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REFIT

Refinement and test of sustainability and tools with regard to
European Transport policies

Deliverable 7:
Final report of the REFIT project

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Executive summary

Introduction

The objective of the REFIT study is to provide a set of sustainability indicators for assessing the effect of various policies/packages of priority interest through state-of-art models at European scale. The challenge was therefore to develop, test and validate a "modelling tools-based" methodology that produces data on a set of identified indicators and that enables *ex-ante* evaluation of the European Common Transport Policy considering the economic, environmental and social dimensions of sustainability.

The objective op WP 7 is to make a synthesis of the results of the previous work packages in an integrated assessment framework that enables transport policy makers to address impacts on sustainable development issues in their economic, environmental and social dimensions.

The methodology described in this deliverable clarifies how the different pieces of the analysis are linked together in the REFIT operational framework. Besides the developed framework recommendations for further research, adjustments and improvements that can be made in future updates within the REFIT framework are provided. Indicators that are not addressed yet are elaborated and pathways for further development are sketched.

In a meeting with the EC in Brussels on September 11, 2008, the application of REFIT framework has been discussed. The findings of this discussion have been used as input for this deliverable.

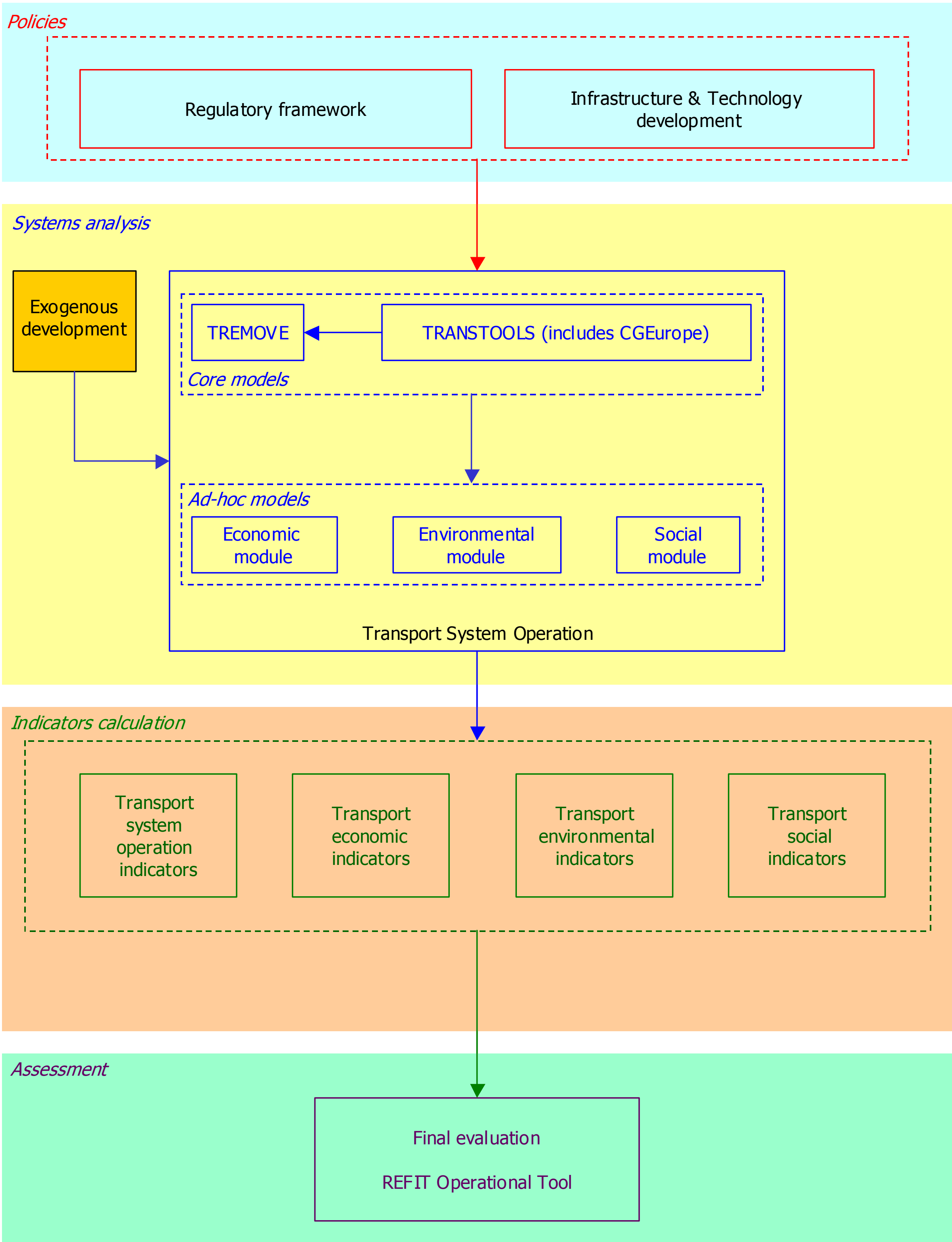
The REFIT operational framework

The REFIT operational framework is aimed at producing a set of forecasting indicators for the assessment of European Transport Policies sustainability. The main components of the framework are included in four main areas as shown in the picture on the next page.

The "Policy" area

The first area includes the leverages that will be used to design the policies. These leverages act on two main domains. On the one side, leverages may modify the regulatory (e.g. open rail market to competition, road pricing, environmental taxation). On the other side, policies can include measures concerned with the 'hardware' side, that is the improvement of infrastructures (e.g. the implementation of new roads and rails on TEN corridors) as well as the technological development (e.g. reduced emissions of pollutants from transport modes). The Policy area provides inputs to the *core* and *ad-hoc* models of the "Transport System Operation" box within the System Analysis area.

The REFIT operational framework



The “Systems Analysis” area

This area is the ‘engine’ of the operational framework, where the input defined in the Policy area are translated into raw output which will serve to compute the indicators. The main element in this area is the “Transport System Operation”, which includes the *core* models and the *ad-hoc* models.

The *core* models are the two European based models: TRANS-TOOLS and TREMOVE.

Ad-hoc models have been developed within the REFIT research project to analyse specific aspects which are not addressed by the *core* models in sufficient detail; these have the twofold aim of extending the quantification of (indirect) policy effects with reference to specific domains and processing direct outcome of the *core* models to produce indicators. The *ad-hoc* models are the economic model, the environmental model and the social model.

The “Indicators Processing” area

The System Analysis area produces a wide range of quantitative results. Such results are transferred to the Indicator Processing area for the calculation of the sustainability indicators. The indicators are grouped by topic according to the classification given earlier in the project: transport system operation indicators, transport economic impact indicators, transport environmental indicators and transport social indicators. The indicators produced will provide the basis for the assessment phase carried out in the last area of the operational framework.

The “Assessment” area

The Assessment area is the place where the indicators developed in the previous steps of the operational framework are used to derive a final response concerning the impacts of the transport policies on the sustainability. Different domains (economy, environment, society) are considered and within each domain a wide range of indicators is available. The Assessment area addresses the task of using the whole set of indicators in order to obtain a synthetic measure of sustainability.

Implementation of the REFIT operational framework

The implementation of the operational framework concerns the following main issues:

- Criteria for the policies definition, i.e. the way of implementing transport policy measure within the models;
- The flow of data across models (between the *core* models and from these to the *ad-hoc* models) in order to perform a consistent simulation and
- The identification of the modelling output required to compute the indicators (which variables, for which geographical detail, from which model etc.).

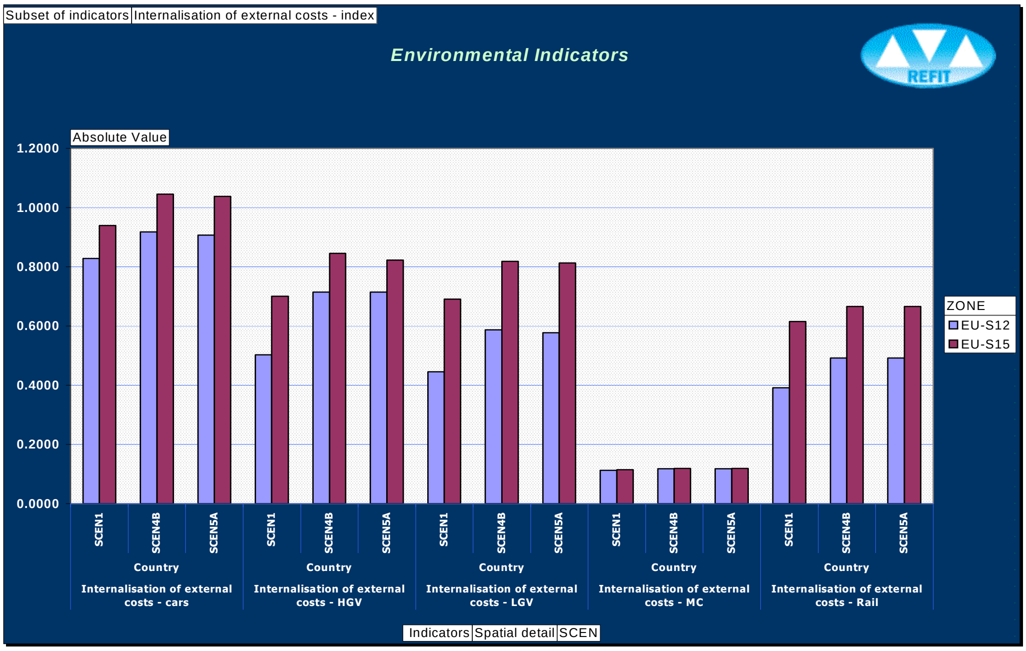
The REFIT Operational Tool for sustainability assessment

The REFIT Operational Tool is the instrument where the indicators developed in the previous steps of the operational framework can be used to derive a final response concerning the impacts of the transport policies on the sustainability. In REFIT is explicitly recognised that the measurement of the impacts of transport policy requires a multidimensional approach. Therefore different domains (economy, environment, and society) are considered and within each domain a wide range of indicators is available. The Assessment area addresses the task of using the whole set of indicators in order to obtain a synthetic measure of sustainability. However, this issue has not a neutral solution. The objective of REFIT is not to suggest to use one methodology instead of another one, but to provide the elements required for applying alternative methods. The choice of the methodology is left to the applications of the framework.

So, in this area the values of the indicators are first collected from the different tools and made available in a coherent form (e.g. in terms of geographical scope and segmentation).

In its practical form, the operational tool is represented by Excel worksheets including: the output of the models (see for example fig. 0.1), the indicators values of the policy grouped by domain, also compared to base case.

Fig.S. 1 Operational Tool - Environmental indicators graph



The REFIT operational tool has been used for the IMPACT scenario results of the impact assessment of the internalisation of external costs.

Application of REFIT

Interpretation of results

The reliability of REFIT indicators is tightly linked to the reliability of the models outputs they are derived from and to the calculation criteria. As far as concern the reliability of the models outputs, it is obviously influenced by the availability and the quality of data used as input for the models and by the correct calibration of the modelling tool. The calculation criteria may have a big influence on the indicators when more than one method is available for their computation.

The interpretation of the results of the ad-hoc models differs per model. This is further elaborated in paragraph 5.1.

Maintenance

In order to be able to use the REFIT framework in future some maintenance will be needed. This maintenance consists of updates of the models (core and ad-hoc) and updates of the data used in the models.

It might in some cases also be linked to updates of the core models. If the core models will entail a larger geographical area for instance this is not matching the ad-hoc models; the ad hoc models in this case can still be applied for the current number of countries. In most cases an update of the core models should just be seen as improved input data for the REFIT framework not requiring necessarily updates of the ad-hoc models.

Each ad-hoc model has its specific maintenance needs, in the ideal case these ad-hoc models should be updated every one or two years with new data for input and calculations of parameters.

Further research

When discussing improvements to the REFIT Framework we concentrate on the ad-hoc model. Improvements on the core models are discussed in different forums and are considered as out of scope to this project.

To improve the reliability of the REFIT indicators, it is advisable to establish a tighter linkage between the ad-hoc models themselves and preferably also with the core models; creating a benchmark of the assumptions at the basis of each ad-hoc model (e.g. countries demographic, social and economic parameters) is important to avoid inconsistencies among them.

The list of current REFIT indicators can be reorganized. The REFIT methodology includes 102 indicators. Especially within the environmental domain, the number of the indicators may be too high for many policy assessment exercises and a review and simplification might be done in order to focus on the most significant and to shorten the list.

The European scale of the REFIT models is not suitable to perform analysis at a local scale. For further developments it could be explored the possibility to apply the REFIT methodology to other regional scale models in order to compute local scale indicators while concentrating the application of strategic models like TRANS-TOOLS and TREMOVE to national and European level.

It could also be explored the possibility to enlarge the suite of the REFIT models to produce more indicators in domains not addressed in the current REFIT framework; for example it could be useful to enrich the analysis by introducing indicators covering the energy domain.

Finally, functional improvements could also be also made in the REFIT operational tool.

Each ad-hoc models has their own improvements. In general, the ad-hoc models can be further refined by including new countries or providing more detailed information of regional level.

1 Introduction

1.1 The REFIT project

The objective of the REFIT project is to provide a set of sustainability indicators for assessing the effect of various transport policies packages of priority interest through state-of-art models at European scale. In order to achieve the project aims a “modelling tools-based” methodology to developed, tested and validated that produces data on a set of identified indicators and that enables *ex-ante* evaluation of the European Common Transport Policy considering the economic, environmental and social dimensions of sustainability.

The aim of the subsequent REFIT work packages was:

- to define the ideal transport sustainability impact assessment framework and to provide a list of transport sustainability indicators encompassing the economic, environmental and social impacts of transport policies (Work Package 1),
- to refine as needed the available indicators (Work Package 2),
- to quantify the effects of transport policies on the economic indicators and to develop a new economic module (Work Package 3),
- to quantify the effects of transport policies on the social indicators and to develop a new social module (Work Package 4),
- to quantify the effects of transport policies on the environmental indicators and to develop a new environmental module (Work Package 5),
- to use the core-modelling framework and the additional modules developed in previous WP’s to simulate policy packages (Work Package 6).

1.2 Report structure

Deliverable 7 part of WP7 activities is produced when the main project activities are concluded and all previous reports have been delivered and accepted. The aim of report D7 is to provide a synthesis of the results of the previous work packages in an integrated assessment framework that enables transport policy makers to address impacts on sustainable development issues in their economic, environmental and social dimensions. Also, recommendations for further developments will be given. Indicators that are not addressed yet will be elaborated and pathways for further development will be sketched.

After this introduction, the second chapter deals with the description of the methodology for assessing transport policies sustainability and the components of the operational framework. The third chapter illustrates the *core* models TRANS-TOOLS and TREMOVE and the features of the *ad-hoc* modules referring to economic, environmental, social domains.

The details about the implementation of the REFIT operational framework, which computes the transport sustainability indicators, are presented in the fourth chapter. The fifth chapter describes interpretations of the results, needed maintenance of the framework and recommendations for further research. In chapter 6 the conclusions of the project are formulated.

1.3 Outline of the REFIT deliverables

Since D7 does not describe all work done in the REFIT project in full detail, in this paragraph a short summary is given of all deliverables produced within the REFIT project where the details can be found.

Deliverable 1.1

Outline of policy priorities and sustainability criteria and targets (public)

In this deliverable the first step of the REFIT project is described. It provides a comprehensive overview of EU transport policy priorities which are relevant to achieve the EU sustainable development goals and to define the ideal transport sustainability impact assessment framework.

Deliverable 1.2

Transport sustainability indicators: Existing sustainability indicators, knowledge gaps and roadmap towards better indicators and tools (public)

In this deliverable a comprehensive list of transport sustainability indicators was presented, which includes already available indicators and new indicators which can be developed in a reasonable time and at a reasonable cost.

Deliverable 2.1 (first version) and 2.2 (second version)

The REFIT framework for Strategic Sustainability Assessment of European Transport policies (public)

In these deliverables, the comprehensive set of sustainability objectives and indicators were linked with possible quantification methods and models to compute indicators. D2.1 was completed in the first stage of the project and illustrates the design of the framework and of the ad-hoc modules.

D2.2 was produced towards the end of the project life in order to describe the actual implementation of the framework. The methodology described in these deliverables clarifies how the different pieces of the analysis are linked together (including inputs and outputs of each component of the system) in the REFIT operational framework, identifies the criteria to be followed for the policies definition, for their implementation in the modelling tools, for using model output in building indicators and for identifying sustainability indicators.

Deliverable 3.1

Assessing the economic dimension of sustainable transport policy: an overview (public)

In this deliverable is investigated which elements in economic modelling would need to be improved. The advantage of the CGEurope model is that the outcome of policies can be evaluated on spatial level so that equity aspects can be studied. However the spatial detail has resulted in a more aggregated description of financial flows such as the investment in infrastructure and the revenues from pricing policies. A description is made how to overcome these gaps in modelling.

Deliverable 3.2

Assessing transport policy impacts on spatial distribution of economic activity and (un)employment with the CGEurope-model (public)

In this deliverable the innovations contained in CGEurope-R model developed in the REFIT project are described, compared to the CGEurope model version included in the TRANS-TOOLS package.

The two main innovations are:

1) allowing for labour market response to transport policies;

2) allowing for international and interregional capital mobility;

3) incorporating the investment theory into an operational dynamic modelling approach (forward-looking dynamics not implemented in multiregional setting, only results of comparative steady-state analysis reported).

Deliverable 3.3

Assessing transport policy impacts of the Internalisation of Externalities of Transport (public)

In this deliverable a methodology is developed how to assess transport policies regarding their contribution to the objective of fair pricing. The indicator "Level of Internalisation of Externalities (LoI)" is the degree, to which external costs have been internalised according to the polluter pays principle. Two approaches have been identified to compute the LoI: The Equity Approach, based on the full cost assessment, and the Efficiency Approach, based on the marginal social cost pricing principle.

Deliverable 4.1

Assessing the social dimension of sustainable transport policy: an overview (public)

In this deliverable it is investigated which elements in modelling related to the social effects would need to be improved. One of the conclusions of the ASSESS project was that there is no readily-available modelling tools, which allow one to calculate the sustainability indicators related to the social dimension of sustainability. This deliverable identified some solution for this problem and points out the remaining problems.

Deliverable 4.2

Assessing transport policy impacts on transport safety, on equity and on income distribution with the EDIP model (public)

This deliverable describes in details elements of REFIT modelling related to the assessment of social effects. In particular, it presents the new tools constructed for the assessment of safety effects and income distribution and inequality effects of transport-related policies.

Deliverable 5.1

Assessing the environmental dimension of sustainable transport policy: an overview (public)

In this deliverable it is investigated which elements in environmental modelling would need to be improved. TREMOVE is the main model used under the REFIT approach for the calculation of the sustainability indicators related to the environment. The model covers a lot of areas and allows for the calculation of most environmental sustainability indicators. The deliverable assesses, which indicators could be calculated with TREMOVE and which not.

Deliverable 5.2

Modelling population exposure to noise and air pollutants NO2 and PM10 (public)

Aim of the environmental model described in this deliverable is to estimate the effect of changes in transportation in the EU on the population exposure to air quality pollutants PM10 and NO_2 as well as noise in urban areas. The method described here is based on the use of detailed calculations of population exposures in prototypical situations. Input for the model is traffic flows, modelled by

TREMOVE and TRANSTOOLS. Using data on population density and urban area in Europe, the prototypical cases are extrapolated to EU level.

Deliverable 6.1

Working paper on scenarios (confidential)

This deliverable describes the scenarios that are defined in the IMPACT study. This part relates directly to the original objectives of this deliverable. Furthermore this deliverable describes the changes in objectives and work plan of WP 6. This new work plan of WP 6 overruled the original proposal.

Deliverable 6.2

Strategic Sustainability Assessment of European Transport policies (confidential)

This deliverable describes the results achieved running the ad hoc models with the TRANS-TOOLS and TREMOVE results from the IMPACT project. The values of the indicators are reported in the enclosed REFIT operational tool, consisting in five Excel spreadsheets. It also provides a brief guide about the content of the spreadsheets, explaining how to interpret the data and commenting the main results of the application.

Deliverable 6.3

Sensitivity analysis (public)

This deliverable presents the sensitivity analysis performed for the REFIT ad hoc models. Sensitivity analysis aims at providing information on the robustness of the analysis with respect to main assumptions and parameters of the models: it is the study of how the variation in the output of a model can be apportioned, qualitatively or quantitatively, to different sources of variation in the input of a model. Given the complex modelling structure, each sensitivity analysis has been performed separately for each ad-hoc model.

2 The REFIT operational framework

2.1 General description

The REFIT operational framework is aimed at producing a set of forecasting indicators for the assessment of European Transport Policies sustainability; forecasting indicators are different form monitoring indicators, which report on the current state of the system under analysis, and are designed to provide information of the future development of such system by means of ex-ante models.

The starting point is the definition of the transport policy, which constitutes the input for the modelling tools, under form of assumptions on the value/state of a set of variables (the policy leverages of the models). The modelling tools are formed by the *core* models and the *ad-hoc* models: the *core* models simulate the change induced by a policy on a wide range of variables and produce a set of data which are either the input of the three *ad-hoc* models, which in turn produce the sustainability indicators respectively for the economic, environmental and social dimension, or are directly used to compute indicators.

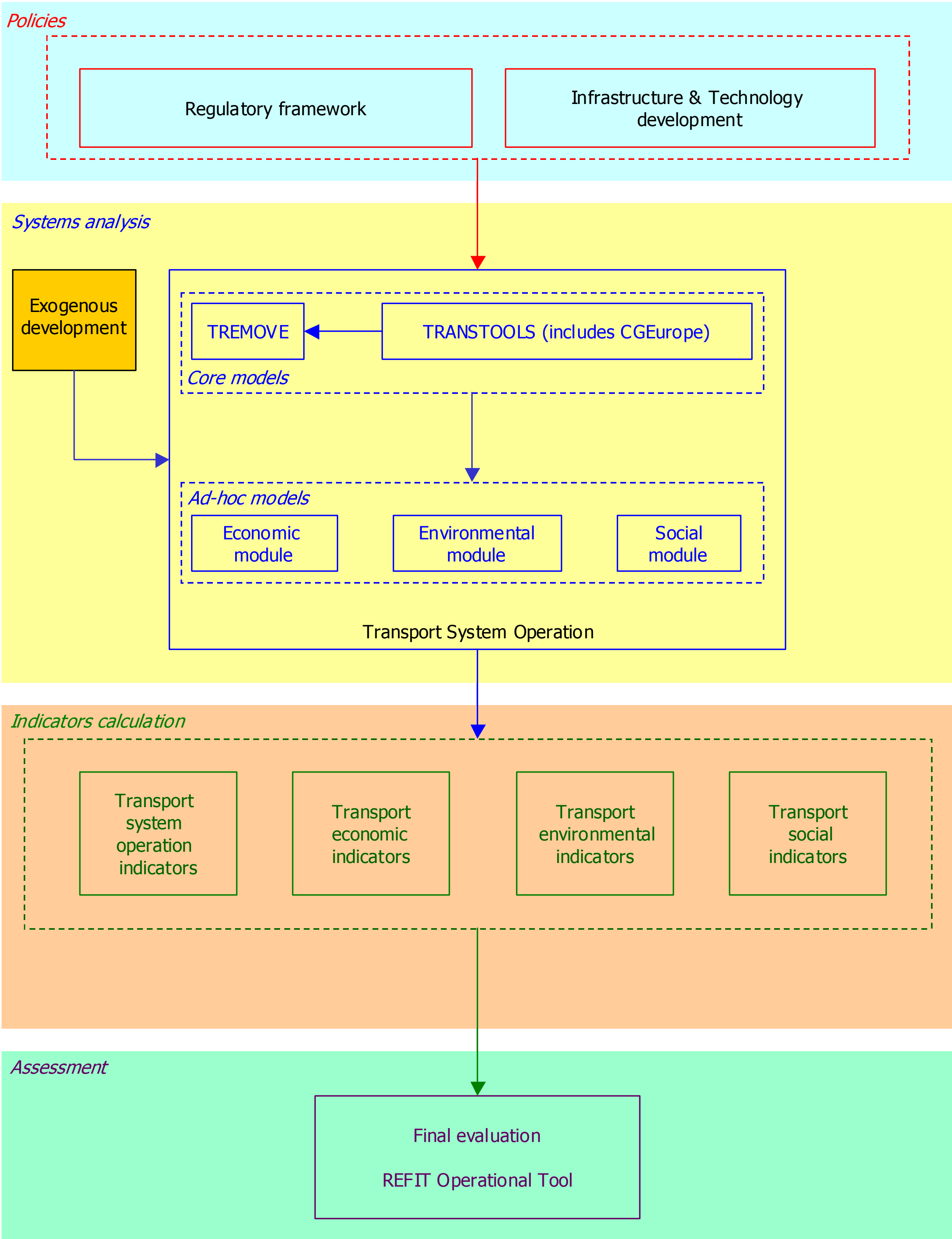
The *core* models are the two European based models: TRANS-TOOLS[1] and TREMOVE. *Ad-hoc* models will be developed to analyse specific aspects not addressed in sufficient detail by the *core* models; these have the twofold aim of extending the quantification of (indirect) policy effects with reference to specific domains and processing direct outcome of the *core* models to produce indicators. Indicatively:

- the *economic module* considers the linkages between transport and economy, mainly in terms of the effects of transport policy measures on economic variables like GDP or employment;
- the *environmental module* is focused on health impacts of air-pollution and traffic noise;
- the *social module* considers the effects of policies on the social side, addressing aspects like distribution of costs and benefits and safety.

The main role of the modules is to produce sustainability indicators to provide synthetic measures of the effects of transport policies on given domains like economy and environment. Indicators will be policy sensitive in the sense that their ingredients will include variables whose value is affected by the policy implementation. The effect of specific measures will be generally reflected by a change of the value or one or more indicators. Figure 2.1 shows the main components of the operational framework. It includes four main areas, which are described in some detail below.

[1] Note that the operational framework is valid also if other transport models are applied instead of TRANSTOOLS. In this case, the economic model of TRANS-TOOLS, CG-Europe, should be considered separately.

Fig. 2. 1 The REFIT operational framework



2.2 The "Policy" area

The first area includes the leverages that will be used to design the transport policies. These leverages act on two main domains. On the one side, leverages may modify the regulatory framework of the transport system. The term "regulatory" is used here in a wide sense to include not only elements like market regulation (e.g. open rail market to competition), but also measures which affect directly transport costs like road pricing or environmental taxation, etc. On the other side, policies can include measures concerned with the 'hardware' side, that is the improvement of infrastructures (e.g. the implementation of new roads and rails on TEN corridors) as well as the technological development (e.g. reduced emissions of pollutants from transport modes). From a conceptual point of view, the definition of a policy implies a "change of assets" which might be either positive (the creation of new assets, e.g. new transport infrastructures) or negative (resource consumption, which is a reduction of assets). The Policy area provides inputs to the *core* and *ad-hoc* models of the "Transport System Operation" box within the System Analysis area.

2.3 The "Systems Analysis" area

This area is the 'engine' of the operational framework, where the input defined in the Policy area are translated into raw output which will serve to compute the indicators. The main element in this area is the "Transport System Operation", which includes:

- the *core* models, TRANS-TOOLS and TREMOVE, and
- the *ad-hoc* models, which produce sustainability indicators respectively for the economic, environmental and social dimension.

The components of the transport system operations are described in chapter 3. Another component of this area is the definition of the "Exogenous development". It includes all those trends which are relevant to define the mobility patterns although these are not part of the transport system (e.g. economic growth, population development, etc.) and also out of control of the European transport policy maker. Assumptions concerning such exogenous elements enter as input in the modelling tools and allow them to provide forecasts about the development of transport demand and its effects.

2.4 The "Indicators Processing" area

The System Analysis area produces a wide range of quantitative results. Such results are transferred to the Indicator Processing area for the calculation of the sustainability indicators. The indicators are grouped by topic according to the classification given in Work Package 1: transport system operation indicators, transport economic impact indicators, transport environmental indicators and transport social indicators. In some cases, the modelling output will be directly translated into indicators while in other cases additional processing will be needed. Therefore, even if the 'heart' of the quantification of impacts of the policies is in the System Analysis area, the Indicator Processing area plays a key role as well. The indicators produced will provide the basis for the assessment phase carried out in the last area of the operational framework.

2.5 The "Assessment" area

The Assessment area is the place where the indicators developed in the previous steps of the operational framework can be used to derive a final response concerning the impacts of the transport policies on the sustainability. In REFIT is explicitly recognised that the measurement of the impacts of transport policy requires a multidimensional approach. Therefore different domains (economy, environment, society) are considered and within each domain a wide range of indicators is available. The Assessment area addresses the task of using the whole set of indicators in order to obtain a synthetic measure of sustainability.

However, this issue has not a neutral solution. The objective of REFIT is not to suggest to use one methodology instead of another one, but to provide the elements required for applying alternative methods. The choice of the methodology is left to the applications of the framework.

So, in this area the values of the indicators are first collected from the different tools and made available in a coherent form (e.g. in terms of geographical scope and segmentation) within an operational tool made under the form of excel worksheet presented in detail in the section 4.

3 The modelling tools in the REFIT framework

3.1 Introduction

Modelling tools represent the instruments to simulate the effect of the transport measures, that is to measure the change induced by a policy on a wide range of variables. As already mentioned, the REFIT “tool box” includes two *core* models and three modules created ad hoc to analyse specific aspects which are not addressed by the two main models in sufficient detail.

The TRANSTOOLS/TREMOVE integrated model structure is the *core* of the quantitative procedure: TRANSTOOLS is a network-based transport model; TREMOVE simulates aggregate demand and includes a detailed description of fleet development, fuel consumption, emissions factors. The two models can deal with a variety of measures, ranging from new infrastructures (TEN-T network) to pricing policies, from technological improvements to enhancing intermodality.

In this chapter a short description of the *core* models is provided. The input/data and output necessary for the *core* models run are shortly described, mainly focusing on the parameters needed for the REFIT framework. The second part of the chapter is dedicated to the additional modules. These are relatively simple tools including the relevant relationships required for a twofold aim of: extending the quantification of (indirect) policy effects with reference to specific domains, and processing direct outcome of the TRANSTOOLS/TREMOVE framework to produce additional indicators. In more detail:

1. the economic module considers the linkages between transport and economy, mainly in terms of the effects of transport policy measures on economic variables like GDP or employment;
2. the environmental module focuses on impacts of air-pollution and traffic noise;
3. the social module considers the effects of policies on the social side, addressing aspects like distribution of costs and benefits. (Within the social dimension the safety indicator is calculated by using a safety ad-hoc model that will be described in section 3)

3.2 The TRANS-TOOLS model

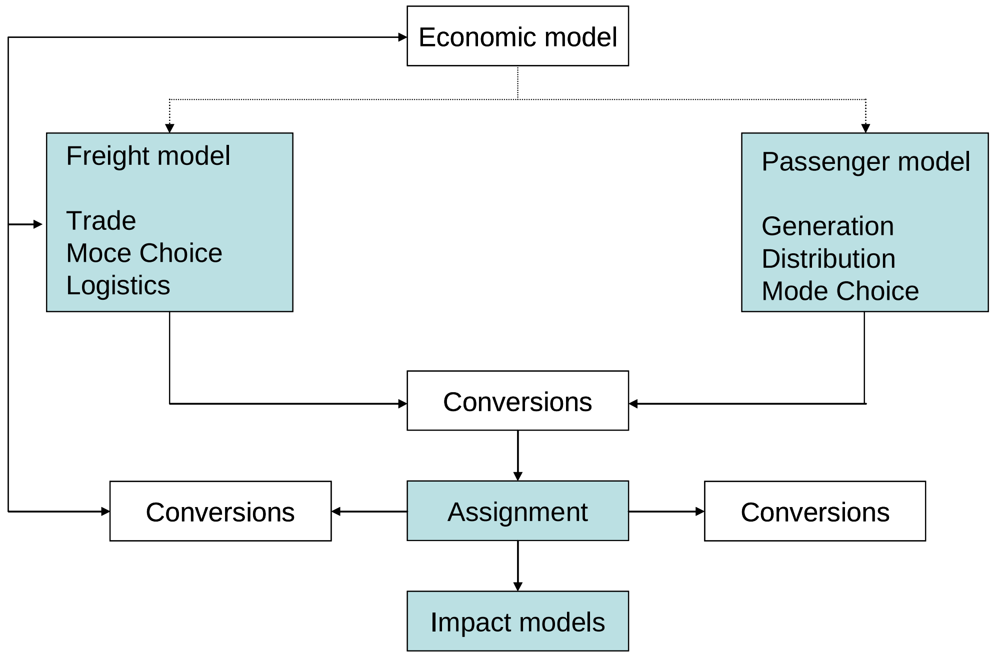
TRANS-TOOLS is a European transport network model covering both passenger and freight, as well as intermodal transport[2]. The TRANS-TOOLS model consists of different modules, which exchange information according to a sequential approach (i.e. the origin/destination matrix produced by the passenger model is transferred to the modal split model, etc.), although feed back effects are taken into account (i.e. transport costs and times produced by the assignment model are fed back to the modal split model). The main sub-models are:

- freight demand model;
- passenger demand model;
- assignment model.

[2] The project has been developed within the 6th Framework Program RTD for the Directorate General for Transport of the European Commission. More information on www.inro.tno.nl/transtools/

In additions to these main elements of the model system, the TRANS-TOOLS Model also includes a regional economic model based on CGEurope and impact models. The different models are linked applying a number of conversion routines. The principle of the model in overview is illustrated in Figure 3.1. The model framework allows feedbacks between the sub-models to achieve equilibrium between supply and demand.

Fig. 3. 1 Overview of the TRANS-TOOLS model



All model components are integrated into ArcGIS, which allow the user to edit, operate and illustrate results from the same common GIS-based platform. The innovations obtained from the TRANS-TOOLS model are:

- new set up of a demand/supply model that is IPR free for the Commission;
- intermodality for passenger/freight as this is part of the national and European transport policy to promote intermodality through different measures;
- full coverage of Central and Eastern Europe (accession countries and the countries at the borders of the enlarged Union);
- integration of New Member States at a similar level as the EU15;
- feedback infrastructure development-economy;
- logistics/freight chain explicitly included;
- coupling with local traffic in order to address the effect of road congestion;
- a software approach which results in a modelling tool on network level and GIS based interfacing.

3.3 The TREMOVE model

TREMOVE[3] is a transport and emissions simulation model developed for the European Commission. It is designed to study the effects of different transport and environment policies on the emissions of the transport sector. The model estimates the transport demand, the modal split, the vehicle fleets, the emissions of air pollutants and the welfare level under different policy scenarios. All relevant transport modes are modelled, including air and maritime transport. The model covers the 1995-2020 period, with yearly intervals.

TREMOVE predicts the overall emissions from the transport sector in different policy scenarios. The strength of the model is that it also enables to assess the effects of environmental policies on future vehicle fleets and on overall transport demand and its modal split. The calculated welfare effect of a policy then is not only determined by technology costs and emission reductions, but also by effects on household mobility, industry logistic processes and government tax income from the transport sector.

TREMOVE is made of 21 parallel country models, and one maritime model. TREMOVE consists of three inter-linked '*core*' modules: a transport demand module, a vehicle turnover module and an emission and fuel consumption module, to which we add a welfare cost module and a life cycle emissions module. An overview map can be found in the next figure 3.2.

The *transport demand module* describes transport flows and the users' decision-making process when it comes to making their modal choice. Starting from the baseline level of demand for passenger and freight transport per mode, the module describes how the implementation of a policy measure (or a package of measures) will affect the baseline allocation of demand across different modes and different vehicle categories.

The key assumption here is that the transport users will select the volume of transport and their preferred mode based on the generalized cost for each mode. The generalized cost is the sum of money costs and time costs. To be more specific, the generalized price per pkm or tkm is the sum of three elements i) producer price (this is the price producers receive), ii) tax or subsidy and iii) time cost per km travelled by a certain mode.

The choice for a certain transport type is not equal for all private consumers or all firms. They differ by income and personal preferences for private consumers and for production processes for firms. In TREMOVE, this choice of transport type is modelled in a *nested way*. On top, the choice between transport and other goods is made, given a certain fixed production level (firms) or utility (consumers). Consequent choices are between private and public transport, peak and off-peak, etc.

For non-work and commuting passenger trips, transport demand is determined by generalized prices and observed consumer preferences. For freight transport and business trips, demand level and modal choice are determined by generalized prices, desired production quantities and substitution possibilities with other production factors.

The output of the demand module consists in passenger kilometres (pkm) and ton kilometres (tkm) that are demanded per vehicle category for a given policy environment.

The *vehicle stock turnover module* describes how changes in demand for transport across modes or changes in price structure influence the number, the age and the type of vehicles in the stock. For this purpose both vehicle sales and vehicle scrappage decisions have been modelled for most modes. The sales model enables to estimate the share of different vehicle technologies in the yearly vehicle

[3] More information on www.tremove.org

sales under various policy scenarios. The sales model is based on the discrete choice methodology and uses nested logit demand function as its basis. The vehicle stock module has been calibrated using historical data on the vehicle stocks in the countries considered.

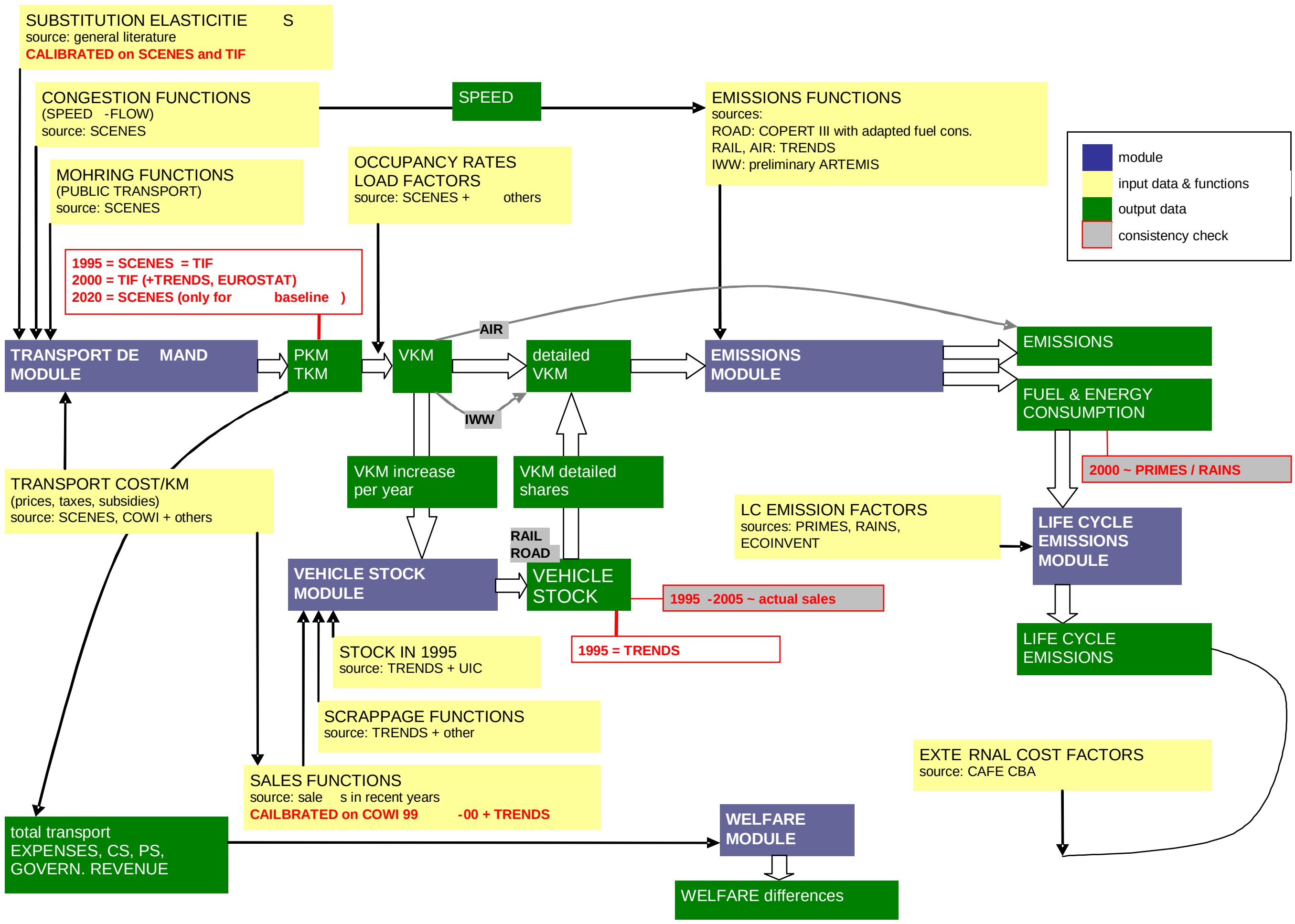
For each vehicle category, the evolution of the detailed vehicle fleet and the related number of vehicle-km is estimated, based on 3 major elements:

- the historical vehicle fleet;
- the growth of the transport volumes;
- the characteristics of the available vehicle types and technologies on the market.

The most influencing vehicle characteristics are costs. Others are acceleration, size, fuel type, annual mileage etc. The output of the vehicle stock module is twofold: we split both the total fleet and the number of km for each year according to vehicle type and age.

The *fuel consumption and emissions module* is used to calculate fuel consumption and emissions, based on the structure of the vehicle stock, the number of kilometres driven by each vehicle type and the driving conditions. As indicated in the figure 3.2, outputs from the vehicle stock and fuel consumptions and emissions modules are fed back into the demand module. As fuel consumption, stock structure and usage influence usage costs, they are important determinants of transport demand and modal split.

Fig. 3. 2 TREMOVE model structure



The TREMOVE model includes a lifecycle emissions and a welfare cost module. The *lifecycle emissions module* enables to calculate emissions during production of fuels and electricity. Thus, the TREMOVE model does not only take into account operational vehicle emissions, but also those due to production of fuel and electricity. Since the operational emissions tend to decrease in the future, the relative share of "pre-processor" emissions will increase and may become substantial. For each year and each country, the lifecycle module derives the total fuel (and electricity) consumption by aggregating the outcomes of the fuel consumption and emissions module. The total electricity consumption (in kWh) and fuel consumption (in tones) is calculated for the following fuels: diesel (road vehicles), gasoline (road vehicles), LPG (liquefied petroleum gas for road vehicles), CNG (compressed natural gas for road vehicles)[4], train diesel (rail vehicles), electricity (rail vehicles), gasoil (inland waterway vessels), kerosene (air transport).

The *welfare cost module* has been developed to compute the cost to society associated with emission reduction scenarios in European urban and non-urban areas. The welfare effect of a policy change is calculated as the discounted sum of changes in utility of households and costs of

4 CNG fuel consumption had to be converted into tonne unit. The fuel consumption module calculates first the CNG fuel consumption in terms of tonne-diesel-fuel-equivalent. Then, conversion to CNG tonnes was by using the energy densities of diesel and CNG respectively.

production, and benefits of tax recycling. These benefits of tax recycling represent the welfare effect of avoiding public funds to be collected from other sectors, when the transport sector generates more revenues. External costs of congestion and pollution are also included in the welfare cost.

The difference in social welfare is calculated as the sum of 4 components:

(i) change in utility of households (consumers);
(ii) change in productions costs (firms);
(iii) change in government revenues (taxes-subsidies);
(iv) change in external effects.

These four components have to be expressed in monetary terms, which enable one to compute a global level of social welfare.

Maritime transport is treated separately and allocated to maritime regions, thus is not coupled directly to the different country models. The European sea area is subdivided in 8 modelled maritime regions.

The maritime model estimates both the maritime movements (km) and port callings (#) for all maritime freight vessels and passenger ferries for 1995-2020. The fuel consumption, emissions and welfare are also modelled.

3.4 The *ad-hoc* model for the economic dimension: *CGEurope-R*

The REFIT *ad-hoc* economic model is an extension of CGEurope, called CGEurope-R, in which dynamic framework with imperfect labour market is considered. CGEurope-R will take the place of CGEurope, thus becoming part of the TRANS-TOOLS model.

CGEurope-R[5] is a multiregional computable general equilibrium model covering the whole world, essentially neoclassical in nature with two important deviations. First, the production structure is similar to that common to the new economic geography literature, with two sectors: local goods characterized by perfect competition and tradable goods, characterized by monopolistic competition with each firm producing a different variant of a good. The consumer demand is correspondingly characterized by the “love for variety”. Another important deviation from the perfectly competitive markets is the labour market characterized by a certain degree of wage rigidity. The country-specific values of the unemployment elasticity of pay are taken from the rich “wage curve” literature.

The feature that allows the model to assess impacts of transport policies is the explicit incorporation of interregional trade costs. The changes in these costs, occurring for example due to the implementation of a certain road-pricing scheme, would affect relative prices that the economic agents face, and in the general equilibrium framework that will give rise to the whole series of interdependent adjustments of trade flows, production and income in all model regions.

We introduce two components of trade costs: travel costs or costs related to geographic distance, and costs for overcoming impediments to international trade. The first are modelled under the assumption that travel costs (out of pocket as well as time costs) are increasing with distance but at diminishing rate. Travel costs are subdivided into costs for business passengers on the one hand, and freight costs on the other hand. The change of these costs will constitute the policy scenario. The values for the international trade impediments are calibrated within the model and include tariffs (not relevant within EU anymore), but also, and more important, all costs stemming from non-tariff

5 For a full description of the CGEUROPE-T model see the REFIT Deliverable D3.2

barriers, like costs due to language differences, costs of bureaucratic impediments, time costs spent on border controls and so forth.

An important component of the model is the capital mobility. This feature allows the effects of policy change on regional GDP and regional income (later approximating the welfare effects) differ quite substantially, because the domestic owners of capital are allowed to invest abroad, when they are seeking higher returns.

The most important results for policy assessment generated by comparative static analysis using CGEurope-R are the monetary measures of regional welfare effects of the evaluated projects. They convert utility gains of regional households to monetary amounts by the concept of equivalent variation. For small changes, relative equivalent variation approximately equals the change in the log real income compared to the do-nothing scenario.

The advantage of the indicators produced by CGEurope-R is that the calculations are based on solid economic theory, incorporating the features that have in a series of earlier EU-funded projects (IASON, ASSESS, FUNDING) proved to be important for the analysis of transport policies. It is a multiregional model with 268 NUTS2 regions in Europe and 2 “rest of the world” regions, and thus the effects of transport cost changes that can be very local in reality can be taken into account more precisely. In the same time many important interdependencies between neighbouring as well as distant regions are taken account of.

3.5 The *ad-hoc* model for the social dimension: *EDIP*

The socio-economic model called the European Model for the Assessment of Income Distribution and Inequality Effects of Economic Policies (EDIP) is constructed using the Computable General Equilibrium (CGE) framework.

The EDIP model is based on the social, economic, environmental transport and energy data for the year 2005. The EDIP database covers EU27 countries, Norway, Switzerland, Croatia and Turkey.

The EDIP model has a single mathematical formulation for all European countries. It is one model with 31 different versions, which are estimated using the country-specific dataset. The main element of the country-specific dataset of the EDIP model is the Social Accounting Matrix (SAM), which represents the annual monetary flows between different economic agents for the year 2005.

The EDIP model has broad coverage of different socio-economic types of individuals and households. That allows it to compute the effects of transport and energy policies on different population groups including the five income quintiles, three education levels and ten occupation types. The composition of households is based on the extensive socio-economic dataset for the year 2005. The model also calculates a set of the inequality and poverty coefficients including the Gini coefficient, the GE family of inequality indexes and the Foster-Green Thorbecke family of poverty indexes. The welfare of each household type (population group) in the EDIP model is calculated as the equivalent variation measure and depends upon consumption of commodities and the level of emissions.

The sectoral disaggregation of the model includes three transportation sectors: land, water and air. Production technology of these three sectors is represented in great detail in the model. Production output of each sector can be either delivered to the domestic market or exported to EU25 trade zone or to the rest of the world.

The unemployment in the EDIP is modelled according to the search-and-matching approach, which explains the existence of frictional unemployment in the country. The main idea behind this approach is that there exists a mismatch between the available vacancies and the unemployed labour. The level of this type of unemployment varies between the education levels and occupation types.

The EDIP model incorporates the representation of the federal government. The governmental sector collects taxes, pays subsidies and makes transfers to households, production sectors and to the rest of the world.

The equilibrium prices of all commodities and capital are defined by the market equilibrium conditions. Under the market equilibrium the sum of demands for a particular commodity is equal to the sum of its supplies. Due to the existence of unemployment and wage bargaining on the labour market, it is in disequilibrium. The level of the wages is determined by the bargaining process between the trade unions and firms. It depends positively upon the probability to find a new job and the firms' profits.

The EDIP model is a dynamic, recursive over time, model, involving dynamics of capital accumulation and technology progress, stock and flow relationships and backward looking expectations. A recursive dynamic structure composed of a sequence of several temporary equilibriums. The first equilibrium in the sequence is given by the benchmark year.

The model can help with an evaluation of both separate measures and packages of policies. Despite its broad nature, the main focus of the EDIP model is an assessment of impact of transport-related policies on inequality and income distribution in the economies of European countries.

3.6 The *ad-hoc* model for the social dimension: the safety model

The Safety Impact Model developed in REFIT is based on the Safety Impact Model developed in the TRANS-TOOLS project that calculates safety based on the output of the assignment model.

Within the REFIT project the original TRANS-TOOLS Safety Impact Model has been updated, extended and made more accurate. Like the previous version, it is based on the vehicle kilometre outputs from the TRANS-TOOLS assignment and the number of fatalities and safety impact costs are determined based on calculated risk factors. The risk factors represent the risk of being killed per driven kilometre. The model can predict road safety impacts until 2030 for all EU member states (except Malta and Cyprus due to data unavailability).

Using updated data, risk factors and the average yearly change of these risk factors have been calculated for all modes in each country. Combined with the vehicle kilometres travelled for each vehicle type, these are used to determine the number of fatalities for future years.

The safety impact costs for future years are calculated using the number of fatalities, severe and slight injuries, each multiplied by the indirect and direct economic costs of slight, serious or fatal injury. The safety impact costs are only provided on country level. These costs are based on fatalities and injuries. The estimation of the number of injuries per travel mode or road type is too rough (because injury data are less accurate) to present these numbers, and therefore also the safety impact costs for each travel mode or road type level. Therefore, the choice has been made to present only these costs on country level.

Tab. 3. 1 The new TRANS-TOOLS Safety Impact Module: inputs and outputs

IN	OUT
Vehicle kilometres	Fatalities, road safety costs
BY	**BY**
Country	Country
Road type (urban, not urban, motorway)	Road type (urban, not urban, motorway)
Mode (car, truck)	Mode (car, HGV, LGV, other)

The key parameters of this model are, the:

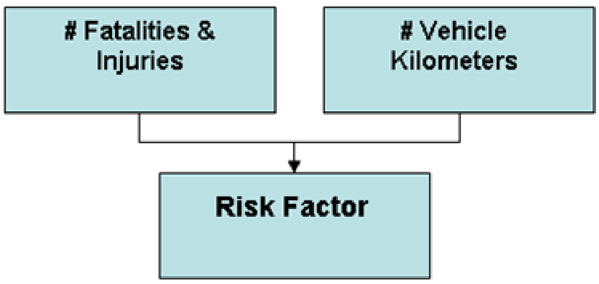
- Vehicle kilometres;
- Risk factors;
- Value of safety and direct & indirect economic impact of a fatality or injury;
- Change in value of safety and direct & indirect economic impact.

In this safety analysis we use the vehicle kilometres and the risk factors. These are the main key variables. The economic impact is not analysed because it is only a translation of the number of fatalities into monetary values.

The vehicle kilometres are the number of kilometres travelled by vehicle type and road type. The vehicle kilometres can be extracted from the TRANS-TOOLS demand model and loaded into the new TRANS-TOOLS safety model.

The risk factors are calculated by dividing the number of fatalities (by vehicle type by road type) with the amount of vehicle kilometres (by vehicle type by road type). This relation is shown in figure 3.3. We analysed the risk factors for the four modes of transport and for the 3 types of road in the model.

Fig. 3. 3 Relation Risk factors, vehicle kilometres and number of fatalities and injuries



Risk factors change every year because the number of people involved in a fatal accident or an injury and also the amount of vehicle kilometres changes. The change has been calculated at country level.

3.7 The *ad-hoc* model for the environmental dimension

The REFIT environmental model is based on Urbis, a TNO GIS instrument for local environmental surveys.

With Urbis, exposures to traffic noise and air pollution (NO_2 and PM10) and the related health effect are calculated in a number of cities with a high level of detail.

In Urbis, noise emissions are calculated on the basis of digital road maps in which traffic volume, speed and road surface type are attributes of road segments. Further input for the noise transmission calculations are digital maps of land use from which the surface type is derived, and maps of buildings and other objects (e.g. noise screens). Meteorological, ground, object and screen attenuation, and first order reflections close to the noise source are included in the modelling of noise transmission. Noise immissions are calculated for receptor points at a height of 5 meter on a 25 x 25 meter grid, supplemented with receptors close to the noise sources and receptors at the façades of buildings with direct sight on a noise source. A 3×3 meter noise grid is derived by interpolation from the calculated noise levels at these receptors. The noise levels (L_{Aeq}) are calculated for the day, evening and night, and combined to a map of the DENL.

Emissions of air pollutants are calculated on the basis of practically the same input data on traffic flows and speeds. Near the sources (the roads) concentrations are determined by the contribution of the street, using the TNO CAR model, combined with the local background, using a Gaussian plume model and a regional background. For calculation point further than 30 meters from a road or calculation points that are shielded by buildings from the road, only the local and regional background is used. The concentration levels are interpolated to detailed concentration maps.

On the basis of these maps, exposures on dwellings of noise, NO_2 and PM10 are calculated. For each city that has been mapped using Urbis, the distributions of human exposures to noise and the air pollutants NO2 and PM10 are calculated.

On the basis of exposure distributions collected in other cities, scaling factors of the distributions are derived. This way, the cases are made representative for the Urban areas in the EU. Changes in traffic volumes, per vehicle type, per road category can be evaluated in the cities mapped with Urbis. These effects can be scaled to EU 25 level.

4 Implementation of the REFIT framework to compute indicators

4.1 Introduction

The implementation of any policy affects the economic, social and environmental system. Different types of indicators can measure the size of this impact. The aim of REFIT framework is to provide a quantitative measure of such impact by means of specific indicators opportunely selected.

The road pricing could be an example of policy to be assessed. The implementation of this policy means different tolls costs comparing to a base case.

Getting more into the details of the dynamics for computing the indicators related to a road pricing measure within the REFIT framework, the first step is the definition of the size of the toll, the type of infrastructure to be charged, the transport modes targeted and so on. This definition is translated into a set of modelling inputs for the TRANS-TOOLS model. An increase of tolls costs entails a different modal assignment and in general different road transport demand: these changes are modelled in TRANS-TOOLS. The detailed output produced by TRANS-TOOLS is then translated in the format required by TREMOVE and transferred into this model to produce additional output concerning total emissions. The demand and cost data is then provided from TRANS-TOOLS to the ad hoc models in order to extend the analysis to the social, environmental and economic side.

In the end, the output of the framework consists of the value of the selected indicators. It is expected that the change in tolls costs affects transport sustainability indicators, for example "Traffic of road passenger per vehicles and Transport generalised costs" (selected as transport system operation indicators), as well as Environmental indicators (e.g. "Emission of pollutants by transport mode", "Internalisation of external costs" and social indicators (e.g. "Transport affordability index").

Another example could be the introduction of more restrictive limits concerning polluting emissions of road modes (e.g. EURO 6 standards). In this case is not necessary. Whereas TREMOVE model can produce the emission values for road transport which are expected to change as consequence of this policy. Of course, environmental indicators are expected to be directly changed by this measure and can be derived by TREMOVE. Nevertheless, also other indicators can be affected by this policy such as social indicators (e.g. Health effect of air pollution) or economic indicators (Household transport expenditure) that will be provided by the other REFIT ad-hoc models (EDIP and CG-EUROPE.

The way in which the different indicators will be compared to each other refers to the last step of the framework. In this phase the sustainability assessment of the policy is finally performed.

This chapter specifically deals with the issues related to the general use of the modelling tools available in REFIT to compute the sustainability indicators. It should be mentioned that a factual simulation of policies have been tested by using the IMPACT scenarios concerning transport policies of internalisation of external costs. The description of the scenarios tested along with the results achieved is contained in the Deliverable 6.2. The steps described below are general and apply to any computing process of indicators involving no specific transport policy.

The main aspects addressed below are:

- the policies definition, i.e. the way of implementing transport policy measure within the models;
- the flow of data across models (between the '*core*' models and from the '*core*' models to the '*ad-hoc*' models) in order to perform a consistent simulation and
- the identification of the modelling output required to compute the indicators (which variables, for which geographical detail, from which model etc.).

4.2 Policies definition

European transport policy measures deal with several topics. For instance, looking at the list of policy measures included in the EC White Paper, one can find a number of interventions ranging from opening markets to enforcing rules about safety, from harmonising taxation to setting limits for pollutants in fuels and so on.

Considering the purpose of the REFIT framework, transport policy measures can be classified into three main groups:

1. Measures whose direct impacts can be simulated in the REFIT framework (e.g. infrastructure charging can be directly coded in the TRANS-TOOLS model);
2. Measures whose impacts can be simulated only indirectly in the REFIT framework (e.g. liberalisation is expected to modify transport costs and only such modifications – quantified exogenously – can be coded in the models);
3. Measures whose impacts cannot be simulated by the REFIT framework (e.g. the regulations concerning safety of third countries aircraft is out of the domain of all modelling tools in REFIT).

Thus, a preliminary condition for using the REFIT models to compute indicators is to select the policy measures properly, i.e. those which can be dealt with in modelling terms. Even if some possible transport policy measures cannot be handled in the REFIT framework, there is a relevant number of interventions which can be directly simulated and assessed by making use of the modelling tools described in the previous chapter.

In principle, each measure could be assessed in itself using the REFIT framework (and this is relevant for some 'heavy' measures such as an extensive application of social marginal cost pricing), even though the framework potential is better exploited when assessing measures 'packages'. Such measure packages can be defined according to different criteria. For instance, all policies whose translation in modelling terms consists in *changing* costs of road modes can be grouped, in order to represent the net effect of the transport policy on road costs. An alternative criterion considers the difference between those policies whose effect on model variables is direct and those policies for which an indirect effect is assumed. For instance, infrastructure charging measures have a *direct effect* on the transport costs variables while liberalisation measures cannot be simulated in itself, they can be simulated in terms of their *indirect effect on transport costs*. The degree of judgement and the need for assumptions is higher for the group of measures whose modelling strategy consists in simulating indirect effects and so they can be analysed independently as a separate package.

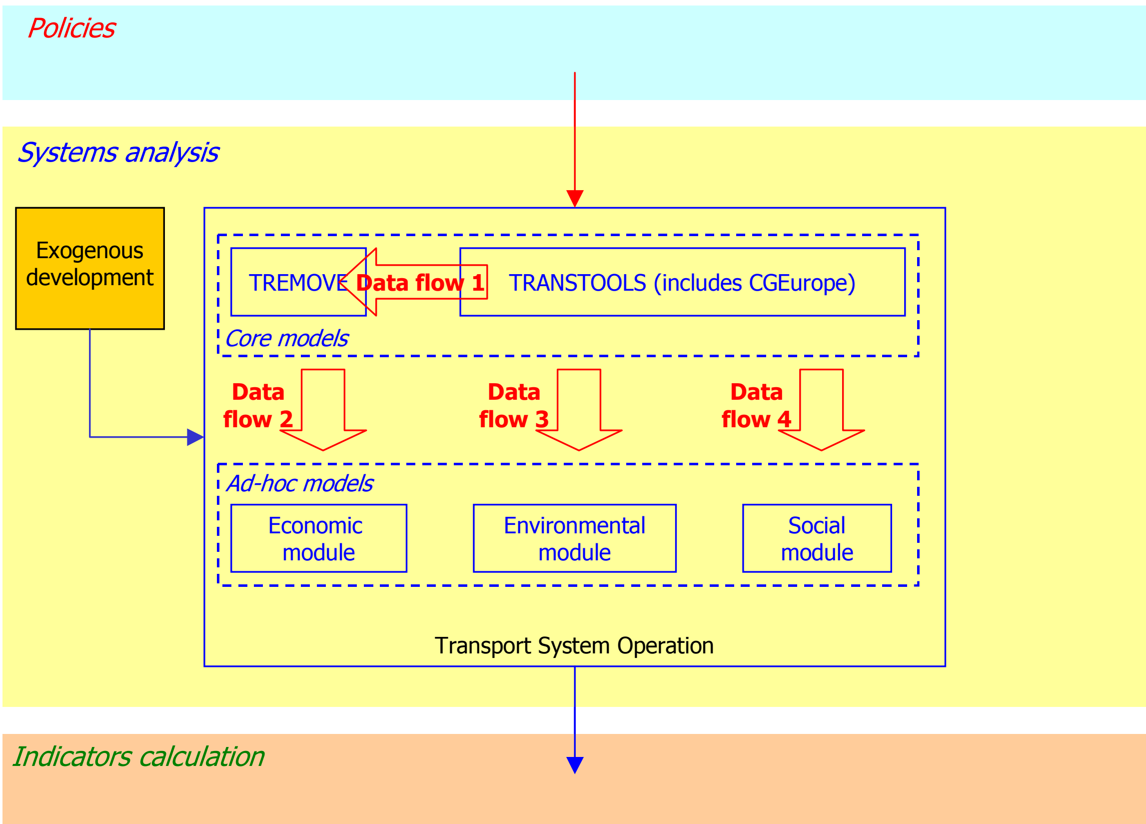
4.3 Data flow across REFIT models in the simulation process

Assuming that a policy has been defined in general terms (e.g. liberalisation measures), the first action to be taken is the quantification of the modelling input. This concerns the two *core* models only, because the implementation of a policy should always take place in such tools, while *ad-hoc* models will be fed with intermediate output produced by *core* models rather than original policy input. Once modelling input has been quantified, the steps required to perform the simulation within the REFIT framework are described in the following.

As far as policies involve several measures affecting the transport sector, their simulation requires using all modelling tools in a co-ordinated way. Even if one simple measure is modelled, so that input could change in one model only, all tools are needed in order to compute all indicators required for the assessment .The models are independent tools, but a coherent simulation process requires that inputs are consistent across the models.

Figure 4.1 provides a synthetic view of data flows between models. Policy simulation inputs are provided exogenously to the TRANS-TOOLS and the TREMOVE model. Also, the former feeds the latter with data on transport demand and transport costs. Finally, both "*core* models" provide inputs for the *ad-hoc* models. For instance, if road pricing is the measure to be simulated, the first implementation takes place in the TRANS-TOOLS model (where road pricing can be applied on a link by link base). The detailed output produced by TRANS-TOOLS about transport demand is translated in the format required by TREMOVE and transferred into this model to produce additional output concerning total emissions, welfare, etc. As a further step, detailed demand data is suitably provided from TRANS-TOOLS to the environmental and the economic models while other data are transferred from TREMOVE to the environmental and EDIP models.

Fig. 4. 1 Data flows within the TREMOVE modelling framework



So, in total, four endogenous data flows can be identified. Data flow 1 concerns the transfer of data from TRANS-TOOLS to TREMOVE, the other three data flows concern the output produced by the *core models* (TRANS-TOOLS and TREMOVE) fed into the *ad-hoc models*. Main issues involved in the four data flows are discussed in deliverable 2.2.

4.3.1 The linkage between TRANS-TOOLS and TREMOVE

The application of the REFIT methodology requires the linkage between TRANS-TOOLS and TREMOVE (core models in REFIT). In fact, as described in the previous section, the TRANS-TOOLS/TREMOVE integrated model structure is the *core* of the quantitative procedure.

The main objective of the linkage between the core models is to translate the TRANS-TOOLS derived data in the needed transport data for the TREMOVE model, which requires traffic volumes expressed in passenger-km, tones-km and vehic-km, and other data concerning travel times, travel costs, population, GDPs etc.

The definition of the linkage is complex as TRANS-TOOLS and TREMOVE models have a very different structure. Then, implementing the interface has required several steps: at first a detailed analysis of the structures of the two models has been performed; then the main requirements of the process have been defined and agreed between the TRANS-TOOLS and TREMOVE teams. In a next step a system of databases and queries has been developed in order to achieve an automatic process for the data processing. In the final step the consistence of the whole conversion procedure has been tested. In this final step it was found out that the baseline data of the two models do not match completely.

Therefore, within the REFIT project the physical linkage between the *core* models has been activated.

4.4 The calculation of the sustainability indicators

As explained in chapter 2, the modelling tools within the REFIT framework have different features and therefore play a different role in the process required to simulate policy measures and compute indicators. Basically, the role of models can be summarised as follows.

- The TRANS-TOOLS model simulates the interaction between transport demand and supply in detail at the European level and is therefore able to provide a number of results about impact on transport demand. Secondary effects of transport demand are also modelled (e.g. emissions, economic performance at regional level).
- The TREMOVE model simulates the impacts of economic and technology policies (e.g. road pricing, public transport pricing, emission standards, and subsidies for cleaner cars on the emissions) on the transport sector and on overall welfare. With respect to TRANS-TOOLS, the transport system is modelled in an aggregate form, but some specific modules, like the vehicle fleet module or the energy consumption module, deal with variables which are not addressed in TRANS-TOOLS or are addressed in a simplified way.
- The *ad-hoc* models are developed to simulate specific circumstances and widen the level of detail of results available on economic, environmental and social impacts (e.g. distribution effects, noise exposure).

Making reference to the list of indicators introduced in deliverable D1.2, models are able to provide the largest part of the indicators. In some cases, more models can compute one indicator, although the level of detail can be different. In other cases, indicators are not direct outcomes of the models, but can be computed using their results. Finally, some indicators of the D1.2 list concern variables which can be computed only at level of geographical detail which is not addressed by TRANS-TOOLS model. This is especially the case for land use indicators.

The following tables (from Tab 4.1 to Tab 4.5) provide a complete picture of the indicator coverage within the REFIT operational framework identifying the linkage to the specific model used and at what geographical detail it is calculated.

Tab. 4. 1 Transport system operation indicators

Theme	CODE	INDICATOR	Linkage to REFIT models	Spatial Detail
Freight transport performance indicator	**TPFR**	Load factors of road freight vehicles	TREMOVE	Country
	TPCS	Port callings	TREMOVE	Country
	TTFR	Road freight traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	TTFT	Rail freight traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	TTFI	Inland waterways freight traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	TCF	Freight transport costs	TREMOVE	Country/ Metropolitan / non urban / urban
Passenger transport performance	**TPPR**	Occupancy rates of road passenger vehicles	TRANS-TOOLS	Country
	TPPOR	Car ownership rate	TREMOVE	Country
	TTPA	Air passenger traffic at airports	TRANS-TOOLS	Country
	TTPR	Road passenger traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	TTPT	Rail passenger traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	TTPS	Sea passenger traffic at ferry ports	TRANS-TOOLS	Country
	TCP	Passenger Transport costs	TREMOVE	Country /non urban
Transport Infrastructure	**TNR**	Total road network	TRANS-TOOLS	Country
	TNT	Total rail network	TRANS-TOOLS	Country
	TNI	Inland waterways network	TRANS-TOOLS	Country
	TQCR	Percentage of congested road network during morning peak hours [F/C > 0.8]	TRANS-TOOLS	Country / Motorway / No-motorway
	TQAS1	Average speed on inter-urban road links during morning peak hours	TRANS-TOOLS	Country / Motorway / No-motorway
	TQAS2	Average speed on inter-urban road links during normal week days	TRANS-TOOLS	Country / Motorway / No-motorway
	TNET	Percentage of electrified rail track	TRANS-TOOLS	Country
Vehicles stock indicators	**TSR**	Stock of passenger cars	TREMOVE	Country
	TST	Rail rolling stock	TREMOVE	Country
	TQAR	Average age of road vehicles	TREMOVE	Country

Tab. 4. 2 Transport economic indicators

Theme	CODE	INDICATOR	Linkage to REFIT models	Spatial detail
Spatial impact indicators	**ECAMF**	Accessibility measures freight	TRANS-TOOLS	Country
	ECAMP	Accessibility measures passenger	TRANS-TOOLS	Country
	ECGDP	GDP effects induced by transport policies	CGEUROPE-R	Country
	ECTR	Trade	CGEUROPE-R	Country
	ECWE	Welfare effects induced by transport policies	CGEUROPE-R	Country
Sectorial impact indicators	**ECGVA**	Share of GVA generated by the transport sector	EDIP	Country
	ECEM	Transport sector employment	EDIP	Country
Transport budget indicators	**ECBEX**	Business transport expenditures	EDIP	Country
	ECGNR	Government net revenues from transport	TREMOVE	Country
	ECHEX	Households transport expenditures	EDIP	Country

Tab. 4. 3 Transport environmental indicators

Theme	CODE	INDICATOR	Linkage to REFIT models	Spatial detail
Environmental indicators	**ENCTEC**	Share clean technology vehicles stock	TREMOVE	Country
	ENWNEL	Waste vehicles	TREMOVE	Country
	ENAENO	Emission of NOx from road rail air IWW traffic traffic	TREMOVE	Country/ non urban
	ENAENOTOT	Total emission of Nox	TREMOVE	Country/ / non urban
	ENAENM	Emission of NMVOC from road / rail /air /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAENMTOT	Total emission of NMVOC	TREMOVE	Country/ non urban
	ENAES	Emission of SO2 from road / rail /air /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAESTOT	Total emission of SO2	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAECO2	Emission of CO2 from road / rail /air /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAECO2TOT	Total emission of CO2	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAECO2P	Emission of CO2 per capita from road / rail /air /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban

Tab. 4. 4 Transport environmental indicators - *continued*

Theme	CODE	INDICATOR	Linkage to REFIT models	Spatial detail
Environmental indicators	**ENAECO2TOTP**	Total emission of CO2/per capita	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAECO	Emission of CO from road / rail /air /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAECOTOT	Total emission of CO	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAEPM	Emission of PM from road / rail /air(life cycle) /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAEPMTOT	Total emission of PM	TREMOVE	Country/ Metropolitan / non urban / urban
	ENEFC	Fuel consumption from road / rail /air /IWW traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENEECT	Energy consumption from rail traffic	TREMOVE	Country/ Metropolitan / non urban / urban
	ENAQPM	Population exposure to PM10 emissions	Environmental Model	Country
	ENAQNO	Population exposure to NO2 emissions	Environmental Model	Country
	ENPEP	Population exposure to noise	Environmental Model	Country
	ENWT	Waste tyres	Environmental Model	Country
	ENPEXC	Internalisation of external costs - cars	LOI	Country
	ENPEXM	Internalisation of external costs - MC	LOI	Country
	ENPEXH	Internalisation of external costs - HGV	LOI	Country
	ENPEXL	Internalisation of external costs - LGV	LOI	Country
	ENPEXL	Internalisation of external costs - Rail	LOI	Country

Tab. 4. 5 Transport social indicators

Theme	CODE	INDICATOR	Linkage to REFIT models	Spatial detail
Equity and accessibility	**SEDI1**	Distributional impacts of transport policies - The Gini coefficient	EDIP	Country
	SEDI2	Distributional impacts of transport policies - GE index - mean logarithmic deviation	EDIP	Country
	SEDI3	Distributional impacts of transport policies - GE index - Theil's entropy	EDIP	Country
	SEDI4	Distributional impacts of transport policies - Amount of people that fall below the poverty line	EDIP	Country
	SEDI5	Distributional impacts of transport policies - Measure of the intensity of poverty	EDIP	Country
	SEDI6	Distributional impacts of transport policies - Measure of the inequality of poverty	EDIP	Country
	SEAI	Affordability Index	TREMOVE	Country
Safety	**SOSA**	Safety	SAFETY model	Country / urban / non urban / motorway

4.5 The choice of the most appropriate model

For some indicators that can be computed in different models it has been necessary to choose the reference model, in order to avoid duplications.

A criterion to make a choice was considering that the procedure for the simulation of policies can be interpreted as a flow of data through the various modelling tools, starting from TRANS-TOOLS and finishing to the *ad-hoc* models. Each tool adds to the simulation its specific capability and so as the data flow proceeds, more impacts can be modelled. Therefore, modelling outputs were extracted at the end of the data flow and thus most of transport operation indicators were extracted from TREMOVE, because it is the place where the full impact of measures on transport demand can be captured[6].

In some cases, especially for the economic indicators, overlapped capabilities concern CGEurope-R (Economic *ad-hoc* model) and TREMOVE/social *ad-hoc* model, which are both able to compute welfare measures. As the TREMOVE/social model is the source for several indicators also in the environmental and transport operation domains, in order to maintain a clear distinction of competences, economic related indicators were drawn, wherever possible from CGEurope-R.

6 However, there well might be policies which can be dealt with using TRANS-TOOLS only. In such cases, this criterion would not be of practical use.

4.6 The geographical detail

The policy assessment makes reference to a given geographical scope where the policy measures are applied. In order to use different indicators for the assessment, all of them are computed with the same geographical detail. The REFIT framework deals with the European transport policy, whose measures are mainly related to the European Union level and the member states level. Therefore, it seems reasonable that the indicators were computed for each EU country. Actually, given the features of the modelling tools, several indicators can be computed also for a sub-national level. However, there are some indicators which are only available for the countries and not for their regions. Furthermore, in most of the cases TREMOVE is the reference model for extracting the indicators and such a model does not provide regional data. The conclusion is that in order to have a complete set of results for the assessment, the reference geographical detail is the country.

At the same time, several TREMOVE outputs are available for three region types (metropolitan city, other cities, non-urban). It is therefore reasonable that at least transport system operation indicators and environmental indicators are produced also for such a three region types.

In summary, a two levels approach has been followed:

- At the first level all indicators which can be computed from modelling outputs are produced for each country;
- At the second level transport system operation indicators and environmental indicators are produced for the three region types: metropolitan city, other cities, non-urban.

Some indicators, namely percentage of congested road, average speed on inter-urban road links and safety, provide values for motorway and non-motorway, other than per country.

4.7 The REFIT Operational Tool for sustainability assessment

The REFIT Operational Tool is the instrument where the indicators developed in the previous steps of the operational framework are gathered in a coherent way in order to provide the policy makers with a clear overview of the indicators and their individual and total response to a certain transport policy.

The operational tool is represented by Microsoft Excel workbooks: one for each scenario considered, plus one workbook containing an overview of all scenarios. Each scenario workbook contains the indicators values computed for that scenario and allows for an analysis of the changes caused by the policy for each sustainability domain compared to the reference scenario[7].

Due to the overwhelming amount of indicators and to the several information that can be drawn from them, the REFIT team produced two differentiated tools: a tool for the policy maker, where key priority indicators are reported, and a tool collecting all detailed results for each indicators where users can go into more details.

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[7] The REFIT scenarios workbooks are directly dependent of a set of spreadsheets containing the output of the specific REFIT models. These *output spreadsheets* have been used as collector of the output models; they are part of the REFIT operational tool but, as all the indicators have been aggregated in the scenarios spreadsheets, they will not be attached to this document.

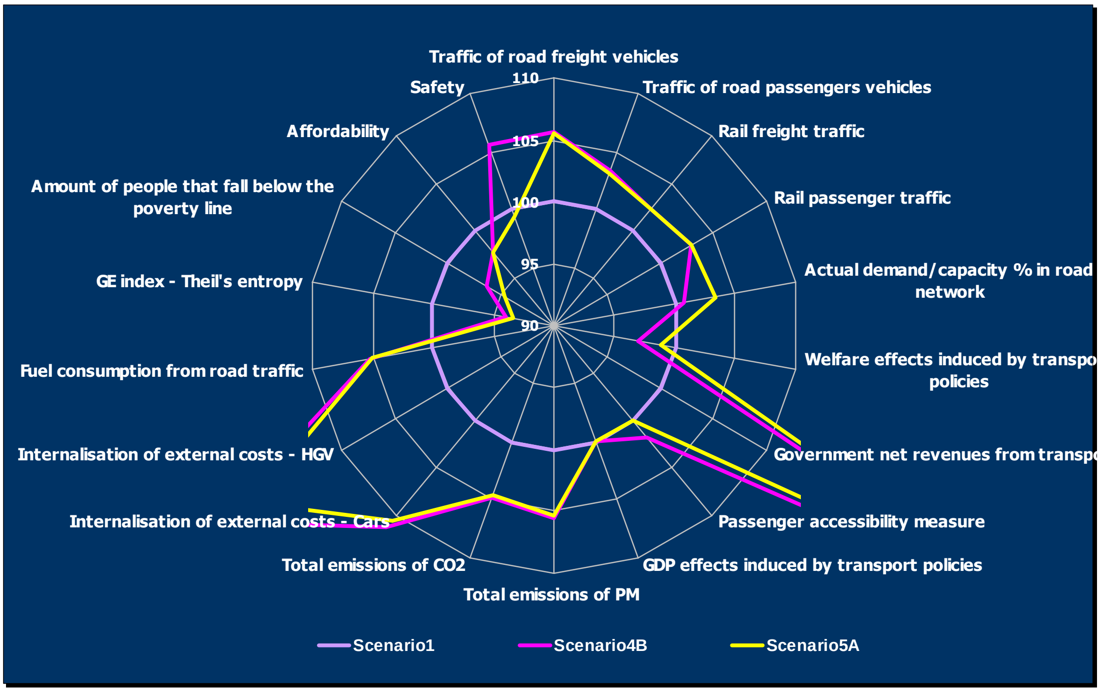
In deliverable 2.2 the complete operational tool is described. The REFIT consortium produced also a movie tutorial, which is available for the users to help exploring the REFIT spreadsheets and better understand the usage potential of the operational tool.

The version of the operational tool dedicated to the policy maker includes only the policy description sheet and the priority indicators, to allow a faster and more immediate analysis of the key impact of the policies[8]. This workbook allows for a comparison of all scenarios at once in terms of priority indicators. Such indicators have been chosen as main representatives of the full set of indicators for each domain.

In these spreadsheets, the priority indicators are shown in tabular form as well as in graphical form (web chart). The values are indexed (100 corresponds to the value in Scenario 1) and reported in a way that higher values correspond to a more sustainable situation starting from the base case

In figure 4.2, the graphical form contained in the priority indicators spreadsheet displays the behaviour of selected indicators computed for two different scenarios compared to the reference case (Scenario 1 in the picture).

Fig. 4. 1 Operational Tool- Priority indicators



8 The full set of indicators for all scenarios is hidden sheets in this version of the tool.

4.8 The application of the REFIT framework for the internalization of external costs

As reported in Deliverable 6.2 and 6.3, the first application of the REFIT accounting framework has been done for the internalization of external costs, in cooperation with the IMPACT project.

In fact, in order to be able to test the ad-hoc models on an actual question, on request of DGTREN, the scenario results, as calculated by the IMPACT project with TRANS-TOOLS and TREMOVE, were used as direct input to the REFIT ad-hoc models and were used to calculate REFIT indicators.

The REFIT indicators based on the IMPACT framework are reported in deliverable 6.2 and 6.3. Since the model runs provided by the IMPACT team have been performed without any linkage between the two core models, in some cases the comparability of the REFIT indicators, when they are computed from the output of different models, is complex.

It should be noted that this first application of the REFIT framework has been done in a specific case that did not require the linkage between TRANS-TOOLS and TREMOVE (data flow 1). The finalization and application of the linkage has been passed through to the iTREN-2030 project where a consistent baseline between the two models will be achieved.

5 Application of REFIT and further developments

Paragraph 5.1 describes how the REFIT framework should be applied. This includes the interpretation of results.

Paragraph 5.2 consists of the longer term application involving maintenance adjustments. Maintenance is needed to guarantee a correct working of the REFIT framework in the future. Improvements that can be made in future updates within the REFIT framework are given in paragraph 5.3. Also indicators that are not addressed yet will be elaborated and pathways for further development will be sketched. Furthermore, new models can be added or different indicators might help to get better outputs. It also focuses on possible improvements within the ad-hoc models.

5.1 Interpretation of results

5.1.1 Framework

The reliability of REFIT indicators is tightly linked to the reliability of the models outputs they are derived from and to the calculation criteria. As far as concern the reliability of the models outputs, it is obviously influenced by the availability and the quality of data used as input for the models and by the correct calibration of the modelling tool.

The calculation criteria may have a big influence on the indicators when more than one method is available for their computation (e.g. the LoI indicator can be computed in different ways and under different hypothesis).

For most of the TRANS-TOOLS and TREMOVE models derived indicators, where the calculation method is quite straightforward, the improvement of the reliability lies essentially in the improvement of the models themselves. The two models are currently being applied and refined in a number of European projects: 6th and 7th Frameworks Research Programmes, service contracts of DG TREN, DG ENV and JRC IPTS.

5.1.2 CGEurope and CGEurope-R

The CGEurope model was designed as an alternative to the usual CBA methods, specifically aimed at picking up the indirect additional benefits (or costs) that can arise as a consequence of the working-through of changes in accessibility in terms of changes in the location of activities, with consequent economic and social (welfare) implications. In particular, agglomeration effects can arise, stimulating some regions (and activities) possibly at the expense of others.

The CGEurope team had no intent to propose an alternative to CBA for transport schemes of the sort that are routinely evaluated in the transport sector – by-passes, routine additions of motorway capacity, or local public transport extensions. Only when a transport policy or a strategic transport investment is important enough to change economic activity in the area under consideration would spatial computable general equilibrium (SCGE) method of the CGEurope model be thought necessary – or even feasible.

The main exogenous parameters introducing the policy effect into the model are the transport cost factors. Thus, only the effects reflected in the transport cost changes are further accounted of in calculating economic indicators. The important examples here are the congestion costs, and other external effects. Within the REFIT framework, the congestion costs in freight transport are taken into account in the assignment module of Trans-Tools model. These are then passed on to the freight demand modules and the economic module. On the other hand, the indirect environmental effects, such as noise and pollution, are not taken into account in the economic indicators.

Neither are the effects on local (in particular, urban) transport taken into account in the current version of Trans-Tools. This can be viewed as a serious drawback, but its removal would basically require a systemic update of all modules. In the case of CGEurope that would require introducing passenger demand for transport in the form of commuting and other private trips. In a multiregional setup, that would mean a need for a corresponding database with the detailed information about household expenditures for transport. Unfortunately, we view it as a currently infeasible task.

5.1.3 EDIP

Inequality and poverty indicators

The applicability of the indices for inequality and poverty depends on the area of study of the researcher. We have chosen a set of 3 different inequality indicators and 3 poverty indicators with different ranges of sensibility, covering other aspects of inequality and poverty.

However, the indices for inequality and poverty we use in REFIT explicitly need a representation of the income distribution in a given population. Therefore in the EDIP model, it was necessary to estimate this distribution for each European country. The income distributions were eventually estimated and constructed using Eurostat data on earnings, employment and unemployment, income inequality and data of the International Labour Organization and OECD.

We believe that the inequality and poverty indicators are representative for each country and that the output of the indicators is reliable. Improvements could be made of course. The income distributions we use in EDIP were carefully assembled, but could be improved with an access to household micro-data on European level. However, this was not possible within the REFIT framework.

Economic indicators of the transport sector

These are simple indicators that focus on the position of the transport sector in the national economy, such as: the share of gross value added of transport or the share of employment in transport. They are reliable in the sense that they largely depend on the output of the economic model and not on exogenous data.

Level of internalization indicator

The level of internalization indicator or LoI, gives an indication of how much of the external costs a specific transport mode provokes are internalized through taxation. It is basically the coefficient between private costs (paid by the user) and social costs (cost to society). A value of 1 means that the transport mode has internalized all external costs to society.

REFIT distinguishes 2 ways to calculate the level of internalization: the efficiency and the equity approach. The main difference between these indicators is actually the nature of the costs: in the equity cost approach we use average costs, while costs in the efficiency approach are required to be marginal costs.

The REFIT database provided data on a national level, reflecting total or average quantities of transport volumes, impacts and costs. This made it impossible for us to use the efficiency approach for our calculations, as our database contains only average costs for each component. Development of a new database, considering the marginal costs of different components of the LoI calculation would not compatible with the strategic level of detail kept in the REFIT project, nor with the data currently available for the REFIT project. For that reason only the equity LoI was computed.

Another essential need for further improvement of the LoI relate to the costs of transport infrastructure. Since in the LoI these costs only appear in the denominator, they have a considerable impact on the final outcome. Even though the best available data are provided, certain reservations prevail regarding the inter-county comparison of the data. The uncertainty is due to the fact, that data are collected from individual country sources, which might not be as compatible as desired. The present data were obtained from preliminary results of the IMPACT study on transport infrastructure costs, by transport mode and included both fixed and variable costs. The quality could be considerably improved, if a homogeneous approach would be used when collecting and compiling the data on the country level. The experiences gained in UNITE and IMPACT show, that this task requires considerable time and effort. However, the outcome will be a LoI, which much more reflects the real situation on the country level than it presently does.

5.1.4 Safety model

The safety model is based on the predicted transport volumes of TRANS-TOOLS for passenger cars and trucks (see D4.2). In the TREMOVE model a very detailed division of vehicle kilometres among all types of vehicles is given. This division can be used to calculate the proportions of LGVs and HGVs that make up the Trans-Tools 'truck' vehicle kilometres. This distribution is assumed fixed over the years but can shift in reality, which influences then the number of fatalities for these modes.

All risk factors until the year 2010 are based on historic data and the trends in development of the risk factor between 2000 and 2005. This has been done for all countries separately. For some counties data were not available on a detailed level (e.g. road type or mode). In that case a same distribution among over road types of modes is assumed as in neighbouring countries. The result is that on a higher scale level (total fatalities per country), the results are more accurate and reliable than on a highly detailed level (e.g. HGV fatalities on a urban road).

In the safety model the changes in risk factors post-2010 were calculated by looking at the development level of the countries, based on the assumption that the less developed EU countries would experience the same road towards the same low risk factors. The decrease in risk after 2010 is estimated. Based on the level of development the height of the risk factors and the relative number of fatalities, the countries are divided into four groups, each with a different development path. It is possible that countries might change from one group to another in the future because their development might change. Therefore, the results are more reliable when the forecasts are closer to the present.

5.1.5 Environmental model

The environmental model for noise predicts for the number of people highly annoyed due to road traffic values in the range of 5.5% to 6.6% for various EU zones. See D6.2 for more details. This prediction is consistent with preliminary noise data for several EU cities, which result in values in the range of 5% to 7%. Although the method for the environmental model for noise is based on only one prototypical city (Amsterdam) and could be refined in the future, a plausible result for the noise impact is obtained.

The method for determining the population exposure at EU level was developed in detail for road traffic in urban areas. Presently the method is not suitable for other noise sources and rural areas, but this could be the case after further research.

5.2 Maintenance

5.2.1 Framework

In order to be able to use the REFIT framework in future some maintenance will be needed. This maintenance consists of updates of the models (core and ad-hoc) and updates of the data used in the models.

It might in some cases also be linked to updates of the core models. If the core models will entail a larger geographical area for instance this is not matching the ad-hoc models; the ad hoc models in this case can still be applied for the current number of countries. In most cases an update of the core models should just be seen as improved input data for the REFIT framework not requiring necessarily updates of the ad-hoc models.

Each ad-hoc model has its specific maintenance needs, in the ideal case these ad-hoc models should be updated every one or two years with new data for input and calculations of parameters.

Input data of high quality is necessary to have high quality output. Therefore, in the ideal case recent data is needed and the data should be updated regularly. This is mostly input data without further consequences, but in some cases these new available data might lead to new parameters in the model. New calibration of the model should then be carried out to guarantee accurate outputs of the model.

5.2.2 CGEurope

The input-output and regional accounts information should be updated regularly. The source of these data is Eurostat. Another important piece of information is the international trade matrix. Here, a reliable source of data is the UN Comtrade database. The updating of these data leads to reestimation of the many share parameters in the model, like the relative shares of traded and non-traded goods, and so on. The model is then calibrated to fit the updated information.

Another set of parameters in the model are the elasticities. An update of elasticities is a less likely event, because it is not the case that the corresponding new data is appearing on a regular basis. The change of elasticity values rather represents a sensitivity test, and is routinely performed for every scenario under analysis.

5.2.3 Safety model

The safety model should be updated every year with new data for all parameters per country. The source of the road safety data is the CARE database. In the current model these road safety parameters are based on available data between 2000 and 2005 (most recent year available) for road safety. When data for newer years is available, the trend lines for decrease in risk factor will become more accurate because it is based on a longer period.

5.2.4 EDIP

An ad-hoc social model (EDIP) uses a set of Social Accounting Matrices (SAMs) for 29 European countries in order to calibrate most of the parameters of the model. Ideally the SAMSs should be updated each year or each two years in order to take into account the structural changes in the economy and allow the model to give the most reliable results.

5.2.5 Environmental model

The environmental model's population exposure distributions, which are extrapolated to EU scale, are based on one prototypical city for noise and one for the air pollutants PM10 and NO_2. In case more prototypical cities are taken into account the population exposure distributions may deviate somewhat from the presently used ones.

5.3 Recommendations for further research

5.3.1 Further developments on the structure of the framework

When discussing improvements to the REFIT Framework we concentrate on the ad-hoc model. Improvements on the core models are discussed in different forums and are considered as out of scope to this project.

The first application of the REFIT framework has shown that further improvements are possible and advisable. Firstly, it can be noted that in many cases the progresses in the REFIT framework lie in the improvement of the models suite. As reported in the REFIT deliverables, some indicators are currently incomputable because of the reliability of some TRANS-TOOLS model outputs (i.e. freight accessibility). Furthermore a large part of the indicators are computed in ad-hoc models developed specifically for REFIT and, as any new tool, also the ad-hoc models need to be extended and improved. As far as concerns TRANS-TOOLS model improvements, it is currently being revised in several European projects (i.e. TEN-CONNECT, iTREN-2030, WorldNet); concerning the improvements for the REFIT ad-hoc models, suggestions are presented below.

Secondly, to improve the reliability of the REFIT indicators, it is advisable to establish a more tight linkage between the ad-hoc models themselves: creating a benchmark of the assumptions at the basis of each ad-hoc model (e.g. countries demographic, social and economic parameters) is important to avoid inconsistencies among them.

To improve the framework, also a reorganization of the current list of the REFIT indicators should be taken into account. So far the REFIT methodology includes 102 indicators, grouped into: 24 transport system operation indicators; 10 transport economic indicators; 59 transport environmental indicators including the LoI (Level of Internalisation); 9 transport social indicators. It can be seen that, especially within the environmental domain, the number of the indicators may be too high for many policy assessment exercises and a review and simplification might be done in order to focus on the most significant and to shorten the list.

Concerning the spatial detail of indicators, the experience performed in the first application of the REFIT framework taught that the proposed classification into *metropolitan*, *urban* and *non-urban* values is hardly applicable to those indicators that are not derived from TREMOVE; in fact, the European scale of the REFIT models is not suitable to perform analysis at a local scale. For further developments it could be explored the possibility to apply the REFIT methodology to other regional scale models in order to compute local scale indicators while concentrating the application of strategic models like TRANS-TOOLS and TREMOVE to national and European level.

It could also be explored the possibility to enlarge the suite of the REFIT models to produce more indicators in domains not addressed in the current REFIT framework; for example it could be useful to enrich the analysis by introducing indicators covering the energy domain. In fact, especially nowadays, the sustainability of transport policies cannot leave out of consideration this aspect and, for this purpose, it could be useful to add models like e.g. POLES to the REFIT model suite.

Improvements can be also made in the REFIT operational tool, mainly within the scenarios overview spreadsheets, in which the comparison among results of all different scenarios is shown currently in this spreadsheet, it is possible to display in a graphical form the indicators only at EU group level. The tool might be extended, for example, by providing a graphical overview on all scenarios for each country

Furthermore, in the current operational tool, the direct comparison of different domains indicators, it is possible only for some indicators, i.e. the priority indicators that are displayed in a radar chart in the priority spreadsheets. These indicators have been selected *a priori*, thus including additional indicators in the priority spreadsheet is not automatic and requires an extra work to be done on the tool. To this aim, a more flexible system might be thought up.

5.3.1.1 Integrating environmental and social dimensions

Several factors play a role in assessing the distributional effects of policies. E.g. an increased purchase price for cars, due to the introduction of emission standards, is likely to reduce car ownership in poorer households due to increased purchase cost. On the other hand, improved air quality due to policy measures can be unequal for different social groups.

Different policy measures can have different distributional effects:

- Taxes: literature shows that environmental taxes tend to be (weak) income regressive yet research seems to be inconclusive. Distributional effects also depend on the way of revenue recycle.
- Tradable permits: distribution effects depend on the choice of allocation of the permits and the way the revenue is recycled.
- Subsidies: distribution effects remain unclear.

Although these policy examples are rather general (in fact focused on environmental policy), it is shown that depending on the type of policy measure, different distribution effects can be expected. This is likely to be also the case for transport policy.

When focusing on transport policy, more specific, transport policy aiming to improve noise exposure or air quality, we can observe several effects:

Returning to the example of air quality in England and Wales, researchers studied the distribution effects of improved air quality (without examining the reason for the improvement). Different levels of improvement could be observed between different social groups: The more deprived benefited proportionally more from the improved air quality. Again, different levels of distribution between cities could be observed. These differences can be explained by the same factors as explained above, for air quality (namely population density, air quality, etc.).

It is the objective, when modelling this socio-environmental link, to allocate, on a detailed level, the environmental “goods” and “bads”, which have been calculated in previous steps, over the different social groups, in the model these are the 5 income-classes. This distribution will add a new dimension when calculating the indicators.

Literature about distributional effects is plenty; unfortunately quantitative analysis which could be used to add to the REFIT modelling framework is scarce, especially in a European context.

Different distributional effects, which have been shown in previous research, will need to be evaluated and the ones that are relevant and applicable in the framework of REFIT will need to be identified in future research.

5.3.2 Missing indicators within the framework

In all domains, most of the indicators can be computed using the output of the REFIT models. In the economic domain, the exceptions are the indicators concerning “Job-housing proximity and commuting flows” and “Agglomeration of firms/jobs - City attractiveness”, because the REFIT models are at the European scale and therefore do not simulate local aspects like job-housing proximity or agglomeration of firms.

For the same reason, in the environment domain two indicators cannot be computed: “Land take by transport infrastructure” and “Land consumption due to urban sprawl”. Additionally two other environmental indicators fall beyond the range of available modelling results: “Water pollution” and “biodiversity”.

The social domain is the most problematic as four of the proposed indicators out of eight cannot be computed using the REFIT models. Also in this case, the scale of the application is the main explanation for the unavailability of modelling results for “public transport accessibility”, “Employment accessibility”, “Availability of basic services in a short distance from home” and “Availability of open areas in a short distance from home”.

Finally, almost all transport system operation indexes can be computed. The exception are: the “Total urban PT network”, again because of the large scale of the models, while, “Airports capacity”, “Ports capacity” and “Air freight transport at airports” cannot be computed because TRANS-TOOLS does not simulate non-road capacity nor air freight transport.

In most of the cases, the correspondence between the indicator and the modelling variables is straightforward. In some cases, however, the indicator is not a direct output of the models, so that further work is required.

Tab. 5. 1 Indicators that cannot be computed by REFIT modelling tools

Domain	Indicator	Note
Transport	Air freight transport at airports	None of the REFIT models can simulate this variable
	Airports capacity	Too coarse scale of analysis
	Ports capacity	Too coarse scale of analysis
	Total Urban PT network	Too coarse scale of analysis
Economic	Job-housing proximity and commuting flows	Too coarse scale of analysis
	Urban access quality (Agglomeration of firms/job – City attractiveness)	Too coarse scale of analysis
	% change of industry output between reference case and policy case	Too coarse scale of analysis
Environmental	Air quality in urban areas	Too coarse scale of analysis
	Land take by transport infrastructure	Too coarse scale of analysis
	Land consumption due to urban sprawl	Too coarse scale of analysis
	Water pollution	Too coarse scale of analysis
	Biodiversity	None of the REFIT models can simulate this variable
Social	Public transport accessibility	Too coarse scale of analysis
	Employment accessibility	Too coarse scale of analysis
	Availability of basic services in a short distance from home	Too coarse scale of analysis
	Availability of open areas in a short distance from home	Too coarse scale of analysis
	Health effects of air pollution	None of the REFIT models can simulate this variable

5.3.2.1 Description missing indicators within the transport domain

Air freight transport at airports

To model this indicator it should be necessary to know more about the size of air transport. These data are not collected in databases at the moment. Most of the air freight is intercontinental transport instead of transport within Europe. TRANS-TOOLS is only able to model transport flows within Europe. Besides the flows of air transport, also the connecting access and egress transport need to be known to model the total chain of transport.

Airports and Ports capacity

These indicators are hard to model because the capacities of airports and ports are regulated by authorities. These authorities allocate the capacity. The capacity is dependent on a number of general indicators (e.g. wind, specific access of certain types of airplanes and ships) which make it hard to model.

Total Urban PT network

One of the less developed parts in TRANS-TOOLS are the urban areas. Only a small amount of the total amount of urban transport is modelled. As a result, it is not possible to model the urban public transport networks within TRANS-TOOLS. More data about type and size of urban public transport are needed to use this indicator.

5.3.2.2 Description missing indicators within the economic domain

The main reason for not incorporating these indicators is the poor data availability at a European scale for the variables that are relevant for the calculation of these indicators.

Total change of industry output and employment due to transport investments and policies

In order to model industry output response to transport policies, one has to introduce industry-commodity framework into CGEurope. A necessary additional piece of information is then the disaggregation of base year transport flows and costs between regions into different commodity groups (using e.g. NSTR nomenclature). A correspondence must then be created between these commodity groups and the industries as defined in country-level input-output tables. An example of such industry classification would be NACE or ISIC nomenclature. As was clarified during the work in the TRANS-TOOLS project, creating such a correspondence is not particularly straightforward, and, more importantly, the final usefulness of this exercise relies fully on the existence of high-quality disaggregated flows and costs data mentioned before. Because the main source of European transport data, the ETIS-BASE, suffers from certain problems, described in the TRANS-TOOLS early deliverables (D3), the work on modelling industry output response was postponed. This work could of course be continued once e.g. the ETIS-BASE is updated and the mentioned problems are removed.

Modelling the response of employment by industry is a much more demanding exercise, and was not feasible to make for the project mainly focusing on European transport sector.

Job housing proximity and commuting flows

In order to be able to access the changes in the commuting flows and in the home-job locations pair of the households', a very detailed geographical representation is necessary. The most disaggregate regional level at which the REFIT models operate is the NUTS3 level. Even this detailed regional level is not enough for the reliable and full representation of the commuting and location behaviour of the households. This means that within the present set of the REFIT models one cannot calculate this sustainability indicator. Constructing a much more detailed regional model incorporating commuting and location of different household type is the subject of the future research.

Urban access quality

The quality of the urban access depends upon the quality of the infrastructure of a particular city as well as upon the density of public and private transport in the city. This indicator can be assessed only with the transportation model describing the city network and the transportation flows on it. None of the REFIT models include the representation of such urban transport network and hence they are not able to calculate the value of this sustainability indicator. However, the indicator can be calculated using the existing transportation network models for the major European cities.

5.3.2.3 Description missing indicators within the environmental domain

Population exposure indicators:

For noise we used as indicator the percentage of people highly annoyed due to road traffic noise. Indicators not being evaluated in the REFIT project are the people highly annoyed due to railway and aircraft noise. Furthermore, besides the percentage of people highly annoyed also the percentage of people highly sleep disturbed due to noise may be considered as an indicator. After further research these indicators could also be incorporated.

Biodiversity

This indicator is impossible to calculate using the existing European modelling tools and methodologies. In order to assess the impact of the transportation system performance upon the biodiversity one needs to represent the major links between the European transport system and its ecosystem. In the last decade, there have been made several attempts to model the linkages between the economic and ecological systems using the integrated GEM/GEEM approach (general equilibrium/general ecological equilibrium). Models of this type have been constructed for Alaska and California. The models do not focus on the transportation system but may provide a methodological basis for further development of the integrated economic-ecological modeling in Europe.

A possible way to introduce impact of transport on biodiversity can be trough using a two way approach. On one side there is a direct effect on biodiversity through fragmentation of habitat caused by transportation infrastructure. On the other side a secondary effect can be calculated due to impact of emissions from transport, mainly emissions concerning climactic changes like CO2. As mentioned above, making the (direct) link between transport and biodiversity is a difficult task. Possibly a detour via fragmentation is needed because the link between fragmentation and biodiversity and the link between fragmentation and transportation are better documented.

5.3.2.4 Description missing indicators within the social domain

Public transport accessibility

In order to calculate this indicator it is possible to use the existing set of European urban transport network models. These models are available in each large city of Europe and are owned either by the city authorities or by the independent consultants. The quality of the public transport access depends upon the quality of the infrastructure of a particular city as well as upon the density of public and private transport in the city.

In order to be able to calculate this indicator within the REFIT framework, it is necessary to refine the TRANS-TOOLS model by incorporating the representation of urban level transportation network within it. This requires a lot of work on data collection, modeling of urban networks and will increase the complexity of TRANS-TOOLS.

Employment accessibility

In order to calculate this indicator it is possible to use the existing set of European urban transport network models. These models are available in each large city of Europe and are owned either by the city authorities or by the independent consultants. The quality of the public transport access depends upon the quality of the infrastructure of a particular city as well as upon the density of public and private transport in the city.

In order to be able to calculate this indicator within the REFIT framework, it is necessary to refine the TRANS-TOOLS model by incorporating the representation of urban level transportation network within it. This requires a lot of work on data collection, modeling of urban networks and will increase the complexity of TRANS-TOOLS.

Availability of basic services and open areas in a short distance from home

The calculation of these two indicators requires a microscopic representation of the geographic space including the open areas, location of different types of services, location of the residential areas etc. This information is available for some main European cities from the existing integrated land-use and transport models. However quite few of the cities have those models available.

In order to be able to calculate the two indicators at the European scale one needs to refine the network representation, used in the TRANS-TOOLS model, by including the urban networks of main European cities. The new network representation should be combined with the microscopic European level land use data from Corine land cover database of EuroStat. The use of land for a particular purpose can be changed exogenously as a consequence of change in the land-use related policies. The integrated land-use and transport version of TRANS-TOOLS can be further used for the calculation of the availability of basic services and open areas.

5.3.3 Ad-hoc models

5.3.3.1 CGEurope-R

Incorporating forward-looking dynamics

CGEurope-R is still a static model. It calculates the impact of transport cost changes by comparing two static equilibria, representing the reference situation and a counterfactual, respectively. For the counterfactual it is assumed that certain infrastructure components are in place that are not yet existing in the reference situation.

This approach allows for a good approximation of the welfare gain that in the real world would be obtained in the course of time. But it has shortcomings. First, policymakers might be interested in the *time paths* of the effects as well. Second, handling of incomplete factor mobility is not really possible in a comparative static framework. Either one assumes factors to be completely immobile (as it was assumed in the CGEurope version incorporated in the TRANS-TOOLS model), or one assumes it to be perfectly mobile. As labour mobility is still low in Europe, the first assumption may be acceptable with respect to labour, but with respect to capital both assumptions are unrealistic extreme cases. If factor returns change, capital will respond, though not by equalizing rates of return instantaneously. Capital already nailed to the ground will not move, but investments shift to places with higher returns and lead to higher capital stocks in these places after some time of capital accumulation. Obviously, this can not be dealt with in other than a *dynamic framework,* making the time path of capital accumulation explicit. A dynamic solution for a system of many regions proves to be a hard exersize, but the work in this direction has to be continued.

5.3.3.2 EDIP

Given the good data availability of the REGIO EuroStat statistical database, it is possible to refine the geographical dimension of the ad-hoc social model (EDIP) to NUTS2 or even NUTS3 geographical level. In order to disaggregate the ad-hoc social model to NUTS2 or NUTS3 level it is necessary to construct the Social Accounting Matrices for each of the European regions bases on the REGIO statistical database. Sector disaggregation of the REGIO database does not coincide with the NACE95 classification of EuroStat used in the present version of EDIP. Hence, it is necessary to map the REGIO sectors to the NACE95sectors. This task can prove to be difficult and might require some strong assumptions for simplification.

Besides the geographical disaggregation of the production data one also needs to disaggregate the consumptions data. The REGIO database does not include detailed information on consumption and income of regional households. Hence, it is necessary to use additional data sources in order to be able to perform the task. One possibility is the use of the micro-data of the European household budget survey together with the data of the national household budget surveys. These surveys include information about the location of households as well as about their consumption and income.

Refining indicators for distributional effects

REFIT modeling framework provides a set of important indicators for the distributional effects of transport related policies. However, more research can be done in this area. At present we are using the aggregated results of the households' budget survey from EuroStat in order to model consumption preferences of different households. This restricts our modeling approach as we are not able to have the disaggregation necessary for a more detailed analysis of distributional issues.

If we acquire from EuroStat the micro-data of the households' budget survey, it would be possible to implement more refined classification of household groups as well as use the classification of consumption expenditures, which is more useful for the analysis of transport-related policies. The data necessary for further improvement of the indicators for distributional effects are available from EuroStat only upon payment.

The modelling of distribution of the environmental quality and emissions between different household groups in EDIP was based on the recent study carried out for a number of cities in Great Britain. Results provided by the study proved to be interesting and useful, but more research is needed on the topic of the distribution of emissions between the household groups.

One can perform similar analysis for several major European cities. This includes an estimation of the environmental quality distribution function based on both the data on emissions by the city part and the data on the distribution of households with different income between the city parts. The later data is available from Urban Audit database of EuroStat.

5.3.3.3 Safety model

In case of the safety impacts assessment model, there is scope for further improvements to be made in the future. New countries can be included as and when new road networks are included in the TRANS-TOOLS model. The priority for this should be the two remaining EU member states, Cyprus and Malta. After that Iceland and several Balkan countries should ideally be included.

It is recommended to do a European study dedicated to the collection of road safety data. New data should also be included as and when it becomes available. This is particularly important in the case of the national data that were not available and were therefore estimated (e.g. the division of fatalities among travel modes in several new member states), but also in terms of generally updating the model, for example with new road safety and economic data and updated economic forecasts.

5.3.3.4 Environmental model

Further improvements can be foreseen for the environmental model; in particular concerning the aspect of the prototype data used in calculations for population exposures. Both for the noise and air quality exposure indicators one prototypical case was used for performing detailed calculations for population exposures. It was assumed that the geography of the buildings and urban road network of the prototype is representative for any urban area in the EU. Using data on population densities and urban areas in the EU, the exposure indicators found in for the prototypical cities were extrapolated to the EU level.

This method for calculating the exposure indicators at an EU level, described in more detail in D5.2, is able to take into account various prototypical cities. Presently one prototype is used for noise exposure and one for air pollution exposure. It is likely that more prototypes could be incorporated in the future as more data will become available.

Future research on the method for air quality might improve the accuracy of the calculated exposure indicator by using prototypes for larger cities. In larger cities the urban background will be larger than in the presently used prototype. The omission of such a prototype possibly results in an underestimation of the population exposure.

The method for calculating the exposure indicators at an EU level was developed in detail for road traffic in urban areas. After further research the methodology could be made suitable for rural areas as well as other noise sources.

6 Conclusions

The objective of the REFIT project, “to provide a set of sustainability indicators for assessing the effect of various transport policies packages of priority interest through state-of-art models at European scale”, has been successfully achieved.

The REFIT transport sustainability impact assessment framework which has been developed in this project consists of a set of models and a large set of indentified indicators that enable ex-ante evaluation of the European Common Transport Policy considering the economic, environmental and social dimensions of sustainability.

In this project it has been proven that it is possible to calculate some additional indicators that were up to now considered as an information gap. The framework has been established in such a way that the two core-models, TRANS-TOOLS and TREMOVE, provide several new developed ad-hoc models with input. The other data needed for the ad-hoc models is collected from existing sources and the input of the core models is used. These ad-hoc models are designed to quantify the effects of transport policies on specific indicators.

The REFIT Framework and the ad-hoc models are tested and validated with help of the scenario calculation results of the IMPACT study.

The REFIT Framework can in principle be used for all sustainability impact assessments within the EU. To keep the REFIT Framework working properly, maintenance on the models is necessary. This maintenance consists of the use of updated data and in some cases new calibration of parameters.

Future research in this area could focus on the use of different and more developed indicators to provide more detail on the level of sustainable impact assessments. Additional or improved data collection would also improve the availability of new indicators and in some cases the quality of the existing indicators. Suggestion for further research have been listed in this report.

The Commission has stated that REFIT has in the mean time been used by the Commission and that it clearly meets a need for additional indicators and corresponding tools for impact assessment at the Commission.