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METHODOLOGY FOR ANALYSIS OF EFFECTS OF GREENHOUSE GASES REDUCTION BYINTERMODAL SHIFT ON SOUTH-EAST EUROPE CORRIDORS

Zlatan Šoškić
soskic.z@mfkv.kg.ac.rs

Faculty of Mechanical and Civil Engineering Kraljevo, University of Kragujevac
Dositejeva 19, 36000
SERBIA

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Abstract: *The paper presents methodology for quantitative estimation of absolute and relative reduction of greenhouse gas emission, as well as for monetary valuation of the effects of the actions aimed at the reduction of greenhouse gas emission. The methodology is developed and adjusted for the estimations of effects of introduction of new transport schemes that use intermodal transport on South-East Europe transport corridors. It was shown that the methodology provides insight into environmental, social and economic effects of the studied measures for reduction of greenhouse gas emission.*

Introduction

One of many efforts to reduce the effects of the greenhouse gases (GHG) emission is the project “Greening Intermodal Freight Transport in South-East Europe” (acronym “GIFT”) [1], which is carried out within the framework of South-East Europe (SEE) Transnational Cooperation Programme. The aim of the project is “to map, analyse and evaluate the status of the transport in SEE, and to propose new policies and strategies in infrastructure, processes, assets, ICT, legislation, norms and harmonization/ standardization issues, in order to promote innovative green intermodal freight transport corridors”. The project goals are:

- Identification of innovative green freight transport corridors in the region-GIFT;
- Development of proposals for the establishment of regional authorities for freight transport management and issuing of green certificates;
- Development of an ICT tool for intermodal trip planning that will support the minimization of environmental impact.

The GIFT project work plan includes carrying out of a study that will investigate the impact of green (sustainable) transport in freight movement along SEE corridors. In order to estimate the impact of the proposed measures, a methodology for quantification of their effects and costs.

The foundations of the proposed methodology represent the needs of the GIFT project, the data acquired during the project, the European Union environmental policies, legislation, procedures, recommendations for Strategic Environment Appraisal (SEA), recommendations for Environmental Impact Appraisal (EIA) of UK Department of Transport and the published results of studies of impact of transport corridors in Europe and North America.

The following general SEA steps tend to be commonly adopted [2]:

1. Screening to determine the need for SEA at this stage of the planning process;
2. Determining the objectives of the strategic action and the environmental goals and/or targets;
3. Scoping, meaning identification of the physical/regional limits, the impacts to be addressed, the alternative actions that need to be assessed;
4. Carrying out of the assessment, meaning predicting the environmental impact of the action and its alternatives, evaluating the significance of the impact, proposing recommendations: preferred alternative, mitigation and monitoring measures;
5. Preparation of the SEA report and review by competent authority
6. Decision: taking into account the findings of the SEA and the consultation;
7. Making arrangements for monitoring;
8. Conducting further environmental assessments (at later stages of planning process);

The first and the third SEA step is performed in course of the GIFT project and its outputs are defined and described in the GIFT project deliverables [1], and the outputs of the second SEA step are defined in the project description. The task of the methodology that is presented here is to establish preconditions for carrying out of the fourth SEA step of the GIFT project. Therefore, the methodology defines the procedure that will predict the environmental impact of the innovative corridor schemes that are proposed, as well as to evaluate their significance and relevance for the achievements of the GIFT project goals. The study of environmental impact of the GIFT project actions, which will be carried out according to the proposed methodology, will essentially represent the SEA report that is the object of the fifth SEA step.

The sixth, seventh and eight SEA steps are the matter of the GIFT project follow-up activities and are not the matter of the methodology that is proposed here.

Methodology

The proposed methodology follows the outlines of the environmental impact appraisal methodology of UK Department of Transport (in the text that follows also referred as UK DT). The methodology was selected as model because it covers wide spectrum of environmental aspects, it is harmonized with EU policies and regulations, but also because it is publicly available and well-documented [3][4].

It is important to recognise the distinction between of environmental impact assessment and environmental impact appraisal processes and to appreciate how these two processes should be linked together during the project cycle. The aim of environmental impact assessment is to ensure that the environmental implications of decisions on schemes are made available, so that they can inform the design and decision making process. The environment impact appraisal is the process of developing environmental impact information for inclusion in a transport appraisal. It builds on the baseline data and impact assessment. The baseline data on the transport schemes proposed by the GIFT project and the impact assessment procedure of the proposed innovative transport schemes are given in deliverables [1].

The environmental impact appraisal methodology of UK Department of Transport considers noise impacts, air quality impacts, GHG emission, impacts on landscape, townscape, historic environment, biodiversity and water environment, but the scope of the environment assessment and appraisal in GIFT project is limited just to environmental impact appraisal of GHG emission. According to the UK Department of Transport [4] the methodology of environmental impact appraisal of GHG emission is a four-step process that comprises:

a) Scoping,
b) Estimation of changes in energy consumption,
c) Estimation of changes in emissions of greenhouse gases and
d) Monetary valuation of changes in greenhouse gases

By the UK DT methodology, the energy consumption and emissions calculations should be done for the project-opening year and at least for one other forecast year. In the methodology that is proposed for application in the GIFT project, the calculations of the energy consumption and emissions should be performed for years 2015, 2020 and 2030.

<u>Scoping</u>

The scope of the methodology of environmental impact appraisal should be consistent with the scope of the methodology of the respective environmental impact assessment. The environmental impact appraisal in the GIFT project represents a follow-up activity of the desktop testing of the proposed alternatives to the present freight transport links along the GIFT corridors. Therefore, the methodology for environmental impact appraisal should be performed for the same transport schemes analysed within the GIFT project activity 5.1 “Desktop & Ground (real-life) Corridors Testing”, therefore, for five “as is” transport schemes and ten “to be” transport schemes. The result of the methodology should be to value the application of individual and combined proposed alternatives.

<u>Estimating the impact of the transport schemes on energy consumption and GHG emissions</u>

The estimations of energy consumption and GHG emission of individual schemes was already performed during the impact assessment phase. In order to calculate the expected effect of the proposed actions it is necessary to obtain estimations of market share of each of the alternative schemes for transport along the studied route of a GIFT corridor.

There are several techniques for analysis of the impact of proposed transport schemes to environment. The key tools at the analyst’s disposal are [3] expected value estimation, sensitivity analysis, identification of switching values, scenario formation and Monte Carlo simulations.

The expected value estimation method, sensitivity analysis method and the method of scenario formation are combined in this proposal.

The effects of the proposed actions for modal shift on a route of a GIFT corridor denoted by index i will be analysed by studying different scenarios of future distribution of market shares between the alternatives. One scheme may include one or several alternative links on the route. A mandatory scheme is so called “do-nothing” scheme, when only “as-is”, with no proposed alternatives, is considered. Essentially, various schemes describe various technical solutions of freight transport along a route.

A scenario, denoted by index k, is described by market shares of each of the alternatives, including the “as-is” alternative. The market share of the m-th alternative in the k-th scenario of development of the j-th scheme of freight transport over the i-th route is denoted by $q_{jkm}^{(i)}$. The “as-is” alternative will be denoted with the index k=0. Being that various alternatives of a scenario share all the transport over a route in that scenario, sum of all market shares of all alternatives (including “as-is”) of a scenario must be 100%. If a number of proposed alternatives in the j-th scheme of freight transport over the i-th route is denoted by $M_j^{(i)}$ the following equation should hold:

$$\sum_{m=0}^{M_j^{(i)}} q_{jkm}^{(i)} = 100\%$$

Essentially, various scenarios reflect the market reactions to the respective policies. Even the rough estimation of the market shares is a complex task, requiring multiple expertises and a lot of time. Besides, even the complex transport market models (e.g. [5]) contain substantial amount of uncertainty, making sensitivity analysis a necessary part of each GHG emission analyses. For the sake of the sensitivity analyses, in the methodology that is proposed for application in the GIFT project, market shares of each scheme should be estimated at least for scenarios with the least, highest and most probable future scenarios of modal shift. For each of the future scenarios a respective probability should also be estimated. The probability of the *k*-th scenario of development of the *j*-th scheme of freight transport over the *i*-th route is denoted by $p_{jk}^{(i)}$. Sum of probabilities of realization of all scenarios for a transport scheme on a route must be also 100%. If a number of proposed alternatives in the *j*-th scheme of freight transport over the *i*-th route is denoted by $K_j^{(i)}$ the following equation should hold:

$$\sum_{k=1}^{K_j^{(i)}} p_{jk}^{(i)} = 100\%$$

Market shares may vary with time in a certain scenario, and variations of market shares from year to year should be known for estimation of the future effects of an action over a certain period. However, if a steady development may be expected during a period, linear interpolation of market share development between the first and the last year of the period may be sufficient. If the first year of a period is denoted as t_1 and the last year of the period is denoted as t_2, market share q in any year during the period may be calculated as

$$q(t) = q(t_1) + \frac{q(t_2) - q(t_1)}{t_2 - t_1}(t - t_1)$$

The estimations of scenario probabilities and market shares, along with the estimations of GHG emissions that were obtained during an earlier activity of the GIFT project will be used for calculations of the expected values of absolute and relative changes of the GHG emissions due to the schemes proposed by the GIFT project. Let $G_0^{(i)}$ denotes the equivalent emission of GHG gases per unit mass of the transported load (measured in kilogram-equivalent-of-CO_2-per-ton) in the "as-is" transport scheme over the *i*-th route, and $G_{jm}^{(i)}$ denotes the equivalent emission of GHG gases per unit mass of the load over the *m*-th alternative of the *j*-th "to-be" transport scheme. These emissions may be derived from the emissions and transported masses calculated within the aforementioned activity. The estimated absolute (denoted as $\Delta_{jk}^{(i)}$) and relative (denoted as $\delta_{jk}^{(i)}$) reduction in GHG emission in year *t* of *k*-th scenario of the development of the *j*-th transport scheme of the *i*-th route can be then calculated as:

$$\Delta_{jk}^{(i)}(t) = G_0^{(i)} - \sum_{m=1}^{M_j^{(i)}} q_{jkm}^{(i)}(t) \cdot G_{jm}^{(i)} \text{ and } \delta_{jk}^{(i)}(t) = \frac{\Delta_{jk}^{(i)}(t)}{G_0^{(i)}}$$

The expected absolute (denoted as $\overline{\Delta_j^{(i)}}$) and relative (denoted as $\overline{\delta_j^{(i)}}$) reduction in GHG emission in year *t* of the *j*-th transport scheme of the *i*-th route can be then calculated as:

$$\overline{\Delta_j^{(i)}}(t) = \sum_{k=0}^{K_j^{(i)}} p_{jk}^{(i)} \cdot \Delta_j^{(i)}(t) \text{ and } \overline{\delta_j^{(i)}}(t) = \frac{\overline{\Delta_j^{(i)}}(t)}{G_0^{(i)}}$$

<u>Monetary valuation of greenhouse gas impacts</u>

The methodology for monetary valuation of greenhouse gas impacts is based on the estimated abatement costs per unit of carbon dioxide equivalent to achieve the emissions targets. The method to be used for transport appraisal is consistent with the more general methodology for monetary valuation of the effects of greenhouse emissions, which is developed by the UK Department of Energy and Climate Change (in the text of this proposal also referred as UK DECC). While the cost of the GHG emission effects abatement in the UK might be considered higher than in the SEE region, the global and regional nature of the effects of GHG emission may justify the adoption of this method for monetary valuation of the effects of GHG emission [7]. Although other simple methods for the estimation costs of GHG emission effects abatement in SEE region may be envisaged (like scaling to the other costs), these methods cannot be considered more justified than the proposed method. More complex models and indications are available [9], but they either treat the Europe as a whole [8] or do not present data relevant for countries of SEE region [6]. Any input or recommendation from the participants in the project on this topic will be appreciated and carefully considered.

When carrying out monetary valuation, it is important to distinguish between the emissions from those sectors that are included within the EU Emissions Trading System (EU ETS)- the "traded sector emissions")-and those that are not included in the EU ETS (the "non-traded sector emissions"). The traded sector covers emissions from power and heat generation, energy-intensive industry and, since 2012, aviation. Emissions arising from electricity consumption in transport belong to the traded sector emissions. The non-traded sector covers all other greenhouse gas emissions, so the emissions from other types of transport fuel, including petrol, diesel and gas oil, are in the non-traded sector. Inclusion in the traded sector caps relevant emissions and creates a market for them. In this way, they are 'internalised' through the requirement for the relevant sectors to purchase EU allowances (EUAs) to cover relevant emissions. The cost of any EUAs to cover traded emissions will be reflected in the purchase price of traded sector goods. Since the purchase price is used in transport appraisal, the cost of the relevant EUAs will be included in the cost benefit analysis. Therefore, the costs of the emission in the traded and in the non-traded sectors are not the same, so the emissions in the traded and the non-traded should be valuated separately whenever possible. One of the objectives of the European Climate and Energy Package is to make the costs of the emission in the traded and in the non-traded sectors are the same until 2030. The costs of the GHG emission abatement in both sectors are given in British pounds in [3]. In order to convert the costs in EUR, an exchange rate of 1.233 EUR/£ is proposed in methodology of UK DECC.

The UK DECC provided the estimations of the GHG emission marginal abatement costs for the period 2008-2100 [3]. These estimations will be used in the methodology proposed here for calculation of the monetary value of reductions of GHG emission per unit mass of the transported load in the period 2014-2030, according to the formula:

$$V_j^{(i)}(t) = c(t) \cdot \Delta_j^{(i)}(t)$$

where $c(t)$ represents the estimation of marginal GHG abatement cost for the year and $V_j^{(i)}(t)$ stands for the estimated monetary value of reductions of the GHG emission using the j-th scheme on the i-th GIFT corridor, during the considered year.

There are different ways of assessing cost-effectiveness of an action. The most straightforward way of assessing whether an action is good value-for-money is to consider the Net Present Value (NPV). NPV is the sum of all monetised costs and benefits, discounted to the base year chosen. When the NPV has positive value, the analysed action brings benefits to the society. In the proposal that is described here, the base year will be $t_0 = 2014$, and the yearly discount rate will be adopted to be $d = 3{,}5\%$ during the considered period, as adopted in the methodology of the UK Department of Transport and recommended for the periods shorter than 30 years by the standard HM Treasury rates. The NPVs of the traded and non-traded sector will be considered separately, according to the recommendations of UK Department for Energy and Climate Change. Let $C_0^{(i)}$ denotes the cost of transport per unit mass of the transported load (measured in EUR-per-ton) in the "as-is" transport scheme over the i-th route, and $C_{jm}^{(i)}$ denotes the cost of transport per unit mass of the load in the m-th alternative of the j-th "to-be" transport scheme. These costs may be derived from the emissions and masses calculated within the aforementioned activity of the project GIFT. The

NPV of the effects of *k*-th scenario in year *t* of development of the *j*-th transport scheme of the *i*-th route can be then calculated as:

$$NPV_{jk}^{(i)}(t) = (1-d)^{t-t_0} \cdot \left[c(t) \cdot \Delta_{jk}^{(i)}(t) + \left(C_0^{(i)} - C_{jk}^{(i)} \right) \right]$$

The expected NPV in year *t* of the *j*-th transport scheme of the *i*-th route can be then calculated as:

$$\overline{NPV_j^{(i)}(t)} = \sum_{k=0}^{K_j^{(i)}} p_{jk}^{(i)} \cdot NPV_{jk}^{(i)}(t)$$

Conclusion

The paper presented the methodology that will be used during the GIFT project for estimation of effects and costs of the proposed actions. The methodology introduces an approach that is based on experiences of countries that have vast experience in dealing with environment impact appraisal, which has to balance environment protection issues with demands of sustainable economic and social development. Therefore, the approach simultaneously quantifies environment impact and economic effects of proposed actions in order to find the optimal alternatives for future programmes, plans and actions.

The methodology is tailored to study the effects of intermodal shift on SEE corridors. However, it may be applied without any changed studies of intermodal transport shift in any region, regardless of its size and transport fleet composition. On the other hand, its application for studies of effects of other measures aimed at reduction of GHG gases would require more or less substantial modifications.

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МЕТОДИКА ЗА АНАЛИЗ НА ВЪЗДЕЙСТВИЕТО ОТ НАМАЛЯВАНЕ НА ГАЗОВИТЕ ЕМИСИИ ЧРЕЗ ПРЕНАСОЧВАНЕ КЪМ ИНТЕРМОДАЛЕН ТРАНСПОРТ ПО КОРИДОРИТЕ НА ЮГОИЗТОЧНА ЕВРОПА

Златан Шошкич
soskic.z@mfkv.kg.ac.rs

Факултет по машинно и строително инженерство в Кралево,
Университет Крагуевац
Dositejeva 19, 36000
СЪРБИЯ

Ключови думи: *емисии на отработени газове, замърсяване от транспорта, SEA*

Резюме: *Статията представя методология за количествена оценка на абсолютното и относителното намаляване на емисиите на отработени газове, както и за финансова оценка на въздействието от мерките, насочени към намаляване на газовите емисиите. Методологията е разработена и се приспособява по отношение на оценките на въздействие от въвеждането на нови транспортни схеми, които използват интермодалния транспорт по транспортнте коридори на Югоизточна Европа. Показано е, че методологията осигурява задълбочено разглеждане на екологичните, социалните и икономическите ефекти на изследваните мерки за намаляване на емисиите от изгорели газове.*