A FRAMEWORK FOR STRATEGIC SUSTAINABILITY ASSESSMENT OF EUROPEAN TRANSPORT POLICIES

Martino A. - TRT Trasporti e Territorio – Italy – martino@trttrasportieterritorio.it

de Stasio C. - TRT Trasporti e Territorio – Italy - destasio@trttrasportieterritorio.it

Tavasszy L.A. - TNO – Netherlands - Lori.Tavasszy@tno.nl

Chen T.M. - NEA – Netherlands - mch@nea.nl

ABSTRACT

Background: In current practice of transport policy three weaknesses can be identified: firstly, the links between existing modelling tools and sustainability indicators are inadequate. Secondly, the existing modelling toolbox is incomplete, especially with respect to the impact of transport policies on regional economic growth, on social equity and on local environmental quality. Finally, measures are often addressed in isolation, without a full understanding of interdependencies between them.

Methodology: REFIT is a research project co-funded by the European Commission within the Sixth Framework Programme that tries to repair these weaknesses producing a comprehensive methodology for assessing the impact of various transport policies and strategies on sustainability. The objective of the REFIT study is to develop a comprehensive assessment framework that links European transport policy objectives and indicators to the growing pool of tools and expertise accumulated within various European research projects. The framework is based on the application of modelling tools to produce a wide set of output, which in turn are processed to derive an array of indicators belonging to different domains.
Within the REFIT study, TRANS-TOOLS and TREMOVE Europe-wide transport models have been combined with three models created ad-hoc for calculating specific indicators to cover the economic, the environmental and the social dimension of transport system sustainability:
(i) the economic module addresses the linkages between transport and economy, mainly in terms of the effects of transport policy measures on regional GDP or employment; (ii) the environmental module, deals with health impacts of air-pollution and traffic noise; (iii) the social module handles the effects of policies on the social dimension looking at aspects like the distribution of costs and benefits.

Outputs: Models outputs are collected for the calculation of four groups of sustainability indicators: transport system indicators, transport economic impact indicators, transport environmental indicators and transport social indicators. These indicators are either derived from the international literature or suitably created for the REFIT project.

Application: The REFIT methodology has been tested by DG TREN on a set of transport charging policies for the internalisation of external costs where the indicators allowed for highlighting some important trade-offs between them.

Keywords: Integrated Assessment, Transport Policy, Sustainability, Indicators, Modelling.

DEFINITION OF THE STRATEGIC SUSTAINABILITY ANALYSIS (SSA) FRAMEWORK

Background and REFIT objective

Although sustainability is a goal for international and national policy-makers, there is no easy yardstick against which to assess practical policy programmes in the area of sustainability (WCDE, 1987; Hinteerberg et al., 1997). Sustainability is difficult to define or measure because it is an inherently vague and complex concept (Frame, 2008). However, what would be needed in any sector of application is adequate information that is tailored to quantitative sustainability objectives. Brink (1991) states that such information should: (a) give a clear indication as to whether objectives of sustainability are met, (b) concern the system as whole, (c) have a quantitative character, (d) be understandable to non scientist, and (e) contain parameters which can be used for periods of one or more decades.
The REFIT[1] project has attempted to limit the inherent vagueness of the sustainability concept. The lack of a consistent approach emerged during the ASSESS project, the mid-term evaluation of the White Paper (Transport Mobility Leuven, 2005). The identified problem did not concern just the lack of indicators or tools, but that they focussed on individual projects and instead of complete programs.
Some clear measures or, at least, indicators of sustainability already existed, but the effectiveness of policies towards a goal of sustainability cannot be assessed by simply applying single indicators. Several examples of measuring sustainability using the economical, the ecological, or a combined economical-economic approach may be found in the literature (e.g. Pearce and Atkinson, 1993; OECD, 1994; Sherp, 1994; IUCN/IDRC, 1995; Rennings and Wiggering, 1997), but the results lack of universal acceptance.

The REFIT project idea was developed as a remedy to the identified problems, to allow systematic, program-level (strategic) evaluation. More concretely the project objective of REFIT was to link the current EU transport policy priorities and indicators to a sound set of quantification methods and models.

REFIT and Strategic Sustainability Analysis (SSA)

Any systemic method of integrated assessment shall be based on a clear definition of sustainability. In general, we set a number of criteria for the sustainability of a system and we call this system sustainable if its dynamics never drives it outside the boundaries of acceptable values of these criteria. All the different definitions acknowledge that there are three dimensions of sustainable development: ecological sustainability, economic viability and social liveability.

[1] REFIT (Refinement and test of sustainability and tools with regard to European Transport policies) is a research project co-funded by the European Commission within the 6th Framework Programme.

To assess whether current transport policies contribute to achieving this ambition of sustainable transport, rigorous and scientifically sound assessment methodologies are needed. This may be the reason why the terms of reference of the REFIT study explicitly argued that there is a need for unambiguous sustainability targets and indicators that can be assessed with operational European forecasting tools regarding economic growth, social and environmental aspects.

In conformance with this goal, there has been much advancement in the area of ex-ante and ex-post evaluation methods since the sustainability debate started in 1970s. Initially, the basic arguments in favour of infrastructure investments were economic (better infrastructure fosters the economy) and social (better infrastructure improves accessibility); Cost-Benefit Assessment (CBA) and Social Impact Assessment (SIA) methodologies were used. However, when the environmental awareness grew after the Brundlandt Report and the Rio Earth Summit, Environmental Impact Assessment techniques (EIA) were developed, to include for example emissions of NO_x and CO_2.

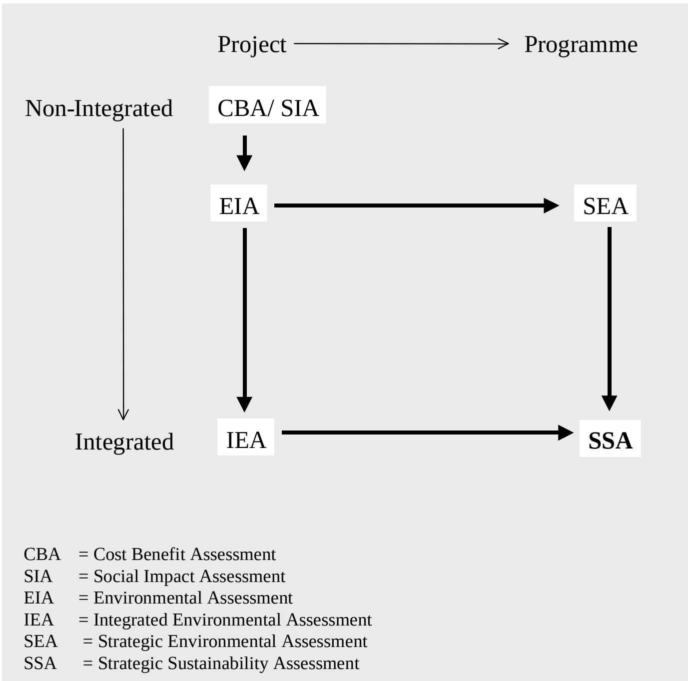

Figure 1 – The development of transport impact assessment methodologies

Starting from these EIAs, two major innovations have been made the last decade. Firstly, environmental assessment methods were developed which were able to evaluate complete policy packages (SEAs), since many environmental issues need to be tackled on higher decision-making levels than the project level. Secondly, it was tried to integrate environmental assessments with the more traditional economic and social assessment methods since decisions are not based on environmental issues only.

Such an Integrated Environmental Assessment (IEA) has been developed for the project level, but recently there have been demands for closer integration of strategic environmental assessment methodologies like Strategic Environmental Assessment (SEA) with strategic economic and social assessments methodologies.

An appropriate working title for this new assessment approach seems to be Strategic Sustainability Analysis (SSA), which stems from the OECD/ECMT conference on SEA in Warsaw 1999. The emphasis of SSA is on comprehensive transport programmes such as the European Commission White Paper on transport policy, assessing policies simultaneously in order to detect possible interdependencies and cumulative impacts, handling the three basic aspects of sustainability (economic, social and environmental) equally.

REFIT tries to establish a linkage between these different sustainability aspects enriching the modelling toolbox with new models able to assess the impact of transport policies on regional economic growth, on social equity and on local environmental quality. The way these models help to make progress in their respective fields is motivated by the wide framework for assessment adopted in REFIT.

REFIT transport sustainability indicators system

The system of indicators needs to be in accordance with European Commission general indicators of sustainable development and needs to feed the evaluation of policies according to specific targets set for the transport system (Figure 2). It is with these starting points in mind that the REFIT system of indicators was developed.

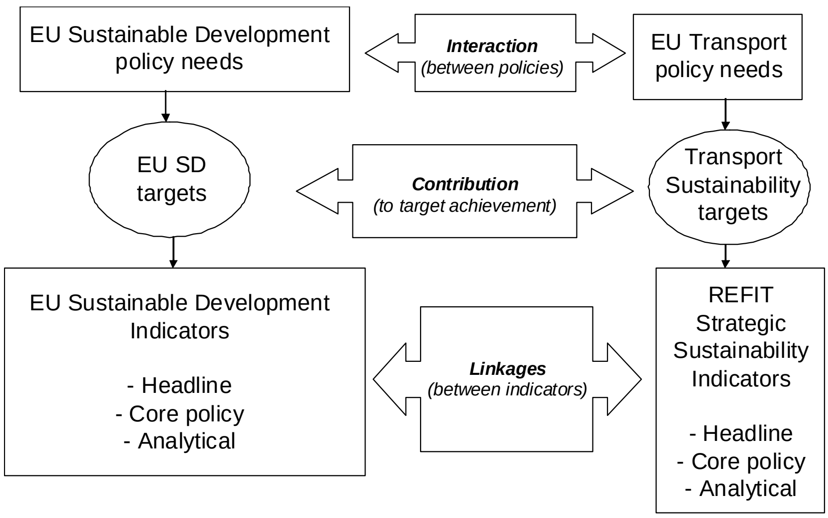

Figure 2 – System of indicators embedded in EU sustainability and transport policy

The methodology provides policy makers with a full set of transport sustainability indicators, encompassing the economic, environmental and social impact dimensions:

- 24 transport system operation indicators;
- 10 transport economic indicators;
- 59 transport environmental indicators;
- 9 transport social indicators.

Indicators are computed both for EU macro-regions aggregations[2] and for countries and allow for the assessment of the effects of transport policies with respect to a baseline scenario.
The complete list of REFIT indicators is provided in the Annex; here below the main indicators are briefly described.

Transport system operation indicators

Transport system operation indicators provide the information concerning: infrastructure consistency, passengers and freight transport performances, vehicle stock size etc. They allow assessing the effects of a specific transport policy (change in modal shares, traffic volumes etc.) on the "pure" transport domain.

Economic indicators

The *economic sustainability* of transport policies covers the requirements for strong and durable economic growth, such as preserving financial stability, a low and stable inflationary environment, and capacities to invest and innovate; therefore the basic economic indicators of policy impacts should include changes in e.g. incomes and prices, revenues and expenditures etc. Among the REFIT economic indicators it can be found:

- *GDP effects induced by transport policies*: GDP is expected to change, e.g. as a consequence of faster connections provided by new transport infrastructure (TENs). In fact, journey time savings and increased reliability for business travel represent a productivity gain and contribute to GDP. Moreover, there are effects in the labour market that may mean further effects of transport on GDP if transport directly or indirectly causes an increase in labour supply. In this case, GDP rises because time savings have an impact on the labour supply decisions of individuals.

- *Households and Business transport expenditures*: transport pricing and taxation policies clearly influence the budget spent by families and business sector for transport services.

- *Government net revenues*: the net amount of funds (taxes – subsidies) raised by the government on transport activities is directly influenced by transport prices and taxes.

Environmental indicators

The *environmental sustainability* focuses on maintaining the integrity, productivity and resilience of biological and physical systems, and on preserving access to a healthy environment. Most relevant indicators calculated by REFIT are:

[2] The EU27 plus Switzerland and Norway; EUS-12 (new Member States since 2004); EUS-15 (old Member States).

- *Emissions of pollutants (*CO_2, CO, PM_{10}, NO_x, SO_2 and NMVOC*) by transport mode*: this information is highly relevant for urban areas and for all those policies addressing the reduction of road congestion or the reduction of GHG emission levels.

- *Population exposure to emissions*: the indicator is expressed as percentage of population highly annoyed by NO_2 and PM_{10} concentration and noise considering the limits imposed by the EU legislation.

- *Final energy consumption by transport mode*: the type of policies expected to influence energy consumption includes the rationalisation of urban transport and R&D driven technological improvement.

- *Uptake of cleaner fuels*: the uptake of cleaner fuels may be seed-up by transport pricing and taxation measures, as well as urban transport rationalisation measure, which will make more convenient to use cleaner vehicles and fuels.

- *Internalisation of external costs*: it represents the degree to which social costs caused by transport activities are carried by the users; it is clearly linked to transport pricing and taxation policies.

Social indicators

The *social sustainability* emphasises the importance of high employment, of learning skills, of safety nets capable to adapt to major demographic and structural changes, of equity and of democratic participation in decision-making. The social impacts include the financial effects on income distribution and equity concerns - which would need to be considered alongside the aggregate economic benefits of transport policies – as well as the social impacts in terms of distribution of external costs and benefits, e.g. the effects on people health, city liveability etc. This dimension is evaluated through the following main indicators:

- *Distributional impacts of transport policies*: this is expressed through three different indexes which make reference to the distribution of the impacts across different income groups: Gini coefficient, GE index - mean logarithmic deviation and Theil's entropy. Distributional effects are also represented by the amount of people that fall below the poverty line.

- *Transport affordability index*: it reflects any change of average trip costs and consists of the transport expenditure made by a household measured as a percentage of its income.

- *Safety*: this indicator captures the impact of specific measures addressing road safety as well as the indirect impact of the realisation of new TEN infrastructures, which determines the likely increasing of traffic volumes and at the same time offer safer infrastructures to drivers.

THE MODELLING TOOLS

Modelling tools represent the instruments to simulate the effect of the transport measures on a wide range of variables. As already mentioned, the REFIT "tool box" includes the two *core* models and three modules created to analyse specific impacts, which were not addressed in sufficient detail by the core models with respect to the economic, environmental and social dimension. The heart of the toolbox lies with the models for transport and environment developed within the EU framework research programmes, with public funding and in use by the European Commission itself for regular impact assessments. The TRANS-TOOLS/TREMOVE integrated model structure is the *core* of the quantitative procedure: TRANS-TOOLS[3] a is a European transport network model covering both passenger and freight network-based transport model whereas TREMOVE[4] is a transport and emissions simulation model developed for the European Commission that simulates aggregate demand and includes a detailed description of fleet development, fuel consumption and emissions factors. These two models simulate the change induced by a policy on a wide range of variables and produce a set of data, which are either indicators themselves or the input of the detailed impact models.

Indicatively: the *economic module* addresses the linkages between transport and economy, mainly in terms of the effects of transport policy measures on regional GDP or employment; the *environmental module*, deals with health impacts of air-pollution and traffic noise; the *social module* handles the effects of policies on the social side in terms of aspects like the distribution of costs and benefits.

The TRANS-TOOLS model

TRANS-TOOLS is a European transport network model covering both passenger and freight that has been expressly developed to supply the European Commission with a tool designed to be the reference model for transport policy analysis. It's mainly made of three different modules for freight demand, passenger demand and assignment which exchange information according to a sequential approach. The model framework allows feedbacks between the modules to achieve equilibrium between supply and demand. The *network assignment module* produces the direct output of TRANS-TOOLS and also generates level-of-service data (LoS) as input to passenger and freight modules in a feed back loop. In the TRANS-TOOLS model, transport networks are defined at unimodal level and the following assignment models are developed: road network (passenger and freight); rail network (passenger and freight); inland waterway (freight); air network (passenger).

[3] More information on http://energy.jrc.ec.europa.eu/transtools/TT_model.html.

[4] More information on www.tremove.org.

The TREMOVE model

TREMOVE 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 covering the 1995-2020 period, with yearly intervals. 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.

Starting from the baseline level of demand for passenger and freight transport per mode, the model 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. It also 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 and consequently computes the fuel consumption and emissions.

The economic model

The CGEurope-R economic model is a multi-regional Computable General Equilibrium model covering the whole world that uses actual economic data to estimate how an economy might react to changes in policy, technology or other external factors. 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.

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.

The environmental model

An ad-hoc environmental model has been produced within the REFIT project for modelling the percentage of the urban population (per country) in the EU that is exposed to a concentration of NO_2 or PM_{10} that is exceeding EU limit values. The model estimates as well the percentage of the urban population per country that is highly annoyed due to noise. These indicators are determined on the basis of the exposure distribution in urban areas in each country: a number of prototypical cases has been mapped in a high level of detail and the distributions found in these cases have been used to estimate the distributions in EU countries.

The inputs for the exposure assessment are data on EU level derived from TREMOVE and TRANS-TOOLS. For each country TREMOVE model provides detailed data on the type of mileage per road (urban, non-urban, motorway), per vehicle type (cars, light duty, heavy duty) and PM_{10} and NO_x emissions per road category and type of area (urban – non urban). TRANS-TOOLS provides data concerning networks (motorways and main roads) and traffic flows (passenger cars and trucks).

The social model

The social model (European Model for the Assessment of Income Distribution and Inequality Effects of Economic Policies EDIP) is constructed using the Computable General Equilibrium framework, which takes as a basis the notion of the Walrasian equilibrium. EDIP is designed to assess the effects of concrete governmental policies by comparing the situation without certain policy measure to the situation with this measure. The model assesses the relative changes in the main variables of the model and the overall welfare resulting from the policy implementation and calculates the effects of the policies over a period of time, which is defined by the model user. It takes as its main inputs the forecast of the future development of the country's population, labour efficiency, the total factor productivity of the industrial and service sectors, transportation costs by vehicle type and distance class, car ownership costs, emissions factors by type of emissions and world prices by commodity type. The main outputs of the EDIP model are the relative changes in a set of social inequality indicators, including the inequality of income distribution Gini coefficient, the amount of people below the poverty line, the inequality and intensity of poverty.

THE REFIT ASSESSMENT FRAMEWORK

The REFIT "modelling tools-based" methodology enables ex-ante evaluation of the European Common Transport Policy considering the economic, environmental and social dimensions of sustainability. Figure 3 (see next page) shows the main components of the REFIT operational framework.

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 and their main role is to produce the sustainability indicators which provide synthetic measures of the effects of transport policies on given domain. Indicators are policy sensitive in the sense that their ingredients include variables whose value is affected by the policy implementation. The effect of specific measures is generally reflected by a change of the value or one or more indicators.

The Policy area

The Policy area provides inputs to the *core* and *ad-hoc* models of the "Transport System Operation" box within the System Analysis area. On the one side, policies 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).

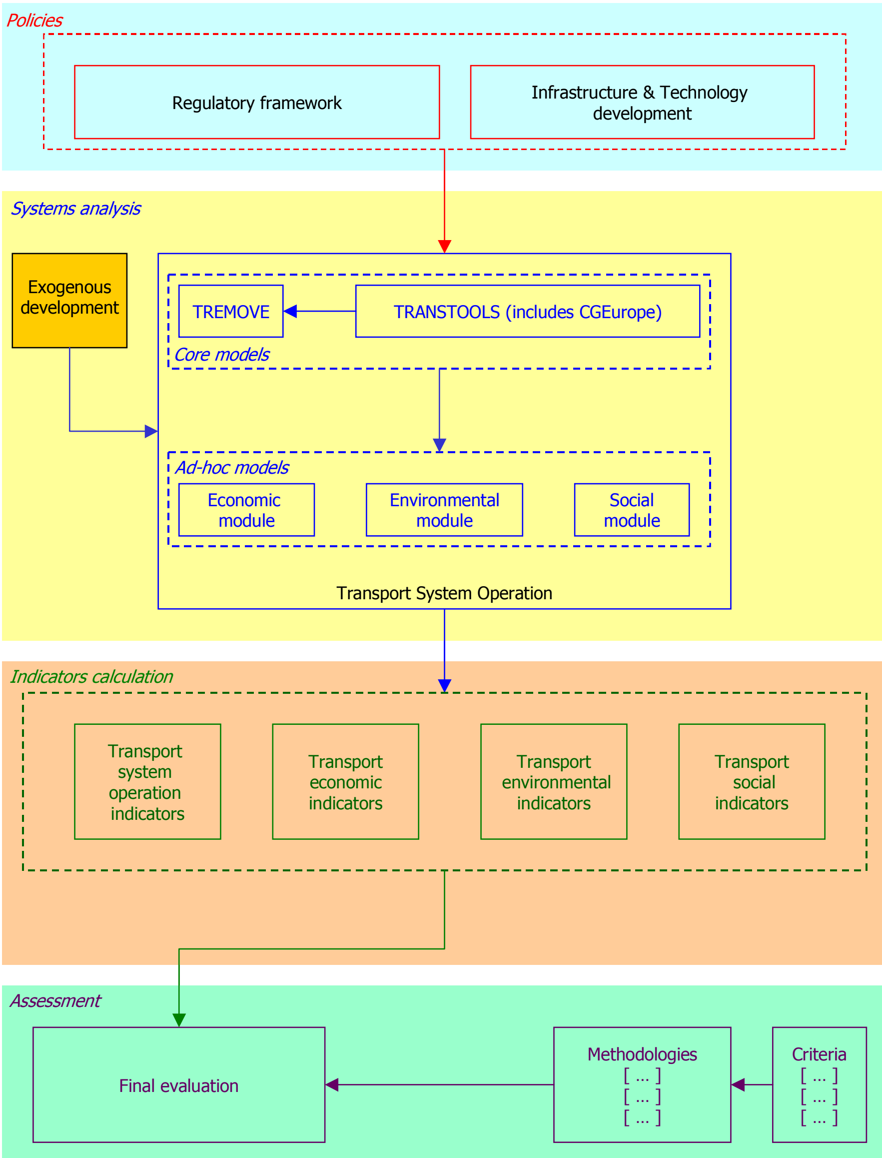

Figure 3 – The REFIT operational framework

The System Analysis area

The "System Analysis" area is the 'engine' of the operational framework, where the input defined in the Policy area is elaborated and then translated into raw output that 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. The system dialogs with the "Exogenous development", which includes all those trends that influence the mobility patterns even though are not treated explicitly by the models (e.g. economic growth, population development, etc.).

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: *transport system operation* indicators, *transport economic impact* indicators, *transport environmental* indicators and *transport social* indicators.

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. Considering that the CBA and MCA are only partly suitable to address sustainability concerns, in particular equity issues being a mayor caveat, the proposed methodology aims at allowing the assessment and the comparison of policies considering more aspects at the same time. This objective involves the need for *integrated assessment.* Integration is required under different respects, for instance:

- a given policy can give rise to positive effects on one side (e.g. environment) but have negative impacts on other sides (e.g. economy);

- policies can have different impacts on different social groups (e.g. consumers/producers, labour/capital);

- costs and benefits of policies can have a very different distribution over time so that inter-generational problems arise.

The integration amongst the sustainability indicators is realised through the use of the "REFIT operational tool": it is the instrument where the indicators 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 REFIT operational tool

The REFIT operational tool is the instrument where the indicators computed in REFIT 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. It contains policies description and implementation, output of the models, indicators values of the policy grouped by domain, indicators values of the policy compared to base case and additional information for the assessment. The operational tool is represented by Microsoft Excel workbook containing set of pivot tables and graphs, which allow for a comprehensible analysis of the changes caused by the policy for each sustainability domain. Due to the high numbers of the indicators that REFIT is able to calculate, synthetic spreadsheets have been set up containing only a small set of selected priority indicators. Such indicators have been chosen as main representatives of the full set of indicators for each domain. Looking at the changes occurred to such indicators with respect to a reference scenario the user can have a quick impression of the policy impact before to explore all indicators in detail.

APPLICATION OF THE REFIT FRAMEWORK

The REFIT framework was tested by assessing different European policies aimed at the internalisation of external costs of transport against a reference scenario (Scenario 1). The specific objective of the policies illustrated in this section was to internalise the five following externalities: climate change, air pollution, noise, accidents and congestion, through the introduction of taxes and charges. Two variants were considered: the application of the charges on all vehicles (Scenario 4B) or only on HGV vehicles (Scenario 5A). The year of the simulation is the 2020.

Priority indicators

Analysing the reduced set of the *priority indicators* it is possible to get a quick idea of the overall impact of the policies: the trade-off is visible and the size of the changes allows the user to identify a first broad hierarchy between scenarios. Indicators are reported in a way that higher values correspond to a more sustainable situation starting from the reference case.

Consequently, in the figure here below, those indicators included in the area edged by the reference case values show a worsening in terms of sustainability comparing to the reference situation. The results in the specific case tested seem suggesting that Scenarios 4B and 5A are significantly effective in internalising external costs, reducing congestion, emissions and accidents while negative economic and social impacts are not too large when compared to the reference scenario.

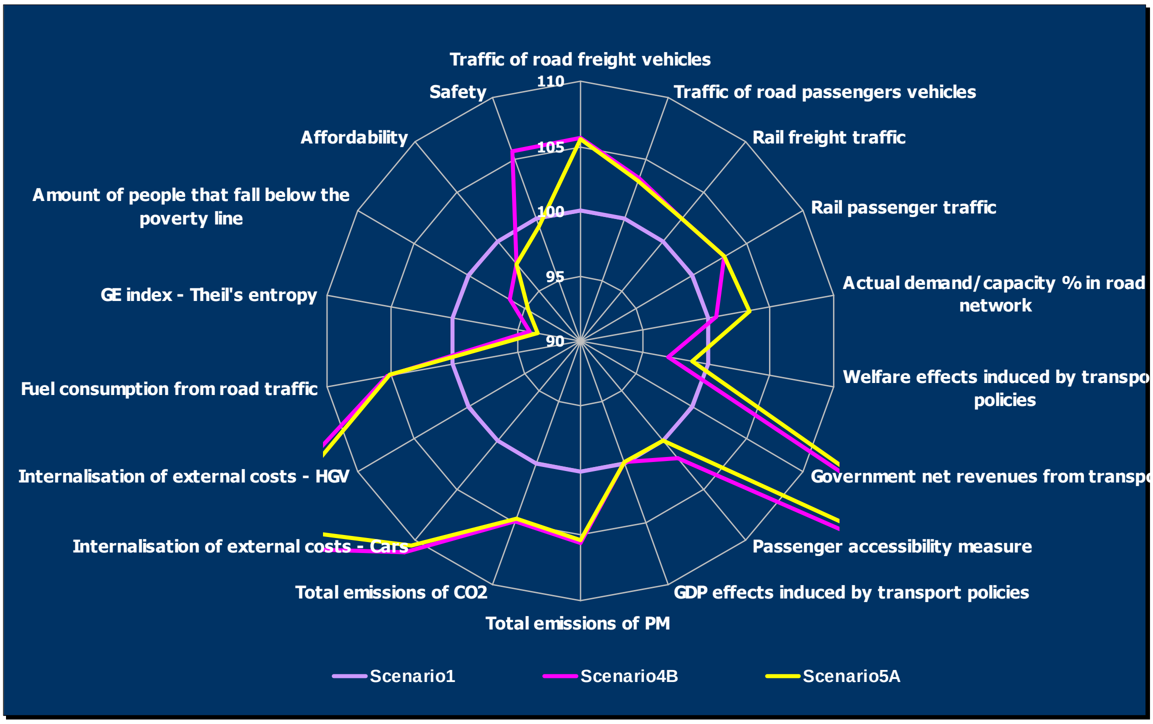

Figure 4 – Priority indicators

Economic indicators

Within the *economic domain*, the figure below shows the percentage changes in GDP due to scenario implementation, in comparison with the reference Scenario 1. In this case, the results suggest that the chosen pricing scheme in combination with the revenue redistribution proportional to GDP is disadvantageous for the new member states, as they suffer relatively more from increased charging. These negative effects are brought about by the capital outflow.

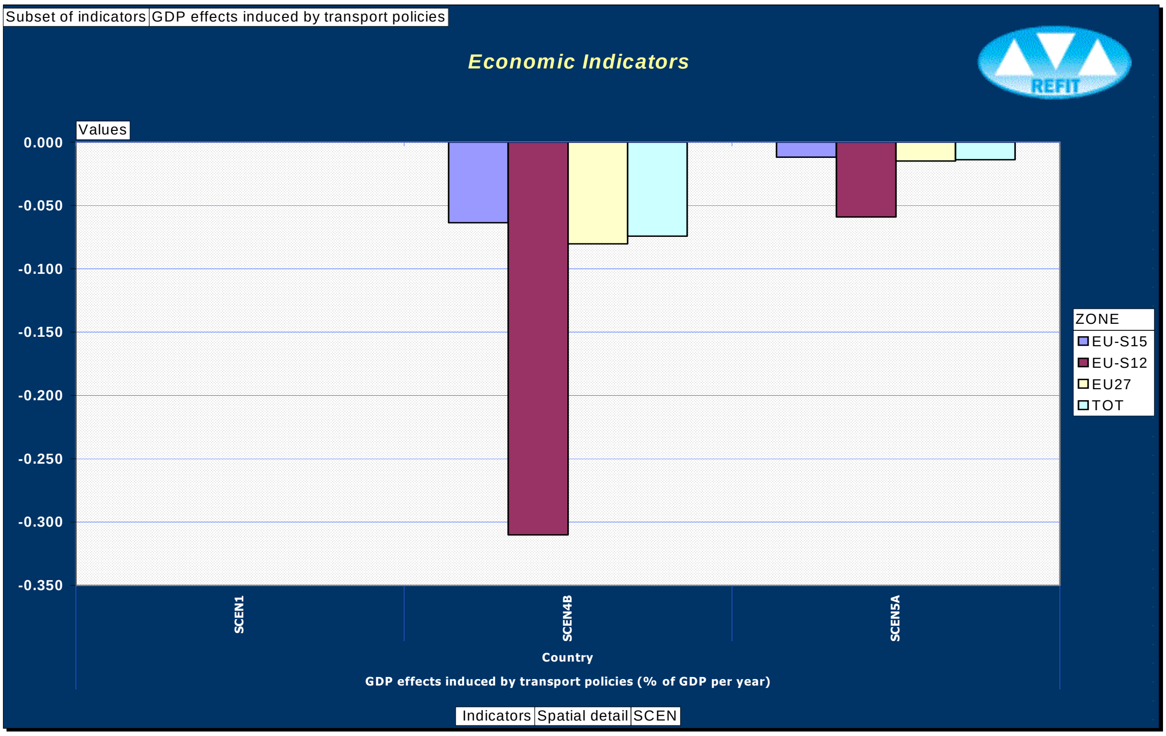

Figure 5 – GDP effects induced by transport policies

Environmental indicators

As mentioned above, the REFIT framework is able to calculate 36 environmental indicators. The NO_x emissions, computed for each transport mode, are reported in the Figure 6 below. The graph shows that the policy scenarios only moderately affect the emissions, mainly via a decrease of road transport volume caused by the additional taxation. For non-road modes, emissions stay more or less the same.

Another indicator used in the REFIT framework is the Level of Internalisation (LoI): this indicator represents the degree, to which social costs caused by transport activities are carried by the users. It is computed as the ratio of private costs for a specific transport user and the social costs generated by this activity, using the basic cost elements of the relevant transport mode. With reference to the graph in Figure 7, the LoI increases significantly in the pricing Scenarios: 4B and 5A reach a LoI above one, which implies that social costs are lower than private cost, i.e. more is paid by the users than their costs they cause. While cars have a high level of internalisation, motorcycles show much smaller values and additionally, the scenarios have no significant impact on the LoI. This implies, that (i) a huge gap exists between private and social costs and (ii) that the envisaged policies of the scenarios have practically no impact with regard to cost-coverage of this mode of transport.

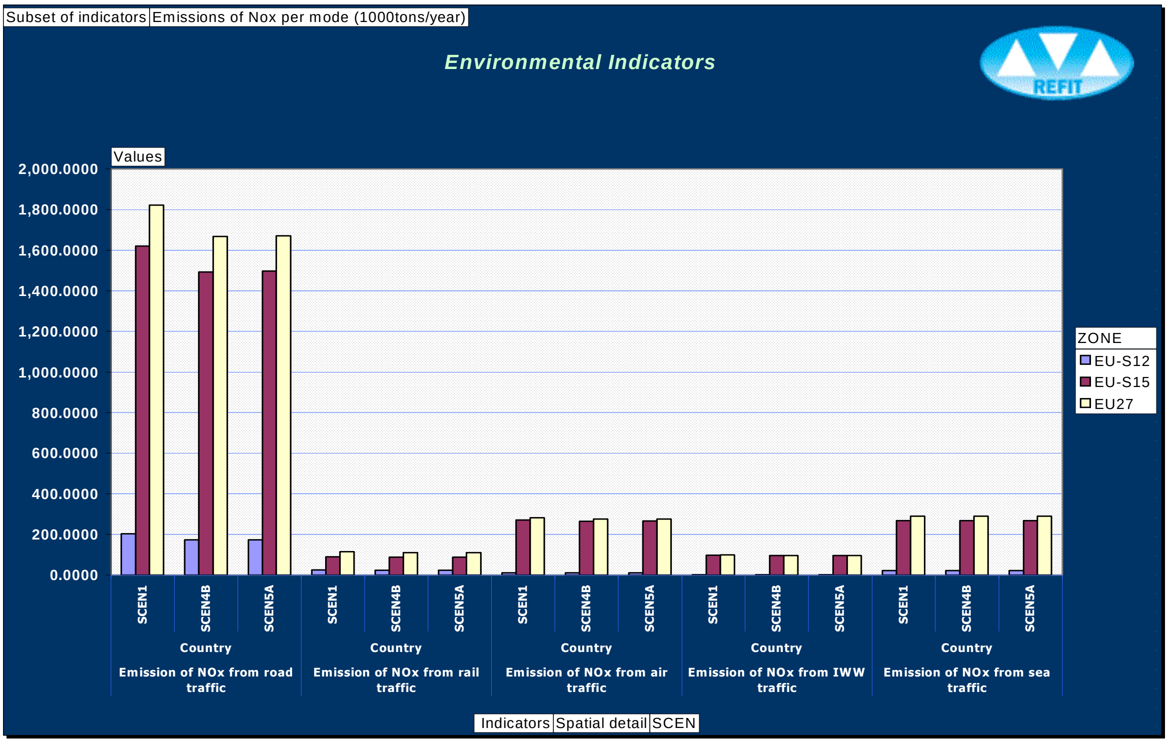

Figure 6 – Emissions of NOx per mode (1000 tons/year)

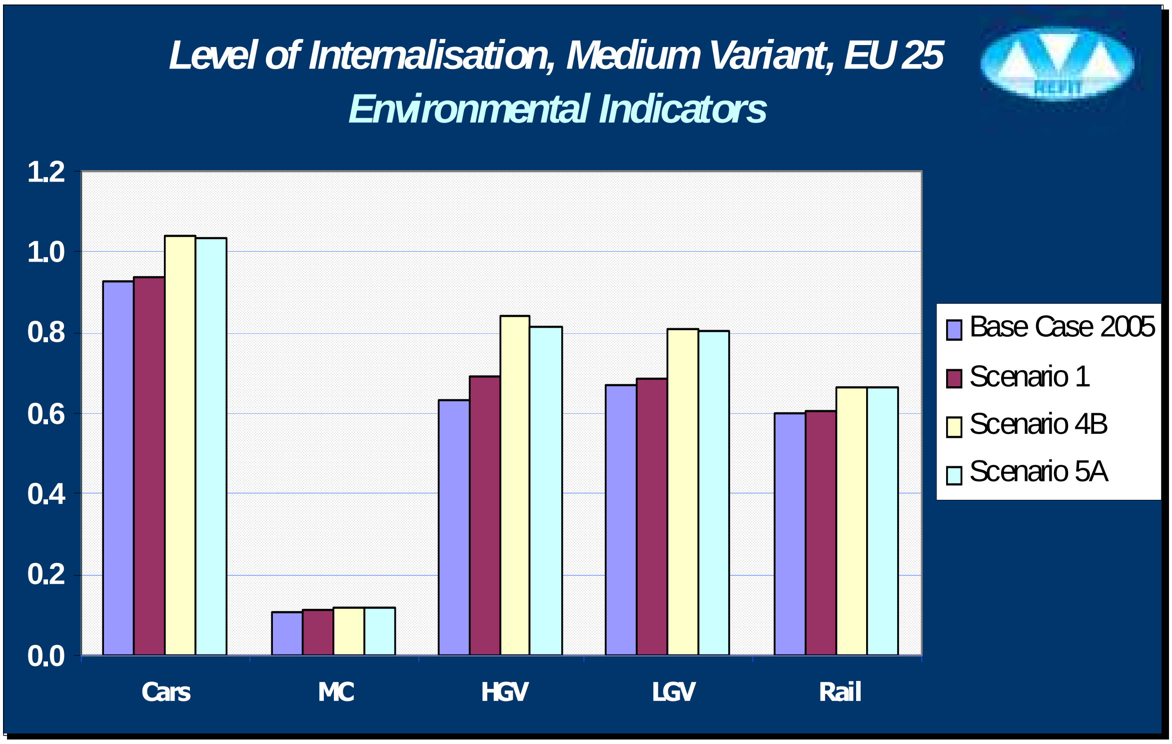

Figure 7 – Scenarios for the LoI in 25 European countries

Social indicators

Within the scenarios analysed, transport taxes are changed in order to better represent its real cost to the society. In general increase in the overall amount of taxes paid by the individuals decreases their disposable income and this leads to negative welfare changes in the neoclassical approach.

Social indicators address a different issue: in order for the income inequality and poverty indicators to show significant changes, the implemented policy measures should have a strong impact upon the welfare and income of two lower income quintiles. This is not the case for the scenarios we have tested since the taxes are significantly increased only for the private transportation.
Three different indicators are computed as each one has a different sensitivity. The Gini index gives a very good overall measure of inequality, while Theil's index gives a lot of information on changes around the middle of the distribution and the mean logarithmic deviation gives more information on changes in the lowest income quintiles.

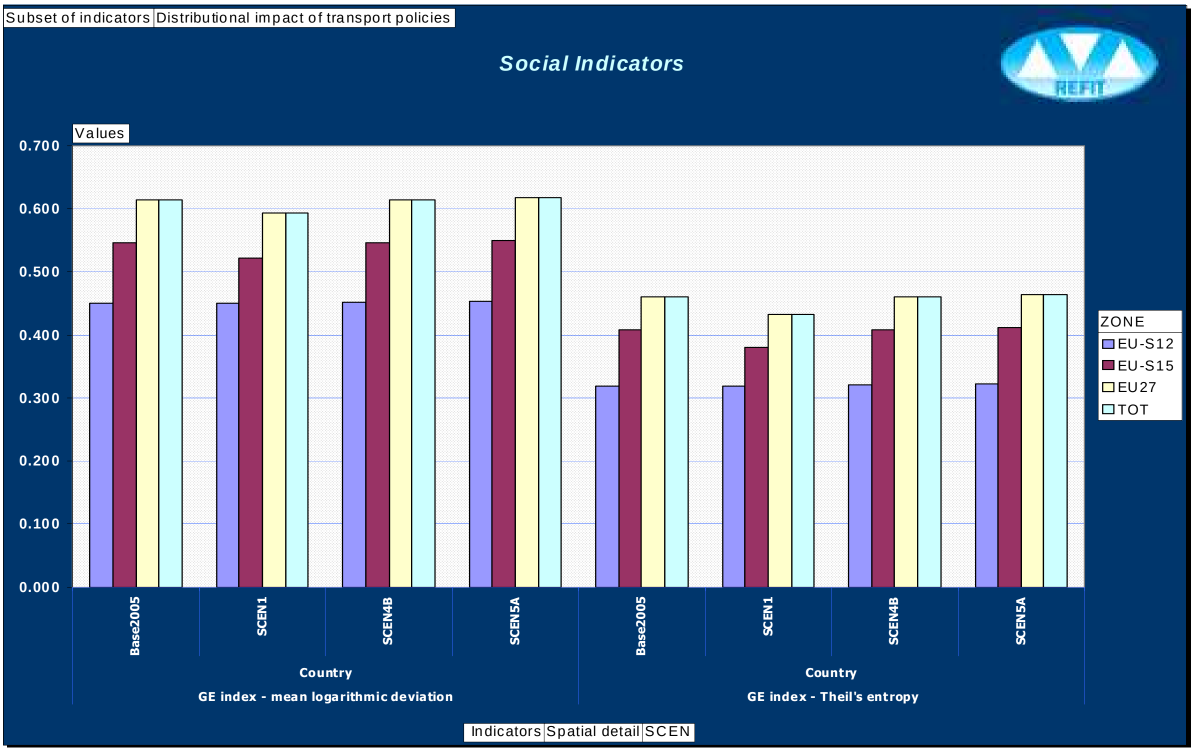

Figure 8 – Inequality indicators: Mean Logarithmic deviation and Theil's entropy

On the European level, inequality increases slightly, as expected. There is no big difference between changes in the index for the EUS-12 (new Member States) and EUS-15 (old Member States) or between the mean logarithmic deviation and Theil's entropy.

CONCLUSION

The application of the REFIT framework for the assessment of the effects of EU transport policies provides a complete set of indicators covering all the sustainability domains and allows the user to analyse the policies impacts in a multidimensional manner and identify advantages and disadvantages of the measures simulated.

The test performed proved the indicators are exhaustive to provide a wide overview on the effects of the internalisation of external costs policies: the indicators behave largely in accordance to theoretical expectations; despite the similarities of the tested scenarios, which concerned different details in the implementation of the same measure (transport charging), the REFIT indicators proved able to discriminate between the different scenarios. Even if such scenarios deal with transport pricing and therefore economic and transport indicators may be the first ones capturing user's attention, environmental and social impacts enrich the description of policy effects and add information for a fair judgement of the measures simulated.

Looking at the indicators, the user can find a confirmation that levying taxes and charges brings about an increase of travel costs, but can appreciate the impact of such increase on the traffic performance as well as on the regional economic activity. The average costs of transport trips is increased to correspond to the level of the external costs associated with transportation: increase in transport tax burden decreases demand for transport, which is reflected in reducing congestion, emissions and accidents, but it also increase the expenditures of both firms and households.

The social indicators reflect the effect of increases in taxation, while the effect is probably limited for the poor population due to their lower consumption of transport services, and small increases in inequality and in poverty can be noted. However, these effects are not as important as the economic effects on the transport sector and differ between countries.

Since a trade-off exists among the different dimensions of sustainability, the best alternative scenario does not become apparent from indicators. And the selection of the 'most preferable one' is not part of the objectives of REFIT; instead, the assessment framework offers several detailed data that can be used for further analysis.

ACKNOWLEDGEMENTS

The authors wish to thank the partners involved in REFIT for making available the documentation prepared in the project: TNO Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (The Netherlands), TRT Trasporti e Territorio (Italy), Transport and mobility Leuven (Belgium), Istituto di studi per l'Integrazione dei Sistemi (Italy), Chiristian-Albrechts-Universität zu Kiel (Germany) and Universität Stuttgart, Institut für Energiewirtschaft und Rationelle Energieanwendung (Germany).

REFERENCES

Borst J., de Kievit M., Zhou H., (2008). REFIT Project Deliverable 5.2: Modelling population exposure to noise and air pollutants NO2 and PM10

Brink, B. J. E. Ten, (1991). The AMOEBA approach as a useful tool for establishing sustainable development. In: O. Kuik and H. Verbruggen (Editors), In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, The Netherlands, pp. 126.

Chen M., Tavasszy L., Korzhenevych A., Bröcker J., De Ceuster G., Ivanova O., (2007). REFIT Project Deliverable 3.1: Assessing the economic dimension of sustainable transport policy: an overview

de Stasio C., Casamassima G., Fiorello F., Ivanova O., Heyndrickx C., Sieber N., Nickel P. Van Rooijen T., Borst J. Korzhenevych A., (2008). REFIT Project Deliverable 6.2: Strategic Sustainability Assessment of European Transport policies

de Stasio C., Casamassima G., Fiorello F., Ivanova O., Heyndrickx C., van Rooijen T., Borst J. , Polinder H., Korzhenevych A., (2008). REFIT Project Deliverable 6.3: Sensitivity Analysis

Frame B., (2008). 'Wicked', 'messy', and 'clumsy': long-term frameworks for sustainability. Environment and Planning C: Government and Policy 2008, volume 26, pages 1113 - 1128.

Hinterberger, F., Lucks, F. and Schmidt-Bleek, F., (1997). Material flows vs. 'natural capital': What makes an economy sustainable. Ecol. Econ., 23: 1-14

ISIS , (2006). REFIT Project Deliverable 1.1: Outline of policy priorities and sustainability criteria and targets

Ivanova O., De Ceuster G., Chen M., Tavasszy L., (2007). REFIT Project Deliverable 4.1: Assessing the social dimension of sustainable transport policy: an overview

Ivanova O., De Ceuster G., Heyndrickx C., Spitaels K., van Rooijen T., Minett C., Chen M., (2007). REFIT Project Deliverable 4.2: Assessing transport policy impacts on transport safety, on equity and on income distribution

Ivanova O., De Ceuster G., Vanherle K., Chen M., Tavasszy L., (2007). REFIT Project Deliverable 5.1: Assessing the environmental dimension of sustainable transport policy: an overview

Korzhenevych A., Bröcker J., Chen M., Tavasszy L., (2008). REFIT Project Deliverable 3.2: Assessing transport policy impacts on spatial distribution of economic activity and (un)employment with the CGEurope-model

Martino A., Fiorello D., Casamassima G., Sessa C., Ivanova O., Tavasszy L., de Kievit M., Korzhenevych A., Bickel P., (2007). REFIT Project Deliverable 2.1: The REFIT framework for Strategic Sustainability Assessment of European Transport Policies

OECD/ECMT (1999). Conference on Strategic Environmental Assessment for Transport, Warsaw, 14-15 October 1999. Conference Conclusions and Recommendations, OECD/ECMT.

Organization for Economic Cooperation and Development (OECD), (1994). Environmental Indicators. OECD, Paris.

Pearce, D. W. and Atkinson, G. D., (1993). Capital theory and the measurement of sustainable development: An indicator of weak sustainability. Ecol. Econ., 8: 103-108.

Rennings, K. and Wiggering, H., (1997). Step towards indicators of sustainable development: Linking economic and ecological concepts. Ecol. Econ., 20: 25-36.

Sessa C., Vendetti A., Fioretto M., de Kievit, M., Tavasszy L. Schelling A., Schneekloth N., Bröcker J., (2007). REFIT Project Deliverable 1.2: Transport sustainability indicators: Existing sustainability indicators, knowledge gaps and roadmap towards better indicators and tools

Sherp, J., (1994). What does an economist need to know about the environment? Directorate General for Economics and Financial Affairs. Economic papers of the European Commission No. 107.

Sieber N., Bickel P., (2008). REFIT Project Deliverable 3.3: Assessing transport policy impacts on the internalisation of externalities of transport

Transport Mobility Leuven at al. (2005), ASSESS Final Report, Assessment of the contribution of the TEN and other transport policy measures to the midterm implementation of the White Paper on the European Transport Policy for 2010, Leuven, (http://ec.europa.eu/transport/evaluations/doc/2005_ten_t_assess.pdf).

ANNEX

REFIT transport sustainability indicators list

Table 1 – REFIT transport system operation indicators

Transport system operation indicators
Total road network
Total rail network
Inland waterways network
Load factors of road freight vehicles
Occupancy rates of road passenger vehicles
Car ownership rate
Air passenger traffic at airports
Percentage of congested road network during morning peak hours [F/C > 0.8]
Average speed on inter-urban road links during morning peak hours
Average speed on inter-urban road links during normal week days
Percentage of electrified rail track
Stock of passenger cars
Rail rolling stock
Port callings
Average age of road vehicles
Road freight traffic
Rail freight traffic
Inland waterways freight traffic
Sea freight traffic at ports
Freight transport costs
Road passenger traffic
Rail passenger traffic
Sea passenger traffic at ferry ports
Passenger Transport costs

Table 2 – REFIT economic indicators

Economic indicators
Accessibility measures Freight
Accessibility measures passenger
GDP effects induced by transport policies
Welfare effects induced by transport policies
Trade
Share of GVA generated by the transport sector
Transport sector employment
Households transport expenditures
Business transport expenditures
Government net revenues from transport

Table 3 – REFIT environmental indicators

Environmental indicators
Share clean technology vehicles stock
Waste vehicles
Emission of NOx from road traffic
Emission of NOx from rail traffic
Emission of NOx from air traffic
Emission of NOx from IWW traffic
Emission of NOx from sea traffic
Total emission of Nox
Emission of NMVOC from road traffic
Emission of NMVOC from rail traffic
Emission of VOC from air traffic
Emission of NMVOC from IWW traffic
Emission of NMVOC from sea traffic
Total emission of NMVOC
Emission of SO2 from road traffic
Emission of SO2 from rail traffic
Emission of SO2 from IWW traffic
Emission of SO2 from sea traffic
Total emission of SO2
Emission of CO2 from road traffic
Emission of CO2 from rail traffic
Emission of CO2 from air traffic
Emission of CO2 from IWW traffic
Emission of CO2 from sea traffic
Total emission of CO2
Emission of CO2 from road traffic/per capita
Emission of CO2 from rail traffic/per capita
Emission of CO2 from air traffic/per capita
Emission of CO2 from IWW traffic/per capita
Emission of CO2 sea traffic/per capita
Total emission of CO2/per capita
Emission of CO from road traffic
Emission of CO from rail traffic
Emission of CO from air traffic
Emission of CO from IWW traffic
Emission of CO from sea traffic
Total emission of CO
Emission of PM from road traffic
Emission of PM from rail traffic
Emission of PM (life cycle) from air traffic
Emission of PM from IWW traffic
Emission of PM from sea traffic

Environmental indicators
Total emission of PM
Fuel consumption from road traffic
Fuel consumption from rail traffic
Fuel consumption from air traffic
Fuel consumption from IWW traffic
Fuel consumption from sea traffic
Energy consumption from rail traffic
Population exposure to PM10 emissions
Population exposure to NO2 emissions
Population exposure to noise
Waste tyres
Internalisation of external costs - cars
Internalisation of external costs - MC
Internalisation of external costs - HGV
Internalisation of external costs - LGV
Internalisation of external costs - Rail
Water pollution

Table 4 – REFIT social indicators

Social Indicators
Distributional impacts of transport policies - the Gini coefficient
Distributional impacts of transport policies - GE index - mean logarithmic deviation
Distributional impacts of transport policies - GE index - Theil's entropy
Distributional impacts of transport policies - amount of people that fall below the poverty line
Distributional impacts of transport policies - measure of the intensity of poverty
Distributional impacts of transport policies - measure of the inequality of poverty
Affordability Index
Safety
Health effects of air pollution