TECHNICAL REPORT SERIES

Policy Support Tools for Transport Issues

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EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

European Science and Technology Observatory

Institute for Prospective Technological Studies

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Institute for Prospective Technological Studies

European Science and Technology Observatory

Policy Support Tools for Transport Issues

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Table of Contents

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Executive summary

The objective of the project "Policy Support Tools for Transport Issues" was to contribute to the in-house capacity of the European Commission in terms of operational models and tools to support transport policy. The work focused on the further development of strategic transport models that are already available to the Commission services, notably models that have been developed under 4th and 5th FP projects.

The project examined the main characteristics of each model and identified their main strengths and weaknesses in addressing specific policy issues. It compared their data requirements and output, and validated their results through a comparison of their projections with official statistics. The analysis suggested that a combination of the various models allows an integrated analysis of several complex policy issues. The model developer team agreed on a methodology to analyse five main policy areas, and defined the operational procedure. The resulting 'blueprints' form the basis for a policy support tool able to capture many direct and indirect impacts of transport and provide useful information for impact assessment in the field of EU transport policy.

Models analysed

The seven models that were analysed in the project were selected on the basis of their relevance to EU level transport policy issues and their availability for further applications by JRC-IPTS. It should be noted that the number of policy oriented European transport models is limited; national models are numerous, but the European dimension is not their strongest element.

Each of the models has been developed in order to analyse specific issues and –consequently- has its own advantages and disadvantages as regards its suitability to address specific transport issues.

TREMOVE is a model that simulates the impact of policy measures relating to transport technologies and provides projections as regards the environmental impact of transport. It does not estimate transport demand, that is an exogenous input, but concentrates on the analysis of the economic factors that influence the market share of each vehicle and fuel type.

TRENDS is a tool that provides a range of indicators concerning environmental pressure caused by transport. These indicators are calculated directly from the activity levels and reflect the potential change in the state of the environment, or the risk of specific environmental impacts which any changes in policy might have. Its strength lies in the underlying COPERT database, a detailed description of emission factors for the majority of transport technologies. Transport demand is exogenous for TRENDS; as a standalone application it should therefore be considered as a conversion tool of COPERT emission factors into total emissions per country. Coupled with a detailed transport demand model, however, it could provide reliable projections as regards the future level of transport emissions.

EXPEDITE is a tool that has been built as an extension of several national (disaggregate) transport models. Its aim is to predict passenger and freight transport demand and it provides projections per population segment, travel mode, travel purpose and distance class for the whole EU. EXPEDITE does not include a transport network, but has been calibrated using the SCENES network allocation. Although the approach used in EXPEDITE may be less accurate for the countries where no national model was available, it still provides rather reliable results at EU level as regards total transport volumes. The focus of the passenger transport model is on short and medium distance trips (up to 160 km).

SCENES is a strategic European multi-modal passenger and freight forecasting model, covering 23 EU countries at NUTS 2 level. It uses a detailed European transport network for assignment. The freight model is based on a complex regional economic model (REM), using input-output techniques. The passenger model uses a more standard trip generation mechanism. The base year for both models is 1995 and forecasts have been produced within the SCENES project for the 2020 horizon. SCENES is one of the few transport network models available at EU level and its network allocation provides input to several other transport models. It is nevertheless becoming outdated, since an update of both the transport network and base year data is long due.

ASTRA has been developed from the start as an assessment tool of the long-term impacts of the European transport policy with respect to the economic, environmental and social implications. The model applies a system dynamics methodology and follows an integrated modelling approach that covers transport, economic, regional development, trade, technological and environmental modelling. Its main advantage is its ability to analyse the direct and indirect impacts of transport policy measures taking into account the interactions with other sectors of the economy. The fact that the scope of the model is large, however, implies that the depth of the analysis of specific transport issues and the reliability of the projections vary according to the level of detail.

POLES is a simulation model for the long-term development of energy markets at global level. It provides detailed scenarios for worldwide energy consumption and GHG emissions and evaluates emission control policies and RTD strategies. The model allows the assessment of Marginal Abatement Costs for CO2 emissions and the simulation of emission trading systems, and includes feedback mechanisms to capture the impact of changing fuel prices on international energy supply and demand. POLES encompasses an extensive transport module that has been designed to capture energy related issues of transport. It is therefore a reliable model for the analysis of the energy dimension of transport technologies but, lacking a representation of the transport networks, is not suitable for the analysis of transport flows below the macroscopic level.

GEM-E3 is not a transport model, although it covers issues that are of high interest to transport policy. GEM-E3 is a General Equilibrium Model designed to analyse market instruments for energy-related environmental policies, such as taxes, subsidies, regulations, pollution permits etc., at a degree of detail that is sufficient for national, sectoral and Europe-wide policy evaluation. Being in principle a macro-economic model, it is best suited for the assessment of the distributional consequences of programmes and policies, including social equity, employment and cohesion targets. In the context of this project, it has been considered as a reliable model for the provision of projections as regards economic growth and employment, variables that most transport models use as exogenous input.

The strengths and weaknesses of the seven models analysed in the project can be summarised as follows:

	Strengths	Weaknesses
TREMOVE	Modular structure by country	The use of a simplified technology for nine EU countries out of 15
TRENDS	Harmonised indicators of environmental impacts of transport	Limited value for policy forecasts
EXPEDITE	Meta-model simplifies simulation and policy analysis; outcomes for many population segments, also on their consumer surplus	Lacks an explicit origin-destination matrix and networks
SCENES	Allocation to European transport network, multimodal	Lacking detail outside EU-15
ASTRA	Integrated approach, indirect impacts	Limited geographic detail, lack of transport network
POLES	Fuel markets and technology introduction modelling	Lacks sufficient detail for an in-depth analysis of transport issues
GEM-E3	Interactions between economic sectors and simulation of changing structure of the economy	Inherits the main weakness of general equilibrium modelling family, i.e. it assumes that the economy reaches equilibrium

All models covered in this project are extensive, non-linear simulations of the sector they address (the transport system, energy markets and/or economic activities). Each model covers the sector it addresses sufficiently well, but its interactions with the exogenous variables are limited or, at best, non-dynamic. The coverage of the new EU member states is still incomplete for some of the models, although most have plans for future extensions.

Seen as a whole, the seven models covered in this project can provide useful information for a partial analysis of transport related issues. For broad integrated policy analyses, an approach based on a combination of models is considered as the most appropriate solution. The consensus in the modelling community is to avoid including many aspects in great detail in a single model system. Very large and complex models lose transparency and usability. Instead, researchers prefer models that specialise on treating certain aspects in detail, or models that cover a broad range of aspects at a high level of abstraction.

The combination of two or more independent models in order to carry out integrated analyses permits the various developer teams to concentrate on the issues covered best by their models and their expertise. It also ensures that exogenous variables are modelled in a compatible way, without the need of extensive additional development for each specific model.

Coverage of transport policy issues

Taking the strengths and weaknesses of each model into account, the project identified 17 transport research issues for which the available tools can be applied, either on a standalone basis or combined:

1. Modal split;
2. Distribution/equity;
3. Environmental assessment;
4. Environmental policies related to vehicle type;
5. Regional analysis;
6. Transport forecasting;
7. Traffic forecasting/network;
8. Dynamic analysis;
9. Macro economic effects;
10. New transport technology;
11. Life cycle analysis;
12. Intermodality;
13. Interoperability;
14. Logistics;
15. Decoupling;
16. Quality indicators; and
17. Cost/tariffs/quality.

For most of the above transport research issues, significant methodological improvements are expected to be possible from an exchange of data or results between two or more models. Since the focus of the project was on policy support at EU level, a more detailed analysis was carried out as regards the feasibility of applying a combination of models to address the main EU policy priorities. Five policy issues where the tools could significantly contribute to the analysis were identified:

1. Fuel and carbon taxes and pricing principles;
2. Energy policies and emission standards;
3. Intermodality;
4. Networks / Trans-European Networks; and
5. Economic policies / Environmental assessment.

Focusing on the selected policy issues, the project validated the projections of the models by comparing them to data, identified the requirements for common initial assumptions and data exchanges and developed an operational methodology for the application of the models in order to address each specific policy issue.

Comparison of model projections

Surprisingly, little had been done in the past as regards the validation of the models and the ex-post comparison of their projections with actual developments. Although most models use year 1995 as the base or reference year, several differences can be seen in both the initial conditions and the projections for the future. In order to identify the reasons behind that and suggest improvements, this project discussed and compared, at several levels, the main results of the models that are relevant to the EU policy priorities:

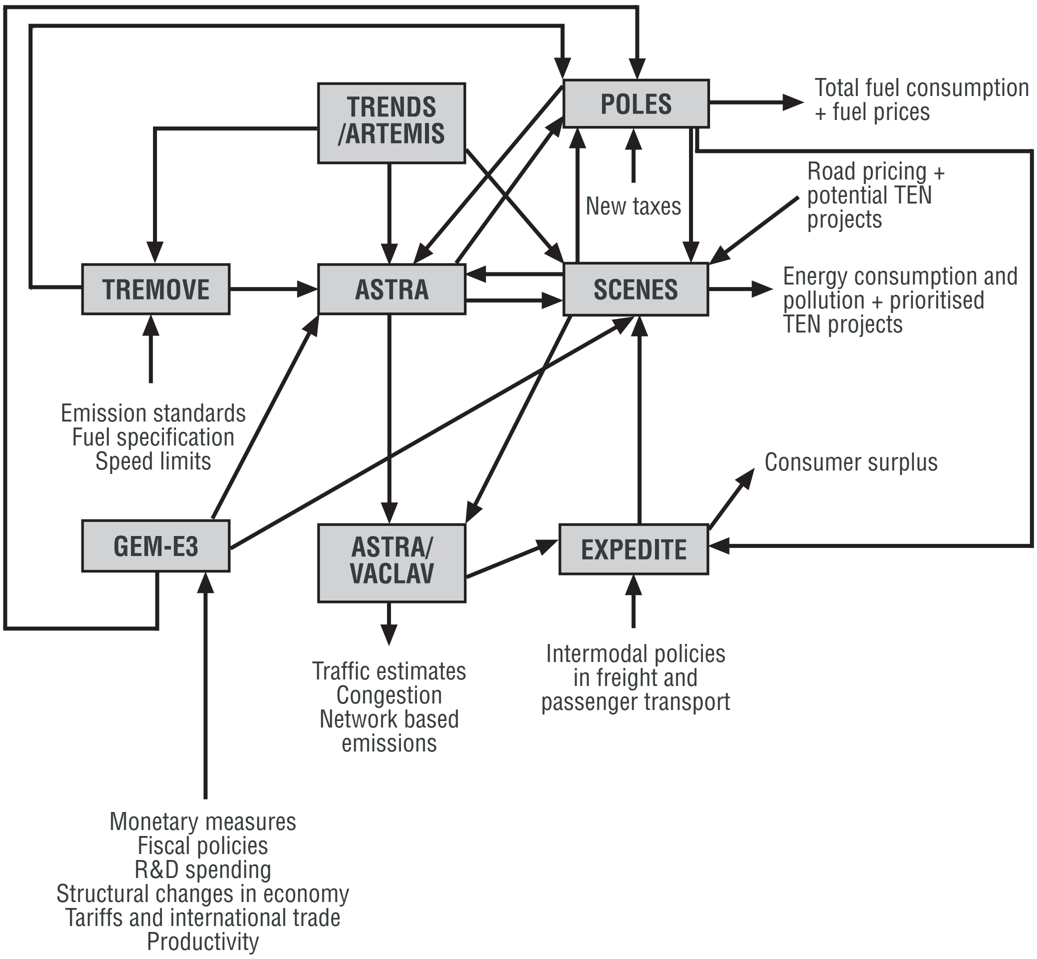
- Input data (comparison of main variables for year 1995): Most models use similar sources of information; for country level data most use EUROSTAT data, where available. However, data is often not available at the level required and each model relies on different assumptions. As a result, in several cases the starting assumptions of the models differ significantly, with obvious repercussions on the results of the models.
- Calibration of the models (comparison of model data with EUROSTAT time series data up to 1995): All models demonstrate a high degree of accuracy in describing the past. Most models have used standard statistical or econometric methods that allow their results to be considered reliable.
- Validation of the models (comparison of model projections for 2000 with EUROSTAT data for 2000): Most models predict the trends for the main variables correctly and demonstrate acceptable error margins; models tend to be less reliable for small countries, for variables for which historical data was incomplete, and in cases where the exogenous assumptions used were incorrect (e.g. future GDP growth rates used as model input).
- Forecasts (comparison of model projections for years 2010 and 2020, comparison with TRENDS extrapolation, comparison with forecasts from national models): Several differences identified; broad agreement in terms of general trends at EU level, significant differences in terms of specific countries for specific variables.

Linking of models

Having identified the strengths and weaknesses of each model, the project explored the possibilities of a combined application of the models. The combinations were checked at conceptual and operational level. At conceptual level, a consensus in terms of definitions of variables has been noticed; even though the simulation methodology may differ, there is an agreement among the various developer teams on what each variable should represent and –with usually minor adjustments- data and model results are in principle interchangeable. At operational level the situation is more complicated. The simulation step of the models varies from ¼ of a year in ASTRA to 5 years in SCENES and GEM-E3, with the rest using 1 year steps. Data exchanges between models using different time steps are still possible, but additional development work should be carried out in order to make the process automatic.

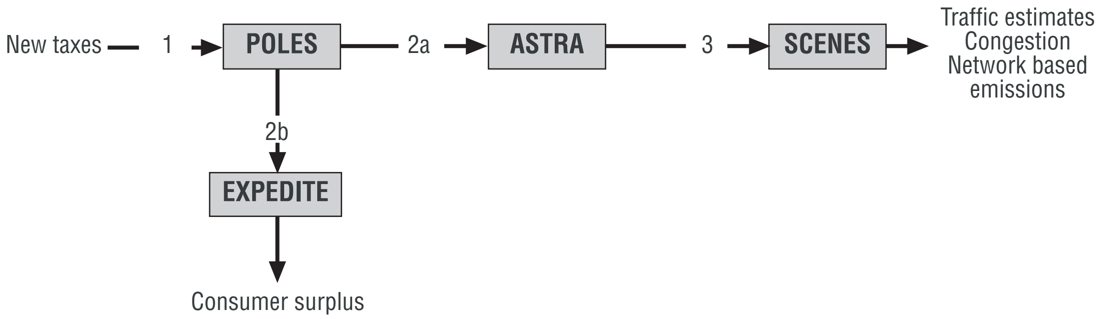
The general linkage possibilities can be seen in diagram 1. It is apparent that, although each model has a clear role in terms of the issues it covers, an integrated analysis would involve the application of at least two models. On the other hand, not all models would be necessary for a comprehensive analysis, since several alternative paths for the simulation of the same policy issue can be used.

Figure S.1: General model linkage possibilities.



The project elaborated on the operational methodology for the analysis of the five main areas identified as important at an EU level. For each area, the developer teams agreed on a 'blueprint', a diagram describing the simulation process, including the order in which the models are run, the main input variables, data exchanges and output variables. The simulation path depends on the formulation of the policy issue, so a different combination is proposed for each type of issue. In the example of figure S.2, the 'blueprint' for the analysis of the impact of fuel taxes describes the operational procedure to analyse impacts on transport. Whereas POLES on its own would be in the position to estimate potential impacts on total transport demand, fuel consumption and CO_2 emissions, combining it with ASTRA, EXPEDITE and SCENES allows the estimation of the impacts on additional areas, such as benefits for the users and congestion.

Figure S.2: Example of operational 'blueprint' for analysis of impacts of fuel taxes



Conclusions

The analysis carried out in this project provides evidence that the combination of the available models at EU level can provide useful input to policy impact assessment. Even though each model has been developed independently in order to address specific issues, the seven models analysed cover between them the main requirements for support of EU transport policy. Apart from the analysis of the main transport issues and the direct impacts of policy measures on transport volumes, the models allow an integrated analysis that encompasses most indirect impacts of transport. In terms of impact assessment, the model combinations potentially allow:

- The identification of the types of environmental, economic and social impacts
- The identification of distributive effects, 'winners' and 'losers'
- The measurement of impacts in qualitative, quantitative and, where appropriate, money terms
- The comparison of impact in terms of cost-effectiveness, cost-benefit and multi-criteria analysis
- The consideration of risks and uncertainties inherent in policy choices
- The assessment of the medium to long term impacts of Trans-European Networks

From the scientific point of view, the project has also contributed to the improvement of available tools. It has assisted the various model development teams in identifying their common data needs and has facilitated the exchange of results and information. Most importantly, it has carried out a preliminary evaluation of the models as policy support tools and has validated their results for selected variables. The analysis suggests that, in principle, the combination of the seven models covered meets the main criteria for good practice of assessment techniques:

- Transparency: the estimation of the impacts of policy measures related to transport using the available models is clear, at least to other developers of models. The publication of additional reports and/or peer reviewed articles would certainly help in improving the policy makers' understanding of their principles, their strengths and their limitations.
- Reproducible results: the convergence of the results of the various models suggests that the main modelling methodologies applied lead to reproducible results; the main problem lies in the use of different data, a factor that explains a large part of the differences between their results.

- Robustness: using different methods or assumptions to estimate impacts leads to comparable results. The comparison of the results of the different models suggests that at least the identification of trends is reliable, since most projections tend to coincide. Differences have been mainly found for small countries, or where data availability was limited.

Improvements are still necessary however. Models are constantly improved, but the limited availability of published statistics hinders their further development, their possibilities for cooperation and the possibilities for an objective evaluation of their results. A possible solution to this problem would be the development of a common information system that would provide all models with the same input data, allow them to exchange information and publish their results.

It can also be argued that a distributed model development and maintenance is preferable to the centralised development of a single model covering all issues. Experience in this and other projects show that cooperation between models is feasible, and that the healthy competition between independent developer teams leads to mutual improvements. It seems therefore that investment in smaller, flexible and specialised models can bring better results than concentrating all efforts in attempting to develop a global model.

Cooperation with model developers and authorities at national, regional and local level would also improve the quality of European models and their acceptability as policy support tools. The provision of harmonized statistics at national level is fundamental for the reliable simulation of transport in each country; a linkage with national models –where available- would also probably improve the accuracy of projections. The exchange of best practices between modellers and analysts is also desirable, especially with respect to the new EU member states.

1 Introduction

This report was written TNO Inro, RAND Europe, IWW (Institut für Wirtschaftspolitik und Wirtschaftsforschung), WSP together with JRC-IPTS. It presents a description of several of the most relevant models for transport policy at EU level and provides a blueprint for linking European Transport Models. The participants were not requested to change the structures of the models, nor to change the existing parameter values in the models. A re-calibration of the models would take too much time and is not the aim of this project. It is more the aim to use the different functionalities of the models to investigate the possible outcomes of certain policies from different perspectives.

The report is divided in three main parts:

1. Description of models
2. Review of available data
3. Development of blueprints for linking European Transport Models

Chapter 2 describes the models TREMOVE, TRENDS, EXPEDITE, SCENES, ASTRA, POLES and GEM-E3 in terms of:

a. Input data (structure and content);

b. Modelling structure (functional form and/or parameter values; and

c. Output data (structure and content).

Moreover a structure is established for describing the models in such a way that linkages between transport models can also be established and therefore a combination of transport models could be realised. It is the aim here to establish where (and which) models can reinforce each other, i.e. for which policy issue/analysis a combination of models is needed.

In Chapter 3, the input and output data of the different models (in aggregated form) is investigated. Moreover, this data is compared with other data sources such as TRENDS and EUROSTAT/CEMT. Also the input and output data of the different European transport models is compared with each other. This analysis presents conclusions about the possibility for updating the model input and output. New calibration of the selected transport models is not carried out, but recommendations are given on this matter. Also a recommendation is given on what would need to be done in order to update the European transport models, given the existing datasets.

Chapter 4 focuses on the development of blueprints for linkages between the selected models (SCENES, EXPEDITE, TREMOVE, TRENDS, ASTRA, POLES and GEM-E3). Five specific blueprints are identified which are related to a specific policy issue. The linkages between models are proposed in order to extend the range of outcomes of the models.

The last chapter draws the main conclusions from the results.

An additional report containing annexes with detailed model information and model results is available in electronic version. Both the present report and the report with the annexes can be downloaded from http://www.jrc.es/home/publications/publications.html.

2 Description of models

This chapter presents a short description of the seven European transport models which have been investigated in this project. These models were selected on the basis of their relevance to EU level transport policy issues and their availability for further applications by JRC-IPTS. Three of the models (POLES, ASTRA, GEM-E3) are already used by JRC-IPTS in the analysis of transport, energy and macro-economic issues. TRENDS will be maintained in the future by JRC-IPTS and is considered as a complimentary tool to the existing set of in-house models. The remaining three models (EXPEDITE, SCENES, TREMOVE) are frequently used by DG TREN and DG ENV for the analysis of transport policy measures and access to them is provided by the ESTO partners. It should be noted that the number of policy oriented European transport models is limited[1]; national models are numerous, but the European dimension is not their strongest element.

Annex A contains a summary of the structures of these seven models. Annexes C to I give an in-depth description and address (among other things) the main strengths and weaknesses (each of the models has been developed in order to analyse specific issues) and the future developments of the different models. Annex J presents the main inputs and outputs of the different models.

The different models which are studied in this project can be used for several policy issues. These policy issues are summarised in table 2.1. The policy issues were identified during a workshop with the several model experts in Seville. Annex B contains a more elaborate description of the policy issues and indicates why a specific model is most suitable for a certain policy issue.

2.1 TREMOVE

TREMOVE is an integrated simulation model developed for the strategic analysis of costs and effects of a wide range of policy instruments applicable to local, regional and European transport markets. The model has been developed to support the policy assessment process within the framework of the second European Auto-Oil Programme (AOPII)[2].

TREMOVE has been used to simulate consumer behaviour with regard to the choice of transport modes and vehicle types, to assess how these choices were affected by the introduction of various policy measures, and to assess what effects these choices had on emissions from the vehicle fleet. The authors stress that TREMOVE is a simulation model, not a transport-forecasting model: i.e. the equations in TREMOVE are specifically designed to analyse changes in behaviour as a result of changes in economic conditions, but incorporate few of the "dynamic" change relationships that would be required in a forecasting model (it relies on exogenous trends and demands for transportation). TREMOVE also incorporates equations to analyse changes in the environmental performance of the vehicle fleet as a result of changes in the technical features of the future fleet. Interactions are accounted for to the extent that the technical conditions influence the economic conditions and vice-versa.

The model describes annual transport flows, vehicle stocks and vehicle usage, and emissions across three modelling domains for each country considered, i.e., a sample-city, the other urban areas and the non-urban areas. Nine countries and ten so-called AOPII-cities are covered. The

1 The SPOTLIGHTS project has identified only 22 transport models with an EU-15 geographical coverage.

2 The aims of the European Auto-Oil II Programme (AOP II) were to make am assessment of the future trends in emissions and air quality and establish a consistent framework within which different policy options to reduce emissions can be assessed using the principles of cost-effectiveness, sound science and transparency; and to provide a foundation (in terms of data and modelling tools) for the transition towards longer term air quality studies covering all emission sources. More information is available at: http://europa.eu.int/comm/environment/autooil/index.htm.

Table 2.1: Policy issues and models.

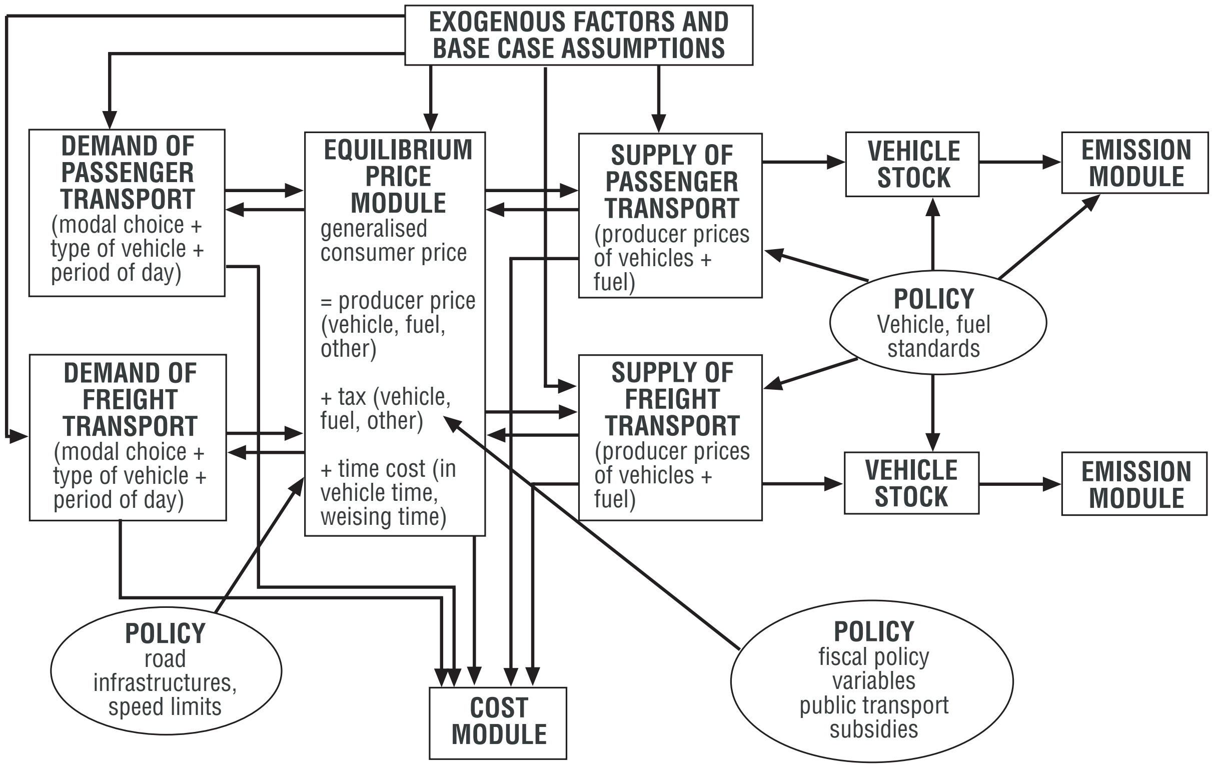
Model	Most suitable policy issue	Other possible policy issues
TREMOVE	Environmental policies related to vehicle type	Modal split
	New transport technologies	Environmental assessment
		Transport forecasting
		Dynamic analysis
		Macro economic effects
		Life cycle analysis
TRENDS		Environmental assessment
		Transport forecasting
EXPEDITE	Distribution/equity	Modal split
		Environmental assessment
		Regional analysis
		Intermodality
SCENES	Modal split	Environmental assessment
	Regional analysis	Macro economic effects
	Transport forecasting	
	Traffic forecasting / network	
	Intermodality	
	Interoperability	
	Logistics	
	Decoupling	
	Quality indicators (congestion, safety, …)	
	Cost/Tariffs/Quality	
ASTRA	Environmental assessment	Modal split
	Dynamic analysis	Environmental policies related to vehicle type
	Macro economic effects	Regional analysis
	Life cycle analysis	Transport forecasting
	Strategic sustainability analysis	Transport forecasting / network
		New transport technologies
		Decoupling
POLES	Environmental policies related to vehicles	Environmental assessment
	Energy policy	Dynamic analysis
		Macro economic effects
		New transport technologies
		Cost/Tariffs/Quality
GEM-E3	Decoupling	Environmental assessment
		Dynamic analysis
		Macro economic effects

time horizon ranges from 1990 through 2020 with annual intervals: the base case data include historical data over the period 1990-1996 and forecast data for the period 1997-2020.

The transport flows covered by TREMOVE include those for on-road passenger and freight transport, rail (both metro and train) passenger and freight transport, and in-land waterway freight transport. Vehicle stocks and usage are specified for a wide range of passenger and freight vehicles, including motorcycles. The main pollutants covered are CO, NOX, VOC (broken down into methane and non-methane VOCs), benzene, and PM10. In addition, other emissions can be calculated such as CO_2 and SO_2.

TREMOVE computes the effects of transport policy measures on the key drivers of transport emissions, i.e. the size and composition of the vehicle stock and vehicle usage. The transport policy measures that can be analysed include emission abatement technologies for vehicles, fuel quality and alternative fuels specifications,

Figure 2.1: Overview of the TREMOVE structure.



inspection and maintenance, non-technical and fiscal measures. The cost modelled in TREMOVE is the total cost to society, including the cost to transport users, the costs to transport producers, and the cost to governments.

When a policy measure is introduced, such as a fuel tax or a tightening of a speed limit, transport users will adjust their behaviour, some reducing their demand for transport and some switching to a different mode. Based on the total demand for 'kilometres' on each mode, the model calculates what the implications will be for the next vehicle stock vintage and the average usage of the vehicles. Because of the need to account for these interactions, the three modules in TREMOVE cannot be run separately, as inputs and outputs from both parts are required at all times. The detailed model structure shown in figure 2.1 holds for every year and region considered: every year from 1990 until 2020 is linked to the previous year via the stock of transport means and the available infrastructure (but not via the total transport demand which is exogenous every year).

Within each country domain or regional module, passenger and freight transport is analysed simultaneously. Both use the same road network, and influence each other through congestion. For example, increased road congestion due to heavier truck traffic will influence passenger transport flows, causing some road transport users to shift to another mode, such as trams & metros.

Policies simulated by TREMOVE belong to the three main categories:

- Vehicle technologies and fuels: motorcycles technology, early introduction of advanced technologies, fuel quality, alternative fuels (CNG, LPG, FAME and E85G).
- Non-technical measures: urban road capacity, urban public transport misutilisation, urban public transport fares, city logistic, park pricing and road pricing, scrappage schemes.
- Fiscal measures: fuel excise rates, tax structure, diesel and petrol taxation ratio, promotion of clean vehicles.

The results of policy measures are presented in terms of percentage changes of relevant variables in comparison to the base case scenario. The base case describes the reference scenario and includes historical data over the period 1990-1996 and forecast data for the period 1997-2020. These base case data are updated at the moment as part of the new TREMOVE model.

2.2 TRENDS

The TRENDS (TRansport and ENvironment Database System) model is a system for calculating a range of environmental pressures due to transport within a PC-based MS Access environment. These environmental pressures include air emissions and energy consumption from the four main transport modes, i.e. road, rail, ships and air. In addition, waste generation and noise emissions from road transport were also addressed. Finally, the system provides an option for simple scenario analysis including vehicle dynamics (such as turnover and evolution) for all EU 15 member states.

The final aim of the model is to produce a range of transparent, consistent and comparable environmental pressure indicators caused by transport. These indicators are calculated directly from the activity levels and reflect the potential change in the state of the environment, or the risk of specific environmental impacts which any changes in policy might have.

The TRENDS project is funded by the European Commission, Directorate General for Transport and Energy and was completed in three phases, starting at 1997 and ending at 2002.

The project was developed in the framework of a collaboration between members of the following institutes and organizations:

- Laboratory of Applied Thermodynamics, Aristotle University, Greece (LAT)
- Department of Energy Engineering, Denmark Technical University (DTU)
- Ψ *A* – Consulting, Austria (PSIAMTK)
- INFRAS, Bern, Switzerland (INFRAS)

2.3 EXPEDITE META-MODEL

Meta-analysis (see for example Button el al., 1999; Nijkamp and Pepping, 1998) can be described as the statistical analysis of analyses. It is a research method for systematically describing and analysing existing findings on some quantitative relationship. These definitions also apply to the EXPEDITE meta-model, but this meta-model differs in two ways from the usual approach in meta-analysis. This is described below.

First, most meta-models are based on results from the literature, whereas the EXPEDITE meta-model integrates results from runs with ‘underlying’ models that have been carried out within the EXPEDITE project itself.

Second, most meta-analyses estimate a regression equation with parameter values or elasticities as dependent variable and attributes of the underlying studies (e.g. type of data used, sample size, year of observation, country, functional specification, estimation technique) and background variables (e.g. income) as explanatory variables. This meta-regression can later on be used to produce values or elasticities for other study areas, for which there is no information on the quantitative relationship (‘value-transfer’). In the EXPEDITE meta-model levels matrices are derived from the runs with the underlying models for the number of tours and kilometres in many segments, and switching matrices for various changes in policy variables (e.g. running cost of the car +10%, +25%). This gives a highly flexible relationship between travel demand and policy variables: simple interpolation would lead to piecewise linear functions and the specific method used (see below) leads to a piecewise non-linear (logistic) functions. In the EXPEDITE meta-model a large number of background variables (segmentation variables) is used, much larger than would be possible in a (dummy) regression model. The models used in EXPEDITE are very similar, which reduces the need for including attributes of the national study methodologies. The value-transfer method is also used in EXPEDITE, but with correction to zonal data.

The EXPEDITE meta-model has been developed because there is a need to explore a large number of policy options and the impacts on many segments of the transport markets in the European context. The requirements for the EXPEDITE meta-model therefore are that it will run fast and extend the available national models to cover the whole (future) EU. In this extension, it is not of vital importance that models for all countries in the EU are included, but that the most relevant segments of the travelling population in the EU are included in the models used and expanded properly, and that the outcomes are calibrated to observed base-year distributions for transport in the respective zones. This method builds on a similar methodology developed for giving the demand impacts of car cost and car time changes in Europe (TRACE consortium, 1999, de Jong and Gunn, 2001)

Since the mid-1980's, a number of model systems have been developed in Europe, predicting future passenger transport at the national scale, using disaggregate, behavioural (based on the concept of random utility) model structures. Within the EXPEDITE consortium, five of these models are available. These are all the existing national models based on this methodology, as far as we are aware. National models based on different methodologies exist in for instance France, Germany, Hungary and Switzerland. Disaggregate, behavioural models have been developed for large regions within a country (e.g. Paris, Portland, Sydney) and have also been used for international corridors (e.g. Great Belt, Fehmarn Belt). The five models are (in the order in which they were originally developed):

- the Dutch National Model System (NMS or LMS);
- the Norwegian National Model (NTM-4);
- the Italian National Model (SISD);
- the Danish National Model; and
- the Swedish National Model (SAMPERS).

Within the EXPEDITE Consortium, there are four national models for freight transport:

- the Swedish model (SAMGODS);
- the Norwegian model (NEMO);
- the Belgian model (WFTM); and
- the Italian model (SISD).

The first three models are all built up around a so-called network model (this is a model that searches for the modes and routes that minimize transport cost on the network) while the latter is based on discrete choice theory (explaining choices between alternatives such as modes on the basis of utility maximization), as the national models for passenger transport. The Italian model contains components for both passenger and freight transport.

A large number of runs have been carried out (up to 80 runs per model) with each of the above national models and with the SCENES model for passenger and freight transport. These outcomes have been synthesised into tour rates and passenger kilometre rates that are non specific for regions in Europe but specific for detailed population segments. These synthesised outcomes have been stored in the EXPEDITE meta-models for passenger and freight transport and are used in those models as a basis for forecasting and policy simulation. These two EXPEDITE meta-models cover transport generated in the following countries (at the NUTS2 level, 250 zones in total):

- the EU15;
- Norway;
- Switzerland;
- Estonia;
- Latvia;
- Lithuania;
- Poland;
- Hungary;
- Czech Republic;
- Slovakia;
- Slovenia.

EXPEDITE consists of the following modules:

- Passenger transport (for trip distances up to 160 km; to get all distance classes, forecasts from the SCENES model need to be added, as has been done in the EXPEDITE Final Publishable Report) :

- Meta-model: tours
- Meta-model: passenger-kilometres
- Evaluation module

- Freight transport (all distance classes):
  - Meta-model: tonnes
  - Meta-model: tonne kilometres
  - Evaluation module.

2.4 SCENES

The SCENES European freight and passenger model was developed within a 4th Framework Research Project for DG TREN that was completed in 2001, although it was based upon a smaller scale, pilot model originated during the preceding European Commission STREAMS project. The methodology and structure of the model is documented in the Deliverable D4, and the results of the model are presented in the Deliverable D7 of the SCENES project. These can be downloaded from: http://www.iww.uni-karlsruhe.de/SCENES/#deliverables

Since 2001, the SCENES model has continued to be updated by its originators, WSP and TRT, as part of various other FP5 research studies, (IASON, MC-ICAM, TIPMAC for DG TREN and the TREMOVE2 project for DG-ENV), in which the model is currently being used.

The SCENES model is a strategic European multi-modal passenger and freight forecasting model, operating at the NUTS 2 zoning level over all fifteen EU countries. It also extends into eight Central and Eastern European Candidate (CEEC) countries to the east: Hungary, Poland, Czech Republic, Slovakia, Slovenia, Latvia, Lithuania and Estonia. It uses a detailed European network for assignment. The freight model is based on a complex regional economic model (REM), using input-output techniques. The passenger model uses a more standard trip generation mechanism. The base year for both models is 1995 and forecasts have been produced within the SCENES project for the 2020 horizon.

Technically the overall model consists of 3 main modules:

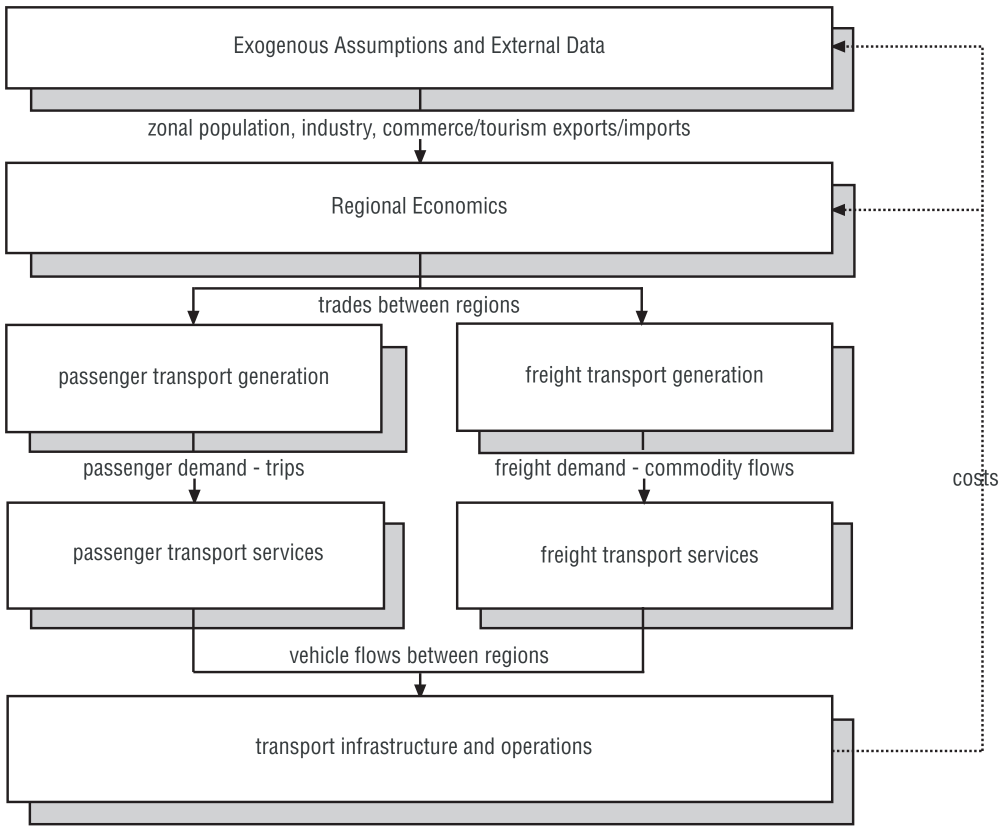
1. *The regional economic module* which implements macro-economic constraints in the base year as well as each future policy period, and estimates the location of production/consumption and the pattern of trade generated therein of commodities, business travel and personal travel.
2. *The multimodal transport module* which builds and validates a multimodal transport network, and given total transport demand and transport infrastructure supply, it estimates the loads of passenger and freight on each mode and route.
3. *The interface module* which connects the two main simulation blocks above. This also does all necessary conversions of units in order to make the information fully compatible before use by the two principle modules.

The following diagram illustrates the processes undertaken within SCENES in order to obtain the output results, showing the individual stages and their respective outputs which are then used as input to the next stage.

The SCENES transport model provides a comprehensive range of transport outputs, including:

- forecast O-D matrices of passenger and freight flows, by mode, commodity type, passenger type, and purpose
- traffic flows on individual links by vehicle type, for all modes and intermodal transfers
- average trip distances, speeds, times and costs by mode
- energy consumption and pollution by mode

The model is calibrated to reproduce (as closely as possible) national aggregate totals of travel by mode, and known international patterns



of passenger and freight transport (based on a variety of EUROSTAT and World Bank data). The sub-national pattern of passenger and freight traffic is entirely generated by the model (i.e., it is 'synthetic'). It is based on typical distributions of travel by distance. The availability of more detailed base year input data would allow for a more localised geographical validation to take place. This would also permit greater use of the model to analyse particular transport policies pertinent to certain sectors, and enable the model to be used at the sub-national, or even corridor level.

The base year model comprises the total amounts of observed passenger travel and freight movements for the EU and for travel and movements to and from the EU. The passenger model also contains travel within and between the eight CEEC Countries. However, freight traffic within the CEEC area is currently not modelled – only freight traffic between the CEEC and the EU. As significant improvements in data quality and availability take place within the Accession countries, it may become possible to fully incorporate them into the 'internal' freight model. These total volumes of travel and movement are also in line with more disaggregate data at the country-pair and national level. This provides a good basis for forecasting future passenger and freight travel at the national and EU level.

2.5 ASTRA

The model for Assessment of Transport Strategies (ASTRA) is developed under the 4th research framework programme (FP) of the European Commission in the ASTRA project and is improved by the Institute for Economic Policy Research (IWW), Germany, and Trasporti e Territorio (TRT), Italy, in the ongoing TIPMAC project in the 5th FP. The objective of the ASTRA project was to develop a tool for the assessment of the long-term impacts of the European transport policy with respect to the economic, environmental and social implications enabling strategic sustainability analysis of European and national transport policies. The technical challenge of ASTRA was to demonstrate that the applied system dynamics methodology is appropriate for such long-term policy assessments that are based on an integrated modelling philosophy developing a truly interdisciplinary and easy to use model.

Since the successful completion of the ASTRA project at the end of the year 2000 the so-called ASTRA family of models has been developed. The first model ASTRA-I covers the Italian nation and enables an assessment of the Italian transport policy. The second model, ASTRA-E, is developed to assess the employment impacts of different technology policies for the European Union. The third model ASTRA-C incorporates an extension of the assessment capabilities with ASTRA towards a dynamic cost-benefit analysis framework.

Now, ASTRA-T, that is the model that is developed in the TIPMAC project, stands for a major increase of complexity of the model. To give an impression on this increase of complexity the number of objects in the original ASTRA model and the ASTRA-T model can be taken for comparison. In the original ASTRA about 120.000 objects were included. In ASTRA-T currently nearly 5.000.000 objects are implemented. This enables an analysis of transport impacts at a much more detailed level. For instance, the spatial differentiation has been extended from four macro regions in the European Union to 14 countries (Belgium plus Luxembourg form one region) plus a nested zoning system of four functional zones for each country that comprises four groups of NUTS II zones. In total these are 53 zones now covered in ASTRA-T, of which 17 are equal to one specific NUTS II zone while 36 zones are composed of more than one NUTS II zone, depending on their population density and settlement patterns. The economic analysis is extended from 12 economic sectors to 25 economic sectors that are coherent with the EUROSTAT Input-Output table system that is based on the NACE-CLIO coding system.

Besides these structural changes also supplementary models have been added. For instance, the government budget is now explicitly considered as part of the macro-economic module. Technical progress that has been modelled exogenously in the original ASTRA is now partially endogenised and depends on influences like investments or changes of transport times. Capacity constraints that have only been considered for different types of road networks in the original ASTRA are now also implemented for all other modes. The implementation of additional countries like Switzerland or Accession Countries with the example of Poland, Hungary and Czech Republic are ongoing. In a further project of the 5th FP, called DESIRE, the ASTRA-T model is linked with the VACLAV network model that is implemented at the NUTS III level for the EU15 member states and the Accession Countries. The open software architecture of ASTRA-T and the applied Vensim software that it uses, enables ASTRA to establish such model linkages and to exchange data with other tools via comma-separated files, tab-delimited files or EXCEL files.

2.6 POLES

The POLES model is a simulation model for the development of long-term (2030) energy supply and demand scenarios for the different regions of the world. The development of the model and of the corresponding scenario studies intends to fulfil five main objectives:

1. *Detailed world energy system scenarios*

The first one is to reduce the uncertainties in future developments of world energy consumption and corresponding GHG emissions by the construction of baseline or reference scenarios. This is done by providing a common consistent framework for demand analysis in the different countries / regions of the world and by the taking into account supply constraints as well as of price dynamics on the international markets.

2. *Strategic areas for emission control policies*

The second one is to provide elements for a global analysis of emission reduction strategies in an international perspective. In fact strictly national or regional energy-environment policies can greatly enhance the performances of the corresponding energy systems from the point of view of their environmental impacts. However it is clear that, from the global environment point of view, these policies have to be replaced in a broader perspective and that cost-effectiveness criteria should be applied while taking into account the opportunities and costs of emission control in different parts of the world. The POLES model provides a framework for the analysis of future GHG emissions in all the regions and at a relatively detailed sectoral level and can thus help in the identification of strategic areas of action.

3. Analysis of RTD strategies

In line with the identification of strategic areas for the development of energy-environment strategies, the model provides, by the detailed treatment of key new energy technologies, insights for the definition of appropriate RTD strategies. The key parameters characterising the costs and performances, as well as the diffusion process of these technologies, are in fact incorporated in the model in order to allow for the simulation of different technological trajectories corresponding to more or less intensive development or diffusion strategies.

4. Assessment of Marginal Abatement Costs for CO_2 emissions and simulation of emission trading systems

Evaluation of the costs of compliance to the Kyoto emission targets to 2010, with and without emission trading. Scenarios for emission targets, entitlements and flexibility mechanisms to 2020 and 2030.

5. Impacts on international markets and price feedback

The last objective of the model is the analysis of the impacts of emission reduction strategies on the international energy markets. The importance given to price mechanisms, either in the national modules or in the international modules, in fact allows for the study of different interconnected issues such as the consequences of emission control strategies on the price of internationally-traded fuels and on the producers revenues or on the corresponding negative price-feedbacks in the consumer countries. It can be noted finally that the detailed treatment of price-effects in each part of the model also allows for the simulation of internalisation strategies through prices and the use of ecotaxes.

2.7 GEM-E3

The GEM-E3 model is developed and maintained by the National Technical University of Athens. It is an applied general equilibrium model in which the world is divided into 18 zones that are linked together with endogenous trade. Each of the zones has the same model structure, but parameters and variables are zone specific.

The economy is divided into 18 sectors. Four of the sectors are involved in the supply and distribution of energy and the remaining sectors are broad aggregates of the rest of the economy. The production in each sector is modelled by using a nested constant-elasticity-of-substitution (CES) production function. The use of inputs and primary factors in each sector follows from a procedure involving several steps; at each step, inputs and primary factors are optimally combined according to a constant-returns-to-scale CES production function and the producer behaviour is modelled on the basis of standard assumptions about profit maximisation in a perfectly competitive environment.

The two primary factors of production are capital and labour. The labour market is assumed to be perfectly competitive and total labour supply is determined by households that maximise their utility functions. For each period, the model endogenously allocates the available labour force over sectors. Capital is a quasi-fixed variable, and is defined in a way that allows firms to change next year’s capital stock by investing in the current year. It is further assumed that the stock of capital is immobile between sectors and countries.

Government activities are modelled almost in the same manner as the other sectors of the economy.

Thus, the use of inputs is determined through cost minimisation. However, the remaining parts of government activities (expenditures, investment demand and tax levels) are exogenous. Financing of government expenditures is provided from nine different sources of government revenues: indirect taxes, environmental taxes, direct taxes, value-added taxes, product and export subsidies, social security contributions, import duties, foreign transfers and profits or losses from state-owned firms.

The households are modelled as one representative household, which can supply labour, save, invest and consume thirteen consumer goods. The representative household allocates its resources in an inter-temporal environment. The household's consumption behaviour is derived from utility maximisation, and consists of two steps. Firstly the household allocates its resources between future and present consumption, given the wage rate, the interest rate and the long-term time preference. Secondly the household takes total consumption in a period as given and makes an intra-temporal decision about how to divide the total consumption between the different consumer goods in the economy.

The demand for products by the household, the producers and the public sector constitutes the total demand. It is allocated between domestic products and imports, following the Armington specification. In this specification, cost minimising sectors and households use a composite commodity that combines domestically produced and imported goods, which are considered as imperfect substitutes. The GEM-E3 model also distinguishes between goods imported from EU countries and from those from the rest of the world. An index for optimal allocation of imported goods according to country of origin and price is calculated, and this index price is then used to allocate consumption between the imported and the domestically produced goods, as discussed above. It is further assumed that countries apply a uniform rule for setting export prices, independently of the country of destination. The Armington assumption implies that the various countries within the European Union can supply exports at different prices.

The main types of issues that the model has been designed to study are:

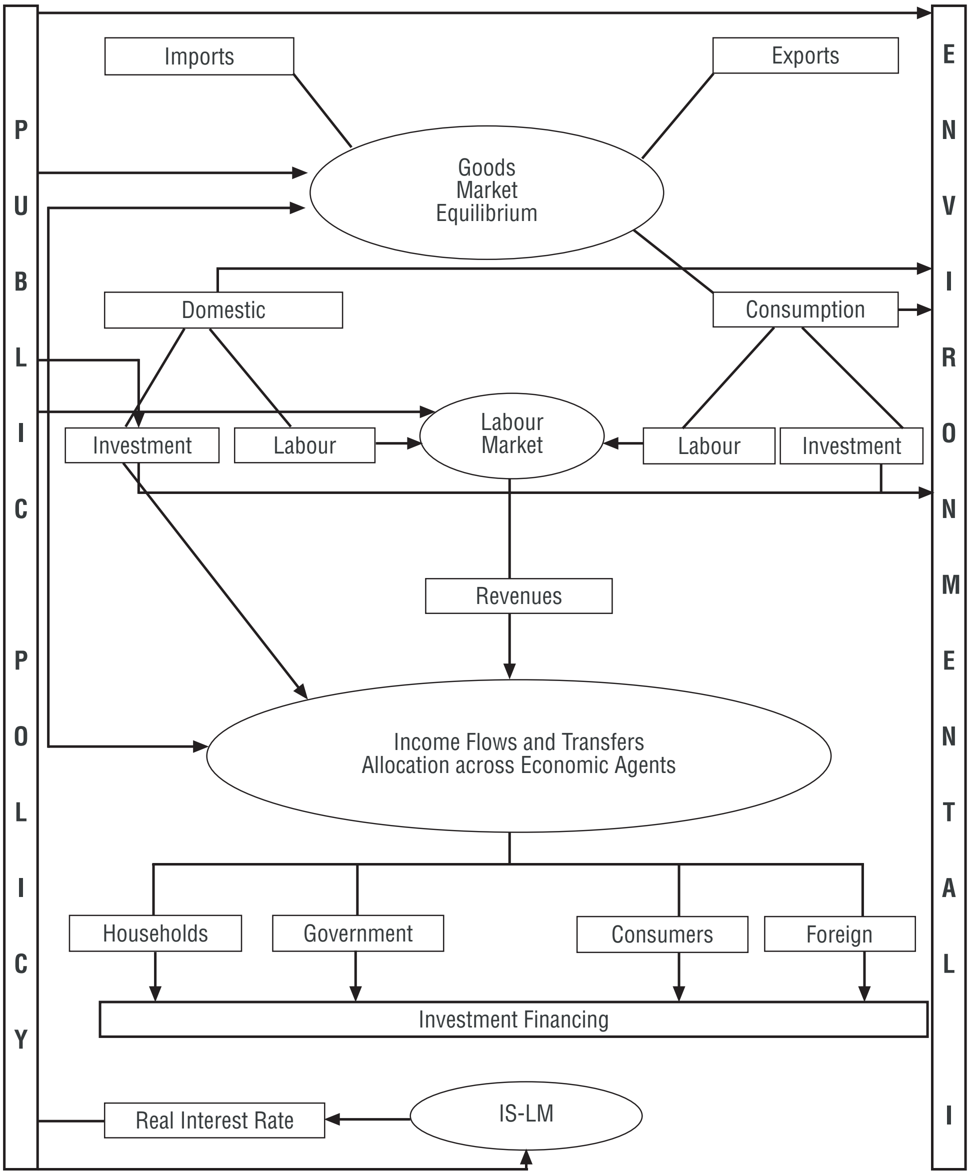
- The analysis of market instruments for energy-related environmental policy, such as taxes, subsidies, regulations, pollution permits etc., at a degree of detail that is sufficient for national, sectoral and Europe-wide policy evaluation.
- The evaluation of European Commission programmes that aim at enabling new and sustainable economic growth, for example the technological and infrastructure programmes.
- The assessment of distributional consequences of programmes and policies, including social equity, employment and cohesion targets for less developed regions.
- The consideration of market interactions across Europe, given the perspective of a unified European internal market, while taking into account the specific conditions and policies prevailing at a national level.
- Public finance, stabilisation policies and their implications on trade, growth and the behaviour of economic agents.
- The standard need of the European Commission to periodically produce detailed economic, energy and environment policy scenarios.

Policies that attempt to address the above issues are analysed as counterfactual dynamic scenarios and are compared against baseline model runs. Policies are then evaluated through their consequences on sectoral growth, finance, income distribution implications and global welfare, both at the single zone level and for the EU taken as a whole.

The model is designed to support the analysis of *distributional effects* that are considered in two senses: distribution among European countries and distribution among social and economic groups within each country. The former issues involve changes in the allocation of capital, sectoral activity and trade and have implications on public finance and the current account of member states. The latter issues are important, given the weakness of social cohesion in European member-states, and regard the analysis of effects of policies on consumer groups and employment. The assessment of allocation efficiency of policy is often termed "burden sharing analysis", which refers to the allocation of efforts (for example taxes), over member-states and economic agents. The analysis is important to adequately define and allocate compensating measures aiming at maximising economic cohesion. Regarding both types of distributional effects, the model can also analyse and compare coordinated versus non coordinated policies in the European Union.

Technical progress and infrastructure can convey factor productivity improvement to overcome the limits towards sustainable development and social welfare. For example, European RTD strategy and the development of pan-European infrastructure are conceived to enable new long-term possibilities of economic growth. The model is designed to *support analysis of structural features of economic growth related to technology and evaluate the derived economic implications for competitiveness, employment and the environment*.

Figure 2.2: Structure of the GEM-E3 model.



2.8 Main strengths and weaknesses of the models

The most important strengths and weaknesses of the seven European transport models are summarised in table 2.1. A more in-depth overview of the strengths and weaknesses is presented in the in-depth model descriptions as included in the Annexes.

	Strengths	Weaknesses
TREMOVE	Modular structure by country	The use of a simplified technology for nine EU countries out of 15
TRENDS	Calculating a range of environmental pressures due to transport in a harmonised way	Limited value for policy forecasts
EXPEDITE	Many policies can be translated into inputs of the meta-model and be simulated in a few seconds	EXPEDITE only provides the amount of travel generated in some zone (by mode, distance band, etc.), not an explicit origin-destination matrix
SCENES	Transport supply is reflected within detailed European networks for several modes, together with a set of analytical functions to determine the costs and times of travel	The representation of the CEEC countries is less complete than that of the EU15 countries
ASTRA	Strategic approach allowing for an integrated fully dynamic evaluation of various European and national policies in the transport field starting from large scale infrastructure policies over regulation and pricing policies leading finally to technology policies	Limited geographic detail, lack of transport network
POLES	Fuel markets and technology introduction modelling	Lacks sufficient detail for an in-depth analysis of transport issues
GEM-E3	Interactions between economic sectors and simulation of changing structure of the economy	Inherits the main weakness of general equilibrium modelling family, i.e. it assumes that the economy reaches equilibrium

2.9 Availability of the models

Most of the models as studied in this project are available for JRC-IPTS. The following table is summarising the availability.

	Availability	Remarks
TREMOVE	TREMOVE is available at www.tremove.org	GAMS software is needed to run the model
TRENDS	TRENDS is available at ftp.infras.net/download/TRENDS_TAB_V04h.zip	Office 97 needed to open the Access database
EXPEDITE	The EXPEDITE meta-model is available for third parties, if DG TREN agrees	
SCENES	DG TREN owns the input data and the calibrated data. Besides they own the results output from the policy test runs of the model.	MEPLAN modelling software package is needed to run the model
ASTRA	JRC-IPTS has already available the ASTRA model that was developed for the employment study (ASTRA-E). Moreover, they will have access to the model that will include the Accession Countries.	
POLES	POLES is available to the European Commission services and it's results are available to research projects for the EC.	
GEM-E3	GEM-E3 is not publicly available.	

2.10 Use of the models

The seven models are frequently used by the Commission Services in different project. The table below presents an up-to-date use of the models.

Model	Use
TREMOVE	TREMOVE is used in the AUTO-OIL II programme and to support DG TREN (SUMMA project) and DG ENV (policy study) regarding CO_2-emissions from light commercial vehicles. Moreover TREMOVE is used in the FP5 projects PREMTECH II, D-ULEV, SUVA and GET-CO2.
TRENDS	TRENDS is used by EUROSTAT and DG Transport.
EXPEDITE	EXPEDITE is used for the SUMMA project to support DG TREN.
SCENES	SCENES is used in the FP5 projects MC-ICAM, IASON, TIPMAC and SPECTRUM. Moreover, SCENES is used for DG ENV to support the development of the new TREMOVE model and DG TREN to carry out a pilot SEA of the TENs and to provide support for other policy analysis.
ASTRA	In the FP5 projects DESIRE, REVENUE, TIPMAC and IASON. Moreover, ASTRA is used to support DG ENV, DG TREN and IPTS.
POLES	POLES is used for studies to support DG Research and Energy and Transport.
GEM-E3	GEM-E3 is used for studies to support DG Research and Taxation.

3 Blueprints for linking models

This chapter presents blueprints for a useful combination of models. These blueprints give possible linkages between models in order to answer specific policy issues. The linkages between models are proposed in order to extend the range of outcomes of the models. Models are a representation of reality and models are constructed for specific goals (see also section 2.8). However, when dealing with (global) issues that have a widespread effect in different markets it is useful to link models. This chapter will be concluded with an overview of the difficulties that arise when linking models.

3.1 Development of blueprints for linking models

The models described in this ESTO project are all fairly sophisticated, large and usually non-linear systems. The development of each model has taken several years. A formal merger of two or more models into a common model would also be a major multi-year project (if possible at all), and is clearly outside the scope of this ESTO project[3]. Also in recent years, many researchers have given up on the idea of including many aspects in great detail in one and the same model system. Very large and complex models would result that completely lack transparency. The trend is towards models that specialise in treating certain aspects in detail, or models that cover a broad range of aspects at a high level of abstraction. The results of the 5th Framework project THINK-UP are stressing this trend. From the conclusions of discussions between national model experts, particularly in relation with the European oriented models, that have been organised in this project one can state that the diversity of models in Europe *is not a problem as long there is a good segmentation in the models in terms of the policy effects they encompass.*

The different models described in this project have their own strong and weak sides. Some examples are:

- SCENES has explicit transport networks, but no components for the composition of the vehicle stock or interaction with land use.
- TREMOVE has a vehicle stock component within a rather simplified transport demand framework.
- ASTRA has a vehicle stock module and interactions between land use and transport, but no explicit transport networks.
- EXPEDITE has a detailed segmentation of the population, but no explicit transport networks, transport-land use interactions of module for the vehicle stock composition.

By linking two or more models, we try to benefit from the strong sides of the models, and get around the weaker sides. 'Linking' here means that the outputs of one model are used as inputs of another: the models are applied in a particular sequence. In some cases this sequence may be seen as representing the behavioural reactions to a policy measure over time (e.g. transport reacts first to a transport policy measure, land use reacts later), in other cases the sequence is just a heuristic device to get the overall long term outcome (following an iterative procedure).

In linking models in this way, we should be aware of the differences in the nature of the models. Especially important in application here is the difference between dynamic models and long-term equilibrium models. The dynamic models (ASTRA, TREMOVE, POLES) are applied in annual or quarterly steps, in which the outcomes of a period t are affected by those of period t-1 (and possibly further lags). These models have also been calibrated to represent behaviour over time. The other models

3 Also see the discussion on this in chapter 4 of IASON deliverable 4: Development of a methodology for the assessment of network effects in transport networks, IASON Consortium, 2003.

can be regarded as long-term equilibrium models, although not all of them have included formal market mechanisms. What distinguishes these models from the dynamic models is that they have been estimated on cross-sectional data. If an input variable, representing a policy measure, in these models changes, the model gives the new equilibrium situation. How long it will take before this equilibrium will be reached, is usually not given by these models. In general one might say that this depends on the type of behavioural reaction (several of which are included in each transport model system). Changes of route or departure time, after the implementation of a policy, may be regarded as a short-term reaction (most of the effect taking place within a year). Mode choice reactions may take somewhat more time to reach a new equilibrium. Changes in distribution (destination choice), especially for commuting, will probably take several years, as will changes in the number and the type of car(s). Changes in land use (reaching not just equilibrium on the transport markets, but also on the land market and between markets) and the regional economy will take even longer. Because of this long-term equilibrium nature of the models, it does not make sense to apply models such as SCENES on an annual basis, unless one would only use the (multi-modal) assignment part. These models can only be used for large time steps (e.g. 5-10 years apart). Another, more practical, reason for not applying models such as SCENES using one-year simulation steps is the run time of the model: the time required would exceed one month.

Some experience with 'linking' models (in the sense of using one model's outputs as another model's inputs) has already been obtained in recent research projects:

- ASTRA and VACLAV have been used in combination (to get traffic estimates consistent with ASTRA, but for a more detailed zoning system, and with assignment to explicit transport networks).
- For freight, EXPEDITE uses outputs (O-D matrices) from SCENES and NEAC.
- ASTRA has been linked to GEM-E3 in order to simulate the impacts of productivity growth on economic development.
- There is an on-going project in which SCENES will be linked to TREMOVE to provide transport demand projections to the latter.
- In the SUMMA project, EXPEDITE and TREMOVE will be combined.
- In IASON, the SASI model for regional development has been linked to the spatial computable general equilibrium model CGEurope.
- In the TIPMAC project the E3ME model is linked to the SCENES model.

All these examples concern linking only two models, or three at most. This goes to show the complexity of even linking models by linking outputs and inputs.

There are also experiences with developing blueprints. In the TEN-STAC project a blueprint to assess transport policy measures in relation with the TEN's has been developed. The base of the modeling of TEN-STAC consists of a Common Modelling Platform (blueprint) built-up to join together strategic European modelling tools. The models NEAC, VACLAV, EUFRANET and SCENES are integrated into this Common Modelling Platform.

Combinations of models which are feasible are linking long-run equilibrium models in terms of their forecasts for 2020 (e.g. for different geographical areas, or the emission factors from one model and the transport demand from another model). A long-run equilibrium model and a dynamic model can be combined for instance by running the former for 2010 (for the transport reactions) and then run the dynamic model with these transport inputs for the period 2010-2020. Another example would be to use the dynamic model for 10 or 20 consecutive years and insert the outputs for the final year in the assignment part of a cross-sectional traffic model. Linking two dynamic models (e.g. TREMOVE and ASTRA) by inserting each model's output into the other model for each period, would run the risk of entering into an uncontrollable loop.

In linking models by using one model's outputs as another model's inputs, inconsistencies can arise. First a number of conversions (dimension, currency, price level, spatial aggregation) may be required before the output of model A can be read in by model B. But more fundamentally, model B may be capable of producing this input itself, and model A may be capable of producing the output of model B itself. In other words, in a combination of models, some outcomes of the models are overwritten and some other model outputs are ignored. This is simply an unavoidable consequence of overlaps between models. To some degree this problem could be solved by the re-calibration of one model, to reproduce the results of another model, as closely as possible, but this is outside the scope of this project. The main issue for this project is a proper selection of models: to use the outcomes from the model that is best suited to produce those specific outputs. Results from other models on the same aspect are not used, because these models are judged to be less suited for this aspect. Similarly, the chosen model for this aspect will not be the chosen model for other aspects. On these aspects its outcomes will be overwritten or will not be used.

3.2 Selection of policy issues

This chapter describes blueprints of five policy issues which are of major importance for the European policy maker. These policy issues were identified by means of discussions between the participants of this study and White Paper analysis. We have identified 17 policy issues (an explanation of the policy issues is given in Annex B):

1. Modal split;
2. Distribution/equity;
3. Environmental assessment;
4. Environmental policies related to vehicle type;
5. Regional analysis;
6. Transport forecasting;
7. Traffic forecasting/network;
8. Dynamic analysis;
9. Macro economic effects;
10. New transport technology;
11. Life cycle analysis;
12. Intermodality;
13. Interoperability;
14. Logistics;
15. Decoupling;
16. Quality indicators; and
17. Cost/tariffs/quality.

The next step has been a clustering and selection of the policy issues which are of major importance at a European Union level. This selection has resulted in five policy issues:

1. Fuel and carbon taxes and pricing principles;
2. Networks / Trans-European Networks;
3. Energy;
4. Environmental assessment; and
5. Intermodality.

After a "brainstorm" between the partners, we have decided to merge *energy* and *environmental assessment* into one blueprint: Energy policies and emission standards, Moreover, we have decided to add another policy issue to the list: Economic policies. The result of this has been the following five policy issues:

1. Fuel and carbon taxes and pricing principles;
2. Energy policies and emission standards;
3. Intermodality;
4. Networks / Trans-European Networks; and
5. Economic policies / Environmental assessment.

The liberalisation of the railways is an important topic at the EU level. However we have decided not to include this policy issue in this project. The reason for this is that such specific issues, which are dealing with institutional reforms, are very difficult to include in transport models. Models are only valid within their institutional context and are in many cases not suitable for issues which are dealing with alterations.

3.3 Blueprints

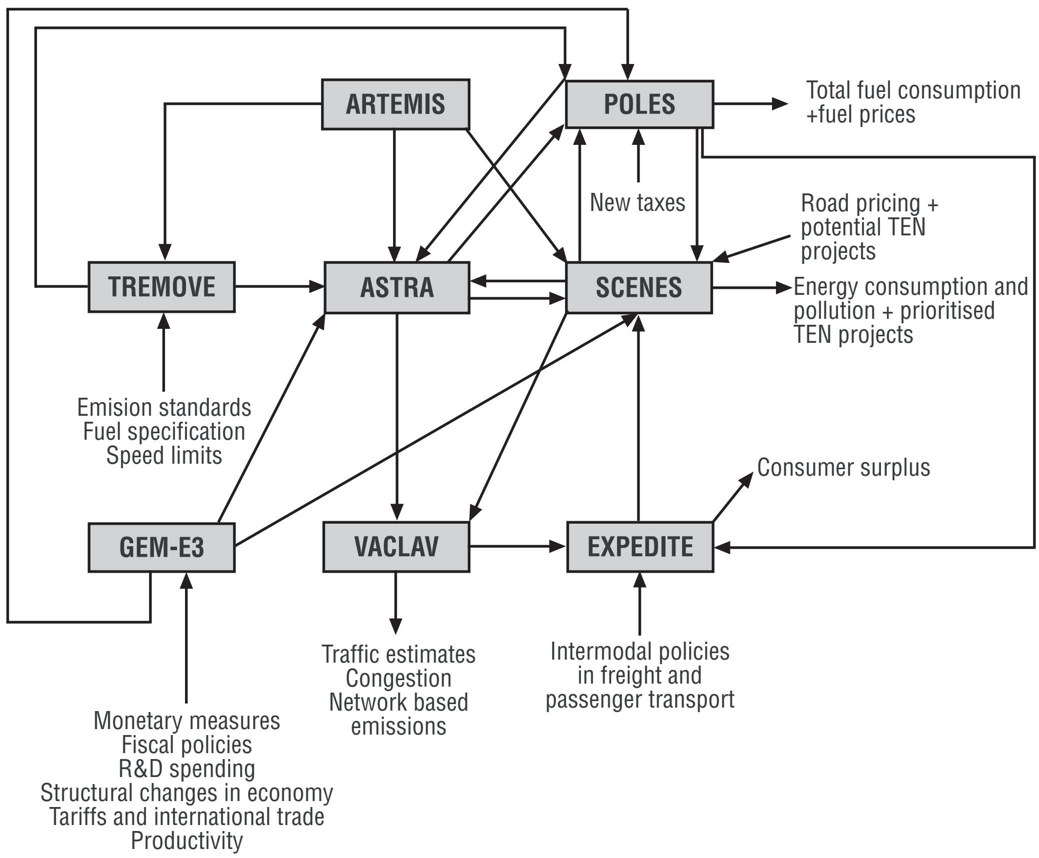
In this chapter blueprints for linking models are presented. The blueprints as identified in the following sections could be summarised into the following figure.

As it can be observed in the overall blueprint that summarises all useful combinations between models and is able to answer all identified policy issues, we have included two new models which are not described in the previous chapter; ARTEMIS and VACLAV. Moreover, the model TRENDS is not included in this overall blueprint. The reason why TRENDS is not included in this blueprint is that TRENDS does not use exogenous inputs. Moreover, the TRENDS model is a trend extrapolation model and not a simulation or forecasting model. VACLAV and ARTEMIS are included because of their strong relationship with the seven models studied in this project. ARTEMIS will be in the (near) future **the** model that will provide the other models with emission factors data and both the VACLAV and the ASTRA model are developed by IWW and used together in practice.

It should be stressed that it is not necessary to follow all steps as identified in the five different blueprints. The moment to finish the blueprint is dependent on the level of aggregation. For detailed analysis the whole blueprint should be followed. At last it should be emphasized that each blueprint starts with the model that is most able to answer the specific policy issue.

3.3.1 Fuel and carbon taxes and pricing principles

One of the drivers of this blueprint is to provide new insights to be used when revising transport pricing and taxation policies. These are essential elements of the EU's Common Transport Policy (CTP as reflected in the White Paper: European Transport Policy for 2010: Time to Decide, of 2001). The CTP points out that the price structure



to be applied in transport should be following the principle that the prices reflect the costs. In the ideal situation this would mean that the cost of using the infrastructure would reflect the following cost components:

- the maintenance and operating cost
- the external cost resulting from: noise, pollution, accidents and congestion

In order to attain this situation the Commission plans to propose a framework directive on the principles of charging for the use of infrastructure and on a pricing structure, along with a common methodology for charging to incorporate external costs, and conditions to ensure fair competition between modes. Furthermore, a directive on the interoperability of tolls on the Trans-European road network will be proposed.

Also taxation measures are proposed in the White Paper. At present there are minimum rates of taxation for each fuel according to its use. However, the thresholds are exceeded, resulting in a situation that taxes vary greatly between Member States. Also it is the case that excise duties on diesel are on average lower than those imposed on unleaded petrol, even though diesel is more polluting. The Commission proposes in the CTP immediate tax exemption for hydrogen and bio fuels. In the short term the White Paper proposes to install harmonized taxation of fuel used for commercial purposes. In the long term there would be a similar taxation for all consumers.

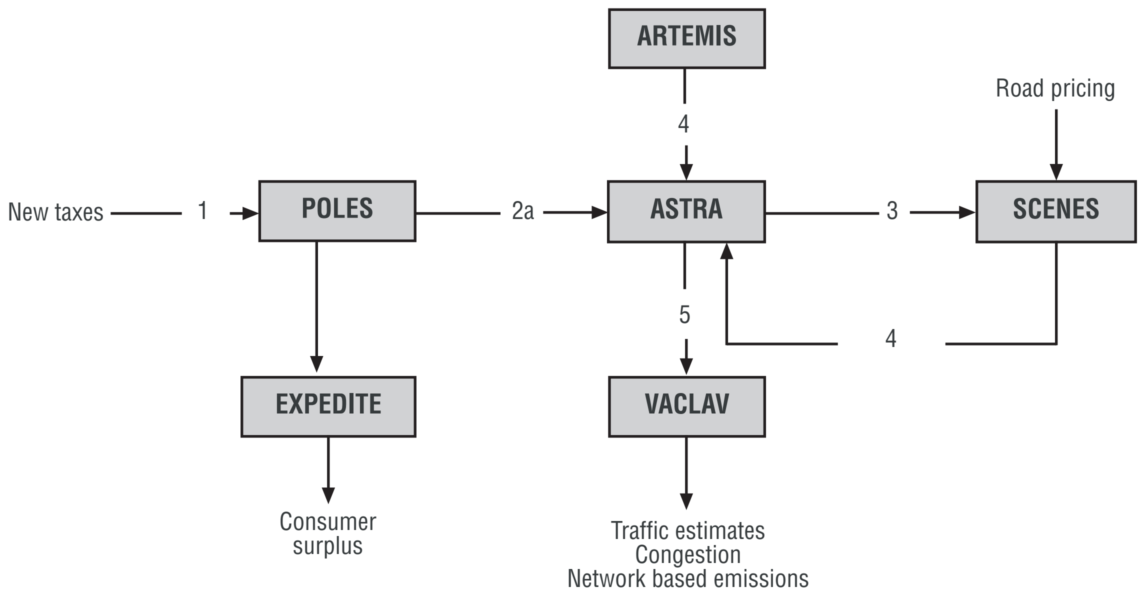
The shortcomings in the models are that in ASTRA there is not an explicit network, but the choice between tolled and (currently) non-tolled roads, new tolls can be coded to simulate a policy. Policies like charging for parking space or road pricing in urban centres are more difficult to represent in a detailed way. ASTRA works at a strategic level rather than at a local level and therefore costs of parking or accessing city centres can be simulated only indirectly, by means of extra-costs. In ASTRA, such extra-costs can be confined to some functional zones only (e.g. metropolitan areas).

In SCENES the elasticity of demand with respect to cost is not different according to the source of costs. In other words, an increment of transport cost stemming from fuel taxes gives the same effect if it has the same size.

However, in ASTRA the effects of tolling would be different to those of tax policies. For instance, fuel taxes affect the purchase on new cars (in terms of choice between diesel/gasoline and among cubic capacity) and as far as average cost of using car reflects the composition of fleet, it will grow less than the fuel taxes. Also, fuel taxes revenues can be used to reduce other taxes, with effects for disposable income which do not take place when a tolling policy is applied. Toll revenues can also be used to finance transport infrastructure. In this way less tax revenues is necessary to finance the transport infrastructure.

In terms of transport policy scenarios, the main purpose of the models included in the blueprint is to simulate the effects of policies on the use of different modes of transport or fuels for transport. For example, the introduction of a new fuel tax would affect fuel prices and demand and resulting emissions. In turn the activities of fuel users are affected. This then feeds back into the general economy through changes in industrial costs and output (i.e. ASTRA). Other tax rates can be adjusted to compensate for the additional revenue. As the cost of transport is a determining factor of the region's comparative advantage, the economic effects of cost changes can be evaluated in terms of different levels of demand from each region. In turn, this affects production, employment, aggregate demand and the whole economic system.

To answer policy issues related to taxes, POLES will be the most appropriate model to start with. The influence of road pricing should preferably be calculated with SCENES. The following blueprint presents an overview of the steps to be conducted when assessing the influence of fuel tax changes and the implementation of road pricing. It should be stressed that it is not necessary to follow all the identified steps.



The combined model system is summarised in the table below.

The impact of new taxes regimes on the economy and transport demand could be studied

Step	Model	Input	Calculation / estimation	Output
1	POLES	New taxes (for each zone and/or market segment) Road pricing schemes	- New final fuel prices - New supply/demand (all sectors) - New prices	- Final fuel price (for each country and fuel, annual average) - New registrations per technology (annual basis)
2a	ASTRA	- **POLES**: Fuel prices (for each country, annual average) - **POLES**: Registrations (annual basis, %-change)	New generalised costs	New O-D matrix (NUTS II, quarterly)
2b	EXPEDITE	- **POLES**: Fuel prices (for each country, annual basis, %-change) - **POLES**: Registrations (annual basis)	- Change in transport volume for passenger and freight transport - Change in modal split for passenger and freight transport	- Number of pkm and tkm generated in each NUTS II zone by population segment - Consumer surplus by population segment (e.g. income groups)
3	SCENES	**ASTRA**: O-D matrix (NUTS II, quarterly)	Modal split/ allocation to network	Traffic estimates (only 2010, 2020)
4	ASTRA	- **ARTEMIS**: Emission factors - **SCENES**: traffic estimates (only 2010, 2020)	- New generalised costs - Fuel consumption, emissions	Potential outputs: - GDP - Employment - Income - Car-ownership - Transport Demand - Modal-split - Accessibility - Emissions
5	VACLAV	**ASTRA**: Transport demand	Modal split / allocation to network	- Traffic estimates - Congestion - Network based emissions

by means of linking POLES and ASTRA. The influence of new taxes regimes on the fuel prices and new registrations per technology would be established in POLES. In the ASTRA model the new generalised costs would be calculated and the result would be an estimation of the impact of new tax regimes on the economy (e.g. GDP, employment, income, etc.) and transport demand. If necessary the results of ASTRA could also be allocated to a network. In that case it would be necessary to feed new O-D matrices of the ASTRA model into SCENES. Because ASTRA is a dynamic model and SCENES is a network / equilibrium model problems would arise in the time scale. Therefore it is suggested that the following steps would be followed:

- Run ASTRA for the year 1995/2010/2020 using the 1995/2010/2020 results of POLES; new O-D matrix for the year 1995/2010/2020 passed to SCENES.
- Run SCENES for the year 1995/2010/2020 using the new O-D matrix for the years 1995/2010/2020 of ASTRA to adjust to the SCENES matrices; 1995/2010/2020 traffic estimates allocated to a network would be the result.

If it is desirable to allocate the impact of new tax regimes to population segments EXPEDITE would be the most appropriate model. The same as has been true for the coupling between ASTRA and SCENES would be the case if POLES and EXPEDITE should be linked with each other. POLES is a dynamic model, whereas EXPEDITE is an equilibrium model. To run this system the following steps must be followed.

- Run POLES for the year 1995 using a new taxes scenario; %-change of fuel prices and registrations for each country passed to EXPEDITE.
- Run EXPEDITE for the year 1995 using the POLES data; number of pkm within each NUTS II zone passed to POLES.
- Run POLES from 1995-2010 using number of pkm within each NUTS II zone of EXPEDITE; %-change of fuel prices and registrations between 1995 and 2010 for each country passed to EXPEDITE.
- Run EXPEDITE for the year 2010 using the POLES data; number of pkm within each NUTS II zone passed to POLES.
- Run POLES from 2010-2020 using number of pkm within each NUTS II zone of EXPEDITE; %-change of fuel prices and registrations between 2010 and 2020 for each country passed to EXPEDITE.
- Run EXPEDITE for the year 2020 using the POLES data; number of pkm within each NUTS II zone and consumer surplus will be the result.

The impact of road pricing on economy could be established using SCENES and ASTRA.

Chapter two describes the difficulties which would exist when long-run equilibrium (SCENES) and dynamic (ASTRA) models are run together. A solution to overcome this barrier is presented below:

- Run SCENES for the year 1995 using a road pricing scenario; traffic estimates passed to ASTRA.
- Run ASTRA from 1995-2010 using traffic estimates of SCENES; O-D matrixes on NUTS II levels passed to SCENES.
- Run SCENES for the year 2010 using O-D matrixes on NUTS II levels of ASTRA to modify those in SCENES; the resulting traffic estimates passed to ASTRA.
- Run ASTRA from 2010-2020 using traffic estimates of SCENES; O-D matrixes on NUTS II levels passed to SCENES.
- Run SCENES for the year 2020 using O-D matrixes on NUTS II levels of ASTRA; traffic estimates passed to ASTRA.
- Run ASTRA for the year 2020 using traffic estimates of SCENES; the influence of road pricing on the economy will be the result.

Possibly also emission factors from ARTEMIS could be fed into ASTRA. The potential outputs of this activity are described in the table above.

If it is necessary to estimate not only economic effects but also congestion and traffic estimates, ASTRA output should be transferred to VACLAV. VACLAV is a long-term equilibrium model, whereas ASTRA is a dynamic model. Model experiments of IWW have already shown that these two models can be combined (see overview of experiences with linking models in chapter two).

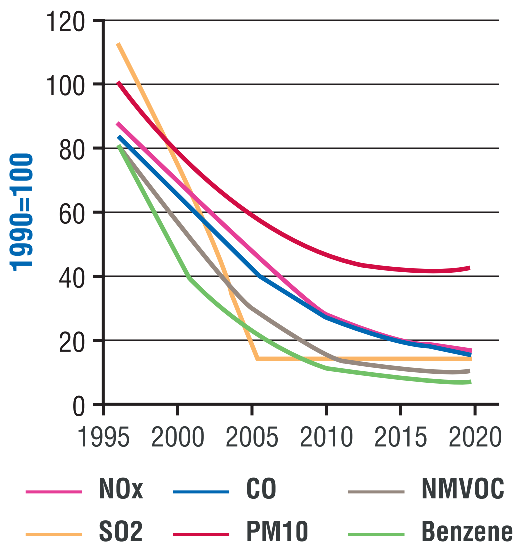
3.3.2 Energy policies and emission standards

One of the targets mentioned in the White Paper is that in 2020 a 20% share of substitute fuels is to be attained. A proposal is made for a directive setting a minimum % for consumption of bio fuels, which should attain 6% in 2010 and 20% in 2020. Further the White Paper stimulates demand by experimentation by supporting programs that aim at clean car technology. This is amongst others supported by research programs (FP6) from the Commission. In 1998 about 28% of all CO2 emissions, the leading greenhouse gas, can be related to transport activities. About 98% of energy consumption in the transport sector is oil related (accounting for 67 % of final demand for oil). Reducing this dependency is stimulated by the use of alternative fuels. One of the measures is providing tax reductions for alternative fuels. In the figure below it is shown that the Commission expects a decrease in road pollution towards 2020. Besides tax measures also other restrictions such as the gradual tightening of motor vehicle emission standards by the Commission should reduce air pollution.

The main purpose of modelling is to evaluate the effect of policy measures on emissions as well as the welfare costs of these policies. The changes in volume of transport, modal choice and vehicle choice (size & technology) for passenger as well as for freight transport should be analysed.

TREMOVE is the model to start with if it is necessary to assess the effects of energy policies and emission standards. By using the several models (as studied in this project) it is possible to

Expected reduction in road pollution



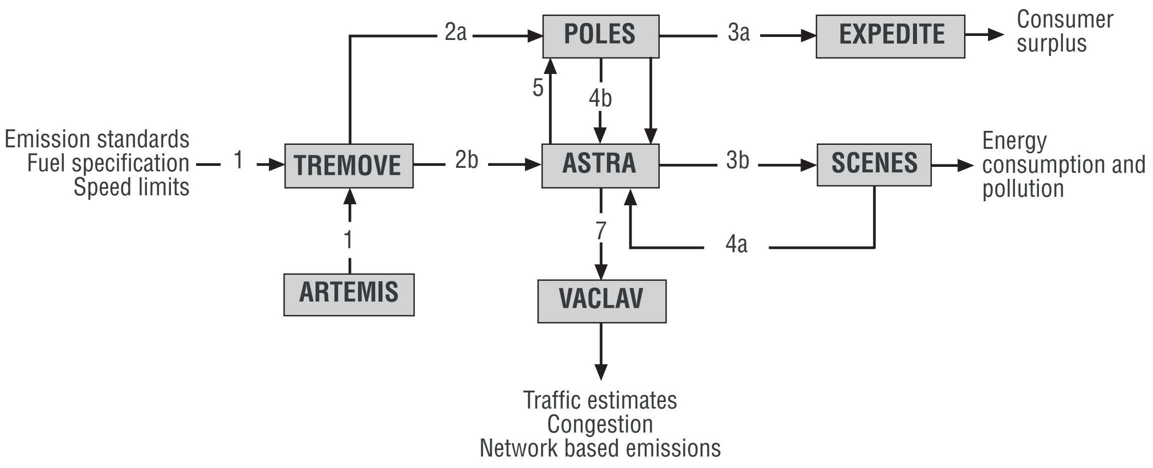
assess the influence of emission standards, fuel specifications and speed limits on:

- Total fuel consumption;
- Energy consumption and pollution;
- Traffic estimates;
- Congestion; and
- Network based emissions (will be developed).

To conduct this assessment it is necessary to carry out at maximum seven steps. These steps have been represented in the next figure and table.

In the first step the influence of emission standards, fuel specification and speed limits on traffic demand will be established. ARTEMIS is developing emission specific functions for all modes and therefore the emission factors could be transferred to TREMOVE.

In the next step, the impact on total fuel consumption and economy caused by a change of traffic demand will be established. POLES is the appropriate model to calculate the impact on total fuel consumption because it is a simulation model for the development of long-term energy supply and demand scenarios for the different regions of the world. The relationship TREMOVE – ASTRA is necessary if the influence of emission standards,



Step	Model	Input	Calculation / estimation	Output
1	TREMOVE	- Emission standards - Fuel specification - Speed limits - **ARTEMIS:** emission factors	- Fuel efficiency - Emission factors - Fuel use - Emission of each pollutant	% change of traffic demand by mode
2a	POLES	**TREMOVE:** % change of traffic demand by mode	Fuel consumption per technology and type of use	- Total fuel consumption - Fuel prices (next year)
2b	ASTRA	**TREMOVE**: % change of traffic demand by mode	- Fuel consumption - Car ownership	- Transport demand - Car ownership
3a	EXPEDITE	- **POLES**: Fuel prices (for each country, annual basis, %-change) - **POLES**: Registrations (annual basis)	- Change in transport volume for passenger and freight transport - Change in modal split for passenger and freight transport	- Number of pkm and tkm generated in each NUTS II zone by population segment - Consumer surplus by population segment (e.g. income groups)
3b	SCENES	**ASTRA**: Car ownership and transport demand	Modal split / allocation to network	Energy consumption and pollution by network mode and link type by country by broad commodity type / purpose
4a	ASTRA	**SCENES**: traffic estimates (only 2010, 2020)	- New generalised costs - Fuel consumption, emissions	Potential outputs: - GDP - Employment - Income - Car-ownership - Transport Demand - Modal-split - Accessibility - Emissions
4b	ASTRA	**POLES**: Fuel prices (next year)	New generalised costs	Potential outputs: - GDP - Employment - Income - Car-ownership - Transport Demand - Modal-split - Accessibility - Emissions

Step	Model	Input	Calculation / estimation	Output
5	POLES	**ASTRA**: Transport demand	- Supply / demand (next year) - Fuel prices (next year)	- Supply / demand (next year) - Fuel prices (next year)
6	ASTRA	**POLES**: Fuel prices (next year)	New generalised costs	Potential outputs: - GDP - Employment - Income - Car-ownership - Transport Demand - Modal-split - Accessibility - Emissions
7	VACLAV	**ASTRA**: Transport demand	Modal split / allocation to network	- Traffic estimates - Congestion - Network based emissions

fuel specification and speed limits on the economy should be established. If it is necessary to calculate the impact of fuel price changes (caused through e.g. new emission standards) on economy, TREMOVE, POLES and ASTRA (step 1, 2a and 4b) should be used. The SCENES model makes it possible to differentiate the energy consumption and pollution by network mode and link types.

It is likely that the impact of emission standards and fuel specifications on energy prices will be substantial. Therefore, the loop with the POLES model (5 and 6 in the above figure and table) is probably of great importance.

Step 4a and 7 are the same as step 3 – 4 in blueprint 1. This will give the impact on the economy and congestion of the energy policy and emission standards. As in all other blueprints it should be stressed that it is not necessary that all steps are conducted.

3.3.3 Intermodality

Eurostat and ECMT define intermodality as follows:

Intermodal transport is the movement of goods (in one and the same loading unit or vehicle) by successive modes of transport without handling of the goods themselves when changing mode.

We shall call this the *strict* definition of intermodal transport. It restricts intermodality only to goods transport first, and within goods transport only to transports using standard loading units or vehicles: containers, swap bodies, semi-trailers. This makes possible a change of mode without handling the goods themselves.

A broader definition is given in deliverable 1 of the INTERMODA project, carried out for DGTREN (INTERMODA, 2002):

Intermodality is a characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain. In addition it is a quality indicator of the level of integration between different transport modes. In that respect more intermodality means more integration and complementarity between modes, which provides scope for a more efficient use of the transport system.

This definition does not prescribe the use of standard loading units or vehicles. It is so general, that intermodality could be used for passenger transport as well (e.g. park-and-ride, bicycle parking facilities at train stations, integration of timetables of buses and trains). In the INTERMODA project, intermodality is only studied for freight transport. In the EXPEDITE project intermodality was studied both for passenger and freight transport.

Whatever the definition, intermodality is mainly an issue for freight transport. In the European Commission's White Paper 'European Transport Policy in 2010: Time to Decide'

(European Commission, 2001), the discussion on the contribution of intermodality to shifting the balance between the modes is limited to measures and programmes in freight transport (motorways of the sea, Marco Polo, encouraging the emergence of freight integrators and standardising containers and swap bodies). In the White Paper, intermodality is seen as one of the main clusters of policies to reach the objective of shifting the balance between modes from road (and air) transport to rail and water-based transport. The latter modes cannot offer door-to-door services for the large majority of the flows and need transport chains which include road-based transport to deliver such services. It is generally acknowledged nowadays that a major obstacle for the growth of transport by chains, which include rail or water-based trips, is the often low quality (long duration, high probability of damage, high costs) of the transfer between road transport and rail and waterborne transport. Intermodality policies try to remove this obstacle. The White Paper also discusses intermodality for people (integrated ticketing, baggage handling and continuity of journeys), but not in the context of the balance between modes, but in the context of placing users at the heart of transport policy (more specifically under 'transport with a human face').

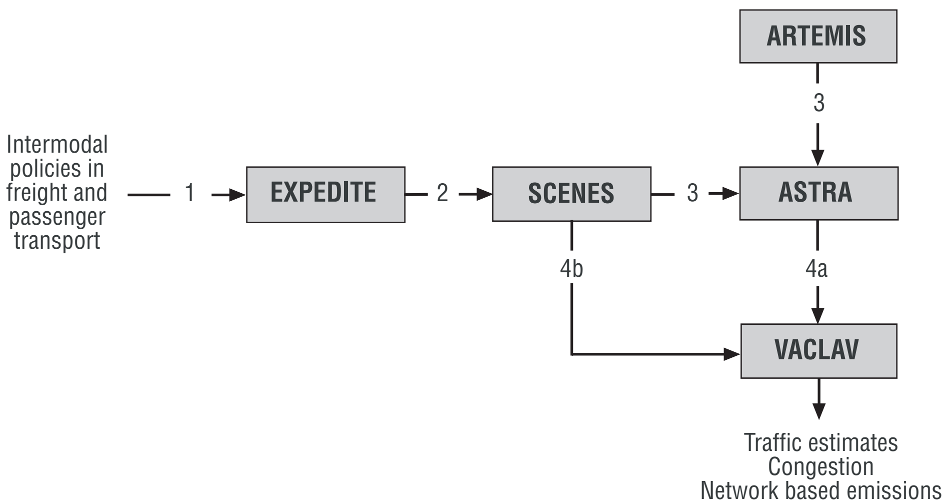
In Annex K, previous modelling exercises on intermodality policies are discussed.

Most previous investigations (IQ, EUFRANET and INTERMODA) focussed not on the likely market share of intermodal transport, but on the potential demand for it in Western Europe or the CEEC. These outcomes should be interpreted as a sort of upper bound for the market share of intermodal freight transport. EXPEDITE on the other hand tried to give the likely impact on the market share of intermodal passenger and freight transport of measures to promote intermodality, but in a very general way.

The EXPEDITE meta-model could be used for more specific runs, and in combination with the SCENES model, the impact of policy measures to support intermodality can be studied in considerably more detail. Nevertheless, for project evaluation (e.g. the costs and benefits of building a specific terminal), we recommend to use a model for the relevant corridor instead of a European model such as EXPEDITE or SCENES.

The blueprint below concerns model simulations to estimate the likely market share of intermodal transport (passenger and freight) that would result from the implementation of policy measures in this field, not the upper bound.

EXPEDITE or SCENES is the most suitable starting point for intermodality issues. The following figure explains more about the steps to be conducted in this assessment.



The following table summarises the combined model system.

Step	Model	Input	Calculation / estimation	Output
1	EXPEDITE	New and expanded intermodal terminals (freight) and transfer sites (passengers), specified as savings in terminal handling and storage costs and transfer time	Change in transport volume for passenger and freight transport; Change in modal split for passenger and freight transport	Effective and ineffective policies in terms of impact on modal split in passenger and freight transport
2	SCENES	**EXPEDITE**: effective intermodal policies in general terms. New and expanded transfer and transhipment sites in the network, leading to lower transfer en transhipments times and costs for certain routes	Transport volumes/Modal split/ allocation to network for passenger and freight transport	Traffic estimates by mode on an OD basis (NUTS II) for a forecast year for reference scenario and intermodal variants
3	ASTRA	- **ARTEMIS**: Emission factors - **SCENES**: traffic estimates (only 2010, 2020)	- New generalised costs - Fuel consumption, emissions	Potential outputs: - GDP - Employment - Income - Car-ownership - Transport Demand - Modal-split - Accessibility - Emissions
4a	VACLAV	**ASTRA** : O-D matrix (NUTS II, quarterly)	Modal split / allocation to network	- Traffic estimates - Congestion - Network based emissions
4b	VACLAV	**SCENES :** O-D matrix (NUTS II; only 2010, 2020)	Modal split / allocation to network	- Traffic estimates - Congestion - Network based emissions

In the first step the EXPEDITE meta-models for passenger and freight transport are used to do a quick scan: which policy measures in which areas (modes, distances classes, some geographical distinction) can be labelled effective and ineffective? This is only meant to produce an initial categorisation into good and bad policies.

In the subsequent step, the effective policy measures are implemented in SCENES (one could also start directly with step 2). For many measures to promote intermodal transport, this can be done in much more detail than in EXPEDITE. SCENES uses multimodal networks for passenger and freight transport, which include specific terminals (e.g. rail terminals, ports) for changes of mode. SCENES carries out a multimodal assignment of the flows to these networks. To each individual link that is used within a trip from origin to destination, a network mode is assigned. The user mode is the mode for the entire trip, which can be a collection of network modes. This would give intermodal transport. A mode hierarchy is used to give the main mode of the trip. What happens in the second step is that the effective intermodal policies from EXPEDITE are translated into specific new transfer and transhipment sites in the SCENES networks or the expansion of the existing ones, resulting in lower transfer and transhipment costs and shorter transfer and transhipment times for certain routes. SCENES is then run for the reference network and the revised network to give the impacts in terms of trips, passenger km, tonnes and tonne km.

The steps 3-4 are the same as the steps 4-5 in blueprint 1. This will give the impact on emissions, the economy and on congestion of the policy measures to promote intermodality. As in blueprint 1, not all four steps given above are required for each policy application, depending on the output a user is looking for (traffic, emissions, congestion).

The land use and regional-economic impacts of the intermodality policies can expected to be modest, except for policies that yield very large changes in the distribution system, but can be included through ASTRA. A practical combination of models to simulate the impacts of intermodality could include EXPEDITE, SCENES and ASTRA (steps 1, 2 and 3).

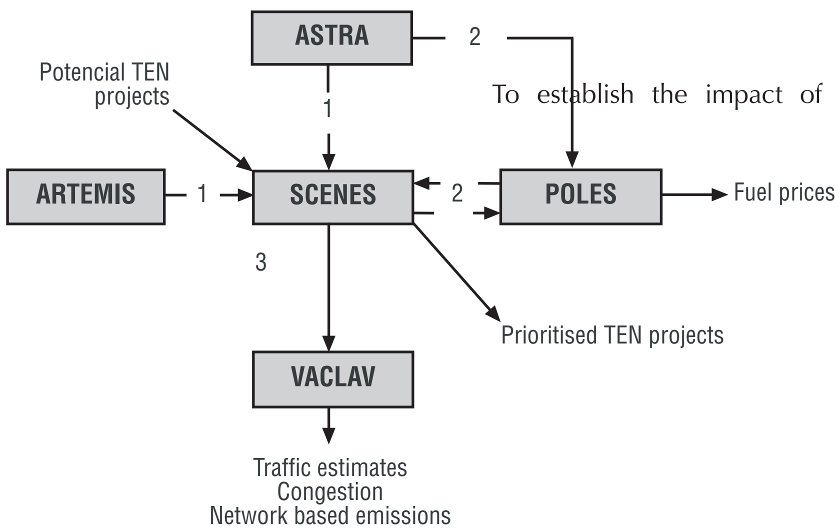
3.3.4 Networks / Trans-European Networks

This blueprint has been designed with the intended application of assessment of the medium to long term impacts of Trans-European Networks in mind. The idea of Trans-European Networks (TENs) emerged by the end of the 1980s in conjunction with the proposed Single Market. It made little sense to talk of a common, Europe-wide market, with freedom of movement within it for goods, persons and services, unless the various regions and national networks making up that market were properly linked by modern and efficient infrastructure. The construction of TENs is also significant in the generation of economic growth and the creation of employment at the national and local level (http://europa.eu.int/comm/ten/index_en.html).

A large number of projects of common interest have already begun to be implemented and there have been significant levels of financial support allocated from the Community budget, as well as the Structural Funds and Cohesion Fund. However, many more TENS have been proposed but are still awaiting funding. Therefore, there is a distinct need to prioritise the various proposed infrastructure projects on a basis of a cost and benefit assessment at both the European level (i.e. how the projects contribute to the interconnection and interoperability of the various modal networks as well as how the accessibility to such networks are improved); and the impacts upon the local network, economy and environment (i.e. in terms of how widespread are the costs and benefits of each individual scheme).

The proposed blueprint for model integration described below has therefore been designed as a basis for this type of multi-level analysis for the assessment and prioritisation of large-scale infrastructure projects such as the TENs.

The design of this blueprint is centred around the SCENES transport forecasting model which was selected on the basis that it offers a detailed network model for the whole of Europe and combines some regional economic aspects which could be used along with the network impacts of TENs to define cost benefit zones. The links between SCENES and VACLAV and SCENES-EXPEDITE-VACLAV address issues at the national and local level. This blueprint could potentially be used for testing any major infrastructure developments within Europe.



To establish the impact of potential TEN

Step	Model	Input	Calculation / estimation	Output
1	SCENES	- Potential TEN projects - **ASTRA**:GDP, employment, population and car ownership growth rates. - **ARTEMIS**: Emission factors - **POLES**: Fuel Price growth rates by means of iterative process	Modal split/ allocation to network	- Transport demands - Cost-benefit zones - Prioritised TEN projects
2	POLES	- **ASTRA**: GDP and population inputs - **SCENES**: Transport demands	Calculate fuel prices by means of iterative process.	Fuel prices (next year)
3	VACLAV	**SCENES**: OD matrices and regional economic changes for cost benefit zones	Modal split / allocation to network	- Traffic estimates - Congestion - Network based emissions

projects the SCENES transport forecasting model will be the starting point. The demographic inputs (GDP, employment, population and car ownership growth rates) to SCENES would be taken from the ASTRA model baseline as % per annum growth rates to apply to the SCENES base year values (this linkage has already been proven in the original SCENES project). Furthermore, emissions functions (to be applied to vehicles on the SCENES networks in the form of speeds and characteristics of links) would be supplied from ARTEMIS.

The linkage depicted above between POLES and SCENES has been envisaged as an iterative process, though it is likely that the temporal differences between the two models may cause hinderance in this respect. Here POLES would also take GDP and population inputs from ASTRA for consistency with SCENES. SCENES would first run in the base year (1995) and use the POLES % per annum growth for fuel prices from a POLES run of base year to yr+1 to create an initial estimate for 2010/2020. The transport demand outputs from SCENES 1995 v 2010/2020 would then be translated into a % per annum growth rate for input to POLES for the next years and the process would iterate producing a continual improvement of the 2010/2020 baseline forecast from SCENES. The final run of the SCENES baseline forecast would then be re-run with provisional TENs included in the network and the differences between the baseline and TEN scenarios would be used to evaluate the cost and benefits of the full package of TEN projects at the European level.

The next stage has been designed as a potential extension to the blueprint to address issues at the national and regional level. Buffer zones based on the differences between the SCENES model assignment outputs could be created to define the geographical scope of cost benefit zones. The segments of the OD matrices and regional economic changes within these zones could then be input into VACLAV to re-run a more detailed assignment and congestion analysis at the national level for each project.

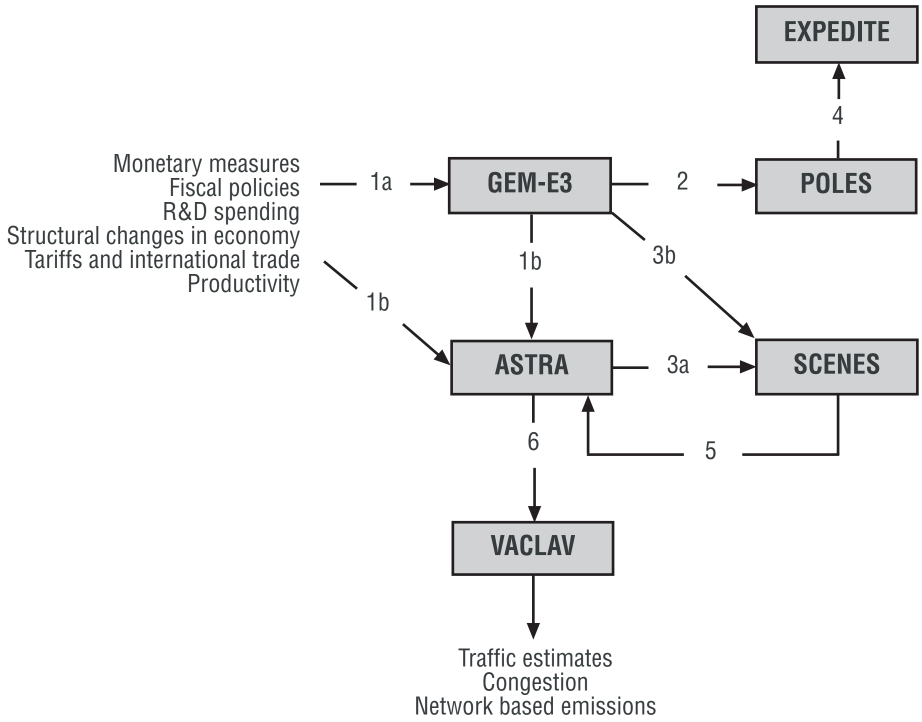
3.3.5 Economic policies / Environmental assessment

Economic policies (non-transport fiscal policies; outlays for R&D; structural changes in economy; tariffs and international trade; productivity improvements) are usually implemented to stimulate economic growth and employment. Economic policy measures have only very infrequently been proposed because of their potential impact on transport: staggered working hours, part-time working, telecommuting, longer opening hours for shops. All these policies could reduce peak hour congestion. But also policies that have a main objective outside the transport field, can have repercussions on transport, which should be taken into account in an integral evaluation of these measures.

Both GEM-E3 and ASTRA are suitable for policy issues in the field of economic policies.

Examples of economic policies are: monetary measures; fiscal policies; R&D spending; structural changes in economy; tariffs and international trade; and productivity. The following figure presents a possible blueprint for this kind of policy issues.

In the first step, the economic policy measures are inserted in either GEM-E3 (which produces GDP growth input and sectoral input-output tables for ASTRA) or ASTRA. In both situations, ASTRA will give the new transport demand and vehicle



Step	Model	Input	Calculation / estimation	Output
1a	GEM-E3	- monetary measures (interest rates, etc.) - fiscal policies (tax systems, etc.) - R&D spending - Structural changes in economy - Tariffs and international trade - Productivity growth	- New Input-Output tables - Productivity, output, prices per sector - Supply and demand per sector	- GDP, sectoral input and output
1b	ASTRA	- monetary measures (interest rates, etc.) - fiscal policies (tax systems, etc.) - R&D spending - Structural changes in economy - Tariffs and international trade - Productivity growth - **GEM-E3:** GDP growth rates, I-O tables	- Trade flows - Investment per sector - Supply in transport sector	New generalised costs Vehicle ownership O-D matrix
2	POLES	**GEM-E3:** GDP growth	- New final fuel prices - New supply/demand (all sectors) - New prices	- Fuel prices - New registrations

Step	Model	Input	Calculation / estimation	Output
3a	SCENES	**ASTRA** : O-D matrix (NUTS II, quarterly)	Modal split/ allocation to network	Traffic estimates (only 2010, 2020)
3b	SCENES	**GEM-E3**: GDP	Modal split/ allocation to network	Traffic estimates (only 2010, 2020)
4	EXPEDITE	- **POLES:** Fuel prices (for each country, annual basis) - **POLES:** Registrations (annual basis)	Change in transport volume for passenger and freight transport; Change in modal split for passenger and freight transport	- Number of pkm and tkm generated in each NUTS II zone by population segment - Consumers surplus by population segment (including income groups)
5	ASTRA	**SCENES:** traffic estimates (only 2010, 2020)	- New generalised costs - Fuel consumption, emissions	Potential outputs: - GDP - Employment - Income - Car-ownership - Transport Demand - Modal-split - Accessibility - Emissions
6	VACLAV	**ASTRA**: O-D matrix (NUTS II, quarterly)	Modal split / allocation to network	- Traffic estimates - Congestion - Network based emissions

demand. This could lead to changes in the demand for fuels and in the fuel prices, which is simulated in POLES in the second step. SCENES could add the network detail (step 3a) and EXPEDITE the consequences of the policy measures for different population groups (step 4). An alternative for step 1b, 2 and 3a would be to go directly from GEM-E3 to SCENES, by inserting the GDP forecasts from GEM-E3 into SCENES (step 3b; one could also go from GEM-E3 to EXPEDITE using GDP). The confrontation of transport demand with the supply of network capacity in SCENES will give new estimates for transport demand (after equilibration with supply), which can be inserted in ASTRA (step 5) to give new estimates of the impacts on land use and the economy. Finally, VACLAV can be used to provide congestion indicators and network-based emissions.

3.4 Difficulties in linking models

Linking models is not as easy as it looks like. Several barriers make it impossible to transfer the output of a model to another model (in which it will be used as an input). Time steps for example could be a main barrier. An example of this is the differences in time steps between POLES, ASTRA and SCENES; POLES uses a 1 year step, ASTRA a quarterly and SCENES a 10 year time step. This chapter presents the difficulties which could arise if policy issues are going to be solved by means of the identified blueprints.

The following table presents the different input and output data as described in the blueprints of chapter one. Moreover the units and spatial scale/ coverage is included in the table.

Variable	Model	Unit	Spatial scale/coverage	Difficulty
Final fuel price (for each country and fuel, annual basis)	POLES	Euro/toe Euro/kWh Euro/l (l of specific fuel and of gasoline equivalent)	Country level By technology (Gasoline, diesel, natural gas / hydrogen, electricity)	The models present fuel prices in Euro/l or a % change and present this mostly at country level
	ASTRA	EURO/l	Country level	
	EXPEDITE	% change in variable car cost	NUTS II zone	
	SCENES	% change in variable vehicle operating cost for each passenger and freight vehicle type	Country level	
Registrations per technology (annual basis)	POLES	No. of vehicles	Country level By vehicle size (small/large), user type (urban, semi-urban, rural) and technology (gasoline, diesel, fuel cells, electric, hybrid)	All models present the results in vehicles and on a country level.
	ASTRA	Vehicles	Country level, though fleet later on is distributed on zones	
	EXPEDITE	Vehicles	Country level, though fleet later on is distributed on zones	
O-D matrix (NUTS II, quarterly)	ASTRA	Passenger: vol: 1000 trips/day distance: km/trip time: hours/trip Freight: vol: 1000 tonnes/day distance: km/tonne time: hours/tonne	53x53 Zones based on NUTS II Passenger: by mode, by trip purpose or any aggregation thereof Freight: per mode per goods category or any aggregation thereof	ASTRA presents results in * 1000 and SCENES in * Mio. ASTRA and SCENES in km/trip and VACLAV in km/day. Number of zones ASTRA (53x53 based on NUTS II) is different from SCENES (244 based on NUTS II) and VACLAV (1250 x 1250 based on NUTS III.
	SCENES	Passenger: Mio*Trips/day Average Distances Km/Trip Average Cost ECU/Trip Average Time Hours/Trip Freight : Mio*Tonnes/day Average Distances Km/Tonne Average Cost ECU/Tonne Average Time Hours/Tonne	244 Zones based on NUTS II plus external zones outside Europe. Passenger: by mode, by trip purpose or any aggregation thereof Freight: by mode, by goods category or any aggregation thereof	
	VACLAV	vhc-km/day pkm/day tkm/day	NUTS III matrix plus some rest-of-the-world about 1250x1250	
Emission factors	ARTEMIS	g/km	Per vehicle type according to size, cleaning technology	No difficulties
	ASTRA	g/km	Per vehicle type according to size, cleaning technology	
Traffic estimates	SCENES	Passenger: Mio*Trips/year Mio*Pkm/year Freight: Mio*Tkm/year Mio*Tonnes/year Mio*vehkm/year can also be calculated for road modes	Totals by NUTS II zone or Country aggregates thereof, By mode, by purpose/goods category, by link type, by distance band	No difficulties
	ASTRA	Mio*vhckm/year	Totals per mode per country Per trip purpose, per country and if available per distance category	

Variable	Model	Unit	Spatial scale/coverage	Difficulty
Transport demand	TREMOVE	% change from base case	By mode By country By region (urban – non-urban) By vehicle type	ASTRA presents pkm and tkm results in Mio and SCENES not. Only TREMOVE presents results in %; other models present a value. ASTRA, TREMOVE and POLES present results at country level, whereas SCENES presents it on NUTS II level and VACLAV on levels from NUTS III to NUTS o.
	ASTRA	Mio*trips/year Mio*tonnes/year Mio*pkm/year, Mio*tkm/year	Totals per mode per country Per trip purpose, per country and if available per distance category	
	POLES	Vehicle*km	Country level By vehicle size (small/large), user type (urban, semi-urban, rural) and technology (gasoline, diesel, fuel cells, electric, hybrid)	
	VACLAV	Mio*pkm/year Mio*tkm/year Mio*vhc-km/year (road) Mio*trips/year	Loaded network that can be aggregated NUTS III to NUTS 0	
	SCENES	Passenger: Pkm Freight: Tkm	NUTS II level for EU15 freight + EU15 & CEEC8 pax Domestic Intra EU15 International	
Car ownership	ASTRA	Cars/(1000*pers)	Per NUTS II zone	No difficulties.
	SCENES	Cars/(1000*pers)	Per NUTS II zone	
GDP	SCENES	1995 Mio*ECU	EU 15 + CEEC8; country level totals	SCENES, EXPEDITE, ASTRA and POLES present results in Euro, whereas GEM-E3 presents results in US $. SCENES, EXPEDITE and ASTRA in Mio and POLES not. GEM-E3 presents GDP results of EU-15 for 4 zones. SCENES, EXPEDITE, ASTRA and POLES present GDP results by country level.
	GEM-E3	US $ 1995 constant values	18 sectors in 17 zones (EU15 divided in 4 zones)	
	ASTRA	Mio*EURO	Per country	
	POLES	Euro, constant prices	Country level, EU15 (14 zones), 13 CC, USA, Canada, Japan, China, India, Mexico (34 countries in total)	
Population	ASTRA	Persons	Totals per country 1-year-age cohorts per country	All models present population data in persons by country.
	POLES	Persons	34 countries	
	SCENES	Persons Households	Persons by age / employment status (5 groups) by country	
I-O tables	GEM-E3	US $ 1995 constant values	18 sectors in 17 zones (EU15 divided in 4 zones)	GEM-E3 presents results in US $, whereas ASTRA presents results in Euro. GEM-E3 divides EU15 in 4 zones, whereas ASTRA presents results by country.
	ASTRA	Mio*EURO	25 sectors and per country Exports intra Europe as well as Europe to RoW	

Moreover, it is very important to check if all units of the same exogenous inputs and main outputs are equal to each other. The following table presents these exogenous inputs and main outputs.

Variable	Exogenous inputs	Main outputs
Average speed	TREMOVE; EXPEDITE	TREMOVE; SCENES
Vehicle stock	EXPEDITE	TREMOVE; ASTRA; POLES
Emission		TREMOVE; TRENDS; SCENES; ASTRA; POLES; GEM-E3
Passenger kilometre		TRENDS; EXPEDITE; SCENES ; ASTRA
Freight tonne kilometre		TRENDS; EXPEDITE; SCENES ; ASTRA
Population	TREMOVE; EXPEDITE; SCENES; POLES	ASTRA
Car ownership	EXPEDITE; SCENES	TREMOVE; ASTRA; POLES
GDP	EXPEDITE; SCENES; POLES	ASTRA; GEM-E3
Labour productivity	ASTRA; GEM-E3	
Consumption	GEM-E3	ASTRA
Employment	SCENES	ASTRA; GEM-E3
Exports	SCENES (to rest of world from EU)	ASTRA; GEM-E3
Imports	SCENES (from rest of world to EU)	ASTRA; GEM-E3
Passenger vehicle kilometre		TREMOVE; TRENDS; EXPEDITE; SCENES, ASTRA; POLES (only totals)
Freight vehicle kilometre		TREMOVE; TRENDS; EXPEDITE; SCENES, ASTRA; POLES (only totals)
Fuel consumption	SCENES	TREMOVE ;ASTRA; POLES

The following table presents the results of comparing the units and spatial scale/coverage of these variables.

Variable	Model	Unit	Spatial scale/coverage	Difficulties
Average speed	TREMOVE (input)	Km / hour	By mode By country By road type	TREMOVE calculates average speed by country and EXPEDITE and SCENES by NUTS II zone. TREMOVE calculates %-change, SCENES km/hour and EXPEDITE %-change in travel time.
	TREMOVE (output)	% change from base case	By mode By country By road type	
	SCENES	Km/hour	By mode By NUTS II zone By road type	
	EXPEDITE	% change in travel time	By mode, By NUTS II zone	
Vehicle stock	EXPEDITE	Cars	By NUTS II zone	All models present vehicle stock levels in cars. Only EXPEDITE presents vehicle stock data by NUTS II zone, whereas other models present data per country.
	POLES	Cars	By country, technology, use	
	TREMOVE	% change from base case	Per country By vehicle type By age By emission technology	
	ASTRA	Vehicles (based on this % change from base case)	Total (cars, vans, trucks, buses) per country, simple split per NUTS II zone	

Variable	Model	Unit	Spatial scale/coverage	Difficulties
Emission	TREMOVE	% change from base case (CO, FC, NO_x, PM, C_6H_6, VOC, NMVOC, CH_4, SO_2, CO_2)	By country By region (urban – non-urban) By vehicle type By emission technology	The level of detail is different. TREMOVE calculates most emissions and SCENES and POLES calculate only CO2 emissions. TREMOVE, ASTRA and POLES calculate emissions by country level, whereas SCENES calculate it by NUTS II zone and GEM-E3 divides EU15 in 4 zones. Units of emissions are different: TREMOVE (%), SCENES (g), ASTRA (tonnes/kg), POLES (g/km(/year), GEM-E3 (tonnes).
	SCENES	gCO_2 for road modes only	By NUTS II zone or country aggregates thereof	
	ASTRA	Emissions (tonnes/kg) per year (CO_2, NO_x, PM)	Per country, per mode	
	POLES	g/km, g/km/year (only CO_2)	Country level By vehicle size (small/large), user type (urban, semi-urban, rural) and technology (gasoline, diesel, fuel cells, electric, hybrid)	
	GEM-E3	Tonnes (CO_2, NO_x, SO_2 and VOX)	18 sectors in 17 zones (EU15 divided in 4 zones)	
Passenger kilometres	TREMOVE	% change from base case	By mode By country By region (urban – non-urban) By vehicle type	All models present passengers kilometres per year. TREMOVE and ASTRA present data per country and EXPEDITE and SCENES by zone. All models make a difference by mode. EXPEDITE, ASTRA and SCENES differentiate in distance classes.
	EXPEDITE	pkm/year	By zone, person type, area type, mode, purpose, distance class	
	ASTRA	Mio * pkm/year	totals per mode by country, per trip purpose, per country, per distance category	
	SCENES	Mio * pkm/year	By zone, person type, area type, mode, purpose, distance class.	
Freight tonne kilometres	TREMOVE	% change from base case	By mode By country By region (urban – non-urban) By vehicle type	All models present tonne kilometres per year. TREMOVE and ASTRA present data per country and EXPEDITE and SCENES by zone. All models make a difference by mode. EXPEDITE, ASTRA and SCENES differentiate in distance classes.
	EXPEDITE	Tonne km/year	By zone, mode, flow and distance class	
	ASTRA	Mio*tkm/year	Totals per mode per country per trip purpose and per distance category	
	SCENES	Mio * tkm/year	By zone, mode, commodity type and distance class	
Population	EXPEDITE	Persons	By NUTS II zone and person type	SCENES, POLES, TREMOVE and ASTRA calculate population by country and EXPEDITE (but also SCENES) by NUTS II zone.
	SCENES	Persons	EU15 country totals and NUTS II level data by person type	
	POLES	Persons	34 countries	
	TREMOVE	Persons	Totals per country per area	
	ASTRA	Persons	Totals per country 1-year-age cohorts per country	
Car ownership	EXPEDITE	Cars/(1000*pers)	Per NUTS II zone	EXPEDITE, SCENES and ASTRA calculate car ownership rates per NUTS II zone, whereas POLES calculates it per country.
	SCENES	Cars/(1000*pers)	Per NUTS II zone	
	ASTRA	Cars/(1000*pers)	Per NUTS II zone	
	POLES	Cars/ (1000*persons)	Per country	

Variable	Model	Unit	Spatial scale/coverage	Difficulties
GDP	SCENES	Mio*ECU (1995)	EU15 NUTS II level totals and country level	SCENES, EXPEDITE, ASTRA and POLES present results in Euro, whereas GEM-E3 presents results in US $. SCENES, EXPEDITE and ASTRA in Mio and POLES not. GEM-E3 presents GDP results of EU-15 for 4 zones. SCENES, EXPEDITE, ASTRA and POLES present GDP results by country level.
	ASTRA	Mio * euro (1995 prices)	Per country	
	POLES	Euro	Country level, EU15 (14 zones), 13 CC, USA, Canada, Japan, China, India, Mexico(34 countries total)	
	GEM-E3	US $ 1995 constant values	18 sectors in 17 zones (EU15 divided in 4 zones)	
	EXPEDITE	Mio*ECU (1995)	NUTS II level totals and country level	
Labour productivity	ASTRA	Euro/ (full-time equivalent employee)	Sectoral	Unit of labour productivity in ASTRA is Euro and in GEM-E3 %. ASTRA simulates EU15 countries, whereas GEM-E3 divides EU15 in 4 zones.
	GEM-E3	% annual growth rate	18 sectors in 17 zones (EU15 divided in 4 zones)	
Consumption	ASTRA	Mio*EURO (1995 prices)	Sectoral for 23 out of 25 sectors. No private consumption in the other two sectors	ASTRA presents results in Euro, whereas GEM-E3 presents results in US $. ASTRA simulates EU15 countries, whereas GEM-E3 divides EU15 in 4 zones.
	GEM-E3	US $	18 sectors in 17 zones (EU15 divided in 4 zones)	
Employment	SCENES	Persons	Per NUTS II zone	SCENES and ASTRA present employment data by persons and GEM-E3 (and ASTRA) by full time equivalent jobs. The differentiation in zones is different for each model.
	ASTRA	Persons (Total and Full-time equivalent)	Country totals Sectoral	
	GEM-E3	Full time equivalent jobs	18 sectors in 17 zones (EU15 divided in 4 zones)	
Exports	SCENES	Mio * euro (1995 prices)	24 Sectors per zone pair intra EU	SCENES and ASTRA present exports in euro and GEM-E3 in US $. The differentiation in sectors is different for each model.
	ASTRA	Mio * euro (1995 prices)	Sectoral and per country pair; intra Europe as well as Europe to RoW	
	GEM-E3	US $	18 sectors in 17 zones (EU15 divided in 4 zones)	
Imports	SCENES	Mio * euro (1995 prices)	24 Sectors per zone pair intra EU	SCENES and ASTRA present exports in euro and GEM-E3 in US $. The differentiation in sectors is different for each model.
	ASTRA	Mio * euro (1995 prices)	Sectoral and per country pair; intra Europe as well as Europe to RoW	
	GEM-E3	US $	18 sectors in 17 zones (EU15 divided in 4 zones)	

Variable	Model	Unit	Spatial scale/coverage	Difficulties
Passenger transport volume	ASTRA	Mio * trips/year	Totals per mode per country O/D, Domestic and International, per mode, per trip purpose and if available per distance category	ASTRA, SCENES and EXPEDITE present passenger transport volumes in trips per year, whereas POLES presents data by vehicle kilometre. ASTRA and POLES differentiate by country and SCENES and EXPEDITE by zone. ASTRA, SCENES and EXPEDITE differentiate by mode and POLES by vehicle size.
	POLES	Vehicle*km	Country level By vehicle size (small/large), user type (urban, semi-urban, rural) and technology (gasoline, diesel, fuel cells, electric, hybrid)	
	SCENES	Mio * trips/year	Totals per mode per zone pair by purpose for domestic and international	
	EXPEDITE	Tours/year	By zone, person type, area type, mode, purpose, distance class	
Freight transport volume	ASTRA	Mio * tonnes/year	Totals per mode per country O/D, Domestic and International, per mode, per trip purpose and if available per distance category	ASTRA, SCENES and EXPEDITE present freight transport volumes in tonnes per year, whereas POLES presents data by vehicle kilometre. ASTRA and POLES differentiate by country and SCENES and EXPEDITE by zone. ASTRA, SCENES and EXPEDITE differentiate by mode and POLES by vehicle size.
	POLES	Vehicle*km	Country level By vehicle size (small/large), user type (urban, semi-urban, rural) and technology (gasoline, diesel, fuel cells, electric, hybrid)	
	SCENES	Mio * tonnes/year	By zone pair, mode, commodity type for domestic and international	
	EXPEDITE	Tonnes/year	By zone, mode, flow and distance class	
Fuel consumption	SCENES	Mio*l/year	by vehicle type by link type by zone for passengers and freight	SCENES, ASTRA and POLES present fuel consumption in litres per year and TREMOVE presents data as a % change from the base case. ASTRA, POLES and TREMOVE differentiate by country and SCENES by zone.
	ASTRA	Mio*l/year	Per country	
	POLES	Toe, l, kWh (l of specific fuel and of gasoline equivalent)	Country level By vehicle size (small/large), user type (urban, semi-urban, rural) and technology (gasoline, diesel, fuel cells, electric, hybrid)	
	TREMOVE	% change from base case	By country By vehicle type	

3.5 Conclusions

In this chapter five different blueprints for linking European transport models are described. However, if a specific blueprint should be chosen that is most interesting to study in detail in a follow-up project, it should be the *Energy policies and emission standards* blueprint. The reason for this is that energy policies and emission standards will become more important in the (near) future at an EU level (see one of the targets mentioned in the White Paper that is indicating that in 2020 a 20% share of substitute fuels is to be attained). Besides, this blueprint runs less modelling risk compared to the blueprints in which network models play a more important role.

As implementing the blueprints (as identified in this chapter) is still very difficult (many models; different definitions of variables, etc.) it is even better to start with the implementation of linking only two transport models. The most fruitful linkage is the connection between ASTRA and SCENES. In this way it is possible to relate the interaction between land-use and economy (as identified in ASTRA) to the network model SCENES. Before this 'integration' could be realised it is first necessary to update the models, as input and output values, are sometimes different between the models and the definition of variables and units is not always the same. The first remark will be elaborated in more detail in the following chapter.

Finally, it should be stressed that this is only a theoretical exercise. It is necessary to work out at least one of the blueprints in a case study. Moreover, linking models cannot be automatized and the expert view is still necessary.

4 Review of available data

In this chapter we will provide a comparison of the input and output data of the models that we have studied. In the previous chapter we have identified the main exogenous inputs and the main outputs. From this we have specified a list of variables which are the same in the different models. From this list of 16 overlapping variables we have chosen the nine most crucial variables that we want to compare with each other, these are:

- GDP(Gross Domestic Product)
- Population
- Passenger kilometres (if possible by mode)
- Freight tonne kilometres (if possible by mode)
- Passenger vehicle kilometres (if possible by mode)
- Freight vehicle kilometres (if possible by mode)
- Vehicle stock
- Car ownership
- Emissions

Data for these elements have been collected for the following models that were included in the study:

- TREMOVE
- TRENDS
- EXPEDITE
- SCENES
- ASTRA
- POLES
- EUROSTAT

In principle, for these models the data for 1995, 2000, 2010 and 2020 were collected. It proved that 1995 was the best common ground for comparison of the models. This is available for all models included (only ASTRA and POLES have 2000 as base year). Further we have included EUROSTAT since this is the reference database. It was hoped that at the time of carrying out the study, that results from ETIS-BASE[4] could be provided, so that more recent observed data could have been available. Secondly, it was decided to compare the dynamics of the model for the period 1995-2020, this gives a long period and makes the outcome more pronounced than instead taking a short period. So absolute data levels are compared for 1995 and growth 1995-2020 in relative terms (% growth) is compared.

The partners within the ESTO project have provided the datasets for the models. Beforehand, it was organised that the data elements had the same dimensions and a similar domain, so that a like with like comparison could be carried out.

The structure of this chapter is that we provide first a scheme for comparison of the data elements (section 4.1), thereafter we provide the actual comparison in a graphical way (section 4.2). The extended dataset is included in Annex L - U. Section 4.3 closes this chapter with conclusions.

4.1 Scheme for comparing data

In the table below we provide an overview of the data elements that can be compared between the models. Also it is indicated whether it concerns input, output data or whether it is from observed statistics (EUROSTAT).

4 DGTREN FP5 project. This project will develop the core database of the ETIS project. It will work towards building a consensus view of the reference pan-European transport modeling data set. It will develop an open methodology to generate a version of a data set from existing international and national sources.

Table 4.1: Overview of data elements that were compared.

	TREMOVE	TRENDS	EXPEDITE	SCENES	ASTRA	POLES	EUROSTAT
GDP	-	-	I	I	O	I	B
Population	-	-	I	I	O	I	B
Passenger kilometres	-	-	O	O	O	O	B
Freight tonne kilometres	-	-	O	O	O	O	B
Passenger vehicle kilometres	I/O*	O	O	O	O	O	-
Freight vehicle kilometres	I/O*	O	O	O	O	O	-
Car ownership	-	-	I	I	O	O	B
Vehicle stock	O	-	I	I	O	O	B
Emission	O	-	-	O	O	O	-

NB:- means not available, I: exogenous input, O: output, B: base data from statistical recording.
**:TREMOVE uses total vehicle kilometres as input and divides this over the modes.*

The idea behind comparing model results is that the outcomes of the models should be in the same domain in order for models to communicate as we proposed within the development of the blueprints. At the same time we want to observe whether similar model input has been used so that "like with like" is compared for the output.

4.2 Comparison of data elements

In this section we will present the following data comparisons:

- GDP
- Population
- Passenger kilometres
- Freight tonne kilometres
- Passenger vehicle kilometres
- Freight vehicle kilometres
- Car ownership
- Vehicle stock
- Emission

4.2.1 GDP

In the figure 4.1 below, the GDP for 1995 is shown as used in different models. In general one can see that there is convergence on the level of GDP for most countries. A few countries show differing input for the models, notably Italy, Spain and UK. It is POLES that is for these countries on the high end. In figure 4.2 we show the growth of GDP as assumed in different base case scenarios in the models. As it can be seen the assumed growth patterns between countries differ substantially (a difference of 20% in a period of 25 year means a difference in 0.7% yearly growth). It is interesting to see that ASTRA, which produces the growth of GDP endogenously, is for most countries in line with other models, except for Ireland, Denmark, Finland and Germany. For Accession Countries EXPEDITE assumes considerable higher growth than SCENES and POLES. It is important to bear in mind that for the EXPEDITE, SCENES and POLES the GDP is exogenously determined input for the model, while for ASTRA this is endogenously determined.

4.2.2 Population

Figure 4.3 below shows the input per model for 1995, although there are some small differences. In general it can be stated that it coincides with observed data (as represented by the EUROSTAT figures. However when looking at the growth scenario's in figure 4.4 then some

Figure 4.1: GDP1995 Mln EURO/ECU 1995.

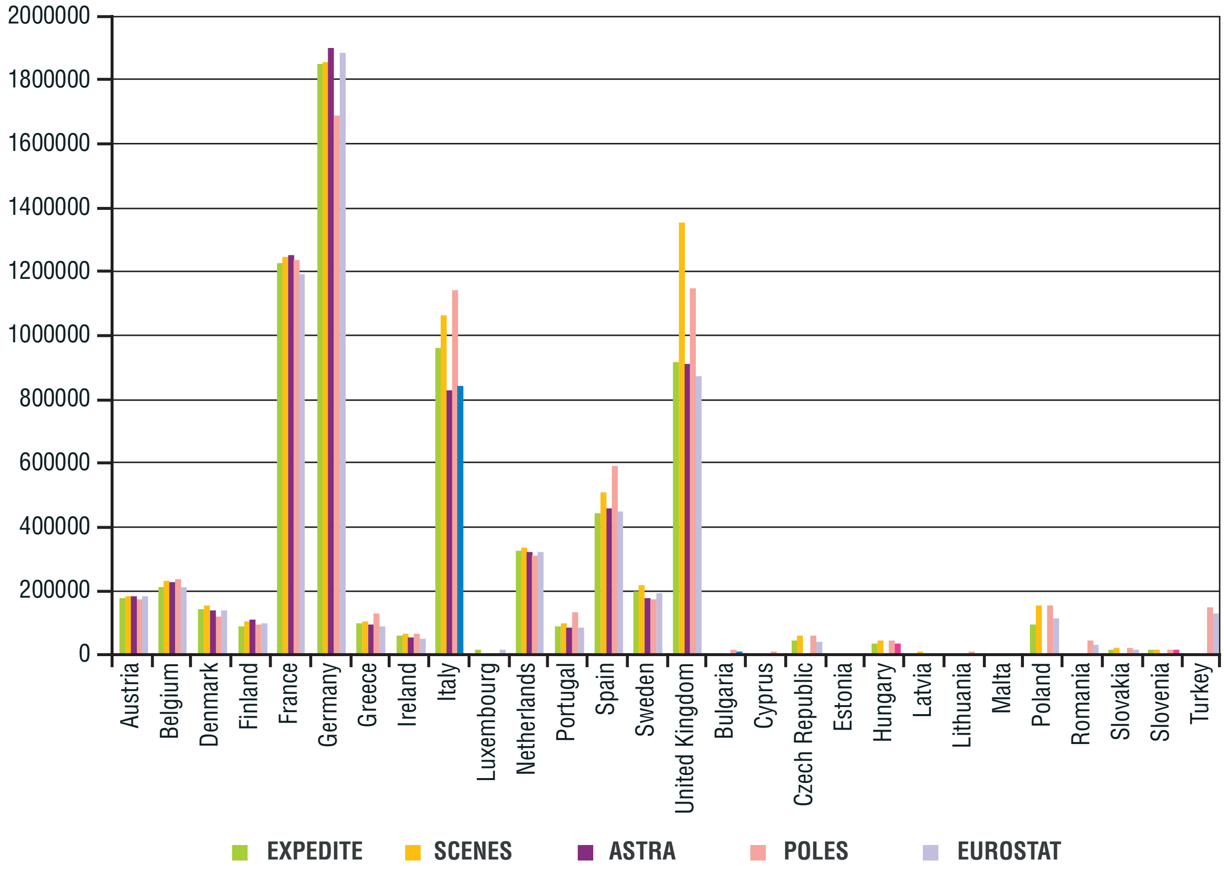


Figure 4.2: GDP 1995 – 2020 (% increase).

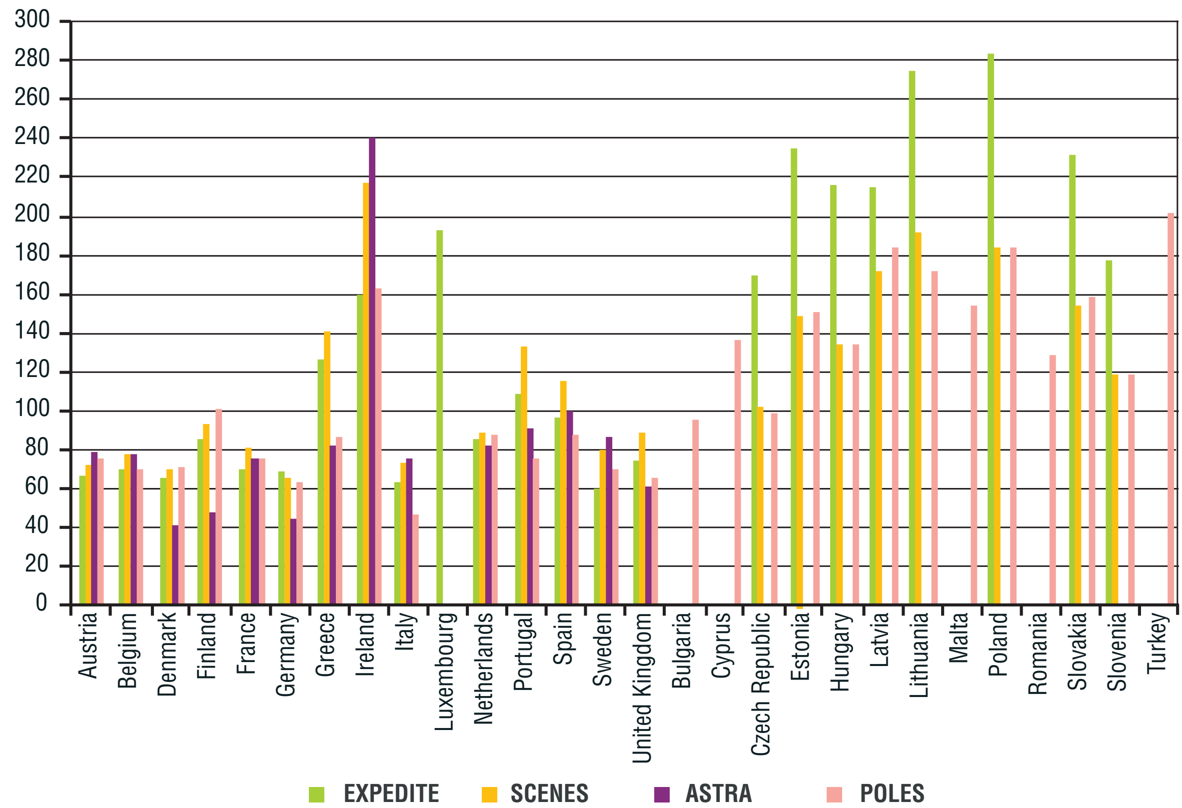


Figure 4.3: Population 1995.

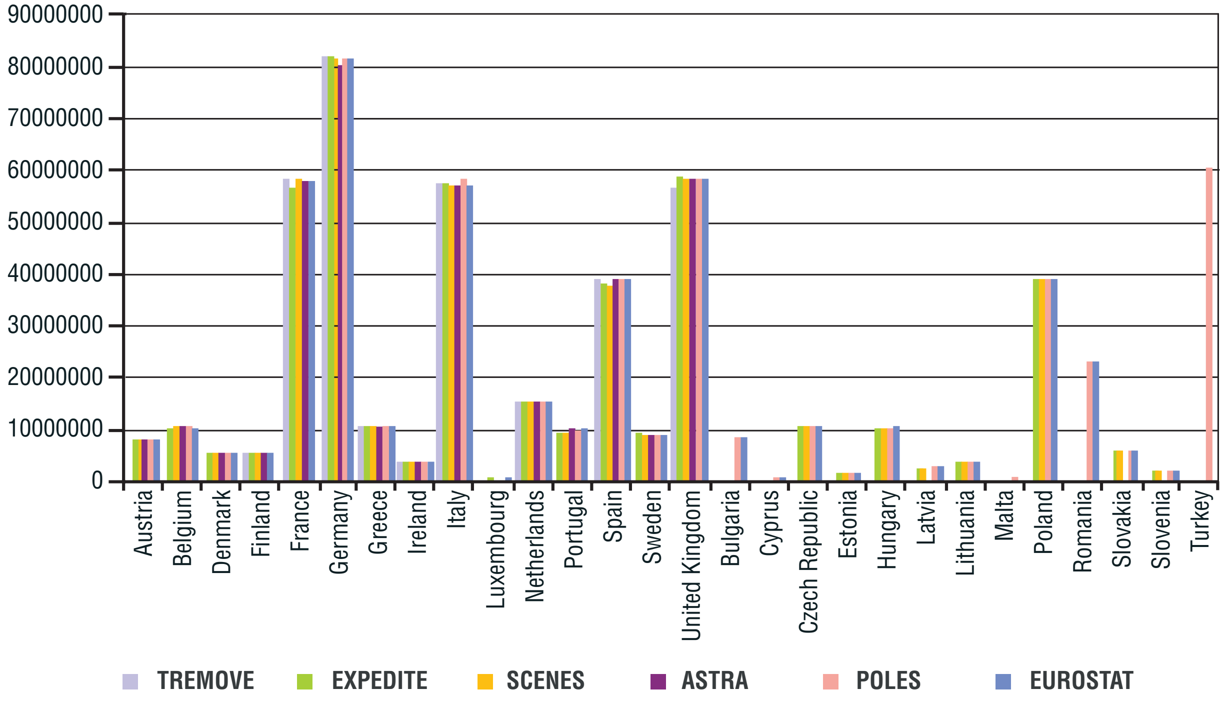
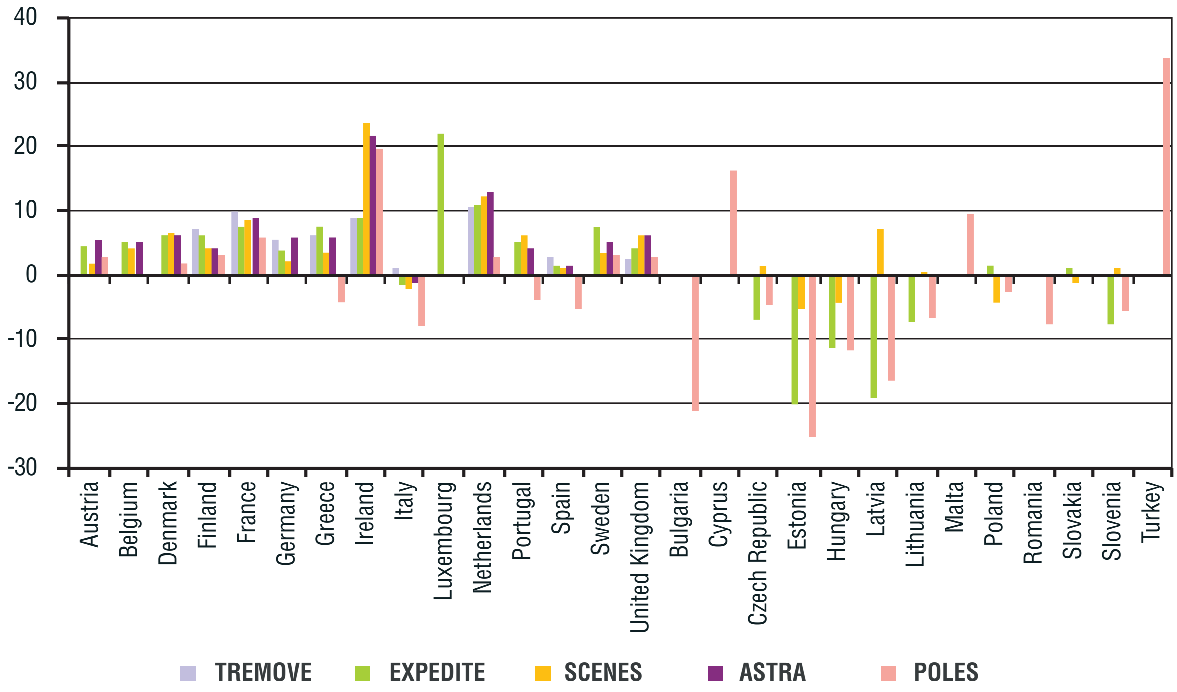


Figure 4.4: % growth population 1995-2020.



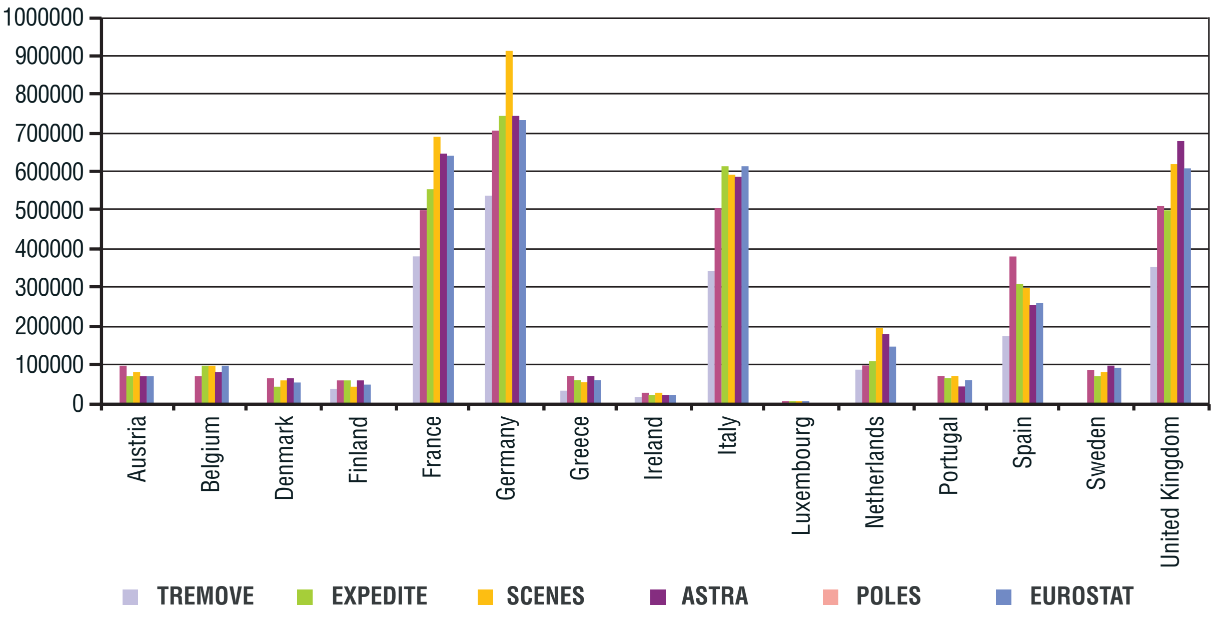
considerable differences are noted, in general in Accession Countries a decline in population is expected. The POLES model expects for a number of EU countries a slight decline in population. For Italy in all models a decline is included, except for TREMOVE. Also here, like for GDP, the population development is endogenous in ASTRA. It is interesting to note that the ASTRA projection lies within the range of projections as used exogenously in other models.

4.2.3 *Passenger kilometres*

The policy indicator passenger-kilometres is an endogenous output of most models. In figure 4.5 the volume of passenger-kilometres is given for transport by passenger cars for 1995 in the EU. In figure 4.6 this figure is given for the Accession Countries. It is interesting to note that the average kilometres travelled for the Netherlands within the models TREMOVE, EXPEDITE, SCENES, ASTRA, EUROSTAT, is respectively[5] 5634, 6983, 12557, 11590, 9250 kilometres per year for private car transport. In the table 4.5 it can be observed that TREMOVE is for all countries on the lower end in number of passenger kilometres. It should further be noted that EUROSTAT is on the higher end, this is the "official figure" as reported by the member states. However most countries do not have a census for passenger transport performance, so results of EUROSTAT should not be given a higher weight to. The SCENES model is in most cases higher or similar to EUROSTAT, ASTRA is for most cases in line with EUROSTAT. It should be noted that geographical definitions are not really important here since a majority of passenger kilometres is made within the boundary of the national territory (unlike freight where a large part of tonne kilometres is made internationally).

The growth pattern as shown in figure 4.7 for the period 1995-2020 gives a varying result. ASTRA is the highest in its prediction of passenger kilometre transport growth (notably Ireland shows a growth of about 250%). It is interesting to see that for Ireland SCENES and ASTRA produce more or less a similar growth of GDP (see table 4.2, GDP is one of the drivers of transport growth), but that the outcome in terms of passenger car transport growth is quite different (SCENES shows a growth of about 65%). Further, the EXPEDITE model shows the lowest growth of all 4 models that provide passenger car kilometre projections[6]. TRENDS as a result from time series takes a position between EXPEDITE and SCENES.

Figure 4.5: Passenger kilometres 1995 Car (mln).



5 Number of passenger kilometres divided by population (table 4.5 divided by table 4.3).

6 Both for 1995 and for the projections one should keep in mind that EXPEDITE pkm are for trip distances up to 160 km.

Figure 4.6 : Passenger kilometres 1995 Car (mln).

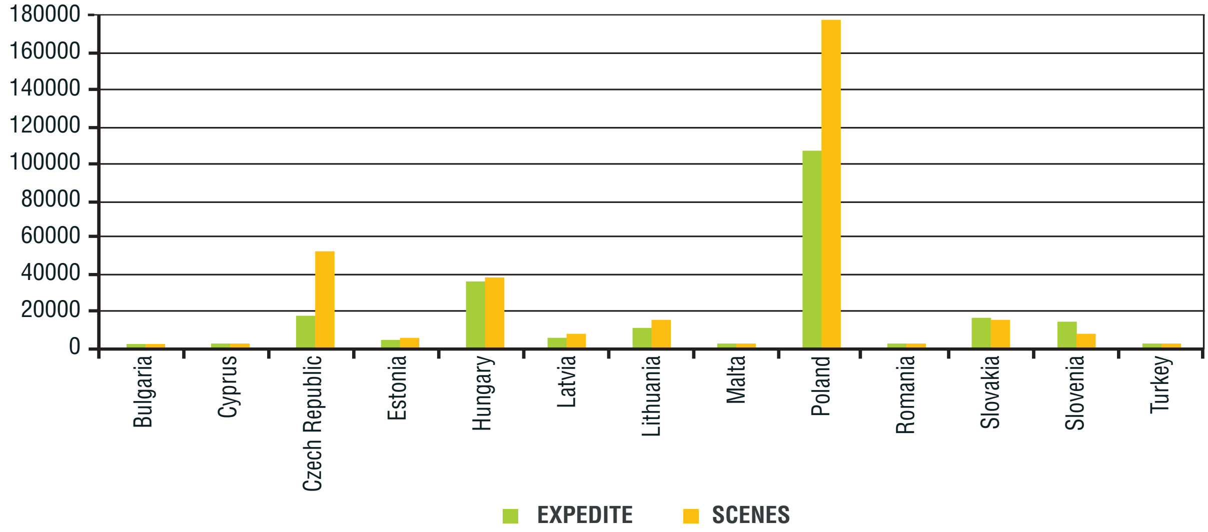
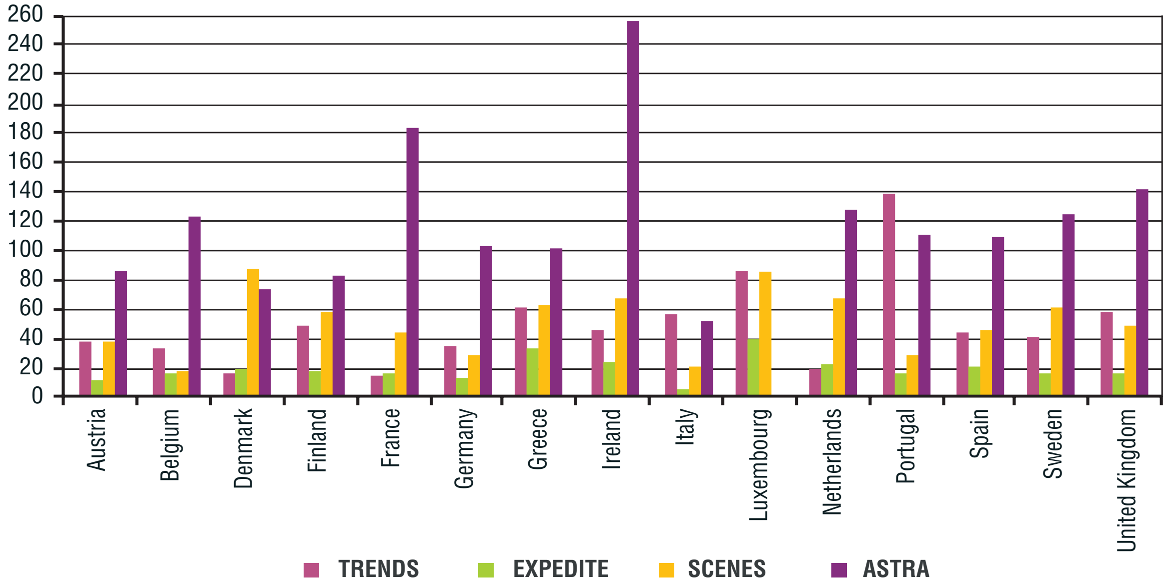


Figure 4.7: % Growth Passenger kilometres Car 1995-2020.



4.2.4 Freight tonne kilometres

In figure 4.8 the volume of tonne kilometres is given for road, rail and inland waterways together for 1995. The TRENDS model has significant higher values for tonne kilometres than the other models. The EXPEDITE, SCENES and ASTRA cluster around the value of EUROSTAT. It should be noted that for Accession Countries, SCENES only provides tonne kilometres for movements to or from the Western European countries but not for the domestic traffic within the country. EXPEDITE uses the values as reported by NEAC for Accession Countries.

In figure 4.9 the projections are given for the period 1995-2020. It can be observed that for most countries ASTRA provided the highest projections and TRENDS the lowest. SCENES in its turn provides higher growth rates than EXPEDITE.

In figure 4.10 and 4.11 the tonne kilometres for road freight transport for 1995 and the growth for the period 1995-2020 are given. In figure 4.10 it can be observed that TRENDS is in most case significant higher than for other models for 1995.

The divergence between the forecasting results from the models for road freight is considerably higher than for road passenger (compare 4.6 with 4.10). The average growth level for freight is considerable higher than for passenger transport in road transport (respectively 80% to 50%). For freight transport of all inland modes together the same growth pattern as for road transport solely is observed, not surprisingly since the road transport is the dominating mode within inland freight transport.

Figure 4.8: Freight Tonne km 1995 (mln) road, rail, iww tkm combined together.

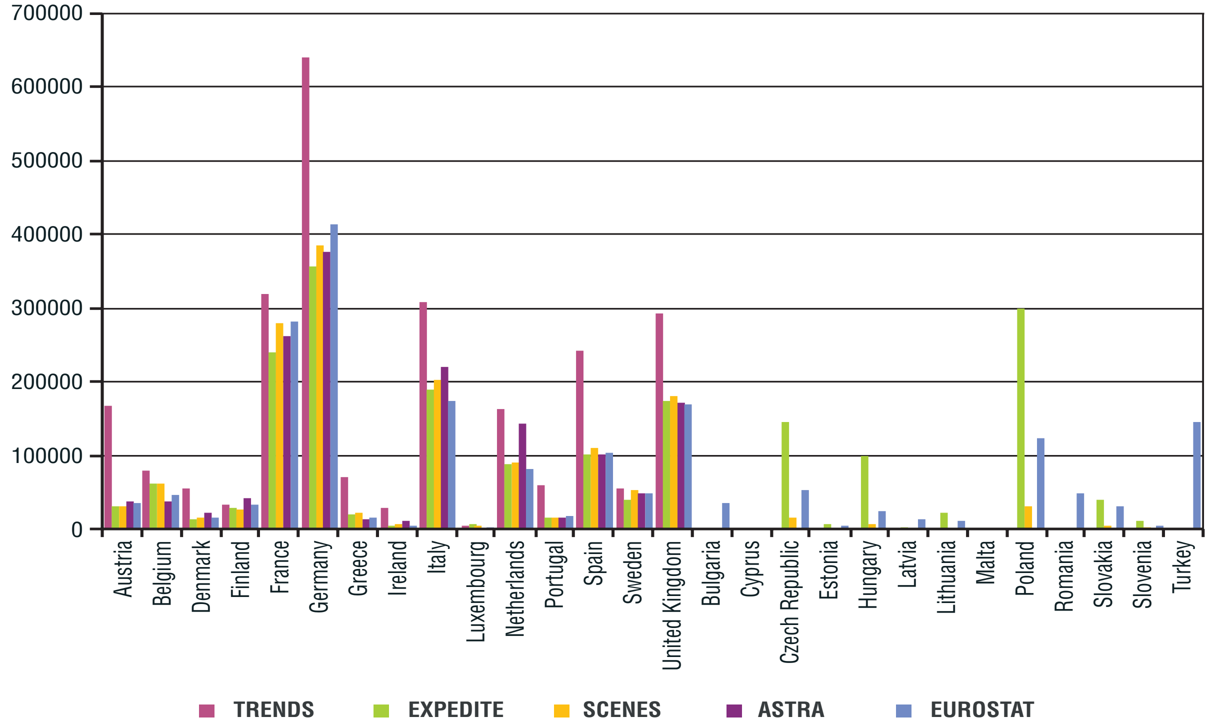


Figure 4.9: %Growth Freight Tonne km 1995-2020 road, rail, iww combined together.

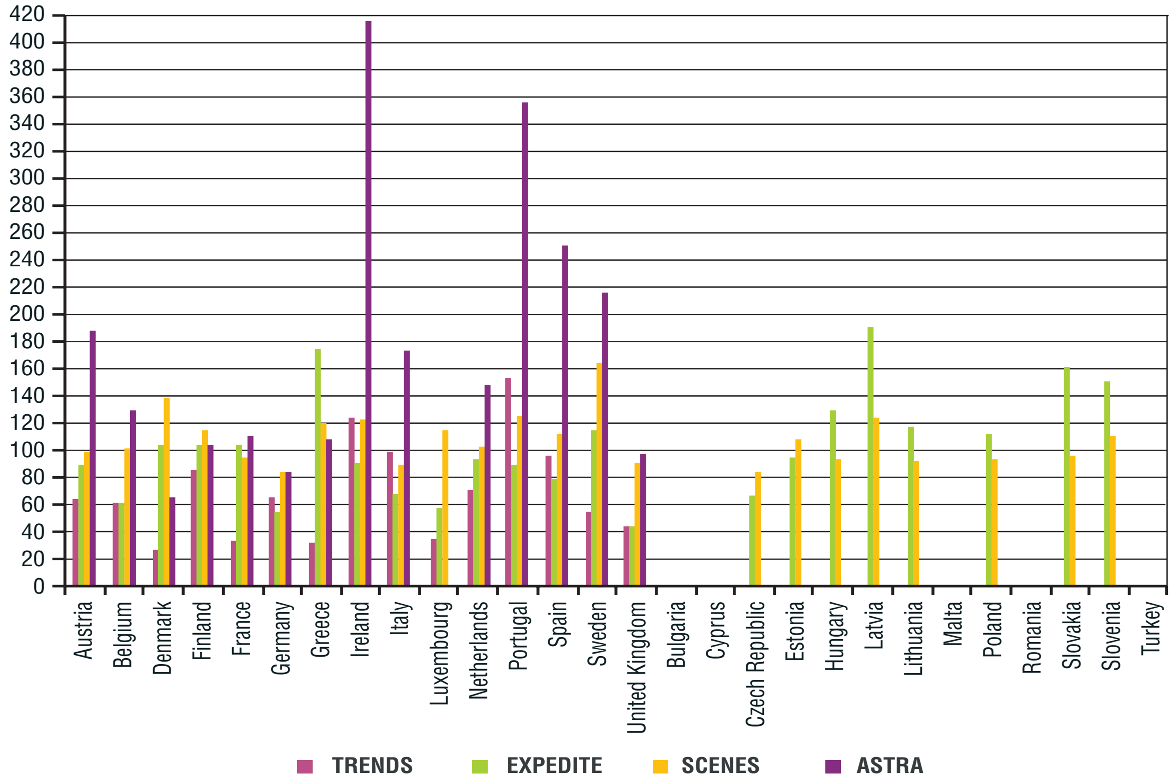


Figure 4.10: Freight Tonne km 1995 (mln) road.

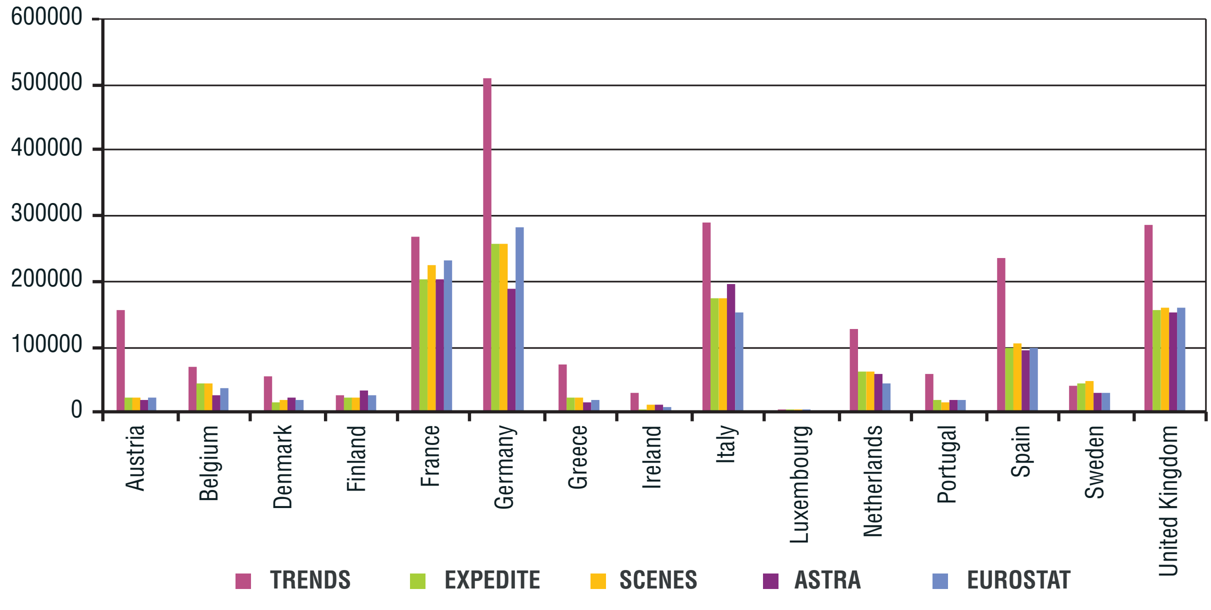
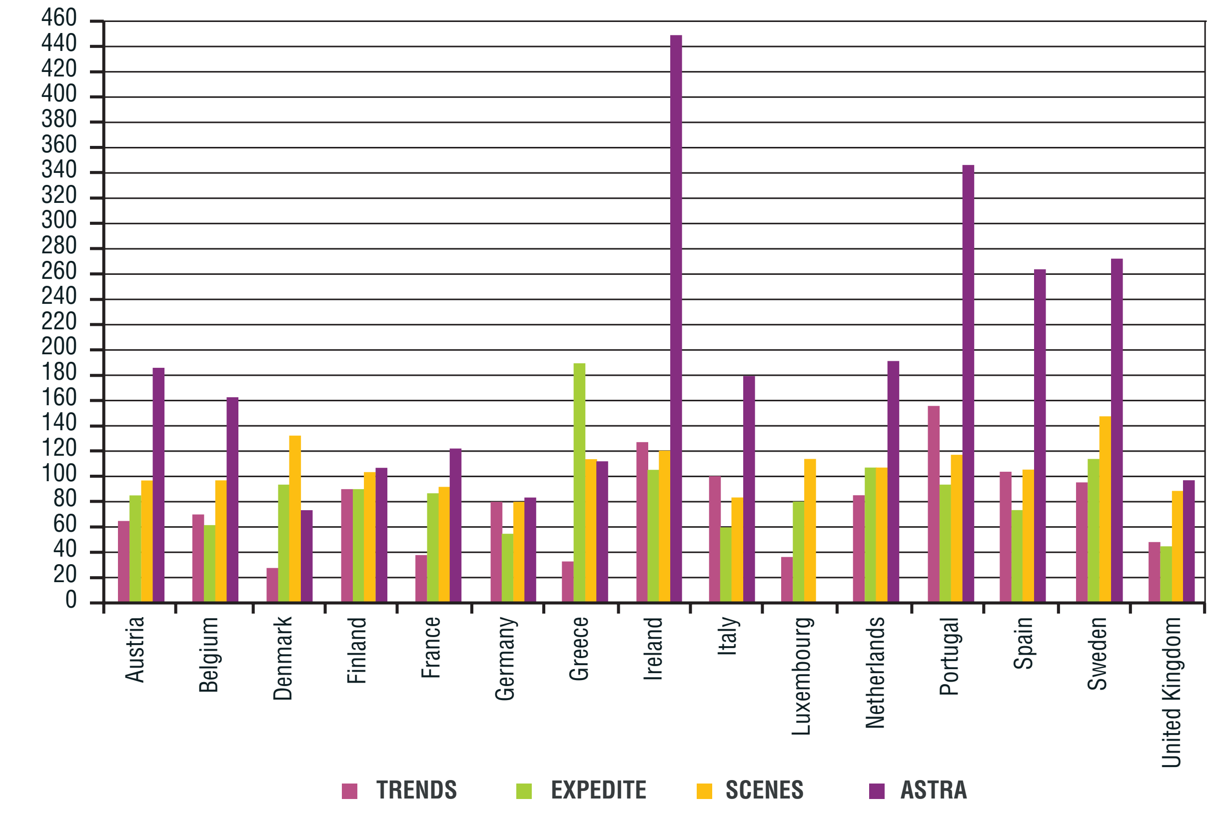


Figure 4.11: % Growth Freight Tonne km 1995-2020 road.



4.2.5 Passenger vehicle kilometres

In figure 4.12 and 4.13 a comparison is made for 1995 model inputs for passenger transport in terms of vehicle kilometres of private car, figure 4.12 shows the EU member states and 4.13 the Accession Countries. The 1995 data shows more or less comparable inputs with some variance for the larger countries (France, Germany, Italy, UK and Spain). For all countries the POLES model is on the lower end compared to other models.

Figure 4.14 show the growth in the period 1995-2020, POLES, TRENDS and TREMOVE show higher growth rates for the vehicle kilometres, than other models. This is remarkable since these 3 models are not very detailed transport models designed for providing detailed forecasts through time. In general the occupancy rate does not vary much, so vehicle km and passenger km projections should be similar (compare 4.13 with 4.6). The growth rates projected by most of the models are comparable except for the ASTRA model where kilometre projections are significantly higher than passenger kilometre projections.

Figure 4.12 : Passenger Vehicle km 1995 (mln) Car.

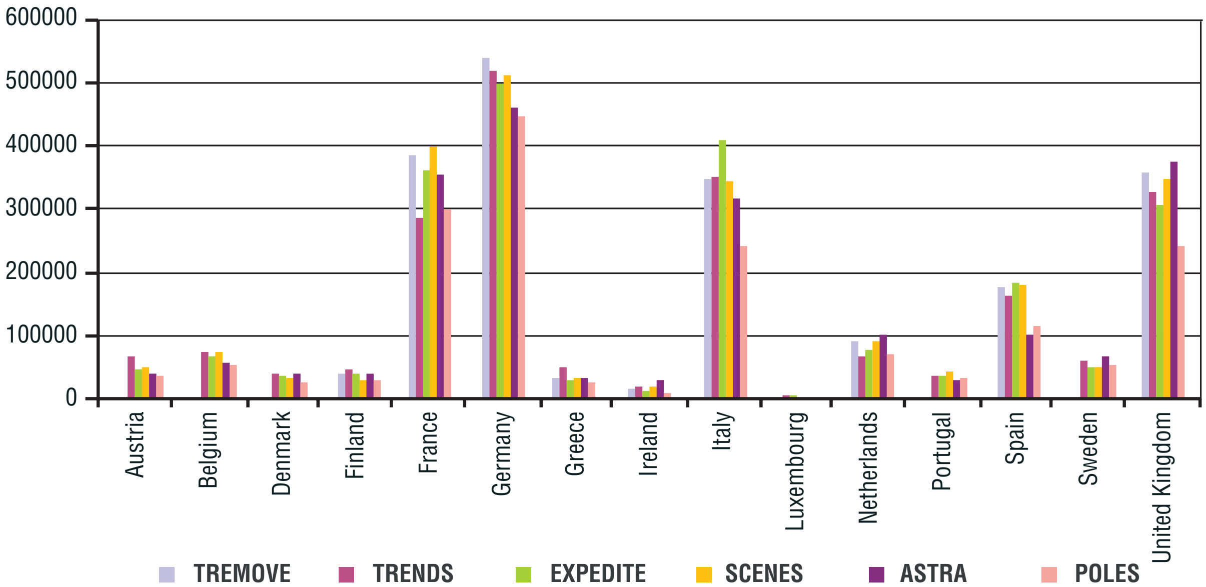


Figure 4.13 : Passenger Vehicle km 1995 (mln) Car.

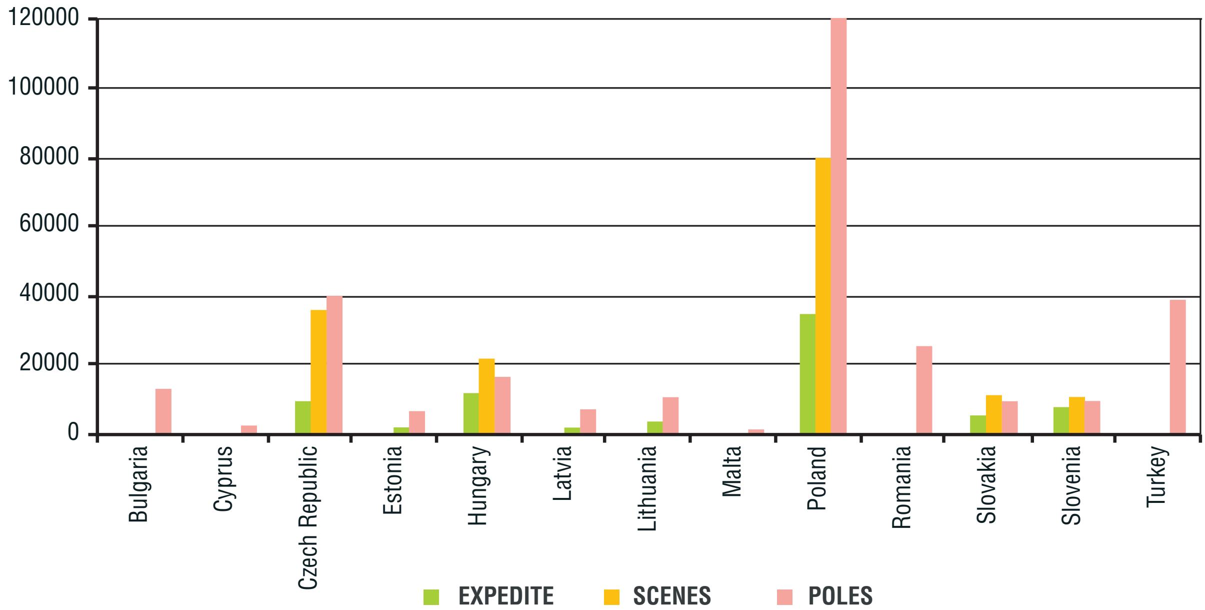
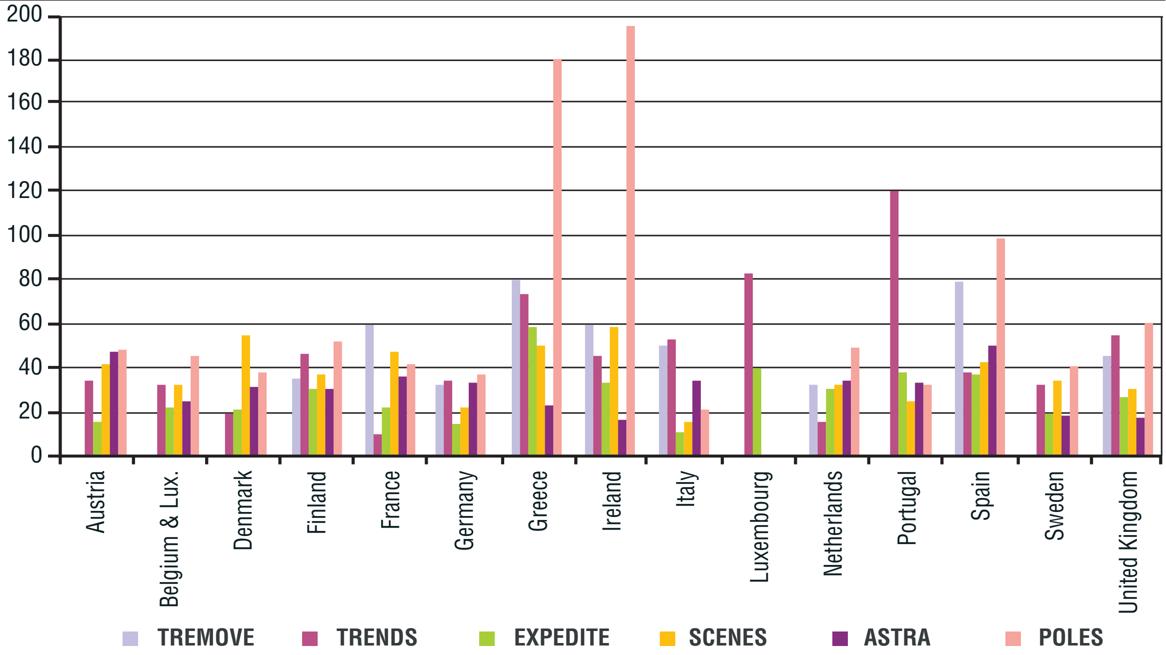


Figure 4.14: % Growth Passenger Vehicle km Car 1995-2020.



4.2.6 Freight vehicle kilometres

In figure 4.15 the vehicle kilometres for road freight transport in 1995 is given and in figure 4.16 the growth of freight vehicle kilometres in the period 1995-2020 is given. The relation with tonne kilometres is the average load factor of a vehicle (including empty vehicles), depending on factors such as international and domestic transport the load factor is about 7 tonnes to 10 tonnes per vehicle for respectively domestic and international transport. This should in general be the relation between tonne and vehicle kilometres, in addition it could be that different logistical developments are included: i.e. smaller/larger consignments, longer distances from production to consumption. In comparing figure 4.16 with 4.11, it is the case that for the TRENDS model the vehicle kilometre projections are similar to the tonne kilometre projections. For all other models the tonne kilometres projections are higher than the vehicle kilometre projections, which means that consignment sizes and/or vehicle sizes.

Figure 4.15: Freight Vehicle km 1995 (mln) Road.

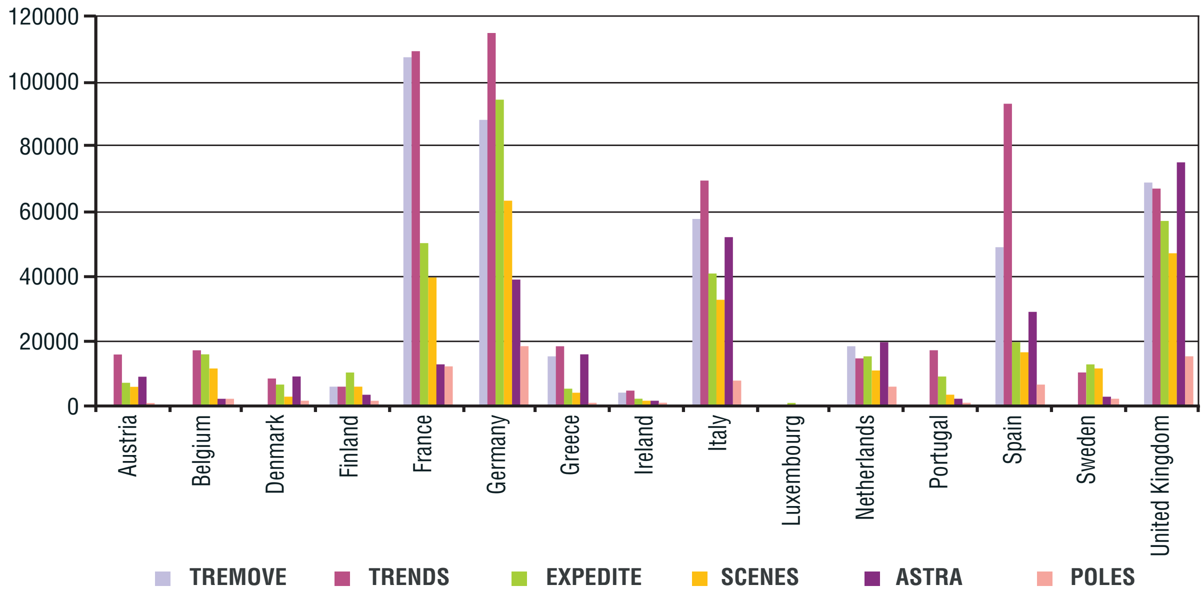
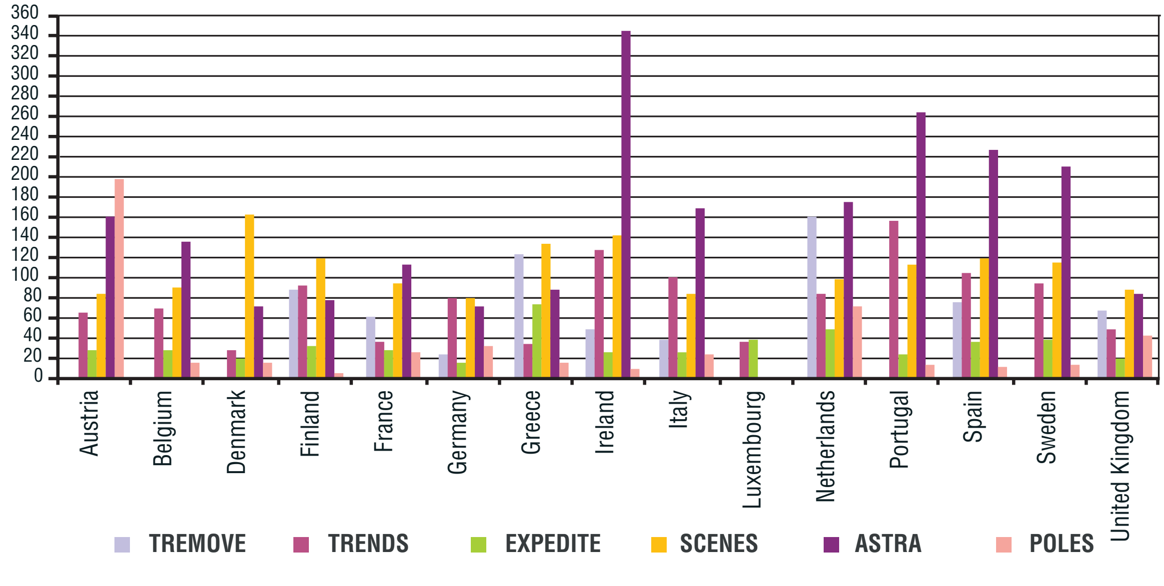


Figure 4.16: % Growth Freight Vehicle km Road 1995-2020.



4.2.7 Vehicle stock

The number of private vehicles registered in each country in 1995 is shown in figure 4.17. In general this is a figure obtained from vehicle registrations and there should not be any difference between the models. As can be observed most figures do not coincide exactly but are to a large extent in line with the official EUROSTAT figure.

The growth of the vehicle stock in the period 1995-2020 is shown in figure 4.18. Notably in the Accession Countries a higher growth of the number of private cars is anticipated and further in Spain, Portugal, Greece and Ireland a higher growth of the vehicle stock is expected.

Figure 4.17: Vehicle stock, #private cars registered in 1995.

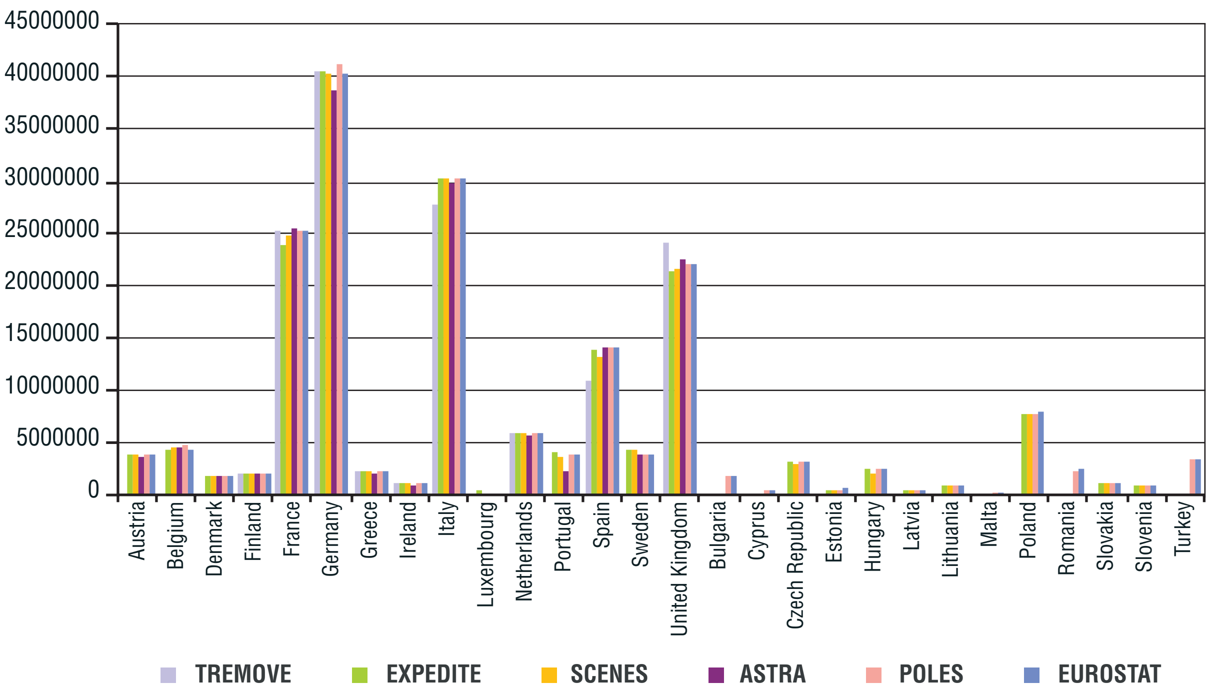
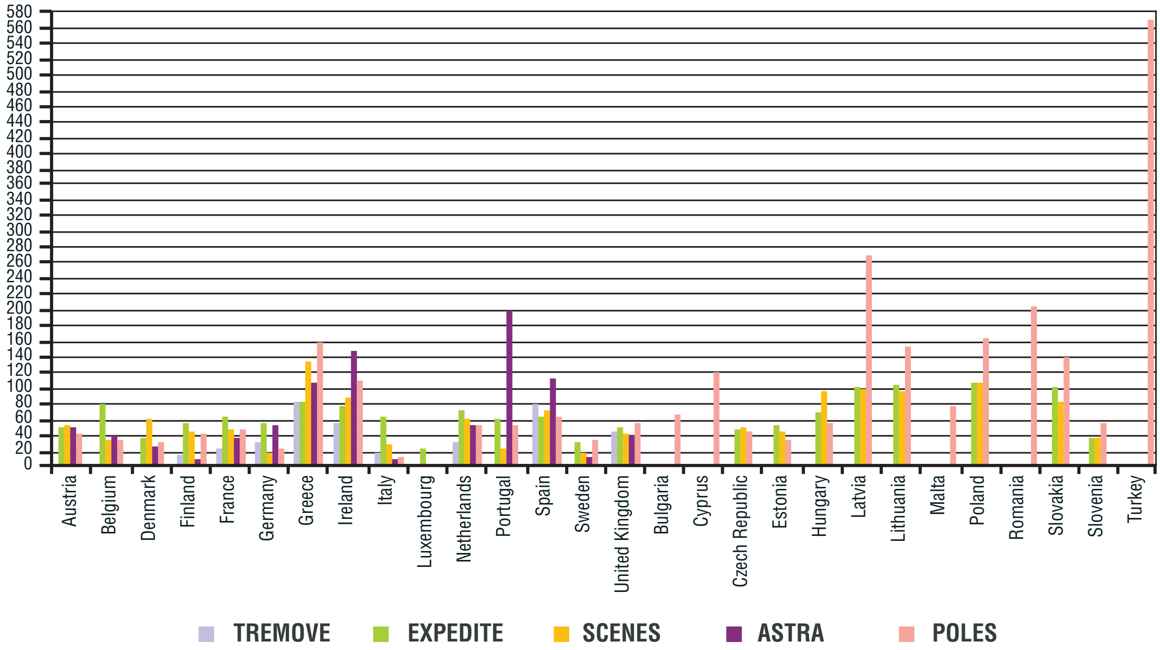


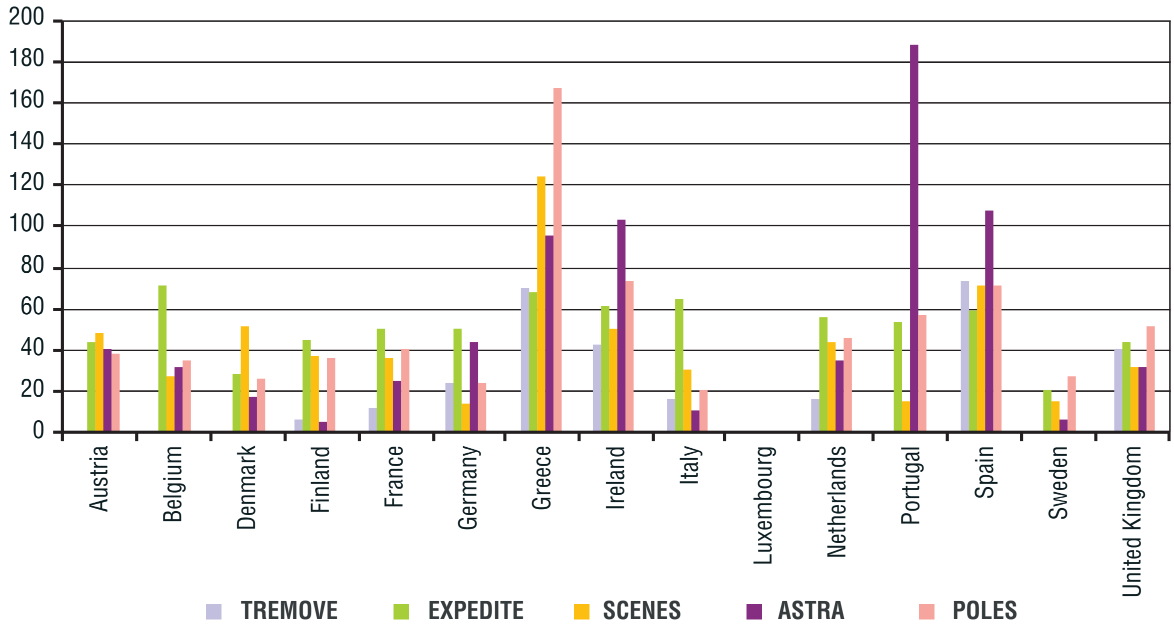
Figure 4.18: % Growth of vehicle stock 1995-2020.



4.2.8 Car ownership

In figure 4.19 we have only included the growth of car ownership (defined as number of vehicles per 1000 inhabitants) in the period 1995-2020 (this relates to population growth and the growth of the vehicle stock, see figure 4.4 and figure 4.18). As the population increases quite slowly and the vehicle stock is increasing, it means that on average the car ownership will increase.

Figure 4.19: % Growth of car ownership 1995-2020.



4.2.9 *Emission*

In figure 4.20 and 4.21 respectively the CO_2 emissions related to passenger and freight transport activities (measured in tonne emission) for 1995 and the growth of CO_2 emissions in the period 1995-2020 are given.

With respect to figure 4.20 there is quite some variability in what the models use as baseline for 1995. In most cases ASTRA is on the high end with its values for 1995. All other models cluster around the official figures from EUROSTAT for most countries.

One can say that the growth varies quite significantly with the model used. TRENDS and ASTRA produce a similar growth pattern. POLES is the only model that produces CO_2 projections for Accession Countries, these are considerably higher than for Western Europe, this has off course to do with the growth of transport in these countries. TREMOVE on average predicts the lowest increase of CO_2.

Figure 4.20: CO2 emissions 1995 (tonne).

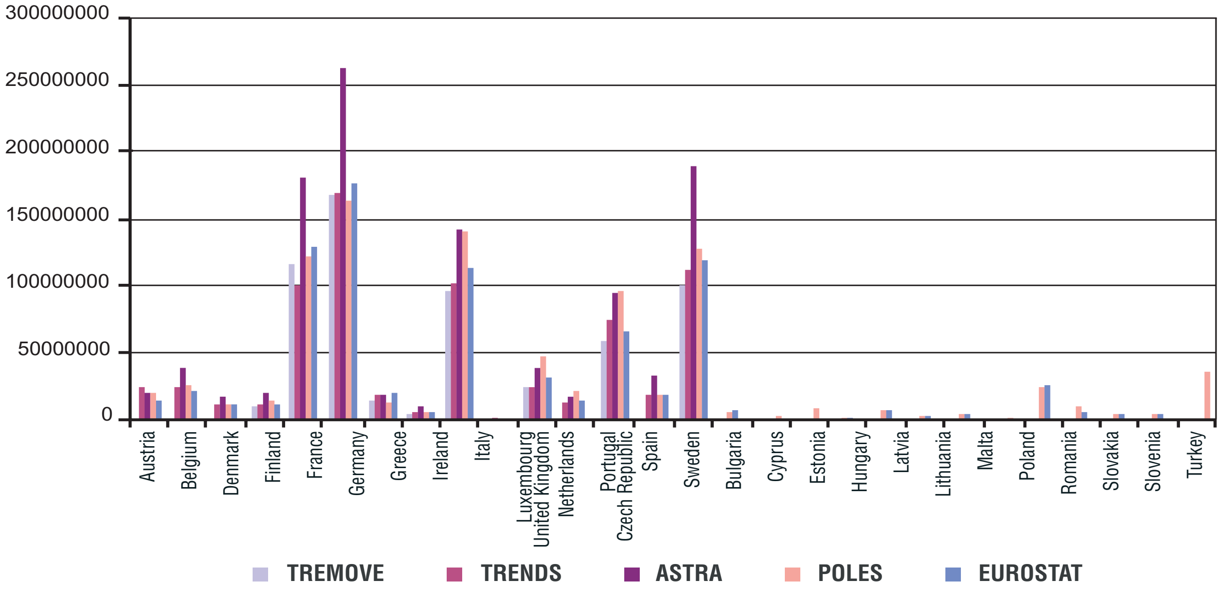


Figure 4.21: % Growth CO2 emissions 1995-2020.

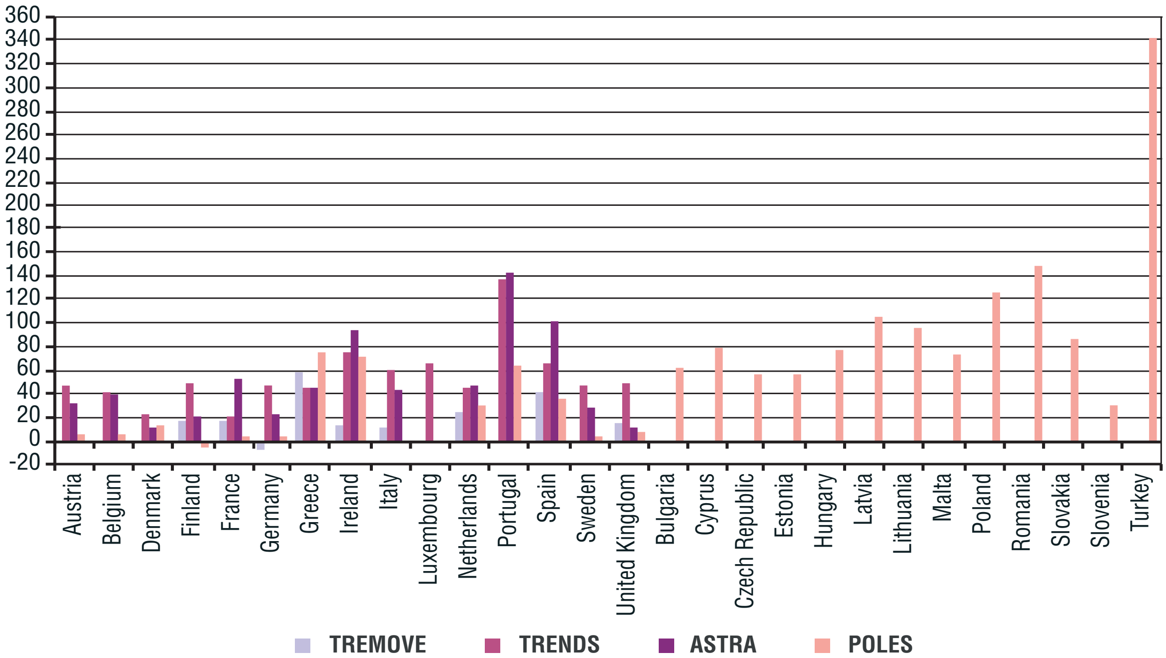


Figure 4.22 and 4.23 respectively give the NO_x emissions related to passenger and freight transport activities (measured in tonne emission) for 1995 and the growth of NO_x emissions in the period 1995-2020. ASTRA in general uses higher figures for 1995, TREMOVE has for most countries the lowest input.

In terms of growth of NO_x emissions, all models predict a decrease of NO_x emissions. TREMOVE predict the largest decrease due to the fact that technology improvements are included (similar to why CO_2 emissions are lower in TREMOVE than other models).

Figure 4.22: NOx emissions 1995 (in tonne).

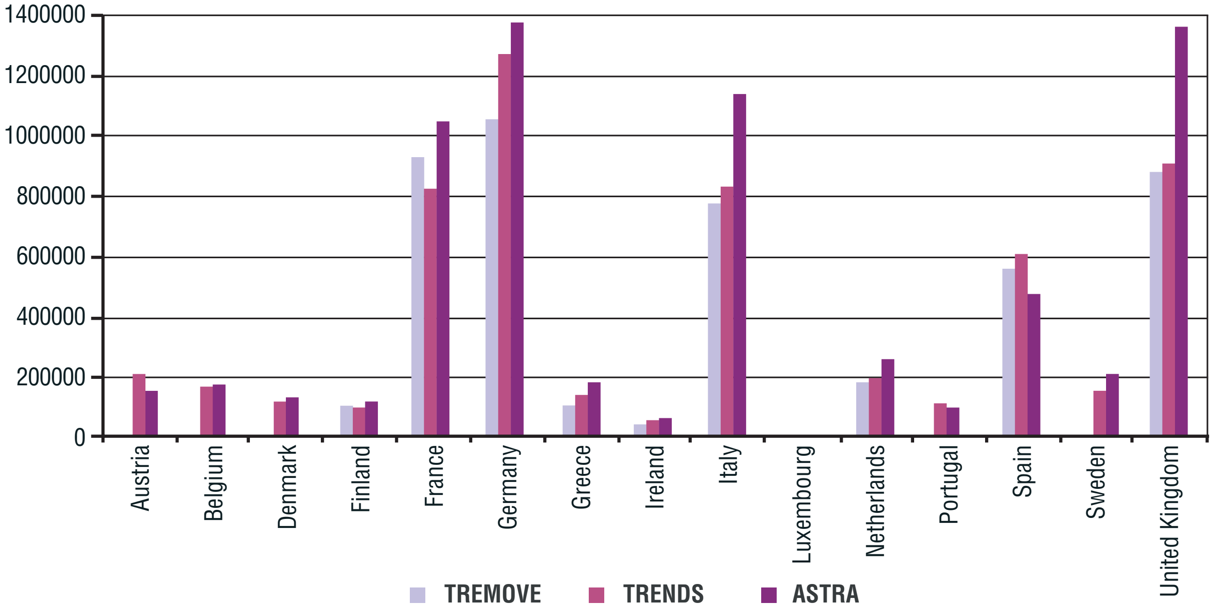
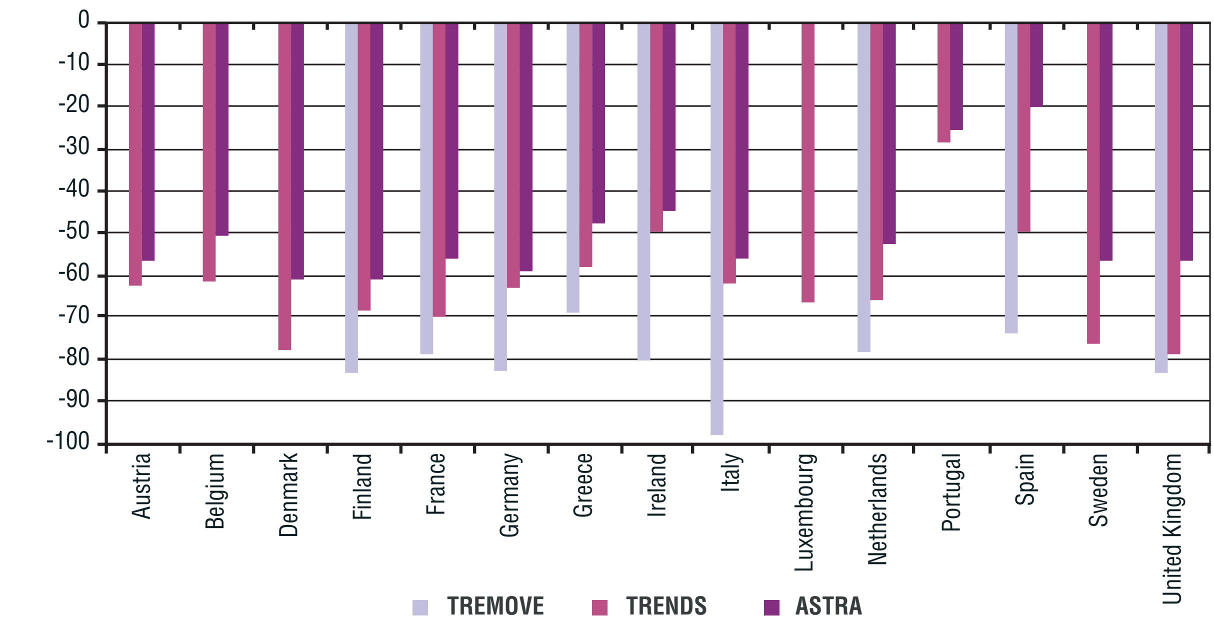


Figure 4.23: % Growth NOx emissions 1995-2020.



4.3 Conclusion

All models analysed in this chapter vary with respect to the model input and to the outcome of the forecasting procedure included in the models. In a broad sense one can say that forecasted trends in most cases show the same direction. The extent to which the difference in the outcome of forecasts is explained by differences with respect to different input data (i.e. differences with respect to GDP growth, population growth), could not be established within this study. However for a large number of Western European countries the GDP growth is quite similar (see figure 4.2) which should give a good basis for comparing the model results. In developing the blueprints it was assumed that models would fit and that the results they produce would be in a comparable domain. It is interesting in this respect to see that the endogenous obtained GDP from ASTRA lies within the range of other models.

For 1995 the TRENDS and EUROSTAT functioned as a reference for the models because EUROSTAT reports what member states report on this issue. TRENDS was thought to be in line with EUROSTAT but on some issues substantial differences occurred. Further for projections TRENDS is interesting to compare with other models, since it produces forecast on the basis of time series (with time as the only explanatory variable). Other models aim at reproducing behavioural aspects in order to try to give a representation of decision processes within transportation. The best example is figure 4.22 on the previous page where TREMOVE includes in its forecast the development of vehicle technology which in its turn leads to lower NO_x emissions. In general, the consideration of technological change and innovation in transport models (including the ones taken into account in this report) seems to be underdeveloped, both in terms of using forecasted changes in technological performance parameters and in terms of endogenising key innovation mechanisms in the models themselves (e.g. interdependencies between vehicle technology development and infrastructure development). For policy makers it is good to know about the determining factors that influence the behaviour, so that they can develop adequate policies. In this sense TRENDS is not really satisfactory because it doesn't give an explanation of driving forces. Besides, the aim of ESTO is to provide a richer explanation for phenomena by linking models.

It should be noted that ASTRA plays a pivotal role in the blueprints as a model that incorporates feedback processes where economy has an influence on mobility and more important vice versa, a feature which is lacking in other models. Nevertheless the growth of freight tonne- and passenger kilometres are significantly higher for ASTRA than other models (e.g. reflecting the strong growth of trade for all countries and of car ownership for some countries like Ireland). It should be noted that ASTRA is a system dynamic model that includes dynamic formulations. One of the critiques is that it doesn't comprise a market mechanism wherein changes of demand are levelled out through price changes. An argument against equilibrium thinking is that it is never attained and disturbances as well as structural changes always occur.

All in all the best comparison would have been obtained if all exogenous input data was similar for all models. ETIS BASE (an FP5 project) is aiming at this goal. When results of ETIS BASE are available it would be fruitful to rerun the models and then carry out an extensive comparison.

5 Conclusions and recommendations

The objective of the project "Policy Support Tools for Transport Issues" was to contribute to the in-house capacity of the European Commission in terms of operational models and tools to support transport policy. The work focused on the further development of strategic transport models that are already available to the Commission services, notably models that have been developed under 4th and 5th FP projects.

The project examined the main characteristics of each model and identified their main strengths and weaknesses in addressing specific policy issues. It compared their data requirements and output, and validated their results through a comparison of their projections with official statistics. The analysis suggested that a combination of the various models allows an integrated analysis of several complex policy issues. The model developer team agreed on a methodology to analyse five main policy areas, and defined the operational procedure. The resulting 'blueprints' form the basis for a policy support tool able to capture many direct and indirect impacts of transport and provide useful information for impact assessment in the field of EU transport policy.

5.1 Conclusions

The analysis carried out in this project provides evidence that the application of the available models at EU level can provide additional policy support tools. Even though each model has been developed independently in order to address specific issues, the seven models analysed cover between them the main requirements for support of EU transport policy. Apart from the analysis of the main transport issues and the direct impacts of policy measures on transport volumes, the models allow an integrated analysis that encompasses most indirect impacts of transport. In terms of impact assessment, the model combinations potentially allow (if this is really possible is outside the scope of this study):

- The identification of the types of environmental, economic and social impacts
- The identification of distributive effects, 'winners' and 'losers'
- The measurement of impacts in qualitative, quantitative and, where appropriate, money terms
- The comparison of impact in terms of cost-effectiveness, cost-benefit and multi-criteria analysis
- The consideration of risks and uncertainties inherent in policy choices
- The assessment of the medium to long term impacts of Trans-European Networks

Conducting an integrated analysis (by means of using the proposed blueprints for linking European transport models) means one should aware of the following issues:

- Linking models in order to answer specific policy issues and to extend the range of outcomes of the models is useful. However, when dealing with (global) issues that have a widespread effect in different markets, it is useful to link models so that complexity of the "real world" is well represented in policy analysis where necessary.
- By linking two or more models it is possible to benefit from the strong sides of the models and get around weaker sides. 'Linking'; means that the outputs of one model are used as inputs of another model.
- In linking models we should be aware of the differences in the nature of the models. Especially important in application here is the difference between dynamic models (ASTRA, TREMOVE and POLES) and long-term equilibrium models.
- In linking models by using one model's outputs as another model's inputs, inconsistencies can

arise. A number of conversions (dimensions, currency, price level, spatial aggregation) may be required initially, before the output of model A can be read in by model B.

From the scientific point of view, the project has also contributed to the improvement of available tools. It has assisted the various model development teams in identifying their common data needs and has facilitated the exchange of results and information. Most importantly, it has carried out a preliminary evaluation of the models as policy support tools and has validated their results for selected variables. The analysis suggests that, in principle, the combination of the seven models covered meets the main criteria for good practice of assessment techniques:

- Transparency: the estimation of the impacts of policy measures related to transport using the available models is clear, at least to other developers of models. The publication of additional reports and/or peer reviewed articles would certainly help in improving the policy makers' understanding of their principles, their strengths and their limitations.
- Reproducible results: the convergence of the results of the various models suggests that the main modelling methodologies applied lead to reproducible results; the main problem lies in the use of different data, a factor that explains a large part of the differences between their results.
- Robustness: using different methods or assumptions to estimate impacts leads to comparable results. The comparison of the results of the different models suggests that at least the identification of trends is reliable, since most projections tend to coincide. Differences have been mainly found for small countries, or where data availability was limited.

Improvements are still necessary however. Models are constantly improved, but the limited availability of published statistics hinders their further development, their possibilities for cooperation and the possibilities for an objective evaluation of their results. A possible solution to this problem would be the development of a common information system that would provide all models with the same input data, allow them to exchange information and publish their results.

It can also be argued that a distributed model development and maintenance is preferable to the centralised development of a single model covering all issues. Experience in this and other projects show that cooperation between models is feasible, and that the healthy competition between independent developer teams leads to mutual improvements. It seems therefore that investment in smaller, flexible and specialised models can bring better results than concentrating all efforts in attempting to develop a global model.

Cooperation with model developers and authorities at national, regional and local level would also improve the quality of European models and their acceptability as policy support tools. The provision of harmonized statistics at national level is fundamental for the reliable simulation of transport in each country; a linkage with national models –where available- would also probably improve the accuracy of projections. The exchange of best practices between modellers and analysts is also desirable, especially with respect to the new EU member states.

The conclusions that could be drawn from this study are based on a fruitful and professional cooperation between the project partners. During the project the partners had a useful workshop in which, in a very open and informal way, debates had been organised to identify possibilities to answer multiple policy issues with existing transport models. Experience of the project shows that model developers speak "the same language" and are able to communicate with each other. In fact all felt that this was one of the very few times that one could discuss in a focused way about models and model results, and this has led to an exchange of experiences. In addition, a workshop with the European Commission was organised. Finally, a representative of the project team had attended a meeting of the ETIS project, in which he has presented the preliminary results of this study. From this presentation it became clear that also the members of the ETIS project were intrigued by the idea of linking European transport models and providing data linkages, instead of having one "mother of all models" that is covering all aspects.

5.2 Recommendations

The blueprint exercise as has been conducted in this study is mainly a theoretical exercise. It is necessary to work out at least one of the blueprints in a case study. Preferably the blueprint on *Energy policies and emission standards* should be worked out in a follow-up project. The reason for this is that energy policies and emission standards will become more important in the (near) future at an EU level (see one of the targets mentioned in the White Paper that is indicating that in 2020 a 20% share of substitute fuels is to be attained). Further this blueprint is an interdisciplinary case as it is dealing with price forming on energy markets. Finally, this blueprint is less risky in terms of political sensitivity[7] compared to the blueprints in which network models play a more important role.

Harmonising the study results with ETIS-BASE is very useful in terms of the scenarios used and the analysis of the similarity of the inputs to models so that comparable outputs could be obtained. However, this study shows that there are still substantial differences with relation to input data. This shows the need for carrying out the ETIS-BASE project. Moreover, this study has given the relevant dimensions and policy variables from models. The ETIS-BASE project could include this list (in so far it is not already covered).

Adopting a common European baseline could overcome the differences with relation to input data. A full description, that is easily available for users, of how the passenger and freight data, published by Eurostat in *Transport in Figures* and elsewhere, has been collected, processed and adjusted for each country is useful. Without clarity of these definitions it is difficult to know which differences in model inputs from published European sources are serious and which are less so. The ETIS project is a first starting point for this at it is describing the methodology used to come from a data collection set of several (European) databases to the developed reference database.

This study has shown that Accession Countries are still a major problem in terms of data and modelling. ASTRA and TREMOVE have not yet projections on transport variables for these countries and other models have not included the data of all Accession Countries on some variables (e.g. for EXPEDITE and SCENES data of some Accession Countries are lacking for passenger kilometre). Therefore ETIS BASE is a relevant study as this project will work towards building a consensus view of the reference pan-European transport modelling set.

In this report the focus has been on how to update input and output data of transport models. However, it is also important to compare the behaviour of the models (elasticitys for example), as the behaviour of the models is an important indicator for the output of the model. As shown in chapter four, growth patterns between models differ substantially. This difference is not only caused by the exogenous inputs of the model, but also by assumptions on the behaviour of people in certain cases.

Finally, it is recommended to create a combination with national models in order to be more specific on detailed corridor developments. A European transport model, such as EXPEDITE or SCENES, does not provide the necessary level of detail as is expected for project evaluation (e.g. the costs and benefits of building a specific terminal).

7 If one focuses on networks there is usually a strong involvement of national authorities at a detailed level, so if one small error occurs, member states loose their confidence quickly, therefore a blueprint at an aggregated level is a better example to start with.

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About ESTO

The European Science and Technology Observatory (ESTO) is a network of organisations operating as a virtual institute under the European Commission's – Joint Research Centre's (JRC's) Institute for Prospective Technological Studies (IPTS) - leadership and funding. The European Commission JRC-IPTS formally constituted, following a brief pilot period, the European Science and Technology Observatory (ESTO) in 1997. After a call for tender, the second formal contract for ESTO started on May 1st 2001 for a period of 5 years.

Today, **ESTO is presently composed of a core of twenty European institutions**, all with experience in the field of scientific and technological foresight, forecasting or assessment at the national level. These nineteen organisations have a formal obligation towards the IPTS and are the nucleus of a far larger network. Membership is being continuously reviewed and expanded with a view to match the evolving needs of the IPTS and to incorporate new competent organisations from both inside and outside of the EU. This includes the objective to broaden the operation of the ESTO network to include relevant partners from EU Candidate Countries.
In line with the objective of supporting the JRC-IPTS work, ESTO **aims** at detecting, at an early stage, scientific or technological breakthroughs, trends and events of potential socio-economic importance, which may require action at a European decision-making level.

The ESTO **core-competence** therefore resides in prospective analysis and advice on S&T changes relevant to EU society, economy and policy.

The **main customers** for these activities is the JRC-IPTS, and through it, the European policy-makers, in particular within the European Commission and Parliament. ESTO also recognises and addresses the role of a much wider community, such as policy-making circles in the Member States and decision-makers in both non-governmental organisations and industry.

ESTO members, therefore, **share the responsibility** of supplying IPTS with up-to-date and high quality scientific and technological information drawn from all over the world, facilitated by the network's broad presence and linkages, including access to relevant knowledge within the JRC' Institutes.

Currently, ESTO is engaged in the following **main activities:**

- A series of **Specific Studies**, These studies, usually consist in comparing the situation, practices and/or experiences in various member states, and can be of a different nature a) *Anticipation/Prospective analysis*, intended to act as a trigger for in-depth studies of European foresight nature, aiming at the identification and description of trends rather than static situations; b) *Direct support of policies in preparation* (ex-ante analysis); and c) *Direct support of policies in action* (ex-post analysis, anticipating future developments).
- Implementation of **Fast-Track** actions to provide quick responses to specific S&T assessment queries. On the other hand, they can precede or complement the above mentioned Specific Studies.
- To produce input to **Monitoring Prospective S&T Activities** that serves as a basis of experience and information for all other tasks.
- ESTO develops a "**Alert/Early Warning**" function by means of Technology Watch/Thematic Platforms activities. These actions are putting ESTO and JRC-IPTS in the position to be able to provide rapid responses to specific requests from European decision-makers.
- Support the production of **"The IPTS Report"**, a monthly journal targeted at European policy-makers and containing articles on science and technology developments, either not yet on the policy-makers' agenda, but likely to emerge there sooner or later.

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