ASSESS

Assessment of the contribution of the TEN and other transport policy measures to the mid-term implementation of the White Paper on the European Transport Policy for 2010

FINAL REPORT
ANNEX VII TREMOVE MODEL RESULTS

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Preface

This is ANNEX VII of the final report for *'Assessment of the contribution of the TEN and other transport policy measures to the mid-term implementation of the White Paper on the European Transport Policy for 2010'*.

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Scope

Scope of the ASSESS project

The ASSESS study is about the ***"Assessment of the contribution of the TEN and other transport policy measures to the mid-term implementation of the White Paper on the European Transport Policy for 2010"***.

The European Commission's White Paper of 12.9.2001 "European transport policy for 2010: time to decide" aims to promote a sustainable transport policy. The White Paper proposes to achieve sustainability by gradually breaking the link between transport growth and economic growth, principally in three ways: changing the modal split in the long term, clearing infrastructure bottlenecks and placing safety and quality at the heart of the transport policy.

As foreseen, the White Paper on Transport undergoes in 2005 an overall ***assessment concerning the implementation of the measures it advocates and to check whether its targets*** - for example, on modal split or road safety - ***and objectives are being attained or whether adjustments are needed.***

ASSESS provides technical support to the Commission services for the above mid-term assessment of the White Paper.

The analysis accounts for the economic, social and environmental consequences of the proposed measures and their contribution to sustainable development objectives. It provides also a detailed analysis of those effects of enlargement likely to affect the structure and performance of the EU transport system.

The study takes a three pillar approach based on the use of analysis, indicators and models. National transport policies are reviewed for compatibility and coherence with the White Paper objectives. The models used allow a detailed analysis of the freight market, the passenger market and their infrastructure networks under a number of scenarios.

Scope of this Annex

This annex provides an overview of the TREMOVE model structure, the setup of the four ASSESS scenarios and a presentation of the model results.

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ANNEX VII TREMOVE model results

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TREMOVE is a transport and emissions simulation model developed for the European Commission Directorate-General Environment. The model has been developed by the Catholic University of Leuven and Transport & Mobility Leuven, in collaboration with their subcontractors[1].

The model estimates the transport demand, the modal shifts, the vehicle stock turnover, the emissions of air pollutants and the welfare level under different policy scenarios. TREMOVE models both passenger and freight transport in the EU15 plus 6 extra countries, and covers the period 1995-2020.

The TREMOVE model has been used within the ASSESS project. Four scenarios have been developed using the SCENES model. TREMOVE then has been used to assess these scenarios in further detail and to calculate indicators. The application of TREMOVE enables a detailed assessment of vehicle fleet and emission evolutions up to 2020 for all transport modes. The model also provides estimates on changes in governments tax revenues from the transport sector, impacts on travel times and eventually changes in overall welfare.

This annex provides an overview of the TREMOVE model structure, the setup of the four ASSESS scenarios and a presentation of the model results.

VII.1. TREMOVE model structure

VII.1.1. Overview

TREMOVE is a policy assessment model to study the effects of different transport and environment policies on the emissions of the transport sector. It is an integrated simulation model developed for the strategic analysis of the costs and effects of a wide range of policy instruments and measures applicable to local, regional and European transport markets.

The first versions of the TREMOVE model were developed in 1997-1998 by the university of Leuven and Standard & Poor's DRI as an analytical underpinning for the European Auto-Oil II Programme (European Commission, Standard & Poors' DRI, K.U.Leuven, 1999). The ASSESS analysis has been performed using TREMOVE version 2.3 (De Ceuster, Franckx, 2005), which has been developed in the context of the European Clean Air for Europe Programme.

TREMOVE 2.3 covers 21 countries and 8 sea regions. All relevant transport modes are modeled, including air and long-distance maritime transport. The model covers the 1995-2020 period, with yearly intervals.

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[1] Subcontractors included WSP, TRT, INFRAS, COWI, TRL, GAMS software and ADPC

Figure 1 maps the modular structure of TREMOVE. The model performs a year-by-year loop over its modules. The same modules are used for both the construction of the baseline scenario as for the evaluation of policy scenarios.

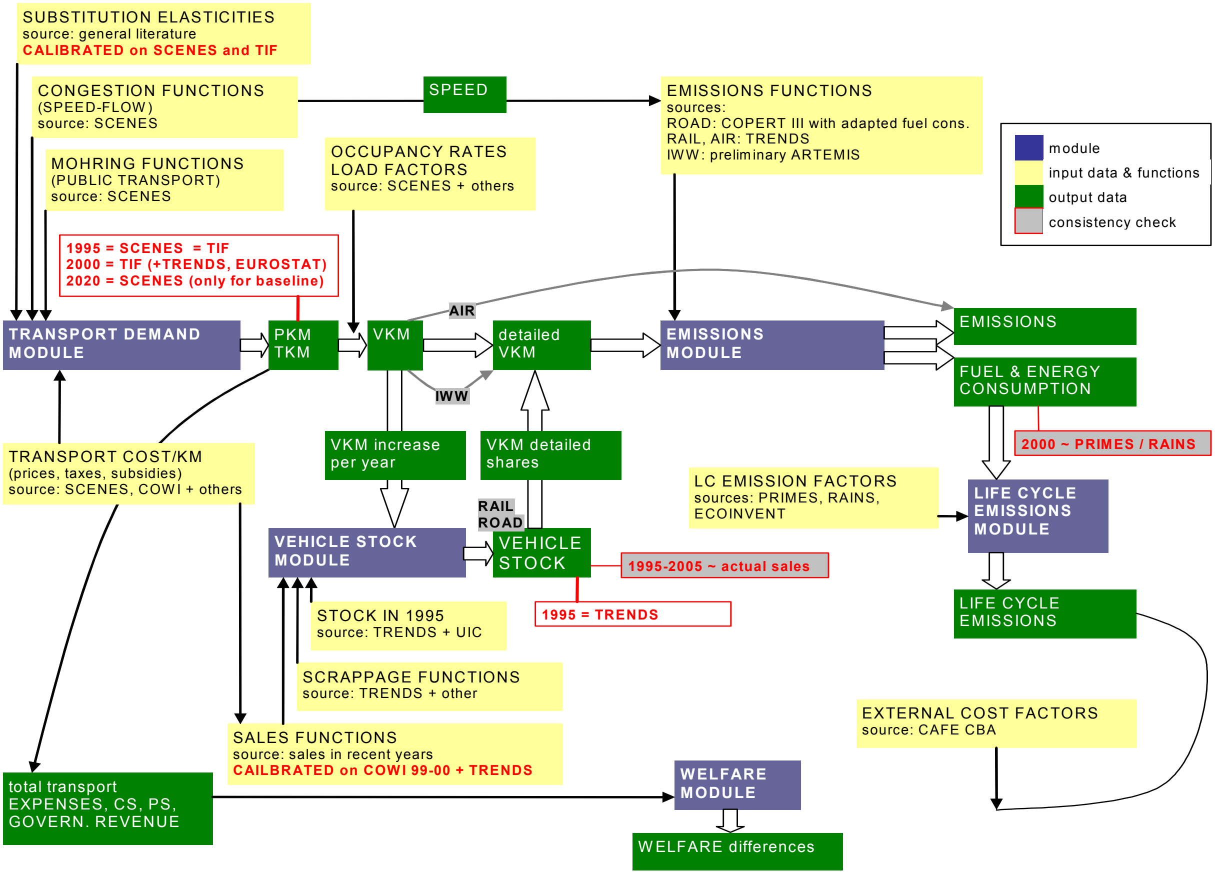

Figure 1 : Modular Structure of TREMOVE 2.3 model

VII.1.2. Transport demand and welfare modules

VII.1.2.1. Scope of the TREMOVE demand module

The TREMOVE model consists of separate country models. While the numeric values of the model differ from country to country, the structure is identical across countries. Each country model describes transport flows and emissions in three model regions: one metropolitan area, an aggregate of all other urban areas and an aggregate of all non-urban areas. Trips in the non-urban areas are further separated in short (-500 km) and long (+ 500 km) distance trips. The model explicitly takes into account that, depending on the area taken into consideration, the relevant modes and road types differ significantly.

The transport demand module represents, for a given year and transport mode, the number of passenger-kilometres (pkm) or ton-kilometres (tkm) that will be performed in each “model region” of the country considered. In this representation, demand is broken down in peak and off-peak demand. With this demand module, the impact of policy measures on the transport quantity of all transport modes is calculated.

Transportation modes for passenger trips comprise small car, large car, light duty trucks, motorcycle, moped, slow mode, bus, train and plane. Freight trips are using inland waterways, freight train, light duty trucks or heavy duty trucks. Furthermore four road types are distinguished as well as three freight categories (bulk, unitized and general cargo) and three passenger trip purposes (non-work, commuting and business trips).

TREMOVE models the transport activities within these areas without explicit network disaggregation. This simplification allows us to calibrate a simple but complete policy simulation model on top of a baseline of transport flows. These baseline transport flows are taken from the SCENES model (ME&P, 2000) which is a genuine network model. Thus, to a certain extent, the TREMOVE demand module is a reconstruction of the SCENES model.

VII.1.2.2. Modeling transport decisions of households and firms

Private transport and business transport are modelled separately in the transport demand module.
The demand for private transport (non-work and commuting passenger trips) is the result of the decision processes of all households in a country. Therefore, private traffic demand has been determined assuming that, within the constraints of their available budget, households choose their preferred consumption bundle. I.e. they choose the combination of goods that maximizes their utility. The demand for goods and services follows then from this maximizing behaviour.

The decision processes of households are modelled using nested Constant Elasticity of Substitution (or CES) utility functions (Keller, 1976). These represent the preference relation of all households for the different transport options. Knowing the substitution elasticities between the different transport options, it is possible to model the change in consumed quantities in policy simulations.

The demand for business transport (freight transport and business passenger trips) is modelled as a result of the decision processes within firms. The business transport demand is determined by generalized prices, desired production quantities and substitution possibilities with other production factors.

It is assumed that, in any given year, the production level of all firms in a country is given and kept constant. For a given production level, profit maximization then is equivalent with cost minimization. The cost-minimizing substitution processes is represented by a nested CES production function. At the highest level, there is the total production, which is a function of the components at the lower levels. At the lowest level, the arguments are the inputs in the production process. The latter inputs include, amongst others, freight transportation and business passenger trips.

VII.1.2.3. Transport prices

Transport users react on the generalized price of transport. Therefore, the price is represented as a sum of detailed price components.

The resource cost for transport services consists of the monetary producer costs of all inputs necessary for these services (cars, fuels, maintenance, etc.). The resource costs are calculated in detail in the vehicle stock module or derived from the SCENES model (depending on the mode).

On top of the resource costs, the consumer usually pays taxes or receives a subsidy. Both have been taken into account to calculate the market price. The distinction between user prices and costs is important for the welfare assessment module, as it determines the governments tax revenue from the transport sector. In the demand module, transport users are assumed to make their decision on the basis of user prices.

Furthermore, time costs are added in the generalized price. Time costs depend on the 'value of time' of the considered travel mode and the travel speed. The speed is modelled explicitly and varies with transport demand, time period and road type. The speed values are also used in the calculation of emissions as discussed in Section VII.1.3.

VII.1.2.4. Simulations

Baseline transport demand is taken from the SCENES model. The TREMOVE demand module then enables to assess changes in transport demand under various policy scenarios. Policy measures will affect the generalised prices of transport in the demand module. The prices can be affected by technological measures and new taxation or regulation policies as illustrated in Section VII.1.5. Within the demand module, these new prices will lead to a change transport demand. Overall transport volumes will alter and substitution between modes will occur. As a consequence also congestion, travel speed and the time price of transport will be affected.

VII.1.2.5. Welfare module

To evaluate policies in TREMOVE, a welfare assessment module has been constructed. Differences in welfare between the base case and the simulated policy scenarios are calculated.

Based on the utility functions for the private transport demand, the aggregate utility level of households is quantified. The modelling of business decisions leads to an aggregate measure for the change in production costs of firms. Additionally, welfare changes stemming from changes in tax revenues are incorporated by using the marginal cost of public funds. This latter approach accounts for the options of the government to beneficially use additional tax revenues from the transportation sector to lower taxes in other sectors. The external costs caused by emissions are calculated in detail as explained in the next section. The costs of these emissions are also incorporated in the welfare evaluation of policy measures.

VII.1.3. Vehicle stock and emissions modules

VII.1.3.1. Vehicle stock

The demand module produces aggregate transport quantities by mode. The vehicle stock module disaggregates these into detailed vehicle-kilometer figures by vehicle type, vehicle technology and vehicle age. This requires a detailed modeling and forecasting of the vehicle fleet structures for each mode.

Road and rail vehicle fleet evolution is modelled using a classic scrap-and-sales approach. Each year scrap rates are applied to estimate the number of scrapped vehicles. Total vehicle sales by mode then can be derived by comparing remaining vehicle stock to the stock needed to fulfill transport demands. The following step then is to disaggregate total sales by mode into sales by vehicle type and technology.

For cars, motorcycles, light duty trucks and buses the disaggregation by vehicle type is performed using a discrete choice (multinomial) logit model. The logit models have been calibrated on (mainly) data from COWI (COWI, 2001) and EUROSTAT. The most extended logit model is used for car purchase modeling. The market shares of the 13 car types (including 6 hybrid types) in total sales are a function of following parameters:

- Engine displacement (< 1.4 litre, 1.4-2.0 litre, > 2.0 litre)
- Fuel type

- Acceleration performance
- Total (lifecycle) cost per vehicle-kilometer

The heavy duty trucks and trains disaggregation in the baseline is based upon exogenous inputs. The share of the four truck weight classes is derived from German and Italian road counts on different road types. The baseline sale shares for trains have been determined such that the 1995-2020 evolution of the train fleet is consistent with the long-term trends in the TRENDS database (Georgakaki, Coffey, Sorenson, 2002)[2]. Both for trains and heavy duty trucks the exogenous assumptions can be changed in policy simulations.

For road vehicles, the vehicle types are further split up according to their technology. The technologies modelled in the baseline correspond with the EU emission standards. They are directly linked to the vintage of the vehicle.

TREMOVE distinguishes 21 inland waterway vessel types, classified according to size and freight category. The model does not include an explicit scrap-and-sales model for vessels. Instead, shares of different vessel types in total transport are exogenous. Though the model includes a module for the simulation of engine replacements/maintenance, retrofit of after-treatment equipment and alternative fuel quality standards. The baseline fleet composition forecast for the 21 vessel types in TREMOVE is based upon detailed Dutch statistics (CBS[3]) and predictions (AVV[4]) on domestic and international movements. Where needed extrapolations to other countries have been performed taking into account differences in inland waterway network characteristics between countries.

No vehicle fleet is modelled for aircrafts. The demand module disaggregates total air transport into 5 distance classes. Fuel consumption and emissions then are calculated using factors that implicitly account for differences in fleet composition for the 5 distance classes.

VII.1.3.2. Fuel consumption and emissions

In the *fuel consumption and emissions module* fuel consumption and exhaust and evaporative emissions are calculated for all modes. Emission factors have been derived consistently from EU sources, thus might deviate from national estimates.

For road vehicles TREMOVE 2.3 emission factors are based upon the copert III emission calculation methodology (Ntziachristos, Samaras, 2000), to which following additions have been made :

- Disaggregation of COPERT diesel car fuel consumption factor into three factors according to engine displacement, based upon EU CO_2 monitoring data[5];
- Upward scaling of COPERT fuel consumption factors for 2002 cars, based upon EU test-cycle monitoring data and information on the difference between test-cycle and real-world fuel consumption (a.o. Van den Brink, Van Wee, 2001);

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[2] Note that, within the ASSESS project, the shares of HST trains in the future fleet has been derived from the SCENES model and its assumptions on the implementation of the TENs.

[3] Dutch Central Bureau for Statistics

[4] Dutch Ministry of Transport, Public Works and Water Management.

[5] The monitoring decision can be found in the Official Journal of the European Communities L 2020, 10.8.2000, p.1

- Introduction of fuel efficiency improvement factors up to 2009. For cars these are based upon the voluntary agreements between EU and the car industry[6]. For other road vehicles predictions are derived from the Auto Oil II Programme;
- Update of moped and motorcycle emission factors based on recent information (Ntziachristos, Mamakos, Xanthopoulos, Iakovou, 2004);
- Emission factors for CNG buses (based on a.o. MEET : Hickman, 1999) and hybrid cars.

Fuel consumption and emission factors for diesel trains and aircrafts (by distance class) have been derived from the TRENDS dB (Georgakaki, Coffey, Sorenson, 2002) and pSIA Consult, 2002). For electric trains, trams and metros only total energy consumption (kWh) is calculated in this module.

The fuel consumption and emission factors for inland waterway vessels have been calculated following the *first version* of the approach developed within the ARTEMIS project (Georgakaki, 2003). Factors have been estimated using data on vessel characteristics for the 21 types included in TREMOVE and using estimates on waterway characteristics.

VII.1.3.3. Lifecycle emissions

In TREMOVE, a restricted lifecycle assessment module is implemented, focusing on the fuel cycle only. To concentrate on fuel implies that not only operational emissions of vehicles, but also emissions due to production and distribution of the fuel (or electricity) are taken into account. I.e. well-to-tank and tank-to-wheel emissions are calculated. Well-to-tank emission factors for fossil fuels were derived from the Swiss ECOINVENT database (Ecoinvent Centre, 2004). Electricity production emission factors by country have been provided by the RAINS (IIASA, 2004) and PRIMES (Mantzos, Capros) modellers, except for CH_4 and CO emission factors, which have been taken from MEET.

VII.1.4. The maritime model

The approach adopted for maritime transport is based on the recent work performed by ENTEC (2002) on activity and emissions from ships in the European Community. As maritime transport is allocated to maritime regions, it is not linked directly to the different country models. TREMOVE covers freight vessels and ferries. Fishing vessels are not included.

Different reasons suggest that the demand modelling approach adopted for the other modes (using the CES trees) is not feasible for maritime transport. As substitution possibilities between maritime transport and other modes are very limited, it is assumed that the maritime movements are not affected by policy measures on land based transport and vice versa. In addition, TREMOVE does not include an endogenous link between total maritime transport demand and maritime transport costs and prices. For policy simulations, we can overcome these shortcomings by imposing demand changes exogenously.

So far simulations focussed on after-treatment technology, shore-side electricity and fuel specifications. Some options for simulations have already been implemented. Shifts between ship types are not foreseen in the model.

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[6] Three agreements have been made. The full texts can be found in the Official Journal of the European Communities L 350, 28.12.1998 p. 58, L 100, 20.4.2000 p. 57 and L 100, 20.4.2000, p. 55.

VII.1.5. Simulations

With TREMOVE version 2.3, a transport model has become available that can be applied for environmental and economic analysis of different policies and measures to reduce atmospheric emissions from all modes of transport in the enlarged European Union. So far, the model has been used to evaluate following policy scenarios in the context of the EU Clean Air for Europe Programme :

- Reductions of car emissions beyond EURO IV standard levels.
- Fuel efficiency improvements beyond the 2008/2009 voluntary agreements of the car industry.
- Increased road fuel excise taxes for financing development aid
- Heavy duty truck road charge schemes with charges covering external polluting costs
- Shore side electricity, aftertreatment technology and changes in fuel specifications for marine vessels.

VII.1.6. Future plans with TREMOVE

In the remainder of 2005 and in 2006 further applications (and updates) of the TREMOVE model are scheduled within the Clean Air for Europe Programme and other programmes coordinated by EC DG Environment, such as the revision of the National Emission Ceilings. Furthermore the model has been and will further be applied in the context of the thematic network PREMTECH II[7] on improved road vehicle environmental technology.

Next to the further application of the current model for policy scenario analysis, further development of the model is envisaged. Future developments could include, amongst others :

- A full extension to 27 countries (EU 25, Switzerland and Norway)
- Update for all modes to the emission calculation methodology developed in the EC DG Transport and Energy ARTEMIS project[8].
- Introduction of endogenous scrap rates in order to simulate policies focussed at increased renewal of the vehicle fleets.

VII.2. Setup of the four ASSESS scenarios in TREMOVE

Within ASSESS four implementation scenarios of the White Paper are assessed. These are :

- ‘Do nothing’ (N) scenario
- ‘Partial’ (P) scenario
- ‘Full implementation’ (F) scenario
- ‘Extended’ (E) scenario

Each of these scenarios has, firstly, been developed using the SCENES transport forecasting model. The outcomes of SCENES are transport activities on the EU transport networks. For a further analysis of the impacts of the four scenarios, the SCENES results have been fed as an input into TREMOVE. In addition, some White Paper measures, of which the impacts could not be assessed in the SCENES model,

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[7] www.networkpremtech.org

[8] Currently no final methodologies are available from the ARTEMIS project.

have been added to the TREMOVE scenario setup. This primarily concerns policies focussing on environmental improvements. This way, the four ASSESS scenarios have been developed with the TREMOVE model. TREMOVE results in detailed outcomes on energy consumption, emissions, tax revenues and eventually differences in overall welfare between the four scenarios.

In order to single out the effect of the biofuel policy, the P, F and E scenarios have been developed twice. Once without biofuel, and once with biofuel.

The link between the four SCENES scenarios and the four TREMOVE scenarios is discussed in section VII.2.1. Section VII.2.2 then describes the modelling of additional measures in TREMOVE, i.e. measures of which the impact could not be assessed with the SCENES model. Thereafter we shortly discuss the approaches used to analyse the welfare differences between the four scenarios and to generate emission estimates for the six New Member States that are not covered by the TREMOVE model.

VII.2.1. Data exchange between SCENES and TREMOVE

As explained in section VII.1.2.1 TREMOVEs baseline transport flows are derived from the SCENES model. From each SCENES scenario passenger-kilometres and ton-kilometres by mode, region, trip purpose and period (peak versus off-peak) are fed into TREMOVE. This procedure results in four TREMOVE baselines, each based on a SCENES scenario.

Next to the exchange of transport flows, the following data are also exchanged between SCENES and TREMOVE for each scenario :

- Vehicle speeds and travel times by transport mode
- Occupancy rates for cars, motorcycles, mopeds, buses, coaches and light duty trucks
- Load factors for light duty trucks[9]
- Fuel costs, excise taxes and VAT rates
- Transport costs for all modes except cars, motorcycles, mopeds and light duty trucks[10]
- Network tax levels
- The proportion of HST traffic in total passenger train transport

This interaction procedure makes that all impacts of policy measures that are simulated in the SCENES scenarios, are automatically transferred to the TREMOVE scenarios. The impact of the White Paper policies on rail transport growth in SCENES is taken onboard in the TREMOVE scenarios; the increased importance of HST train transport resulting from the investment in TEN infrastructure is accounted for in the TREMOVEs calculation of train fleets and train emissions; the network taxes resulting from social marginal cost pricing are included in the government tax revenue calculations of TREMOVE; ... .
In short, the TREMOVE scenarios are fully consistent with the SCENES scenarios.

In addition, a number of White Paper measures, of which the impacts could not be assessed in the SCENES model, have been implemented in the TREMOVE scenarios. This primarily concerns policies focussing on environmental improvements, as discussed in the next section VII.2.2.

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[9] For other freight modes (heavy duty trucks, trains and vessels) the load factors are determined endogenously in TREMOVE, taking into account the fleet structure.

[10] For these modes TREMOVE calculates transport costs in detaild, based on the fleet structure

VII.2.2. Additional policy measures included in the TREMOVE scenarios

As already indicated, the TREMOVE scenarios are fully consistent with the SCENES scenarios. Thus they include all policy measures analysed in SCENES. Though a limited number of policies with environmental impacts could not be assessed in the SCENES model. Therefore these have been added into to TREMOVE scenario setups. More specifically these policies are :

- Enter the dialogue with the rail industries in the context of a voluntary agreement to reduce adverse environmental impacts (INDIC code 15)
- Promote the use of clean vehicles in urban public transport (INDIC code 70)
- The environmental impact of the Single European Sky programme (INDIC code 17)
- Introduction of a minimum share of biofuels consumption in road transport (INDIC code 63)

VII.2.2.1. Enter the dialogue with the rail industries in the context of a voluntary agreement to reduce adverse environmental impacts

The impacts of this policy measure are taken onboard in the F ('full implementation') and E ('extended') scenarios. The policy preliminary focuses on noise reduction, which can not be assessed with the current TREMOVE model. The TREMOVE scenarios are restricted to the impacts on pollutant emissions to the air. As it is not clear at this point what the outcome of a dialogue with the rail industry could be, assumptions had to be made on the possible impact of this measure. Following assumptions have been taken in the F and E scenarios :

- The dialogue would lead to an increased replacement of diesel trains by electric trains from 2005 onwards, resulting in a diesel train fleet in 2020 which is only half of that in the P scenario.
- Diesel trains will use 40 ppm low sulphur fuel (i.e. the same fuel quality as current diesel for road vehicles) from 2008 onwards.
- Diesel train emission factors for particulate matter, volatile organic compounds and nitrogen oxides will decrease by 10% in 2010, through a limited introduction of aftertreatment devices (e.g. particulat traps and catalysts).

It is clear that these assumptions are only an illustration of what the dialogue with the rail industry could achieve. Therefore the model outcomes should be treated as an illustration of the possible impacts of the policy measure.

VII.2.2.2. Promote the use of clean vehicles in urban public transport

The promotion of clean vehicles in urban public transport addresses the accelerated renewal of the urban bus fleet. In the P, F and E scenarios it is assumed that by the year 2010 all buses in the fleet are at least EURO I and by the year 2020 at least EURO III. Thus in TREMOVE all remaining pre-EURO I busses are gradually scrapped in the years 2005-2009, and replaced by new busses. In 2010-2019 all EURO I and II busses are scrapped and replaced.

VII.2.2.3. The environmental impact of the Single European Sky programme

The EC Green Paper on energy reports that, from the implementation of Single European Sky, a reduction of fuel consumption is expected due to shorter flight routes. In SCENES the impact of this measure on future transport flows is taken into account by adjusting the air travel times downwards. In TREMOVE aircraft fuel consumption and emissions are calculated based on the actual route lengths, which are longer than the crow-fly distances between origins and destinations. The difference between actual route lengths and crow-fly distances is represented by a ‘detour factor’, which varies depending on the trip length. The Single European Sky policy leads to a decrease in the detour factors, thus in calculated fuel consumption and emissions per trip. Table 1 displays the decrease in route lengths implemented in the P, F and E scenarios.

	2010	**2020**
P scenario	-1.5%	-2.5%
F scenario	-2.5%	-5%
E scenario	-5%	-10%

Table 1 : Decrease in aircraft route lengths (compared to N scenario)

VII.2.2.4. Introduction of a minimum share of biofuels consumption in road transport

As explained in section VII.2.1, the four SCENES scenarios lead to four ‘base case’ scenarios in TREMOVE. The TREMOVE model is structured such that it enables to assess ‘simulation’ scenarios next to the ‘base case’ scenarios. A simulation scenario is a scenario in which additional policy measures (or packages of measures) are taken on board, which are not included in the base case scenario. The model structure then enables to compare the outcomes of both the base case and the simulation scenario. This way the effects of the additional policy measure on transport flows, fuel consumption, emissions, travel speeds, tax revenues and eventually welfare can be studied in detail. For example, for the assessment of new car emission standards, more than 15 simulation scenarios (with varying assumptions on emission limit levels and technology costs) have been calculated and compared with each other and with the base case scenario (which only included the existing car emission standards).

Within ASSESS the introduction of biofuels has not been implemented in SCENES nor in any of the four TREMOVE base case scenarios. Instead, biofuels have been taken on board in three TREMOVE simulation scenarios, based on respectively the P, F and E base case scenarios. This approach enables to single out the effects of the biofuel policy in the P, F and E scenarios.

In the biofuel simulation scenarios it is assumed that there will be a gradual penetration of biofuel towards 5.75% of all petrol and and diesel fuel consumed by road transport in 2010 and up to 8% in 2020. The biofuel will be blended in the oil-based fuels. There will be tax reductions and/ or subsidies for biofuels leading to consumer prices for the blended fuels that are the same as for conventional petrol and diesel. I.e. the tax exemption and/or subsidy cover the difference between the resource cost of the oil-based fuel and the biofuel additive. A resource cost of 0.5 euro per litre of biofuel is assumed, which remains constant over time independent of the crude oil price evolution. As the biofuel policy does not affect the fuel prices for the consumer, the policy is assumed not to affect transport demands nor vehicle purchase behaviour[11].

No sufficient measurements exist to introduce solid assumptions on changes in exhaust emission factors resulting from the use of blended fuels. Tank-to-wheel CO_2 emissions related to biofuel use are excluded from the external environmental cost calculations, as they are considered not to contribute to global warming. Well-to-tank emission factors for biofuel production are taken from MEET (Lewis, 1997), which provides estimates for the production of biofuel from rapeseed oil. It should be noted that well-to-tank emission estimates in the existing literature show significant variations depending on the specification of the biofuel and its production process.

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[11] The use of blended of fuels is expected not to require significant additional costs to convert vehicle engines.

VII.2.3. Welfare calculations

As indicated in section VII.2.2.4 TREMOVE in principle is designed to analyse welfare differences between a 'base case' scenario and alternative 'simulation' scenarios. Within ASSESS however four 'base case' scenarios have to be compared, each based on a specific SCENES scenario. This requires a significant change in the setup of TREMOVEs welfare module.

The welfare analysis in TREMOVE is based on the analysis of four components. For each year, the total difference in welfare between two scenarios is the derived from :

- The difference in aggregate utility level of all households
- The difference in production costs for all industry and service activities
- The difference in external environmental costs
- The difference in governments tax revenues from the transport sector

Total external environmental costs and total government tax revenues related to the transport sector can easily be calculated within TREMOVE for each of the four scenarios and for each year. Thus, the comparison of these two components between the four ASSESS scenarios is fairly easy. The model however is not able to calculate total consumer surplusses over all consumer markets and total productions costs including all input factors. As the model only covers the transport sector in detail, it only enables to calculate the differences in consumer surplus and production costs between two transport scenarios. This means that one of the scenarios must be chosen as the 'reference' scenario, so that for each of the other scenarios the difference in consumer surplus and production costs compared to the 'reference' level can be reported. Within ASSESS the N scenario is chosen as reference scenario, the model then enables to calculate the welfare difference between this reference scenario and the P, F and E scenarios[12] respectively.

VII.3. Model Results

In the remainder of this annex, we discuss the results of the model simulation for the four scenarios. The results of the P, F and E scenarios are compared to the N scenario. This way, the effects of different degrees of implementation of the White Paper policies are evaluated against a scenario in which none of the White Paper measures would be implemented.

The focus will be on the EU15 countries and the four additional New Member States that are included in TREMOVE (Czech Republic, Hungary, Poland and Slovenia).

The presentation of the model results starts with a short recapitulation of the main SCENES model outcomes on transport flows in the four scenarios (section VII.3.1). This will be the basis for the assessment of the TREMOVE results on energy consumption in the transport sector in section VII.3.2. Section VII.3.3 then will analyse the impact of the White Paper measures on greenhouse gas emissions, including a discussion on the effects of the biofuel policy. Thereafter a section on the other pollutants will follow. The overall effects of the policy scenarios on overall welfare and its components (consumer surplus, effects on cost of production and service sectors, external environmental costs and government budget) will be summarised in section VII.3.5.

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[12] We refer here to the P, F and E 'base case' scenarios, thus excluding the biofuel policy of which the welfare effects are analysed and discussed separately.

VII.3.1. Recapitulation of main SCENES outcomes

An extensive discussion on the SCENES outcomes can be found in Annex VI of this final report. In this section we restrict to a short recapitulation of the main SCENES outcomes.

VII.3.1.1. Passenger transport

Figure 2 displays the SCENES forecast for passenger transport flows in the N scenario for the EU15 countries. In the absence of the White Paper policy measures, the transport situation is expected to follow the recently observed trend since the late 1990s. The SCENES model suggest that, in EU15, total passenger travel demand will grow approx. 17% by 2010 and 34% by 2020. Under the N scenario, the modes that see significant demand growths would be air and car. Train, bus/coach and slow modes (walking/cycling) are expected to grow more slowly.

Figure 3 is a similar graph for the 4 New Member States that are included in the TREMOVE model. The SCENES model suggest that in these New Member States overall growth will be significant faster than in the EU15 countries. Total passenger travel demand will grow more than 30% by 2010 and 60% by 2020. As in EU15 the modes that see significant demand growths would be air and car, but in contrast to EU15 bus/coach and train demand is likely to decline.

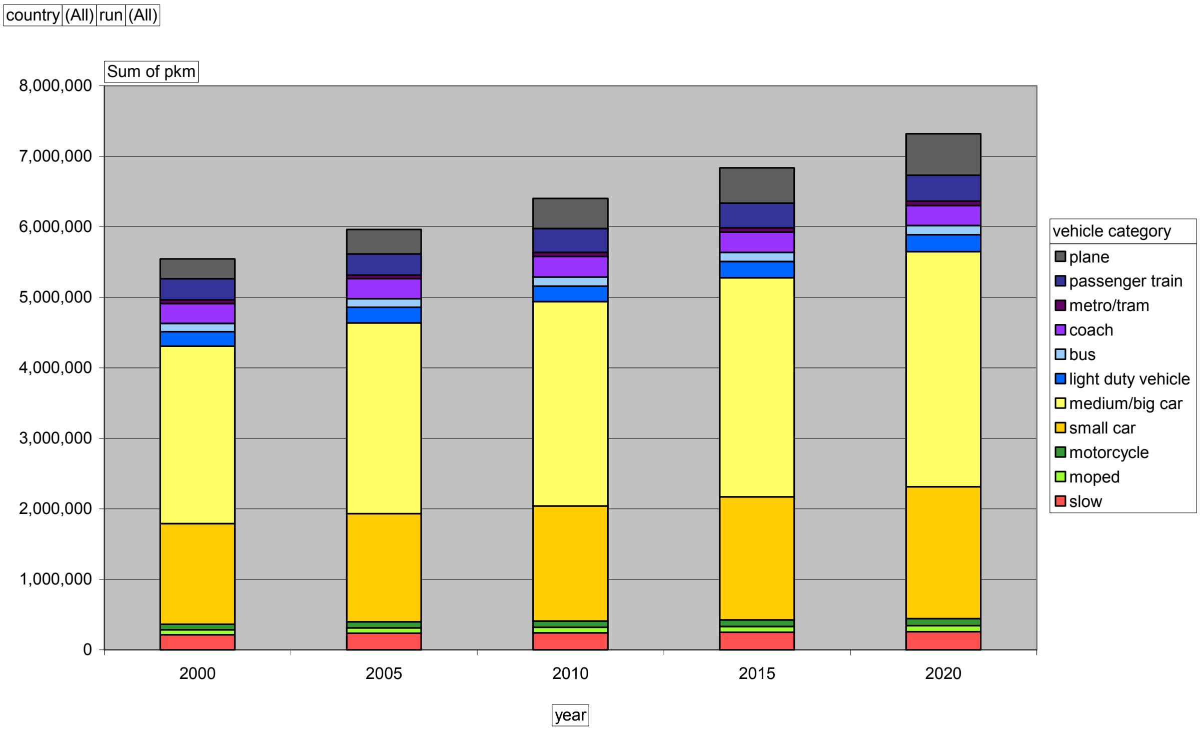

Figure 2 : EU15 Passenger-kilometres by mode in N scenario – millions

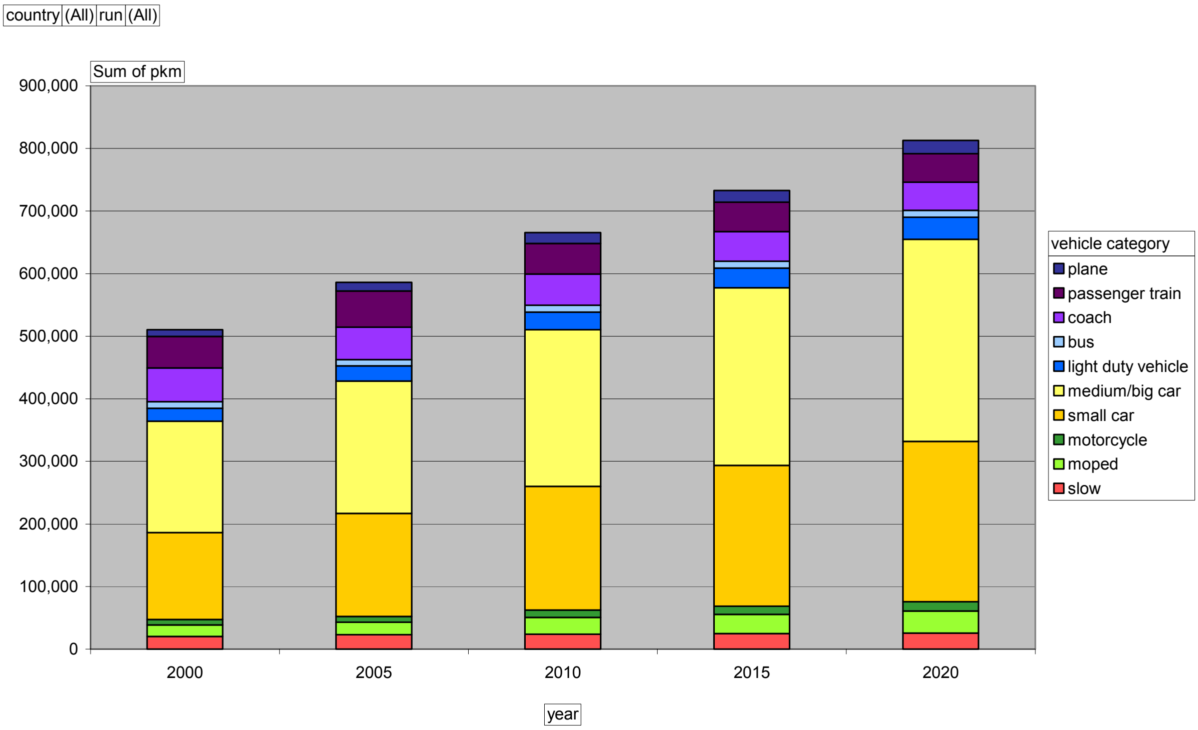

Figure 3 : 4 NMS Passenger-kilometres by mode in N scenario – millions

A comparison of the four scenarios for the EU15 countries can be found in Figure 4 and Table 2. Similar information for the 4 New Member States is reported in Figure 6 and Table 3. Figure 5 and Figure 7 show the predicted evolution of traffic activity in the four scenarios, relative to the year 2005 results.

When the P scenario is compared with the N scenario, overall passenger demand does not appear to be significantly different. The improvements in rail services under the P scenario will lead to a modest gain in passenger demand in the EU15 countries.

The F scenario sees a slight increase in overall passenger mobility compared to N and P. Stemming from a range of measures to improve public transport services and better traffic management supported by the Galileo programme. On air, compared to the N scenario, the application of a 7% VAT rate dampens the air passenger transport demand growth rate for 2010 by -12% in 2010, and by -5% in 2020.

The E scenario includes partial social marginal cost pricing for car and air transport. This leads to a decrease in car and air demand, while public transport and slow modes gain. Overall, this reduces the passenger mobility by 5% compared with the Null scenario.

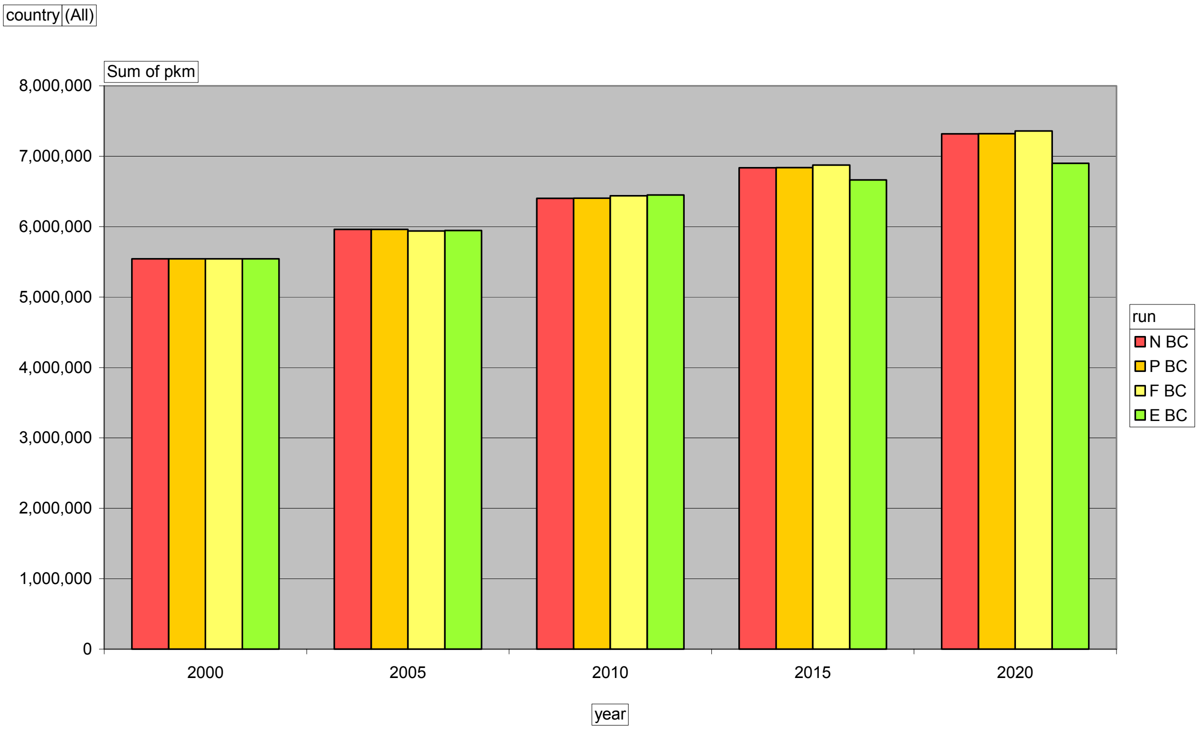

Figure 4 : EU15 Total Passenger-Kilometres by scenario - Millions

	2000	2005				2010				2020			
		N	P	F	E	N	P	F	E	N	P	F	E
slow	**3.9%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**3.8%**	**3.8%**	**3.8%**	**3.7%**	**3.5%**	**3.5%**	**3.4%**	**3.7%**
small car	25.7%	25.7%	25.7%	25.9%	25.8%	25.5%	25.5%	25.8%	25.7%	25.6%	25.6%	25.7%	25.2%
medium/big car	45.4%	45.4%	45.4%	45.5%	45.5%	45.2%	45.2%	45.7%	45.6%	45.5%	45.5%	45.8%	45.2%
moped	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
motorcycle	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%
light duty vehicle	3.6%	3.7%	3.7%	3.7%	3.7%	3.5%	3.5%	3.5%	3.5%	3.3%	3.3%	3.4%	3.5%
Total private road	**77.5%**	**77.5%**	**77.5%**	**77.8%**	**77.7%**	**76.8%**	**76.8%**	**77.5%**	**77.4%**	**77.0%**	**77.0%**	**77.4%**	**76.3%**
bus	2.2%	2.0%	2.0%	2.1%	2.1%	2.0%	2.0%	2.0%	2.1%	1.7%	1.7%	1.8%	2.0%
coach	5.1%	4.8%	4.8%	4.8%	4.8%	4.6%	4.6%	4.6%	4.6%	3.9%	3.9%	4.0%	4.5%
Total public road	**7.2%**	**6.8%**	**6.8%**	**6.9%**	**6.9%**	**6.6%**	**6.6%**	**6.7%**	**6.7%**	**5.6%**	**5.6%**	**5.8%**	**6.5%**
metro/tram	0.9%	0.8%	0.8%	0.9%	0.8%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
passenger train	5.4%	5.0%	5.0%	5.0%	5.0%	5.3%	5.3%	5.3%	5.2%	5.0%	5.0%	5.0%	5.6%
Total rail	**6.3%**	**5.9%**	**5.9%**	**5.9%**	**5.9%**	**6.2%**	**6.2%**	**6.2%**	**6.1%**	**5.9%**	**5.9%**	**5.9%**	**6.6%**
Plane	**5.1%**	**5.8%**	**5.8%**	**5.4%**	**5.5%**	**6.7%**	**6.7%**	**5.9%**	**6.0%**	**8.0%**	**8.0%**	**7.4%**	**6.9%**

Table 2 :EU 15 Modal shares passenger transport by scenario

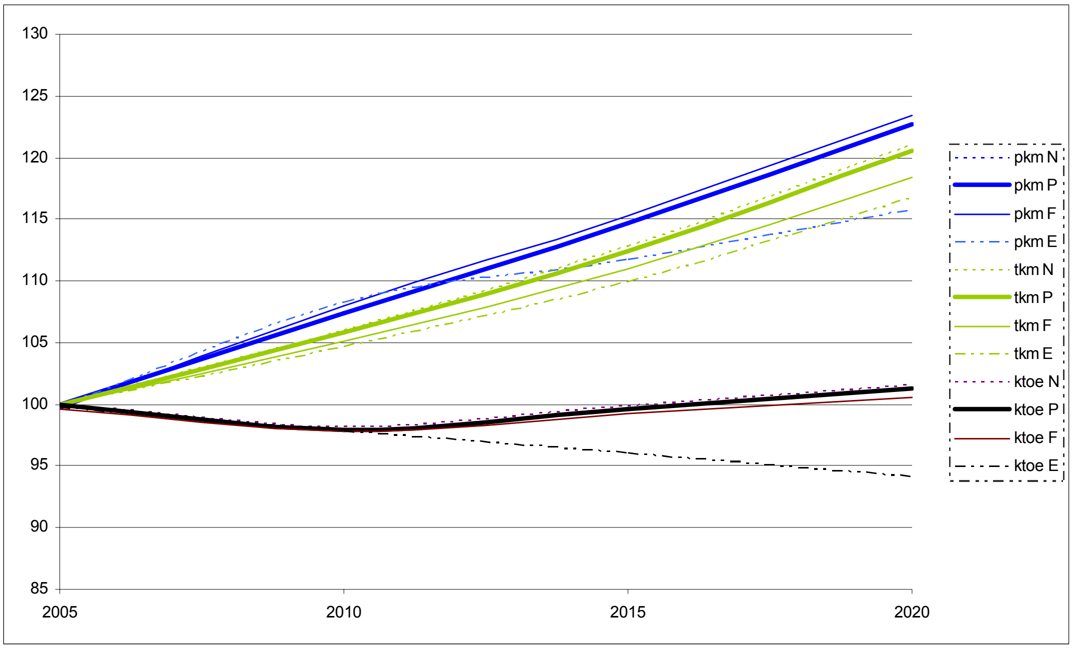

Figure 5 : EU15 Transport activity and energy consumption by scenario (2005 = 100)

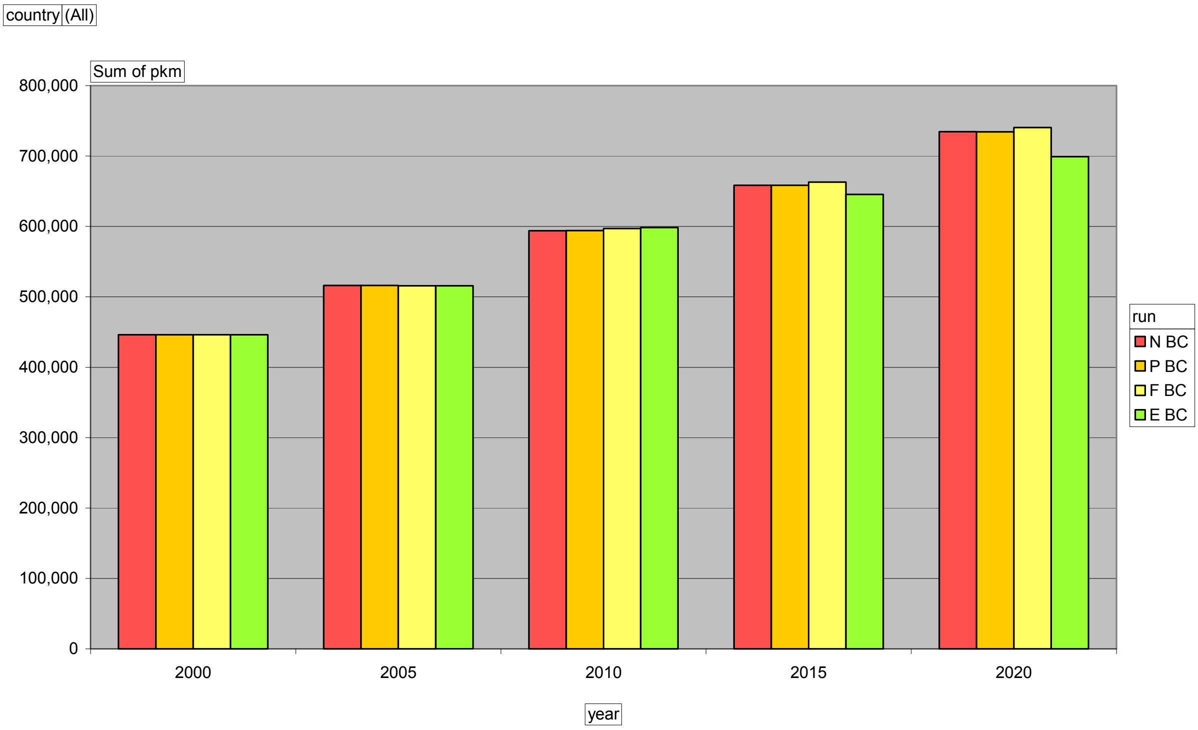

Figure 6 : 4 NMS Total Passenger-Kilometres by scenario - Millions

	2000	**2005**				**2010**				**2020**			
		N	**P**	**F**	**E**	**N**	**P**	**F**	**E**	**N**	**P**	**F**	**E**
slow	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**4.0%**	**3.6%**	**3.6%**	**3.6%**	**3.5%**	**3.2%**	**3.2%**	**3.1%**	**3.5%**
small car	28.5%	29.4%	29.4%	29.4%	29.4%	31.1%	31.0%	31.1%	31.1%	32.7%	32.6%	32.7%	31.6%
medium/big car	32.1%	33.6%	33.6%	33.6%	33.6%	35.6%	35.6%	35.6%	35.6%	37.8%	37.7%	37.7%	36.4%
moped	4.0%	3.8%	3.8%	3.8%	3.8%	4.5%	4.5%	4.5%	4.5%	4.7%	4.7%	4.7%	4.6%
motorcycle	1.7%	1.7%	1.7%	1.7%	1.7%	1.8%	1.8%	1.8%	1.8%	1.9%	1.9%	1.9%	1.9%
light duty vehicle	4.2%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.5%	4.5%	4.5%	4.6%
Total private road	**70.6%**	**72.8%**	**72.8%**	**72.9%**	**72.9%**	**77.4%**	**77.3%**	**77.5%**	**77.5%**	**81.7%**	**81.5%**	**81.5%**	**79.0%**
bus	1.9%	1.6%	1.6%	1.6%	1.6%	1.6%	1.5%	1.6%	1.6%	1.2%	1.2%	1.3%	1.3%
coach	11.6%	9.6%	9.6%	9.6%	9.6%	8.0%	7.9%	7.9%	8.0%	5.8%	5.8%	5.8%	6.8%
Total public road	**13.5%**	**11.2%**	**11.2%**	**11.2%**	**11.2%**	**9.5%**	**9.5%**	**9.5%**	**9.6%**	**7.0%**	**7.0%**	**7.1%**	**8.1%**
Total rail	**10.6%**	**10.5%**	**10.5%**	**10.5%**	**10.5%**	**7.7%**	**7.8%**	**7.8%**	**7.7%**	**5.7%**	**6.0%**	**6.0%**	**7.2%**
Plane	**1.3%**	**1.5%**	**1.5%**	**1.5%**	**1.5%**	**1.8%**	**1.8%**	**1.7%**	**1.7%**	**2.4%**	**2.4%**	**2.2%**	**2.2%**

Table 3 : 4 NMS Modal shares passenger transport by scenario

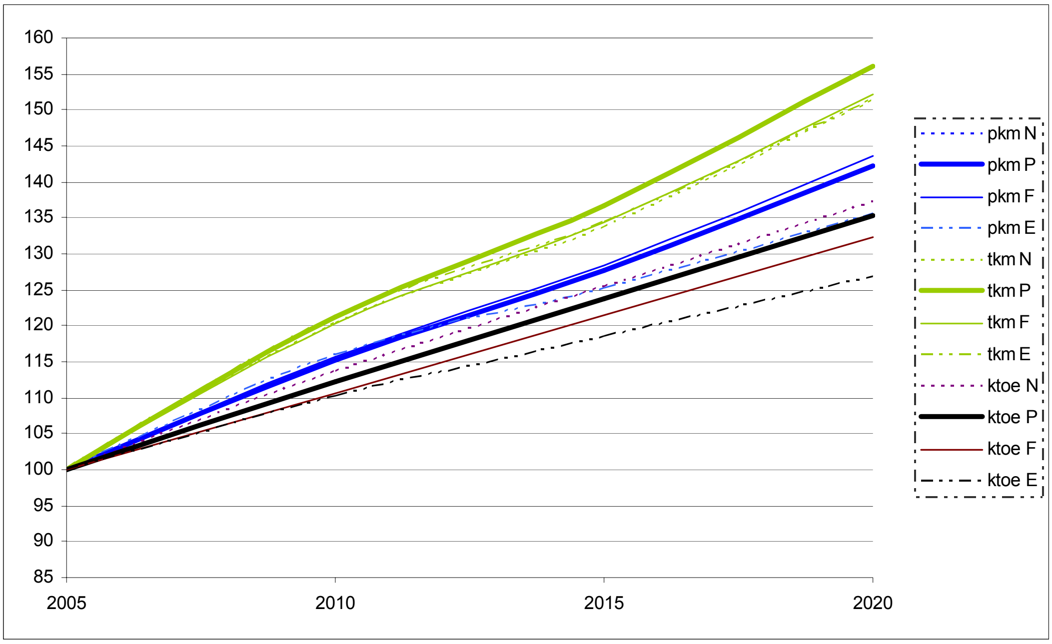

Figure 7 : 4 NMS Transport activity and energy consumption by scenario (2005 = 100)

VII.3.1.2. Freight transport

Figure 8 and Figure 9 display the SCENES forecast for freight transport flows in the N scenario for the EU15 countries and the 4 New Member States respectively. The N scenario represents a contra-factual situation in which of no White paper policy measures had been applied. SCENES suggests that road freight would grow strongly. In EU15 road freight growth rates are 18% and 42% respectively for 2010 and 2020. In the 4 New Member States, road freight is expected to have much stronger growth of 70% and 133% respectively for 2010 and 2020. Rail freight declines in general, whilst inland waterway gains a modest growth in some countries.

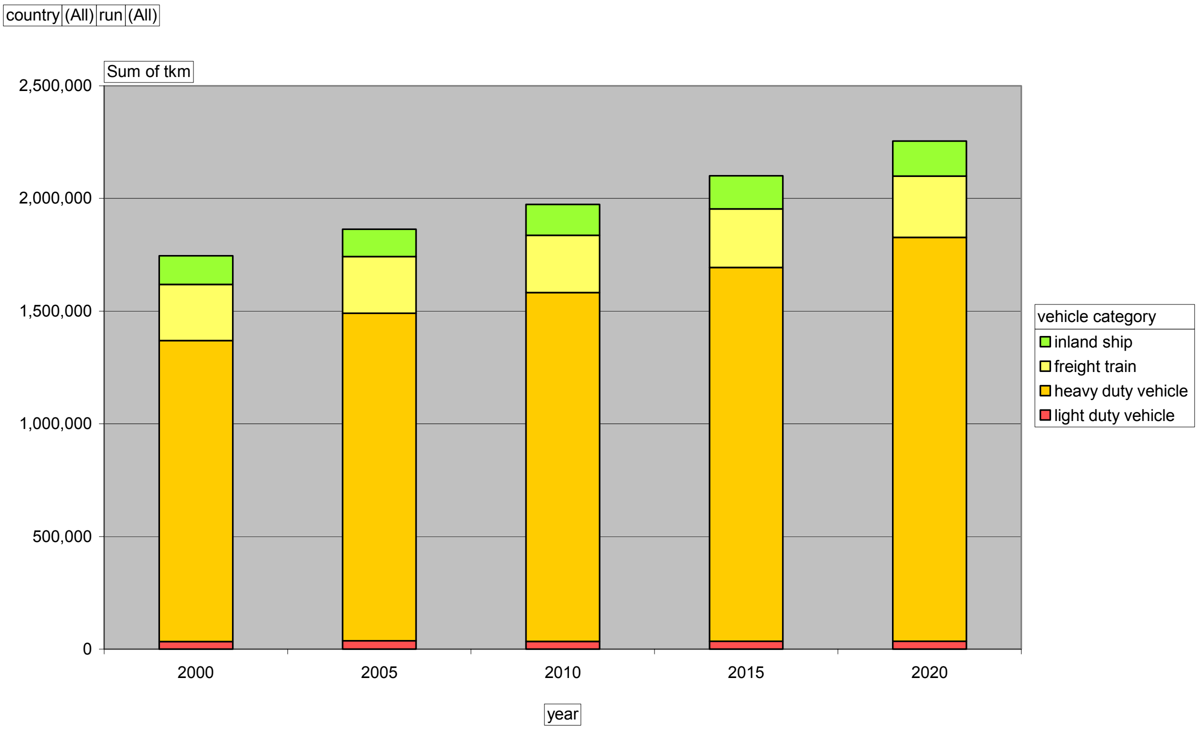

Figure 8 : EU15 Tonne-kilometres by mode in N scenario – millions

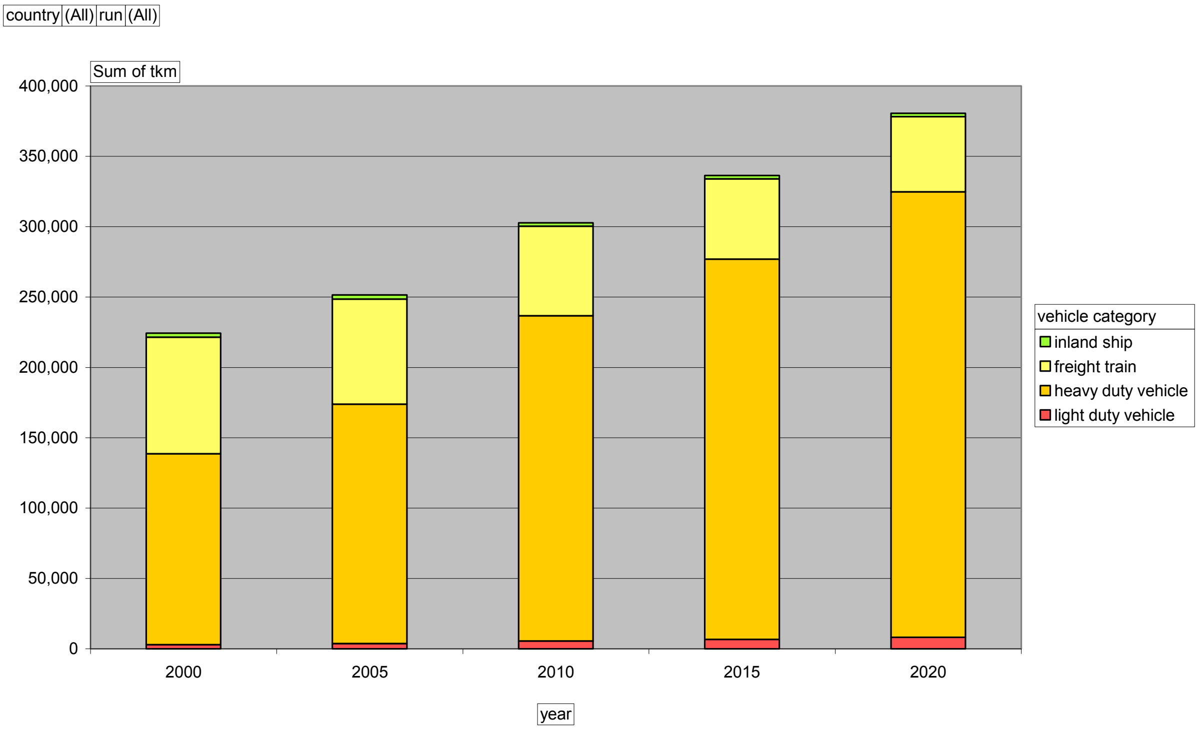

Figure 9 : 4 NMS Tonne-kilometres by mode in N scenario – millions

A comparison of the four scenarios for the EU15 countries can be found in Figure 10 and Table 4. Similar information for the 4 New Member States is reported in Figure 11 and Table 5. Figure 5 and Figure 7 show the predicted evolution of traffic activity in the four scenarios, relative to the year 2005 results.

Compared with the N scenario, the policies implemented under the P scenario lead to a lower rate of growth in road freight demand. As the measures that lead to the road cost increases are still in the process of being implemented, the transport sector will not have adjusted fully to these measures by 2010. However, by 2020, the impact of these cost changes are likely to lead to larger impacts. As a result of road cost increases, and the improvements on rail, shipping and inter-modal transport, rail freight is expected to grow by a modest amount in the EU15 countries. Despite this latter increase in rail freight, total freight transport in EU15 will, in the P scenario, be lower than in the N scenario. In the 4 New Member States the policy measures in the P scenario almost halt the significant decrease of rail freight in the N scenario. This eventually leads to an increase in total freight transport compared to the N scenario.

Under the F scenario limited social marginal cost pricing is applied for truck transport. This has a significant impact on the modal shares, i.e. a lower share of road and a higher share of rail and inland waterway compared to the N and P scenarios. Although, SCENES indicates that only a limited proportion of the freight tonne-kilometres are transferred from road to rail and inland waterways. Therefore, the overall freight transport quantitities in the F scenario are lower than that in the N and P scenarios.

The E scenario includes full social marginal cost pricing for road freight, as well as further improvements in the quality of rail freight services. This leads to a lower growth in road freight transport than in the P scenario. Rail and inland waterway growth rates come close to those for trucks.

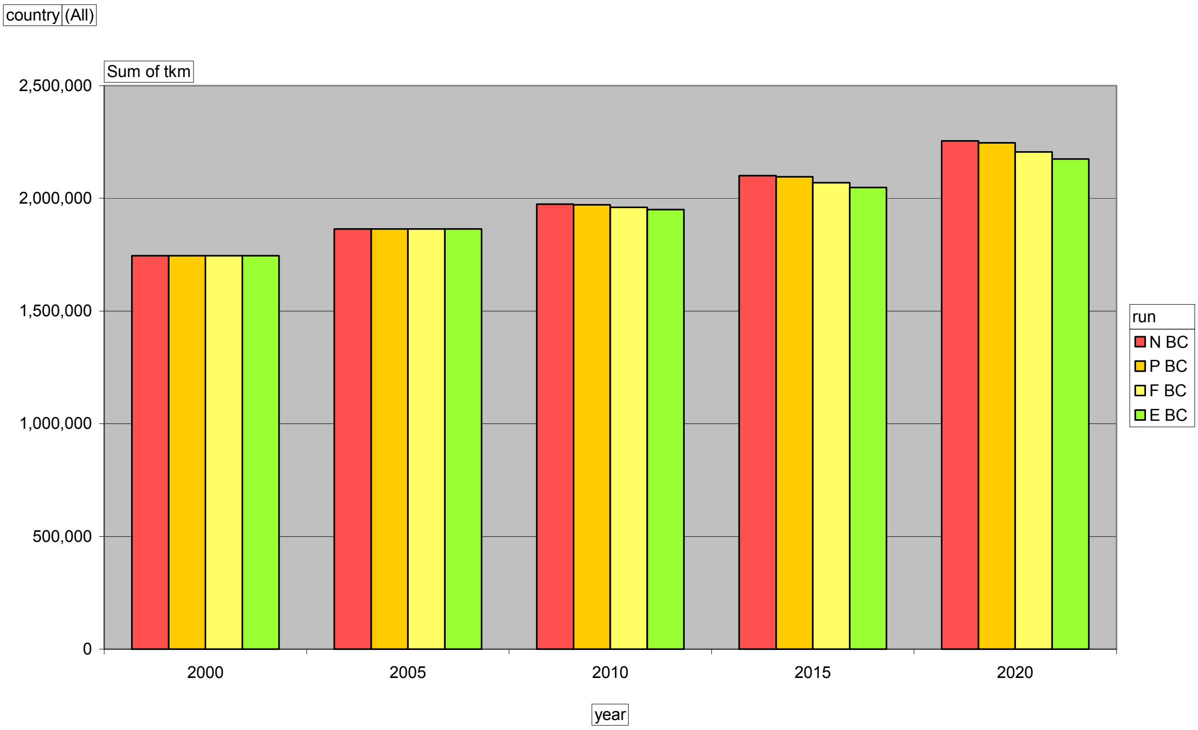

Figure 10 : EU15 Total Tonne-Kilometres by scenario – Millions

	2000	2005				2010				2020			
		N	P	F	E	N	P	F	E	N	P	F	E
light duty vehicle	1.9%	2.0%	2.0%	2.0%	2.0%	1.8%	1.8%	1.7%	1.7%	1.6%	1.6%	1.5%	1.4%
heavy duty vehicle	76.5%	78.0%	78.0%	78.0%	78.0%	78.4%	78.3%	77.8%	77.4%	79.5%	79.3%	77.8%	76.0%
Total road	**78.4%**	**80.0%**	**80.0%**	**80.0%**	**80.0%**	**80.2%**	**80.1%**	**79.6%**	**79.1%**	**81.0%**	**80.8%**	**79.3%**	**77.4%**
Rail	**14.3%**	**13.5%**	**13.5%**	**13.5%**	**13.5%**	**12.8%**	**12.9%**	**13.3%**	**13.7%**	**12.0%**	**12.2%**	**13.6%**	**15.2%**
Inland ship	**7.3%**	**6.5%**	**6.5%**	**6.5%**	**6.5%**	**7.0%**	**7.0%**	**7.2%**	**7.2%**	**6.9%**	**7.0%**	**7.2%**	**7.4%**

Table 4 : EU15 Modal shares freight transport by scenario

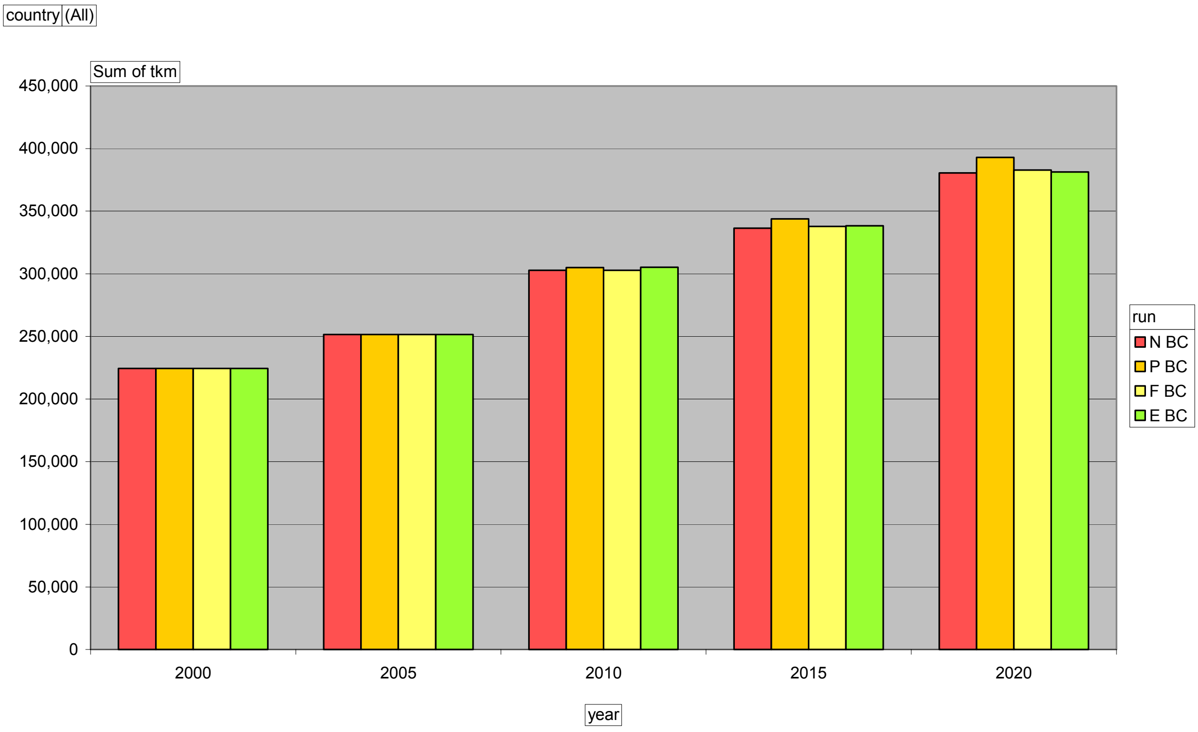

Figure 11 : 4 NMS Total Tonne-Kilometres by scenario - Millions

	2000	2005				2010				2020			
		N	P	F	E	N	P	F	E	N	P	F	E
light duty vehicle	1.3%	1.5%	1.5%	1.5%	1.5%	1.9%	1.7%	1.7%	1.6%	2.1%	1.9%	1.9%	1.8%
heavy duty vehicle	60.5%	67.6%	67.6%	67.6%	67.6%	76.3%	73.2%	70.4%	68.8%	83.2%	77.3%	75.4%	73.3%
Total road	**61.8%**	**69.1%**	**69.1%**	**69.1%**	**69.1%**	**78.2%**	**74.9%**	**72.1%**	**70.4%**	**85.3%**	**79.3%**	**77.3%**	**75.1%**
Rail	**36.9%**	**29.7%**	**29.7%**	**29.7%**	**29.7%**	**21.0%**	**24.2%**	**27.1%**	**28.7%**	**14.0%**	**20.1%**	**22.1%**	**24.2%**
Inland ship	**1.3%**	**1.2%**	**1.2%**	**1.2%**	**1.2%**	**0.8%**	**0.8%**	**0.8%**	**0.9%**	**0.6%**	**0.7%**	**0.7%**	**0.7%**

Table 5 : 4 NMS Modal shares freight transport by scenario

VII.3.2. Transport sector energy consumption

Figure 12 shows the total energy consumption by transport mode in the EU15 countries' P scenario. All vehicle fuel consumption as well as electricity consumption is included. A limited increase in energy consumption is expected. The growth of passenger and freight transport activity is compensated to a large extent by improvements in fuel efficiency of road vehicles. This is a consequence of the voluntary agreement of car producers to reduce CO_2 emissions of new cars, as well as of the continuous development of technologies to reduce fuel costs in the road freight sector. The promotion of clean urban transport also contributes to this evolution, as it leads to an accelerated replacement of older, less fuel-efficient vehicles. Improvements in air transport efficiency, by way of the Single European Sky programme, will not offset the strong increase in air transport activity.

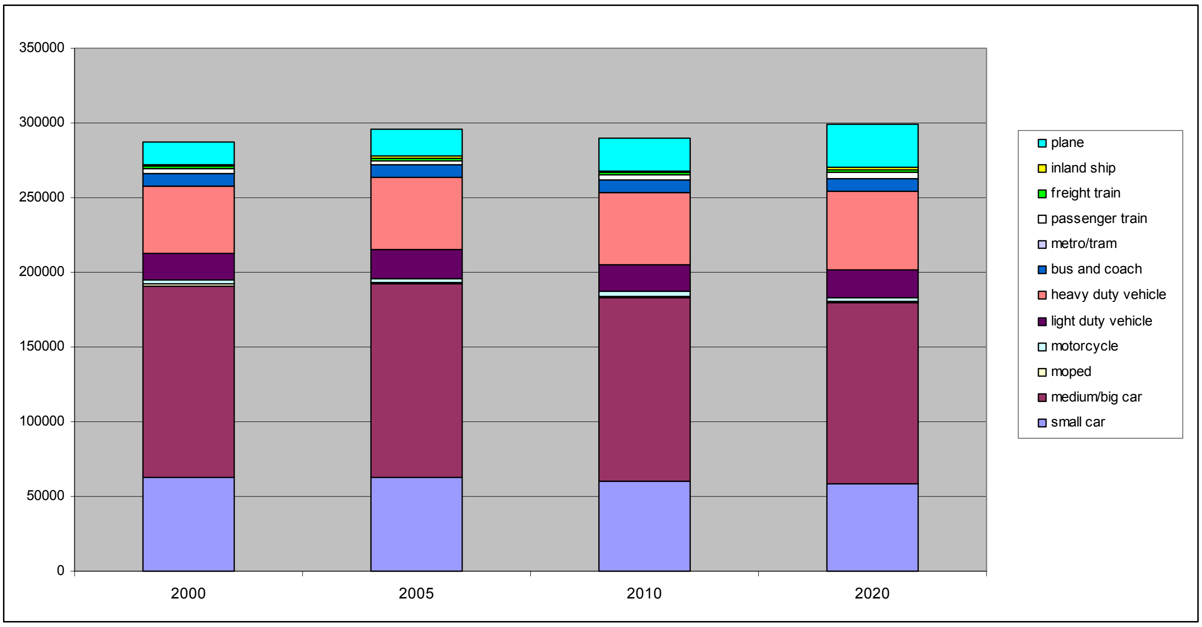

Figure 12 : EU15 Energy consumption by mode in P scenario - ktoe

In the New Member States (Figure 13) a stronger growth in both passenger and freight transport is expected. Although similar improvements in efficiency are expected as in EU15, these cannot avoid a strong growth in overall energy consumption in these countries.

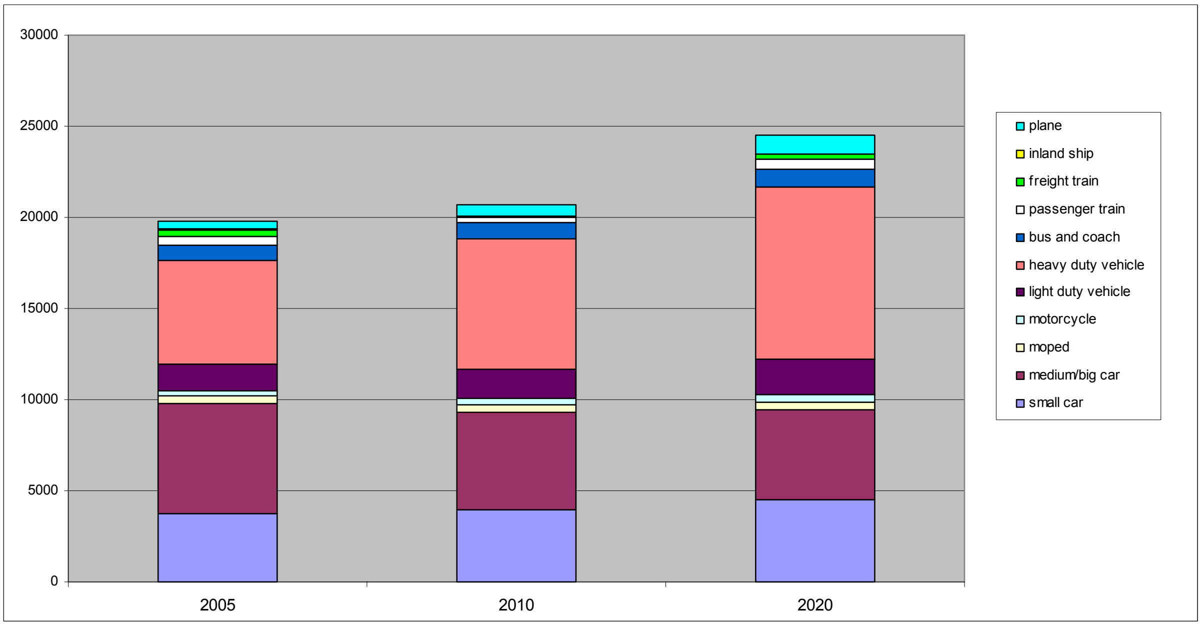

Figure 13 : 4 NMS Energy consumption by mode in P scenario - ktoe

Figure 14 and Table 6 show the total energy consumption in the four scenarios in the EU 15 countries. Similar figures for the 4 New Member States can be found in Figure 15 and Table 7. Figure 5 and Figure 7 show the energy consumption predictions for the four scenarios, relative to the year 2005 results.

In the EU15 countries predicted energy consumption for the N scenario is somewhat higher than that for the P scenario. This is in line with the fact that total transport activity, especially for freight, in N is a bit higher than in P. More specifically these demand changes result in first place in a higher truck fuel consumption in N, but also to a lower train energy consumption. Other factors that contribute to the higher energy consumption in N are the absence of the promotion of cleaner (and more fuel efficient) busses, as well as the longer aircraft flight routes due to the non-implementation of the Single European Sky Programme.

As for the EU15 countries, forecasted energy consumption in the N scenario is higher than in the P scenario in the four New Member States. Though total transport flows, especially for freight, in the N scenario are lower than in P. This result can be explained by the fact that the energy efficiency of freight transport in the N scenario is lower than that in the P scenario. This difference in energy efficiency mainly stems from a higher modal share of road freight transport in the N scenario (see Table 3).

Compared to the P scenario, total road vehicle energy consumption in the F scenario is higher in the EU15 countries. This increase is the consequence of the higher passenger activity in the F scenario. The reduction in truck transport caused by the introduction of social marginal cost pricing for road freight leads to a decrease in truck energy consumption, but this does not compensate the increase for road passenger transport. As the latter pricing measure also leads to an increased modal share for inland waterway and freight rail, an increase of energy consumption for these modes is predicted. Although total passenger mobility is increased in the F scenario, compared to P, energy consumption for rail and air decreases significantly. For passenger rail transport the increase in demand is compensated by the effects of the agreement to reduce environmental impacts. More specifically this agreement leads to a substitution of diesel train traffic by more energy-efficient electric train traffic. The lower kerosene consumption for air transport is due to both the lower activity growth rate caused by the application of a harmonised VAT rate, and the higher efficiency (routing) improvements enabled by the Single European Sky Programme. The net effect over all transport modes is a decrease of total energy consumption in the F scenario compared to P.

In the 4 New Member States F has a lower road vehicle energy consumption than P, as the decrease of truck transport caused by the pricing measure is larger than the increases relating to passenger road transport. As in western Europe there is an increased modal share of inland waterway and freight rail, and a decrease in air traffic. Together with efficiency gains in rail and air transport, this results in an overall decrease of energy consumption in these countries.

Full implementation of marginal social cost pricing in the freight sector and partial marginal social cost pricing for passenger car and air transport will lead to a significant decrease in the 2020 energy consumption of road and air transport in the E scenario. These measures, together with further improvements in the quality of road freight services, will lead also to an increase in energy consumed by rail and inland waterway tranport. The decline in road transport dominates however, such that the E scenario is the scenario with the lowest overall energy consumption. In the EU15, this policy scenario even is predicted to bend the upward trend in transport energy consumption into a decrease (Figure 5).

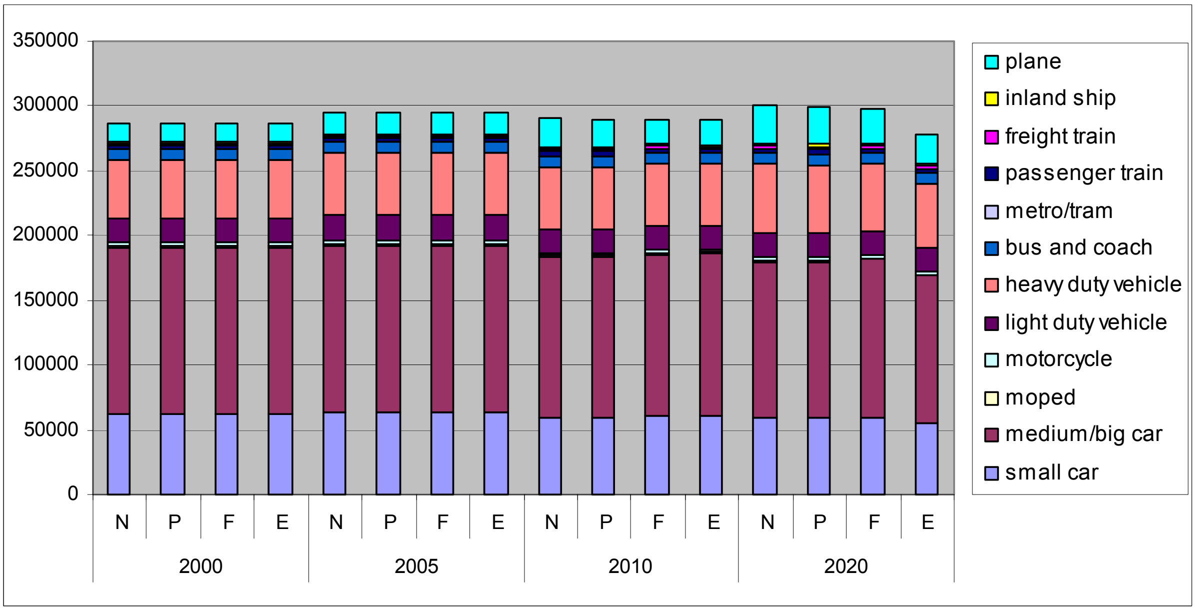

Figure 14 : EU15 Energy consumption by mode and scenario - ktoe

	2000	2005				2010				2020			
		N	P	F	E	N	P	F	E	N	P	F	E
small car	62572	62924	62924	62924	62924	59789	59788	60653	60685	58836	58829	59528	55086
medium/big car	128109	129061	129061	129061	129061	123211	123211	124854	125046	120568	120562	121970	113606
moped	1486	1418	1418	1418	1418	1315	1315	1328	1327	1117	1117	1126	1049
motorcycle	2419	2611	2611	2611	2611	2666	2666	2713	2718	2904	2904	2938	2694
light duty vehicle	18003	19251	19251	19251	19251	17993	17988	18135	18038	18268	18250	18230	17714
heavy duty vehicle	45314	47982	47982	47982	47982	48135	48036	47471	47108	53318	52985	51134	49365
bus and coach	8529	8509	8509	8509	8509	8544	8488	8597	8630	8265	8234	8495	8732
Total road	**266433**	**271756**	**271756**	**271756**	**271756**	**261653**	**261491**	**263750**	**263552**	**263277**	**262880**	**263420**	**248246**
metro/tram	89	90	90	90	90	102	102	103	102	114	114	115	114
passenger train	2777	2839	2839	2839	2839	3231	3259	3193	3157	3436	3532	3397	3519
freight train	1797	1846	1846	1846	1846	1872	1878	1870	1916	2111	2126	2210	2458
Total rail	**4662**	**4775**	**4775**	**4775**	**4775**	**5204**	**5239**	**5166**	**5175**	**5661**	**5772**	**5723**	**6091**
inland ship	1313	1258	1258	1258	1258	1454	1454	1469	1479	1652	1652	1663	1700
plane	14602	17777	17777	16561	16866	21725	21400	18788	18926	29613	28931	26431	22081
TOTAL	***287011***	***295566***	***295566***	***294350***	***294655***	***290036***	***289584***	***289173***	***289133***	***300204***	***299236***	***297238***	***278119***

Table 6 : EU15 Energy consumption by mode and scenario – ktoe

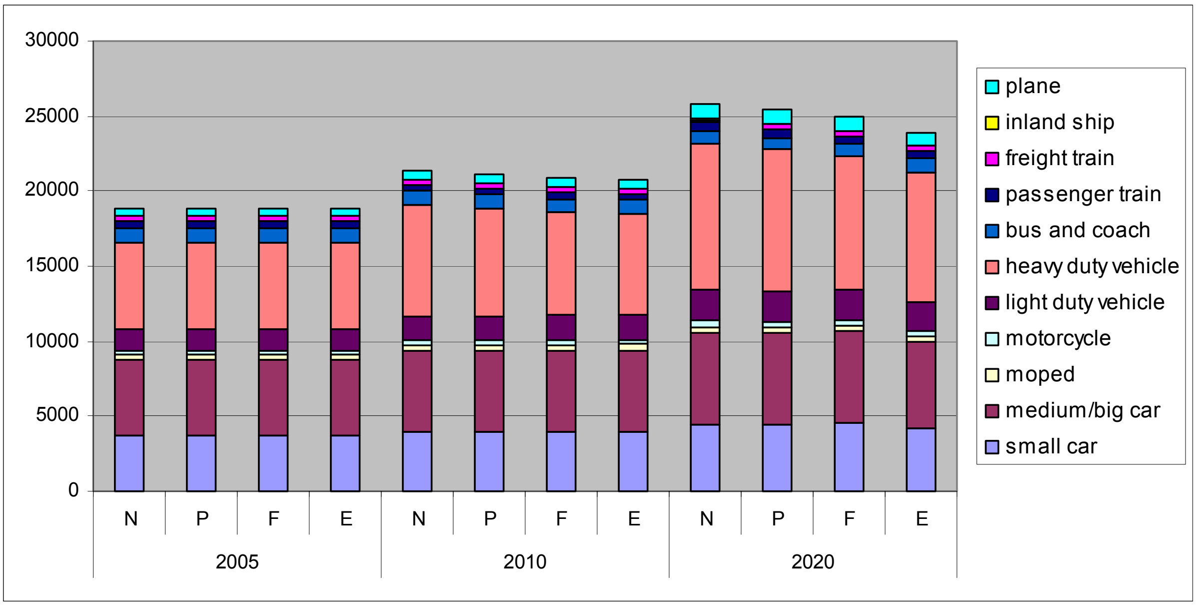

Figure 15 : 4 NMS Energy consumption by mode and scenario - ktoe

	2005				2010				2020			
	N	P	F	E	N	P	F	E	N	P	F	E
small car	3750	3750	3750	3750	3973	3973	3993	3999	4495	4485	4523	4259
medium/big car	4980	4980	4980	4980	5331	5331	5358	5363	6072	6055	6110	5748
moped	418	418	418	418	424	424	426	426	388	387	390	363
motorcycle	249	249	249	249	309	309	312	314	397	396	400	369
light duty vehicle	1448	1448	1448	1448	1655	1633	1619	1607	2030	1989	1965	1914
heavy duty vehicle	5723	5723	5723	5723	7384	7149	6849	6742	9835	9446	8975	8641
bus and coach	981	981	981	981	937	927	930	939	820	812	831	879
Total road	**17549**	**17549**	**17549**	**17549**	**20014**	**19746**	**19486**	**19389**	**24038**	**23570**	**23194**	**22173**
passenger train	499	499	499	499	444	440	414	422	509	513	422	463
freight train	307	307	307	307	275	313	342	362	230	365	342	375
Total rail	**806**	**806**	**806**	**806**	**719**	**753**	**756**	**784**	**739**	**877**	**763**	**838**
inland ship	24	24	24	24	14	15	15	15	14	14	14	15
plane	466	464	450	452	648	633	590	578	1038	1021	942	857
TOTAL	***18845***	***18843***	***18829***	***18831***	***21396***	***21146***	***20847***	***20767***	***25828***	***25483***	***24914***	***23882***

Table 7 : 4 NMS Energy consumption by mode and scenario – ktoe

VII.3.3. Transport sector greenhouse gas emissions

Figure 16 and Figure 17 show the predicted evolution of vehicle exhaust CO_2 emissions in scenario P, relative to the year 2005 levels. High altitude (>3000 ft.) emissions from aircrafts are included.

In the EU15 total CO_2 exhaust emissions will remain almost stable at the 2005 level. The growth in transport activity will be compensated mainly by increases in the fuel efficiency for all road vehicles, through dieselisation of the fleets as well as through genuine technology improvements. For cars, the latter improvements are driven by the voluntary agreement of the car industry to reduce CO_2 emissions of new cars. Also the Single European Sky policy, as well as the accelerated replacement of older urban busses contribute to this stabilisation of CO_2 emissions. The small increase of CO_2 emissions for the freight sector is, compared to passenger transport, explained by the stronger growth in freight transport and the lower expectations w.r.t. future fuel efficiency improvements for trucks (compared to cars).

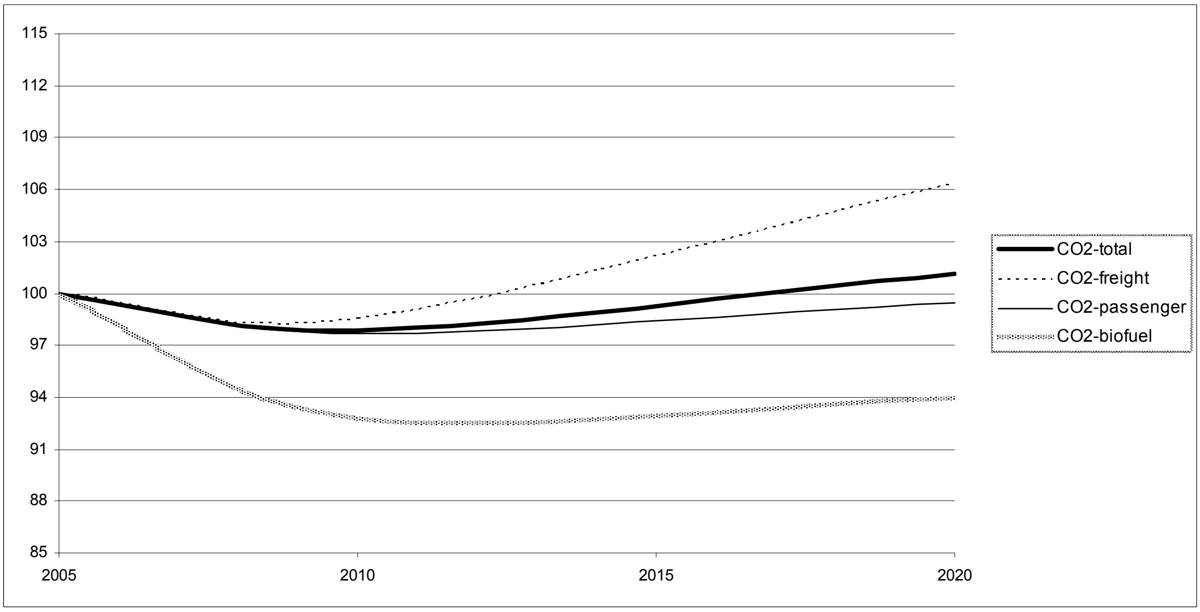

Figure 16 : EU15 Total exhaust CO_2 emissions for all modes, P-scenario, (2005 = 100)

In the New Member States CO_2 emissions will increase. The growth in transport activity is much stronger in these countries, and is not offset by the improvements in energy efficiency.

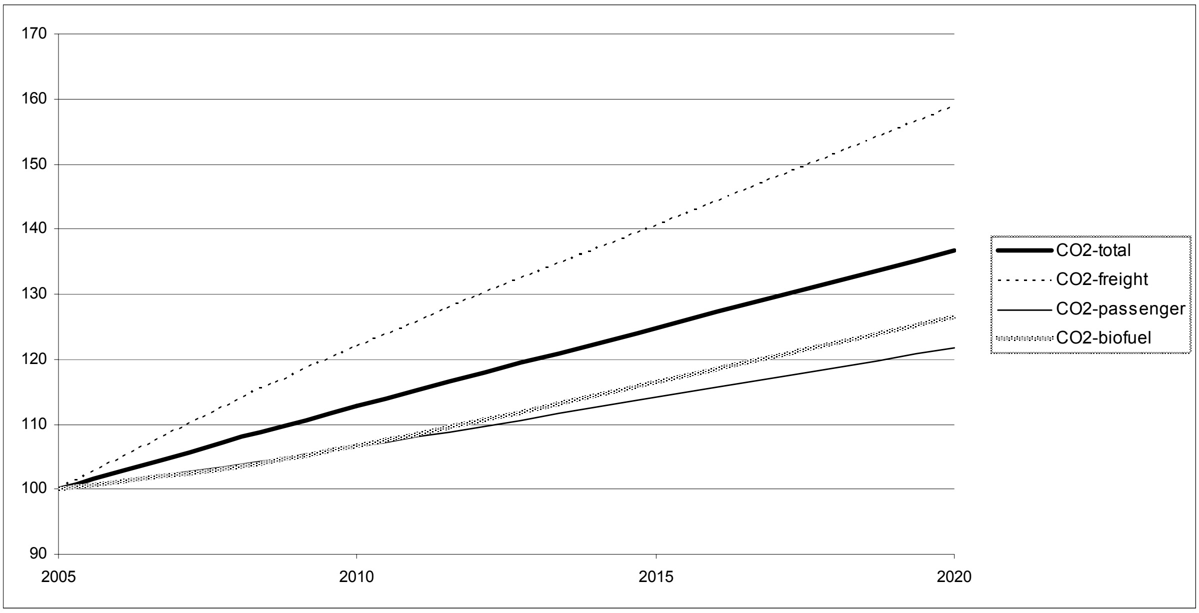

Figure 17 : 4 NMS Total exhaust CO_2 emissions for all modes, P-scenario, (2005 = 100)

In the P scenario it is expected that the 5.75% (2010) and 8% objectives on biofuel penetration are reached. If CO_2 emission related to the use of biofuels are excluded ("CO2-biofuel" lines in the graphs), a 6% CO_2-gain can be expected in the EU15 states by 2020, as well as a significant reduction of the CO_2 growth in the New Member States.

Figure 18 and Figure 19 show a comparison of ground level (below 3000 ft.) exhaust CO_2 emissions between the scenarios. CO_2 emissions related to the use of biofuel are included.

The differences in transport flows between the N and P scenarios are limited, except for the increase in freight rail transport which leads to an increase in freight rail emissions. The main other effects on emissions in the P scenario, compared to N, are a reduction in aircraft emissions resulting from the European Sky Programme and a decrease in bus emissions due to the accelerated introduction of cleaner busses. Overall, if the biofuel policy is not included in the analysis, none of these effects lead to a significant change in total emissions from the transport sector.

The F scenario is characterised by a lower tonne-km growth and a higher passenger-km growth than the P scenario. This results mainly in a decrease in truck emissions and an increase in private transport emissions (car, two-wheelers). The net result, compared to P, of these effects is a very small increase in CO_2-emissions in the EU15 countries, while it is a decrease of the CO_2 emissions in the New Member States. Focussing at rail transport, the dialogue with the rail industry leads to a significant decrease in rail exhaust emissions. Note that part of this positive effect will be compensated by increases in electricity consumption and a related increase in lifecycle emissions, i.e. in the emissions from electricity power plants. For air the impact of the Single European Sky programme is stronger in F than in P. As rail and air have only a modest share in total ground level transport, the effect of the rail and air improvements on total transport ground level exhaust emissions is very limited.

As for energy consumption, 2020 road and air CO_2 exhaust emissions in the E scenario show a significant decrease compared to the other scenarios, which is only partially compensated by an increase for rail and inland waterway. In the EU15, this policy scenario would even lead to a reduction of CO_2 exhaust emissions of about 5%, without accounting for the introduction of biofuels.

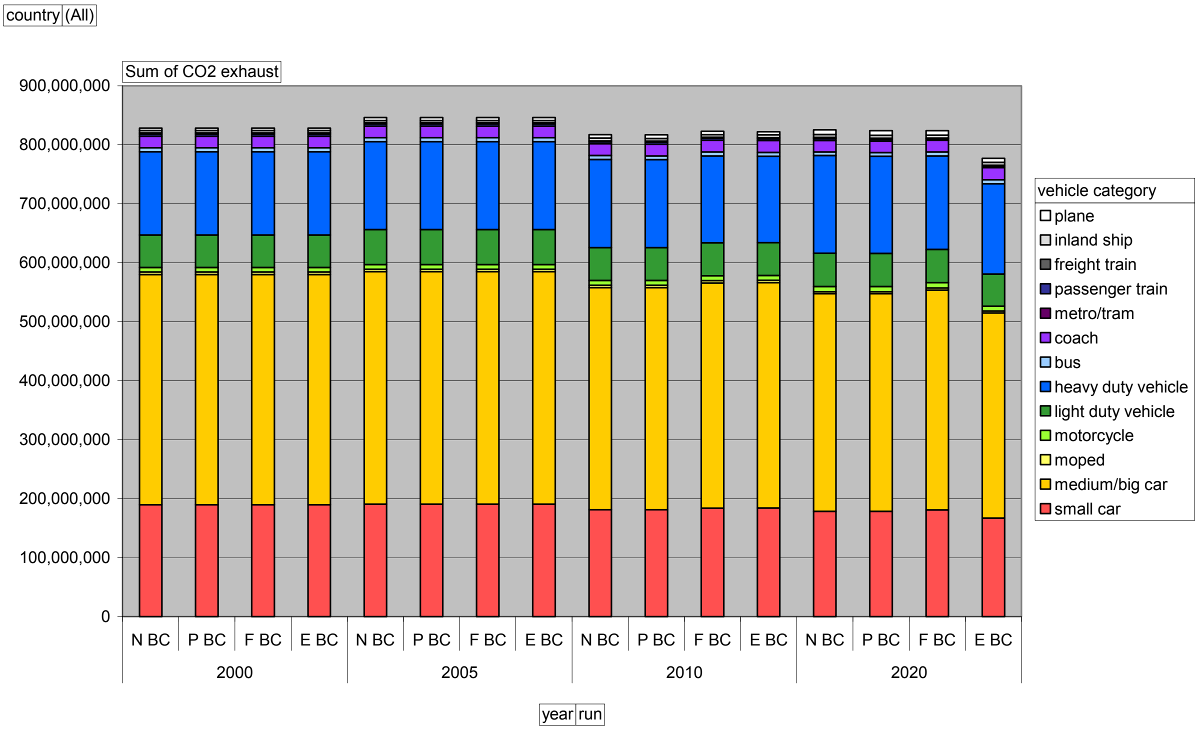

Figure 18 : EU15 Ground level CO2 exhaust emissions by scenario - tonnes

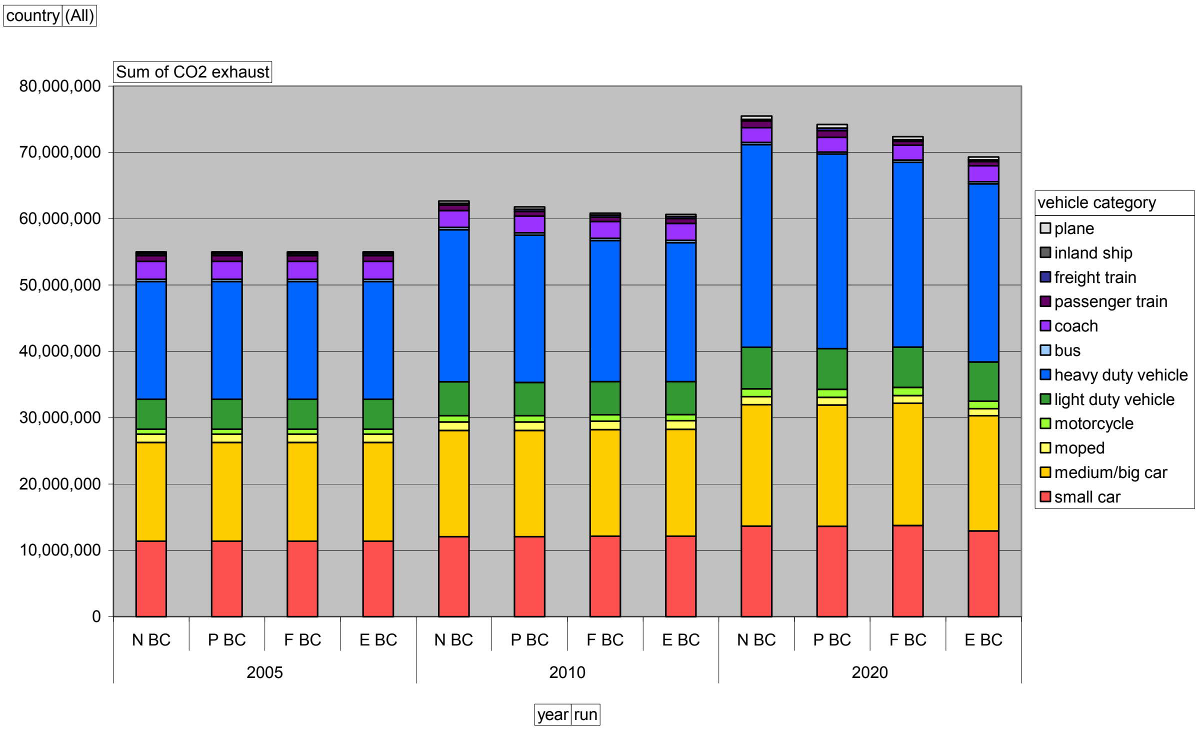

Figure 19 : 4 NMS Ground level CO2 exhaust emissions by scenario - tonnes

VII.3.3.1. Introduction of a minimum share of biofuel

As explained in section VII.2.2.4, the P, F and E scenario have been processed with and without the biofuel policy. This enables a specific assessment of the impact of this policy. Table 8 summarises the main results from the simulation of the introduction of a minimum share of biofuel.

In the biofuel simulation scenarios it is assumed that there will be a gradual penetration of biofuel towards 5.75% of all petrol and diesel consumed by road transport in 2010 and up to 8% in 2020. For the EU15 countries, in the P scenario, biofuel consumption will account for 14867 ktoe and 20849 ktoe in 2010 and 2020 respectively. The exhaust CO_2 emissions related to this biofuel consumption are respectively 45599 kilo-tonnes and 63987 kilo-tonnes. These CO_2 emissions are considered not to contribute to the greenhouse effect. On the other hand, the production of biofuel causes more well-to-tank CO_2 emissions per energy unit than the production of fossil fuels. This way, the biofuel policy leads to 7950 kilo-tonne extra well to tank emissions in 2010, and 603 kilo-tonnes in 2020. These extra CO_2 emissions do contribute to the greenhouse effect, thus they reduce the effect of the initial tank-to-wheel gain in CO_2. The resulting net effect on greenhouse CO_2 emissions is a decrease by 37649 kilo-tonnes in 2010 and by 52715 kilo-tonnes in 2020.

Table 8 also presents monetised values for the avoided greenhouse gas emissions. TREMOVE uses 12 euro per tonne and 20 euro per tonne as monetisation estimates[13] for CO2 in 2010 and 2020 respectively. These values are estimates for the marginal abatement costs in 2010 and 2020 respectively. In EU15 the monetised CO_2 benefit in 2010 is 452 million euro, while in 2020 it is 1054 million euro.

The biofuel policy also has a cost however. Producing biofuel is more expensive than producing fossil-based fuels. Moreover, this cost difference depends on the crude oil price, with biofuel cost becoming more competitive if crude oil prices increase. The use of biofuel leads to an increase in total EU15 fuel resource costs of 986 million euro in 2010 and 1023 million euro in 2020. As tax exemptions and/or subsidies are introduced to cover this resource cost increase, this leads to a decrease in total excise tax revenues for the governments.

In summary, in the EU15 P scenario the decrease in government revenues per ton CO_2 reduction is 26.2 euro in 2010 and 19.4 euro in 2020, while the benefits would be respectively 12 euro per ton and 20 euro per ton. The 2020 figure is lower than the 2010 figure as the higher (predicted) 2020 crude oil price will lead to a lower extra cost for biofuel production. Comparing the change in revenues per ton with the benefits, the reader might conclude that introducing biofuels is not a cost-effective measure in 2010, but will be cost-effective in 2020. It should be emphasized though that the model results are based on a number of assumptions w.r.t. future oil prices, (constant) biofuel production costs and related CO_2 emissions. Moreover, the welfare cost of a decrease in tax revenues depends on how it is compensated, e.g. by increasing taxes in other sectors (as explained in section VII.3.5).

In the 4 New Member States P scenario, the decrease in government revenues per ton CO_2 reduction is 30.6 euro in 2010 and 23.4 euro in 2020. These values are higher than the EU15 estimates, amongst others due to differences in fuel production costs and fleet composition (share of petrol and diesel vehicles) .

The results for the F and E scenarios are similar to those of the P scenario, as illustrated in Table 8.

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[13] As suggested by Directorate-General Environment

	EU15						4NMS					
	2010			2020			2010			2020		
	P	F	E	P	F	E	P	F	E	P	F	E
Share biofuel	5.75%	5.75%	5.75%	8.00%	8.00%	8.00%	5.75%	5.75%	5.75%	8.00%	8.00%	8.00%
Biofuel consumption - ktoe	14867	14994.99	15000	20849	20890	19649	1083	1067	1062	1828	1797	1717
Change in total fuel resource cost - million euro	986	995	989	1023	1029	1004	83	82	82	108	106	102
Change in total excise tax revenue - million euro	-986	-995	-989	-1023	-1029	-1004	-83	-82	-82	-108	-106	-102
Avoided CO2 emissions (tank to wheel) - kton	45599	45988	45960	63988	64107	60470	3329	3282	3266	5623	5527	5289
Related external cost - million euro	*547*	*552*	*552*	*1280*	*1282*	*1209*	*40*	*39*	*39*	*112*	*111*	*106*
Extra CO2 emissions (well to tank) - kton	7950	8012	7967	11273	11277	11049	603	593	591	1028	1007	992
Related external cost - million euro	*95*	*96*	*95.5994*	*225*	*226*	*220.986*	*7.2*	*7*	*7.08631*	*21*	*20*	*19.8338*
Total efect on CO2 emissions - kton	-37649	-37976	-37993	-52715	-52831	-49421	-2726	-2689	-2675	-4595	-4521	-4297
Related external cost - million euro	*-452*	*-456*	*-456*	*-1054*	*-1057*	*-988*	*-33*	*-32*	*-32*	*-92*	*-90*	*-86*
Change in tax revenue per ton CO reduction - euro	**26.2**	**26.2**	**26.0**	**19.4**	**19.5**	**20.3**	**30.6**	**30.6**	**30.6**	**23.4**	**23.4**	**23.8**
Benefit per kton CO2 reduction - euro	**12.0**	**12.0**	**12.0**	**20.0**	**20.0**	**20.0**	**12.0**	**12.0**	**12.0**	**20.0**	**20.0**	**20.0**

Table 8 : Model results for the biofuel policy

VII.3.3.2. Lifecycle and total well-to-wheel CO_2 emissions

Figure 18 and Figure 19 showed the tank-to-wheel CO_2 emissions in the scenarios. However, to assess the full impact of the policy scenarios on greenhouse gas emissions, the impact on well-to-tank emissions should as well be included in the analysis. Figure 20 and Figure 22 present these latter well-to-tank emissions, more specifically the emissions related to the production of fuels and electricity consumed by the transport sector. Note that in the biofuel (SIM) scenario figures, 'diesel' and 'gasoline' should be interpreted as the blended fuels, i.e. including a biofuel additive. In general these 'life-cycle' emissions follow the general trends in energy consumption over time and over the scenarios. Three important remarks should be made however.

Firstly, the shift from diesel to electric trains in the F and E scenarios leads to a decrease in tank-to-wheel CO_2 emission, as less fossil fuels are used. This reduction, of course, is to a large extent compensated by increased electricity generation emissions. The net effect however still is a decrease in total (well-to-wheel) CO_2 emissions. The magnitude of this overall benefits depends significantly on the mix of power plant types (fossil fuel, nuclear, renewable) in the country considered. In countries with a large share of nuclear power plants, e.g. France, the benefit in terms of CO_2 emissions is larger.

Secondly, as already indicated in section VII.3.3.1, the well-to-tank emissions in the biofuel (SIM) scenarios are higher than in the base (BC) scenarios, as producing blended fuels leads to more CO_2 emissions than producing pure fossil-based fuels.

Thirdly, TREMOVE does not account for possible changes/improvements in the production processes for transport fuels. In other words, the model assumes constant emissions per unit of fuel produced in the 1995-2020 period. For electricy production however, TREMOVE accounts for expected changes in the mix of electricity production plants and related changes in emissions per unit of electricity production ((based on RAINS (IIASA, 2004) and PRIMES (Mantzos, Capros) projections).

Finally, Figure 21 and Figure 23 show the evolution in exhaust (including high-altitude) and total well-to-wheel (WTW) CO_2 emissions of the transport sector by scenario. Exhaust emissions shown in these graphs are for the scenarios without biofuel policy. When the biofuel policy is not accounted for, both well-to-tank and tank-to-wheel CO_2 emissions follow the trend in energy consumption. The evolution of total well-to-wheel emissions then is similar to that of exhaust emissions. When the biofuel policy is included in the scenario, well-to-tank emissions will be somewhat higher (as illustrated in Figure 20 and Figure 22). CO_2 emissions relating to the burning of biofuel in engines (exhaust), should then not be accounted for however. As a result, the net effect of the biofuel policy is a significant reduction in total well-to-wheel emissions compared to a scenario without biofuels.

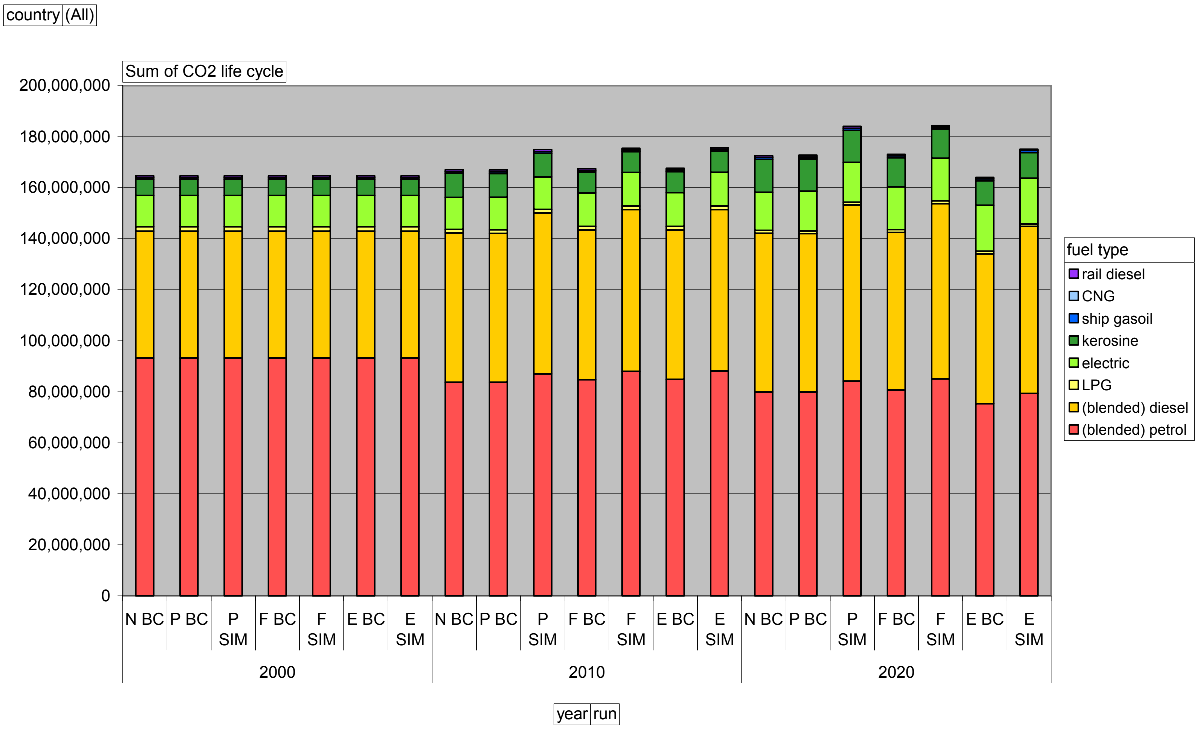

Figure 20 : EU15 Life-Cycle CO_2 emissions by fuel type and scenario - tonnes

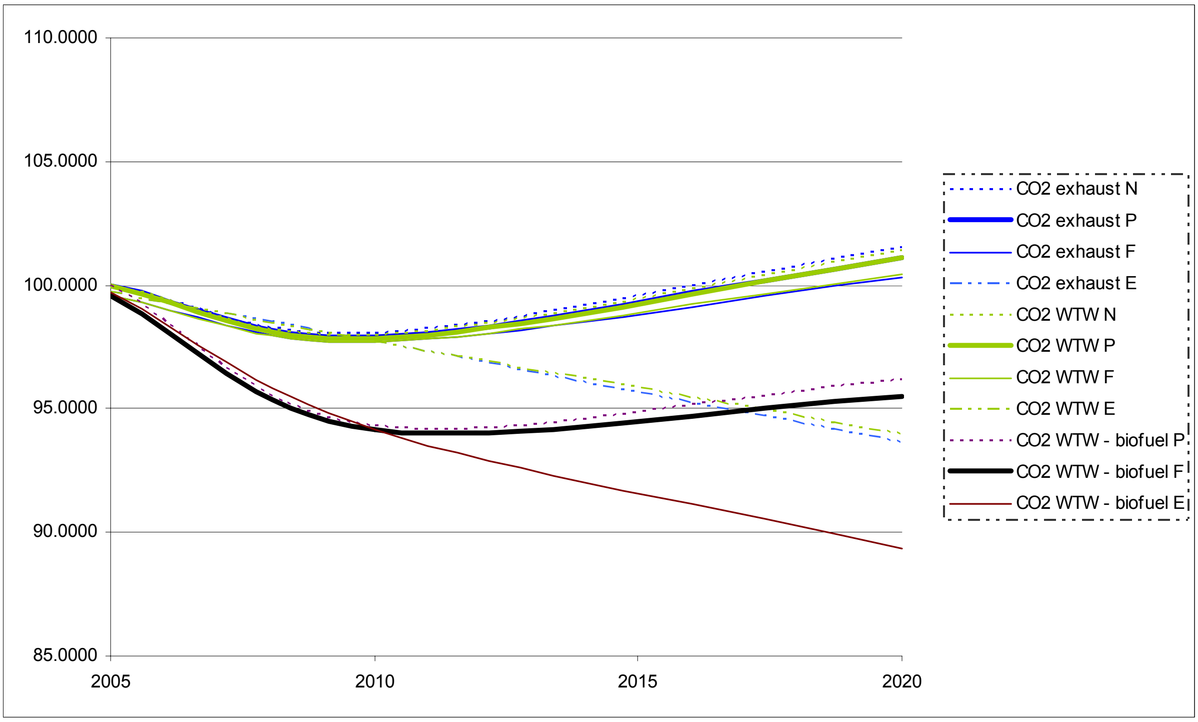

Figure 21 :EU15 Exhaust and well-to-wheel CO_2 emissions by scenario (2005 = 100)

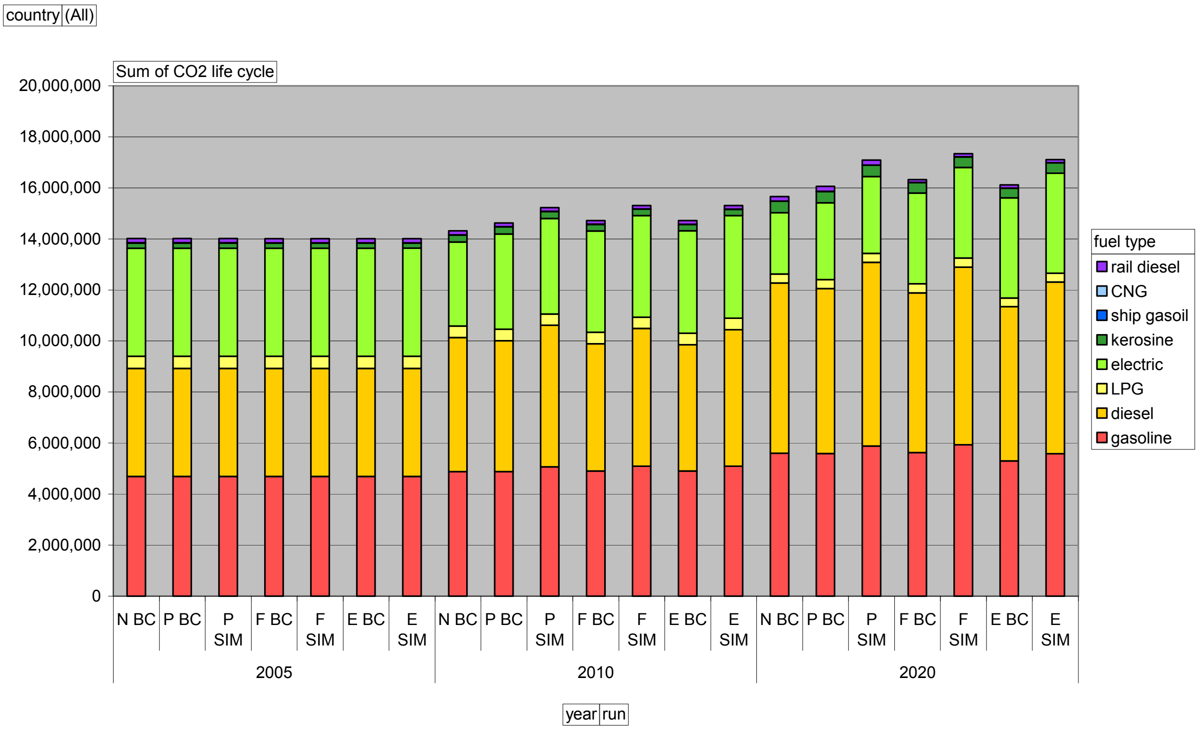

Figure 22 : 4 NMS Life-Cycle CO_2 emissions by fuel type - tonnes

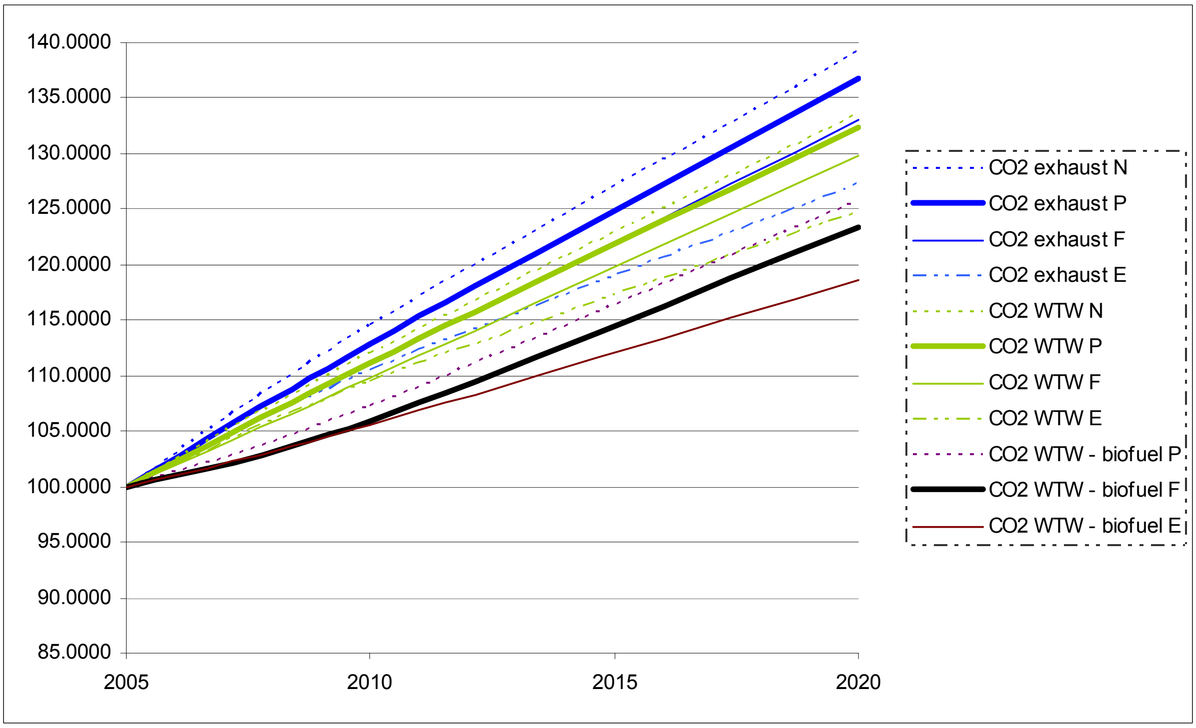

Figure 23 : 4 NMS Exhaust and well-to-wheel CO_2 emissions by scenario (2005 = 100)

VII.3.4. Transport sector non-greenhouse gas pollutant emissions

Although TREMOVE also includes calculations for pollutants as CO and volatile organic compounds (as methane and benzene), the discussion in this section is restricted to the pollutants considered to be most relevant in this project, i.e. NO_x, particulates and SO_2. Information on the other pollutants is available in the TREMOVE output tables.

Figure 24 and Figure 25 show the predicted evolution of vehicle exhaust emissions in scenario P, relative to the year 2005 levels, for NO_x, particulates and SO_2.

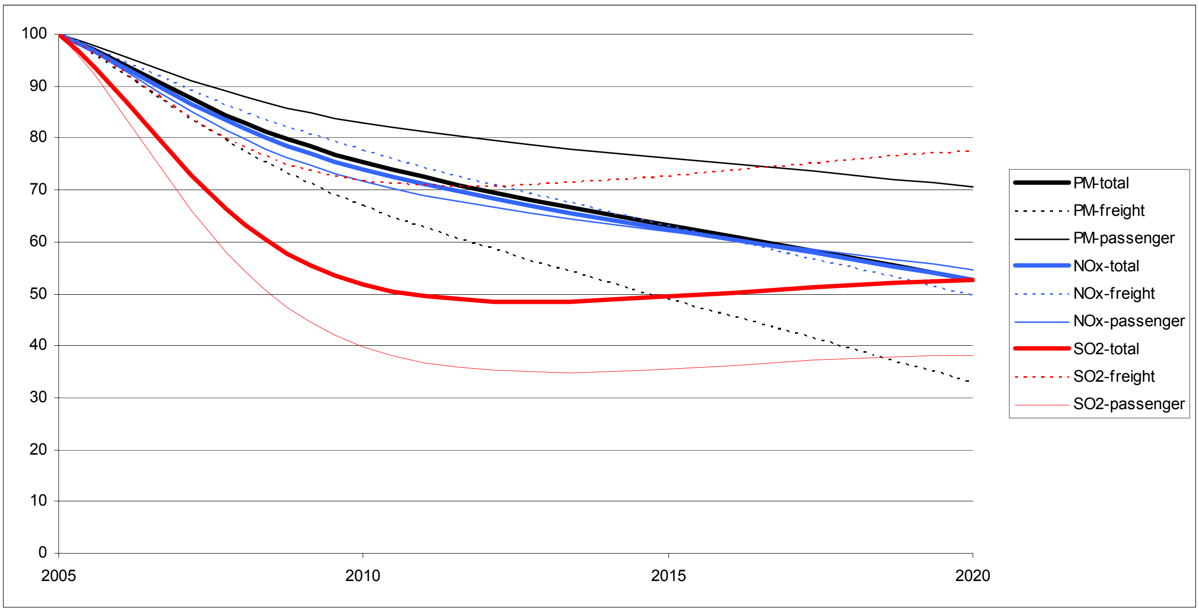

Figure 24 : EU15 Total exhaust emissions for all modes, NOx, PM and SO2, P-scenario (2005 = 100)

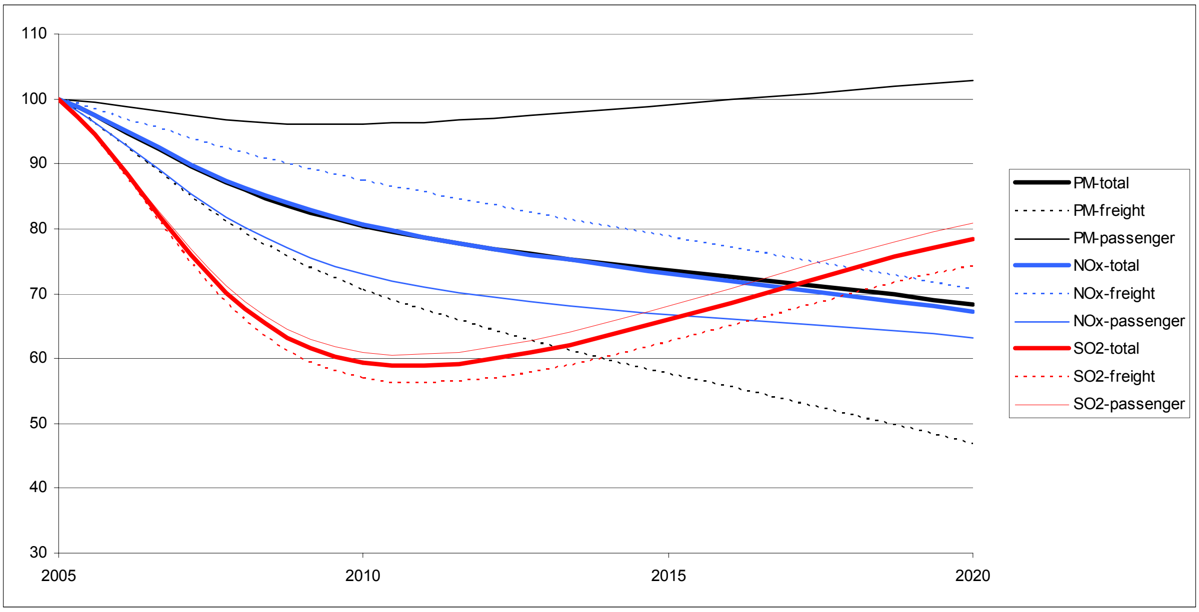

Figure 25 : 4 NMS Total exhaust emissions for all modes, NOx, PM and SO2, P-scenario (2005 = 100)

The major driver for the EU15 reduction in NO_x and particulate emissions is the introduction of road vehicles complying to the most recent emission standards (EURO IV for cars and EURO V for trucks). For busses the policy promoting a faster introduction of clean vehicles of course accelerates this effect. The impact of the new emission standards on particulate emissions is to significant extent hampered by the rising share of diesel cars in the fleet, resulting in a stronger decrease in freight PM emissions than passenger PM emissions. NO_x emissions from passenger road transport decrease stronger then those from freight road transport however. For air transport the reduction of flight route lengths for aircrafts compensates to a certain extent the strong growth for this mode, but it is only a small step towards the general objective on reducing emissions from air transport. Similar to CO_2, the decrease in emissions is more modest in the New Member States due to the stronger growth in activity.

SO_2 emissions decrease strongly in the 2005-2010 period, this is in first place the result of the introduction of low(er) sulphur fuels in the road transport sector. In later years the emission levels follow the growing activity levels.

Figure 26 to Figure 31 display the ground level exhaust emissions in the different scenarios, i.e. all exhaust emissions excluding those from aircrafts above 3000 ft.

The differences in transport flows between the N and P scenarios are limited, except for the increase in freight rail transport which leads to an increase in freight rail emissions. The main other effects on emissions in the P scenario, compared to N, are a reduction in aircraft emissions resulting from the European Sky Programme and a decrease in bus emissions due to the accelerated introduction of cleaner busses. Overall, none of these effects lead to a significant change in total emissions from the transport sector.

The decrease in particulate and NO_x emissions between the F and P scenario is limited in the EU15 countries, while it is more significant in the 4 New Member States. These changes are consistent with the changes in energy consumption and CO_2 emissions. In the 4 New Member States an important decrease in rail particulates and NO_x might be possible by entering the dialogue with the rail industry on environmental improvements. This certainly is also the case for SO_2 emissions. The use of low sulphur fuel in rail transport, as in road transport, might lead to significant emission reductions in both the EU15 countries and the New Member States. Note however that these rail exhaust emission reductions will be partially compensated by related increase in life-cycle emissions, i.e. an increase in electricity power plant emissions. Additional emissions for the desulphurisation process are expected to be low and are not accounted for in the modeling.

In the E scenario, full implementation of marginal social cost pricing in the freight sector and partial marginal social cost pricing for passenger car and air transport will lead to a further decrease in the 2020 road and air transport emissions. The further implementation of the Single European Sky programme contributes to this emission reduction for air transport via a shortening of the flight routes. Emissions of rail and inland waterways will increase slightly compared to F, as also transport activity for these modes is higher in F than in E.

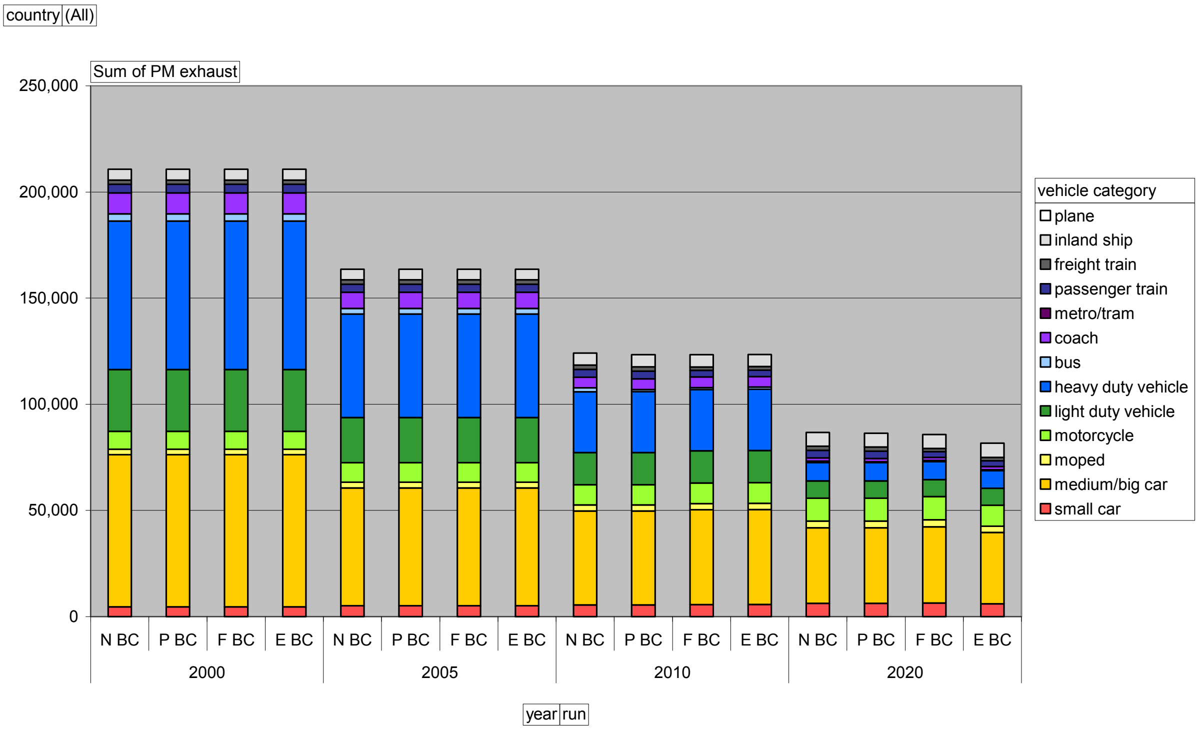

Figure 26 : EU15 Ground level PM exhaust emissions by scenario - tonnes

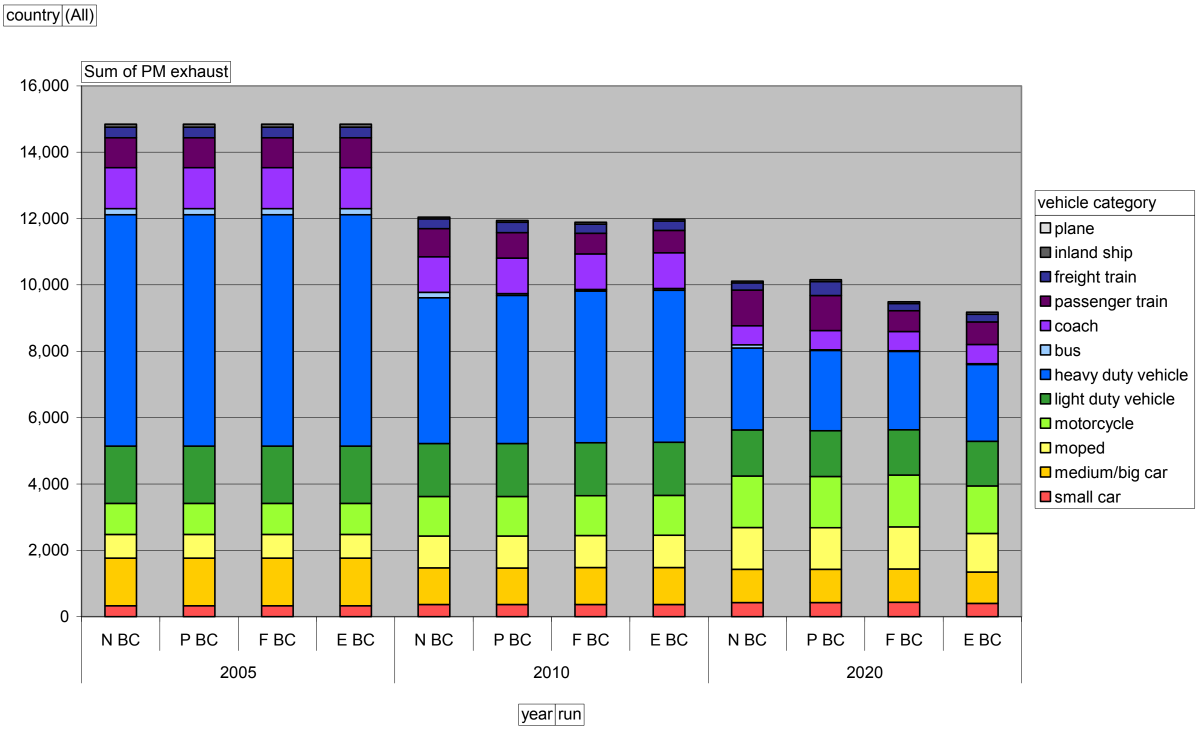

Figure 27 : 4NMS Ground level PM exhaust emissions by scenario - tonnes

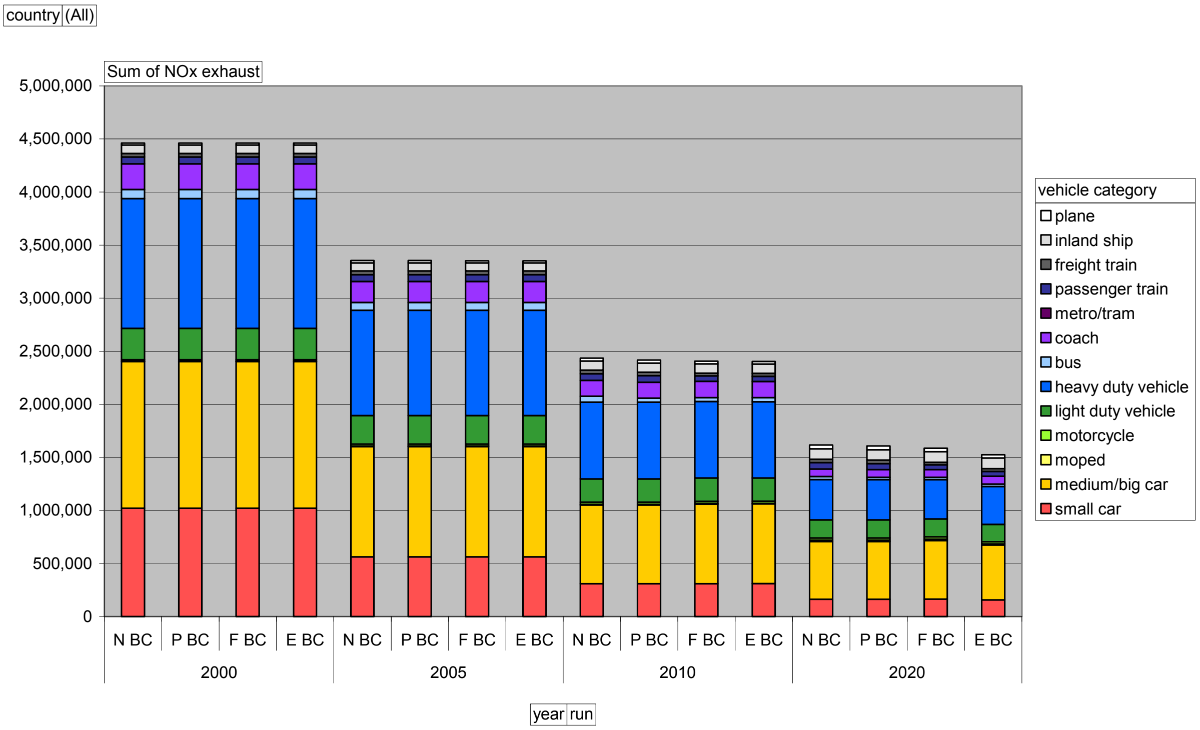

Figure 28 : EU15 Ground level NO_x exhaust emissions by scenario - tonnes

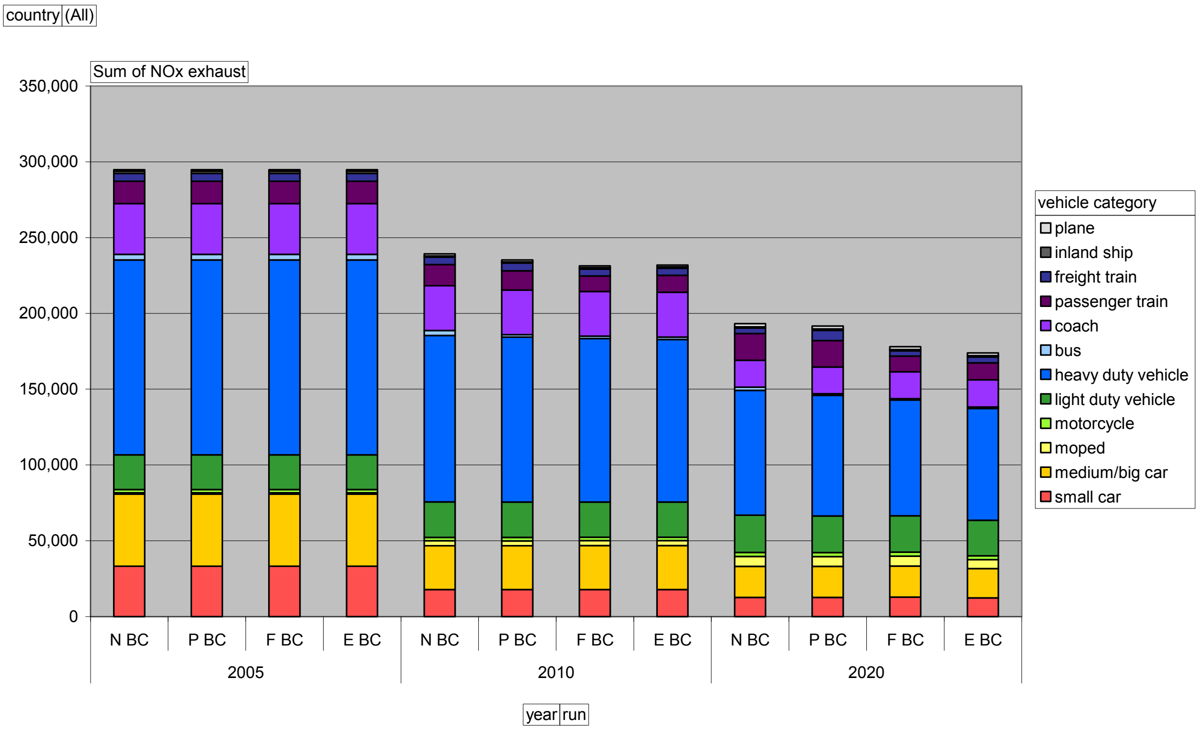

Figure 29 : 4 NMS Ground level NO_x exhaust emissions by scenario - tonnes

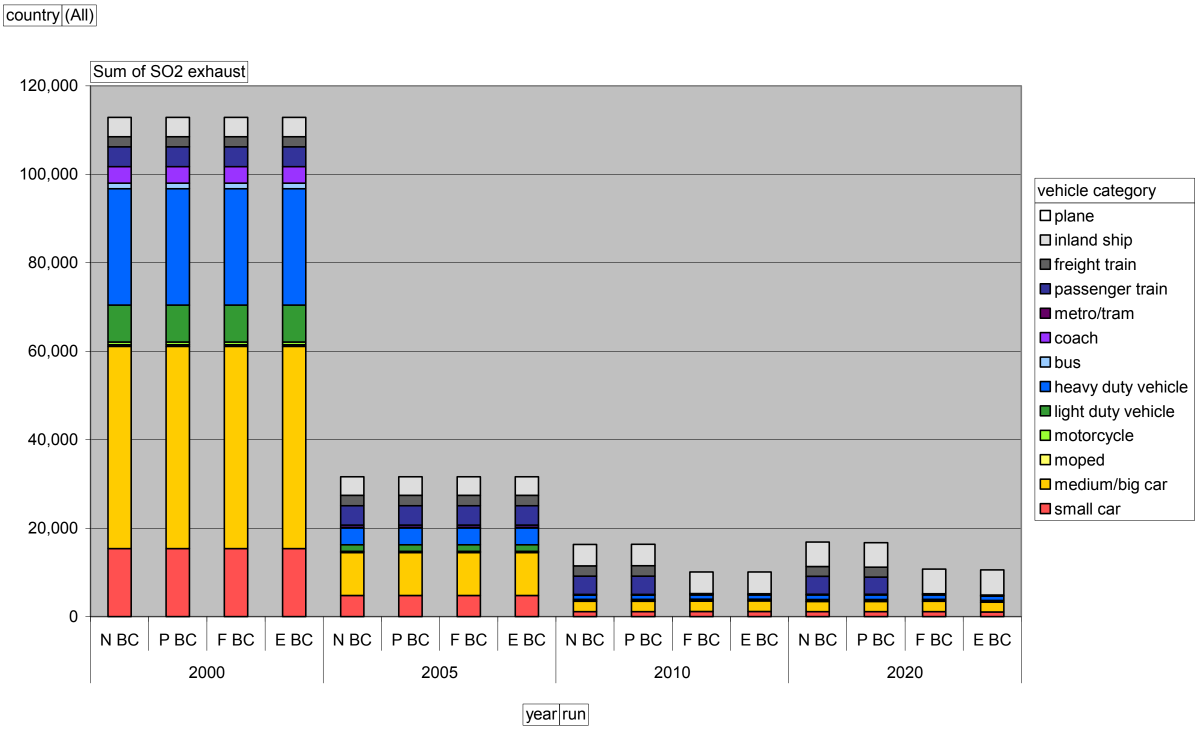

Figure 30 : EU15 Ground level SO_2 exhaust emissions by scenario - tonnes

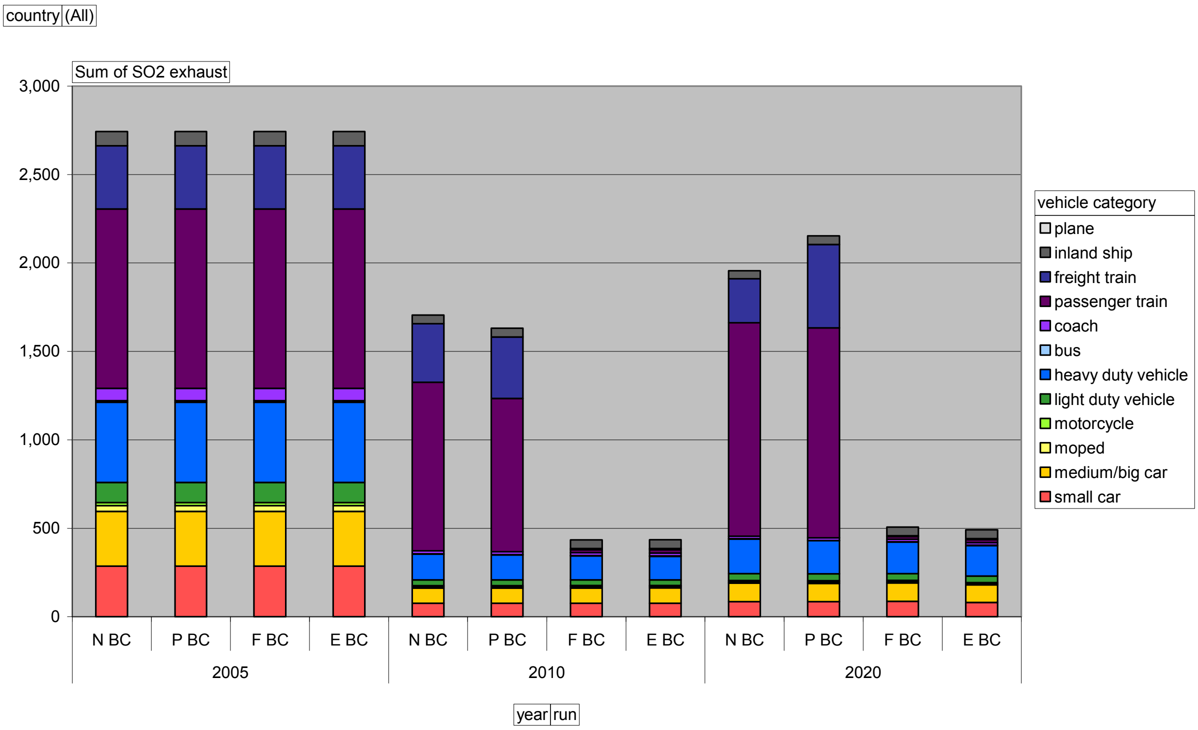

Figure 31 : 4 NMS Ground level SO_2 exhaust emissions by scenario - tonnes

VII.3.4.1. Lifecycle and total well-to-wheel emissions

To assess the full impact of the policy scenarios on pollutant emissions, the impact of well-to-tank emissions has been included in the analysis. Figure 32 to Figure 35 display the evolution of exhaust (including high-altitude) emissions and total well-to-wheel emissions in the four scenarios.

For NO_x and particulates there is an important reduction in exhaust emissions in all scenarios, over 40% and over 30% reductions in the EU15 countries and the 4 New Member States respectively. Well-to-tank emissions in TREMOVE follow the trend of energy consumption[14], with a modest increase towards 2020 in the EU15, except for the E scenario; and a stronger increase in all scenarios in the 4 New Member States. The decrease in well-to-wheel emissions and the increase (except for E in EU15) in well-to-tank emissions leads to an increasing share of well-to-tank emissions in total lifecycle emissions. In EU15, well-to-tank NO_x emissions account for 12% in total NO_x emissions in 2000 and up to 26% in total NO_x emissions in 2020. A similar increase is predicted for particulates in EU15, from 32% in 2000 up to 53% in 2020. This trend is also observed in the model results for the New Member States. Thus, the strong reductions in exhaust emissions, will lead to an increasing importance of well-to-tank emissions. Therefore the predicted percentages reductions in total well-to-wheel emissions are significantly lower than the percentages reductions in exhaust emissions.

This latter conclusion is of even larger importance for SO_2 emissions than for the other pollutants. As, especially in road transport, fuels have a very low sulphur content, the share of well-to-tank emissions in total SO_2 well-to-wheel emissions is very high. The well-to-tank emissions account for more than 90% of total emissions. This makes that, while vast reductions in SO_2 exhaust emissions are predicted, the future reductions in total well-to-wheel emissions are expected to be rather limited.

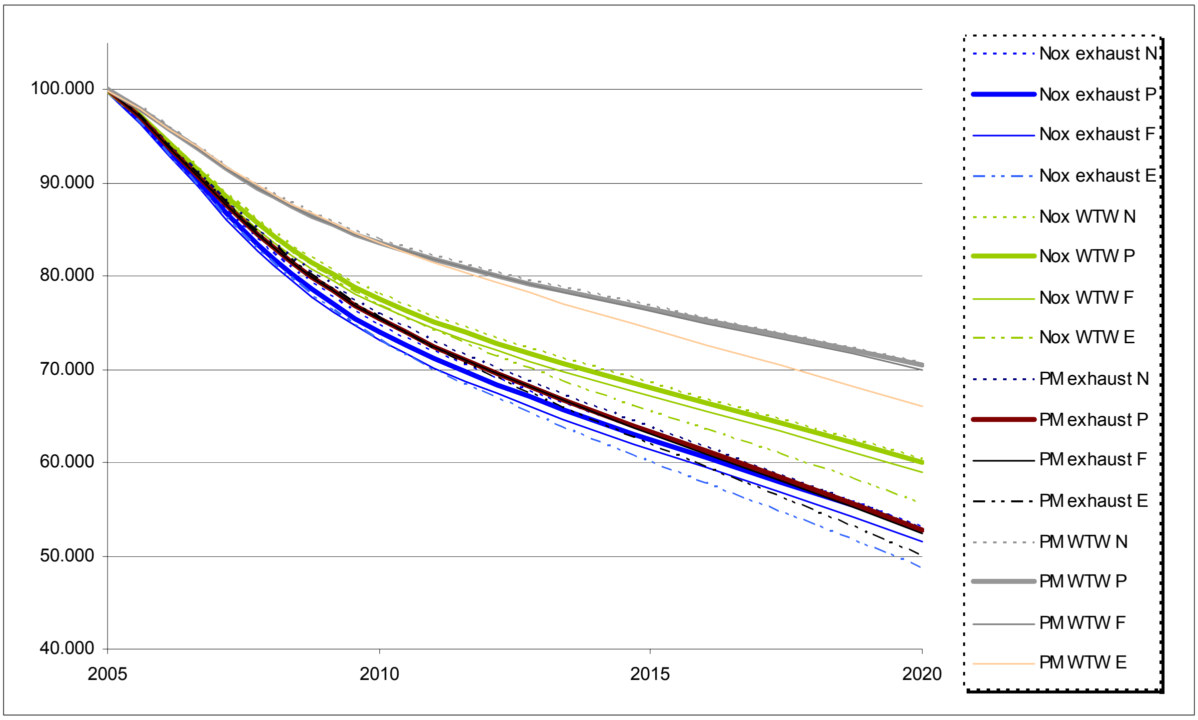

Figure 32 : EU15 Exhaust and well-to-wheel NO_x and particulate emissions by scenario (2005 = 100)

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[14] similar to the CO_2 well-to-tank emissions (see VII.3.3.2). It is important to keep in mind here that TREMOVE does not account for possible changes/improvements in the production processes for transport fuels. In other words, the model assumes constant emissions per unit of fuel produced in the 1995-2020 period. For electricity production however, TREMOVE accounts for expected changes in the mix of electricity production plants and related changes in emissions per unit of electricity production ((based on RAINS (IIASA, 2004) and PRIMES (Mantzos, Capros) projections).

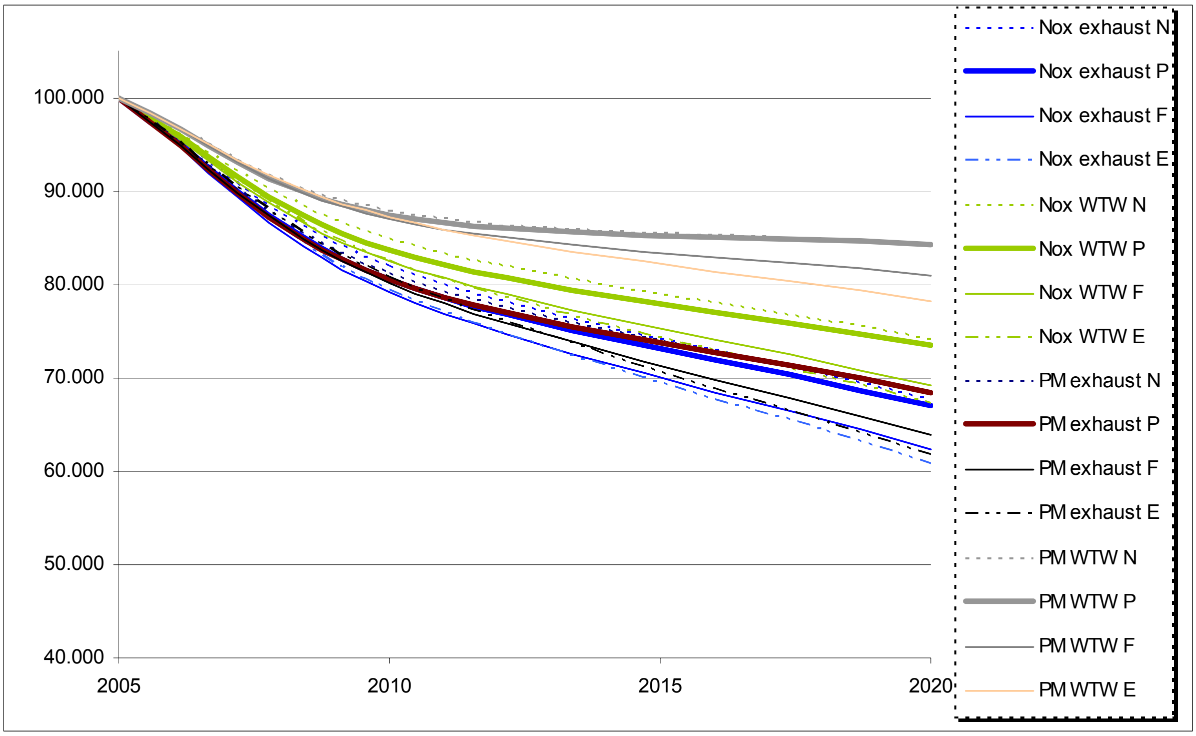

Figure 33 : 4 NMS Exhaust and well-to-wheel NO_x and particulate emissions by scenario (2005 = 100)

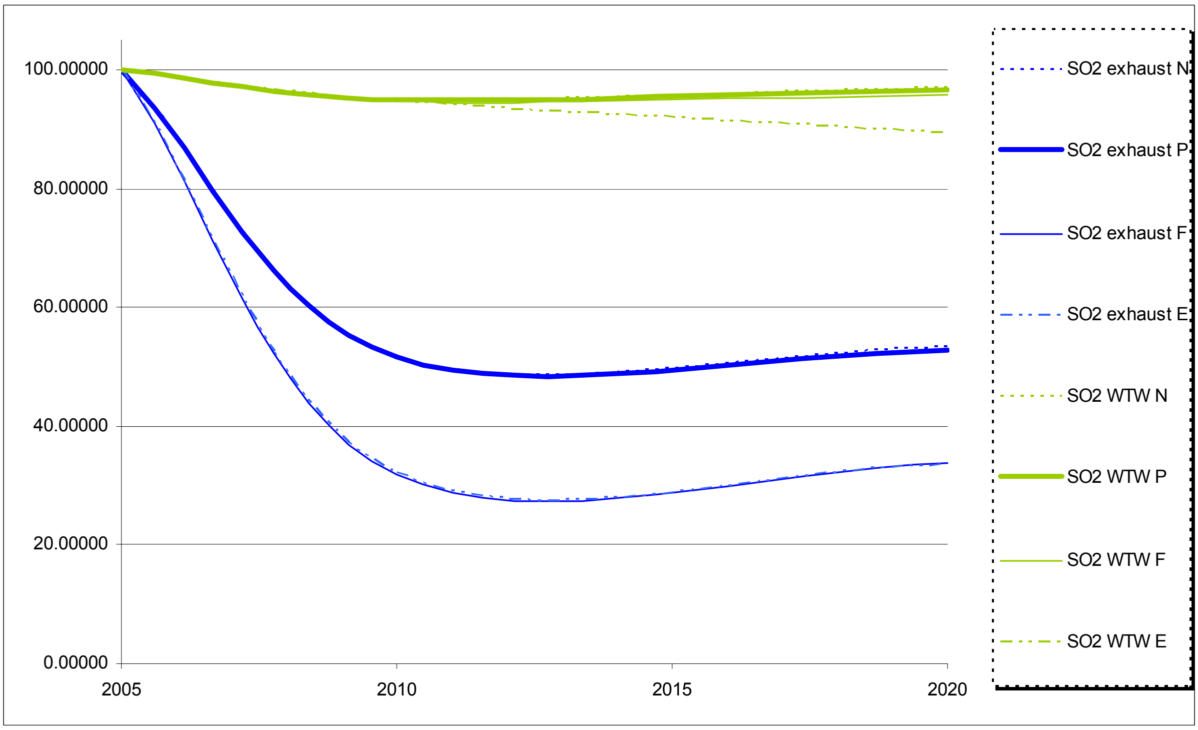

Figure 34 : EU15 Exhaust and well-to-wheel SO_2 emissions by scenario (2005 = 100)

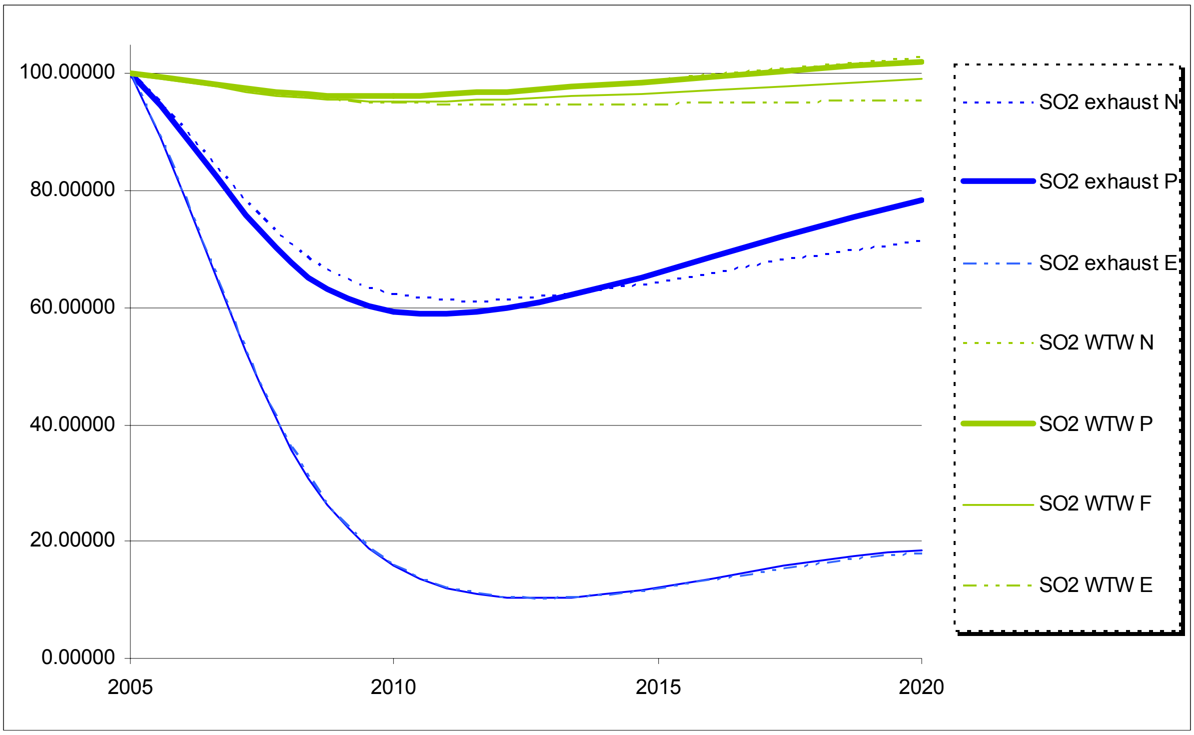

Figure 35 : 4 NMS Exhaust and well-to-wheel SO_2 emissions by scenario (2005 = 100)

VII.3.5. Overall Welfare effect and its components

As discussed in sectionVII.2.3, the TREMOVE 2.3 model is designed to analyse welfare differences between a 'base case' scenario and alternative policy 'simulation' scenarios. Within this ASSESS project however, four 'base case' scenarios (N,P,F and E – without biofuel policy) have been developed, which have to be compared against each other. Therefore the TREMOVE welfare module has been restructured for this project. The differences in welfare levels between the F, P and E scenarios on one hand and the N scenario on the other hand have been calculated. These differences are discussed in this section. On top of that a short analysis of the welfare impact of the biofuel policy is added.

As indicated in VII.1.2.5, the welfare differences calculated by TREMOVE are composed of four components :

- Changes in aggregated utility level of households
- Changes in aggregated production costs of firms
- Welfare changes stemming from changes in government tax revenues
- Changes in external environmental costs

In the remainder of this section, we will firstly discuss the results for these four components individually, before combining the results for an overall welfare assessment of the scenarios.

VII.3.5.1. Changes in aggregated utility level of households

TREMOVE is a 'partial' equilibrium model, not a general equilibrium model. It models the transport sector, but does not include specific links between this sector and other sectors nor the labour market. As a consequence, the model does not directly enable to assess the impact of policy scenarios on households income levels. Therefore the calculation of changes in households utility levels between scenarios is performed under the assumption that household income is equal in all scenarios. The utility level reached in each scenario, then basically[15] is calculated as a weighed sum of the consumption levels of different (transport or other) goods and services. The wheights represent to what extent households associate a higher utility with the consumption of one unit of a good (e.g. one air passenger-km) than with the consumption of one unit of another good (e.g. one bus passenger-km). An increase in utility then can stem from either an increase in consumption or a substitution of low utility goods by high utility goods. Both could be the results of, amongst others, changes in price[16] structures (taxation of certain goods, ...) or changes in infrastructures (availability and quality of public transport, ...).

Table 9 displays the differences in household utility levels between the P, F and E scenarios and the N scenario.

While in 2010 the impact of the policy scenarios is limited, more significant changes result in 2020. The increase in household utility in the P scenario mainly stems from the improvements, and related demand increase, in rail services. The F scenario includes further improvements in public transport, but also higher VAT rates for air transport. The net utility effect is similar to the P scenario. The E scenario however only leads to a very small utility increase. The beneficial effects from the P and F scenario now are compensated by the introduction of car and air social cost pricing, which make transport significantly more expensive. It is important to note however that the related increase in government tax revenues from the transport sector eventually will have an important beneficial effect for the households (as discussed in VII.3.5.3).

VII.3.5.2. Changes in aggregated production costs of firms

Next to the calculation of the impact of policy scenarios on aggregate household utility, TREMOVE also calculates the impacts on the overall production costs[17] of firms and service sectors. As TREMOVE is a partial equilibrium model, it assumes that the overall production level of goods and services is not affected by the policy scenarios.

In the P scenario freight transport by trucks becomes more expensive through a limited introduction of road pricing. Together with the improvements in rail, inland waterway and terminal services, this leads to a substitution of truck freight transport by rail (and inland waterway) freight transport. Overall ton-kilometers decrease however, such that (to maintain the overall production volumes) there must be a limited increase in the use of other production factors (e.g. local logistic infrastructures, ...). The overall result of this restructuring of the production and logistic processes, is a decrease in the total production costs. I.e. it is expected that the benefits from the cost and travel time reductions in rail, inland waterway and terminal services offset the cost increase for truck transport and the increased expenditures for the use of other inputs.

The situation is similar in the F scenario, though the road charges for truck are significantly higher, leading to a lower decrease in production costs than the P scenario.

In the E scenario full social marginal cost pricing for freight transport leads to an increase in production costs. This increase in taxes however is compensated to a large extent by cost and travel time decreases resulting from measures that focus on improvements in quality of services and from decreased congestion due to lower road transport quantities.

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[15] We just describe the utility calculation as simplified as possible in this report. More detail can be found in the TREMOVE 2.3 documentation.

[16] We refer here to generalised prices, i.e. monetary costs and taxes plus time costs.

[17] Here as well we refer to monetary costs as well as costs in terms of time

Note that also for freight transport increases in government tax revenues from the transport sector eventually will have an important beneficial effect (as discussed in VII.3.5.3).

VII.3.5.3. Welfare changes stemming from changes in government tax revenues

The policy scenarios have a significant impact on the governments tax revenues from and subsidies to the transport sector. Table 9 shows these changes in tax revenues (subsidies are accounted for as negative taxes).

Compared to the N scenario, total transport tax revenues in the P scenario are lower. This decrease mainly stems from a substitution from taxed road transport towards subsidised rail transport, in both passenger and freight transport. I.e. the modest truck road charge revenues do not compensate the loss in road vehicle taxes (not only fuel excises but also vehicle registration taxes, yearly circulation taxes, etc.) and the increased subsidies for the extra rail transport (TREMOVE assumes a constant cost coverage for rail transport providers).

The F scenario leads to a similar decrease in tax revenues, which is smaller than in the P scenario however. Although there is a stronger shift from road modes towards other modes in F, the resulting decrease in tax revenues now is more compensated by a higher level of truck social cost pricing as well as higher air VAT rates.

Finally, in the E scenario, the full implementation of social cost pricing in freight transport and its partial implementation for private passenger transport as well as the fuel tax harmonisation for trucks lead to a strong increase in tax revenues for the government.

To evaluate the welfare effect of these changes in tax revenues between the scenarios, an assumption has to be taken on the way in which the government will make use of additional tax revenues from the transport sector, or will compensate decreases in tax revenues from the transport sector. As the government has to balance its revenues and expenses, changes in revenues from the transport sector will have to be compensated in one or another way. For example, a decrease in tax revenues from the transport sector could be compensated by cuts in social security expenses, but also by increases in labour taxes or in general taxes. And the way it is compensated determines the eventual welfare effect of the decrease in tax revenues[18].

In Table 9 the welfare effect of changes in tax revenues from the transport sector are denoted as ‘cost of public funds’ (a decrease in tax revenues from the transport sector means that more public funds will have to be collected from other sources). In TREMOVE it is assumed that changes in transport tax revenues are compensated by either changes in labour taxes, either changes in general taxes. Thus two ‘cost of public funds’ values and two ‘welfare’ values are calculated.

VII.3.5.4. Changes in external environmental costs

Figure 36, Figure 37 and Table 9 show the decrease in environmental external costs in the P, F and E scenario compared to the N scenario.

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[18] Increasing labour taxes, for example, has a distortionary effect on the labour markets in the EU countries where the current labour tax level already is high. It can be proven that increasing labour taxes by 1 euro, actually leads to a decrease in social welfare that is larger than one euro. And this decrease in welfare is higher than when the decrease in transport tax revenue is compensated by an increase in general taxes. An in depth discussion can be found in the TREMOVE 2.3 report.

In order to include the environmental effects of the policy scenarios in the welfare analysis, the emissions (or more specifically their effect on human health, climate change, ...) have to be expressed in monetary terms. In TREMOVE values for external costs per ton of pollutant are derived from the cost-benefit analysis research in the Clean Air for Europe Programme, except for the CO and CO_2 values. The external costs of CO have been taken from ExternE (Friedrich, Bickel, 2001). For CO_2 TREMOVE uses 12 euro per tonne and 20 euro per tonne as monetisation estimates[19] for CO2 in 2010 and 2020 respectively. These values are estimates for the marginal abatement costs in 2010 and 2020 respectively. The external costs for exhaust particulate emissions are differentiated between non-urban, urban and metropolitan areas. All lifecycle emissions are evaluated using the non-urban external cost values, as a.o. power plants and refineries are expected to be located in less populated sites.

As can be observed in Figure 36 and Figure 37, the external costs follow the trends in the total well-to-wheel emissions, with increasing reductions from the N towards the E scenario, and from 2005 towards 2020.

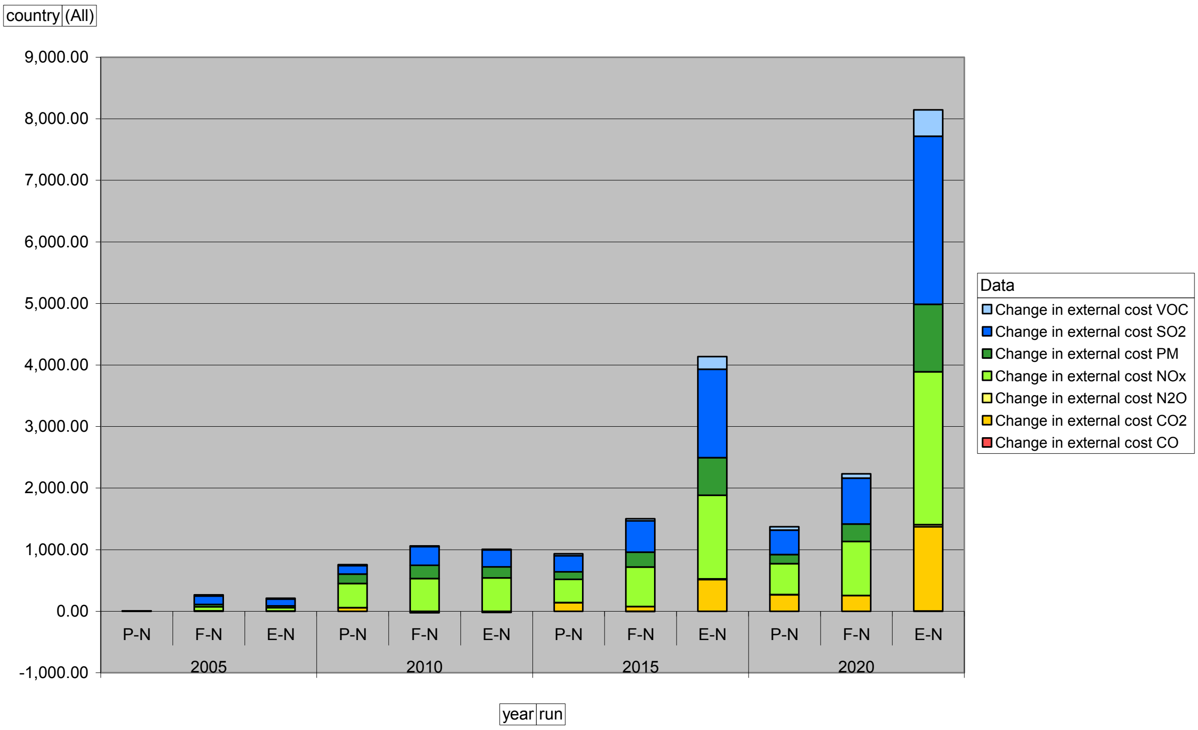

Figure 36 : EU15 Decrease of external environmental costs compared to N scenario – million euro

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[19] As suggested by Directorate-General Environment

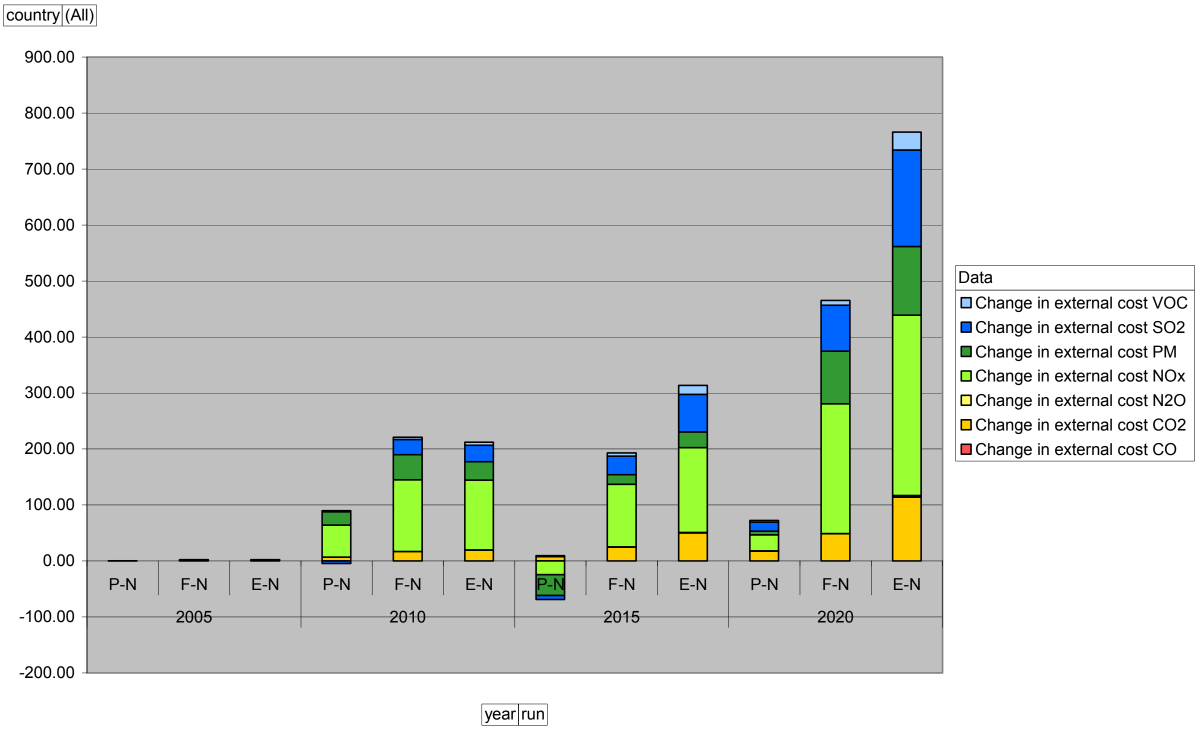

Figure 37 : 4 NMS Decrease of external environmental costs compared to N scenario – million euro

VII.3.5.5. Overall welfare differences between the four scenarios

The overall welfare differences between the scenarios are calculated as the sum of the four components discussed in the preceding paragraphs :

- Changes in aggregated utility level of households
- Changes in aggregated production costs of firms
- Welfare changes stemming from changes in government tax revenues
- Changes in external environmental costs

Table 9 gives an overview of the overall welfare effects and their composition in 2010 and 2020, as well as the net present values in 2005 of the total welfare effect from 2005 up to 2020.

	EU15						4NMS					
	2010			2020			2010			2020		
	P-N	F-N	E-N	P-N	F-N	E-N	P-N	F-N	E-N	P-N	F-N	E-N
Increase in utility of households	-2159	-1363	-107	83192	84761	2353	-9	21	-3	4121	4217	59
Decrease in production costs	65875	45312	-75	194802	127948	1602	9186	8097	-26	44682	31158	62
Increase in government tax revenue	-34163	-9601	44607	-126937	-65951	116908	-5254	-4165	2996	-14998	-2833	22300
Decrease in cost of public funds (labour)	-51155	-16999	63367	-188770	-100104	178121	-6614	-5263	6488	-18987	-3399	39528
Decrease in cost of public funds (general)	-32198	-8741	*44606*	-118265	-58717	*116919*	-5090	-4055	*5029*	-14638	-2577	*30641*
Change in external cost CO	0	0	*0*	0	0	*1*	0	0	*0*	0	0	*0*
Change in external cost CO2	55	-25	*-18*	265	255	*1372*	7	17	*20*	18	48	*114*
Change in external cost N2O	1	-3	*-3*	4	0	*33*	0	0	*0*	0	1	*3*
Change in external cost NOx	395	532	*541*	502	877	*2485*	57	128	*124*	29	232	*322*
Change in external cost PM	152	214	*182*	149	285	*1097*	24	45	*33*	6	94	*122*
Change in external cost SO2	139	306	*274*	399	746	*2729*	-5	27	*29*	16	82	*173*
Change in external cost VOC	16	7	*9*	54	69	*428*	2	4	*5*	3	9	*32*
Decrease environmental external cost	758	1031	*985*	1373	2232	*8145*	85	221	*212*	72	465	*766*
Increase in welfare(labour)	13319	27981	64170	90598	114837	190220	2649	3077	6671	29889	32442	40415
Increase in welfare(general)	32276	36239	45409	161103	156223	129018	4172	4285	5212	34238	33264	31529
Increase in welfare(labour) - 2005 NPV	**381732**	**549701**	**1031123**				**105583**	**116060**	**163413**			
Increase in welfare(general) - 2005 NPV	**730992**	**739077**	**710818**				**128166**	**126401**	**127432**			

Table 9 : Overall welfare effect and its components relative to N scenario – million euro

The importance of the the changes in external environmental costs in the total welfare effects is limited.

In the P scenario, by 2020, there is an important decrease in production costs and a significant increase in the utility of households compared to the N scenario. These beneficial effects however are offset to a large extent by a strong decrease in government revenues. The latter decrease will lead to a compensating increase in labour taxes or general taxes. Total welfare in the P scenario however still is higher than that in the N scenario in 2020 as well as aggregated over all years (net present value).

The F scenario results in a similar change in household utility as the P scenario. Production costs as well as government tax revenues from the transport sector are a lot higher though. Using the assumption that the change in tax revenues is covered by a compensating change in general taxes, both F and P scenario have similar welfare effects in 2020 as well as aggregated over all years. Using the assumption that the extra tax revenues in F are compensated by a decrease in labour taxes, the F scenario leads to a higher welfare level than the P scenario.

In the E scenario the 2020 changes in household utility and production costs are limited. The positive welfare effect stems mainly from a vast increase in tax revenues from the transport sector. Using these additional public funds to lower labour taxes is more welfare-improving than using them to lower general taxes. Using the former assumption (labour), the E scenario leads to the highest welfare level of all scenarios. Using the latter assumption (general) the E scenario leads to a somewhat lower welfare level than P and F. This result is in line with the economic principle saying that tax reforms are welfare improving if they lead to tax levels that are closer to the marginal external costs of the taxed sector or good. Currenlty, taxes in the transport sector (in many cases) are lower than the marginal external costs, while taxes in the labour sector are higher than the marginal external costs.

VII.3.5.6. Welfare impact of the biofuel policy

In the preceding sections we discussed the welfare differences between the four policy scenarios without the biofuel policy. In this section we discuss the impact of an introduction of biofuels in the road transport sector on the welfare analysis.

The blended fuels will be exempted from taxes in order to cover the difference in resource costs between the blended and pure fossil fuels. Consumers nor firms will observe fuel price changes, nor will change their behaviour. Therefore, the biofuel policy will, in first instance[20], have no impact on the utility of households or aggregated production costs of firms.

The policy will lead to a lower excise tax revenue for the government however, as already indicated in Table 8 (these figures are also displayed in Table 10 below). The eventual welfare cost of this decrease depends on how it is compensated, e.g. by increasing general or labour taxes (see VII.3.5.3) or by cuts in social security expenses. This welfare cost (in euro) is most probably similar or somewhat higher than the decrease in tax revenues itself.

diff CO2 lifecycle emissions SIM - BC from emission .xls pivot

	EU15						4NMS					
	2010			2020			0			2020		
	P	F	E	P	F	E	[illegible]	[illegible]	E	P	F	E
Decrease in total excise tax revenue - million euro	***-986***	***-995***	***-989***	***-1023***	***-1029***	[illegible]	[illegible]	***-82***	***-82***	***-108***	***-106***	***-102***
Avoided CO2 emissions (tank to wheel) - kton	*45599*	*45988*	*45960*	*63988*	*64107*	*60470*	*3329*	*3282*	*3266*	*5623*	*5527*	*5289*
Extra CO2 emissions (well to tank) - kton	*7950*	*8012*	*7967*	*11273*	*11277*	*11049*	*603*	*593*	*591*	*1028*	*1007*	*992*
Total efect on CO2 emissions - kton	-37649	-37976	-37993	-52715	-52831	-49421	-2726	-2689	-2675	-4595	-4521	-4297
Extra NOx emissions (well to tank) - ton	96844	97658	97658	136168	136383	130804	7123	7018	7018	12051	11838	11464
Extra PM emissions (well to tank) - ton	4801	4841	4841	6778	6785	6739	358	353	353	608	597	590
Extra SO2 emissions (well to tank) - ton	-40022	-40407	-40407	-55234	-55474	-47424	-2741	-2716	-2716	-4562	-4512	-4011

Table 10 : Welfare results for the biofuel policy

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[20] i.e. not accounting for second order effects due to changes in governments tax revenues.

The benefit of the policy lies in the reduction of greenhouse gas emissions contributing to global warming, as already explained in section VII.2.2.4. This emission benefit however is partially offset by an increase in well-to-tank emissions for CO_2 (see Table 8), as well as for other pollutants. Table 10 shows the impact on well-to-tank emissions for the most relevant pollutants. The external cost increase related to the changes in NO_x, PM and SO_2 well-to-tank emissions is only about 1.5 million euros in EU15 in 2010 and 2 million euros in 2020. The net result of the policy on environmental external costs thus still is a decrease, i.e. these extra well-to-tank emissions do not offset the CO_2 benefit (reported in Table 8), and do not alter the conclusions from section VII.2.2.4.

It should be once again emphasized though that the model results are based on a number of assumptions w.r.t. future oil prices, (constant) biofuel production costs and related well-to-tank emissions and last but not least unsure estimates for the environmental benefits related to a tonne reduction of greenhouse gas emissions and for the health impacts of e.g. particulate emissions.

VII.4. Conclusion

TREMOVE is a transport and emissions simulation model developed for the European Commission Directorate-General Environment. The model estimates the transport demand, the modal shifts, the vehicle stock turnover, the emissions of air pollutants and the welfare level for different policy scenarios. The TREMOVE model has been used within the ASSESS project. Four scenarios have first been developed using the SCENES model. The application of TREMOVE then enables a detailed assessment of vehicle fleet and emission evolutions up to 2020 for all transport modes. The model also provides estimates on changes in governments tax revenues from the transport sector, impacts on travel times and eventually changes in overall welfare. This way, the effects of different degrees of implementation of the White Paper policies are evaluated against a scenario in which none of the White Paper measures would be implemented.

The TREMOVE scenarios are fully consistent with the SCENES scenarios. Though a limited number of policies with environmental impacts could not be assessed in the SCENES model. Therefore these have been added into to TREMOVE scenario setups. More specifically these policies are :

- Enter the dialogue with the rail industries in the context of a voluntary agreement to reduce adverse environmental impacts
- Promote the use of clean vehicles in urban public transport
- The environmental impact of the Single European Sky programme
- Introduction of a minimum share of biofuels consumption in road transport

In the N scenario TREMOVE predicts a limited increase in EU15 transport energy consumption over time, and a strong growth in energy consumption in the 4 New Member States covered by the model. Forecasted energy consumption in the P scenario is somewhat lower than that for the N scenario, and that in the F scenario again is a bit lower than that in the P scenario. The E scenario is the scenario with the lowest transport sector energy consumption. In the EU15, this policy scenario even is predicted to bend the upward trend in energy consumption into a decrease.

If the biofuel policy is excluded from the analysis, both the N and P scenarios lead to an almost stable CO_2 exhaust emission prediction for the EU15 countries. In the New Member States the emissions will increase, due to the much stronger growth in transport activity. Compared to N and P, the F scenario would lead to a very small increase in exhaust CO_2 emissions in the EU15 countries, while it is a decrease in the New Member States. As for energy consumption, CO_2 emissions in the E scenario are significantly lower than those in the other scenarios. The evolution of total well-to-wheel CO_2 emissions is similar to that of the exhaust emissions.

The introduction of biofuel in the road transport sector would, in the EU15 P scenario, lead to a decrease in government tax revenues per ton CO_2 of 26.2 euro in 2010 and 19.4 euro in 2020. In the 4 New Member States, this would be 30.6 euro and 23.4 euro respectively. The results for the F and E scenarios are similar.

The major driver in all scenarios for the future reduction in NO_x and particulate emissions is the introduction of road vehicles complying to the most recent emission standards. For SO_2 emissions, this is in first place the introduction of low(er) sulphur fuels in the road transport sector. Overall, there is no significant change in total emissions for these pollutants between the N and P scenario. The F scenario shows a modest decrease in overall emissions compared to the N and P scenarios. Nevertheless, the F scenario shows that an important decrease in rail emissions might be possible by entering the dialogue on environmental improvements with the rail industry. In the E scenario, full implementation of marginal social cost pricing in the freight sector and partial marginal social cost pricing for passenger car and air transport will lead to a further decrease in the emissions.

The strong reductions in exhaust emissions for these pollutants, will lead to an increasing importance of well-to-tank emissions. Therefore the predicted percentages reductions in total well-to-wheel emissions are significantly lower than the percentages reductions in exhaust emissions.

The overall welfare differences between the 4 scenarios have been calculated by aggregating four components :

- Changes in aggregated utility level of households
- Changes in aggregated production costs of firms
- Welfare changes stemming from changes in government tax revenues
- Changes in external environmental costs

Total welfare in the P scenario is significantly higher than that in the N scenario. Using the assumption that changes in government tax revenues from the transport sector lead to compensating changes in labour taxes, this welfare gain increases from the N scenario over the P and F scenario up to the E scenario. If changes in transport revenues are covered by changes in general taxes, the welfare effects of the P, F and E scenario are in the same range.

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TREMOVE website : www.tremove.org