Strategic Sustainability Analysis (SSA)

Broadening Existing Assessment Approaches for Transport Policies

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ABSTRACT

Assessment tools based on static and linear concepts like traditional cost-benefit analysis can not reasonably be applied for long-term assessments of complex systems. One major reason is that secondary effects of policies caused by endogenous dynamics of the system are not considered.

So, for environmental impacts the Strategic Environmental Assessment (SEA) is developed that already includes a feedback mechanism from the failure to reach environmental targets to changes of policy initiatives and to a repeated impact prediction.

However, the need is realised to further integrate environmental assessment with economic and social assessment to achieve sustainability. Therefore a so-called Strategic Sustainability Analysis (SSA) is suggested. The SSA is applied for integrated long-term assessment of policies and programmes. This paper presents requirements and two prototypical examples (ESCOT, ASTRA) on how to realise SSA´s.

1 INTRODUCTION

The objective of this paper is to outline the specific difficulties that occur with assessment of transport policies on a strategic level and to propose an approach to overcome these difficulties. The meaning of strategic is threefold. First an assessment on a long-term time horizon is aspired; second an integrated or systemic perspective is applied that covers the transport system as well as interlinked systems like environment or economy; third the spatial scope is aimed at transport policies and programmes rather than on project assessment.

Transport forms a complex system that is highly interrelated with socio-economic systems as well as with ecological systems. Negative environmental impacts of transport present a major obstacle in achieving sustainability. However, major determinants of the transport system can only be changed on a long-term horizon. Transport policy assessment approaches therefore have to be capable of reflecting these highly interrelated systems as well as of measuring long-term changes (SCHADE/ROTHENGATTER 1999).

Nevertheless, currently assessment tools like cost-benefit analysis are used widespread amongst economists and other decision-makers though it is shown that such static concepts which perform point-to-point assessments can not reasonably be applied for long-term assessments dealing with complex systems like social systems or interlinked social and ecological systems. One major reason is that secondary effects of the policies caused by the endogenous dynamics of the systems are not considered with static assessment tools.

So methodologies to overcome these problems are developed. Based on the findings gathered with the project level Environmental Impact Assessment (EIA) the Strategic Environmental Assessment (SEA) is introduced for the consideration of environmental effects of policies or major infrastructure plans and projects. For example in the field of transport policies an SEA may include a cost-benefit- or multi-criteria-analysis for impact evaluation but besides it requires the definition of environmental goals, public participation and impact prediction models to be able to react to violations of the goals and subsequently to refine the policies (ECMT 1998, GÜHNEMANN 1999)

Recently arguments are arisen that request for a further integration of these predominant environmental assessments together with assessments of economic and social impacts, which form the two other dimensions of sustainability. The aim of this integration would be to analyze the trade-off between environmental impacts and socio-economic effects of policies and to test the results against sustainability targets. An appropriate working title for this new assessment methodology, coined at the OECD/ECMT conference on SEA in Warsaw in 1999, seems to be Strategic Sustainability Analysis (SSA). The focus of SSA would be more on long-term consequences of policies rather than on infrastructure plans and programmes (ECMT 1999).

2 ASSESSMENT WITH TRADITIONAL METHODOLOGIES

Conventional cost-benefit or multi-criteria analysis starts from an impact matrix, which exhibits the impacts of exogenous stimuli on defined decision criteria. This presupposes that a measurement with and without the exogenous stimulus can be performed, assumed that the stimuli are introduced at an initial state of the system and generate a change which is measured at the end of the time horizon considered. This methodology presupposes that the criteria of evaluation are independent of each other and also the exogenous stimuli as for instance the policy activities, can be clearly separated. Furthermore this approach presupposes that the impact mechanism is one-directional. That means, it starts from an exogenous shock on the transport sector, for instance by introducing investment activities or pricing policies, and ends with a change of social product, employment, environmental indicators or overall social benefit measures.

One of the broadest applications of Cost-Benefit-Analysis is applied within the framework of the German Bundesverkehrswegeplan (BVWP), which is the federal cross-mode investment programme (BMV 1993). Nevertheless the approach within the BVWP demonstrates the weekness of a static and point-to-point concept. The BVWP92 aspires to assess the benefits of infrastructure investments for the base year 1992 and the planning horizon 2010. Generally the assessment follows the sequential and linear approach for impact assessment, which is described as "*identification of the impact, measurement of the impacts and then use of the measures to appraise or evaluate an initiative*" (CEC DGVII 1996).

Baseline of the impact measurement are exogenous influences to the transport system like population, sectoral GDP, income that are forecasted for the time horizon 2010. Based on these exogenous forecasts the classical 4-stage transport model is applied for the zero-variante and for each of the project variants (about 1500 projects are assessed). On the next step indicators like emissions, accidents or transport time differences are calculated. Finally the indicators are evaluated mostly with market or shadow prices and the benefit-cost-ratio is calculated for each project. Based on the benefit-cost-ratios a ranking is created to identify the most profitable projects for society.

However with the scope of the BVWP of e.g. 2300 km new construction of motorways and about 6300 km of new and upgraded national roads with an overall investment volume of 500 Billion DM for sure changes in exogenous variables like sectoral GDP or income are produced over the 18 year time horizon. It is obvious that with such a linear procedure these changes are neither considered in the transport model nor in the indicators that are used for appraisal. As this form of appraisal procedure is applied in Germany at least since 1980 currently one of the “forgotten” effects causes difficulties for further investment decisions. These are the cost for maintenance and renewal of the infrastructure. As state budget can not be increased further the amount of money spent for infrastructure investments and maintenance can also not be increased. As investments produce more infrastructure, which subsequently leads to increased maintenance costs it is obvious that the infrastructure construction comes to an end, when the whole “infrastructure & maintenance” budget is needed for maintenance.

3 SKETCHING IMPROVEMENTS OF THE ASSESSMENT METHODOLOGY

As the basic in favour arguments for infrastructure investments are economic (infrastructure fosters economy) and social (infrastructure fosters accessibility) first assessment methodologies considered only these effects e.g. by measuring time savings for users of new infrastructure. However, environmental effects like increased emissions of NO_x, CO_2 have often been neglected. As environmental awareness grew after the Brundlandt Report and the Rio Earth Summit assessment methodologies for environmental impacts are improved or newly developed. The first step is the development of a comprehensive Environmental Impact Assessment (EIA) that is carried out on project level either in form of a separate assessment scheme (e.g. ecological risk analysis) in parallel to the economic and social appraisal with CBA or MCA or in the form of an integration into these assessment schemes. For instance both approaches can be found in the mentioned German BVWP.

But these approaches are not sufficient as they do not cover environmental issues that can only be tackled on higher decision making levels than project level. E.g. if a group of infrastructure projects respectively an infrastructure plan or programme is developed additional effects (e.g. cumulative or large scale effects) will occur. So, for the consideration of environmental effects of policies, major infrastructure plans and projects, which in terms of the SEA approach are summarised as strategic decisions, the Strategic Environmental Assessment (SEA) is introduced. An SEA may include a cost-benefit- or multi-criteria-analysis for impact evaluation but besides it requires the definition of environmental goals that should not be violated by the decision, impact prediction models to be able to react to violations of the goals, which subsequently requires to refine the decision, and public participation (ECMT 1998, GÜHNEMANN 1999). Results from experiences with SEA in the 1990ies reveal that SEA supports decision making in case of a choice between alternative projects, which also reduces the expense for project level EIA, as well as cumulative environmental impacts can be detected and mitigated. That means for strategic decisions about infrastructure plans and programmes SEA is the appropriate tool. However, weaknesses of SEA can be identified for the assessment of policies and of long-term developments (ECMT 1999).

4 BASIC HYPOTHESES FOR DEVELOPING STRATEGIC SUSTAINABILITY ANALYSIS (SSA)

Recently arguments are arisen that request for a further integration of the described predominant environmental assessment methodologies like SEA together with economic and social assessment, which form the two other dimensions of sustainability. 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 focus of SSA is more on long-term consequences of policies rather than on infrastructure plans and programmes as in SEA. For this purpose two basic requirements can be identified. These requirements can be formulated in the following hypotheses named *Integration* and *Pathfinding*:

A Integration: To assess the long-term consequences of policies methodologies are required that first integrate the concerned real systems into one model and second integrate the impact prediction and impact assessment steps into the same or at least interlinked model.

B Pathfinding: As long run decisions should be guided by desired images of the future the approach has to be capable to show and to investigate the development paths from the future to the current situation respectively reverse. Point-to-point analysis is not sufficient.

The integration hypotheses is due to the realization that in the long-run the partial analysis for the separate policy related real systems (e.g. economic system, environment, infrastructure supply) will be misleading as the systems are not actually independent from each other but instead they are interlinked with feedbacks. In fact the feedbacks might not be noticeable in the short run but can not be neglected in the long run. The integration of impact prediction and evaluation into one model fosters the capability to interactively improve the policies by iterative processes consisting of policy refinement, impact prediction and evaluation leading to further refinements. As the ECMT states "*Options* [for SSA] *are to either broaden the scope of SEA to include socio-economic impacts, or to develop separate assessment processes, which are optimally interlinked*." (ECMT 1999). So, referring to this context we suggest not to follow the second approach with separate assessment processes. Instead a modification of the first approach, which integrates SEA methodology and economic or social models as of the same value, is suggested.

The pathfinding hypotheses consists of two elements. First long-term policies should be driven by a vision or in other words by a desired image of the future, which can be made concrete with identifiable goals. This is in line with Costanza et al. arguing for "*the need to develop a shared vision of a sustainable society*", while the problem of a *"lack of a coherent, relatively detailed, shared vision of what a sustainable society would look like*" still exists (COSTANZA ET AL. 1997). However for the transport sector major international research projects have been undertaken to identify goals for a sustainable transport system (OECD 1996, 1999), such that ideas about a sustainable transport system exist, though one probably can not yet speak about a common shared vision. In any case, presupposing the vision is agreed, the assessment methodology has to be capable of investigating the development paths that link the current situation with the future vision. That means the methodology follows a backcasting approach defining first the desired future and then looking for development paths to achieve it.

5 ELEMENTS OF STRATEGIC SUSTAINABILITY ANALYSIS

As discussed above the description of development paths is a basic element of SSA. Development paths describe the development of real system elements respectively their corresponding model variables over time. Therefore the applied modelling approach for SSA has to be *dynamic*, *quantitative* and *consistent*. **Dynamic** methods are needed to introduce the time axis into the model and to capture the secondary effects of systems that are interlinked with several feedbacks or time lags. As the SSA should be applied for policies a dynamic approach can also take into consideration that policy measures are not introduced at one certain point of time or that not only one policy measure is taken (multi policy implementation or policy packaging).

Several environmental policies (e.g. green taxes) can be implemented stepwise over a longer time period with small changes for every step. For instance a stepwise increase of the fuel tax with several small increases belong to this category (see Figure 1).

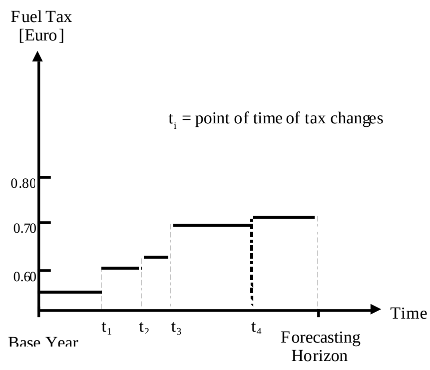

Figure 1: Stepwise increase of fuel tax

The ability for multiple policy implementation means to apply more than one policy measure at different points of time for the assessment. Each policy might be implemented stepwise. This enables to check if synergies or countereffects between the policies exist. With the knowledge on synergies different policy measures can be grouped to more effective and reasonable policy packages.

Quantification is primarily necessary to create operable models of the real systems. Depending on the modelling approach verifiability by experts and decision-makers can be fostered with quantitative modelling as quantified relationships can be reviewed more easy than for example qualitative expert judgements. With quantification and dynamics we receive time-path indicators, which show the development of the indicator during the intermediate time between the base year and the future point of time. Further advantages of these time-path indicators are that they also show the slope of the indicator curve at the future time horizon and that by integrating the indicator curve of a time-path indicator one receives another type of indicator that may be named as "accumulated irreversibility"[1]. E.g. in the case of CO_2 emissions not the emitted quantity in one future year lets say 2030 would be the most important figure but it is the summed quantity of emissions over the period until 2030. With the quantified indicators new types of indicators can be constructed by relating two or more variables with each other. In principle, this can be done with each combination of modelled variables and any mathematical function. A reasonable approach would be to calculate intensity indicators by dividing one variable with another one. For instance CO_2-emissions from transport divided by GDP provides an important information about the CO_2-emission intensity per GDP of different policies.

Consistency means that the baselines for the economic, social and environmental part of the assessment are based on a common system of assumptions. While in current approaches separate partial assessments might be misleading e.g. separate economic assessments of new products if there is no social acceptance for these products. An other example for consistency problems is that a key variable is influencing a number of other variables in different impact areas or is influenced by these (multiple active or passive influences). In this case a traditional partial method tends either to an underestimation of impacts by neglecting multiple influences or to an uncontrollable double counting. A proper integrated modelling that considers the dynamic feedbacks avoids these caveats and helps to generate well-balanced decision support.

Finally explanatory components are needed for the assessment methodology to improve the capabilities for modellers and decision-makers to get insights into the assessment process. This can be provided by graphical user interfaces (GUI) that describe the structure of the model.

6 EXAMPLES OF STRATEGIC SUSTAINABILITY ANALYSIS IN THE TRANSPORT SPHERE

The question for identifying transport as an application field for SSA is: Why is long-term assessment of the consequences of transport policies necessary? This question arises as one might argue that assessments with a time horizon of more then 5 to 10 years are tainted with high uncertainty or even are speculative. This might be right for some systems for which the framework of the system can be changed completely within short-terms e.g. in financial markets where varying money flows can change the whole system within hours or days. However the framework in which the transport system is embedded behaves different. Major driving forces of the transport system can be changed only in the long-term. For instance the construction and planning of transport infrastructure might take up to 10 years and the usage duration is often longer then 40 years. Also on the supply side of the transport system huge industrial structures (e.g. fuel producing industries, car manufacturers) have been built. To change these requires changes of the production structures with an enormous scope and therefore also with a long-term time horizon. On the demand side human habits that increase the need for transport like the preference to live in green suburban areas instead of the city centers also develop over a long time such that they contribute to the self-image of a generation of people. To change these human habits needs longer time periods. Finally, if one looks at the environmental consequences performed by the transport system like the carcinogenic risk caused by particulate matter or the contributions to the greenhouse effect caused by CO_2 emissions from transport, it has to be stated that transport impacts have an effect after an activity period of several decades or might even last for decades or hundreds of years.

Coming back to the problem of uncertainty. When the forecasting time horizon of the assessment is moved further into the future it is important to choose a modelling methodology that diminishes the influence of uncertainty. It is obvious that for methodologies relying strongly on data from the past like econometric or other modelling based mainly on statistical analysis results become less reliable the further into the future these models are applied. Therefore it seems to be reasonable to focus an SSA approach on the investigation of functional cause-and-effect relationships within and between the investigated real systems. This is the domain in which the system dynamics methodology is an appropriate tool. Especially as it also fulfills (most of) the other requirements like dynamic approach, quantification also for time-path indicators, consistent and integrated modelling of different real systems within one framework. Hence, in the following two projects are outlined that can be seen as first prototypical examples for SSA related to transport policies.

In the framework of the OECD project on environmentally sustainable transport (EST) the model for *Economic Assessment of Sustainability Policies of Transport* (ESCOT)[2] is developed. The purpose of ESCOT is to investigate the macroeconomic effects of the transport and environmental policy packages that have been designed by the EST project. The spatial scope of ESCOT covers Germany and the time horizon lasts until the year 2030 (2015). System dynamics modelling is applied to integrate the following five sub-models into ESCOT: macroeconomic sub-model, regional economics sub-model, transport sub-model, environment sub-model and the policy implementation model. Thirteen different policy measures affecting either passenger or freight transport or both can be taken and varied by the user. The measures comprise technical changes (e.g. introduction of 3l cars in the fleet) and behavioural changes (e.g. demand changes driven by price increases for fuel or for road charges). First two scenarios are tested: a business-as-usual scenario (BAU), which depicts the development without any major changes in trends, and the desirable future described by the environmentally sustainable scenario (EST). For the BAU scenario the environmental goals of the EST project will be violated severely in 2030 (they are currently also violated). For the EST scenario EST environmental criteria like 80% reduction of transport related CO_2-emissions compared with 1990 emissions can be met. However, the economic development is negatively effected for important indicators to an extent that can not be accepted. Especially the time-path for employment revealed a sharp decrease compared to BAU. So, an EST-50 scenario is tested, which mainly weakens the environmental goal for CO_2 emissions to a reduction of 50% compared to 1990. With this scenario economic development is even slightly positive compared to BAU and the environmental pressure is reduced remarkebly, such that in the following decade(s) the EST criteria should be met (SCHADE ET AL. 1999, 2000).

Within the European 4th framework research programme the project for *Assessment of Transport Strategies* (ASTRA)[3] is carried out. The objective of ASTRA is to develop a tool for analysing the long-term impacts of the European common transport policy (CTP). That means the spatial scope for ASTRA covers the EU15 countries and the time horizon is the year 2026. As assessment tool a system dynamics model comprising four sub-modules is implemented that is based on state-of-the-art models of four different research disciplines: macroeconomics, regional economics and land use, transport and environment. The structure of the approach is shown in figure 2

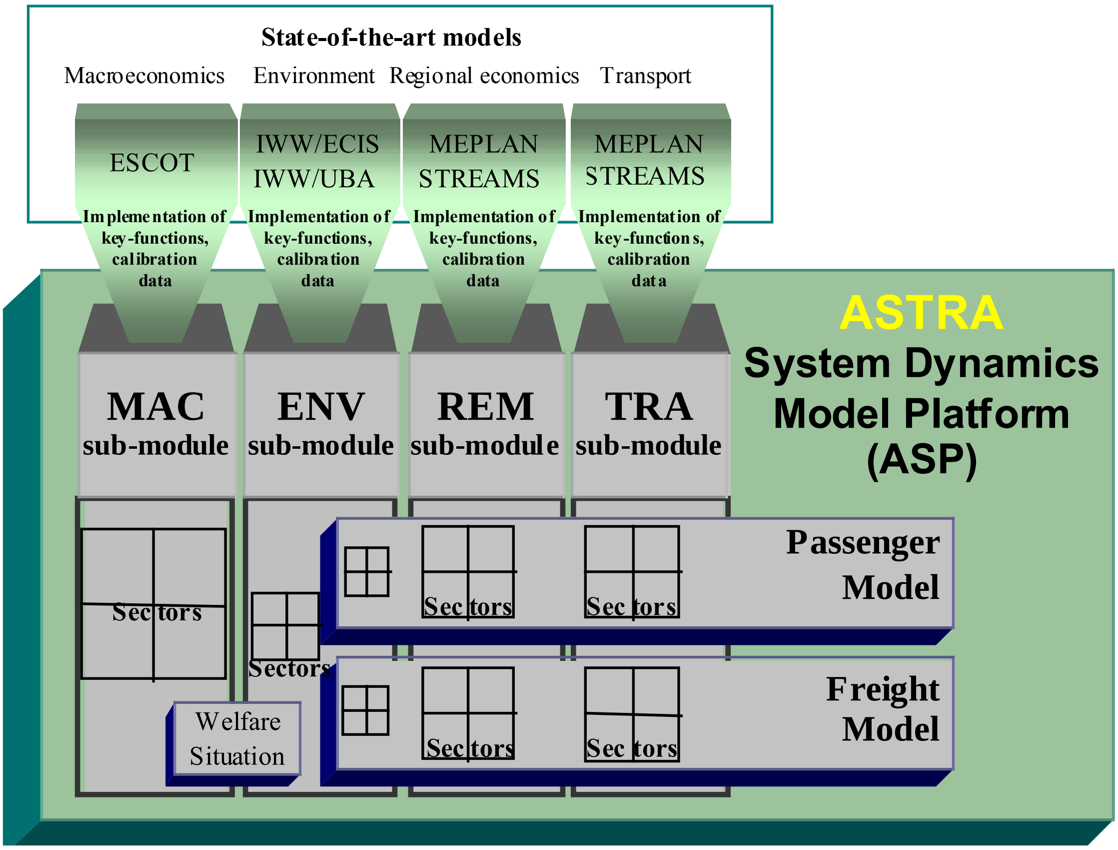

Figure 2: Structure of the ASTRA System Dynamics Model Platform (ASP)

The basic functional relationships and internal feedback loops of the four models are integrated into one system dynamics model platform called ASP. Additionally new feedbacks are implemented between these four models and necessary completions are made (e.g. car-ownership models). The following figure 3 presents the major linkages that are implemented between the four sub-modules.

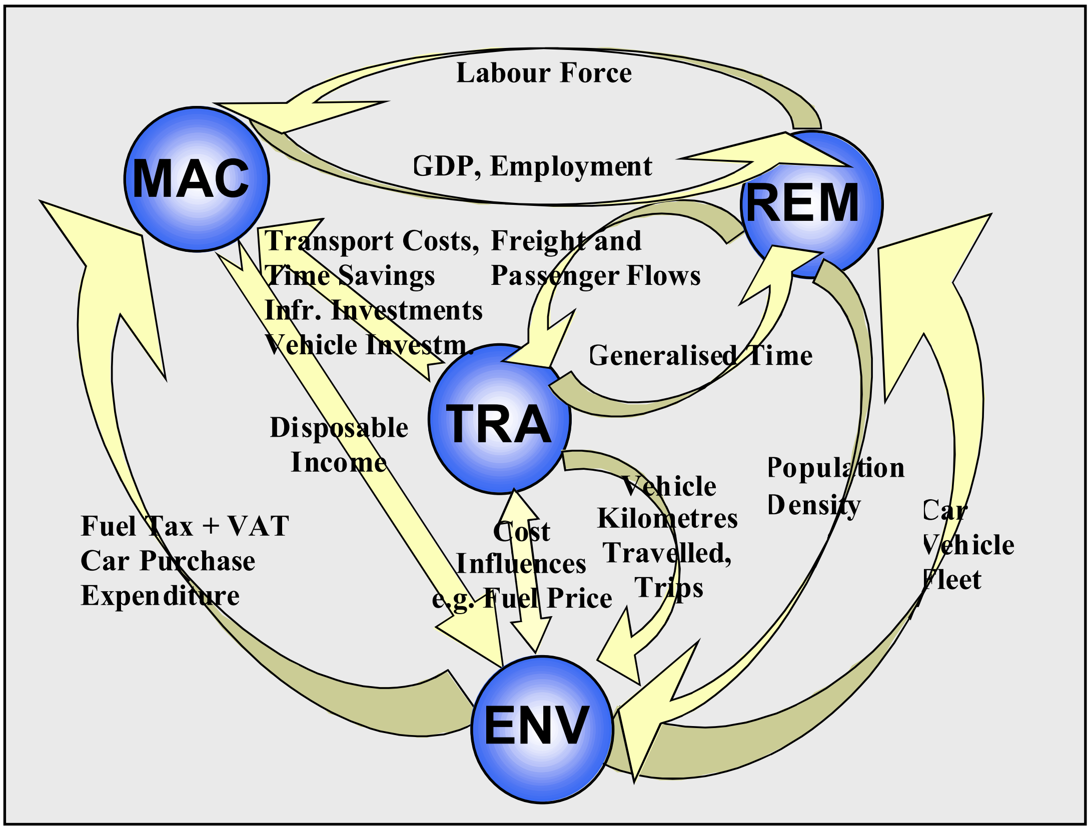

Figure 3: Linkages between the four ASTRA sub-modules

The spatial representation is provided with two functional zoning systems based on settlement patterns for passenger transport and on macroeconomic regions for freight transport. Basically a set of five policy packages (PP) can be tested either individually or against the base scenario. These are: PP1 "Introduction of fuel cell cars from 2010"; PP2 "Improving safety and emissions situation" by strengthened and enforced speed limit and emission legislation; PP3 "Increased fuel tax plus reduction of labour cost"; PP4 "Balanced fuel tax for all modes plus reduction of labour costs"; PP5 "Fuel taxation to finance the investments of the TEN". Each policy package comprises several policy measures that may be individually adjusted by advanced users to construct own policy packages. Expert users might introduce additional policy measures that fulfill their needs.

In the following results for the ASTRA policy package PP2 on improvements of safety and emissions situation are presented. It has to be mentioned that the implementation of policy measures in the model is not yet finally completed such that preliminary results are presented.

The policy package integrates three measures effecting safety and air pollution. The baseline for the safety measures comprises an enforced speed limit for the long distance road network, an increased usage of safety-belts and concerning emissions an enforced emission legislation by a movement of the point of time when new emission standards come into force. In addition the reduced speed limit also effects the emissions.

For the base scenario speed limits are kept constant at the 1995 levels, while for the policies it is aspired to introduce a maximum level of 110 km/h on motorways (90 km/h on other rural roads) for cars. Limits that are already below these values are not changed. For trucks the speed level of 80 km/h should be actually the maximum, which is severely controlled such that no violations occur. For instance, on German motorways where the speed limit is 80 km/h for trucks the actual average truck speed is around 90 km/h.

The safety-belt usage in the reference scenario increases only by 1% from 1996 to 2026, while it is increased by 1% per year to reach a maximum of 98% in all four macro regions (front passengers). The change of safety-belt usage is not yet considered in the presented results.

Emission standards for cars in the base scenario are introduced according to the proposed dates of the EURO I-IV emission legislation. From the years 2010 to 2026 additional reductions of emission factors are considered, because further legislation and technological development will improve the emission factors. The emission legislation will be enforced by moving all points of time when a new standard comes into force three years earlier beginning with EURO II. Also, additional reductions for the emission factors from 2010 to 2026 are introduced. For NO_x this reduction amounts to 10% and for CO_2 it amounts to 30%.

The results of these measures are shown in the following graphs that are differentiated into the four macro regions of the model, which consist for

- E1 of Austria and Germany,
- E2 of France, Belgium, Netherlands and Luxemburg
- E3 of Italy, Spain, Portugal and Greece and
- E4 of United Kingdom, Ireland, Danmark, Finland and Sweden.

The first diagram (figure 1) presents the development of GDP for all macro regions until the year 2026. The taken safety and emission policies provide only a very minor influence on GDP (less than 0.01%) via the effects on consumption because of increase in car prices such that only the results for the base scenario are presented.

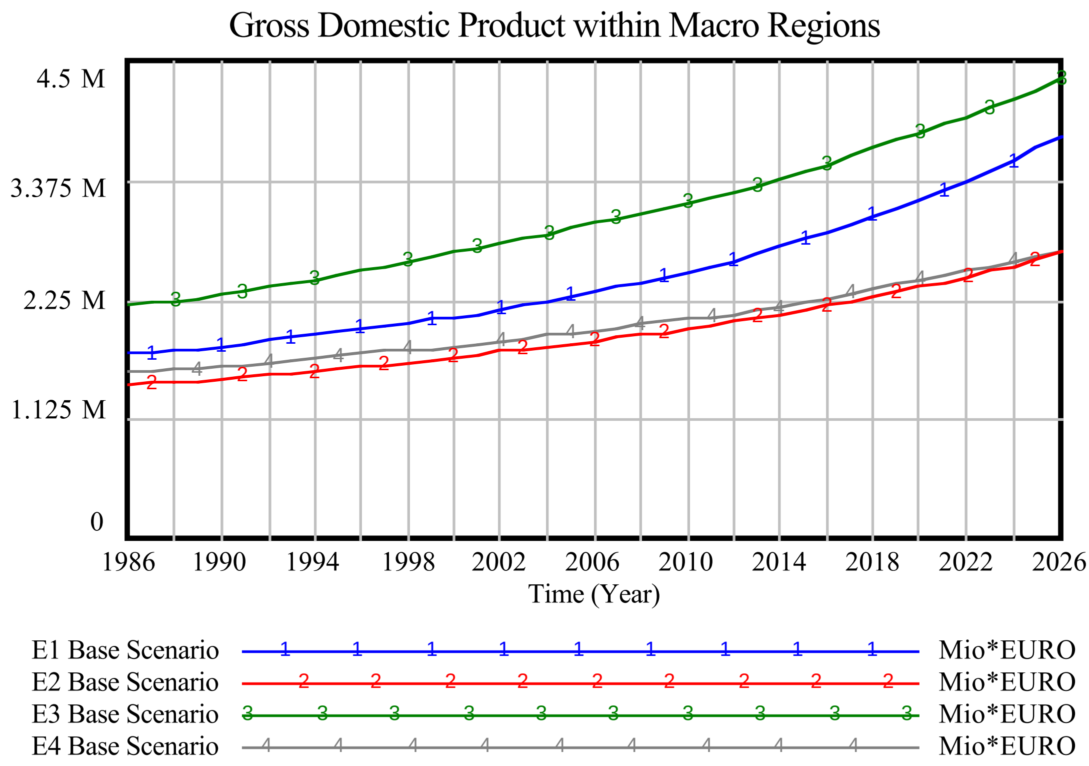

Figure 4: Development of GDP in Macro Regions

Figure 5 presents the effect of the introduction of the speed limit at the year 2000 for regions E1 and E3. The reduction of fatalities is highest in region E1 as the decrease in speed limit is the severest in this region. Also, the reduced speed for heavy duty vehicles by enforced controls of the 80km/h limit for trucks contributes to the reduction of fatalities. These figures are preliminary in the sense that the effect of decreasing safety because of insufficient maintenance investments is not yet considered adequately.

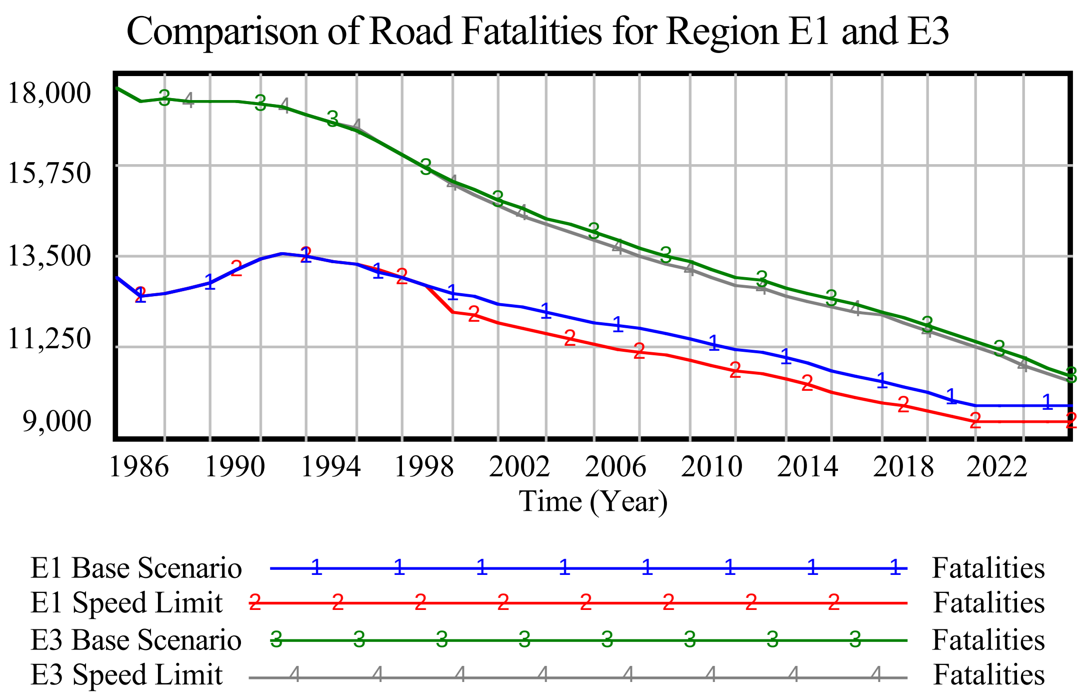

Figure 5: Comparison of Road Fatalities for E1 and E3 in Base Scenario and with Safety Policies

The following figure 6 demonstrates that in the base scenario the CO_2 emissions from transport will hardly decline until the year 2026, which is a problem if one reminds at the CO_2 reduction targets agreed to in the Kyoto protocol. However, especially the enforced emission legislation contributes to the decreasing development in the policy run. The speed limit effects emissions in two ways though the decrease is less than by the enforced emission legislation. The first effect works through the decrease of specific emission factors by decreasing speed and the second effect occurs via the transport model, where the decreased speed increases truck transport times, which provides a slight modal shift away from medium and long distance truck transport.

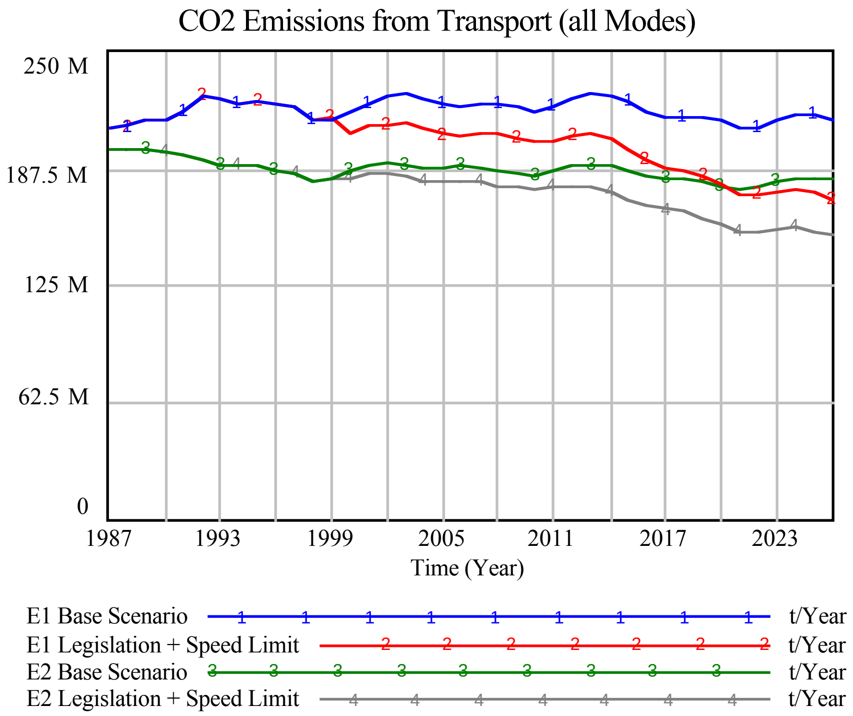

Figure 6: Yearly CO_2 Emissions from Transport aggregated over all Modes for E1 and E2

In figure 7 the development of GDP is related to the calculated environmental externalities, which include accident externalities, externalities of CO_2 and NO_x emissions from transport. Based on these inputs the transport externalities amount to a share of GDP between 3.2% and 4.8% in the different regions in the year 1986. In the year 2026 in the base run the shares decline to 1.3% to 2% and with the taken policies to 1.2% to 1.7%. However, it has to be mentioned that though this indicator presents a positive development for environmental impacts like CO_2 emissions the absolute quantity gives the relevant figure.

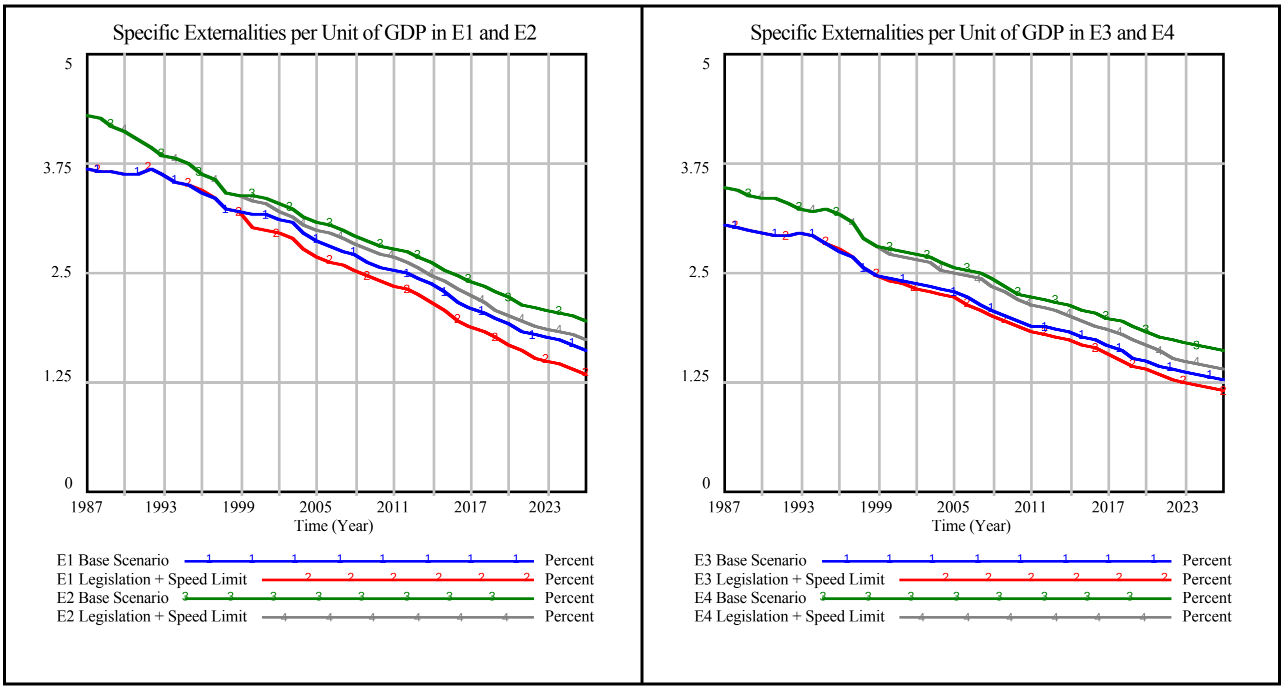

Figure 7: Externalities as Share of GDP for Base Scenario and Legislation + Speed Limit Policiy

Finally, a second indicator describing the welfare situation is presented in figure 8. The intensity of CO_2 emissions from transport per unit of disposable income is decreasing already in the base scenario, which means that a kind of decoupling between transport emissions and income generation is taking place.

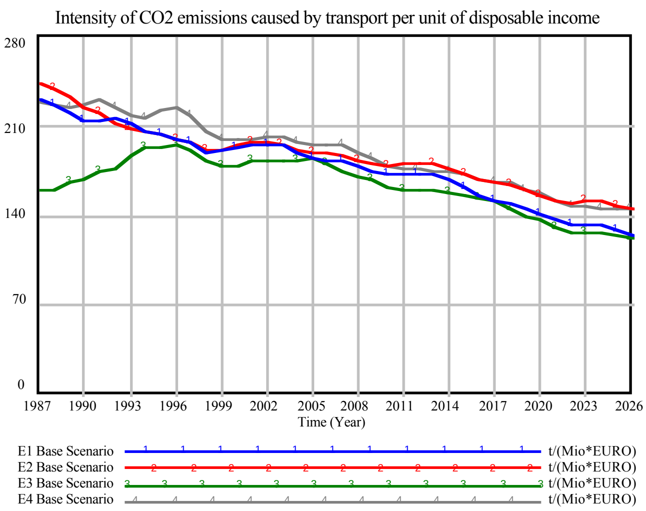

Figure 8: CO_2 Emission intensity per Unit of Disposable Income in Base Scenario for all Regions

Two final comments should be made. System dynamics modelling usually stands for a methodology with only a few data needs to create models. However, for the described projects it is aspired to rely on data as much as possible, which e .g. is supported by the use of the state-of-the art models that are mainly data driven.

Within ESCOT and ASTRA not all necessary elements of a comprehensive SSA are realized. This concerns local impacts e.g. the impact of transport infrastructure on protected areas. However, further developments might establish links to geographic information systems such that all requirements developed on the level of SEA can be met also for SSA. An approach for this task is developed by Kuchenbecker, who linked a high level system dynamics model of Germany with a low level disaggregated conventional transport model (KUCHENBECKER 1999).

7 CONCLUSIONS

Starting with project level assessment a broad range of environmental assessment criteria and approaches has been developed within the Environmental Impact Assessment (EIA). As shortcomings of EIA concerning cumulative impacts or choices between alternatives became apparent the Strategic Environmental Assessment (SEA) is introduced, which is applied for plans, programmes and policies. However, for policies, especially if long-term effects have to be considered, it is felt that SEA is not sufficient. An improved methodology should foster a further integration of environmental issues with economic and social aspects into a consistent assessment scheme that is capable to tackle long-term impacts and to show trade-offs between the three dimensions of sustainability. This new assessment methodology, called Strategic Sustainability Analysis (SSA), is sketched in this paper. Basic elements are integration of the relevant real systems into one appraisal scheme and integration of the impact prediction and assessment procedures into the same model. Furthermore, the scheme is based on quantitative development paths of the relevant indicators instead of point-to-point analysis, which makes it possible to support backcasting approaches. Finally, two prototypical examples for a SSA in the transport sphere are briefly presented.[4]

8 ACKNOWLEDGEMENTS

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[1] In a broader sense the well-known indication „Ecological Footprint“ might be used.

[2] The ESCOT model is also presented on the 3rd ESEE conference in Vienna. A final project report will be available in mid summer 2000.

[3] The completed ASTRA project deliverables with a detailed project description can be downloaded under http://www.iww.uni-karlsruhe.de/ASTRA. Deliverable 4 and 5 should be available in June 2000.

[4] The paper describes SSA mainly in the context of transport policy. However it is also applicable for other policy fields like energy policy.

9 REFERENCES

ASTRA (1998): „Design and Specifications of a System Dynamics Model“, ASTRA Deliverable 2, IWW, TRT, ME&P, CEBR, Karlsruhe.

ASTRA (2000): „ASTRA Methodology (Draft)“, ASTRA Draft Deliverable 4, IWW, TRT, ME&P, CEBR, Karlsruhe.

BMV (1993) Bundesminister für Verkehr: "Gesamtwirtschaftliche Bewertung von Verkehrswegeinvestitionen – Bewertungsverfahren für den Bundesverkehrswegeplan 1992", BMV Schriftenreihe Heft 72, Bonn.

CEC – DG VII (1996) European Commission – DG Transport: "Methodologies for Transport Impact Assessment", APAS Transport Research Report by ME&P, LT, TRT, Brussels.

Costanza, R, Cumberland, J., Daly, H., Goodland, R., Norgaard, r. (1997): "An Introduction to Ecological Economics", St Lucie Press, Boca Raton.

ECMT (1998) European Conference of Ministers of Transport: "Strategic Environmental Assessment in the Transport Sector", Paris.

ECMT (1999) European Conference of Ministers of Transport: "Report on Strategic Environmental Assessment for Transport", Report Prepared for the Committee of Deputies of the Group on Transport and the Environment, Paris.

Gühnemann A. (1999): „Methods for Strategic Environmental Assessment of Transport Infrastructure Plans“, Dissertation Thesis at IWW, Karlsruhe.

Kuchenbecker, K. (1999): "Strategische Prognose und Bewertung von Verkehrsentwicklungen mit System Dynamics", Dissertation Thesis at IWW, Karlsruhe.

OECD (1996) Organisation for Economic Co-operation and Development: "Environmental Criteria for Sustainable Transport", Report on Phase 1 of the Project on Environmentally Sustainable Transport (EST), Paris.

OECD (1999) Organisation for Economic Co-operation and Development: "Environmentally Sustainable Transport – Final Report on Phase II of the OECD EST Project", Synthesis Report, Paris.