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Economic Evaluation of the Implementation of Policy Actions in the Field of Energy Efficiency

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ABSTRACT

This paper presented an analytical tool, based on the cost-benefit analysis instrument, intended to be used to estimate both the financial and economic impacts related to the implementation of policy actions and/or projects (interventions) in the field of energy efficiency. The proposed guidelines are intended to provide relevant information and guidance on why and how to conduct financial and economic assessment to a relatively large number of institutions involved in the preparation and appraisal of energy efficiency actions.

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1. INTRODUCTION

Economic evaluation has to be considered as an analytical tool to be used to appraise investment decisions (e.g., different projects, policy actions, promotional campaigns, etc.) in order to assess the positive changes (financial, environmental, etc.) attributable to them. The purpose of economic evaluation is to facilitate a more efficient allocation of resources, demonstrating the benefits for society of a particular intervention rather than possible alternatives.

Multiple case studies have been analysed in the process of preparation of the presented current tool for economic evaluation of energy efficiency interventions. The common conclusion that can be made is that the majority of the cases are lacking sufficient economic data and economic evaluations have not been performed as of now. It is clear that all cases will have a positive impact over energy efficiency but without economic evaluation it is difficult to establish funding priorities among existing alternatives.

The purpose of this paper is twofold. First, it will provide technical guidance as of how to make an economic evaluation of proposed interventions. Second, and maybe more important, it will guide intervention proponents to think about and collect relevant economic data when formulating different policy actions so that they can make adequate comparisons and take adequate investment decisions.

2. RATIONALE AND OBJECTIVES OF THE GUIDELINES

The proposed guidelines present an analytical tool, based on the cost-benefit analysis (CBA) instrument, intended to be used to estimate both the financial and economic impacts related to the implementation of policy actions and/or projects (interventions) in the field of energy efficiency. The impact of these interventions is assessed against predetermined objectives. The guidelines are intended to provide relevant information and guidance on why and how to conduct financial and economic assessment to a relatively large number of institutions involved in the preparation and appraisal of energy efficiency actions.

There are two principal types of financial and economic evaluation: CBA and cost-effectiveness analysis (CEA). CBA attempts to quantify and compare the economic advantages (benefits) and disadvantages (costs) associated with a particular project or policy for the society as a whole. Thus, it is possible to compare and/or aggregate many different categories of benefits with one another, and with the costs of the intervention. Out of a number of alternative programs being examined, CBA would recommend choosing the one with the largest net benefits, where net benefits are defined as the benefits minus the costs. CEA, on the other hand, seeks to find the best alternative activity, process, or intervention that minimises the costs of achieving a desired result. CEA, therefore, does not ask, nor attempts to answer, the question whether the policy is justified, in the sense that its social benefits exceed its costs.

The rationale for the selection of CBA as a tool to compare energy efficiency interventions can be explained as follows. The more narrowly construed cost-effectiveness framework is suitable when evaluating the efficiency of programmes achieving exactly the same results (e.g., measures for the substitution of use of own vehicles with public transportation). Yet, for interventions from various fields that have many different results and impacts, the cost-effectiveness framework is not appropriate as it risks excluding some important resource savings and non-cash costs and benefits. The CBA involves comparing the costs and consequences of different interventions, enabling conclusions to be drawn about their relative efficiency. It enables explicit and quantitative comparisons of the efficiency of interventions using a simple-to-interpret summary efficiency measure - cost per impact achieved - as the common outcome measure. This provides policy-makers in the public and private sectors comparable data on which to base informed decisions.

The objective of the analysis is to identify and attach a monetary value to all possible impacts of the actions or projects under scrutiny, in order to determine the related costs and benefits (revenues or alternatively cost savings). In principle, all impacts need to be assessed and if possibly monetised: Financial, economic, social, environmental, etc. In the field of energy efficiency, special attention should be paid to cost savings, associated with proposed interventions (European Commission, Guidelines for Cost Benefit Analysis of Smart Metering Deployment, 2012).

According to the EU accepted methodology for conducting similar analyses for investment projects (European Commission, Guide to CBA of Investment Projects, 2014), costs and benefits are evaluated by means of the so called "incremental approach" which considers the difference between a scenario "with the intervention" and an alternative scenario "without the intervention". The results are then aggregated to identify net benefits (benefits minus costs) and to draw conclusions on whether the action or project is desirable and worth implementing from a societal point of view. A positive net benefit indicates that an intervention is worthwhile from an economic (social) perspective.

However, as public funds are limited, some ranking of the alternatives is necessary to enable decision makers to choose the interventions that have the highest return on investment and/or bring the greatest benefit to target populations. Therefore, the primary output of CBA is the benefit-cost ratio (B/C ratio), which shows the factor by which benefits exceed costs and can be used a direct comparison instrument (European Commission, Commission Implementing Regulation 2015). To that extent, the proposed guidelines could be used as a decision-making tool for assessing investments to be financed by limited and competing public resources.

3. GENERAL INFORMATION ABOUT THE PRESENTATION OF RESULTS

After conducting the analysis, the conclusions of the CBA need to be presented in a document with, at least, the following sections.

3.1. Objective of the Intervention

In general, the CBA shall make clear if the analysis is carried out adopting a local, regional or national perspective. The appropriate level of analysis should be defined with reference to the size and scope of the intervention, i.e., to the society in which the intervention has a relevant impact. A clear statement of the intervention's objectives is needed in order to understand if the investment has social value. The objectives should be logically connected to the investment.

3.2. Identification of the Intervention

Highlights of the main characteristics of the proposed action and/or project. Presentation of the results of demand analysis (market study, traffic forecasts, energy consumption statistics) on the basis of which the assessment of revenues and costs has been based and the projections performed.

3.3. Financial Analysis

Provision of details of the financial projections - investments, operating costs and revenues, sources of financing - and conclusions of the analysis with the major profitability indicators (financial rate of return [FRR]/C and financial net present value [FNPV]).

3.4. Economic Analysis

Identification and quantification in monetary terms of the project benefits, correction of project cost with economic prices and calculation of the economic net present value (ENPV), ERR and B/C ratio.

3.5. Conclusion

Summary of the results and the main decision making indicators.

4. FINANCIAL ANALYSIS

Financial analysis is generally the assessment of monetised income, expenditure, cash flows, profit and end-of period balance. Financial analysis of an intervention therefore estimates the financial impact of the intervention on the implementing agency, or those financially affected. As a general rule, it is not essential in terms of decision making as energy efficiency interventions can lead to benefits which are most often not monetary and thus cannot be included directly in the financial analysis.

However, it is a major step towards estimating the overall benefits and costs and has to cover several major steps as follows.

4.1. Assigning a Time Horizon

The question of timing of costs and impacts is a fundamental issue in CBA given that directness of effect declines over time. The time horizon refers to the maximum number of month (years) for which forecasts are provided (period of both investment and operation). Two questions relate to the time horizon: (1) What is the time period of the intervention? (2) What is the time period for following up the impact of the intervention? Forecasts regarding the future of the policy action/project should be formulated for a period appropriate to its useful life and long enough to encompass its likely medium to long term impact.

Traditionally, CBA evaluates investment projects, where intervention costs are incurred at or near the beginning of the project/programme and benefits tend to be delayed and spread over a longer period. Therefore, the time horizon of the CBA can be central to the outcome of the analysis. For example, a CBA with a short time horizon would tend to reduce the benefit-cost ratio of the intervention. For the purposes of the current policy actions, related to energy efficiency, a medium time horizon of 10 years is proposed. Conceptually, at the end of the time horizon one can sum up the accounts and verify whether the investment was a success, or alternatively - one can judge for the cost-effectiveness of each policy action/project by looking at the calculated financial indicators.

4.2. Estimation of the Required Investment and Reinvestment Costs

The first step in the financial analysis is the estimation of how large the total investment cost for the intervention will be. As a first step, the analyst must identify the inputs necessary for an intervention. Subsequently, a decision is needed about which costs will be included in the cost estimation. Different types of intervention will vary in terms of where the main costs lie. Investments include all start-up costs needed for the policy action/project to get under way. These might include the cost of initial advertising campaigns, investment in equipment, construction and supervision, consulting services, research and development, preparatory studies, etc. Ideally, costs need to be classified according to their category, thus making it easier to project them over time. However, a more general presentation is also admissible and a common cost change factor can be established. As a general rule, financial analysis uses constant prices, i.e., prices that have been deflated by an appropriate price index based on prices prevailing in a given base year.

Examples of investment costs on the basis of analysed case studies
Installation of LED lightning;
Investment in local heating plant on alternative fuels;
Organisation of promotional campaigns and events;
Construction of cycle paths;
Organisation of trainings;
Organisation of energy audits;
Development and promoting a new cycling strategy;
Reconstruction of energy inefficient buildings.

Reinvestment costs may be applicable to some of the projects/policy actions in order to sustain the results achieved. These might include replacement of equipment, repetition of campaign initiatives, etc. (World Health Organization, 2006).

4.3. Estimation of Recurrent Revenues and Costs and their Implications in Terms of Cash-flows

Policy actions/projects may generate their own revenues from the sale of goods and services. These revenues are determined by the forecasts of quantities of services provided and by their prices throughout the established time horizon. Alternatively, as is the case with energy efficiency measures, the revenue stream can be comprised of operating cost-savings (i.e., reduction of household costs for electricity, reduction in the cost of fuel used, etc.). These cost-savings generated by the intervention must be considered in the analysis since they are equivalent to net revenues.

4.4. Detailed Description of Revenues (Cost Savings) in Energy Efficiency Interventions on the Basis of Analysed Case Studies

- Electricity savings (expressed in kWh saved multiplied by the current average cost of electricity). The cost of electricity might need to be updated over the proposed time horizon as prices are usually volatile and change over the years. However, it has to be kept in mind that similarly to investment costs normal fluctuations due to inflation should not be considered because the analysis is done in constant prices. Only the real increase (i.e., the one over the normal inflation rate) should be included in financial calculations. If the inflation for year n is 3% and the increase of electricity costs is 4%, then the actual (real) increase of energy costs will be 1%. Realistic assumptions need to be made for the updating procedure over the entire time horizon.
- Fuel savings (expressed in litres of fuel saved multiplied by the current average cost of fuels). The update procedure for fuel costs should follow the same pattern as the procedure for electricity costs.
- Water savings (expressed in cubic metres of waters saved multiplied by the current average cost of water provision services). The update procedure for water costs should follow the same pattern as the procedure for electricity costs.
- Heat savings (expressed as the corresponding measurement units, e.g., cubic metres of gas, mWh, mega joules, etc., multiplied by the current price per unit). The update procedure for heating costs should follow the same pattern as the procedure for electricity costs.
- Other cost-savings, not identified in the case studies but specific to the implemented intervention, which can be monetised should also be considered in the financial analysis following the exact same procedure used for the other types of cost-savings.

Examples of recurrent revenues (cost-savings) on the basis of analysed case studies
Fuel savings due to shifting transport preferences from personal to public transportation;
Electricity savings due to improvements and reconstruction of properties;
Electricity savings due to increased awareness about energy efficiency;
Electricity/heat savings due to encouraging construction beyond existing energy efficiency regulations;
Water savings due to reconstruction of properties;
Electricity savings via promoting and implementing LED in-house lightning.

It is considered that due to the nature of the interventions analysed by means of the case studies, no additional operating costs will be incurred during the implementation period. The above described cost-savings will be the one and only monetary component during the implementation period, which will influence the total financial flows.

4.5. Defining the Action/Project Financial Structure and Profitability

The following indicators need to be calculated in order to determine the financial cost-effectiveness of proposed actions.

4.5.1. FNPV

The FNPV is defined as the sum that results when the expected investment and operating costs are deducted from the value of the expected revenues. Negative values of this indicator usually mean that the "revenues" generated do not cover the initial investments. However, for the purposes of energy efficiency interventions, a positive value of FNPV is not required as the objective of these actions is not to generate a positive net revenue but to raise awareness and contribute to the overall objectives of the initiatives.

4.5.2. FRR

Measures the capacity of the action/project to generate revenues or cost savings to provide an adequate return to the sources used to finance it. It is calculated from a cash flow projection that covers the action's/project's economic life (time horizon of 10 years) and includes initial investments, operation and maintenance costs (if any) as outflows, and revenues (or cost savings) as inflows.

One can judge for the financial cost-effectiveness of the interventions by both these indicators (the larger the calculated values, the more financially cost-effective the project) but it is recommended to use the FRR as it provides a value in percentages that can be used to compare actions/projects with different cash flows. Judging for the cost-effectiveness of the action/project by the value of FNPV can be misleading as there could be different starting points.

Despite the usual usefulness of these financial indicators in standard investment situations, they can only be used as a starting point in the evaluation of energy efficiency interventions. The major reason for this situation is the fact that these interventions mostly result in benefits that are not necessarily financial in their nature, e.g., environmental benefits, improvement of quality of life, etc. These benefits need to be accounted for as the society as a whole (either on regional or national level) will be better off after the implementation of the projects/policy actions. These non-monetary implications need to be captured and quantified (monetized) by means of the economic analysis, reported in Section 4 of the guidelines and added to the results from the financial analysis.

4.6. Procedure for Implementing the Financial Analysis of the Interventions

The financial analysis of energy efficiency interventions needs to be made up as a series of tables that collect the financial flows of policy actions/projects, broken down as total investment, reinvestments, recurring operating costs (if any) and revenues (or alternatively cost savings). The methodology to be used is the discounted cash flow procedure, which uses an incremental approach that compares and presents the difference between a scenario "with the intervention" and the alternative scenario "without the intervention" (also known as "business as usual" scenario). Using the incremental approach allows the financial and economic evaluation of the results of the intervention only without including the already existing measures.

The incremental discounted cash flow procedure is applied as follows:

1. Projections are produced of the intervention's cash-flows in terms of expected revenues (or alternatively cost savings) and costs for each year of operation throughout the established time horizon in the absence of the proposed project/policy action ("without the intervention" or "business as usual" scenario). This is a counter-factual scenario used to establish a baseline for evaluation of the results of the intervention. In short, this is a no-investment forecast of what will happen in future in the context under consideration. The scenario is not necessarily non-costly, because for already existing measures or initiatives, it comprises incurring operational costs (as well as cashing the revenues generated, if any).
2. Similar projections of the intervention's cash-flows have to be produced taking into account the proposed projects/policy actions and their impact in term of operations ("with the intervention" scenario). The project/policy action promoter has to take into account the whole investment plan and account for changes in recurring costs and revenues (or alternatively cost savings).
3. The actual cash flow for the intervention is only the difference between the cash flows in the "with the intervention" scenario and the "without the intervention" scenario. It presents the actual financial impact of the project/policy action.

The result of the process above is the "incremental" impact of the proposed action/project in term of a financial cash-flows statement for all years of operation over the established time horizon. The identified cash flow can then be used to calculate the project financial performance indicators (i.e., the FNPV and the corresponding financial return on the investment or FRR).

A significant driver of overall cost-effectiveness of energy efficiency interventions is the discount rate assumption. Each cost-effectiveness test compares the FNPV of the annual costs and benefits over the life of an efficiency intervention. Typically, energy efficiency measures require an upfront investment (at the beginning of the period), while the energy savings and maintenance costs (if any) accrue over several subsequent years. The calculation of the FNPV requires a discount rate assumption, which can be different for the stakeholder perspective of each cost-effectiveness test. This is meant to reflect the opportunity cost of capital, which could be thoughts as the expected return forgone in the best alternative project.

For a household, the consumer lending rate can be used, since this is the debt cost that a private individual would pay to finance an energy efficiency investment. For a business, the discount rate is the firm's weighted average cost of capital, typically in the 10 to 12% range (EU Reference Scenario, 2016). However, some commercial and industrial enterprises often demand payback periods of 2 years or less, implying a discount rate well in excess of 20%. Public energy efficiency measures do not aim at quick payback of investments. Instead, a long-term impact economic, environmental and social result is targeted. Commission delegated regulation of the European Commission (Official Journal of the European Union, 2014) recommends that a 5% rate in real terms (i.e., when constant prices for a given base year are used in the analysis) is considered as the reference parameter for the opportunity cost of capital in the long term in public investment interventions.

The discounted cash flow procedure can be detailed in an accompanying excel spreadsheet (financial analysis). The excel spreadsheet requires some input data which need to be filled out by the case promoter in order to get sufficient results. These fields are described below as follows:

- Investments broken down by year into three separate categories - construction (e.g., new cycle tracks and alleys, modernisation of properties); delivery of equipment (new led lightning, new boiler for a local heating plant); provision of services (promotional campaigns, increase of awareness, etc.). The differentiation between the types of investments helps to determine the necessary re-investments in a longer run (e.g., a cycle track may need periodic maintenance in a 5-year period; awareness campaigns might need to be repeated on a regular basis). This part of the spreadsheet is obligatory.
- Unit costs for the major cost-savings categories (electricity, fuels, water, heating) in order to determine the financial impact of the interventions over the established time horizon. This part of the spreadsheet is obligatory.
- Inflation rate and rates of increase for the major cost-savings categories (electricity, fuels, water, heating) in order to establish the updating procedure of costs over the established time horizon. Since the financial analysis is performed in constant prices, only the real increase of cost categories (i.e., over the overall inflation rate) needs to be determined. This part of the spreadsheet is obligatory.
- Situation before the implementation of the intervention ("without the intervention"/"business as usual" scenario) - what is the usual consumption of electricity, fuels, water and heating (or other case specific resources) in their specific measurement units in the counter-factual situation where the intervention will not be implemented (e.g., no promotional campaigns carried out to promote the use of public transportation instead of using own vehicles). As this is a fictional situation, sometimes it might be hard to determine exact values. A realistic and justified estimate based on known statistical data or assumptions is often enough to carry out the financial and economic analysis of the intervention (e.g., average commute distance, number of registered cards, average fuel consumption, etc.). This part of the spreadsheet is obligatory.
- Situation after the implementation of the intervention ("with the intervention") - what will be the likely decrease of usage of electricity, fuels, water and heating (or other case specific resources) after the intervention is carried out. This field of the spreadsheet is obligatory.

The resulting update procedures and calculations over the established time horizon will determine the incremental cash flows (i.e., the ones resulting only from the project/policy action) and the major financial profitability indicators which will serve as a basis for the subsequent economic analysis of the interventions and for determining their relative cost-effectiveness.

5. ECONOMIC ANALYSIS

The purpose of the economic analysis is to justify that the energy efficiency intervention has a positive net contribution to society at the adopted territorial level (regional and/or national) and is therefore, worth being implemented. If the net benefits for the society (economic benefits minus economic costs) of the policy action/project are positive, then society is better off with the policy action/project because its benefits exceed its costs.

Economic benefits and economic costs are different than the financial ones. Some project/policy action impacts may exist that are relevant for the society but for which a market value is not readily available (e.g., environmental benefits). These effects (externalities), which can be either positive or negative, need to be identified, quantified and given a realistic monetary value. In addition, applying appropriate conversion factors to the values from the financial analysis will capture the most relevant benefits a project/policy action may generate.

The assessment of economic benefits and costs results in the calculation of the economic performance indicators. The best alternative will have a higher value of the respective economic indicators - ENPV and economic internal rate of return (EIRR) and a benefit/cost (B/C) ratio higher than 1.

The economic analysis is accomplished by using the exact same principles of the discounted cash flow procedure like in the financial analysis with several important differences:

- It is recommended to use a slightly higher social discount rate of 5.5%. Similarly to the financial discount rate, the social discount rate reflects the benefit to society over the long term, and takes into account the reduced risk of an investment that is spread across all of society, such as the entire municipality, region or country. This was selected based on empirical estimations of social rate of time preference for Cohesion and non-Cohesion countries (Massimo, 2014).
- Economic (as opposed to financial) costs are measured in terms of their "resource" or "opportunity" costs; that is, the benefit which has to be foregone (the opportunity lost) by society in using scarce economic resources in the policy action/project rather than in some alternative use. Therefore, appropriate conversion factors need to be applied to reflect the true economic value of these cost categories.
- Policy action/project economic benefits can be measured in terms of the costs avoided as a result of implementing the intervention, or in terms of external benefits that are results

of the implementation of the project and that are not captured by the analysis performed in financial terms.

5.1. Conversion from Market to Accounting Prices

The starting point of the economic analysis is the cash-flows calculated for the financial analysis, which requires two types of corrections to be converted in economic cash-flows: (i) Fiscal and accounting (shadow) pricing correction and (ii) monetization of externalities.

Fiscal corrections are needed for those elements of the financial prices that are not related to the underlying opportunity costs of the resources involved. To that extent, correction shall include deductions for indirect taxes (e.g., VAT), subsidies and pure transfer payments (e.g., social security payments). In particular, investment costs for stakeholders that are not VAT registered (and for which VAT is therefore not recoverable) should include VAT in the financial analysis. This, however, should be excluded from the economic analysis. However, economic prices should include direct taxes.

Once fiscal corrections are taken into account, it is necessary to ensure that the prices used in the economic analysis properly reflect the true economic value of the resources concerned. Converting project costs from market to social (economic) prices implies breaking down the project cost into the different categories listed below, with the required treatment specified for each case:

5.1.1. Traded items

This category comprises all goods and services included in the policy action/project cost that can be valued on the basis of world prices. For an open economy with international tenders for procuring the equipment, materials and services, this category will normally cover most of the project costs. No specific conversion is required since market prices are assumed to reflect economic prices (i.e., opportunity costs).

5.1.2. Non-traded items

This category comprises all goods and services that have to be procured domestically, like for example domestic transport and construction, some raw materials, and water and energy consumption. The conversion from financial to economic prices is usually done through a standard conversion factor (SCF). The SCF is usually computed based on the average differences between domestic and international prices (i.e.,: FOB and CIF border prices) due to trade tariffs and barriers. However, given that costs within this category are normally low with regards to total costs, the SCF will be 1 unless otherwise justified.

5.1.3. Skilled labour

This category comprises the labour component of the policy action/project cost that is considered scarce and therefore adequately priced in terms of opportunity cost. No specific conversion is required since market prices are assumed to reflect economic prices.

5.1.4. Non-skilled labour

This category comprises the labour component of the policy action/project cost that is considered in surplus (i.e.,: In a context of unemployment) and therefore not adequately priced from the economic point of view. The correction to reflect the opportunity cost of labour could be made by multiplying the financial cost of un-skilled workers by the so-called shadow wage rate factor, which can be calculated as (1-u)*(1-t), where u is the regional unemployment rate and t is the rate of social security payments and relevant taxes included in the labour costs.

5.1.5. Land acquisition

This category comprises the land implicitly used in the policy action/project, even when no financial cost is included as part of the policy action/project cost (for example if the land was provided free of cost by the project beneficiary). Correction of land costs intends to adjust for the net output that would have been produced on the land if it had not been used by the project. In those cases in which the land has been acquired at market value, the applicable conversion factor is 1 since it is assumed that the market value reflects the present value of the future output. Otherwise, the adjustment to reflect economic costs will have to be calculated on a case by case basis.

5.1.6. Transfer payments

This category comprises indirect taxes (i.e.,: VAT), subsidies, and pure transfers payments included in the market prices used to estimate the policy action/project costs. All these costs have to be eliminated for the purposes of the economic analysis.

5.2. Treatment of Externalities

Project benefits could take the form of benefits to society that are not properly taken into account in the financial analysis because, even if they are an intended outcome of the project, they are not fully captured by the financial prices due to the lack of a market value.

A typical example is the improvement in the quality of life of people living in an area that benefit from an energy efficiency project. Quality of life could be improved as results of, for example, expected improvements to general human health in the area (as a result of reduction in pollution), or improvement in the attractiveness of the area subject to the intervention (due to improved conditions).

It is anticipated that, once all potential externalities are identified, the challenge is to take them into account in the Economic Analysis, since this will require translating them in economic terms by assigning a “price” (or cost) to them. This step could result being fairly complicated since, by definition, externalities don’t have a price which is established by the market and, therefore, proxies needs to be used to convert them in economic terms.

The general recommendation is to limit the assessment of externalities in the Economic Analysis to those for which a solid economic argument could be presented and for which a monetization or estimates are realistically possible.

Emission	Description
Carbon dioxide (CO_2)	A product of combustion
Fine particulates (PM_{10}; $PM_{2.5}$)	Inhalable particles
Nitrogen oxides (NOx) and nitrous oxide (N_2O).	Various compounds, some are toxic, all contribute to ozone
Sulphur oxides (SOx)	Lung irritant and acid rain
VOC (volatile organic hydrocarbons)	Various hydrocarbon (HC) gasses

Benefits related to policy actions/projects in energy efficiency are expected, among others, in term of reduction of harmful air emissions. The most typical harmful emissions can be summarized as follows (Litman, 2009):

As was already noted in the financial analysis, measuring and quantifying for example electricity savings as a result of specific policy measures or programmes is challenging since it requires a comparison with the electricity consumption in case the measures or programmes had not been implemented. Similar challenges apply to the quantification of economic benefits and costs and need to be taken into account when assessing them.

5.2.1. Reduction of CO_2 emissions

The first step is to determine the quantity of avoided CO_2 emissions from the efficiency programme. Once that quantity has been determined, its economic value can be calculated and added to the financial net benefits of the energy efficiency measures used to achieve the reductions.

The savings of electricity and fuels, resulting from the policy actions/projects have a positive environmental effect in terms of reduction of CO_2 emissions. These can be monetized in order to calculate the positive economic (social) effects from the initiatives. According to the publication of the European Investment Bank (European Investment Bank, Methodologies for the Assessment of Project GHG Emissions and Emission Variations, 2018), the following conversion factors apply: 1 kWh of energy = 0.45 kg CO_2 emissions; 1 L of diesel = 2.7 kg CO_2 emissions; 1 L of gasoline = 2.3 kg CO_2 emissions, 1 L of LPG = 1.5 kg CO_2 emissions.

To date, monetary values for CO_2 emissions have been drawn primarily from studies and journal articles and applied in regulatory programs. While there is widespread agreement that greenhouse gas reduction policies are likely to impose some cost on CO_2 emissions, achieving consensus on a specific value/ton price is challenging. The average price of one ton CO_2 in the second period of the European emissions trade scheme (2008-2012) was 20-25 euro/ton (EU Emissions Trading System, 2018). The prices of carbon credits are linked with the goals of the Kyoto Protocol. The latest objectives after the period of the Kyoto Protocol envisage a higher percentage of reduction of the carbon emissions, (20-30% reduction in 2020 as compared to 1990), resulting in a gradual rise of the price per ton of CO_2 (European Commission, Climate Change and Major Projects, 2014).

5.2.2. Reduction of air pollution (particulate matters, NOx, SO2, VOC)

All air pollution costs are caused by the principal air pollutants - dust particles PM, NOx, SO2 and volatile organic compounds (VOC). The costs incurred by air pollution include: Health costs, material damages, loss of crops, losses caused by damages incurred on the ecosystems (biosphere, soils, water).

The following conversion factors apply:

- 1 L of diesel = 0.005 kg NOx emissions; 1 L of gasoline = 0.005 kg NOx emissions, 1 L of LPG = 0.005 kg NOx emissions.
- 1 L of diesel = 0.0004 kg SO2 emissions; 1 L of gasoline = 0.0004 kg SO2 emissions, 1 L of LPG = 0.0004 kg SO2 emissions.
- 1 L of diesel = 0.00007 kg PM emissions; 1 L of gasoline = 0.00007 kg PM emissions, 1 L of LPG = 0.00007 kg PM emissions.
- 1 L of diesel = 0.007 kg VOC emissions; 1 L of gasoline = 0.007 kg VOC emissions, 1 L of LPG = 0.007 kg VOC emissions.

The following approximate numbers can be used in the process of monetisation: NOx - 2770 Euro/tonne, SO2 - 2830 Euro/tonne, PM2.5 - 54150 Euro/tonne outside built-up areas and 318 850 Euro/tonne within built-up areas, PM10 - 26000 Euro/tonne (HEATCO, 2014).

It is worth keeping in mind that the intervention could also have negative externalities not reflected in the opportunity costs and that need to be taken into account in the economic analysis. Negative externalities could take the form of possible impacts on the environment (spoiling of scenery, naturalistic impact, loss of local land), negative impact due to the opening of building sites (temporary effect from construction) or the unlikely increased emissions due to increased transport activities triggered by the intervention.

Externalities (both positive and negative) are potentially present in all proposed actions and likely to be dependent on the specific characteristics of the projects. To that respect, it is recommended that externalities are identified on a case-by-case basis when performing the economic analysis.

6. CONCLUSION

The ENPV is the difference between the discounted total social benefits and costs. A positive value of this indicator shows that society is better off after the project implementation and therefore the intervention is worth carrying out.

The EIRR is the discount rate at which a stream of costs and benefits has a net present value of zero. The internal rate of return is compared with a benchmark in order to evaluate the performance of the proposed project. Economic rate of return is calculated using the economic values described above.

The benefit-cost ration (B/C ratio) presents the present value of project benefits divided by the present value of project costs. If B/C >1 the project is suitable because the benefits, measured by the present value of the total inflows, are greater than the costs, measured by the present value of the total outflows.

The ENPV is the most important and reliable indicator and should be used as the main reference economic performance signal. Although EIRR is meaningful because it is independent of the project size, it may sometimes involve problems. In particular cases, the EIRR may be multiple or not defined. The B/C ratio is also independent of the size of the investment, but in contrast to IRR it does not generate ambiguous cases and for this reason it can complement the ENPV in ranking projects where budget constraints apply. In these cases the B/C ratio can be used to assess a project's efficiency.

In principle, every policy action/project with an ERR lower than the social discount rate (5.5%) or a negative ENPV should be rejected. A project with a negative economic return, uses too much of socially valuable resources to achieve too modest benefits for all citizens.

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REFERENCES

EU Commission. (2012), Guidelines for Cost Benefit Analysis of Smart Metering Deployment, Available from: https://www.ses.jrc.ec.europa.eu/sites/ses/files/documents/guidelines_for_cost_benefit_analysis_of_smart_metering_deployment.pdf.

EU Commission. (2014), Climate Change and Major Projects. Available from: https://www.ec.europa.eu/clima/sites/clima/files/docs/major_projects_en.pdf.

EU Commission. (2014), Commission Delegated Regulation (EU) No. 480/2014. Available from: https://www.eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0480&from=en.

EU Commission. (2014), Guide to Cost-Benefit Analysis of Investment Projects, Economic Appraisal Tool for Cohesion Policy 2014-2020. Available from: https://www.ec.europa.eu/inea/sites/inea/files/cba_guide_cohesion_policy.pdf.

EU Commission. (2015), Commission Implementing Regulation (EU) 2015/207of 20 January 2015, Available from: https://www.eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R0207&qid=1548610669214&from=EN.

EU Commission. (2016), EU Reference Scenario, Energy, transport and GHG emissions Trends to 2050; Available from: https://www.ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf.

European Investment Bank. (2018), EIB Project Carbon Footprint Methodologies, Methodologies for the Assessment of Project GHG Emissions and Emission Variations. Available from: http://www.eib.org/attachments/strategies/eib_project_carbon_footprint_methodologies_en.pdf.

HEATCO. (2014), Developing Harmonized European Approaches for Transport Costing and Project Assessment. Available from: http://www.heatco.ier.uni-stuttgart.de.

Litman, T. (2009), "Air Pollution Costs," Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute; the EU Emissions Trading System 2018. Available from: http://www.ec.europa.eu/clima/policies/ets/index_en.htm.

Massimo, F. (2014), Applied Welfare Economics: Cost-Benefit Analysis of Projects and Policies. New York: Routledge.

World Health Organization. (2006), Guidelines for Conducting Cost Benefit Analysis of Household Energy and Health Interventions. Available from: http://www.who.int/indoorair/publications/guideline_household_energy_health_intervention.pdf.