios.

2 THE MODEL AND ITS DATABASE

2.1 THE MODEL

The PRIMES-transport model has been developed, with financing from the EU (DG RES and DG TREN) for the evaluation of the energy consumption and emissions in the transport sector and to study the penetration of new transport technologies and their effects on emissions with a long term emphasis (2030). A full description is given in Knockaert, Proost and Van Regemorter (2002).

2.1.1 Scope of the model

The model's scope (table 1) is to represent all energy use for transport purposes in the EU, country by country. The transboundary traffic flows are not explicitly considered.

table 1: Scope of the model

Horizon	1990-2030, year by year or by 5 years periods
spatial dimension	EU, country by country
transport activities covered	urban passenger transport non urban passenger transport freight transport
transport modes represented	urban passengers: car, public transport, motorcycle non urban passengers: car, bus, rail, air, navigation freight transport: truck, rail, air, navigation
technologies represented	6 to 10 alternative technologies for each mode (car, bus, truck); more limited number of alternatives for rail, air and navigation
energy use and air pollutants represented	energy use by type of product, conventional air pollutants (NO_X, VOC, PM, SO_2) and CO_2, inclusive their external cost (damage)

2.1.2 General overview of the model structure

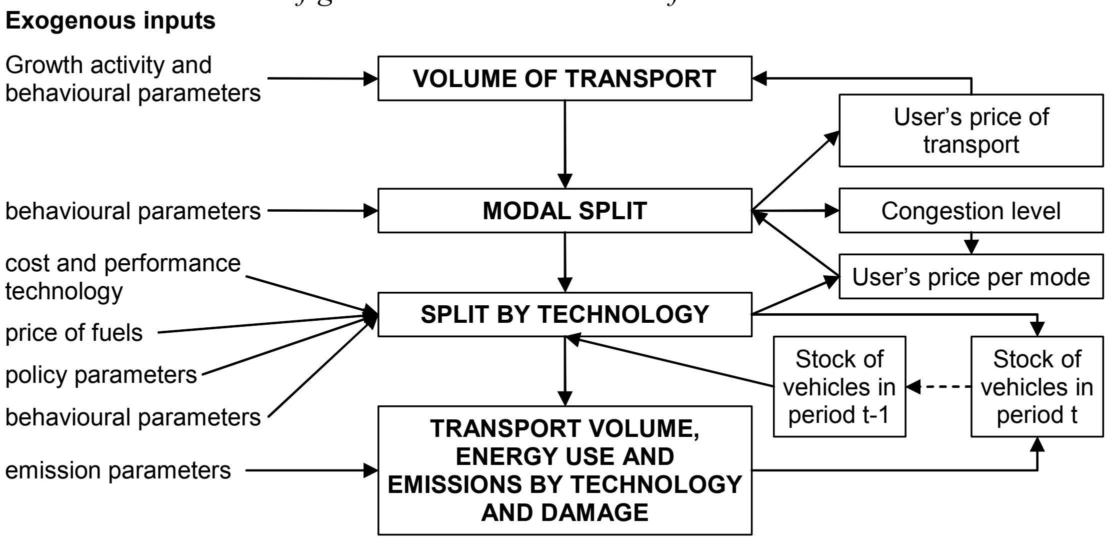
2.1.2.1 General structure

For each country the model covers three types of transport activity:

- urban passenger transport;
- non urban passenger transport;
- freight transport;

and for each type, the model contains four levels as shown in figure 1.

figure 1: General structure of the model



The aggregate demand for transport (passenger kilometres, ton kilometres) is determined by income/activity growth and by the aggregate price of transport. The aggregate price of transport is determined endogenously, as a function of the modal split and of the price per mode.

The split of the aggregate transport activity over the different modes is driven by the price per mode and by behavioural parameters. The user's cost per mode depends on the choice of technology for new vehicles, on past investment for each transport mode and on the influence of congestion on travel time. The choice of technologies for new vehicles is based on the minimisation of the expected usage cost given myopic expectation: the user does not take into account possible future price evolutions of e.g. fuel prices in his decision.

New vehicles are added to the stock of vehicles inherited from the previous period in function of the transport needs per mode. The composition of the stock of vehicles (new and inherited) determines the aggregate price per mode.

In the final stage, the transport volumes, fuel consumption and emissions per technology are computed per transport mode. A simple welfare evaluation function is included in the model that computes the total consumer surplus, the damage from air pollution and total tax revenues.

As the price and income elasticities are important parameters, they are given in annex.

2.1.2.2 User price concept

The choice of technology and of mode is driven by relative user prices. In this model, the user price concept (table 2) is close to the generalised cost concept in transport economics.

table 2: User price concept

Component	Function
fuel cost	cost element
vehicle and maintenance cost	cost element
(dis)comfort cost	in order to represent differences in trunk space, refuelling time, driveability among technologies
time cost	in order to represent changes in average speed due to congestion or policy measures

The generalised price concept is useful to represent the time costs per km and quality characteristics in addition to the out of pocket costs. In transportation economics, the time cost per km (equal to the value of time multiplied by inverse of speed) is used as an important component in the choice of travel mode. It allows to represent growing congestion and their impact on the modal choice (second level in figure 1). The model assumes that congestion would only occur for the road network without however a detailed modelling of the transport flows over time and of the infrastructure capacity extensions. It is modelled with a congestion function linking travel time to total transport flows on the road with an aggregated elasticity. A different congestion function is used for urban and non-urban transport. For the urban areas, we assume transport levels near to saturation, whereas for non-urban transport we assume the marginal travel time increase to be far lower.

The user cost concept can also take into account differences between technologies in other characteristics than out of the pocket costs. Quality differences are translated into (subjective) comfort costs per vehicle kilometre. Take as an example the more frequent refuelling of the CNG car compared to a reference technology (gasoline car). The subjective discomfort of this can be approximated by the increased refuelling time multiplied by the time cost.

2.2 DATABASE: CONSTRUCTION OF A CONSISTENT EU-WIDE DATASET FOR MODEL CALIBRATION

The PRIMES-transport model has been calibrated for two base years. For this calibration, a consistent set of data on fuel consumption, transport activity, vehicle stock, fuel efficiencies, mileages and loads needs to be provided for the different modes in both urban and non-urban passenger transport as well as for freight transport. The calibration procedure has been carried out for each of the EU15 countries separately.

Because of data availability, 1990 and 1995 have been chosen as calibration years. For more recent years, the information needed is only very partially available, and the quality of the data is low. For Germany, 1992 data has been used instead of 1990 figures, because of major political, economical and social changes in the early nineties, making it senseless to compare 1990 to 1995 data.

Most important data sources for the base year statistics are Eurostat, DG TREN (European Commission) as well as the outcomes of some dedicated projects realised for the European Commission, e.g. the MEET project (Hickman et al, 1999).

The update of base year statistics made clear that it is difficult to find EU15 wide figures for some transport statistics. Moreover, energy and transport statistics tend not to cover the same transport activity for some modes. Within transport statistics, figures turn out to be sometimes inconsistent when comparing different statistics, even when issued by the same source. Furthermore, data are not always published with the same degree of detail and that they do not necessarily match because of differences in aggregation and definition. For energy consumption, only aggregate figures for each fuel per mode are available. Other sources provide very detailed data. This leads to the problem that more data are available than the degrees of freedom in the calibration allow us to use. Therefore additional assumptions were needed in the calibration procedure to ensure consistency in the whole set of calibration data.

Besides the statistical problems, the modelling framework implemented in PRIMES-transport, imposes some constraints on the data in the calibration procedure, e.g. to be able to compare the costs of competitive vehicles (using different fuels), the annual mileage must be the same for all vehicles of the same mode (e.g. urban passenger cars).

Some statistical sources provide data on average load and overall vkm (in contrast to pkm). We decided not to use these figures in the calibration of the PRIMES-transport model, because this data are only available for a limited number of years, countries and transport modes (whereas the transport activity (pkm/tkm) statistics are provided for all countries and years needed), and they are often inconsistent with other statistics (e.g. comparing vkm statistics to the transport activity statistics in pkm).

3 THE REFERENCE SCENARIO

3.1 BASIC ASSUMPTIONS FOR THE REFERENCE SCENARIO

The reference scenario is a business as usual scenario, implying no major shifts in the transport activity. It is in line with the latest DGTREN projections (European Commission, 2003) and consistent with detailed EU transport modelling exercises that were set up to forecast transport flows by motive and mode on given transport networks (STREAMS (Marcial Echenique & Partners Ltd (ME&P) et al. 2000) and SCENES (ME&P, 2002)).

3.1.1 Macroeconomic activity and fuel prices assumptions

The assumptions for macroeconomic growth and for oil prices are given in table 3, they are based on the assumptions in the DGTREN projection (European Commission, 2003). The country specific assumptions give an EU-average growth rate of 2.3 % for economic activity. Beyond 2005, the crude oil price increase in real terms is 1.6 % and natural gas has a similar evolution with an average annual growth of 1.7 %. The associated prices for gasoline, diesel, LPG, heavy fuel (RFO) and kerosene are assumed to follow the same evolution. For biofuels (ETBE, biodiesel and bio-ethanol) the prices and their evolution until 2030 are derived from IEA (1999).

table 3: Assumption for EU growth and fuel prices in the reference scenario (annual average growth rate in %)

	2000-2005	**2005-2010**	**2010-2020**	**2020-2030**
GDP	2.3	2.5	2.3	2.2
Crude oil price	-7.5	1.0	1.8	1.6
Natural gas price	-0.7	2.5	1.9	1.2
Biodiesel	0.0	3.0	3.0	0.0
ETBE and bio-ethanol	0.0	2.3	2.3	0.0

3.1.2 Reference Policy Assumptions

3.1.2.1 Fuel taxation

Excise taxes and VAT rates for the period 2000-2030 were assumed to be equal to the values for 2000. For CNG taxes have been taken equal to those in LPG. Taxes on hydrogen are assumed to be the same as those for electricity. For bio-ethanol and ETBE the tax were put equal to those on gasoline, in order to respect current legislation. For biodiesel, the diesel figures were applied. The new EU rules on energy taxation (Directive 2003/96/EC) are not included in the reference scenario.

3.1.2.2 Fuel efficiency and CO_2 regulation

The main target of the voluntary commitment of the European, Japanese and Korean car manufacturers ("ACEA" agreement) is to reduce CO_2 emissions of new cars to an average of 140 g/km by 2008, compared to 186.4 g/km in 1995 (European Commission, 2000). Indicative target ranges to be met by 2003 are 165-170 g/km. This agreement implies a fuel efficiency improvement of 2.5 % a year between 2005 and 2010 and of 1 % between 2010 and 2015, above the general trend of 0.5 % a year.

This additional fuel efficiency improvement has been included in the reference scenario and is assumed to apply to all car technologies with internal combustion. A corresponding increase in the car prices is also assumed, estimated through the indirect method. This method is based on the "efficient market" assumption: in a competitive market manufactures will try to offer cars that have, for given comfort and size characteristics, the lowest users' cost, if for whatever reason a car manufacture can offer a more fuel-efficient vehicle at a lower capital cost such as to lower the total user's cost, he will do it. Therefore any car that, because of a standard, has to meet a better fuel efficiency than the one given by the reference technical progress, will be produced at a higher capital cost.

3.1.2.3 Conventional emission (non CO_2) regulation of vehicles (SO_2, NO_X, VOC, PM)

The reference takes into account for passenger cars the EURO 1, 2, 3, 4 regulations on conventional emissions and for heavy-duty vehicles, the regulations EURO 1 through 5. The sulphur content is lowered to 50 ppm from 2005 onwards for diesel and gasoline fuel, conform the EU regulation.

For rail and air transport no specific regulations are introduced. For waterborne transport, the existing regulations on diesel and gasoil are implemented (0.2 % sulphur content, lowered to 0.1 % by 2008).

3.2 MAJOR REFERENCE SCENARIO RESULTS

3.2.1 Evolution in the transport activity

The annual growth rate of transport activity (pkm for passenger and tkm for freight traffic) follows the assumed general activity evolution, though at a slightly lower rate for passenger transport and especially urban passenger transport. This slowdown is more pronounced after 2010 because of a certain saturation level and because of increased congestion on urban roads, which increases the cost of road transport.

Private car remains the dominant passenger transport mode though there is a slight shift towards rail transport for urban transport because of congestion. Air transportation is also a fast growing activity.

For freight transport, road is the dominant transport mode and the fastest growing, though there are some country differences in the shares, e.g. the Netherlands have about 40 % of their freight moved by boats.

The results are shown in table 4 for the EU as a whole, but they are an aggregate of individual country results.

table 4: Annual growth of activity in the EU (pkm or tkm) in %

	00-05	05-10	10-15	15-20	20-25	25-30
Urban passengers	**1.0 %**	**1.1 %**	**0.7 %**	**0.7 %**	**0.5 %**	**0.5 %**
Private car	1.1 %	1.1 %	0.7 %	0.6 %	0.4 %	0.3 %
Bus	0.1 %	0.2 %	0.0 %	0.0 %	-0.1 %	-0.1 %
Rail	1.1 %	1.4 %	1.1 %	1.1 %	1.0 %	0.9 %
Motorcycle	2.0 %	2.1 %	1.8 %	1.8 %	1.8 %	1.8 %
Non-urban passengers	**2.0 %**	**1.8 %**	**1.5 %**	**1.5 %**	**1.4 %**	**1.3 %**
Private car	1.7 %	1.5 %	1.2 %	1.0 %	0.9 %	0.8 %
Bus	0.9 %	0.8 %	0.5 %	0.4 %	0.3 %	0.2 %
Rail	1.0 %	0.9 %	0.7 %	0.6 %	0.5 %	0.5 %
Navigation	1.9 %	1.8 %	1.4 %	1.4 %	1.5 %	1.5 %
Aviation	4.8 %	4.3 %	3.8 %	4.2 %	3.8 %	3.3 %
Total passengers	**1.6 %**	**1.5 %**	**1.2 %**	**1.2 %**	**1.1 %**	**1.0 %**
Freight	**2.1 %**	**2.4 %**	**2.4 %**	**2.4 %**	**2.3 %**	**2.3 %**
Road	2.3 %	2.6 %	2.5 %	2.5 %	2.4 %	2.3 %
Rail	2.0 %	2.3 %	2.2 %	2.3 %	2.2 %	2.2 %
Navigation	1.6 %	2.0 %	2.1 %	2.2 %	2.3 %	2.3 %

3.2.2 Technology shares, energy demand and emissions

There is a further penetration of diesel in passenger car transport in nearly all countries because of a certain convergence between the production cost of gasoline and diesel (table 5, table 6). As mentioned before, the new EU Directive on energy taxation has not been included in PRIMES-transport. LPG technologies are also increasing their market share but it remains very low. RFO is penetrating substantially for navigation because of a favourable cost difference. There is quasi no penetration of new technologies over the entire horizon because of the moderate growth of the oil prices and because of the assumption that the current conventional fuel taxation level also applies to alternative fuels. Note that leaving out this tax would mean subsidising these technologies: indeed, the present fuel excises act as congestion and revenue raising taxes; as long as new fuels are exempted of fuel excises, this represents a huge implicit subsidy.

table 5: Technology share in urban and non urban passenger transport in the EU (%)

	Urban			Non-urban		
year	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Private car						
Gasoline Car	76 %	74 %	73 %	51 %	51 %	52 %
Diesel Car	22 %	24 %	25 %	44 %	42 %	38 %
LPG car	2 %	2 %	2 %	6 %	7 %	10 %
Ethanol Car	0 %	0 %	0 %	0 %	0 %	0 %
Electric Car	0 %	0 %	0 %	0 %	0 %	0 %
Compressed NG Car	0 %	0 %	0 %	0 %	0 %	0 %
Hydrogen Fuel Cell Car	0 %	0 %	0 %	0 %	0 %	0 %
Hydrogen ICE Car	0 %	0 %	0 %	0 %	0 %	0 %
Bus						
Diesel Bus	92 %	91 %	84 %	93 %	92 %	91 %
LPG Bus	1 %	2 %	3 %	1 %	1 %	2 %
Ethanol Bus	0 %	0 %	0 %	0 %	0 %	0 %
CNG Bus	0 %	0 %	0 %	0 %	0 %	0 %
Electric Bus	1 %	2 %	7 %	0 %	0 %	0 %
Hydrogen ICE Bus	0 %	0 %	0 %	0 %	0 %	0 %
Gasoline Bus	7 %	5 %	4 %	6 %	6 %	6 %
Rail						
Diesel Train	0 %	0 %	0 %	24 %	20 %	17 %
Electricity Train	100 %	100 %	100 %	76 %	80 %	83 %
Navigation						
Diesel ship				58 %	55 %	47 %
Gasoline ship				38 %	31 %	24 %
RFO ship				5 %	14 %	29 %

table 6: Technology share in freight transport in the EU (%)

year	**2010**	**2020**	**2030**
Road			
Diesel Trucks	95 %	97 %	98 %
LPG Trucks	0 %	0 %	0 %
Ethanol trucks	0 %	0 %	0 %
Compressed NG Trucks	0 %	0 %	0 %
Electric Trucks	0 %	0 %	0 %
Hydrogen ICE Trucks	0 %	0 %	0 %
Gasoline Trucks	5 %	3 %	2 %
Rail			
Diesel Train	21 %	18 %	15 %
Electricity Train	79 %	82 %	85 %
Navigation			
Diesel ship	66 %	58 %	48 %
Gasoline ship	2 %	1 %	1 %
RFO ship	32 %	40 %	51 %

The energy demand (table 7) follows the transport activity growth. There is a shift from gasoline to diesel and LPG in road transport and towards RFO in navigation associated with the shift in technologies.

table 7: Annual growth of the EU energy demand in %

	00-05	05-10	10-15	15-20	20-25	25-30
Gasoline	-1.2 %	-1.3 %	-0.8 %	-0.7 %	-0.3 %	-0.1 %
Diesel Oil	2.8 %	2.1 %	1.6 %	1.8 %	1.6 %	1.6 %
Ethanol	598.0 %	13.1 %	7.1 %	5.0 %	3.9 %	3.3 %
LPG	5.3 %	2.0 %	1.1 %	2.4 %	3.0 %	3.7 %
Electricity	1.5 %	1.6 %	1.4 %	1.4 %	1.4 %	1.4 %
RFO for navigation	6.5 %	6.1 %	5.4 %	5.1 %	4.9 %	4.5 %
Kerosene	4.4 %	4.0 %	3.7 %	4.1 %	3.7 %	3.3 %
Total (all fuels)	1.7 %	1.4 %	1.3 %	1.7 %	1.7 %	1.7 %

The CO_2 emissions are increasing continuously following the energy demand (table 8). The fuel efficiency improvement (resulting from the ACEA agreement between the European Commission and the car manufacturers) is cancelled out by the overall increase in transport activity.

The conventional emissions are decreasing mainly in road transport because of the EU regulations to comply with after 2005. The (small) move towards RFO fuelled boats has an important influence on the evolution of SO_2 emissions, cancelling partially the effect of the introduction of low sulphur fuels in road transport.

table 8: Index of EU emissions in ton (100 = emissions 2000)

	2000	2005	2010	2015	2020	2025	2030
CO_2	100	109	117	125	136	148	162
SO_2	100	89	86	91	102	118	138
NO_X	100	87	78	73	74	78	84
VOC	100	79	67	62	62	65	70
PAR	100	76	60	48	41	37	34

4 THE POLICY SCENARIOS

Four policy scenarios are considered:

- Enhanced fuel efficiency improvement for road vehicles
- Implementation of bio-fuels directives
- Reduction of the sulphur content in fuels for navigation
- Introduction of a distance-based toll for heavy duty vehicles on all motorways in Germany

An overall comparison of the social costs associated with the different scenarios is briefly discussed in the conclusions.

4.1 AN ENHANCED FUEL EFFICIENCY IMPROVEMENT FOR ROAD VEHICLES

4.1.1 The scenario specification

In this scenario a further improvement in the fuel efficiency for all road vehicles is assumed, above the actual ACEA-agreement which applies to private cars only and has already been included in the reference scenario. The definition of the level of improvement is based on the ACEA agreement as ACEA committed itself “to review the situation to evaluate the prospects for further reduction towards the Community’s objective of

120 g CO_2/km by 2012" (Acea, 1998). The assumption is that an enhanced agreement will allow for a further decrease of CO_2 real world emissions to 120 g CO_2/km by 2020. The efforts needed to meet this target are similar to those required in the pre-2012 period.

Moreover, besides the improvement in car fuel efficiency, it is assumed that an improvement in fuel efficiency for buses and freight vehicles would also be imposed. The assumption is that the reduction in CO_2 emissions for these categories would occur at the same pace as for private cars under the current agreements up to 2012. This means in PRIMES-Transport a decrease of 2.5 % p.a. for the 2005-2010 period and 1 % p.a. for the next period up to 2015.

As for the implementation of the ACEA agreement in the reference scenario, an increase in the capital cost of the technologies is computed through the indirect method.

4.1.2 Impact of the enhanced fuel efficiency

As the enhanced fuel efficiency standard increases the road transport cost and therefore the overall transport cost (table 9), it reduces the transport activity both for passenger and freight (table 10). The increase in cost is slightly tempered by the decrease in congestion, especially for urban passenger transport where its impact is the greatest for public transport. This induces a shift towards this transport mode.

table 9: Transport cost per pkm/tkm in the EU (% difference compared to reference)

	2010	2020	2030
Urban	**0,0 %**	**0,6 %**	**0,4 %**
Private car	0,0 %	0,8 %	0,7 %
Bus	0,1 %	-0,4 %	-1,1 %
Rail	0,0 %	0,0 %	0,0 %
Moto	0,0 %	0,1 %	0,2 %
Non-urban	**0,0 %**	**0,4 %**	**0,5 %**
Private car	0,0 %	0,6 %	0,8 %
Bus	0,2 %	0,4 %	0,3 %
Rail	0,0 %	0,0 %	0,0 %
Navigation	0,0 %	0,0 %	0,0 %
Aviation	0,0 %	0,0 %	0,0 %
Freight	**0,5 %**	**1,8 %**	**2,2 %**
Road	0,7 %	2,3 %	2,8 %
Rail	0,0 %	0,0 %	0,0 %
Navigation	0,0 %	0,0 %	0,0 %

table 10: Transport activity in the EU (% difference compared to reference)

	2010	2020	2030
Urban passengers	**0.0 %**	**-0.4 %**	**-0.3 %**
Private car	0.0 %	-0.5 %	-0.4 %
Bus	0.0 %	0.0 %	0.2 %
Rail	0.0 %	-0.1 %	0.0 %
Motorcycle	0.0 %	-0.1 %	0.0 %
Non-urban passengers	**0.0 %**	**-0.2 %**	**-0.3 %**
Private car	0.0 %	-0.3 %	-0.4 %
Bus	-0.1 %	-0.1 %	-0.1 %
Rail	0.0 %	0.0 %	0.0 %
Navigation	0.0 %	0.0 %	0.0 %
Aviation	0.0 %	0.0 %	0.0 %
Total passengers	**0.0 %**	**-0.3 %**	**-0.3 %**
Freight	**-0.3 %**	**-0.9 %**	**-1.1 %**
Road	-0.4 %	-1.3 %	-1.6 %
Rail	-0.1 %	0.0 %	0.2 %
Navigation	0.0 %	0.0 %	0.2 %

The improvement in fuel efficiency associated with the reduction in transport activity induces a decrease in energy demand and in the emissions (table 11) having thus a positive impact on the damage from the transport activity which is reduced with 8.9 % in 2030.

table 11:EU energy consumption and emission (% difference compared to reference)

	2010	2020	2030
CO_2	-1.8 %	-7.2 %	-9.5 %
SO_2	-0.2 %	-1.5 %	-1.0 %
NO_X	-1.4 %	-6.9 %	-8.5 %
VOC	-0.9 %	-5.2 %	-7.0 %
PAR	-0.5 %	-8.4 %	-12.0 %
Total energy consumption	-1.7 %	-7.0 %	-9.2 %

The technology cost increase is however not sufficient to induce a shift to alternative fuels or technologies. One observes only a slight shift towards gasoline cars in detriment of diesel car and LPG busses are replaced with diesel and electric busses.

4.2 IMPLEMENTATION OF THE BIOFUELS DIRECTIVES

4.2.1 The scenario specification

A recent directive by the European Parliament and the Council promotes the introduction of biofuels (among other renewable fuels) in the transport market (directive 2003/30/EG). This directive can contribute to the Kyoto GHG reduction target and also reduce the oil dependence of the EU.

The directive requires the member countries to reach certain targets for the shares of biofuels in the transport sector: 2 % in 2005, 5.75 % by 2010. How to reach this target is not stipulated. Different approaches can be applied, going from general blending (e.g. 5 % biodiesel in all diesel consumed) to switching entire fleets to neat biofuel engines.

The biofuels included in PRIMES-transport are biodiesel, ETBE and bio-ethanol. In this scenario, it is assumed that biodiesel and ETBE are blended with mineral diesel respectively gasoline for all transport applications. As these blends can be used in all conventional engines without adaptation providing the biodiesel or ETBE share is not higher than 5 %, the share assumed is 1 % in 2005 and 5 % from 2010 on. These assumptions are based on Arcoumanis (2000). The change in emission factors resulting from the biofuel blends is calculated based on data provided by the same source. For diesel powered vehicles, we assume particulate matter and VOC emission to decrease when biodiesel is blended whereas a small increase in NO_X emissions is expected. For vehicles running on gasoline, only very small changes to emission factors are assumed. In both applications, zero CO_2 emissions are assumed for the biofuel share. Moreover, bio-ethanol is available in a 85/15 mix (15 % gasoline) to be consumed by dedicated vehicles.

These technical options are complemented with an assumption on the excise taxes, following an EU directive in preparation, which will allow for reduced excise taxes on biofuels (European Commission, 2001). It is expected that the allowed reduction will be equal to the share of the biofuel in the blend but not higher than 50 % of the excise on the corresponding unblended mineral component. As it is meant to promote an initial penetration of biofuels, it is limited up to 2011. For this scenario it is assumed that the excise taxes on the 85/15 ethanol mix are reduced to 50 % of those on gasoline up to 2010 and the excise taxes on the diesel and gasoline bioblends are reduced by the share of the bio-component (in other words, the biofuel share is untaxed) up to 2010, in line with the directive proposal from the Commission.

It is important to note that in the reference no blending of biodiesel or ETBE is assumed and that the excise taxes on the 85/15 ethanol/gasoline mix are equal to those on gasoline.

4.2.2 Impact of the biofuels policy

Imposing the blending of biofuels in gasoline and diesel increases slightly the cost of the fuels (table 12) even with the excise tax abatement until 2010. Hence the transport activity decreases (table 13). Non urban passenger transport and freight transport are decreasing respectively with 0.1 % and 0.3 %. There are no significant changes in urban passenger transport, the decrease in congestion compensating the cost increase and favouring bus transport.

table 12: Transport cost per pkm/tkm in the EU (% difference compared to reference)

	2010	2020	2030
Urban	**0,2 %**	**0,0 %**	**0,0 %**
Private car	0,2 %	0,0 %	0,0 %
Bus	0,1 %	0,0 %	-0,1 %
Rail	0,0 %	0,0 %	0,0 %
Moto	0,2 %	0,1 %	0,2 %
Non-urban	**0,4 %**	**0,3 %**	**0,2 %**
Private car	0,6 %	0,5 %	0,3 %
Bus	0,2 %	0,2 %	0,1 %
Rail	0,2 %	0,2 %	0,1 %
Navigation	0,2 %	0,2 %	0,1 %
Aviation	0,0 %	0,0 %	0,0 %
Freight	**0,4 %**	**0,6 %**	**0,5 %**
Road	0,5 %	0,7 %	0,6 %
Rail	0,1 %	0,1 %	0,1 %
Navigation	0,2 %	0,3 %	0,2 %

table 13:EU Transport activity (% difference compared to reference)

	2010	2020	2030
Urban passengers	**-0.1 %**	**0.0 %**	**0.0 %**
Private car	-0.1 %	0.0 %	0.0 %
Bus	0.0 %	0.0 %	0.0 %
Rail	0.0 %	0.0 %	0.0 %
Motorcycle	-0.1 %	-0.1 %	-0.1 %
Non-urban passengers	**-0.2 %**	**-0.2 %**	**-0.1 %**
Private car	-0.3 %	-0.2 %	-0.2 %
Bus	-0.1 %	-0.1 %	0.0 %
Rail	-0.1 %	-0.1 %	-0.1 %
Navigation	-0.1 %	-0.1 %	-0.1 %
Aviation	-0.1 %	0.0 %	0.0 %
Total passengers	**-0.2 %**	**-0.1 %**	**-0.1 %**
Freight	**-0.2 %**	**-0.3 %**	**-0.3 %**
Road	-0.3 %	-0.4 %	-0.4 %
Rail	-0.1 %	-0.1 %	0.0 %
Navigation	-0.1 %	-0.2 %	-0.1 %

The overall energy consumption is decreasing slightly (table 14). Besides the shift towards biofuels due to the blending assumptions, there is no further penetration of biofuels. Ethanol cars remain too expensive even with the tax exemption. There is also a slight shift towards LPG which cost does not increase.

table 14: EU energy consumption and emission (% difference compared to reference)

	2010	2020	2030
CO_2	-4.2 %	-4.0 %	-3.7 %
SO_2	-2.3 %	-0.9 %	-0.1 %
NO_X	1.0 %	1.1 %	1.1 %
VOC	-4.1 %	-3.4 %	-2.9 %
PAR	-3.9 %	-4.8 %	-5.4 %
Total Energy Consumption	-0.2 %	-0.2 %	-0.2 %

The main impact of this scenario is on emissions and principally on CO_2 and particulates emissions and on SO_2 emissions in the begin period when the SO_2 standards are not yet so stringent in the reference scenario (table 14). Total damage is reduced with 1.4 % compared to the reference. The loss in tax income is limited to the first two periods 2005 and 2010, after 2010 the reduction in tax income accompanies the reduction in transport activity.

4.3 SULPHUR CONTENT OF FUEL FOR NAVIGATION

4.3.1 The scenario specification

The sulphur content in gasoline and diesel for road transport has been declining for years and following the latest EU directive will reach 50 ppm in 2005. A recent communication of the European Commission to the European Parliament and the Council puts forward a strategy to reduce atmospheric emissions from seagoing ships (European Commission, 2002). Together with this communication, a proposal for a directive was issued to amend the existing directive 1999/32/EC concerning the sulphur content of marine fuels (European Commission, 2002a).

The policy measures considered in the proposal include the introduction of a sulphur limit of 1.5 % (15000 ppm) for all marine fuels, including heavy fuel oil (residual fuel oil - RFO), used in the North Sea, English Channel as well as the Baltic Sea. This limit should also apply to all regular passenger ship services to or from any EU port. In order to reduce local pollution in port areas, the use of fuels by ships at berth in all Community ports will be required to contain 0.2 % sulphur or less (0.1 % by 2008). The proposal also includes measures to ensure the availability of the required fuels in all ports as well as the prohibition to sell fuels with a sulphur content exceeding a given limit.

As in the PRIMES-transport model only domestic navigation, both maritime and inland waterways transport, is considered which is only part of the navigation transport activity, the proposal's policy could not be implemented exactly. However, we put forward a similar policy measure for the navigation in PRIMES: it is assumed that the fuel content of RFO will go from 2.7 % in the reference to a maximum of 1.5 % by 2005 The cost of this reduction of the sulphur content is taken into account by increasing the price of RFO by € 12.5 (ECU90) per toe (European Commission, 2002a). No measures are considered for the other emissions from marine transport, though the accompanying communication includes other emission reduction targets to be met in future.

Transport activity figures on international navigation activity in the EU are difficult to estimate. Energy consumption statistics are available from the DG TREN energy balances, providing some indication on the ratio international to domestic navigation. For RFO, bunker sales amount to 30,485 ktoe in 1997, whereas domestic navigation consumes 1,114 ktoe. However, one should be careful in linking bunker sales to emissions location, as the merchant fleet is known to bunker large volumes where fuel is cheap rather than between every two trips.

4.3.2 Impact of a decrease of the sulphur content in RFO for navigation

The rise in the price of RFO (table 15) induces a reduction in navigation freight transport and a shift away from RFO for both freight and passengers navigation. However it does not have an impact on the overall transport activity as navigation represents only a small share of the total. The SO_2 emissions (table 16), the principal target of the policy measure, drop significantly, due to the large share of navigation with RFO in the reference especially at the end of the horizon where it is the main source of SO_2 emissions. It should be noted that there is a large potential for reduction of SO_2 emissions through a further reduction of the sulphur content of marine fuels. Moreover the RFO consumption considered in the model (around 2.4 Mton in 2005) is lower than the consumption projected by the Commission for 2006, 11 Mton. This could also increase the impact of the policy measure. A rise in the demand for low sulphur RFO is likely to increase the price for low sulphur RFO inducing a further decrease in activity and a larger shift to other fuels in navigation. Both evolutions will reinforce the aimed policy result.

table 15: Transport cost per tkm in the EU (% difference compared to reference)

	2010	2020	2030
Freight	**0,0 %**	**0,0 %**	**0,0 %**
Road	0,0 %	0,0 %	0,0 %
Rail	0,0 %	0,0 %	0,0 %
Navigation	0,1 %	0,2 %	0,4 %

table 16: Energy consumption and emission (% difference compared to reference)

	2010	2020	2030
CO_2	0.0 %	0.0 %	0.0 %
SO_2	-11.6 %	-23.2 %	-30.5 %
NO_X	0.0 %	0.0 %	-0.1 %
VOC	0.0 %	0.0 %	0.0 %
PAR	0.0 %	0.0 %	0.0 %
Total Energy Consumption	0.0 %	0.0 %	0.0 %

The reduction in SO_2 emissions brings also a reduction of the damage from transport activity. Combined with a policy aiming at a reduction of the direct particulate emission, another main source of damage in the transport sector, this policy could contribute in a substantive way to the reduction of damage from transport.

4.4 THE LKW-MAUT ROAD FREIGHT TAX IN GERMANY

4.4.1 The scenario specification

The German Federal Government plans the introduction of a distance-based toll for heavy duty vehicles on all motorways (Bundesautobahnen) from August 31, 2003. This system is called “LKW Maut” and will apply to all freight vehicles with a gross weight of 12 tons and above, both domestic and foreign. The number of kilometres driven will be registered making use of an automatic electronic system mounted in each vehicle, discarding the need for toll boots.

The level of the toll is a function of the number of axis and of the emission class - see table 17 (Toll Collect GmbH, 2003).

table 17: Road freight toll in Germany (€/km)

Number of axis	Emissions class A	Emissions class B	Emissions class C
up to three	€ 0.09	€ 0.11	€ 0.13
four or more	€ 0.10	€ 0.12	€ 0.14

As in PRIMES-transport no distinction is made between motorways and other roads, emission classes vintages and number of axis, an average toll has been implemented for all road freight vehicles such that the overall revenue for the government stays the same and taking into account the emissions classes shares and the shares of Bundesautobahnen and Bundesstrassen at one hand and the sub 12 ton and heavier vehicles at the other hand from a report by Prognos and IWW (2003). In Primes, where 5 year period are considered, the toll has been applied in Germany from 2005 onwards and its level amounts to € 0.045 (€2003) per kilometre on all roads. This increases the cost per tkm about 8 %.

4.4.2 Impact of the road freight tax in Germany

The distance based road toll for freight vehicles results in a small reduction of overall freight transport activity (table 19). There is a small decline also for non-road freight transport although only the price of road freight (table 18) is directly increased because the overall activity is decreasing. However there is a shift towards non road transport and this shift is increasing over time. A smaller number of trucks on the roads means less congestion, resulting in a decrease of road passenger transport costs and a small increase in passenger transport activity.

table 18: Transport cost per pkm/tkm in Germany (% difference compared to reference)

	2010	2020	2030
Urban	**-0,3 %**	**-0,4 %**	**-0,5 %**
Private car	-0,3 %	-0,4 %	-0,6 %
Bus	-0,9 %	-0,9 %	-1,0 %
Rail	0,0 %	0,0 %	0,0 %
Moto	0,0 %	0,0 %	0,0 %
Non-urban	**-0,1 %**	**-0,1 %**	**-0,2 %**
Private car	-0,1 %	-0,2 %	-0,2 %
Bus	-0,1 %	-0,2 %	-0,2 %
Rail	0,0 %	0,0 %	0,0 %
Navigation	0,0 %	0,0 %	0,0 %
Aviation	0,0 %	0,0 %	0,0 %
Freight	**6,5 %**	**6,3 %**	**6,0 %**
Road	8,4 %	8,2 %	7,9 %
Rail	0,0 %	0,0 %	0,0 %
Navigation	0,0 %	0,0 %	0,0 %

table 19: Freight transport activity in Germany (% difference compared to reference)

Total	**-3.5 %**	**-3.3 %**	**-3.1 %**
Road	-4.6 %	-4.6 %	-4.5 %
Rail	-1.1 %	-0.4 %	+0.1 %
Navigation	-0.8 %	-0.3 %	+0.1 %

Specific fuel consumption is lower for freight transport, due to a shift away from road to more fuel efficient modes (train and navigation). There is an overall decrease in energy consumption of around 1.5 % which is accompanied by a decrease in emissions and therefore in damages. As such, the net environmental result of the LKW Maut system is clearly positive but still limited.

5 CONCLUSION

Different policy proposals on the table at EU and national level to address some of the main issues linked to transport were evaluated with the applied partial equilibrium model of the EU transport sector, PRIMES-transport. The policies evaluated are an enhanced fuel efficiency improvement for road vehicles, the implementation of the EU bio-fuels directives, a reduction of the sulphur content in fuels for navigation and the introduction of a distance-based toll for heavy duty vehicles on all motorways in Germany.

Both the extension of the ACEA agreement and the biofuels blending have a positive impact on CO_2 emissions and conventional emissions and contribute to the energy security target through a reduction in energy consumption, either directly or through the substitution of imported mineral oils. They do not have a great impact on transport activity. Reducing the excise tax in the initial period of the biofuel policy may represent a rather high cost (table 20), as it does not contribute to a penetration of the dedicated bio fuels technologies. In the long term (2030), fuel efficiency improvements remain less costly per unit of environmental damage decrease compared to the introduction of biofuels. We should remind that social costs related to energy security are not considered in PRIMES-transport and may influence the overall assessment of these scenarios.

Imposing a sulphur standard on RFO for navigation, one of the remaining sources of SO_2 emissions can induce a drastic reduction in sulphur emissions and the generated damage. The overall decrease in environmental damage is comparable to the biofuels scenario. However, the cost of this measure remains very low, as the increase in the cost per tkm in navigation is not more than 0.5 %. In comparison to the fuel efficiency scenario, we observe a lower cost per unit of environmental damage increase in the low sulphur RFO scenario. We should remind that only part of the marine navigation is included in PRIMES-transport and therefore the potential of the RFO measure may be considerably larger as assessed here.

table 20: Scenario cost in million ECU90 (for EU15)

	Fuel efficiency		**Biofuels**		**Low sulphur RFO**	
	2010	**2030**	**2010**	**2030**	**2010**	**2030**
Consumer surplus loss	3362,7	30778,4	5795,8	5793,2	74,2	360,6
Environmental damage	-209,1	-1498,3	-209,6	-222,1	-47,3	-235,7
Tax income loss	2114,2	4462,2	6944,3	444,9	-3,7	-13,2
Total welfare loss	5267,8	33742,3	12530,5	6015,9	23,2	111,7
Total welfare loss/GDP	0,06 %	0,23 %	0,13 %	0,04 %	0,000 %	0,001 %

The introduction of a toll for heavy duty vehicles in Germany reduces the freight transport activity considerably through the tax increase. Compared to the other measures, the decrease of environmental damage relative to the loss in consumer surplus remains modest. However, this scenario generates a large tax income for the government, resulting in a overall welfare gain.

table 21: Scenario cost in million ECU90 (for Germany)

	Fuel efficiency		**Biofuels**		**Low sulphur RFO**		**LKW-Maut**	
	2010	**2030**	**2010**	**2030**	**2010**	**2030**	**2010**	**2030**
Consumer surplus loss	267,3	5059,2	1068,2	1042,5	0,6	10,4	3338,8	3824,8
Environmental damage	-61,0	-429,1	-43,0	-37,8	-1,8	-26,0	-68,1	-84,9
Tax income loss	355,6	1672,2	1493,4	35,6	-0,2	-2,2	-4881,4	-7263,0
Total welfare loss	561,9	6302,2	2518,6	1040,2	-1,4	-17,7	-1610,6	-3523,2
Total welfare loss/GDP	0,02%	0,17%	0,10%	0,03%	0,00%	0,00%	-0,06%	-0,09%

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ANNEX: THE BEHAVIOURAL PARAMETERS IN PRIMES-TRANSPORT

5.1 INCOME AND PRICE ELASTICITIES

5.1.1 Passenger traffic

The values for the income and price elasticities of passenger traffic used in the PRIMES-transport model can be found in table 22.

table 22: Passenger traffic (pkm) elasticities of overall traffic demand

	Price elasticity (money cost)	**Income elasticity (CE) 1990-2010**	**Income elasticity (CE) 2010-2030**
High GDP/pop countries	0.6	0.8	0.8
Low GDP/pop countries	0.6	1.1	0.8

The mode specific elasticities are given in table 23.

table 23: Passenger traffic (pkm) elasticities for different modes

	income elasticity (CE)	**price elasticity (money cost)**
Private car	1.2	-0.7
Bus	0.7	-0.2
Train	0.9	-0.2
motorized two-wheelers	1.2	-0.3
navigation	0.8	-0.1
air	2.2	-0.7

5.1.2 Freight traffic

The elasticities for overall freight traffic are given in table 24 and for modal split in table 25.

table 24: Freight traffic (tkm) elasticities of overall traffic demand

	Price elasticity (money cost)	**Income elasticity (Value added in three sectors)**
High GDP/pop countries	-0.6	1.0
Low GDP/pop countries	-0.6	1.0

table 25: Freight traffic (tkm) elasticities for different modes

	income elasticity (VA)	**price elasticity (money cost)**
trucks	1.1	-0.9
train	0.9	-0.2
navigation	0.7	-0.2

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