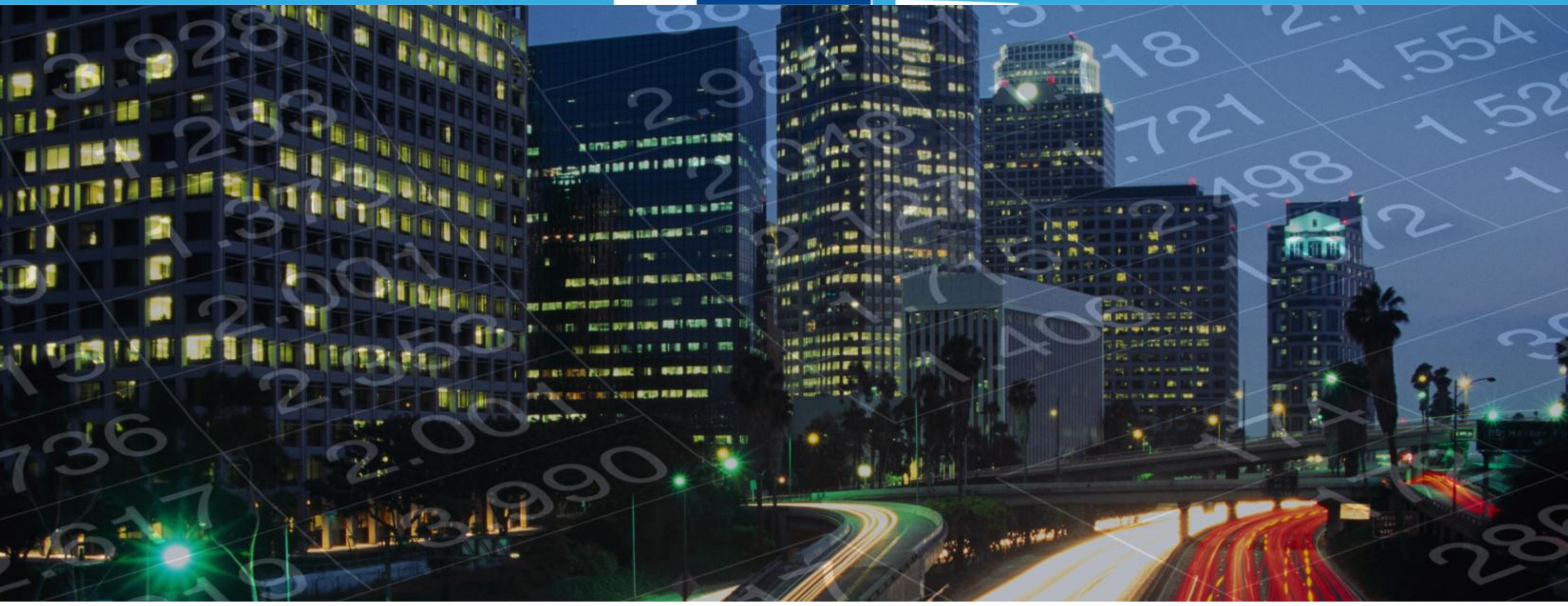

JRC TECHNICAL REPORTS

Modelling Future Mobility - Scenario Simulation at Macro Level

OPTIMISM WP3: Demand and supply Factors for Passenger Transport and Mobility Patterns Status Quo and Foresight

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OPTIMISM

optimising passenger transport systems

The project is partially financed by the EC

OPTIMISM's scope is to provide a scientifically documented insight of the transport system and people‘s travel choices via the study of social behaviour, mobility patterns and business models. The overall aim of OPTIMISM project is to define which of the future changes in the travel system would lead to a sustainable way of travel-ling, as people could travel more efficiently, cleaner and more safely, without compromising mobility.

The OPTIMISM project consists of six work packages (WPs):

- Work Package 1: Management
- Work Package 2: Harmonisation of national travel statistics in Europe
- Work Package 3: Demand and supply factors for passenger transport and mobility patterns – status quo and foresight
- Work Package 4 : Analysing measures for decarbonisation of transport
- Work Package 5: Elaborating on strategies for integrating and optimising transport systems
- Work Package 6: Dissemination and Awareness

OPTIMISM is a project partially financed by The European Commission under the framework programme. It is coordinated by the Coventry University Enterprises (UK). The consortium includes partners from different EU Member States and Associated Countries such as Zürcher Hochschule für Angewandte Wissenschaften (Switzerland), Signosis (Belgium), DLR – German Aerospace Center (Germany), Forum of European National Highway Research Laboratories (Belgium), Universita Degli Studi di Roma La Sapienza (Italy), Transport & Mobility Leuven (Belgium), CE Delft (Netherlands) and the IPTS Joint Research Centre (European Commission)

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List of Abbreviations

ACEA	European Automobile Manufacturers Association
CO_2	Carbon dioxide
DG CLIMA	Directorate-General for Climate Action
DG ENER	Directorate-General for Energy
DG JRC	Directorate-General Joint Research Centre
DG MOVE	Directorate-General for Mobility and Transport
EC	European Commission
ETIS	European Transport Policy Information System
EU	European Union
EUROSTAT	Statistical Office of the European Union
GHG	Greenhouse Gas
GIS	Geographical Information Systems
GPS	Global Positioning System
GSM	Global System for Mobile Communications
ICT	Information and Communication Technologies
JAMA	Japan Automobile Manufacturers Association
KAMA	Korea Automobile Manufacturers Association
NOx	Nitrogen Oxides
NUTS	Nomenclature of Territorial Units for Statistics
OPTIMISM	Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility
PC	Passenger Cars
Pkm	Passenger Kilometres
PM10	Particulate Matter
PT	Public Transport
TEN-T	Trans-European Transport Network
Vkm	Vehicle Kilometres
WP	Work Package

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1. Introduction

1.1. The OPTIMISM project

The OPTIMISM (Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility) project aims to propose a set of strategies, recommendations and policy measures, through the scientific analysis of social behaviour, mobility patterns and business models, for integrating and optimising transport systems based on the impact of co-modality and information and communication technologies (ICT) based solutions for passenger transport.

OPTIMISM project is based on three main blocks of activities:

- Identifying the gaps and harmonisation of data in travel behaviour. This will lead to a unified set of data that will serve as reference material for future exploitation of existing studies and baseline information (or data),

- Defining demand and supply factors that shape the transportation system and mobility patterns. This will aim to give an outlook on future developments by modelling and scenario simulation, and

- Defining the potential decarbonisation of the passenger transport system and ensuring the sustainability of the system. The decarbonisation potential and co-benefits of best practices and solutions will be based upon an analysis of ICT and co-modality options with an impact assessment of the research results.

These activities are carried out in several work packages (WPs) as following:

WP1 Management: to manage and coordinate all different activities within the OPTIMISM project and to secure that the project consortium can deliver the results while at the same time fulfil contractual obligations.

WP2 Harmonisation of national travel statistics in Europe: to describe social behaviour, mobility patterns and business models through analytical insights into the data of Europe-wide national travel statistics – aiming to harmonise possible differences of the identified data.

WP3 Demand and supply factors for passenger transport and mobility patterns – status quo and foresight: to provide insights into the factors and key drivers shaping the transportation system and mobility patterns concerning passengers – aiming to give an outlook on future development.

WP4 Analysing measures for decarbonisation of transport: to provide a broad overview of ways to enhance co-modality, with a focus on ICT-solutions and to identify best practices for passenger transport.

WP5 Elaborating on strategies for integrating and optimising transport systems: to develop roadmaps including strategies, technologies and methodologies for integrating and optimising transport systems for passengers with the help of several policy papers.

WP6 Dissemination and Awareness: to ensure that the project�much practical outcomes are widely disseminated to the appropriate target communities, at appropriate times, via appropriate methods.

1.2. OPTIMISM WP3: Demand and supply factors for passenger transport and mobility patterns – status quo and foresight

The main objective of the work package 3 is to provide insights into the factors and key drivers shaping the transportation system and mobility patterns concerning passengers – aiming to give an outlook on future developments. More specifically:

- to provide a theoretical and practical research framework for data analysis in the context of passenger transport and mobility,
- to understand the transport and mobility system by analysing the demand and the supply side of the market,
- to identify the key drivers for changing behaviour in passenger transport (e.g. mode choice towards a more sustainable option; modal split favourable to public transport),
- to identify megatrends and their current and future impact on passenger transport and mobility behaviour,
- to build datasets on issues of passenger transport and mobility patterns.
- to formulate future multimodal mobility scenarios for passengers and modelling future mobility scenarios on micro and macro level.
- to provide input for WP5 development of strategies for integrating and optimising transport systems to feed policy guidelines promoting sustainable mobility and transportation systems.

In order to achieve these objectives, three separate tasks were identified of which the first two have already been accomplished. A brief description of these preceding tasks and their findings are given below:

Task 3.1: Identification of relevant factors and key drivers

The main objective of the Task 3.1 was to provide a research framework for the work package by analysing the passenger transport system with its demand and supply factors. Within this framework, collecting available information on demand factors (economic development, income, age, gender, etc.), gathering data on supply factors (infrastructure, car ownership, mobility costs, etc.) and analysing the gaps and interdependencies between demand/supply factors and travel statistics were included. At first, megatrends – as main influencing factors of the system – were detected by a meta-analysis of current socioeconomic and technological developments; than they were evaluated regarding to their impact on future development of the transportation system and mobility behaviour.

The output of the task, Deliverable 3.1: Research scheme for transport system and mobility behaviour key factors, includes the list of identified variables, relevant factors that influence passenger transport and a conceptual framework characterising transport system in terms of its variables and their main interactions (Hoppe et al., 2012).

Task 3.2: Future trends and their requirements for passenger transport
In the first step of Task 3.2, the identified megatrends for passenger transport were further elaborated and discussed by experts and ranked with regard to their potential impact for future transportation system. The megatrends identified within the task are as follows: urbanisation, shortage of resources, globalization 2.0, climate change and environmental ethics, technology change, crisis of mobility and European policy reaction, world population growth, demographic and social change of Europe, European market deregulation, increase of inter- / intra-national social disparities, and knowledge society and economy Europe. The results were presented in Deliverable 3.2: List of potential Megatrends influencing transport system and mobility behaviour (Delle Site et al., 2012).

In the second step of the task, the aim was: I) ranking of key factors according to their importance in terms of impact on passenger transport system and mobility patterns, and the uncertainty of their trend, II) selection of the main scenario variables, and III) description of OPTIMISM scenarios in terms of trends of external factors and policies. The main method to carry out these activities was a Delphi study, structured into three rounds: I) first expert online questionnaire, II) expert workshop, and III) second expert online questionnaire. On the basis of its results two key factors that shape policy scenarios were determined as energy prices and support of sustainable mobility policies. According to these two variables the following 5 scenarios (a reference scenario and four policy scenarios) have been defined in Deliverable 3.3 of the project (Delle Site et al., 2013a):

- S0 : Reference scenario
- PS1: Baseline trend for oil price /"Do-as-today" for co-modality
- PS2: "Global Action" trend for oil price/"Do-as-today" for co-modality
- PS3: Baseline trend for oil price/"Do-maximum" for co-modality
- PS4: "Global Action" trend for oil price/"Do-maximum" for co-modality

1.3. The aim, scope and structure of the deliverable

The aim of the deliverable is to simulate OPTIMISM policy scenarios using Europe-wide transport models, estimate their potential impacts and demonstrate how do they differ from each other and from the reference scenario for 2030. In more detail, the main objectives of the deliverable can be given as follows:

- to model future multi-modal mobility scenarios for passengers formulated within the previous tasks of the project,
- to simulate impacts of identified trends and selected strategies on demand, supply and technology at macro level,
- to analyse impacts of selected policies and identified trends on mobility patterns such as in travel demand and modal split,
- to estimate potential impacts of selected policy measures on environmental indicators via transport emissions and vehicle fleet sizes,
- to compare impacts of different scenario options in quantitative terms and provide useful insights for exploring best policy scenarios and strategies for sustainable passenger transport.

In order to estimate possible mobility and environmental impacts of different policy scenarios, two main modelling tools were used at EU level: TRANS-TOOLS and TREMOVE. TRANS-TOOLS was used to estimate transport activity indicators and TREMOVE was used to estimate environmental impacts of the OPTIMISM policy scenarios. A brief description of these tools is given below and further information is provided in the sub-sequent sections of the deliveable.

- TRANS-TOOLS (TOOLS for TRansport Forecasting ANd Scenario testing) is a European transport network model that has been developed in collaborative projects funded by the European Commission Joint Research Centre's Institute for Prospective Technological Studies (IPTS) and DG TREN. TRANS-TOOLS is a European transport network model covering both passengers and freight, as well as intermodal transport. It combines advanced modelling techniques in transport generation and assignment, economic activity, trade, logistics, regional development and environmental impacts (http://energy.jrc.ec.europa.eu/TRANS-TOOLS/).
- TREMOVE is a policy assessment model, designed to study the effects of different transport and environment policies on the emissions of the transport sector. The model estimates for policies as road pricing, public transport pricing, emission standards, subsidies for cleaner cars etc., the transport demand, modal shifts, vehicle stock renewal and scrap page decisions as well as the emissions of air pollutants and the welfare level (http://www.tremove.org/).

Section 2 of the deliverable describes development of OPTIMISM policy scenarios. The main characteristics of transport models used in scenario simulations are given in section 3. Specification of policy scenarios for modelling exercise is given in section 4 with the main assumptions. The results including transport activity indicators and environmental and vehicle fleet indicators for Europe are presented in section 5 together with an overall evaluation and comparison of OPTIMISM policy scenarios. The concluding remarks are given in section 6.

Finally, it is worth mentioning that the quantitative results presented in this deliverable are going to be used and further evaluated in Task 5.2 and Task 5.3 of the project as an input to final assessment of OPTIMISM strategies that support co-modality and integration in passenger transport.

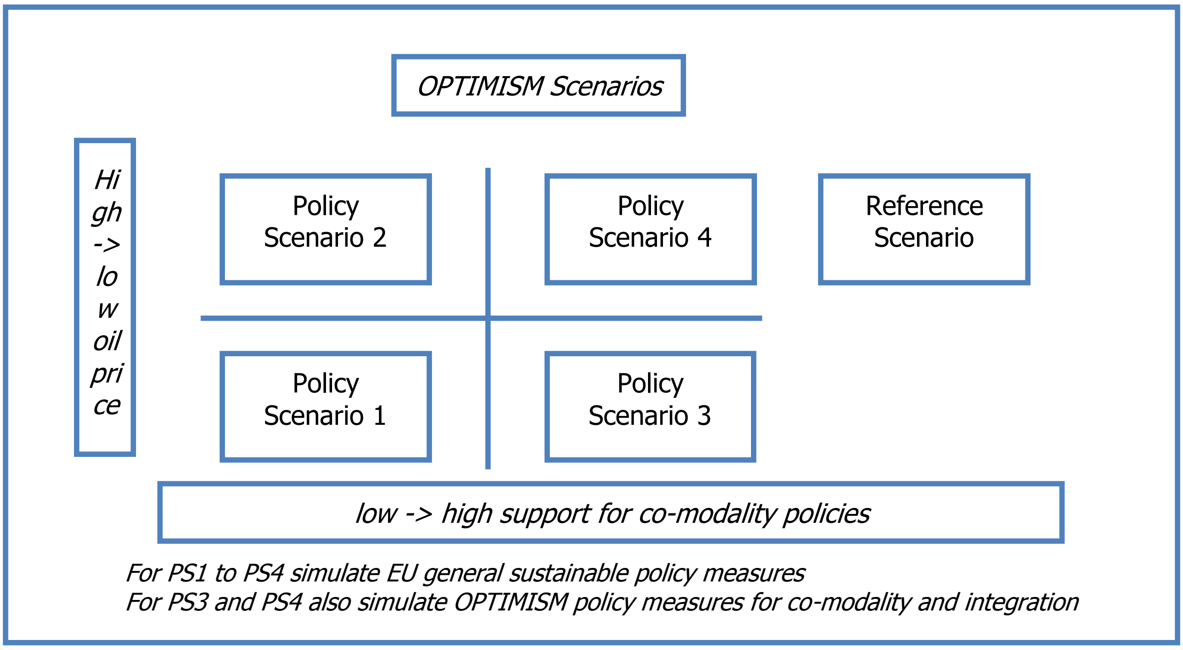
2. Definition of OPTIMISM policy scenarios and strategies

Based on the results of Delphi expert survey in OPTIMISM WP3, two main drivers were determined that shape future of passenger transport: energy prices and support to sustainable mobility policies. These two variables were selected among several other variables with regards to their importance and the uncertainty. The information for the selection was collected through the OPTIMISM first online questionnaire on future trends and the expert consultations of the workshop organized in Rome for the purpose. According to these two variables, four policy scenarios were established apart from a reference scenario for 2030. A brief description of these scenarios is given below and demonstrated with the main drivers in Figure 1. Additional information on scenario construction process can be seen in OPTIMISM Deliverable 3.3 (Delle Site et al., 2013a).

- Reference Scenario: It is the baseline scenario for Europe, from a recent study of the EC (European Commission, 2012). In particular it includes EC transport policies and transport activity estimations up to 2030.
- Policy Scenario 1: Baseline (increasing) trend for oil prices / business as usual policies for supporting co-modality and integration. This scenario is based on the reference scenario. In addition, it includes transport policy measures considered by the impact assessment of the transport White Paper which are most likely to be implemented by 2030.
- Policy Scenario 2: Global action (not increasing) trend for oil prices / business as usual policies for supporting co-modality and public transport. This scenario is also based on the reference scenario. In addition, it includes transport policy measures considered by the impact assessment of the transport White Paper which are most likely to be implemented by 2030, and it considers a different trend for oil prices.
- Policy Scenario 3: Baseline (increasing) trend for oil prices / sustainable policies for supporting co-modality and integration (maximum support). This scenario is also based on the reference scenario. Additionally, it includes transport policy measures most likely to be implemented by 2030, as well as transport measures specifically aimed at co-modality and integration.
- Policy Scenario 4: – Global action (not increasing) trend for oil prices / sustainable policies for supporting co-modality and integration (maximum support). This scenario is also based on the reference scenario. Additionally, it includes transport policy measures most likely to be implemented by 2030 and transport measures specifically aimed at co-modality and integration. It differs from policy scenario 3 with a different trend for oil prices.

Briefly, the policy scenarios 3 and 4 are supposed to include sustainable policy measures and strategies that support especially the co-modality and integration in passenger transport system. Both of the two scenarios are intended to demonstrate potential impacts of selected strategies and measures in different environments: the policy scenario 3 in a high fuel prices environment and the policy scenario 4 in a low fuel prices environment as indicated in Figure 1.

Figure 1: OPTIMISM scenarios and main drivers



Source: Delle Site et al., 2013a, Delphi expert report on the future scenarios of transport and mobility, p. 53.

After building up the scenarios, Task 5.1 of the project identified the OPTIMISM strategies and policy measures in order to test them in policy scenarios 3 and 4. Within the project, a measure is defined as *an action devised to follow an aim*; where a strategy is defined as *a combination of different measures fulfilling a set of policy objectives*. Several policy measures (mainly ICT-based) were defined and included in five separate strategies of the project aiming at optimising and integrating passenger transport systems (Delle Site et al., 2013b):

- Seamless international travel;
- Seamless regional/national travel;
- Integrated urban and metropolitan transport;
- Integrated and personalised information;
- New mobility paradigm based on public means of transport both individual and collective.

The scope of the passenger travel was the first element taken into consideration when developing the OPTIMISM strategies. All passenger trips can be categorised into one of these three types of travel: urban/metropolitan, regional/national, and international. The bigger the scope, the more complex and difficult is the integration and optimisation of passenger transport systems. In fact they involve different geographical/administrative/jurisdictional levels, and, therefore, different level of required time and cost for their implementation.

Collection and provision of information is key to the optimisation of transport systems, and therefore it was decided to develop a specific strategy aiming at improving the transport information system and its services. The efficient use of different modes on their own and in combination is the core idea of co-modality. The current extremely spread use of private car is unsustainable and inefficient. Therefore, the compelling offer of more efficient alternatives to the use of private cars can significantly improve the overall efficiency and sustainability of passenger transport systems. That is why the fifth strategy was proposed.

All strategies are described in terms of their co-modality objectives, functionalities (ICT-based and Non-ICT-based measures), supporting measures (which identify actions on the side of public policy to support the implementation of ICT-based and non-ICT-based measures), and expected impacts on passengers' travel choices.

The strategies consist of a common subset of co-modality measures selected from a set of broader co-modality measures identified in task 5.1 (Delle Site et al., 2013b). Instead of simulating the impacts of each OPTIMISM strategies, it was decided to simulate the impacts of OPTIMISM co-modality measures implemented simultaneously. Apart from this, impacts of individual strategies are assessed qualitatively in Task 5.2 of the project separately.

Finally for the modelling exercise in this deliverable, the following policy measures are included in policy scenarios 3 and 4 aiming to optimize passenger transport system and support co-modality and integration:

- Provision of travel Information
- Integrated ticket and innovative ticketing
- Improvement of luggage transport and passenger check-in
- Innovative local mobility services
- Improvement of mobility service at local level
- Improvements at interchange points
- Transport system infrastructure and rolling-stock improvements

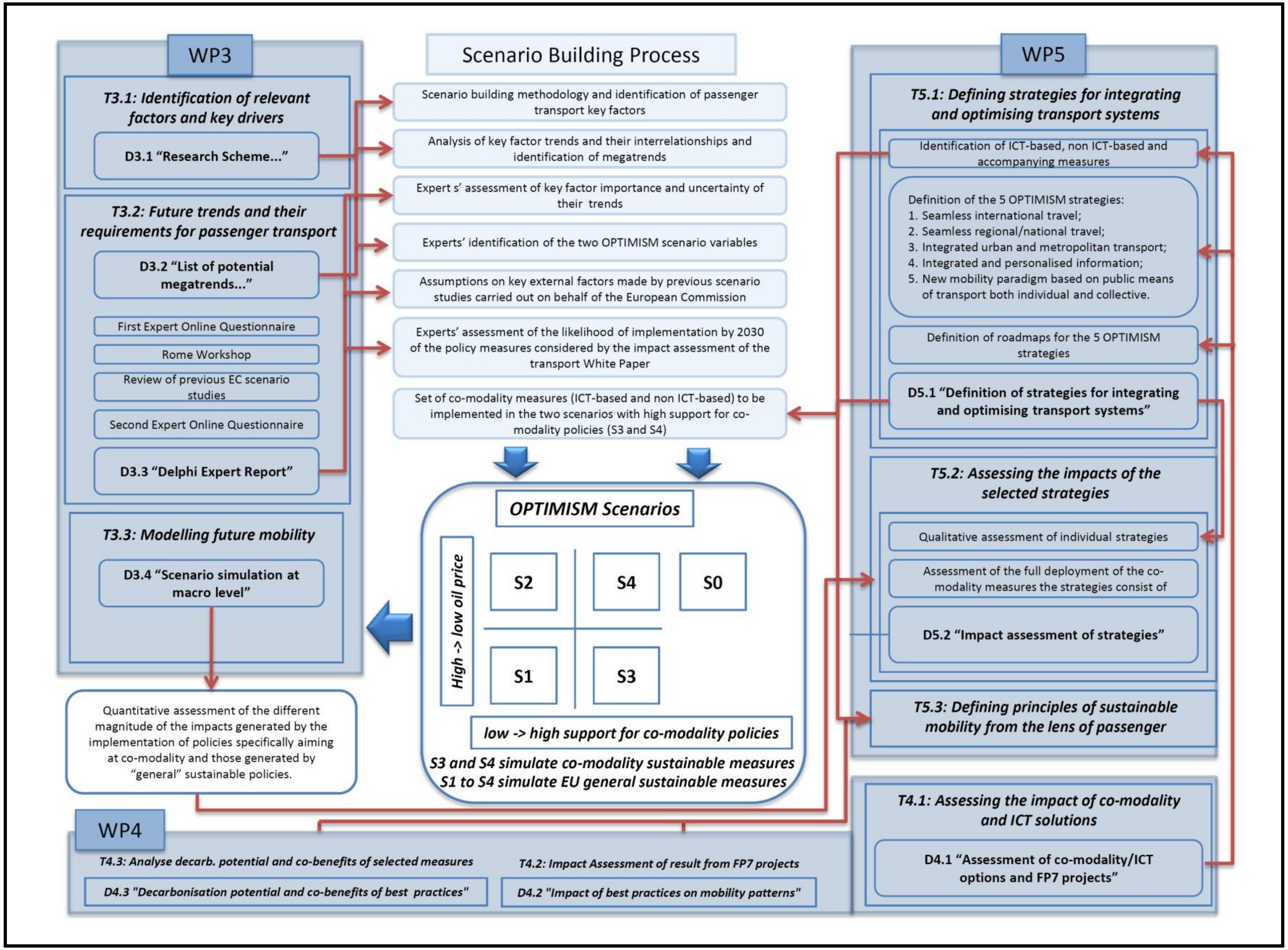
As mentioned earlier, the other identified scenario variable is "energy prices" which may follow two possible trends according to the project: the first is the baseline trend (increasing) included in several EC studies (Christidis et al., 2010; European

Commission, 2011a; 2011b; 2012); the second is the Global Action trend (not increasing) for oil prices defined in a study again by the EC (2011b).

The policy scenarios also include transport policy measures considered by the impact assessment of the transport White Paper which are most likely to be implemented by 2030 especially in pricing, taxation and emission policies. Only different trends in fuel prices brought a distinction in implementation of these policies for scenario simulation. Different than the reference scenario and the policy scenarios 2 and 4, it was decided to ensure internalization of external costs of road transport costs in an increasing fuel prices environment in policy 1 and 3.

Further specification of scenarios and their implementation are discussed in section 4 after introducing the transport models used for the simulations. Figure 2 shows the whole process for building and evaluating OPTIMISM policy scenarios and strategies together with interrelations between the other project's WPs.

Figure 2: Building and Evaluating OPTIMISM Policy Scenarios and Strategies: Interrelations between WPs



3. Description of transport models: TRANS-TOOLS and TREMOVE

3.1. TRANS-TOOLS and TRANSTOOLS-S Demand Module (TDM)

TRANS-TOOLS

TRANS-TOOLS (TOOLS for TRansport Forecasting ANd Scenario testing) is a European transport network model that has been developed in collaborative projects funded by the European Commission's JRC-IPTS and DG MOVE (TRANS-TOOLS, 2008b). It is used by several services of the European Commission as one of the main models for transport policy analysis. It combines conventional 4-step transport modelling approach with economic activity, trade, logistics and environmental outputs. The model covers 42 countries and the network for all main transport modes. It gives results both for passenger and freight transport at NUTS3 level. It is mainly used to measure changes in transport networks, especially TEN-T, changes in transport demand and its distribution, changes in logistics and distribution systems and impacts of pricing and taxation policies.

The first version of TRANS-TOOLS v1 was operational in June 2007 at the end of the (FP6-founded) TRANS-TOOLS project. TRANS-TOOLS v2 was finalized in 2009 as result of the DG Move study TENConnect. The current version of the model (v2.5 and onwards) was developed for the DG MOVE with TENConnect 2 project (Hansen, 2011b, p. 4).

Main drivers of the TRANS-TOOLS can be summarized as following:

- Transport networks and their attributes (time, cost, fuel cost, charge etc..)
- Socio-economic data (population, workplaces, car ownership etc..)
- Regional GDP
- Congestion (endogenously)

Types of impact analyses that can be realized with TRANS-TOOLS are:

- Network impacts (multimodal model)
    - Change of route and mode
    - Freight mode chains
- Demand effects
    - Change of trip frequency and destination choice
    - Change of freight logistics (warehousing)
- Externalities
    - Travel time and generalised costs
    - CO_2, other emissions, energy use etc..

In addition to this, TRANS-TOOLS is capable of analysing any baseline or policy scenario that can be specified within the assumptions or its exogenous data. Conceptually, prospective scenarios could be categorized into 3 groups given as below. Often scenarios being investigated can contain elements from all groups in TRANS-TOOLS (Hansen, 2011a).

- Economic development (such as high/low economic growth)
- Infrastructure (major network analysis, TEN-T, corridor analysis etc..)
- Strategy and policy (fiscal policies, taxation, regulatory scenarios etc..)

Further information on the model can be obtained through the documentation available at its website (TRANS-TOOLS, 2008a). Since it is important for the OPTIMISM scenario simulations, further information on its input output structure is given in APPENDIX I.

TRANS-TOOLS-S and TRANS-TOOLS-S Demand Module (TDM):

TRANS-TOOLS-S, corresponds to a 'stripped-down' version of the original TRANS-TOOLS model, a proof-of-concept prototype version developed by Joint Research Centre of the European Commission. It is a tool that allows the assessment of the impact of policy measures affecting a large number of drivers of transport demand, transport volume, costs and the performance of the transport system as a whole. The assumptions, modelling approach, operation and main results of the first phase of development of this in-house transport network model is documented a report with the name of "TRANS-TOOLS-S: A comprehensive approach for an EU transport network model" (Vannacci et al., 2013). Based on this documentation, a brief description of the model can be given as follows:

The TRANS-TOOLS-S model uses a simplified architecture and concentrates on the issues directly relevant to transport demand and the performance of the transport networks. Its main characteristics can be summarized as below (Vannacci et al., 2013, p.2):

- Matrix based structure, based on origin-destination matrices at NUTS3 level,
- Disaggregate formulation of transport demand equations per mode and type of trip,
- Demand linked to socio-economic drivers and levels of economic activity; possibility of further detail in demand equations through the inclusion of additional variables,
- Assignment to the network keeps previous TRANS-TOOLS versions' module (Traffic Analyst); possibility to replace with third-party assignment algorithms,
- Improved treatment of road congestion through capacity constraints; possibility to apply congestion simulation in other modes,

- Iterative approach allows user-defined level of convergence of model results
- Flexibility in definition of policy relevant indicators,
- Possibility to connect with economic, fleet and energy models.

The main conceptual difference between TRANS-TOOLS and this stripped-down version (TRANS-TOOLS-S) is the selection of a more comprehensive approach in connecting the various model elements between them. Whereas the original TRANS-TOOLS included several modules by different developers each addressing a specific issue independently, TRANS-TOOLS-S uses a leaner structure, expressing all model relationships in an easy to follow interconnected matrix structure. This allows a transparent process and minimizes the risk of bad communication between the various modules. TRANS-TOOLS-S follows conceptually the same standard transport model as adopted in TRANS-TOOLS, namely the widely accepted 4-step model approach, trip generation, trip distribution, mode choice and traffic assignment in a stylized fashion allowing for a simpler method of calibration and alignment with EUROSTAT statistics. The development process involved an iterative process of combining the simplified (matrix based) model structure and (TEN-T based) networks with the improved demand, assignment and reporting modules. The new tool builds on three main building blocks that are linked with clear and robust algorithms and maintain a coherent structure that allows future improvements and connections with other tools and models (Vannacci et al., 2013, p.3):

a) A demand module for passenger and freight transport disaggregated at NUTS3 level using an Origin-Destination (O-D) matrix structure: the matrices are an important building block that allow the analysis of transport demand and costs for each mode and trip purpose, but also by distance class.

b) Transport networks that reflect the actual policy requirements without adding excessive operational complications: the networks used by the model are based on the comprehensive networks of the TEN-T.

c) An improved assignment algorithm that allocates the demand (from the origin-destination matrices) to the transport networks (comprehensive TEN-T networks) in an operationally efficient manner.

For the simulation of OPTIMISM policy scenarios, only the first step - TRANS-TOOLS-S Demand Module (TDM) - of the model was used. Considering the OPTIMISM policy scenario structure and the policies to be tested, country based estimations of demand with corresponding modal shifts were found sufficient. Therefore, transport activity indicators at year 2030 for each policy scenarios were only estimated at country level, without any assignment to the network links and without distribution of demand to the NUTS 3 regions.

The structure of TRANS-TOOLS-S Demand Module is mainly based on the GLADYSTE Model (Hidalgo et al., 2011). It was further improved for scenario simulation in OPTIMISM using up-to-date data from the latest TRANS-TOOLS versions and from the ETIS+ database. It was also recalibrated to ensure having parallel results with the EUROSTAT data for 2010 and with the EC baseline scenario for 2030. The structure of the demand module and the logic behind it can be seen in GLADYSTE Model report (Hidalgo et al., 2011). The specific section for its demand module is also given in the APPENDIX II including the main assumptions and equations of the module.

3.2. TREMOVE and TREMOVE SYSTEM DYNAMICS (TSD)

This section includes description of TREMOVE and TREMOVE System Dynamics model which the latter was used to measure environmental impacts of OPTIMISM policy scenarios. TSD model is a simplified, *system dynamic* version of TREMOVE model used since years to assess the impacts of European Commission's transport policies. The next section starts with a short introduction of TREMOVE model followed by TSD. This presentation will allow readers to understand the objectives, the purposes and the use of both TREMOVE and TSD models as well as the differences between them. The sub-sections will also explain the reason for using TSD instead of TREMOVE model.

TREMOVE Model

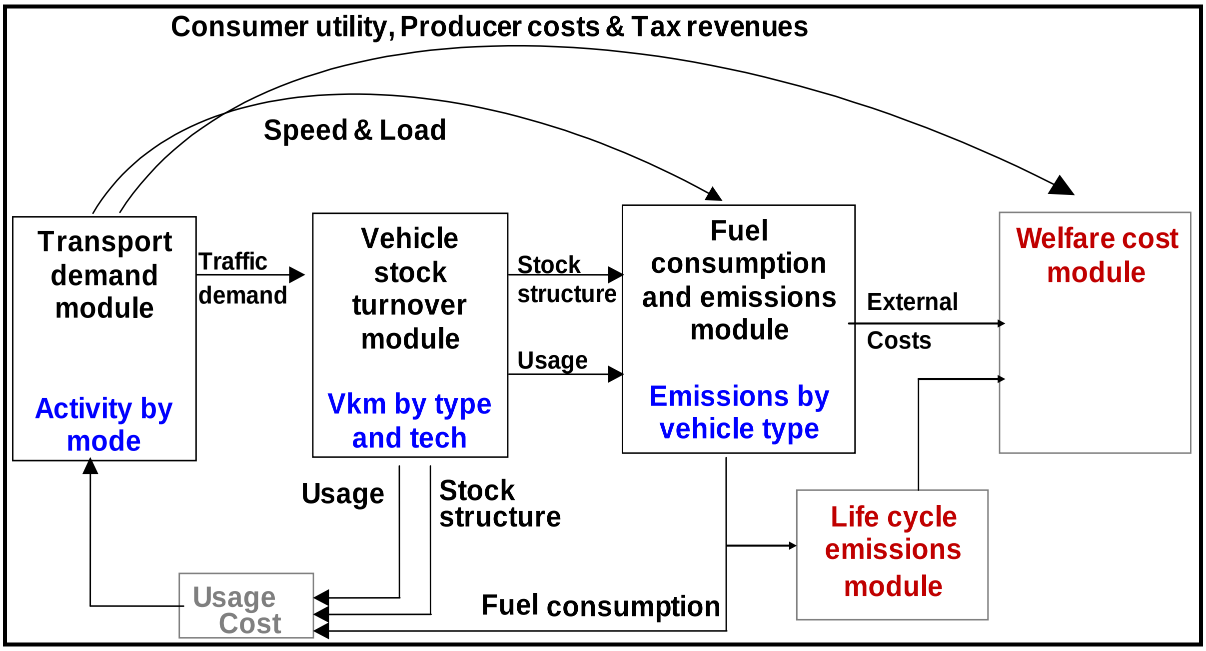
TREMOVE (De Ceuster, et al. 2007) is a transport and emissions simulation model developed for the European Commission, to be able to make policy assessments in transport sector and to be able to measure effects of different transport and environment policies on the emissions of the transport sector. 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.

TREMOVE covers 31 countries and 8 sea regions. All relevant transport modes are modelled, including air and long-distance maritime transport. The model covers the period between 1995-2030 with yearly intervals. The TREMOVE model consists of separate country models. While the numeric values of the model differ from country to country, the model code distinguished into four linked module, is identical across countries.

Figure 3 shows 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.

The TREMOVE model consists of separate country models. While the numeric values of the model differ from country to country, the model code 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 this separation, depending on the area taken into consideration, the relevant modes and network types differ.

Figure 3: Modular Structure of TREMOVE



Source: Transport & Mobility Leuven (TML), 2007, TREMOVE model description, at http://www.tremove.org/documentation/TREMOVE_Short_Description.pdf, p. 2.

The main modules of the TREMOVE model can be described as follows as indicated in De Ceuster (2007) and Transport & Mobility Leuven (2007):

> The **transport demand module** represents, for a given year and transport mode, the number of passenger-kilometres or ton-kilometres that will be performed in each "model region" of the country considered. This module enables to assess changes in transport demand under various policy scenarios in comparison to the demand in the reference scenario fed originally as an exogenous demand produced by TRANS-TOOLS model. The **vehicle stock module** disaggregates transport quantities per mode produced by the demand module, into detailed vehicle-kilometer figures by vehicle type, vehicle technology and vehicle age. This requires a detailed modelling and forecasting of the vehicle fleet structures for each mode. 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. Finally, to evaluate policies in TREMOVE, **the welfare assessment module** has been constructed. Differences in welfare between the baseline and the simulated policy scenarios are calculated.

Tremove System Dynamics (TSD)

TREMOVE System Dynamics abbreviated as TSD is a simplified, *System Dynamic* model version of TREMOVE. TSD basically replicates the TREMOVE vehicle stock and emissions modules, while the demand input is fully exogenous, i.e. transport demand produced by TRANS-TOOLS model.

TSD has been developed during the GLADYSTE project[1] of the European Commission Joint Research Centre, Institute for Prospective Technological Studies. The data required by TSD are taken from the current TREMOVE version 3.3.1. It was developed during the iTREN-2030: Integrated Transport and Energy Baseline until 2030 project (Schade and Krail, 2010). During the GLADYSTE project, the baseline results on emissions, fuel consumption and vehicle fleet stocks of TSD have been fully calibrated to that TREMOVE version, i.e. using results of the reference scenario of the iTREN-2030 project, as well as TSD model reactions to policy measures.

In TSD, the transport demand fed exogenously is sent to a demand segmentation module, in which transport demand is further disaggregated using a range of techniques from simple allocation keys to full logit functions. TSD requires exogenous datasets representing transport demand. Basically demand data and forecast in term of vehicles-kilometres and passenger-kilometres are needed. Such dataset must include yearly demand data of the five transport mode categories in TREMOVE model (air, rail, inland water ways, road, and metro-tram) for the whole period between 2000 and 2030.

One of the main differences between TREMOVE and TSD is found in this demand module. TSD does not allow assessing changes in transport demand due to policy measures. The model takes simply transport demand as it is delivered by TRANS-TOOLS model. Transport demand is fed to TSD model and proceeds directly to the vehicle stock module where the calculation of the fleet dynamics is conducted. All demand changes due to prices changes due to technological measures and new taxation or regulation policies are assumed to completely happen in the transport model (TRANS-TOOLS).

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[1] GLADYSTE project internet page: http://www.tmleuven.be/project/tremovegladyste/home.htm as accessed on 24 September 2013.

The vehicle stock module is split in 2 sub modules: transport costs and fleet planning. The transport costs module holds a detailed breakdown of the costs of transport, ranging from purchase cost over different kinds of taxes to labour cost. The detailed cost breakdown allows for detailed policy analysis influencing specific elements of transport cost. The fleet planning module focuses on the fleet dynamics and includes a copy of the TREMOVE sales logit for passenger cars and light duty trucks.

Finally, the emissions module is somewhat simplified compared to TREMOVE; instead of including the full COPERT IV functions in the model code, emission factors, at the highest level of detail, are determined in an offline setting and introduced in the model as input. This approach is chosen as it simplifies the model and little feedback exists between other parts of the module and the emission factors (apart from fuel consumption and related pollutants, which is taken into account). Moreover, this approach allows for changing emission factor directly at the input, so it is easier to update the emission factors when new research is available.

Considering the characteristics of the OPTIMISM policy scenario simulations, which are mainly based on changes in fuel prices and transport costs to capture impacts of internalizations and co-modality measures, both of the TREMOVE and TSD models could have been used. However, since TSD has computational advantages in terms of model running time, and since the transport demand is estimated by TRANS-TOOLS, it was decided to use TSD for modelling only environmental impacts of the policy scenarios.

4. Specification of OPTIMISM scenarios for modelling exercise

The main characteristics of the OPTIMISM policy scenarios were already introduced in section 2 of this deliverable based on the information provided by previous tasks of the project. Here in section 4, further refinement and specification of the scenarios are introduced with their implementation steps in modelling with TRANSTOOLS-S Demand Module (TDM) and TREMOVE System Dynamics (TSD).

The simulation process of OPTIMISM scenarios was divided into two steps: at first, the TDM was used to estimate transport activity for 2030 for all policy scenarios including passenger and ton kilometres for all modes; than the output of TDM (mainly country based transport activities and modal shares) was used as an input to TSD simulations for estimating transport emissions and vehicle fleet sizes for each policy scenarios.

Before starting to specify policy scenarios to estimate transport activity, it is worth mentioning the reference scenario for 2030 and the main socio-economic variables used in the scenario simulations:

- The reference scenario for transport activity was derived from a recent study conducted by the European Commission (2012): "*2012 EU Reference Scenario modelling - Draft transport activity projections*". The reference scenario described in this study includes transport activity estimations for all EU countries for all main types of transport modes. Two models were used for developing the transport activity projections in the reference scenario: TRANSTOOLS and the PRIMES-TREMOVE models. Both models are managed by the TranScenario consortium mainly by experts from DG ENER, DG MOVE and DG CLIMA of the European Commission. The reference scenario of the TDM in OPTIMISM was calibrated according to the TranScenario estimations on transport activity.

- In addition to this, main variables of the models such as GDP, population and baseline oil prices used in the policy scenario simulations are also directly taken from the TranScenario reference scenario for 2030. The projections for GDP and population used in the reference scenario and in the OPTIMISM policy scenario simulations are given in APPENDIX 3.

- As mentioned earlier, the oil prices follow two different trends in policy scenarios as shown in Table 1. The baseline trend (increasing) is derived from the TranScenario study (European Commision, 2012), and the alternative trend (global action scenario/not increasing) is derived from another study: *"a* *roadmap for moving to a competitive low carbon economy in 2050"* (European Commission, 2011b).

- Considering alternative oil price trend (fuel prices in model simulations), it can easily be observed that there is no increase between 2010 and 2030 in the oil prices. Strictly, it is $79.5 for 2010 and $81 for 2030. Therefore, in the policy scenarios 2 and 4 with lower/alternative oil prices it was assumed that the fuel prices in the models should remain same from 2010 to 2030.

- Apart from these, according to the transport policy measures which are most likely to be implemented by 2030 in policy scenarios 1 and 3, it was decided to ensure internalization of external costs of road transport costs in an increasing fuel prices environment. For the purpose, fuel prices in policy scenarios 1 and 3 are assumed to increase 10 per cent gradually from 2010 to 2030.

Table 1: Oil price projections: baseline and global action trends

Year	Baseline (Increasing)Trend Oil price ($'2010/boe)	Alternative (not increasing) Trend Oil price ($'2010/boe)
2000	36,2	-
2005	-	-
2010	79,5	-
2015	-	-
2020	114,9	85,5
2025	-	-
2030	120,8	81,0
2035	-	-
2040	133,1	76,9
2045	-	-
2050	142,9	71,3

Source: OPTIMISM Deliverable 3.3: Delphi expert report on the future scenarios of transport and mobility (Delle Site et al, 2013, p.56).

Based on the initial definitions of the policy scenarios and the above mentioned assumptions on their main characteristics, further refinement of the scenarios can be shown as in Table 2. The policy scenarios 3 and 4 include OPTIMISM policy measures (mainly ICT based) that support co-modality and integration. As mentioned earlier, these are, provision of travel information, integrated ticket and innovative ticketing, improvement of luggage transport and passenger check-in, innovative local mobility services, improvement of mobility service at local level, improvements at interchange points and transport system infrastructure and rolling-stock improvements.

Table 2: Description of OPTIMISM scenarios for passenger transport

Scenario Name	Main Characteristics
Reference Scenario 2030	▪ Higher oil prices (Table 1) ▪ Socio-economic data for 2030 (see Appendix 3) ▪ EU policy implications by 2012 (already included within the models) ▪ Business as usual for co-modality
Policy Scenario 1 - Higher oil prices (baseline trend) - Business as usual for co-modality Internalisation of external costs for road transport	▪ Business as usual for co-modality ▪ Higher oil prices (same with the reference scenario) ▪ Internalisation of external costs for road transport
Policy Scenario 2 - Lower oil prices (alternative trend) - Business as usual for co-modality	▪ Business as usual for co-modality ▪ Alternative trend for oil prices (Table 1)
Policy Scenario 3 - Higher oil prices (baseline trend) - Strategies for supporting co-modality - Internalisation of external costs for road transport	▪ Full support for co-modality and integration of passenger transport systems (implication of selected OPTIMISM policy measures, Table 3) ▪ Higher oil prices (same with the reference scenario) ▪ Internalisation of external costs for road transport
Policy Scenario 4 - Lower oil prices (alternative trend) - Strategies for supporting co-modality	▪ Full support for co-modality and integration of passenger transport systems (implication of selected OPTIMISM policy measures, Table 3) ▪ Alternative trend for oil prices (Table 1)

In order to identify possible impacts of these policy measures: first they were further elaborated in terms of their sub-elements and then their impacts were qualitatively assessed before the modelling exercise. The qualitative assessment was mainly based on findings of OPTIMISM WP4 and two recent studies (AMITRAN, 2013; Lopez-Ruiz et al., 2013). The Table 4 gives full list of policy measures with their sub-elements and their possible impacts which are used to modify model parameters afterwards.

According to this preliminary assessment and based on the findings from the literature, the following potential impacts were initially estimated: I) in total, 1%

decrease in private car demand, 5% increase in public bus and rail demand, II) in average, 5%-10% increase in travel per person by public bus and rail, and IV) additionally, 10% decrease in public transport travel times/transport costs.

These estimations used as an input to modify TDM and TSD model parameters and two main variables in policy scenarios were modified/changed with respect to the reference scenario: fuel prices and transport costs for public transport (Table 3). In principle, policy scenarios 1 and 3 are with internalisation of transport externalities with 10% additional fuel cost and policy scenarios 3 and 4 are with OPTIMISM policy measures with 10% less transport costs for bus, rail and tram.

Table 3: Implementation of OPTIMISM Scenarios in TDM and TSD: Assumptions for fuel prices and public transportation costs

Policy Scenarios	Fuel prices	Transport costs for bus, rail and tram
PS 1	Fuel prices increase gradually from 2010 to reach 10% increase in 2030 with regard to the reference scenario. This increase is assumed to capture the internalisation measures of road transport.	Transport costs remain same as with the reference scenario.
PS 2	Fuel prices stay at 2010 level for the whole period up to 2030.	Transport costs remain same with the reference scenario.
PS 3	Fuel prices increase gradually from 2010 to reach 10% increase in 2030 with regard to the reference scenario. This increase is assumed to capture the internalisation measures of road transport.	10% reduction in public transport costs with regard to the reference scenario due to the co-modality measures.
PS 4	Fuel prices stay at 2010 level for the whole period up to 2030.	10% reduction in public transport costs with regard to the reference scenario due to the co-modality measures.

These assumptions were implemented in both of the transport models during the scenario simulations: at first, transport activity indicators for each policy scenarios were estimated with TDM, then the estimations fed into the TSD to estimate environmental impacts of the policy scenarios. The implementation of scenario simulations in both TDM and TSD are summarized in Figure 4 and 5.

Table 4: OPTIMISM Policy Measures to support co-modality and integration in passenger transport

Policy Measures	**Expected Impacts**			**Expected Impacts in Numbers**
	OPTIMISM Project (OPTIMISM 2012, Akkermans and Maerivoet, 2013)	**AMITRAN Project** (AMITRAN, 2013)	**JRC Analysis for SUMP** (Lopez-Ruiz et al., 2013)	
Provision of Travel Information: multimodal route planners, personalised travel information services, infrastructure-bounded travel information and in-vehicle travel information which provide pre-trip or on-trip information to passengers for their single mode or multimodal travel and give passengers to optimise their transport activity with better use of limited transport infrastructure and services. ▪ *multimodal journey planner; dynamic and real-time route planners, personal travel information services, infrastructure-bounded information sources, pre-journey information about interchanges and connections, information on pricing and payment systems*	- Impact on user choice determinants: reduced travel times, travel cost savings and convenient ticket purchasing, - multi-modal journey planners may encourage people to travel more and this results in increased transport volumes, - on the contrary people may choosing more efficient routes and travel less kilometres, - multi-modal journey planners may lead to 5% modal shift from car to public transport, - personal travel information services are expected to result in modal shift around 3% to 8%, from passenger cars to public buses (80%) and trains (20%).	- High potential impact systems for CO2 reduction, - pre- and on-trip route choice will influence the vehicle-kilometres which leads to 16 % less kilometres, - static and dynamic route planners contributes to a reduce congestion and travel time, and may result using 4%-8% less fuel. - real time traffic information may affect traveller decisions and reduce transport volumes (e.g. for congestion or disruptions) - several studies show that travel information services increase travel time savings, public transport occupancy rates and bring efficiency in scheduling and capacity usage.	- Impact on modal shift: Travel information provision systems, LOW Multimodal travel information provision, LOW	- PC* Demand: No significant impact - PT* Demand: Increase by 2% - Modal shift: from PC to Bus 2% - Modal shift: from PC to Rail 0.5% - Increase in PT occupancy rates, 2.5% - Reduction in fuel consumption, 5% - Less kilometres by PC, 5%, - Reduction in travel times, 2%
Integrated ticket and innovative ticketing: integrated ticket refers to the combination of tickets for different legs of trip. It is a single ticket for international/regional journeys in a given area, ticket for the combination of air and rail, for parking and public transport, for long-distance rail & local public transport and for rail or air with local taxi journeys. Innovative ticketing, on the other hand, refers to concepts as e-ticketing, multi-modal smart cards and mobile phone ticketing.	- Impact on user choice determinants: reduced travel times, ease of transfer, travel cost savings and convenient ticket purchasing, - integrated and innovative ticketing could result in a modal shift from private to public transport modes which is approximately 2%. - total transport volumes are expected to be positive but small.	- Medium potential impact systems for CO2 reduction - the system will have an influence on all kind of mode choice (strategic, pre-trip, on-trip) because fewer barriers for using public transport may occur,	- Impact on modal shift: Interoperable ticketing and payment systems, MEDIUM	- PC Demand: No significant impact - PT Demand: Increase by 2% - Modal shift: from PC to Bus 0.5% - Modal shift: from PC to Rail 0.5% - Increase in PT occupancy rates, 2.5% - Reduction in travel times, 2%

▪ *e-tickets, smart cards, mobile phone tickets and mobile phone payments*	- mobile payment devices can lead to a modal shift between 1% to 2.5%, from private cars to public transport (mainly bus) modes, - monthly or yearly public transport pass (e.g. smart cards) may create additional transport demand for bus and rail services			
Improvement of luggage transport and passenger check-in: door-to-door luggage transport, flight luggage check-in at train station, RFID tagging for luggage, post-flight luggage collection from local train station, self-service luggage check-in and drop-off, passenger check-in at other sites such as railway station or on board of train ▪ *door-to-door luggage transport, passenger and luggage check –in at railway stations*	- Impact on user choice determinants: reduced travel times, ease of transfer, ease of travel with luggage, increased travel comfort, - flight check-in in railway stations or on board of trains and more efficient luggage transfers can increase travel comfort and reduce travellers' time and efforts.	Not included	Not Included	- PC Demand: No significant impact - PT Demand: No significant impact - Modal shift: No significant impact - Reduction in travel time for international travel, 2%
Innovative local mobility services: includes bike-sharing, car sharing schemes and demand responsive transport schemes which aims to reduce passenger car usage and increase the share of collective public transport modes. ▪ bike sharing, car sharing and demand responsive transport schemes.	- Impact on user choice determinants: travel costs savings and ease of transfer, - car sharing services may result in decreased transport volumes due to lower car ownership rates, - a decrease in private car usage by 1.5% to 2.5% may be expected with car sharing, it is replaced by public transport mainly with public buses, - the modal shift from private cars to public transport modes with bike sharing services is positive but small,	- High potential impact systems for CO2 reduction, - car sharing has both reducing and increasing impacts on transport demand the estimations of impacts are contradictory, - it increases car occupancy rates, - there is no evidence to evaluate quantitatively its modal shift impacts, - for bike sharing a shift from public transport to bicycles can be expected,	- Impact on modal shift: Car sharing & carpooling schemes, LOW Dedicated walking and cycling infrastructure investment and maintenance & bike sharing schemes, MEDIUM	- PC Demand: Decrease by 1% - PT Demand: Increase by 1% - Modal shift: from PC to Bus 0.5% - Modal shift: from PC to Rail 0.5% - Increase in PC occupancy rates, 2.5% - Increase in cycling share, 2%
Improvement of mobility service at local level: improvement of the scheduling of the local public transport services (robust schedules, integrated schedules) and improvement of the accessibility of areas poorly connected to interchange points (e.g.	- Impact on user choice determinants: reduced travel times, ease of transfer, ease of travel with luggage, increased travel comfort,	- Medium potential impact systems for CO2 reduction,	- Impact on modal shift: Taxi services (individual and collective), LOW Public transport coverage (line	- PC Demand: No significant impact - PT Demand: No significant impact - Modal shift: from PC to Bus 0.5% - Modal shift: from PC to Rail 0.5%

by shuttle busses, additional general bus lines, taxi services, etc. ▪ *integrated schedules for public transport, additional shuttles, bus and taxi service at interchange points*	- flexible solutions in public transport services may increase share of collective transport services and create additional demand for public transport		density, stop density, walking distances between stops) & public transport frequencies, MEDIUM	- Reduction in PT travel time, 2%
Improvements at interchange points: improved accessibility and quality of facilities (additional car parks, better connections to public transport networks, etc.), information and indication improvements and service improvements at interchange points (e.g. improved waiting areas, improved lighting, information desks, retail outlets) and access control to interchange points. ▪ improved accessibility and services, increased information availability and access control at interchange points	- Impact on user choice determinants: reduced travel times, ease of transfer, travel cost savings, convenient ticket purchasing and increased travel comfort, - Increasing accessibility to interchange points may increase public transport share by 1%.	Not included	- Impact on modal shift: Multimodal connection platforms, LOW Park and ride areas, LOW	- PC Demand: No significant impact - PT Demand: No significant impact - Modal shift: from PC to Bus 0.5% - Modal shift: from PC to Rail 0.5% - Reduction in PT travel time, 2%
Transport system infrastructure and rolling-stock improvements: includes improved links between city centres and interchange points (including ferry, tram, train, bus etc.), improved maintenance of public transport infrastructure/vehicles and an upgrade of the vehicles and/or services to increase comfort and convenience for travellers. ▪ *Improved public transport links between city centre and interchange points, improved maintenance and management and more comfortable public transport vehicles*	- Impact on user choice determinants: reduced travel times, ease of transfer, travel cost savings, convenient ticket purchasing and increased travel comfort,	Not included	- Impact on modal shift: Investment and maintenance, including safety, security and accessibility, LOW Reallocation of road space to other modes of transport, e.g. dedicated bus lanes, MEDIUM	- PC Demand: No significant impact - PT Demand: No significant impact - Modal shift: from PC to Bus 0.5% - Modal shift: from PC to Rail 0.5% - Increase in PT occupancy rates, 2.5% - Reduction in PT travel time, 2%

* PC: Passenger Car, PT: Public Transport

Figure 4: OPTIMISM policy scenario implementation for transport activity estimations with TDM

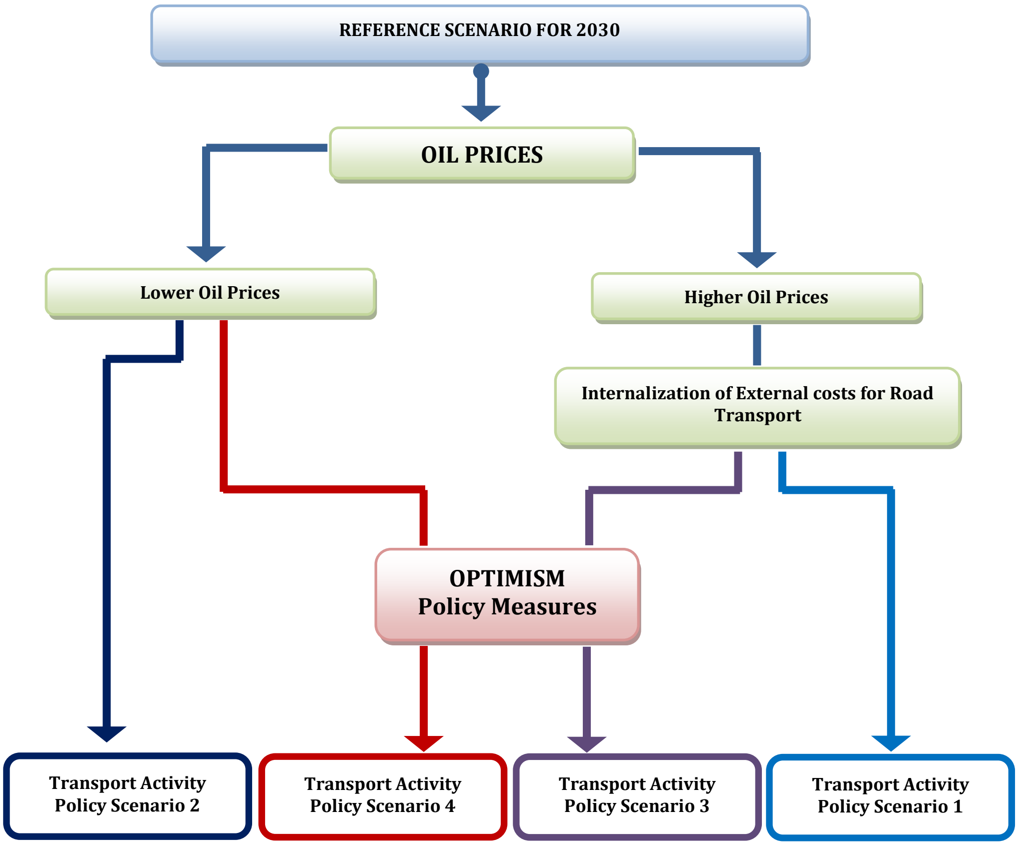
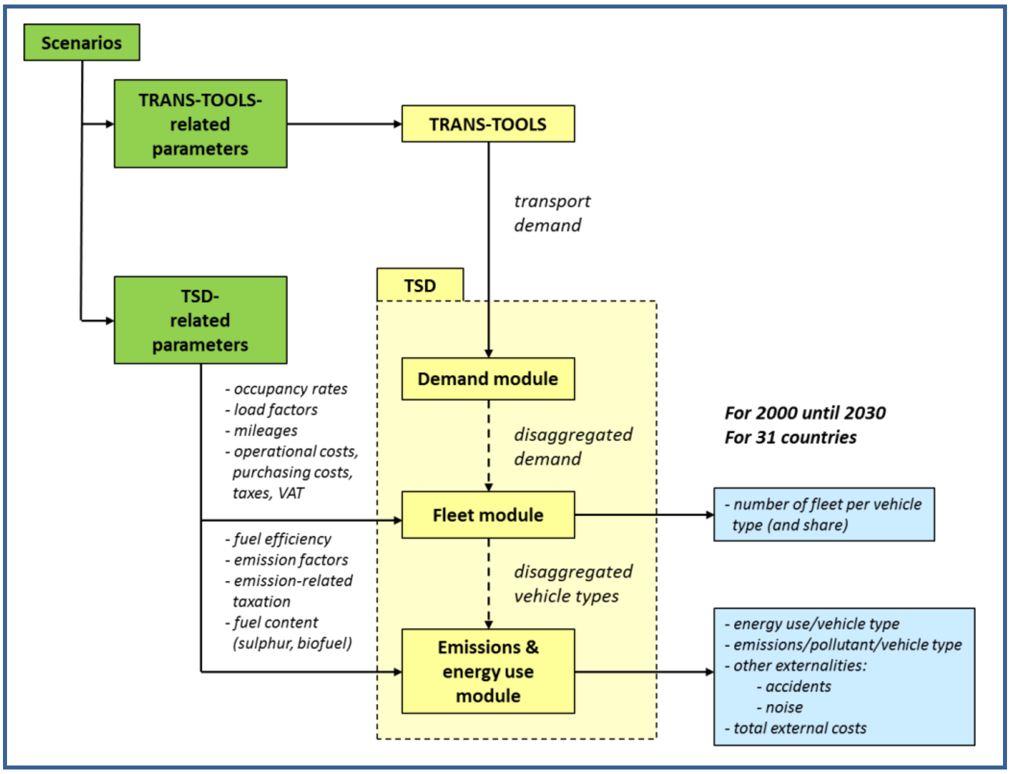


Figure 5: Estimation of transport emissions and vehicle fleet sizes for OPTIMISM policy scenarios with TSD



5. Modelling results and comparison of policy scenarios

5.1. Transport activity indicators for Europe

Transport activity indicators for Europe were estimated using the TRANS-TOOLS-S Demand Module (TDM) through implementing the assumptions given in section 4. The results were only estimated for OPTIMISM policy scenarios for 2030. For the reference scenario for 2030, TranScenario estimations, conducted by the European Commission (2012), were used. The results mainly indicate potential impacts of different trends in fuel prices and implementation of OPTIMISM policy measures on transport demand and modal share:

- Reference Scenario: with increasing (high) fuel prices,
- Policy Scenario 1: with increasing (high) fuel prices and internalization of external costs for road transport,
- Policy Scenario 2: with not increasing (low) fuel prices,
- Policy Scenario 3 (sustainable 1): with increasing (high) fuel prices and internalization of external costs for road transport & sustainable policies for promoting public transport and supporting co-modality and integration.
- Policy Scenario 4 (sustainable 2): with not increasing (low) fuel prices & sustainable policies for promoting public transport and supporting co-modality and integration.

The transport activity indicators measured for both of the passenger and freight transport are as following:

- Passenger transport activity
    - Public road transport, private cars, motorcycles, rail and aviation
- Freight transport activity
    - Trucks, rail, Inland water ways
- Travel per person (km per capita)
- Travel per person by private cars and motorcycles (km per capita)
- Travel per person by public road transport and rail (km per capita)
- Freight activity per unit of GDP (tkm/000 Euro'10)

The transport activity indicators estimated for 2030 based on the simulation with the TDM are given in Table 5, 6 and 7. The tables first indicate absolute values of transport activity by transport modes starting from 1990 and then continues with the percentages and the percentage changes. All the results are given and further evaluated in section 5.3 at EU 28 level since any country specific policy was not included in the scenario simulations. However, country based estimations are also given in APPENDIX 4 in which some slight differences between countries might be observed with the implementation of identical policy measures at EU level.

Table 5 : Transport activity indicators with absolute values

EU 28	1990	2010	2030 Reference Scenario	2030 Policy Scenario 1	2030 Policy Scenario 2	2030 Policy Scenario 3	2030 Policy Scenario 4
Passenger transport activity (Gkms)	**4838.7**	**6418.9**	**7902.3**	**7889.6**	**7939.1**	**7905.9**	**7930.2**
Public road transport	551	513.5	610.6	618.3	593.4	661.3	610.6
Private cars	3380	4763.3	5509.34	5473.4	5596.1	5413.9	5540.6
Motorcycles	135.2	120.3	153.94	153.0	156.3	150.9	154.5
Rail	454.4	496.2	735.8	750.3	703.1	786.9	735.8
Aviation	318.1	525.6	892.6	894.6	890.2	893.0	888.7
Freight transport activity (Gtkm)	**1714.5**	**2306.1**	**3008.8**	**3005.7**	**3017.4**	**3005.7**	**3017.4**
Trucks	1062.9	1764.4	2245.83	2241.4	2256.9	2241.5	2256.9
Rail	532.8	392.5	583.63	584.5	581.9	584.5	581.9
Inland water ways	118.8	149.2	179.3	179.8	178.6	179.8	178.6
Activity indicators							
Travel per person (km per capita)	**10197**	**12701**	**15003**	**14979**	**15073**	**15010**	**15056**
Travel per person by private cars and motorcycles (km per capita)	**7408**	**9663**	**10752**	**10682**	**10922**	**10565**	**10813**
Travel per person by public road transport and rail (km per capita)	**2119**	**1998**	**2556**	**2598**	**2461**	**2750**	**2556**
Freight activity per unit of GDP (tkm/000 Euro'10)		187	181	180	181	180	181
GDP (in 000 Meuro`10)		12301.9	16667.6	16667.6	16667.6	16667.6	16667.6
Population (Million)	474.5	505.4	526.7	526.7	526.7	526.7	526.7
Main Characteristics of Policy Scenarios							
Reference Scenario	with increasing (high) fuel prices						
Policy Scenario 1	with increasing (high) fuel prices and internalization of external costs for road transport						
Policy Scenario 2	with not increasing (low) fuel prices						
Policy Scenario 3 (sustainable 1)	with increasing (high) fuel prices and internalization of external costs for road transport & sustainable policies for promoting public transport and supporting co-modality and integration						
Policy Scenario 4 (sustainable 2)	with not increasing (low) fuel prices & sustainable policies for promoting public transport and supporting co-modality and integration						

Table 6: Transport activity Indicators with percentages

EU 28	1990	2010	2030 Reference Scenario	2030 Policy Scenario 1	2030 Policy Scenario 2	2030 Policy Scenario 3	2030 Policy Scenario 4
Passenger transport activity (Gkms)	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Public road transport	11.4%	8.0%	7.7%	7.8%	7.5%	8.4%	7.7%
Private cars	69.9%	74.2%	69.7%	69.4%	70.5%	68.5%	69.9%
Motorcycles	2.8%	1.9%	1.9%	1.9%	2.0%	1.9%	1.9%
Rail	9.4%	7.7%	9.3%	9.5%	8.9%	10.0%	9.3%
Aviation	6.6%	8.2%	11.3%	11.3%	11.2%	11.3%	11.2%
Freight transport activity (Gtkm)	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Trucks	62.0%	76.5%	74.6%	74.6%	74.8%	74.6%	74.8%
Rail	31.1%	17.0%	19.4%	19.4%	19.3%	19.4%	19.3%
Inland water ways	6.9%	6.5%	6.0%	6.0%	5.9%	6.0%	5.9%

Main Characteristics of Policy Scenarios	
Reference Scenario	with increasing (high) fuel prices
Policy Scenario 1	with increasing (high) fuel prices and internalization of external costs for road transport
Policy Scenario 2	with not increasing (low) fuel prices
Policy Scenario 3 (sustainable 1)	with increasing (high) fuel prices and internalization of external costs for road transport & sustainable policies for promoting public transport and supporting co-modality and integration
Policy Scenario 4 (sustainable 2)	with not increasing (low) fuel prices & sustainable policies for promoting public transport and supporting co-modality and integration

Table 7: Transport activity indicators with percentage changes

EU 28	2030	2030	2030	2030	2030
	Reference Scenario	**Policy Scenario 1**	**Policy Scenario 2**	**Policy Scenario 3**	**Policy Scenario 4**
Passenger transport activity (Gkms)	**7902.3**	**-0.16%**	**0.47%**	**0.05%**	**0.35%**
Public road transport	610.6	1.27%	-2.82%	8.31%	0.00%
Private cars	5509.34	-0.65%	1.58%	-1.73%	0.57%
Motorcycles	153.94	-0.64%	1.51%	-1.96%	0.34%
Rail	735.8	1.97%	-4.44%	6.94%	0.00%
Aviation	892.6	0.23%	-0.27%	0.04%	-0.44%
Freight transport activity (Gtkm)	**3008.8**	**-0.10%**	**0.29%**	**-0.10%**	**0.29%**
Trucks	2245.83	-0.20%	0.49%	-0.19%	0.49%
Rail	583.63	0.14%	-0.29%	0.14%	-0.29%
Inland water ways	179.3	0.26%	-0.40%	0.26%	-0.40%
Travel per person (km per capita)	**15003**	**-0.16%**	**0.47%**	**0.05%**	**0.35%**
Travel per person by private cars and motorcycles (km per capita)	**10752**	**-0.65%**	**1.57%**	**-1.74%**	**0.56%**
Travel per person by public road transport and rail (km per capita)	**2556**	**1.65%**	**-3.71%**	**7.56%**	**0.00%**
Freight activity per unit of GDP (tkm/000 Euro'10)	181	-0.10%	0.29%	-0.10%	0.29%
GDP (in 000 Meuro`10)	16667.6	16667.6	16667.6	16667.6	16667.6
Population (Million)	526.7	526.7	526.7	526.7	526.7

Main Characteristics of Policy Scenarios	
Reference Scenario	with increasing (high) fuel prices
Policy Scenario 1	with increasing (high) fuel prices and internalization of external costs for road transport
Policy Scenario 2	with not increasing (low) fuel prices
Policy Scenario 3 (sustainable 1)	with increasing (high) fuel prices and internalization of external costs for road transport & sustainable policies for promoting public transport and supporting co-modality and integration
Policy Scenario 4 (sustainable 2)	with not increasing (low) fuel prices & sustainable policies for promoting public transport and supporting co-modality and

5.2. Environmental and Vehicle Fleet Indicators for Europe

Environmental and vehicle fleet indicators for the reference and policy scenarios were estimated using the TREMOVE System Dynamics (TSD). The estimated transport demand for each of the transport mode and for each of the scenarios is fed into the TSD to estimate environmental indicators. TSD model assumptions are in line with assumptions of the TREMOVE model used to produce the reference scenario of the iTREN-2030 (Fiorello et al., 2009). In summary, TSD has three main specific assumptions in relation to vehicle CO_2 reduction target, vehicle and technologies related policies and emissions:

Vehicle CO_2 reduction target:

- TSD used an assumption on the fuel efficiency improvements for cars based on voluntary agreements between the European Commission and the car manufacturers (the so-called ACEA, JAMA and KAMA agreements)[2]. The commitment of the manufacturers consists mainly in improving fuel efficiency by technological improvements to reach an average level of 140 g/km by 2008 (ACEA) and 2009 (JAMA and KAMA). In TSD, it is assumed that this 140 g/km objective is reached in 2009. The related 2002-2009 fuel efficiency improvements by car type, are derived from data and projections reported in the TNO (2006).

Vehicles and technologies related policies:

- TSD first assumes the implementation of Euro V (2009) for cars and Euro V (2010) for N1 vehicles. In relation to these two standards, emission target of TSD is simplified as follow: diesel LDV, vans, and car (5 mg PM, 200 mg NOx), and petrol LDV, vans, and car (50 mg VOC, 24 mg NOx). This measure changes first the PM and NOx emission factors of the car-responding vehicles in comparison to the Euro IV vehicles. This decrease in emission factors is followed by additional purchase costs and increase in fuel consumption due to the use of PM emission trap. Secondly, TSD assumes the implementation of Euro VI (2014) for diesel cars and Euro VI (2014) for diesel N1 vehicles. In TSD Euro VI step of emission limits would focus on reducing the emissions of NOx from diesel cars, vans, and LDV in order to support efforts to achieve European air quality objectives. Main objective of Euro VI is to decrease the NOx level from 200 mg in Euro 5 to 75 mg.

Emissions assumptions:

- On average, no further car fuel efficiency improvements will happen after 2009. However, as a weight increase is expected in the 2009-2012 period, technological improvements are needed to keep the average CO2 emission of new cars at 140 g/km. The related 2009-2012 fuel efficiency changes by car type, are also derived from data and projections reported in the TNO (2006). Also the purchase cost increases related to these fuel efficiency improvements

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[2] Three agreements have been made, the full texts can be found in the Official Journal of the European Communities L 350, 28. 12. 1998, 9 58; L 100, 20. 4. 2000, p. 57 and L 100, 20. 4. 2000, p. 55

are taken from this report. TSD does not include any further changes in fuel efficiency of new cars beyond 2012. For all other road vehicles the 1995-2009 base case fuel efficiency increases were initially taken from the Auto Oil II programme, in which an agreement on improvement estimates has been reached with the manufacturers' representatives. After 2009 no further increases in fuel efficiency and emission reductions were assumed in TSD.

Considering the above mentioned assumptions, the environmental and vehicle fleet indicators measured for both passenger and freight transport are as following:

Environmental Indicators

- CO_2 Transport emissions
- NO_x Transport emissions
- PM_{10} Transport emissions

Vehicle Fleet Indicators

- Car fleet size
- Duty vehicle fleet size

The results on environmental and vehicle fleet indicators are given in Table 8 at EU 28 level. Country level results for the reference scenario and the policy scenario 3 that includes internalization of road transport costs and optimism policy measures that support co-modality and integration are given in Table 9. The results are evaluated in section 5.3 including also the comparison of the scenarios.

Table 8: Environmental and vehicle fleet indicators with absolute values

Variable Name	Reference Scenario				Policy Scenario 1	Policy Scenario 2	Policy Scenario 3	Policy Scenario 4
	2005	**2010**	**2020**	**2030**	**2030**	**2030**	**2030**	**2030**
Environmental Indicators								
CO2 Transport emissions (million tonnes per year)	**853,6**	**844,6**	**904,5**	**1018,9**	**1012,4**	**1026,7**	**1005,8**	**1020,0**
Road freight	167,2	153,4	163,7	182,3	181,6	183,6	181,1	183,1
Road passenger	591,2	585,2	606,2	662,5	656,2	669,7	650,1	663,4
Rail freight	3,8	3,4	4,4	5,3	5,3	5,3	5,3	5,3
Rail passenger	5,0	5,0	5,1	6,1	6,2	5,8	6,5	6,1
Inland navigation	5,8	5,6	6,2	6,7	6,7	6,7	6,7	6,7
Air	80,6	92,1	118,9	156,0	156,3	155,6	156,1	155,4
NOx Transport emissions (thousand tonnes per year)	**3812,3**	**3348,0**	**3350,0**	**3772,1**	**3781,2**	**3823,3**	**3768,1**	**3808,1**
Road freight	1508,4	1055,1	798,5	857,0	854,4	863,9	851,8	861,5
Road passenger	1751,9	1744,0	1843,9	2032,7	2040,8	2084,4	2025,9	2067,4
Rail freight	67,7	60,1	77,7	94,2	94,4	93,9	94,4	93,9
Rail passenger	88,4	88,6	90,8	108,2	110,2	103,0	115,6	108,2
Inland navigation	110,9	106,7	118,5	128,5	128,8	128,0	128,8	128,0
Air	285,0	293,5	420,6	551,4	552,6	550,1	551,7	549,2
PM10 Transport emissions (thousand tonnes per year)	**151,6**	**139,0**	**147,2**	**167,2**	**167,9**	**171,6**	**166,4**	**170,1**
Road freight	55,2	37,2	30,9	36,0	36,0	36,6	35,8	36,4
Road passenger	96,4	101,8	116,2	131,2	131,9	135,0	130,6	133,7
Vehicle Fleet Indicators								
Car fleet size (1000 vehicles)	**211775,5**	**222535,4**	**236077,6**	**255756,5**	**254090,1**	**259801,1**	**251256,3**	**257169,9**
Gasoline	150659,0	140286,1	129026,4	132992,2	129910,2	132652,9	128432,7	131269,4
Diesel	57882,2	79337,0	105057,6	120527,1	121505,6	124540,1	120181,1	123320,4
LPG/CNG	3234,3	2912,2	1993,6	2237,2	2674,3	2608,2	2642,5	2580,1
Duty vehicle fleet size (1000 vehicles)	**13036,2**	**12724,7**	**14373,0**	**16287,8**	**16257,7**	**16365,7**	**16257,8**	**16365,8**
<3.5 tonnes	4454,6	4453,8	4831,5	5573,3	5564,1	5597,5	5564,1	5597,5
3.5-7.5 tonnes	3904,0	3796,7	4432,6	4989,5	4979,6	5015,3	4979,6	5015,3
7.5-16 tonnes	1019,7	989,2	1166,3	1316,6	1314,1	1323,2	1314,1	1323,2
16-32 tonnes	2927,3	2777,4	3123,6	3499,6	3492,8	3517,0	3492,8	3517,0
>32 tonnes	730,5	707,6	818,9	908,8	907,2	912,8	907,2	912,8

Table 9: Environmental and vehicle fleet indicators – country based results for the reference scenario and the policy scenario 3

Country	**Reference Scenario (2030)**					**Policy Scenario 3 (2030)**				
	CO2	**NOx**	**PM10**	**Car fleet Size**	**Duty vehicle fleet size**	**CO2**	**NOx**	**PM10**	**Car fleet Size**	**Duty vehicle fleet size**
Austria	14,68615	0,064032	0,002959	4,920905	0,326293161	14,4276	0,063858	0,002934	4,806727	0,326043
Estonia	2,461566	0,007209	0,000167	0,682417	0,046963196	2,427542	0,007252	0,000166	0,668282	0,046855
Latvia	4,217653	0,014468	0,000363	0,956698	0,235891275	4,171899	0,014464	0,000362	0,939126	0,235346
Lithuania	6,836256	0,019246	0,000857	1,360741	0,122168844	6,777026	0,019297	0,000859	1,360741	0,121889
Belgium	22,47637	0,117629	0,004931	5,613355	0,263304863	22,0685	0,116299	0,004843	5,48562	0,262843
Luxembourg	2,027369	0,009106	0,000332	0,389198	0,020992253	1,995056	0,008999	0,000326	0,377385	0,020959
Denmark	12,31518	0,035123	0,000756	2,139189	0,189883904	12,19004	0,035361	0,000764	2,103125	0,189840
Spain	122,8779	0,425843	0,016571	22,27486	1,313950386	121,6655	0,423936	0,016443	21,89557	1,312000
Finland	15,62598	0,049114	0,002225	2,706283	0,110113713	15,46513	0,04927	0,002224	2,662387	0,109971
France	156,4545	0,669453	0,039542	33,10403	1,626979492	154,4389	0,664837	0,039194	32,60761	1,623422
Great Britain	136,1015	0,599035	0,030342	29,20603	1,187775185	134,1765	0,603888	0,030548	28,72067	1,185551
Greece	22,67632	0,05835	0,000876	1,719148	0,390901545	22,42498	0,058267	0,000874	1,66372	0,390051
Hungary	11,77479	0,037442	0,001219	4,252272	0,288213387	11,63187	0,037531	0,001205	4,150633	0,287368
Ireland	10,67146	0,025103	0,000724	1,704661	0,205735926	10,5439	0,025198	0,000721	1,671226	0,205541
Italy	113,4831	0,380821	0,018282	37,28686	1,602289619	111,7155	0,377316	0,01801	36,57647	1,598841
The Netherlands	34,8236	0,139275	0,003091	7,121361	0,64311455	34,36316	0,138787	0,003054	6,995795	0,641417
Poland	63,01543	0,191905	0,00551	24,06145	2,658589279	62,30456	0,193087	0,005537	23,64842	2,653017
Portugal	17,66145	0,063771	0,002324	2,821423	0,519967443	17,40335	0,063824	0,002307	2,754193	0,518976
Czech Republic	18,1366	0,088796	0,002996	4,396533	0,385946568	17,95267	0,088875	0,002982	4,311638	0,385188
Germany	158,2782	0,525841	0,025416	46,5434	1,735809875	156,0603	0,528041	0,025456	45,81178	1,732458
Republic Slovak	7,57857	0,030753	0,000837	2,318423	0,22542039	7,500689	0,030964	0,00084	2,266016	0,225131
Cyprus	4,008731	0,013856	0,000125	0,36668	0,029174072	3,990576	0,013833	0,000123	0,352165	0,029114
Malta	1,070339	0,003221	2,56E-05	0,212976	0,031120402	1,063531	0,003223	2,55E-05	0,205753	0,031027
Slovenia	5,229931	0,013577	0,000506	1,243789	0,129264442	5,164603	0,01364	0,000508	1,218726	0,129117
Sweden	23,36101	0,058613	0,00217	5,464536	0,170730452	23,07724	0,058762	0,002171	5,376092	0,170450
Bulgaria	8,556239	0,042127	0,001248	3,77189	0,367613831	8,449991	0,041482	0,00121	3,682791	0,366904
Croatia	6,094847	0,019638	0,000601	1,917688	0,057345133	6,061606	0,019708	0,000596	1,894281	0,057220
Romania	16,40741	0,068738	0,002168	7,199709	1,402210754	16,25171	0,068108	0,002112	7,04933	1,401261
EU 28	**1018,909**	**3,772085**	**0,167162**	**255,7565**	**16,28776394**	**1005,764**	**3,76811**	**0,166395**	**251,2563**	**16,257800**
Note: Emissions in millions of ton, vehicle fleet size in millions of vehicle										

5.3. Evaluation of results and comparison of OPTIMISM policy scenarios

Impacts on transport activity

The impacts on transport activity of the OPTIMISM policy scenarios are measured in terms of changes in passenger kilometres for each mode of transport. A summary of transport activity results for all scenarios with comparison to the 2030 reference scenario are given in Table 10. Policy scenarios 3 and 4 included policy measures that strongly supports co-modality and integration. In order to assess impacts of OPTIMISM policy scenarios, at first the results for policy scenario 3, where OPTIMISM strategies in an increasing fuel prices environment were implemented, are compared with the reference scenario. According to the comparison of reference scenario and policy scenario 3 the results indicate that:

- Modal share for private cars decreases 1,7%, from 69,7% to 68,5%
- Modal share for public road transport increases 8,3%, from 7,7% to 8,4
- Modal share for rail transport increases 6.9%, from 9,3% to 10,0%.

In addition to this,

- Travel per person by public road transport and rail increases by 7,5%,
- Travel per person by private cars and motorcycles decreases by 1,7%.

Apart from this, it is also important to see the potential impacts of OPTIMISM policy measures and fuel prices separately. In order to better understand the impact of OPTIMISM strategies solely, a comparison between policy scenarios 1 and 3 is required. In this way the impact of fuel prices (fuel prices are increasing in both of these scenarios) can be removed from the results. With this respect, according to the comparison of policy scenario 1 and 3:

- Modal share for private cars decreases 1,3%, from 69,4% to 68,5%
- Modal share for public road transport increases 7,7%, from 7,8% to 8,4%
- Modal share for public road transport increases 5,2%, from 9,5% to 10,0%

In addition to this,

- Travel per person by public road transport and rail increases by 5.9% from 2598 to 2750 (km per capita)
- Travel per person by private cars and motorcycles decreases by 1,1% from 10682 to 10565 (km per capita)

Table 10: OPTIMISM transport activity estimations for 2030: comparison of scenarios by transport mode

EU 28	2010		2030 Reference Scenario		2030 Policy Scenario 1			2030 Policy Scenario 2			2030 Policy Scenario 3			2030 Policy Scenario 4		
	Value	Rate	Value	Rate	Value	Rate	Change	Value	Rate	Change	Value	Rate	Change	Value	Rate	Change
Passenger transport activity	**6418.9**	**100%**	**7902.3**	**100%**	**7889.6**	**100%**	**-.16%**	**7939.1**	**100%**	**0.47%**	**7905.9**	**100%**	**0.05%**	**7930.2**	**100%**	**0.35%**
Public road transport	513.5	8.0%	610.6	7.7%	618.3	7.8%	1.27%	593.4	7.5%	-2.82%	661.3	8.4%	8.31%	610.6	7.7%	0.00%
Private cars	4763.3	74.2%	5509.34	69.7%	5473.4	69.4%	-0.65%	5596.1	70.5%	1.58%	5413.9	68.5%	-1.73%	5540.6	69.9%	0.57%
Motorcycles	120.3	1.9%	153.94	1.9%	153.0	1.9%	-0.64%	156.3	2.0%	1.51%	150.9	1.9%	-1.96%	154.5	1.9%	0.34%
Rail	496.2	7.7%	735.8	9.3%	750.3	9.5%	1.97%	703.1	8.9%	-4.44%	786.9	10.0%	6.94%	735.8	9.3%	0.00%
Aviation	525.6	8.2%	892.6	11.3%	894.6	11.3%	0.23%	890.2	11.2%	-0.27%	893.0	11.3%	0.04%	888.7	11.2%	-0.44%
Freight transport activity	**2306.1**	**100%**	**3008.8**	**100%**	**3005.7**	**100%**	**-.10%**	**3017.4**	**100%**	**0.29%**	**3005.7**	**100%**	**-.10%**	**3017.4**	**100%**	**0.29%**
Trucks	1764.4	76.5%	2245.83	74.6%	2241.4	74.6%	-0.20%	2256.9	74.8%	0.49%	2241.5	74.6%	-0.19%	2256.9	74.8%	0.49%
Rail	392.5	17.0%	583.63	19.4%	584.5	19.4%	0.14%	581.9	19.3%	-0.29%	584.5	19.4%	0.14%	581.9	19.3%	-0.29%
Inland water ways	149.2	6.5%	179.3	6.0%	179.8	6.0%	0.26%	178.6	5.9%	-0.40%	179.8	6.0%	0.26%	178.6	5.9%	-0.40%
Activity indicators																
Travel per person (km per capita)	**12701**		**15003**		**14979**		**-0.16%**	**15073**		**0.47%**	**15010**		**0.05%**	**15056**		**0.35%**
Travel per person by private cars and motorcycles (km per capita)	**9663**		**10752**		**10682**		**-0.65%**	**10922**		**1.57%**	**10565**		**-1.74%**	**10813**		**0.56%**
Travel per person by public road transport and rail (km per capita)	**1998**		**2556**		**2598**		**1.65%**	**2461**		**-3.71%**	**2750**		**7.56%**	**2556**		**0.00%**
Freight activity per unit of GDP (tkm/000 Euro'10)	187		181		180		-0.10%	181		0.29%	180		-0.10%	181		0.29%
GDP (in 000 Meuro`10)	12301.9		16667.6		---		---	---		---	---		---	---		---
Population (Million)	505.4		526.7		---		---	---		---	---		---	---		---
Main Characteristics of Policy Scenarios																
Reference Scenario	with increasing (high) fuel prices															
Policy Scenario 1	with increasing (high) fuel prices and internalization of external costs for road transport															
Policy Scenario 2	with not increasing (low) fuel prices															
Policy Scenario 3 (sustainable 1)	with increasing (high) fuel prices and internalization of external costs for road transport & sustainable policies for promoting public transport and supporting co-modality and integration															
Policy Scenario 4 (sustainable 2)	with not increasing (low) fuel prices & sustainable policies for promoting public transport and supporting co-modality and integration															

Note: Change column indicates the difference between the policy scenario and the reference scenario in percentages.

Finally, in order to see the potential impacts of different fuel prices and the corresponding policy on internalization of road transport costs, a comparison between the scenarios 1 and 2 could be established. According to this comparison with lower fuel prices and without an internalization policy:

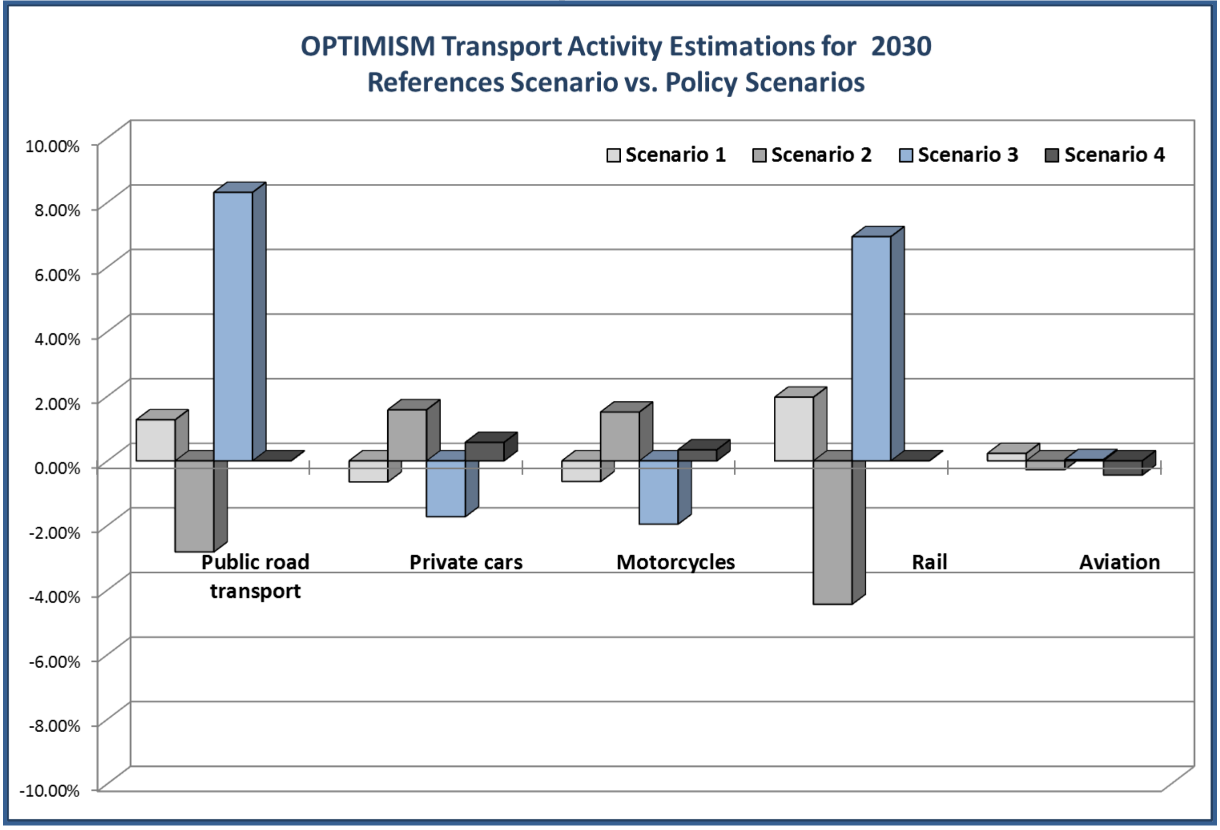
- Modal share for private cars increases 2,3% from 69,4% to 70,5%
- Modal share for public road transport decreases 4,1%, from 7,8% to 7,5%
- Modal share for public road transport decreases 6,3%, from 9,5% to 8,9%

In addition to this,

- Travel per person by public road transport and rail decreases by 5.3% from 2598 to 2461 (km per capita)
- Travel per person by private cars and motorcycles increases by 2,3% from 10682 to 10922 (km per capita)

The comparison of OPTIMISM policy scenarios against the reference scenario is also given in Figure 6. The figure indicates that the policy scenario 3 has the most positive impact on promoting public road and rail transport since it brings higher increase in their modal shares.

Figure 6: OPTIMISM Transport Activity Estimations: Reference Scenario vs. Policy Scenarios



Today, the share of private cars in passenger transport is 74% and it is expected to reduce up to 70% by 2030. It is also expected that the mode share of rail transport will increase from 7,7% to 9,3% and aviation from 8,2% to 11,3% by 2030 (Table 10). The results of the simulations show that the OPTIMISM policy measures may have significant impacts on this existing trend in passenger transport activity.

No significant change in total transport demand is foreseen with the implementation of OPTIMISM policy scenarios. However, it is obvious that the selected policy measures will increase public transport share both for the road and rail transport and decrease the share of private cars and motorcycles in total passenger kilometres. Considering the potential impacts of the OPTIMISM policy measures without the impact of fuel prices (comparison of policy scenarios 1 and 3), average travel per person by public road transport and rail increases by 5.9% and travel per person by private cars and motorcycles decreases by 1,1%.

Environmental impacts

Environmental impacts of the OPTIMISM policy scenarios are estimated using TREMOVE System Dynamics. The environmental impacts for all scenarios with comparison to the 2030 reference scenario are given in Table 11. The tables include the CO_2, NO_x and PM_{10} transport emissions as well as the vehicle fleet sizes. The policy scenarios 3 and 4 include OPTIMISM strategies and policy measures that strongly support co-modality and integration. In order to assess the impact of OPTIMISM strategies, at first the results for policy scenario 3 are highlighted; in this scenario the OPTIMISM policy measures are implemented in an increasing fuel prices environment with an internalization policy. According to the comparison of reference scenario and policy scenario 3 the results indicate:

- CO_2 transport emissions decreases by 1.3% in total and 1.9% for road passenger transport, from 1018 to 1005 and from 662 to 650 (million tons per year),

- NO_x transport emissions decreases by 0.1% in total and decreases 0.3% for road passenger transport, from 3772 to 3768 and from 2032 to 2025 (thousand tons per year),

- PM_{10} transport emissions decreases by 0.5% in total and decreases 0.5% for road passenger transport, from 167.2 to 166.4 and from 131.2 to 130.6 (thousand tons per year),

- Car fleet size decreases from 255 million to 251 million with 1.8% change and number of cars with LPG/CNG technology increases by 18.2%, from 2.2 million to 2.6 million.

Table 11: Environmental and vehicle fleet indicators: scenario comparison - change in percentages

Name of Indicator	Reference Scenario	Policy Scenario 1	Change in percentages	Policy Scenario 2	Change in percentages	Policy Scenario 3	Change in percentages	Policy Scenario 4	Change in percentages
	2030	2030		2030		2030		2030	
ENVIRONMENTAL INDICATORS									
CO2 Transport emissions (Million tonnes per year)	**1018.9**	1012.4	**-0.64%**	1026.7	**0.76%**	1005.8	**-1.31%**	1020.0	**0.10%**
Road freight	**182.3**	181.6	-0.36%	183.6	0.72%	181.1	-0.66%	183.1	0.45%
Road passenger	**662.5**	656.2	-0.96%	669.7	1.07%	650.1	-1.92%	663.4	0.14%
Rail freight	**5.3**	5.3	0.18%	5.3	-0.41%	5.3	0.18%	5.3	-0.41%
Rail passenger	**6.1**	6.2	1.84%	5.8	-5.02%	6.5	6.41%	6.1	0.00%
Inland navigation	**6.7**	6.7	0.23%	6.7	-0.41%	6.7	0.23%	6.7	-0.41%
Air	**156.0**	156.3	0.22%	155.6	-0.26%	156.1	0.04%	155.4	-0.42%
NOx Transport emissions (1000 Tonnes per year)	**3772.1**	3781.2	**0.24%**	3823.3	**1.34%**	3768.1	**-0.11%**	3808.1	**0.95%**
Road freight	**857.0**	854.4	-0.31%	863.9	0.80%	851.8	-0.62%	861.5	0.52%
Road passenger	**2032.7**	2040.8	0.40%	2084.4	2.48%	2025.9	-0.34%	2067.4	1.68%
Rail freight	**94.2**	94.4	0.18%	93.9	-0.41%	94.4	0.18%	93.9	-0.41%
Rail passenger	**108.2**	110.2	1.84%	103.0	-5.02%	115.6	6.41%	108.2	0.00%
Inland navigation	**128.5**	128.8	0.23%	128.0	-0.41%	128.8	0.23%	128.0	-0.41%
Air	**551.4**	552.6	0.21%	550.1	-0.25%	551.7	0.04%	549.2	-0.41%
PM10 Transport emissions (1000 Tonnes per year)	**167.2**	167.9	**0.44%**	171.6	**2.57%**	166.4	**-0.46%**	170.1	**1.73%**
Road freight	**36.0**	36.0	0.04%	36.6	1.65%	35.8	-0.62%	36.4	1.04%
Road passenger	**131.2**	131.9	0.55%	135.0	2.82%	130.6	-0.42%	133.7	1.91%
VEHICLE FLEET INDICATORS									
Car fleet size (1000 vehicles)	**255756.5**	254090.1	**-0.66%**	259801.1	**1.56%**	251256.3	**-1.79%**	257169.9	**0.55%**
Gasoline	**132992.2**	129910.2	-2.37%	132652.9	-0.26%	128432.7	-3.55%	131269.4	-1.31%
Diesel	**120527.1**	121505.6	0.81%	124540.1	3.22%	120181.1	-0.29%	123320.4	2.27%
LPG/CNG	**2237.2**	2674.3	16.34%	2608.2	14.22%	2642.5	15.34%	2580.1	13.29%
Duty vehicle fleet size (1000 vehicles)	**16287.8**	16257.7	**-0.18%**	16365.7	**0.48%**	16257.8	**-0.18%**	16365.8	**0.48%**
<3.5 tonnes	**5573.3**	5564.1	-0.16%	5597.5	0.43%	5564.1	-0.16%	5597.5	0.43%
3.5-7.5 tonnes	**4989.5**	4979.6	-0.20%	5015.3	0.51%	4979.6	-0.20%	5015.3	0.51%
7.5-16 tonnes	**1316.6**	1314.1	-0.19%	1323.2	0.50%	1314.1	-0.19%	1323.2	0.50%
16-32 tonnes	**3499.6**	3492.8	-0.19%	3517.0	0.50%	3492.8	-0.19%	3517.0	0.50%
>32 tonnes	**908.8**	907.2	-0.18%	912.8	0.44%	907.2	-0.18%	912.8	0.44%

In addition to this, if we compare the policy scenarios 1 and 3 to remove the impact of fuel prices and to see the impact of OPTIMISM strategies solely, the results indicate:

- CO_2 transport emissions decreases by 0.7% in total and 0.9% for road passenger transport,

- NOx transport emissions decreases by 0.3% in total and decreases 0.7% for road passenger transport,

- PM10 transport emissions decreases by 0.9% in total and decreases 1.0% for road passenger transport,

- Car fleet size decreases from 254 million to 251 million with 1.1% change.

Several other elements of conclusion can be mentioned as well:

- Increase in fuel prices in order to capture the impact of internalization measures can reduce the total EU-28 truck transport activity by around 0.20% in 2030 as shown by scenarios 1 and 3. Results of both scenarios show decrease of around 0.19% in heavy duty vehicle fleet size in all categories. CO2, NOX and PM10 emissions from road freight transport decrease from 0.3% to 0.6% in both scenarios.

- Scenario 2 that represents low fuel price situation combined with no measures of co-modality appears to be the worst scenario in term of emissions in comparison to the reference scenario. In 2030 we can expect that CO2, NOX and PM10 emission will increase by 0.77%, 1.36% and 2.36% respectively.

- Implementation of co-modality measures through reduction of transport costs in tram, buses and metro only as simulated in the scenario 4 will could slightly improve the situation in comparison to the scenario 2. However emissions of CO2, NOX and PM10 will still increase by 2030 by 0.11%, 0.95% and 1.73% respectively with regards to reference scenario.

Considering the reference scenario for 2030, transport emissions will keep increasing and the road passenger transport will be responsible for 65% of the total CO_2 transport emissions and 54% of the total NO_x transport emissions (Table 11). The modelling exercise indicates that to counter this trend is not an easy task. With the best policy scenario including strategies to support co-modality and integration, only slight differences can be achieved in the transport emissions. The reduction in the transport emissions is approximately 1%.

Slight impacts of the scenarios in term of emissions changes could be explained first by the fact that scenario measures only have limited impact on changes in transport activities of the principal emitters, i.e. trucks and private cars. For example in 2030, changes of transport activities in private cars range only between -1.73 and 1.58% in the four scenarios. These values are even smaller for trucks, i.e. from -0.20% to .49% in the four scenarios since the OPTIMISM strategies focus on passenger transport. Second, as no technological measure is involved all strategies of the different scenarios only affect energy use and emission indirectly, i.e. through changes in generalized costs that induce user to choose more energy efficient vehicle types. The limitations of the modelling exercise - such as lack of proper transfer of policies into aviation sector or into urban transport - could be the other reason. The results show that implementing the OPTIMISM strategy has positive environmental impacts, but they are not, on their own, sufficient to reach EU targets for reducing transport emissions.

6. Concluding remarks

OPTIMISM proposed five strategies aiming to optimize passenger transport system to promote public transport and to support co-modality and integration: a) seamless international travel, b) seamless regional/national travel, c) integrated urban and metropolitan transport, d) integrated and personalised information, and e) new mobility paradigm based on public means of transport both individual and collective. The main objectives when proposing these strategies have been:

- to increase public transport share,
- to improve co-modal transport activities,
- to improve ease of travel with better travel information services, integrated ticketing, and improved transport management,
- to reduce congestion and GHG emissions,
- to improve border-crossings and interchange points,
- to achieve more efficient usage of transport infrastructure and services

The strategies consist of a common subset of co-modality and integration measures selected from a set of broader list. The selected policy measures for the scenario simulation which are mainly ICT-based measures are:

- Provision of travel Information
- Integrated ticket and innovative ticketing
- Improvement of luggage transport and passenger check-in
- Innovative local mobility services
- Improvement of mobility service at local level
- Improvements at interchange points
- Transport system infrastructure and rolling-stock improvements

One of the first objective of macro simulation for passenger transport in this deliverable was to estimate potential mobility and environmental impacts of these selected policy measures. Therefore, "support of sustainable transport policies" was defined as the first scenario variable. The other identified scenario variable was "energy prices" which may follow two possible trends according to the project: the first is the baseline trend (increasing) the second is the global action trend (not increasing) for oil prices. According to the these two drivers, four policy scenarios were designed as well as a reference scenario for 2030:

- Reference Scenario: with increasing (high) fuel prices,
- Policy Scenario 1: with increasing (high) fuel prices and internalization of external costs for road transport,

- Policy Scenario 2: with not increasing (low) fuel prices,
- Policy Scenario 3 (sustainable 1): with increasing (high) fuel prices and internalization of external costs for road transport & sustainable policies for promoting public transport and supporting co-modality and integration.
- Policy Scenario 4 (sustainable 2): with not increasing (low) fuel prices & sustainable policies for promoting public transport and supporting co-modality and integration.

The transport activity indicators for each of the policy scenarios were estimated with TRANS-TOOLS-S Demand Module (TDM), then these estimations on transport demand fed into the TREMOVE System Dynamics (TSD) to estimate environmental impacts of the policy scenarios. At the end, the policy scenarios and the reference scenario were compared between each other to explore the potential impacts of different trends in fuel prices and implementation of OPTIMISM policy measures.

Based on the results of scenario simulations, the following elements of conclusion has to be underlined.

a) As of 2010, the share of private cars in passenger transport is 74% and it is expected to reduce up to 70% by 2030. It is also expected that the mode share of rail transport will increase from 7,7% to 9,3% and aviation from 8,2% to 11,3% by 2030. The results of the simulations show that the OPTIMISM policy measures may have significant impacts on existing mobility pattern through a substantial modal shift from private car to public transport. More specifically, with the implementation of OPTIMISM strategies/policy measures in an increasing fuel prices environment:

- The modal share of private cars may decrease by 1,7% where modal share for public road transport and rail transport may increase by 8,3% and 6.9% respectively,
- Travel per person by private cars and motorcycles may decrease by 1,7% where travel per person by public road transport and rail is increasing by 7,5%.

b) No significant change in total transport demand is foreseen with the implementation of OPTIMISM policy scenarios. However, it is obvious that the selected policy measures will increase public transport share both for the road and rail transport and decrease the share of private cars and motorcycles. Considering the potential impacts of the OPTIMISM policy measures without the impact of fuel prices (comparison of policy scenarios 1 and 3), travel per person by public road transport and rail increases by 5.9% and travel per person by private cars and motorcycles decreases by 1,1%.

c) According to the reference scenario for 2030, transport emissions will keep increasing and the road passenger transport will be responsible for 65% of the total CO_2 transport emissions and 54% of the total NO_x transport emissions. The modelling exercise indicates that it is very difficult to shift this trend. With the best policy scenario including strategies to support co-modality and integration, only slight differences can be achieved in the transport emissions.

d) However, the modal shift from passenger cars to public road and rail transport may still result in positive environmental impacts. Combination of OPTIMISM co-modality and internalisation measures represented in the policy scenario 3 may reduce the CO2, NOx and PM10 transport emissions in 2030 by 1.3%, 0.1% and 0.4% respectively mainly through fall in road transport emissions.

e) Different trends in fuel prices may also have important impacts on mobility pattern. Lower fuel prices without any policy on internalization of road transport costs have significant negative impacts on reducing share of private cars in total transport activity. With lower fuel prices and without an internalization policy, travel per person by public road transport and rail may decrease by 5.3% while travel per person by private cars and motorcycles is increasing by 2,3%.

In conclusion, OPTIMISM strategies/policy measures to support co-modality and integration have positive mobility and environmental impacts. These positive impacts are more noticeable particularly in higher fuel prices environment and with internalization of external costs of road transport. The results show that implementing the OPTIMISM strategies has positive environmental impacts, but they are not, on their own, sufficient to reach EU targets for reducing transport emissions. Since the OPTIMISM scenarios mainly simulated impacts of two specific variables - fuel prices and co-modality strategies - and it was mainly compared with the reference scenario for 2030 which already includes several strategies in the same direction, only slight differences in the environmental impacts have been observed. Apart from this, the OPTIMISM strategies mainly comprise ICT-based policy measures and for only passenger transport excluding the freight transport, hence their impact on transport emissions is rather small. Finally, the OPTIMISM strategies aiming to support co-modal and integrated passenger transport should be supported by other policies in vehicle and fuel technologies and with infrastructure improvements, road charging, taxation and traffic restriction policies in order to be able to achieve better solutions for sustainable passenger transport.

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Appendix

APPENDIX 1: Main input and output variables of the TRANS-TOOLS Model

VARIABLES	LEVEL OF DETAIL	EXPLANATION
GDP	NUTS3	Annual total GDP of the zone
POPULATION	NUTS3	Total population of a the zone
CAR OWNERSHIP	COUNTRY	Car ownership of the zone for per thousand person
JOB	NUTS3	Number of employees at the Zone
HOTEL CAPACITY	NUTS3	Total number of beds at the zone
PURCHASE POWER	COUNTRY	Purchase power parity of the zone
OIL PRICE – FUEL COST	COUNTRY	Fuel costs Including Taxes
NETWORK	1. ROAD 2. RAIL 3. AIR	Road, rail and air Network
• All major transport investments including TEN-T projects are currently available and can be used for a future year simulation. • It also includes inland waterways but for only freight transport.		
VALUE OF TIME	1. BUSINESS 2. PRIVATE 3. VACATION 4. WORK	Value of time
TOLL COSTS	1.PER PURPOSE 2.PER MODE	Toll costs
TRAVEL COSTS	1.PER PURPOSE 2.PER MODE	Free travel time, access egress time, fare costs etc.
• Values of these costs can be changed (in some percentage) based on some certain assumptions to simulate indirect effects of various policy changes.		
MAIN OUTPUTS of TRANS-TOOLS • Generalized cost matrices for per purpose per mode • Trip matrices for per purpose per mode • Passenger/vehicle kilometres at EU, national levels • Traffic on links, congestion times, average speeds etc.. • Traffic volumes which can be used to calculate impacts such as fuel consumption, emission levels for CO_2 and so on.		

APPENDIX 2: Description of Transport Demand Module in GLADYSTE Model Report

Source:	Hidalgo, I., Purwanto, J., Vanherle, K., Fermi, F. and Fiorello, D. (2011), "GLADYSTE: Transposing the structure of the TREMOVE model into a system dynamics coding", Final Report, J02/32/2008, Transport & Mobility Leuven, Belgium.
Pages:	6,7,8,9 and 10.

Transport demand module

Within the demand module (Figure), motorised transport demand is endogenously generated and segmented according to several dimensions (e.g. national/international, long or short distance, etc.). The segmentation includes the choice of mode and road type for each specific context, carried out taking account demand - supply interaction. This approach is applied for domestic as well as international traffic, but the latter is limited to trips within the same macro-region (i.e. Europe or North America). Otherwise, "inter-continental" demand is generated separately under form of matrix between macro-zones, taking into account only a selection of modes (e.g. airplane for passenger, airplane and ship for freight). All phases are directly or indirectly sensitive to parameters whose values change endogenously or exogenously according to specific policy measures implemented. In particular, change of generalised cost occurring in the mode split/road type choice affects both demand generation and aggregate segmentation into distance, etc.

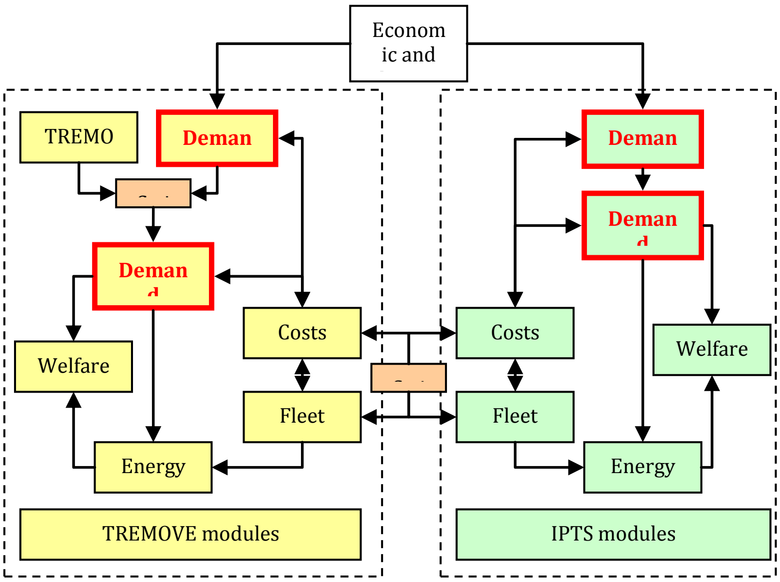

Figure 7: demand module as a part of GLADYSTE

Continental demand modelling

The generation phase is modelled by means of a mathematical equation depending on policy-sensitive variables, coming from exogenous data (e.g. population, trade, GDP) or other parts of the model (motorization rate). Although in the longer term the above mentioned variables are the main drivers of the demand, short terms fluctuations depend also on transport generalised cost and this is accounted for by means of an elasticity factors.

More in details, the first step of demand estimation consists of generating total motorized transport demand with the required level of segmentation (except mode split): namely, pkm are estimated distinguishing:

- Region where the trip is originated (according to the zoning system),

- Purpose: business, commuting or personal,
- Region of destination: intra-regional or inter-regional trip,
- Distance travelled: short distance or long distance (for intra-regional trips only),
- Urban level: urban or non-urban (for intra-regional trips only),
- Time period of the day: peak or off-peak (for intra-regional trips only).

The process of demand generation can be interpreted as a sequence of splits: first aggregated demand is generated, then it is separated into trip purposes, afterwards it is further split into intra-regional and inter-regional, etc. At each step, a specific set of variables and parameters are used for compute the shares.

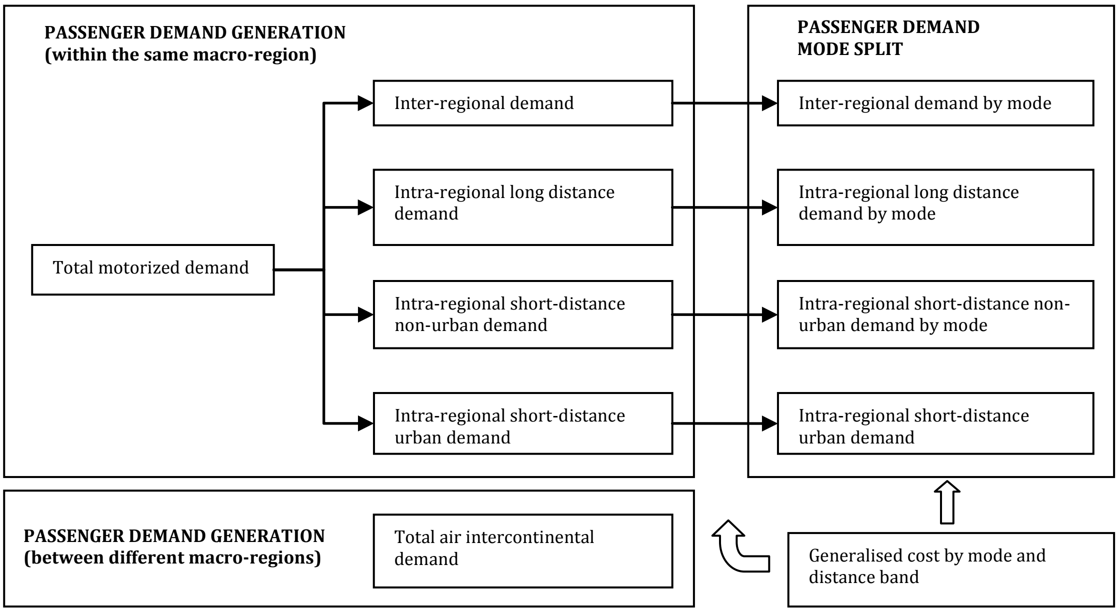

Figure 8: demand module

In modelling terms, this process produces the following level of transport demand segmentation:

- motorized pkm generated by region and purpose with inter-regional destination (referring to trips made within different regions, no matters the distance travelled),
- motorized pkm generated by region and purpose with intra-regional long distance destination (referring to trips made within the same region and with distance travelled above 150 km),
- motorized pkm generated by region, purpose and time period with intra-regional short distance destination at non-urban level (referring to trips made within the same region and with distance travelled below 150 km occurring in non-urban context),
- motorized pkm generated by region, purpose and time period with intra-regional short distance destination at urban level (referring to trips made within the same region and with distance travelled below 150 km occurring in urban context),

The sum of these variables represents the total amount of motorized demand generated within the same world region ("continental" demand).

The second step of transport demand segmentation is related to "micro" decisions, including transport mode and road type. These two elements can be reasonably interpreted in terms of choices between alternatives and it can be reasonably assumed that the key variables in GLADYSTE play a significant role in the choice process. In this case, break down is modelled by means of a discrete choice algorithm (nested logit model) mainly depending on the generalised cost of transport for each alternative (mode or network type). In mathematical terms:

$$Demand_{mode} = \frac{e^{\lambda\cdot(\beta\cdot Cgen_{mode}+K_{\mathrm{mode}})}}{\sum_{mode}\left(e^{\lambda\cdot(\beta\cdot Cgen_{mode}+K_{\mathrm{mode}})}\right)}$$

where ***λ*** is the dispersion parameter, ***β*** the "coefficient of cost variable" and ***K_{mode}*** the calibration value related to each mode.

Where both mode split and segmentation by network for each period (peak or off-peak) is estimated, a nested logit tree structure is implemented based on generalized cost. In general, the approach for the lower level of the structure (network segmentation) is the following:

$$Prob_{mode,network} = \frac{e^{\delta\cdot\left(\beta\cdot Cgen_{mode,network}+K_{network}\right)}}{\sum_{network}\left(e^{\delta\cdot\left(\beta\cdot Cgen_{mode,network}+K_{network}\right)}\right)}$$

where ***δ*** is the dispersion parameter, ***β*** the "coefficient of cost variable" and ***Prob_{mode,network}*** the probability of the network type to be chosen and Knetwork the calibration value related to each network (the network segmentation applies to road modes only, for the others is a matter of mathematical equation only, but there is no choice).
The probability for the aggregated upper level, for mode split, is then given as:

$$Prob_{mode} = \frac{e^{\lambda\cdot\left(IncV_{mode}+K_{mode}\right)}}{\sum_{mode}\left(e^{\lambda\cdot\left(IncV_{mode}+K_{mode}\right)}\right)}$$

With

$$IncV_{mode} = \frac{1}{\delta}\cdot\ln\left(\sum_{network}\left(e^{\delta\cdot\left(\beta\cdot Cgen_{mode,network}+K_{network}\right)}\right)\right)$$

and $\boldsymbol{\delta} > \boldsymbol{\lambda} > 1$.
For generalised cost we mean a function of at least transport cost and travel time expressed in monetary terms (i.e. using the value of travel time savings to convert time into money). In some case, other variables are part of the generalised cost in order to take into account additional endogenous factors or for calibration purposes. For instance, a measure for the simulation of the Mohring effect or of the infrastructure network availability are included in some cases. Also, a constant term is added to the generalised cost for computational reasons, i.e. to set the size of the numerator of the logit formula. This is required for two basic reasons: first in order to calibrate the elasticity of the model and, second, to maintain the magnitude of the utility function of the lower levers of the logit nest within a range that avoid changes of the sign when computing the inclusive value.
Mode split (combined with time period and network choice segmentation) is estimated separately by context, in particular:

- for inter-regional demand,
- for intra-regional long distance demand,
- for intra-regional short distance demand at non-urban level,
- for intra-regional short distance demand at urban level.

Obviously, not all modes are available for all contexts. The following tables show the available modes for each transport context for passenger and freight.

Table 12: Passenger modes available in each transport context

	Car	**Moped and Motorcycle**	**Bus**	**Tram and metro**	**Train**	**Airplane**
Intercontinental						X
Inter-regional	X		X		X	X
Intra-regional long distance	X		X		X	X
Intra-regional short distance non urban	X	X	X		X	
Intra-regional short distance urban	X	X	X	X		

Table 13: Freight modes available in each transport context

	Truck	Train	Inland navigation	Maritime	Airplane
Intercontinental				X	X
Inter-regional	X	X	X	X	X
Intra-regional long distance	X	X	X	X	X
Intra-regional short distance non urban	X	X	X		

Intercontinental demand modelling

The above holds for "continental" demand (e.g. demand of European countries). "Intercontinental demand modelling is simpler. "Intercontinental" demand is defined as transport activity between zones related to different continents (namely macro-areas in the GLADYSTE model), where inland modes cannot physically be used or are unrealistic alternatives. Therefore, passenger demand between e.g. USA and Canada (both part of the North American region) is considered "continental" demand; instead, demand between e.g. Canada and Brazil is part of the intercontinental demand. For passenger, intercontinental demand is basically related to air transport only, while for freight it refers to both maritime and air transport. "Intercontinental" demand is generated with a specific procedure independent from the "continental" demand, at a higher level of aggregation (i.e. by macro-regions instead of countries). Aggregated regions are used in terms of destination, while the zone of generation is consistent with the GLADYSTE zoning system. In the end, intercontinental demand is detailed at country level towards macro-regions (e.g. from France to North America).

In general, the algorithm for estimating intercontinental demand is basically a two step procedure: first overall inter-continental demand is generated in each macro-region by means of a regression function mainly based on GDP or trade, and then destinations are chosen with some attraction measure. The algorithm is sensitive to the (generalised) cost in both generation (e.g. to capture impact of air emission trading schemes on intercontinental air demand) and attraction phases. Attraction is sensitive to both GDP variation of the destination region and changes of generalized cost for each origin-destination pairs.

Linkages with other prototype modules

The demand module is mainly linked with the fleet planning equations. Two main feed-back effects occur:

- First of all, total transport activity estimated in the demand module is one of the inputs for simulating the evolution of vehicle fleet and then the motorization rate. In turn, the motorization rate is one of the inputs for estimating passenger demand trend.
- Secondly, the estimated fleet composition is an input for calculating the average cost by vehicle, which is a major component of the (dis)utility used within the demand module for demand segmentation and mode split.

Other linkages exist, however. For instance, the trend of cost per pkm (or tkm) by mode estimated in the IPTS transport modules is one of the input of the demand module, in order to keep the consistency among the different parts of the model.

Also, the cost per vehicle provided by the fleet planning equations is also influenced by the average fuel consumption per vehicle calculated, introducing a feedback also between this module and the transport demand one.

APPENDIX 3: Projections for GDP and population as an input to reference scenario for 2030

Annual average GDP growth (in percentages) by EU Member States

Countries	05-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	05-30	30-50
EU27	0.9	1.4	1.5	1.6	1.5	1.4	1.4	1.4	1.4	1.5	1.4
Austria	1.4	1.8	1.6	1.4	1.3	1.4	1.4	1.4	1.4	1.5	1.4
Belgium	1.2	1.5	1.4	1.4	1.6	1.7	1.8	1.8	1.7	1.5	1.7
Bulgaria	2.7	2.6	2.0	1.2	1.5	1.5	1.3	1.0	0.8	1.8	1.2
Cyprus	2.4	1.1	1.6	1.8	2.2	2.4	2.2	1.9	1.7	1.7	2.1
Czech Rep.	2.7	2.0	2.2	1.7	1.8	1.6	1.5	1.4	1.1	1.9	1.4
Denmark	-0.1	1.4	1.4	1.6	1.5	1.4	1.5	1.7	1.7	1.5	1.6
Estonia	0.0	3.9	2.3	2.1	2.3	1.9	1.7	1.3	1.0	2.6	1.5
Finland	1.0	1.9	1.4	1.4	1.4	1.5	1.6	1.5	1.5	1.5	1.5
France	0.7	1.5	1.6	1.9	1.7	1.6	1.6	1.6	1.6	1.7	1.6
Germany	1.3	1.5	0.9	0.8	0.6	0.5	0.7	0.9	0.8	1.0	0.7
Greece	0.3	-1.3	1.3	1.2	1.3	1.3	1.1	1.0	1.1	0.6	1.1
Hungary	-0.2	0.9	1.0	1.7	1.9	1.6	1.3	1.1	1.0	1.4	1.2
Ireland	-0.1	1.8	2.3	3.3	3.1	2.4	2.0	1.7	1.8	2.6	2.0
Italy	-0.2	0.7	1.1	1.5	1.5	1.3	1.2	1.3	1.4	1.2	1.3
Latvia	-0.7	3.2	2.3	2.3	2.3	1.6	1.4	0.9	0.4	2.5	1.1
Lithuania	1.0	3.3	1.6	1.7	1.9	1.6	1.7	1.5	0.9	2.1	1.4
Luxembourg	1.9	1.8	2.0	1.9	1.8	1.8	1.7	1.7	1.7	1.9	1.7
Malta	2.2	1.5	1.6	1.9	1.9	1.8	1.5	1.2	0.9	1.7	1.4
Netherlands	1.4	1.6	1.6	1.1	1.1	1.1	1.3	1.4	1.4	1.3	1.3
Poland	4.7	3.3	2.6	1.9	1.6	1.5	1.3	0.9	0.6	2.4	1.1
Portugal	0.4	-0.1	1.2	1.8	2.0	1.7	1.4	1.3	1.1	1.2	1.4
Romania	2.5	2.7	2.1	1.3	1.3	1.3	1.2	0.8	0.6	1.8	1.0
Slovakia	4.6	2.5	2.4	2.6	2.1	1.4	1.0	0.8	0.6	2.4	0.9
Slovenia	1.8	1.6	1.8	1.6	1.6	1.3	1.1	1.0	0.9	1.6	1.1
Spain	0.9	1.3	1.9	2.6	2.6	1.7	1.3	1.0	1.1	2.1	1.3
Sweden	1.5	2.2	1.7	1.8	1.8	1.8	1.8	1.8	1.7	1.9	1.8
UK	0.5	1.5	2.0	2.0	1.9	1.9	2.0	2.0	1.8	1.8	1.9

Source:	European Commission, (2012), "2012 EU Reference Scenario modelling - Draft transport activity projections", Directorate General Energy, Directorate General Climate Action, Directorate General Mobility and Transport.
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Annual average population growth (in percentages) by EU Member States

Countries	05-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	05-30	30-50
EU27	0.4	0.3	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	0.2	0.0
Austria	0.4	0.2	0.3	0.3	0.3	0.2	0.1	0.0	0.0	0.3	0.1
Belgium	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.6	0.4
Bulgaria	-0.5	-0.5	-0.7	-0.8	-0.7	-0.6	-0.5	-0.5	-0.6	-0.7	-0.6
Cyprus	1.4	0.9	1.1	1.1	0.9	0.7	0.6	0.5	0.5	1.0	0.6
Czech Republic	0.6	0.4	0.2	0.1	0.0	-0.1	-0.1	-0.1	-0.1	0.2	-0.1
Denmark	0.5	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.3	0.1
Estonia	-0.1	-0.1	-0.2	-0.3	-0.4	-0.3	-0.3	-0.2	-0.3	-0.2	-0.3
Finland	0.4	0.5	0.4	0.3	0.2	0.1	0.0	0.0	0.0	0.3	0.0
France	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.4	0.2
Germany	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-0.3	-0.5
Greece	0.4	0.3	0.1	0.1	0.0	0.1	0.0	0.0	-0.1	0.1	0.0
Hungary	-0.2	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3
Ireland	1.7	0.6	0.9	1.0	0.9	0.9	0.9	0.8	0.7	0.8	0.8
Italy	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.0	0.3	0.1
Latvia	-0.5	-0.5	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5	-0.6
Lithuania	-0.6	-0.5	-0.4	-0.4	-0.5	-0.4	-0.4	-0.4	-0.4	-0.5	-0.4
Luxembourg	1.7	1.5	1.2	0.9	0.8	0.7	0.6	0.5	0.5	1.1	0.6
Malta	0.6	-0.1	0.1	0.1	0.0	-0.2	-0.3	-0.3	-0.3	0.0	-0.2
Netherlands	0.3	0.5	0.3	0.2	0.2	0.1	0.0	-0.1	-0.2	0.3	-0.1
Poland	0.0	0.1	0.0	-0.1	-0.3	-0.4	-0.4	-0.4	-0.5	-0.1	-0.4
Portugal	0.2	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.2	0.1	-0.1
Romania	-0.2	-0.2	-0.2	-0.3	-0.4	-0.4	-0.4	-0.5	-0.5	-0.3	-0.5
Slovakia	0.2	0.3	0.2	0.1	-0.1	-0.2	-0.2	-0.2	-0.3	0.1	-0.2
Slovenia	0.5	0.6	0.3	0.1	0.0	-0.1	-0.1	-0.1	-0.2	0.3	-0.1
Spain	1.3	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.1	0.4	0.3
Sweden	0.7	0.8	0.7	0.6	0.4	0.3	0.3	0.3	0.3	0.6	0.3
UK	0.7	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.6	0.4
Croatia	---	0.6	0.3	0.1	0.0	-0.1	-0.1	-0.1	-0.2	0.3	-0.1

Source:	European Commission, (2012), "2012 EU Reference Scenario modelling - Draft transport activity projections", Directorate General Energy, Directorate General Climate Action, Directorate General Mobility and Transport.
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APPENDIX 4: Transport Activity Indicators at Country Level

Transport Activity Indicators at Country Level: Reference Scenario for 2030

	Passenger Transport Activity(Gpkm)						Freight Transport Activity (Gtkm)			
Country	**Private Cars**	**Motorcycles**	**Public Road**	**Rail**	**Aviation**	**Total**	**Trucks**	**Rail**	**IWW***	**Total**
Austria	83.4	1.9	11.5	19.1	13.2	129.2	40.7	25.6	3.6	69.9
Belgium	127.0	1.8	22.9	15.9	14.4	182.1	48.6	9.7	8.5	66.8
Bulgaria	50.6	1.2	11.9	4.4	8.7	76.8	24.5	5.2	0.9	30.6
Croatia	33.6	0.4	4.5	3.0	6.7	48.3	12.6	3.6	0.1	16.3
Cyprus	7.6	0.2	1.6	0.0	15.0	24.3	1.3	0.0	0.0	1.3
Czech Republic	83.7	4.7	22.0	22.6	16.5	149.4	69.4	20.5	0.1	90.0
Denmark	55.7	0.7	7.4	8.2	17.9	89.9	21.7	3.1	0.0	24.8
Estonia	12.6	0.3	2.5	0.5	1.3	17.2	7.3	10.7	0.0	18.0
Finland	68.6	1.1	8.3	5.8	15.1	98.8	36.8	13.9	0.1	50.8
France	837.6	18.1	62.3	148.3	102.1	1168.4	230.1	43.5	10.6	284.2
Germany	919.5	20.2	69.2	141.7	96.2	1246.8	331.2	143.6	85.9	560.7
Greece	104.8	7.1	23.5	3.8	44.2	183.4	33.9	0.7	0.0	34.6
Hungary	67.4	1.6	18.9	14.4	7.7	110.0	40.4	12.6	2.1	55.1
Ireland	55.9	0.6	8.7	2.6	18.8	86.5	18.0	0.2	0.0	18.2
Italy	752.3	51.1	113.6	83.8	87.9	1088.7	213.8	26.2	0.2	240.2
Latvia	19.1	0.5	2.5	1.4	4.8	28.3	15.6	25.2	0.0	40.8
Lithuania	35.0	0.8	3.1	0.6	2.9	42.4	25.9	20.0	0.0	45.9
Luxembourg	8.2	0.2	1.2	0.5	1.0	11.1	12.1	0.3	0.5	12.9
Malta	2.3	0.1	0.5	0.1	5.1	8.1	0.3	0.0	0.0	0.3
Netherlands	164.6	4.1	14.7	21.8	23.2	228.4	91.6	8.4	54.3	154.3
Poland	395.7	7.7	29.6	42.4	18.2	493.6	284.0	90.3	3.6	378.0
Portugal	97.8	2.2	12.9	8.4	28.8	150.1	43.8	3.4	0.0	47.2
Romania	107.0	4.1	15.4	20.7	17.4	164.6	58.5	21.6	5.8	85.9
Slovakia	41.3	0.9	8.2	4.5	2.0	56.9	38.0	13.9	2.7	54.6
Slovenia	29.4	0.4	3.7	1.0	0.7	35.2	28.6	7.0	0.0	35.6
Spain	467.4	14.8	63.6	58.3	170.6	774.7	284.7	15.0	0.0	299.7
Sweden	115.9	1.2	10.7	17.2	25.2	170.1	43.3	33.9	0.0	77.2
UK	765.4	5.9	55.7	84.8	127.0	1038.8	189.1	25.5	0.2	214.8
EU 28	5509.3	153.9	610.6	735.8	892.6	7902.3	2245.8	583.6	179.3	3008.8

* IWW excluding Maritime (Not Transcenario estimation)

Source: European Commission, (2012), "2012 EU Reference Scenario modelling - Draft transport activity projections", Directorate General Energy, Directorate General Climate Action, Directorate General Mobility and Transport.

Country Based Transport Activity Indicators: OPTIMISM Policy Scenario 1

	Passenger Transport Activity(Gpkm)						Freight Transport Activity (Gtkm)			
Country	**Private Cars**	**Motorcycles**	**Public Road**	**Rail**	**Aviation**	**Total**	**Trucks**	**Rail**	**IWW**	**Total**
Austria	82.9	1.9	11.6	19.3	13.3	129.0	40.6	25.7	3.6	69.9
Belgium	126.0	1.8	23.3	16.2	14.5	181.8	48.5	9.7	8.5	66.7
Bulgaria	50.1	1.2	12.1	4.5	8.7	76.6	24.5	5.2	0.9	30.5
Croatia	33.4	0.4	4.6	3.1	6.8	48.2	12.6	3.6	0.1	16.3
Cyprus	7.5	0.2	1.6	0.0	15.0	24.3	1.3	0.0	0.0	1.3
Czech Republic	83.2	4.7	22.1	22.8	16.5	149.3	69.2	20.5	0.1	89.9
Denmark	55.3	0.7	7.5	8.4	17.9	89.8	21.7	3.1	0.0	24.8
Estonia	12.5	0.3	2.5	0.5	1.3	17.2	7.3	10.7	0.0	18.0
Finland	68.0	1.1	8.5	6.0	15.1	98.7	36.8	13.9	0.1	50.8
France	832.2	18.0	63.1	151.0	102.5	1166.7	229.6	43.5	10.6	283.7
Germany	914.5	20.1	69.7	144.1	96.5	1244.9	330.6	143.8	86.1	560.5
Greece	104.6	7.0	23.6	3.7	44.2	183.1	33.8	0.7	0.0	34.5
Hungary	67.1	1.6	18.9	14.5	7.7	109.7	40.3	12.6	2.1	55.0
Ireland	55.5	0.6	8.8	2.6	18.8	86.4	18.0	0.2	0.0	18.2
Italy	746.6	50.9	115.6	85.7	88.4	1087.2	213.2	26.2	0.2	239.7
Latvia	19.0	0.5	2.5	1.4	4.8	28.2	15.6	25.2	0.0	40.8
Lithuania	34.9	0.8	3.1	0.6	2.9	42.3	25.8	20.0	0.0	45.9
Luxembourg	8.1	0.2	1.2	0.5	1.0	11.1	12.1	0.3	0.5	12.9
Malta	2.3	0.1	0.5	0.1	5.1	8.1	0.3	0.0	0.0	0.3
Netherlands	163.4	4.1	14.9	22.3	23.2	228.0	91.4	8.4	54.4	154.2
Poland	393.8	7.6	29.7	42.9	18.2	492.3	283.5	90.6	3.6	377.7
Portugal	96.9	2.2	13.1	8.7	28.8	149.8	43.7	3.4	0.0	47.1
Romania	106.3	4.0	15.6	21.0	17.4	164.3	58.4	21.6	5.8	85.9
Slovakia	41.1	0.9	8.2	4.6	2.0	56.8	38.0	14.0	2.7	54.6
Slovenia	29.2	0.4	3.8	1.0	0.7	35.1	28.6	7.0	0.0	35.6
Spain	465.1	14.7	64.1	59.1	170.7	773.7	284.3	15.1	0.0	299.4
Sweden	114.9	1.2	10.9	17.6	25.2	169.9	43.2	33.9	0.0	77.2
UK	759.2	5.9	57.1	88.0	127.2	1037.4	188.7	25.5	0.2	214.5
EU 28	5473.4	153.0	618.3	750.3	894.6	7889.6	2241.4	584.5	179.8	3005.7

Country Based Transport Activity Indicators: OPTIMISM Policy Scenario 2

	Passenger Transport Activity(Gpkm)						Freight Transport Activity (Gtkm)			
Country	**Private Cars**	**Motorcycles**	**Public Road**	**Rail**	**Aviation**	**Total**	**Trucks**	**Rail**	**IWW**	**Total**
Austria	84.8	1.9	11.4	18.5	13.1	129.7	40.9	25.5	3.6	70.0
Belgium	129.5	1.9	22.0	15.2	14.4	182.9	48.8	9.7	8.4	66.9
Bulgaria	51.9	1.3	11.5	4.2	8.8	77.6	24.6	5.2	0.9	30.7
Croatia	34.4	0.4	4.2	2.8	6.7	48.5	12.7	3.6	0.1	16.4
Cyprus	7.8	0.2	1.5	0.0	15.0	24.4	1.3	0.0	0.0	1.3
Czech Republic	84.7	4.8	21.7	22.1	16.5	149.8	69.7	20.4	0.1	90.2
Denmark	56.7	0.7	7.1	7.8	17.9	90.2	21.8	3.1	0.0	24.9
Estonia	12.8	0.3	2.5	0.5	1.3	17.3	7.4	10.7	0.0	18.1
Finland	70.0	1.1	8.0	5.2	14.9	99.2	36.9	13.9	0.1	50.9
France	850.3	18.3	60.7	142.1	101.7	1173.1	231.4	43.5	10.6	285.5
Germany	931.3	20.3	68.3	136.3	95.9	1252.1	332.6	143.4	85.4	561.4
Greece	105.6	7.3	23.4	3.7	44.2	184.2	34.1	0.7	0.0	34.8
Hungary	68.4	1.7	19.0	14.1	7.7	110.9	40.7	12.5	2.0	55.2
Ireland	56.8	0.6	8.3	2.5	18.7	86.9	18.1	0.2	0.0	18.3
Italy	765.0	51.4	108.9	81.5	86.9	1093.7	215.2	26.1	0.2	241.6
Latvia	19.4	0.5	2.5	1.3	4.8	28.5	15.7	25.2	0.0	40.9
Lithuania	35.4	0.8	3.0	0.6	2.9	42.7	26.1	20.0	0.0	46.0
Luxembourg	8.4	0.2	1.1	0.5	1.0	11.2	12.1	0.3	0.5	12.9
Malta	2.4	0.1	0.5	0.1	5.1	8.1	0.3	0.0	0.0	0.3
Netherlands	167.5	4.2	14.3	20.4	23.2	229.5	92.2	8.4	54.2	154.9
Poland	401.3	8.0	29.2	40.9	18.2	497.6	285.6	89.7	3.6	378.9
Portugal	99.9	2.3	12.4	7.6	28.8	150.9	43.9	3.4	0.0	47.3
Romania	108.9	4.4	15.0	19.9	17.4	165.7	58.7	21.5	5.8	86.0
Slovakia	41.9	0.9	8.2	4.4	2.0	57.3	38.1	13.8	2.7	54.6
Slovenia	29.9	0.4	3.5	0.9	0.7	35.5	28.7	7.0	0.0	35.7
Spain	472.9	15.0	62.6	56.4	170.6	777.5	285.7	14.9	0.0	300.6
Sweden	118.3	1.2	10.2	16.2	25.1	171.0	43.5	33.9	0.0	77.3
UK	780.0	6.0	52.5	77.5	126.8	1042.7	189.9	25.6	0.2	215.7
EU 28	5596.1	156.3	593.4	703.1	890.2	7939.1	2256.9	581.9	178.6	3017.4

Country Based Transport Activity Indicators: OPTIMISM Policy Scenario 3

	Passenger Transport Activity(Gpkm)						Freight Transport Activity (Gtkm)			
Country	**Private Cars**	**Motorcycles**	**Public Road**	**Rail**	**Aviation**	**Total**	**Trucks**	**Rail**	**IWW**	**Total**
Austria	81.5	1.9	12.5	20.3	13.2	129.4	40.6	25.7	3.6	69.9
Belgium	124.1	1.8	24.7	17.2	14.4	182.3	48.5	9.7	8.5	66.7
Bulgaria	49.4	1.2	12.8	4.6	8.7	76.6	24.5	5.2	0.9	30.5
Croatia	33.2	0.4	4.7	3.1	6.8	48.2	12.6	3.6	0.1	16.3
Cyprus	7.4	0.2	1.7	0.0	15.0	24.2	1.3	0.0	0.0	1.3
Czech Republic	82.1	4.6	23.4	23.7	16.5	150.2	69.2	20.5	0.1	89.9
Denmark	54.8	0.7	7.9	8.6	17.9	89.9	21.7	3.1	0.0	24.8
Estonia	12.3	0.3	2.7	0.5	1.3	17.1	7.3	10.7	0.0	18.0
Finland	67.4	1.1	8.9	6.2	15.1	98.8	36.8	13.9	0.1	50.8
France	825.0	17.8	66.9	157.5	102.2	1169.4	229.6	43.5	10.6	283.8
Germany	905.2	19.9	75.5	152.2	96.1	1248.9	330.6	143.8	86.1	560.5
Greece	102.7	6.9	25.4	4.0	44.2	183.2	33.8	0.7	0.0	34.5
Hungary	65.8	1.5	20.6	14.9	7.7	110.5	40.3	12.6	2.1	55.0
Ireland	54.8	0.6	9.4	2.8	18.8	86.3	18.0	0.2	0.0	18.2
Italy	738.3	50.3	124.2	90.1	88.1	1091.0	213.2	26.2	0.2	239.7
Latvia	18.7	0.5	2.7	1.5	4.8	28.2	15.6	25.2	0.0	40.8
Lithuania	34.6	0.8	3.3	0.6	2.9	42.3	25.8	20.0	0.0	45.9
Luxembourg	8.0	0.2	1.3	0.5	1.0	11.0	12.1	0.3	0.5	12.9
Malta	2.2	0.1	0.6	0.1	5.1	8.1	0.3	0.0	0.0	0.3
Netherlands	161.7	4.0	15.8	23.6	23.1	228.3	91.4	8.4	54.4	154.2
Poland	388.9	7.5	32.7	44.9	18.2	492.2	283.5	90.6	3.6	377.7
Portugal	95.5	2.1	14.2	9.2	28.8	149.8	43.7	3.4	0.0	47.1
Romania	104.8	3.9	16.5	21.9	17.4	164.4	58.4	21.6	5.8	85.9
Slovakia	40.4	0.9	9.0	4.7	2.0	56.9	38.0	14.0	2.7	54.6
Slovenia	28.8	0.4	4.1	1.1	0.7	35.1	28.6	7.0	0.0	35.6
Spain	459.6	14.5	68.5	61.2	170.6	774.4	284.3	15.1	0.0	299.4
Sweden	114.0	1.2	11.5	18.3	25.2	170.1	43.2	33.9	0.0	77.2
UK	752.7	5.8	59.9	93.7	127.2	1039.3	188.7	25.5	0.2	214.5
EU 28	5413.9	150.9	661.3	786.9	893.0	7905.9	2241.5	584.5	179.8	3005.7

Country Based Transport Activity Indicators: OPTIMISM Policy Scenario 4

	Passenger Transport Activity(Gpkm)						Freight Transport Activity (Gtkm)			
Country	**Private Cars**	**Motorcycles**	**Public Road**	**Rail**	**Aviation**	**Total**	**Trucks**	**Rail**	**IWW**	**Total**
Austria	83.6	1.9	11.5	19.1	13.0	129.1	40.9	25.5	3.6	70.0
Belgium	127.7	1.8	22.9	15.9	14.4	182.8	48.8	9.7	8.4	66.9
Bulgaria	51.2	1.3	11.9	4.4	8.7	77.6	24.6	5.2	0.9	30.7
Croatia	34.3	0.4	4.5	3.0	6.7	48.8	12.7	3.6	0.1	16.4
Cyprus	7.6	0.2	1.6	0.0	15.0	24.4	1.3	0.0	0.0	1.3
Czech Republic	83.6	4.7	22.0	22.6	16.5	149.4	69.7	20.4	0.1	90.2
Denmark	56.3	0.7	7.4	8.2	17.9	90.4	21.8	3.1	0.0	24.9
Estonia	12.6	0.3	2.5	0.5	1.3	17.2	7.4	10.7	0.0	18.1
Finland	69.4	1.1	8.3	5.8	14.9	99.6	36.9	13.9	0.1	50.9
France	843.9	18.2	62.3	148.3	101.4	1174.0	231.4	43.5	10.6	285.5
Germany	922.6	20.1	69.2	141.7	95.6	1249.3	332.6	143.4	85.4	561.4
Greece	103.9	7.1	23.5	3.8	44.2	182.5	34.1	0.7	0.0	34.8
Hungary	67.2	1.6	18.9	14.4	7.7	109.8	40.7	12.5	2.0	55.2
Ireland	56.2	0.6	8.7	2.6	18.7	86.8	18.1	0.2	0.0	18.3
Italy	758.5	50.9	113.6	83.8	86.7	1093.5	215.3	26.1	0.2	241.6
Latvia	19.1	0.5	2.5	1.4	4.8	28.3	15.7	25.2	0.0	40.9
Lithuania	35.3	0.8	3.1	0.6	2.9	42.7	26.1	20.0	0.0	46.0
Luxembourg	8.3	0.2	1.2	0.5	1.0	11.1	12.1	0.3	0.5	12.9
Malta	2.3	0.1	0.5	0.1	5.1	8.1	0.3	0.0	0.0	0.3
Netherlands	165.8	4.1	14.7	21.8	23.0	229.5	92.2	8.4	54.2	154.9
Poland	396.7	7.9	29.6	42.4	18.2	494.8	285.6	89.7	3.6	378.9
Portugal	98.5	2.2	12.9	8.4	28.8	150.9	43.9	3.4	0.0	47.3
Romania	107.4	4.3	15.4	20.7	17.4	165.3	58.7	21.5	5.8	86.0
Slovakia	41.2	0.9	8.2	4.5	1.9	56.7	38.1	13.8	2.7	54.6
Slovenia	29.6	0.4	3.7	1.0	0.7	35.4	28.7	7.0	0.0	35.7
Spain	467.8	14.8	63.6	58.3	170.5	775.0	285.7	14.9	0.0	300.6
Sweden	117.5	1.2	10.7	17.2	25.1	171.7	43.5	33.9	0.0	77.3
UK	772.5	5.9	55.7	84.8	126.7	1045.7	190.0	25.6	0.2	215.8
EU 28	5540.6	154.5	610.6	735.8	888.7	7930.2	2256.9	581.9	178.6	3017.4

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Title: Modelling Future Mobility - Scenario Simulation at Macro Level

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Abstract

The aim of the report is to simulate policy scenarios for passenger transport using Europe-wide transport models, estimate their potential impacts and demonstrate how do they differ from each other and from the reference scenario for 2030. In more detail, the main objectives of the deliverable can be given as follows:

- to model future multi-modal mobility scenarios for passengers formulated within the previous tasks of the project,
- to simulate impacts of identified trends and selected strategies on demand, supply and technology at macro level,
- to analyse impacts of selected policies and identified trends on mobility patterns such as in travel demand and modal split,
- to estimate potential impacts of selected policy measures on environmental indicators via transport emissions and vehicle fleet sizes,
- to compare impacts of different scenario options in quantitative terms and provide useful insights for exploring best policy scenarios and strategies for sustainable passenger transport.
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The research has been conducted under the OPTIMISM project which was received funding from the European Union's Seventh Framework Programme (FP7/2007-2013), grant agreement n° 284892. The report has been produced as the OPTIMISM project deliverable 3.4: Modelling Future Mobility - Scenario Simulation at Macro Level.

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