

JASPERS - ASSISTANCE WITH UPDATE OF PARAMETER VALUES FOR USE IN THE ECONOMIC ASSESSMENT OF TRANSPORT PROJECTS IN ROMANIA

PROJECT APPRAISAL GUIDELINES

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TABLE OF ABBREVIATIONS

AECOM	A firm of consulting engineers, originally an acronym for Architecture, Engineering, Consulting, Operations and Maintenance
AET	Adapted economic test
CAPEX	Capital expenditure
CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
CNSP	Romanian National Commission for Strategy and Forecast
CO ₂	Carbon dioxide
CPR	Common provisions regulation
CursBNR	National Bank of Romania exchange rate calculator
DG MOVE	Directorate General for Mobility and Transport
EA	Economic assessment (or appraisal)
EAV	Economic Appraisal Vademecum
EC	European Commission
EIB	European Investment Bank
ENPV	Economic net present value
ERTMS	European rail traffic management system
ETCS	European train control system
EU	European Union
EU28	The 28 countries of the EU, prior to the United Kingdom leaving
EUR	Euro
FDR	Financial discount rate
FNPV	Financial net present value
FRR	Financial rate of return
g	Gramme
GDP	Gross domestic product
GHG	Greenhouse gas
GJT	Generalised journey time
GTMP	General transport master plan
HGV	Heavy goods vehicle
HICP	Harmonised index of consumer prices
ICE	Internal combustion engine
INSSE	Romanian National Institute of Statistics
IWT	Inland waterway transport
IWTOC	Inland waterway transport operating cost
JASPERS	Joint assistance to support projects in European regions
LCA	Least-cost analysis
LGV	Light goods vehicle (up to 3.5 tonnes gross weight)
MA	Managing authority
MCA	Multi-criteria analysis
NO _x	Nitrogen oxides
NPV	Net present value
NTM	National transport model
NRTM	National road transport model
O&M	Operation and maintenance
PCR	Project completion report
PM _{2.5}	Particulate matter of 2.5 microns
PM ₁₀	Particulate matter of 10 microns
PV	Present value

RON	Romanian Leu
SDR	Social discount rate
SOx	Sulphur oxides
TOC	Train operating cost
ToR	Terms of reference
TP	2021-2027 Romanian Transport Programme
TTW	Tank-to-wheel
UK	United Kingdom
VOC	Vehicle operating cost
VOC	Volatile organic compound
VoT	Value of time
WebTAG	UK Government transport analysis guidance
WOP	Without project
WP	With project
WTT	Well-to-tank
WTW	Well-to-wheel

1 PREAMBLE

The central purpose of project appraisal is to ensure that scarce public funds (from both national and European Union sources) are allocated efficiently by establishing a framework against which both the project's costs and benefits can be assessed.

Throughout both the 2007-2013 and the 2014-2020 programming periods, to ensure scarce public resources were allocated efficiently, Romania required that all EU-funded transport projects undergo rigorous appraisal in line with EU requirements, typically (for projects above defined thresholds) in the form of a project cost benefit analysis (CBA). For such 'major projects'¹ the European Commission formally decided upon them after the receipt and review of project documentation.

EU appraisal requirements were designed to aid the decision-maker at key decision milestones, in deciding whether e.g., intervention is needed and, if so, what the proper scope of the intervention should look like. This requirement for CBA has contributed significantly to ensuring good value for money and has encouraged rigour in the project selection process. It is now established practice that project appraisal should occur at various points in the project development cycle (e.g., in deciding the appropriate option to select and prior to the decision to award the contract).

The requirement to undertake appraisals on all major transport projects has necessitated building up of substantial appraisal capacity (in the form of expertise in e.g., transport modelling, and economic/financial analysis) at both the level of Engineering Consultants (who typically develop project Feasibility Studies), as well as at the level of the transport agencies and within government Ministries.

According to the common provisions regulation (CPR)² approved in June 2021 for the 2021-2027 programming period, there are no longer any legal requirements for 'major projects' with EU ex ante approval as in previous programming periods. In addition, regulations do not explicitly mention the need to perform a CBA, although the art. 73.2(c) does require the Managing Authorities to *"ensure that selected operations present the best relationship between the amount of support, the activities undertaken and the achievement of objectives"*.

In this context, to ensure proper value for money is achieved from projects to be financed with EU Funds, the Romanian Managing Authority (MA) for Transport continues to require systematic appraisal of transport projects.

These guidelines outline the requirements for appraisal of EU-financed transport projects in Romania in the 2021-2027 programming period. This covers all national, regional, and inter-urban projects in the road, rail, port/inland waterway, and intermodal transport sectors. The basic principles of these guidelines apply to all transport projects to be financed from public funds, regardless the source of their financing.

These guidelines:

- Provide an overview of best practices and set out minimum standards for demand modelling and economic/financial/risk appraisal of road, rail, and other public transport projects in Romania.
- Cover various forms of appraisal methods, including CBA (cost-benefit analysis), CEA (cost-effectiveness analysis) and MCA (multi-criteria analysis), in line with the EC guidance, including requirements on when each of these would apply.

¹ According to Article 100 of Regulation (EU) No 1303/2013, a major project is an investment operation comprising "a series of works, activities or services intended in itself to accomplish an indivisible task of a precise economic or technical nature which has clearly identified goals and for which the total eligible cost exceeds" either EUR 75 million (for projects proposed under Thematic Objective 7, or EUR 50 million (all other projects).

² Regulation (EU) 2021/1060 of the European Parliament and of the Council of 24 June 2021 laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Instrument for Financial Support for Border Management and Visa Policy.

- Map out the key project development stages for the main transport sub-sectors and indicate at which stages economic appraisal should be undertaken.
- Contain as an annex an associated Excel database of agreed parameter values for use in the economic assessment of transport projects. This provides the 'level playing field' against which all transport projects are assessed. While the majority of parameters should be taken directly from this source (e.g., social discount rate, value of time), certain parameters (e.g., O&M unit rates, vehicle occupancy rates, accident rates) may be over-ridden based on more appropriate, localised data.

Although not directly applicable to projects financed under other programmes/sources, the Guidelines can be used *mutatis mutandis* to support sound project preparation and appraisal for wider transport investments, (i.e., not under the aegis of the Ministry of Transport, such as municipal transport projects).

The document is meant to be neither exhaustive nor limitative. Whilst it provides general principles and methodological guidance expected to cover most of the typical investments under the sector/programme, specific project particulars may require adaptations or additional considerations. In such cases, consultation with the Managing Authority is recommended at the earliest stage relevant.

It is assumed that the reader is familiar with basic concepts relating to appraisal. There is extensive published documentation to which reference may be made for further information on appraisal; such reference documents are listed in Chapter 2.

2 REFERENCE DOCUMENTS

The Guidelines draw on the Reference Documents listed below.

European Commission (2014) **Guide to Cost Benefit Analysis of Investment Projects**³. This document contains detailed guidelines on how to appraise EU financed projects in the 2014-2020 programming period. It includes specific guidelines for transport sector projects and the general principles still apply. This document is referred to in the current Guidelines as the **2014 CBA Guide**.

European Commission (2021) **Economic Appraisal Vademecum 2021-2027**⁴. A more recent document provides general principles and sector advice for co-financed projects in the 2021-2027 programming period. It is intended to supplement, rather than replace, the 2014 CBA Guide and in general provides for a more flexible and sometimes simplified approach. It is subsequently referred to as the **EAV**.

European Commission (2019) **Handbook on the External Costs of Transport**⁵, prepared by CE Delft on behalf of DG MOVE. This document presents a set of parameter values for external costs including accidents, air pollution, GHG emissions, noise etc. It supersedes the previous 2014 edition. It is supplemented by an Excel database of country specific values. This document is referred to as the **2019 Handbook**. (The previous version is referred to as the **2014 Handbook**.)

JASPERS (2017) **Guidance on Appraising the Economic Impacts of Rail Freight Measures**⁶. This document provides general guidance on the assessment of investment in rail freight facilities, and includes some suggested parameter values including train operating costs, freight values of time, tonnage, reliability, track maintenance etc. It is referred to as **JASPERS Rail Guidance**.

AECOM (2014) **Guide to Economic and Financial Cost Benefit Analysis and Risk Analysis**⁷. The AECOM guide relates specifically to Romania and was prepared within the context of the General Transport Masterplan (GTMP). It includes an appendix of parameter values that were used in Romania in the 2014-2020 programming period. Some of the parameters apply at a level of detail that may not always be available, while others are based on values from other countries that may not be directly applicable. Nevertheless, the guide provided a good base for some of the current parameter values. The document is referred to as the **AECOM Guide**.

JASPERS (2014) **Guidance on the Use of Transport Models in Transport Planning and Project Appraisal**⁸. This document provides guidance on the development of Transport Models for use in the development and appraisal of transport projects. It is referred to as **JASPERS Transport Models Guidance**.

EIB (2020) **Climate Bank Roadmap 2021-2025**⁹ sets out the EIB's commitment to climate action and environmental sustainability. It includes data on the proposed evolution of shadow costs of carbon.

EIB (2022) **EIB Project Carbon Footprint Methodologies**¹⁰ for the assessment of project greenhouse gas emissions and emission variations, version 11.3. This document sets out the methodologies used by the EIB for calculating the carbon footprint of investment projects and includes a wide range of emission factors in the annexes.

EMEP-EEA (2019) **Air Pollutant Emission Inventory Guidebook**¹¹. This document provides technical guidance on how to prepare national emission inventories.

CE Delft (2018) **Review GHG Emission Factors for Transport for the EIB**.

Other documents and sources are referenced in footnotes throughout the Guidelines.

³ [EC \(2014\) Guide to Cost-Benefit Analysis of Investment Projects](#)

⁴ [EC \(2021\) Economic Appraisal Vademecum 2021-2027: General Principles and Sector Applications](#)

⁵ [EC \(2019\) Handbook on the External Costs of Transport](#)

⁶ [JASPERS \(2017\) Guidance on Appraising the Economic Impacts of Rail Freight Measures](#)

⁷ [AECOM \(2014\) Guide to Economic and Financial Cost Benefit Analysis and Risk Analysis](#)

⁸ [JASPERS \(2014\) Guidance on the Use of Transport Models in Transport Planning and Project Appraisal](#)

⁹ [EIB \(2020\) EIB Group Climate Bank Roadmap 2021-2025](#)

¹⁰ [EIB \(2022\) EIB Project Carbon Footprint Methodologies: Methodologies for the assessment of project greenhouse gas emissions and emission variations, Version 11.3](#)

¹¹ [EMEP-EEA \(2019\) EMEP/EEA air pollutant emission inventory guidebook 2019: Technical guidance to prepare national emission inventories](#)

3 OVERVIEW OF ECONOMIC APPRAISAL

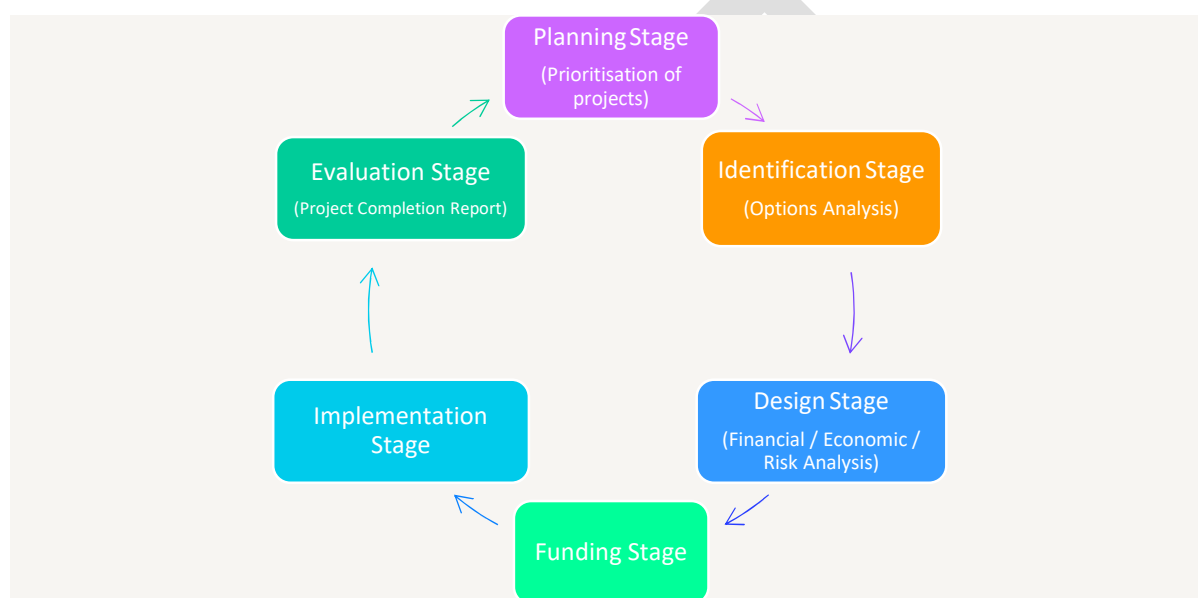
Available resources for the development of transport infrastructure are limited and insufficient to satisfy all potential transport demand through the construction of ever larger and more extensive infrastructure. The need to make choices between transport projects competing for scarce resources is inevitable. Therefore, a mechanism is required to assess the relative attractiveness of alternative investments.

Economic analysis (EA) aids the decision-making process at key project milestones and may also be used at the programme level to rank and/or to prioritise projects.

3.1 The project development cycle

The project development cycle can be variously illustrated, but in a simple form consists of six stages of the planning and execution of actions at programme and project level.

Figure 3.1. The project cycle



Source: Based on various Project Cycle Management handbooks including Handbook for EU Project Design and Project Cycle Management

- The project cycle begins at the **Planning stage**, where programme preparation takes place. Here, in the context of budgetary constraints, projects are ranked or prioritised.
- Next, individual projects are carried forward to the **Identification Stage**, where an analysis of alternative project options is undertaken.
- The preferred option is then carried forward to the project **Design stage**, where the proposed project is further developed and optimised.

Identification and Design stage may be either undertaken together (wherein one complete project Feasibility Study covering both stages is undertaken) or separated into two processes: identification (pre-Feasibility) and design (Feasibility) stages.

- At **Funding stage** projects determined to be feasible are put forward for financing.
- Projects which receive funding are then completed during the **Implementation stage**.
- Good practice requires projects to be evaluated once completed, at the **Evaluation stage**, to gauge the extent to which the expected outcomes were met and to record lessons learned for future planning. This stage is not mandatory for all projects. However, the MA should identify the projects for which this evaluation stage will be undertaken.

3.2 The role of appraisal in the project development cycle

The first stage at which appraisal is undertaken is the **Planning Stage**, as outlined above. This should involve the systematic appraisal and prioritisation of individual proposed projects using CBA and/or MCA.

The prioritised projects are then further developed and appraised as follows (see Figure 3.1 above):

- **Identification Stage.** During this stage, a decision needs to be taken on which option to select from the myriad of available possibilities. To assist in the decision-making process, an **Options Analysis** is undertaken.

When there is a large number of potential options, an initial filtering process to reduce the number of options is often needed. This filtering process may be skipped if there is only a limited number of reasonable options (e.g., 2-5 sensible options). The appraisal techniques during this initial filtering process may vary according to circumstances but generally would likely include either CEA or MCA.

Once limited numbers of reasonable alternatives are defined, a detailed Options Analysis, which assesses each option against a set of predefined criteria, is undertaken. The resulting selection of the preferred option would typically be based on an economic CBA and/or MCA.

- **Design Stage.** Once a preferred option is selected the design and cost estimate are firmed up, and a detailed CBA is normally undertaken confirming whether the preferred variant is financially sustainable and economically viable. There may be a limited number of projects for which a CBA is impractical (e.g., for compliance projects), and alternate methodologies may apply in such circumstances (see Figure 3.2 below).
- **Evaluation Stage.** For projects which have been selected for evaluation, a Project Completion Report (PCR) is prepared. This compares early stage (options, pre-construction) cost and demand estimates against actual outturn cost and demand. The PCR assesses 'lessons learned' during construction (e.g., contract management issues). For the purposes of completing PCRs, a combination of quantitative and qualitative analysis is typically used. [The MA may from time to time review PCRs with a view to determining which issues are arising on transport projects (e.g., cost underestimation, demand overestimation) and proposing changes to appraisal procedures and practices to ensure these issues are addressed over time.]

The figure below illustrates the typical appraisal tools used at each project Appraisal Stage:

Figure 3.2. Typical appraisal tools for each project stage

Project Appraisal deliverables	Purpose	Tool(s) generally recommended
Identification Stage - filtering	Filtering from a longer list of potential options identified to a shortlist of most relevant options (typically 2-5)	CEA and/or MCA
Identification Stage – detailed Options Analysis	Comparing in more detail the shortlisted options to select the preferred alternative	CBA and/or MCA
Design Stage	Evaluating if the proposed investment (preferred option) is of economic benefit for society and is financially sustainable	CBA (e.g., Economic / Risk Analysis)
Evaluation Stage	Ex-post analysis of projects with a view to seeing whether early stage estimates of cost and project demand were accurate, and what were the lessons learned in implementation.	Quantitative and/or Qualitative assessment

Source: JASPERS

The identified appraisal tools are discussed in turn below.

3.3 Economic appraisal tools

Ex-ante project economic appraisal tools include cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), and multi-criteria analysis (MCA). This section considers each method and makes recommendations on when each might be applied.

3.3.1 Cost benefit analysis

CBA is an analytical tool used to assess the economic advantages or disadvantages of an investment decision by quantifying the welfare changes attributable to its implementation. It aims to quantify all benefits and costs for society in monetary terms. These include economic, social, and environmental impacts. It was a general requirement in the 2014–2020 programming period for major projects financed by the European Regional Development Fund or the Cohesion Fund and continues to be a requirement of the MA Transport for the 2021–2027 programming period.

3.3.2 Cost-effectiveness analysis

Cost-effectiveness analysis (CEA) is used to compare two or more project options in relation to their effectiveness and life-cycle costs in accomplishing a single policy-specific objective. By combining information on effectiveness and costs, the project promoter can determine which investment option has the highest effect for a given cost. A variant of CEA determines the investment option that provides the best effect at the lowest cost, and is referred to as least-cost analysis (LCA). CEA can thus take the form of cost minimisation and/or effect maximisation.

CEA differs from CBA because it does not evaluate the benefits in monetary terms. This assumes that all options considered are technically and economically viable and deliver the same single type of output (or process the same single type of input) even if in different volumes.

If the options achieve the same output with the same intensity/volume, and differ only in costs, the CEA can be simplified to an LCA, whereby options are compared based only on the present value of their life-cycle costs.

CEA usually aims to identify the possible alternatives for achieving a set goal and the related costs, and to choose the most effective option. That is, it determines which one among several alternatives is the most cost-effective, but it does not indicate if an alternative is worthwhile in some absolute sense. In other words, unlike CBA, CEA cannot indicate if the preferred option provides a net benefit to society. Therefore, it is always useful to compare the results of the analysis with established benchmarks to verify that the chosen option meets the generally acceptable cost performance criteria.

In the transport sector, its main usage in the 2014–2020 funding period was for national elements of European-level projects, which represent legal compliance objectives such as the implementation of the ERTMS in the railway sector, where the output has been defined in terms of simple physical outputs such as length in kilometres. Where such simple physical outputs are considered, CEA is generally advisable only when the outputs of the options have the same quality and functionality, otherwise the CEA is not a fair comparison.

Cost-effectiveness ratios allow appraisers to rank the options, eliminate those whose cost-effectiveness ratio is higher than others, and then identify the optimal options.

The ratios could and should be expressed in different ways depending on the project particulars, but examples could range from simple measures of cost per kilometre, or per unit of time saving, to more complex formulas possibly involving elements such as traffic, lifecycle costs, externalities, etc.

3.3.3 Multi-criteria analysis

Multi-criteria analysis (MCA) is appropriate for prioritising projects in a development programme or for screening multiple project options. MCA is used in transport for project option analysis when a project has multiple key objectives or impacts for assessment, which cannot be easily monetised and comprehensively or practically assessed using CBA.

This tool is used to rank alternatives or select the best alternative in reference to a set of rational criteria, generally related to technical, economic, environmental, and social characteristics and impacts of the project.

When defining the criteria to be used in the MCA, consideration should be given to avoid double counting. For example, if ERR is used in the MCA, care needs to be taken to ensure its constituent components (i.e., investment cost, O&M, time savings, vehicle operating costs, accidents, climate change, air pollution, noise) are not double counted.

The analyst must provide a description of the rationale behind each criterion and sub criterion and explanations on how it is scored.

The analysis may or may not involve application of criteria weights and option scores, depending on the project particulars and especially on the range and complexity of the key criteria with significant differential impacts across options.

When the analysis involves the application of weights and scores, a sensitivity analysis to changes to the weights attributed to the different criteria should be performed to evaluate if the options selection process is robust and unbiased. The analysis is done by increasing the weight of each group of criteria whilst proportionally adjusting the weights of the rest of the criteria groups with the scope to understand how the ranking of the options is impacted.

An alternate approach would be to test various weightings and scoring systems prior to undertaking the multicriteria analysis with the view to determining the optimal weighting and scoring system for the proposed project. The final decision on the weighting and scoring system should then be taken prior to starting the analysis.

3.3.4 Choice of tool

In theory, the choice of the appropriate ex-ante EA tool (CEA, MCA, or CBA) should be made depending on factors such as: type/nature of the project, the size/value of the investment, and the relevant stage in the project development cycle (see Section 3.1 above).

In the context of the 2021-2027 Romanian Transport Programme (TP), the MA requirements in terms of:

- a) when the different approaches to economic appraisal are applicable, and
- b) the review/validation requirements by the MA before moving to the following project development stage

are outlined in the Table 3.1 below.

Table 3.1. Recommended approach to the economic appraisal of projects in the transport sector

Sector	Investment type	Option analysis to select preferred option		Selected option for investment approval	
		Tools	Validation requirements by MA TP	Tools	Validation requirements by MA TP
ROADS	New motorways, expressways, interurban single carriageway roads	MCA including CBA	Yes, all projects	CBA	Yes, all projects
	By-passes	MCA including CBA	Only if > e.g. 50 MEUR or cost per km > e.g. 10 MEUR	CBA	Only if > e.g. 50 MEUR or cost per km > e.g. 10 MEUR
	Road rehabilitation, upgrading	MCA including CBA	Only if > e.g. 50 MEUR or cost per km > e.g. 2 MEUR	CBA	Only if > e.g. 50 MEUR or cost per km > e.g. 2 MEUR
	Road safety	Prioritisation based on CEA/MCA	Only if > e.g. 50 MEUR	CEA or CBA	Only if > e.g. 50 MEUR
RAIL	Rail corridor sections	MCA including CEA or CBA	Yes, all projects	CBA	Yes, all projects
	Metropolitan rail	MCA including CEA or CBA	Yes, all projects	CBA	Yes, all projects
	ERTMS	Not necessarily required in quantitative terms	Only if > e.g. 100 MEUR	CEA or CBA	Only if > e.g. 100 MEUR
	Rail safety (e.g., level crossings)	MCA including CEA or CBA	Only if > e.g. 50 MEUR	CEA or CBA	Only if > e.g. 50 MEUR
	Rail stations	MCA including CEA or CBA	Only if > e.g. 20 MEUR	CEA or CBA	Only if > e.g. 20 MEUR
	Bridges rehabilitations	MCA including CEA or CBA	Only if > e.g. 50 MEUR	CEA or CBA	Only if > e.g. 50 MEUR
	Rolling stock	Not necessarily required in quantitative terms	Only if > e.g. 50 MEUR	CBA	Only if > e.g. 50 MEUR
WATER	Ports infrastructure	MCA including CEA or CBA	Only if > e.g. 50 MEUR	CBA	Only if > e.g. 50 MEUR
	Fairway	MCA including CEA or CBA	Only if > e.g. 50 MEUR	CBA	Only if > e.g. 50 MEUR
INTERMODAL	IM Terminals (IMT)	Market analysis key to confirm demand, size and location	Only if > e.g. 10 MEUR	CBA	Only if > e.g. 10 MEUR
URBAN	Metro	MCA including CEA or CBA	Yes, all projects	CBA	Yes, all projects

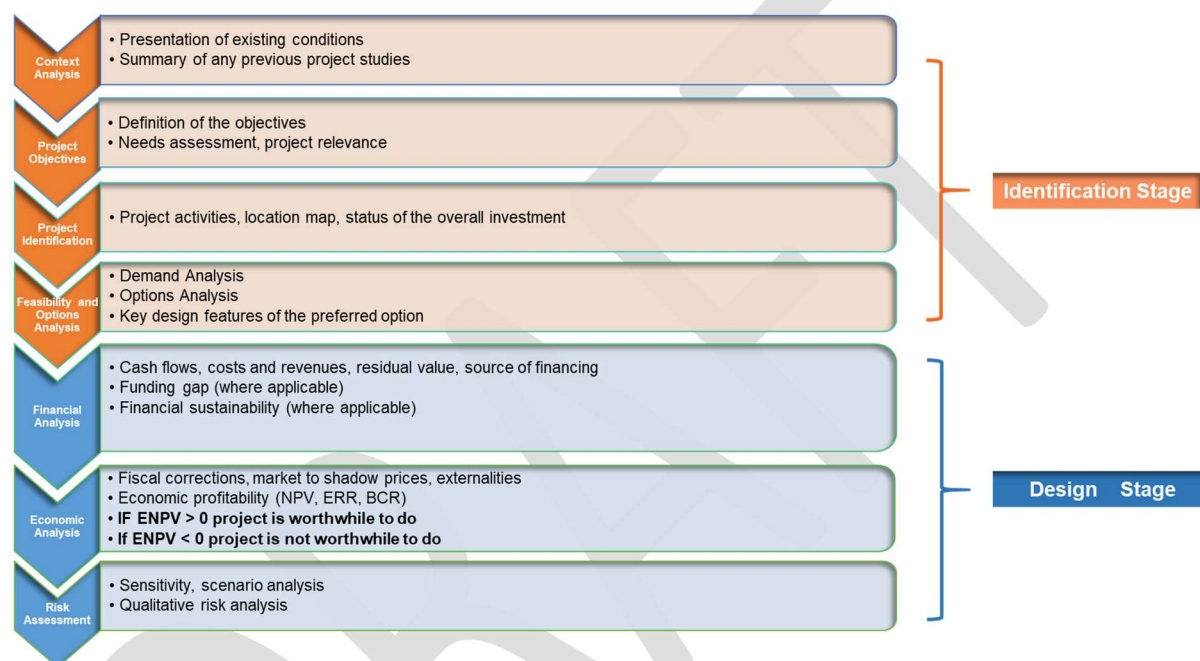
4 COST BENEFIT ANALYSIS GUIDELINES

The use of the CBA methodology is relevant to several proposed sources of EU funding in the financial perspective for 2021–2027 and, in particular, for the TP managed by the Ministry of Transport.

The CBA structure is based on the approach recommended by the European Commission. This is to ensure that projects which seek EU funding will have undertaken adequate analysis while providing a standardised approach across all projects in Romania, needed for effective national project prioritisation.

The 2014 CBA Guide to Cost Benefit Analysis of Investment Projects introduces during the Identification and Design Stages the following seven steps for appraisal. These aspects are discussed in turn below:

Figure 4.1. Steps for project appraisal



Source: JASPERS

4.1 Context analysis

4.1.1 Existing conditions

A description of the existing conditions in the area of the proposed project should include the following elements:

- detailed information about the existing transport infrastructure;
- information about competition from alternative transport modes;
- planned and/or recently executed investments that may affect the project performance;
- information about historic and present traffic patterns, including the identification of main flows (passenger and/or freight segments and any key origins/destinations) to understand the functionality;
- statistics in motorisation, mobility, and accessibility;
- technical characteristics of the service currently provided;
- service quality, frequency, and safety;
- existing infrastructure capacity.

The examination of the existing conditions is the starting point for the identification of current problems and needs. Proposed interventions that are developed should be designed to alleviate current

problems. The scope, design, and size of the proposed interventions should be proportionate with the scale of identified deficiencies and reflect current and forecast demand.

4.1.2 Summary of previous project studies

If the project has undergone previous studies, a summary of the history of project identification and option selection process must be provided, and the rationale behind the choices explained. It is necessary to gather all the outputs from previous project-related studies including pre-feasibility studies, feasibility studies, technical reports and any relevant project data that may be used in the CBA.

4.2 Project objectives

The project objectives are to be derived based on the needs assessment and must be aligned with the priorities identified in the TP and Transport Master Plan/Investment Plan.

The main objectives of a transport project “are generally related to the improvement in travel conditions for goods and passengers both inside the impact area and to and from the impact area (accessibility), as well as improvements in both the quality of the environment and the wellbeing of the population served. In more detail, projects will typically deal with the following objectives:

- reduction of congestion within a network, link, or node by resolving capacity constraints;
- improvement of the capacity and/or performance of a network, link, or node by increasing travel speeds and by reducing operating costs and accidents;
- improvement of the reliability and safety of a network, link, or node;
- minimisation of GHG emissions, pollution, and limitation of the environmental impact (important examples are projects supporting the shift from individual, i.e., cars, to collective transport);
- adjustment to EU standards and completion of missing links or poorly linked networks: transport networks have often been created on a national and/or regional basis, which may no longer meet the transport requirements of the single market (this is mainly the case with railways);
- improvement of accessibility in peripheral areas or regions.

When feasible, the objectives should be quantified and targeted with the use of indicators, logically linked to the project benefits. For example, indicators including expected traffic volumes, travel times, average speeds, etc., can be used to show the link between the materialisation of the project benefits and the achievement of the stated objectives.”

4.3 Project identification

The project description should include, at least, the elements described below:

- description of project works, activities or services (type of infrastructure (e.g., road, railway line, etc.), type of intervention (e.g., new construction, rehabilitation, upgrade, etc.), service provided (e.g., cargo traffic);
- project location map indicating main project components;
- status of the overall investment (in case of the project being a phase or a stage of a larger overall investment);
- context of the project in relevant Strategies and Plans defining Project objectives.

The project activities should be consistent with the project's objectives.

Typical investment typologies are suggested in the 2014 CBA Guide (section 3.4) including:

- new infrastructure that satisfies increasing transport demand;
- completion of existing networks through the construction of missing links;
- extension or rehabilitation of existing infrastructure;

- investment in safety measures on existing infrastructure;
- improved use of existing infrastructure;
- improved inter-modality and inter-operability;
- improved infrastructure investment management.

4.4 Feasibility and option analysis

4.4.1 Demand analysis

A transport project should ideally find its strategic justification in the framework of a comprehensive transport plan, set up at the appropriate territorial level. Such a plan will generally be supported by a demand model.

Consideration should be given to the use whenever possible of either the National Transport Model - NTM (for public transport projects) or the National Road Transport Model - NRTM developed by CESTRIN (for road projects), or the revised NTM developed for railways by the Railway Reform Authority for assessing the project types listed below:

- strategic inter-urban highway schemes;
- rail infrastructure and service proposals including major investments such as corridor line upgradings or metropolitan rail developments;
- investment in inland waterway port infrastructure and navigation;
- national and regional bus strategy development;
- terminals supporting intermodal transport;
- national policy measures such as:
 - implementation of road tax changes and impact on car ownership;
 - differential pricing for use of rail and road;
 - internalisation of external transport costs, and
 - climate change policies.

Alternative modelling approaches may be used for other types of projects as described in the JASPERS Transport Models Guidance and JASPERS Rail Guidance. These guides provide detailed descriptions of best international practice relating to demand modelling.

Demand models generally form the key source of input and assumptions for a transport CBA, so their quality and objectivity are an essential prerequisite of a sound transport economic analysis. Demand models provide forecasts of traffic volumes that are a key basis for the assessment of time savings, vehicle operating cost savings and externalities.

In the 2014–2020 programming period, best practice in terms of demand modelling was outlined in Section 3.5 of the 2014 CBA Guide, and this remains valid. However, the points set out below should be considered in the development of a traffic model.

Transport models are both expensive and time-consuming to create. Therefore, at an early project stage, existing models should be reviewed, and pragmatic decisions taken on whether the demand model needs to be updated or replaced. Even when a new demand model is required, existing sources of information (in the form of traffic counts, origin–destination surveys and coded networks of transport supply i.e., networks of roads, railways, inland waterways, and associated links between them) should be used to the maximum extent possible.

The geographic scope of an existing model may not be appropriate for the project under consideration. While it is unlikely that the modelled area of the NTM/NRTM will be too small (except perhaps for major cross-border projects or investment in rail freight facilities), it may well be too large for many projects and/or lack sufficient local detail. The minimum required modelled scope should be the area within which the main expected transport impacts of the project are expected to occur. If the model is too large

and lacks sufficient detail in the area of the project, it may need to be cut (taking only the relevant part of the network) and further detailing made in terms of network and zoning.

Transport models require proper calibration and validation. Calibration essentially entails setting the values of the various constants and parameters, while validation establishes the credibility of the model by demonstrating its ability to replicate observed traffic behaviour. Data used for validation should be independent (i.e., they should not have already been used in the first steps of model calibration). If an extracted area of the NTM/NRTM is used for a local project, it will not usually be necessary to recalibrate, but a revalidation must always be undertaken. Statistical tests such as the GEH¹² test should be used as part of a rigorous model acceptability test in the validation process. In validating a model, it is also required to verify that the model reflects accurately the speed observed on the network. This should be undertaken preferably via journey-time surveys, or at minimum via online sources such as Google Maps. Journey-time surveys should ideally be carried out over a period of several days and at different times of the day, to enable an accurate estimate of journey-times and speeds. The selected routes for the validation of journey times should cover a range of routes and cover the modelled area to the extent possible. Routes should include those on which traffic will be significantly affected by the proposed intervention. The validation routes should be neither too long (greater than 20km) nor too short (less than 5km).

When a project has a substantial impact on different elements of a door-to-door trip, such as a new railway station, it is advisable that the model and its output into the CBA take into account the perceived cost of each element of the trip. This implies inclusion of and differentiation between access to and from a public transport stop, waiting time and in-vehicle time. Without this, the full benefits of the project will not be measured, which may lead to a low ERR or a distorted option analysis. The full list of weightings of different time elements, as recommended in the EAV, is shown in Table 4.1.

Table 4.1. Recommended weightings of journey time elements

Common perceived time elements	Weighting on in-vehicle unit value of time or fixed penalty	Comment
Door-to-door trip elements		
Walk time	1.5–2	
Wait time (actual time spent waiting for a PT vehicle)	1.5–2	Not to be combined with the PT service headway approach and to be used only for turn-up-and-go services with high frequency (more than four vehicles per hour)
PT service headway (average time interval between services)	0.4–1	Lower weightings are applied to services with lower frequencies (usually longer distance) and can be expressed as a function of service frequency
PT transfer penalties	4–15 minutes fixed penalty	Intrinsic discomfort value after taking into account walking and waiting at interchanges. Lower in high-frequency well-integrated local PT services and higher for longer distance trips
Reliability and congestion		
PT late arrival	2.5–4	Weight applied to lateness / delayed part of travel time
Congested time (in car)	1.5	Applied to time spent in congestion
Travel time standard deviation (car)	0.4–1.2	Applied to the standard deviation of travel time

NB: PT, public transport.

Source: EAV

The demand model must be developed for two scenarios:

- a without project case, in which it is assumed that the project under appraisal is not implemented. (This is sometimes referred to as the “do minimum”, “business as usual” or “counterfactual” case. However, the term “without project” abbreviated to WOP is used for consistency.);

¹² Refer to the JASPERS guidance reference above for detailed information.

- a with project case, abbreviated to WP, which includes the project under appraisal. Apart from data that relates specifically to the project, the WP scenario must be consistent with the WOP scenario in all other respects.

The demand model of the WOP scenario should be developed for a Base Year, for which conditions (traffic, travel time etc.) have been measured. This data is then used for the calibration and validation of the transport model for the base year. The model should also be developed for several forecast years for both the WOP and WP scenarios. Forecast years should include at least the first year of operation of the project and appropriate future years when significant changes in the modelled network may be expected. It is preferable to include the year that corresponds to the final year of the appraisal period, unless it is considered that growth factors can be applied to demand in an earlier year. However, this is less likely to be the case if congestion and/or overcrowding is expected.

For any future years that are modelled, the WOP and WP scenarios should include all other committed infrastructure investment projects that might reasonably be expected to be implemented in the corresponding modelled year and that are located within the sphere of influence of the project under appraisal.

Forecast demand in future years may be influenced by any or all of the following:

- demographic changes;
- socio-economic changes;
- spatial changes relating to housing, commercial activity, industrial activity and logistics;
- elasticity with respect to quality, time and price;
- capacity constraints;
- change of traffic management policies;
- technological changes.

Further details on modelling are to be found in the JASPERS Modelling Guide.

The model outputs should be used for calculating the projects economic benefits (see section 4.7.5)

4.4.2 Option analysis

The project objectives can usually be achieved in more than one way by different project options.

A base case (WOP) is required as the starting point for the generation of any solution options as these will build on it and be benchmarked against it. The WOP scenario describes the base situation against which all investment options will be compared. It includes all necessary maintenance and operation activities required to provide a continued standard of operation without significant deterioration in its technical condition. Thus, even in the WOP scenario, significant investment in periodic maintenance is likely to be incurred. However, it is important not to exaggerate the deterioration of traffic conditions, which could lead to unrealistically favouring investment options.

In defining the project options, the following should be considered:

- The options development process refers to the identification of conceptually different project alternatives. Previous options might also have been generated as part of strategic plans, investigated as part of a feasibility study, or resulted from experience with daily operations. Both previous and new project options would be included in a long list of solution options for the investment need identified. Furthermore, targeted stakeholder consultation should be considered as a possible way of informing the longlist development. This opportunity will need to be assessed on a case-by-case basis, as there will be proposals where such consultation will be critical while it might not be required at all in other situations.

- When defining the options, all the environmental factors, as defined in the EIA Directive, must be considered.
- For a fair comparison between identified options, the cost estimate should be based on the same unit costs and level of aggregation.
- The proposed options should be described in terms of their key parameters (e.g., length, design speed/travel time, carriageway width, cross-section, etc).
- In the 2021-2027 financial perspective, road projects are expected to demonstrate a stronger economic justification in the context of the climate policy. Therefore, when defining project options, adequate design of project capacity versus expected demand is crucial. Excessive capacity on road sections with low traffic levels takes valuable investment resources away from other sections on the network and leads to unjustified operation and maintenance expenditures. In cases where two types of cross-sections might be considered, an incremental analysis comparing costs and benefits could help to determine the optimal selection.
- It is up to the project promoter to establish the number of investment options examined under the CBA. However, the promoter must be able to demonstrate that all reasonable alternative options have been considered adequately and justify the reasons for which the final option was chosen.

The process should normally cover the following key stages (although, depending on the project particulars not all stages may be always required):

- a) Identification of a long list of potentially relevant options (e.g., alignment alternatives);
- b) Filtering the long list to a shortlist of best/most relevant options based on CEA or MCA;
- c) Evaluating in more detail and comparing the shortlisted options to determine the preferred one based on CBA and MCA. For linear infrastructure, the environmental criterion has to be considered in the MCA;
- d) Once a project alternative is selected, options for the implementation/refinement of the selected alternative are to be developed.

4.4.3 Preferred option – key features

The project description should include, at least, the elements described below:

- Description of project technical aspects:
 - Description of the main works/investment components, technology adopted, and design standards (e.g., design speed);
 - Key output indicators, defined as the main physical quantities produced (e.g., length and cross-section of road, length of tunnels, length and width of bridges, number of interchanges/stations, etc.).

4.5 Key assumptions

Key assumptions relate to some general parameters that need to be set in advance and are generally common across all transport projects. These are set out in the following paragraphs.

4.5.1 Appraisal period

The appraisal period (sometimes referred to as the “reference period”) should be long enough to cover the time period over which the bulk of the project’s impacts are captured.

The appraisal period covers the period of construction followed by the period of operation. The period of operation may overlap with the period of construction if, for example, there is a phased opening of

the project with one or more sections of infrastructure coming into operation before full completion of all sections of the project.

The length of the appraisal period for most projects is expected to be 30 years (including construction period), but this can be adapted depending on the actual economic lifetime (longer or shorter) and the construction period. If the expected economic life of the asset is less than 30 years, the appraisal period can be shortened accordingly. (The economic lifetime should normally be estimated as a weighted average lifetime of the main categories of assets, e.g., structures, pavement, buildings, equipment, etc.). Alternatively, where the construction period is considerably longer than average, the appraisal period may be increased accordingly. As a rule of thumb, when the construction period (c) is longer than 5 years, the appraisal period may be set to $30 + (c - 5)$. Where the economic life extends beyond the appraisal period, this should be captured in the residual value (see section 4.7.4 below).

According to the EAV, the expenditure incurred before the start of the analysis should be converted using an appropriate inflation rate (e.g., engineering works cost indices provided by INSSE as included in Annex I) and included in the first year of the analysis.

4.5.2 Currency

The economic analysis should be undertaken in EUR and all prices expressed in RON should be converted to EUR using a consistent exchange rate (as set out in Annex I).

4.5.3 Price base

The CBA is carried out in constant prices (in real terms) i.e., excluding the future impact of inflation. Nevertheless, it is necessary to adjust all costs to a common price base.

Costs of investment, maintenance and operation are typically estimated in nominal prices, in local currency, in the year in which the cost estimate is prepared. They will be first converted to constant prices corresponding to those of the price base year by using the appropriate national price indices, and then converted to EUR using the average exchange rate applicable to the price base year.

Unit values for benefits are included in Annex I. These are expressed in prices of the defined price base year. At the time of writing these guidelines, the price base is fixed at 2021, but may be reviewed by the MA and changed to a later year during the course of the programming period. Prior to conducting the CBA, the analyst should download the latest version of RomTAP, the database of parameter values.

4.5.4 Incremental analysis

CBA requires a comparison of the WOP and WP scenarios (incremental analysis). Costs and benefits are assessed by considering the differences between these scenarios, and only the net impact is considered in the analysis (see 4.4.1 and 4.4.2 above). Therefore, the financial and economic indicators are calculated considering only the incremental cash flows.

4.6 Financial analysis

The EAV summarises the legal framework applicable in the financing period 2021-2027 as follows:

- *No provisions are made in the CPR to assess the project's financial performance. Member States are free to set up their methods and criteria to verify that the project is in need of co-financing. For <some> cases, State aid rules <may> apply.*
- *Article 73.2 (d) of the CPR requires verification 'that the beneficiary has the necessary financial resources and mechanisms to cover operation and maintenance costs for operations comprising investment in infrastructure or productive investment, so as to ensure their financial sustainability'.*

- According to Article 73.2 (c) of the CPR, the managing authority needs to ‘ensure that selected operations present the best relationship between the amount of support, the activities undertaken and the achievement of objectives’. This implies, amongst other considerations, that self-financing and/or the bankability potential of an operation should be taken into account where relevant.

In the specific context of Romania’s transport programme, the following general principles are adopted by the MA:

- For non-revenue generating projects (e.g., any kind of untolled road with no revenue generating from service areas, Danube fairway, etc.) there is no value added in performing either analyses of financial performance or funding gap calculations.
- The same applies for projects/sectors where revenues are generated but typically do not exceed the operational and maintenance costs (e.g., railway infrastructure, metro).
- With regard to the financial sustainability:
 - For project promoters (public companies) financed directly from the state-budget (e.g., national road or railway infrastructure companies, Bucharest Metrorex, etc.) financial sustainability is also considered automatically secured based on a clear and formal commitment from the promoter and the Ministry of Transport to ensure the financing and co-financing of the respective project both during the construction and during the operation period.
 - For other promoters – including private or local companies – financial sustainability should be assessed.
- For projects/sectors covered by state-aid (e.g., ports, local infrastructure such as intermodal terminals), the specific provisions applicable shall be followed, normally including a funding gap calculation.

The table below summarises the guidelines applicable by sector/type of investment:

Table 4.2. Summary of financial analysis requirements

Sector	Investment type	Requirements for financial assessment		
		Funding gap	Financial analysis (FIRR, FNPV)	Financial Sustainability
ROADS	New motorways, expressways, interurban single carriageway roads	Not required, except if tolled or concessioned	Not required	Not required as state budget covered, except if concessioned
	By-passes	Not required.		
	Road rehabilitation, upgrading			
	Road safety			
RAIL	Rail corridor sections	Required	Not required	Not required as state budget covered
	Metropolitan rail	Required	Not required	Required
	ERTMS	Not required		
	Rail safety (e.g., level crossings)	Not required		
	Rail stations	Required	Not required	Not required as state budget covered
	Bridges rehabilitations	Not required unless subject to user charging	Not required	Not required as state budget covered
	Rolling stock	Required	Not required	Required unless owned by the Railway Authority
WATER	Ports infrastructure	Required in conjunction with SA	Not required	Required (including consolidation infra+operator where appropriate)
	Fairway	Not required unless subject to user charging	Not required	Not required as state budget covered
INTERMODAL	IM Terminals (IMT)	Required	Not required	Required
URBAN	Metro	Required	Not required	Required if not covered by state budget

Source: JASPERS

For the less typical cases where a full or partial financial analysis is required, more detailed guidelines are provided in Annex II.

4.7 Economic analysis

The main purpose of the economic analysis is to assess whether the project's benefits exceed its costs and whether it is therefore worthwhile to progress. The analysis is conducted from the point of view of the whole of society, not just the project owners. To capture the range of economic impacts the analysis includes both elements with direct monetary value, such as construction and maintenance costs and vehicle operating cost savings, and elements without direct market value such as time savings, accident reduction and environmental impacts.

In order to allow consistent comparison of costs and benefits across a project, all impacts should be monetised (i.e., attached a monetary value) and then aggregated to determine the net benefits of the project. From this, it can be determined whether the project is desirable and worth implementing, indicated by an economic net present value (ENPV) greater than zero.

4.7.1 Methodology

An economic analysis includes the following steps:

1. Conversion of costs from market to accounting prices.
2. Monetisation of economic benefits.
3. Discounting of estimated future costs and benefits.
4. Calculation of the key economic performance indicators.

The economic analysis converts the costs and benefits of a project into a common unit of account (in this case, EUR) and compares the size of benefits to the size of the costs for individual stakeholder groups (providers, users, and wider society).

Many of the impacts of a project are already expressed in monetary terms, for example investment, maintenance, and operating costs. However, in the economic analysis market prices should be converted into accounting prices using appropriate conversion factors when they do not reflect economic opportunity costs.

For project impacts that do not have a direct market value (for example time savings and local pollution changes) it is necessary to convert the benefits and costs into monetary values using the methods outlined in these guidelines. This allows impacts of varying natures to be combined and compared using a common unit (EUR) as a welfare metric.

There are cases where market price conversions are not available, or very difficult to define reliably and accurately. These include, for example, some environmental impacts such as loss of landscape views, social and wider economic benefits. Many of these impacts are still important to achieving the project's objective and therefore, while not included explicitly in the quantitative economic analysis, may be incorporated (e.g., in an MCA) in the wider appraisal framework.

Economic analysis does not include transfer payments such as taxes, subsidies, tolls and fares. As the name suggests, transfer payments are payments that are transferred from one body to another, with no actual resources produced or consumed.

Once project impacts have been monetised and discounted, the total benefits can be compared against the total costs.

Simplistically, for a project to be viable, the project benefits should exceed the project costs. More specifically, the present value of the project economic benefits (PVB) should exceed the present value of the project economic costs (PVC). In practice, this is shown by a positive economic net present value ($ENPV = PVB - PVC$), a benefit-to-cost ratio ($BCR = PVB/PVC$) greater than one, and an economic internal rate of return (ERR) greater than the discount rate used.

4.7.2 Key parameters

Social discount rate

A project typically incurs costs during the early construction phase and provides benefits (and incurs some operating costs) during the subsequent operation phase. To compare the benefits and costs incurred in different years on a like-for-like basis, it is necessary to 'discount' all costs and benefits to a present value year. The present value considers that costs and benefits incurred in early years are more 'valuable' than the same sized benefit or cost incurred in a more distant year.

A social discount rate of 3% has been set for transport sector projects in Romania, in accordance with the EAV. It is recommended, for ease of understanding, to discount cost and benefits to the same year as the price base.

Conversion factors

Financial cash flows must be converted to economic flows using appropriate factors to convert from financial prices to accounting prices ("shadow prices") which are more effective in conveying social benefits.

The passage from financial prices to accounting (shadow) prices is made in two steps:

- In the first step, fiscal corrections are made directly on the cash flows, involving the removal of direct taxes, indirect taxes, and subsidies.
- In the second step, corrections are made for other factors distorting financial prices from accounting prices. It is assumed for simplification that this includes only corrections to wages (due to imperfections of labour markets) and energy. Weighted conversion factors are calculated to eliminate the remaining distortions on different markets including materials,

labour, energy, and others. The categories correspond to those used in the previous EU Major Project Funding Application Form and may need to be adapted as appropriate in the context of the TP procedures.

The conversion factors are based on average estimated percentages of costs of materials, skilled labour, unskilled labour, energy, land acquisition and other costs. The resulting default conversion factors are as follows:

Table 4.3. Conversion factors from financial to economic prices

Cost category		Conversion factor
CAPEX	Planning/design fees	0.98
	Land purchase	1.00
	Building and construction	0.90
	Plant and machinery or equipment	1.00
	Contingencies	0.00
	Price adjustment	0.00
	Publicity	0.98
O&M	O&M	0.88

Source: JASPERS

Moving from one price base year to another

The parameter values included in Annex I are all expressed in prices of the defined price base year. Those undertaking CBA should generally not have to change the price base year for these general parameters. However, where alternate parameter values are being proposed (e.g., where better / more appropriate unit values have been identified), the project analyst may need to change the price base year of the new values to that of the defined price base year. Details on the approach to follow for moving the parameter values from one price base year to another are provided in Annex I.

Growth in real values over time

Throughout the appraisal period the unit values of certain costs and benefits (e.g., the value of time) is expected to grow. However, future values should be expressed in real terms (i.e., inflation occurring after the price base year will be ignored).

For many, but not all, parameters it is assumed that growth follows that of real GDP per capita at a specific elasticity. (The specific elasticities to be used are noted below in the paragraphs relating to the respective parameters).

Forecast GDP per capita growth is based on the latest forecast provided by the EIU. Current values are 2.8% per year to 2030 and 2.4% per year thereafter. However, the forecast is updated regularly and the latest values for Romania should be obtained at the time of performing the CBA.

Overview of estimation of costs and benefits

It is necessary to consider the impacts of a project in a consistent manner. Impacts are therefore monetised to allow ease of analysis and combination of impacts across different elements.

Costs typically include:

- investment costs;
- maintenance costs/replacement costs;
- operating costs (for operating new infrastructure/services).

Benefits typically include:

- time savings for users;
- vehicle operating cost changes for users;

- changes in external costs:
 - safety;
 - climate change;
 - local air pollution;
 - noise.

4.7.3 Costs

Investment Costs

The estimate of the investment costs should carefully consider the relevant market conditions including forecasted changes for real prices (e.g., if construction inflation is forecast to be higher than general inflation over the investment period).

To this end, it is recommended to ensure that:

- 1) Information on the unit costs and investment overall cost calculation is presented in sufficient detail to provide confidence in the cost estimate.
- 2) The cost estimate is based on up-to-date unit prices reflecting the latest market conditions at the time of the estimation.
- 3) Financial contingencies (or “price adjustment”) are estimated and included i.e., allowance is made for inflation, distinguishing between the “general inflation” (CPI) and “sector specific inflation” (since often construction prices grow faster than consumer prices).
- 4) Technical contingencies (for unforeseen items) are included – typically 10% but can vary depending on the project particulars (specific risks, stage of design, extent of geotechnical studies, etc.).

The investment costs must include all elements of expenditure required to realise the project, including upfront costs such as planning and design costs. As well, the cost of all the environmental measures, as imposed by the EIA Decisions, must be included in the investment cost.

In summary, investment costs must include any costs relating to each of the following items:

- Planning/design fees, including preparatory studies, designs and tests, approvals and permits, management of the procurement process and any other expenditures prior to the construction period;
- Land purchase costs, including associated administrative costs;
- Building and construction, subdivided into all items listed in Table 4.4 below;
- Plant and machinery or equipment acquired or rented during construction;
- Publicity;
- Supervision during construction;
- Technical assistance;
- Financial (price) contingencies;
- Physical contingencies (maximum 10% of the total investment cost);
- Total excluding VAT;
- VAT.
- Total including VAT.

This list is provisionally based on the items to be included in Table C1 of the former EU Funding Application Form. Costs are to be subdivided into total costs, eligible costs and ineligible costs for each cost category. Restrictions on eligible costs are as outlined in EU Regulation 2021/1060 Chapter III – Eligibility Rules and the applicable national regulation.

The VAT, financial (price) contingencies and physical contingencies are not to be included in the calculations of the economic indicators.

Separately, the investment cost should be presented in terms of annual amounts spread across the implementation period.

Operation and maintenance costs

Operation and maintenance (O&M) costs include the cost of all routine maintenance (summer and winter), periodic maintenance (renewals) and costs of the day-to-day operation of infrastructure.

They do not include the operation and maintenance of road vehicles, railway rolling stock or IWT vessels. Such costs are considered separately as vehicle operating costs (VOCs), train operating costs (TOCs) and vessel operating costs (IWTOCs) under project impacts/benefits.

For roads, O&M costs may include:

- Routine maintenance such as cleaning, patching of potholes, reparation of damage to lighting, signage and crash barriers, snow clearance.
- Periodic maintenance such as road resurfacing.
- Operation of traffic control centres and toll facilities.

For railway infrastructure, O&M costs may include:

- Routine maintenance such as ballast cleaning, reparation of damage to equipment.
- Periodic maintenance such as renewal of catenary.
- Traffic management and control.

Nota bene:

- O&M costs are calculated either in the years in which they occur (preferable) or may be averaged as annual values for each year of operation.
- They must be calculated separately for the WOP and WP scenarios, using the same unit rates for a particular operation, so that the incremental costs (or savings) can be calculated.
- The O&M costs in the WP case should be sufficient to maintain the existing level of service (especially if the historic costs are very low due to spending constraints).
- Similarly, the O&M costs in the WP case should be sufficient to maintain the new infrastructure in a condition adequate to support the level of service offered on project opening. In forecasting future operating, maintenance and renewal costs, analysts should consider the impact of increasing usage or patronage if relevant. Where the existing infrastructure is maintained in the WP case, O&M estimates for the existing infrastructure may be reduced to reflect lower forecast demand.
- The proposed unit maintenance costs included in the RomTAP should be considered only for CBA purposes calculation.

4.7.4 Residual value

If the reference period is shorter than the economic life of the project, a residual value of the infrastructure is included in the analysis in the final year of the reference period. If the reference period is equal to the economic life of the project, the residual value is zero.

There are two approaches to the calculation of the residual value:

- 1) The present value of net economic cash flows generated by the assets during the remaining years of the economic life of the project beyond the end of the reference period (the preferred method).
- 2) The outstanding value of the assets at the end of the reference period (depreciation method).

In both cases it is necessary to estimate the physical life of the project. The average of the physical life of the different asset categories is calculated, weighted by the value of the investment attributable to each category. The indicative average physical life of each asset category is set out in the table below.

Table 4.4. Average physical life of assets following construction and rehabilitation (years)

Mode	Assets	Construction
General	Tunnels & bridges	75
	Land	Infinite
Roads	Retaining structures	60
	Earthworks (embankments)	40
	Pavement: concrete	33
	Pavement: asphalt	20
	Drainage (culverts)	40
	Environmental protection measures	25
	Safety measures (signage, guard rails)	15
	Utilities	25
	Installations (mechanical and electrical)	15
	Communication equipment (ITS)	10
Rail	Substructures	60
	Tracks	30
	Technical equipment	20
	Power supply	30
	Environmental installations	30

Source: EIB, JASPERS

For example, if the investment cost of a railway construction project is distributed 50% for substructures, 20% for tracks, and 10% each for technical equipment, power supply and environmental installations, the weighted physical life would be:

$$0.5 \times 60 + 0.2 \times 30 + 0.1 \times 20 + 0.1 \times 30 + 0.1 \times 30 = 44 \text{ years}$$

With a reference period of 30 years and a construction period of 2 years, the remaining physical life would be $44 - (30 - 2) = 16$ years or 36.4% of the total physical life. This is of course an approximation.

The method provides a simple way of estimating the residual value, either by:

- extending the economic cash flow from the last year of the appraisal period over the remaining 16 years (assuming a continuation of a constant value of benefits as estimated in the final year of the appraisal period, and a continuation of the average value of O&M costs during the period of operation) and calculating the NPV over the extended period; or
- calculating (in this case) 36.4% of the investment cost. If this method is adopted, the resulting residual value is included as a negative cost in the final year of the appraisal period.

4.7.5 Economic benefits

In line with best practices, the benefits that are considered in the economic analysis include time savings, changes in vehicle operating costs and changes in external costs.

This section provides information on the methodology to calculate the benefits. The unit values for the benefits are presented in Annex I.

Time savings

Time savings relate predominantly to reduced journey times attributable to passenger journeys resulting from project implementation.

It is recommended to set the passenger values of time (VoT) at national level based on the “willingness to pay” method, by conducting stated and/or revealed preference surveys. Another method to estimate the value of time is the “cost saving approach” which relates to the costs to employers (salaries and overheads) for trips conducted in the course of work and a percentage of net wages for other trips.

At present, in the absence of these national surveys on passenger VoT, the HEATCO Deliverable 5 derived values will continue to be applied (adjusted to the relevant price base year). In Romania constant average values (equity values) differentiated by trip purpose are to be used across all modes of transport so as not to bias CBA results in favour of a particular transport mode.

Note that work trips relate strictly to journeys carried out during paid working hours or productive working time. They do not include travel to or from work unless this is travel in paid working time to a place that is a non-regular and/or non-fixed location. Regular travel between home and work is classified as commuting and treated separately.

Time savings may also be attributable to the transport of freight depending on sector and project specific conditions.

For road freight vehicles only the time savings for drivers are to be considered, and the same unit cost as the one for passenger work trips will be used in the calculations. It is assumed that occupancy for this category of vehicles will equal one occupant per vehicle.

For rail, both the transport cost component (savings of crew time) and cargo cost component of the journey time are considered, and recommendations from JASPERS Rail Guidance apply.

The values of passenger time to be used are set out in RomTAP by year and trip purpose (see Annex I), expressed in terms of EUR per passenger hour. Information on passenger vehicle occupancy is provided as well. Freight values are also included, expressed in EUR per tonne hour (and apply irrespective of mode). Average loadings for goods vehicles, freight trains and IWT vessels are also provided in RomTAP but can be over-ridden if more accurate estimates are available.

Future values of passenger time are assumed to grow in real terms in line with GDP/capita with an elasticity of 0.8 applied. Freight values are to be considered constant in real terms over the reference period.

Road vehicle operating costs

Road user vehicle operating costs (VOCs) are split into fuel costs and non-fuel costs. Non-fuel costs include such items as oil, tyres, maintenance, depreciation, and insurance.

The fuel element of VOCs should be calculated based on an estimate of the litres of fuel or kWh of electricity consumed for each journey based on vehicle type, trip length and average speed. The formula for calculating the quantity of petrol and diesel consumed per kilometre is based on work carried out by Ricardo¹³ for use in UK WebTAG¹⁴ and takes the form:

$$L = a/v + b + c \cdot v + d \cdot v^2$$

¹³ Ricardo (2019) Production of Updated Emission Curves for Use in the NTM and WebTAG
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/942830/Production_of_Updated_Emission_Curves_for_Use_in_the_NTM_and_WebTAG-document.pdf

¹⁴ <https://www.gov.uk/guidance/transport-analysis-guidance-tag>

where L is fuel consumption in litres per kilometre, v is average journey speed and a, b, c, and d are parameters that take different values depending on the type of vehicle and fuel.

The calculation of electricity consumption of electric cars is based on work by Ricardo-AEA¹⁵ and takes the following polynomial form:

$$K = a \cdot v^4 - b \cdot v^3 + c \cdot v^2 - d \cdot v + e$$

where K is electricity consumption in kWh per kilometre, v is speed and a, b, c, d, and e are parameters with predefined values. Information on the electricity consumption of buses, LGVs and HGVs is sparse. Therefore, default values are proposed for these categories of vehicle until the results of more research are available. The default values are assumed to apply to an average speed and are adjusted according to the polynomial curve used for cars to calculate values at other speeds.

It may be noted that the formulae for both conventionally fuelled vehicles and electric vehicles apply to specific speed ranges. Results may be unreliable beyond these ranges.

The VOC non-fuel element should be calculated based on vehicle type, trip length and average speed. The following formula from UK WebTAG can be used:

$$L = a + b/v$$

where L is the non-fuel cost in €/km, v is average journey speed and a, and b are parameters that vary by vehicle type and fuel.

Default parameter values for the fuel and non-fuel elements of VOCs are provided in RomTAP (see Annex I). The total VOC for a particular trip is calculated as the product of the length of the trip (km), fuel consumption per kilometre (litres/km and kWh/km) and the cost per unit of fuel (€/litre or €/kWh exclusive of all taxes and duties), plus the product of the trip length and the non-fuel unit cost.

Fuel costs have varied significantly over the years. Uncertainty over future fuel costs coupled with ongoing improvements in fuel efficiency have meant that traditionally road VOCs have been held constant throughout the appraisal period, the rationale being that any increase in cost may be cancelled out by improved efficiency. RomTAP makes provision for two scenarios: the Baseline Scenario continues current trends (VOCs held constant), and an Adapted Scenario which is intended to be consistent with Paris Agreement objectives and assumes annual fuel cost increases alongside improved fuel efficiencies.

Train and IWT vessel operating costs

Train operating costs (TOCs) and inland waterway vessel operating costs (IWTOCs) are the costs of operating and maintaining the railway rolling stock (as opposed to the infrastructure) and the shipping vessels. They include energy consumption, crew costs, maintenance and repairs, general operating costs (administration, office costs and overheads, IT etc).

The change in train kilometres and IWT vessel kilometres which result from the project should be calculated and then monetised using the unit cost rates. Details of how TOCs and IWTOCs are calculated in RomTAP are included in Annex I.

External cost savings

External costs are costs that are not directly or fully accounted for by the groups causing them. Thus, costs that are caused by transport users but incurred (in full or in part) by others are treated as the

¹⁵ Ricardo-AEA (2015) Speed emission/energy curves for ultra-low emission vehicles
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/942831/Speed_emission_energy_curves_for_ultra-low_emission_vehicles-document.pdf

external costs of transport. They include the costs of accidents, air pollution, noise and greenhouse gas emissions (predominantly CO₂).

Safety improvements

The accident benefit or disbenefit associated with the project should be calculated, monetised, and input into the CBA. The monetary value attached to the avoidance of an accident is related both to the direct cost associated with the accident (for example the cost of emergency services and hospital treatment etc.) and the indirect economic costs, for example in terms of lost productivity from injury time and a proxy value attributed to the pain, grief and suffering caused by accidents.

For projects of all modes, the difference in the number of accidents occurring in the WOP and WP networks must be determined.

This is done by calculating the total vehicle kilometres by network type (road type, rail type, waterway type) and applying appropriate accident rates (number of accidents per year per million vehicle kilometres). For rail accidents it may be further disaggregated into accidents related to total train kilometres, number of level crossings and length of the network.

Casualty rates are then applied to the number of accidents to determine the number of casualties by severity. The severity types are fatal, serious injury, slight injury, and non-injury (material damage only).

The total number of accidents and casualties by severity should be calculated for the WP and WOP scenarios to determine the increase or decrease in accidents associated with the project.

When undertaking detailed project appraisal, local accident data should be used in place of national values where available and considered reliable, in order to derive project specific accident rates. RomTAP provides default national accident rate parameters suitable for strategy appraisal.

Accident rates are assumed to decline over time as infrastructure geometry, vehicle safety features and driver awareness improve. Local historic change in accident experience may be used where available. Alternatively, a default rate of 0.5% per year may be assumed.

For road accidents, monetary values by type of casualty are applied to the accident rates per million vehicle kilometres and casualty rates per accident by type of road in the WOP and WP scenarios. The difference determines the economic benefit. A similar approach is adopted for rail and IWT accidents. The monetary values per casualty are assumed to increase annually in line with GDP/capita with an elasticity of 0.8.

RomTAP includes the annual monetary values per casualty to be used, and presents national road accident rates, road accident costs, rail costs and IWT accident costs by various metrics.

Climate change

Climate change or global warming impacts of transport are mainly caused by emissions of the greenhouse gases (GHGs) carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄). These emissions have a range of impacts which may include sea level changes, agricultural impacts, water supply impacts, health impacts, ecosystem and biodiversity impacts and climate/weather impacts.

Emissions should be estimated using emission rates per litre of fuel or kWh of electricity consumed, as calculated for the fuel element in the VOCs. Rates have been derived for Romania based on UK WebTAG, the electricity emission rates adjusted in line with relative electricity grid emission factors of the UK and Romania.

GHG emissions are considered a global impact and therefore the value of the change in emissions volume is independent of the location at which the change occurs.

Calculating the monetary costs of changes in emissions should be done in terms of the change in the equivalent tonnes of greenhouse gases released as a result of implementing a project. Both absolute

and relative quantities should be calculated and reported, in line with the EIB carbon footprint methodology. For the CBA calculations, the relative quantities are used. The carbon assessment has to be included throughout the project development cycle (e.g., planning stage, option analysis stage, design stage, etc.) with the aim of promoting low-carbon choices and options, in line with Commission Notice “Technical guidance on the climate proofing of infrastructure in the period 2021-2027”.

The cost per tonne of carbon to be used is set out in the EAV in €2016, rising from €80 in 2020 to €800 in 2050. Annual costs are set out in RomTAP, adjusted to the price base. RomTAP also includes sample emission costs per road vehicle kilometre for selected years and vehicle speeds, and sample road vehicle emission rates by vehicle type and speed.

Air pollution

Local air pollution costs are caused by the emissions of air pollutants with differing impacts including particulate matter (PM_{2.5} and PM₁₀), nitrogen oxides (NO_x), sulphur dioxide (SO₂) and non-methane volatile organic compounds (NMVOCs). Impacts include health costs, building/material damages, crop losses and costs of damage to the biodiversity, soil, and water. Health costs (mainly caused by PM, from exhaust emissions or transformation of other pollutants) are by far the most important element.

The scale of the impact will vary depending upon the nature and the location of the project. The main factor that affects the scale of the impact is the population proximity and density near the emission source. Additionally, there are mode specific factors that may be considered:

- Road – the most important factor is the emission standards of the vehicle fleet which depends, in part, upon the age of vehicles. Emissions are then related to the speed of the vehicle, fuel type and driving style.
- Rail – the emission level depends upon the train speed, fuel type, share of electrified services, and the sources and location of electricity generating power plants.
- IWT – the main factors are engine type, vessel type, fuel quality, operation mode and the direction of travel (up/down stream).

It is also important to consider the impacts on populations along alternative routes to the project. For example, a new road or rail line may lead to high volumes of traffic, and thus an air pollution increase along the route. However, the net impact may be positive if the new infrastructure is in a rural area and has removed traffic from an urban route.

For detailed project appraisal, the change in tonnes of air pollutants emitted as a result of the project should be calculated taking into consideration the points raised above. TREMOVE is a policy assessment model commissioned by the European Commission to study the effects of different transport and environment policies on the transport sector for all European countries. This model provides emission rates (tonnes per vehicle km) by vehicle type, which can be used, together with vehicle fleet estimates to determine emissions for the WP and WOP scenarios. From these values the change in tonnes of air pollutants emitted can be calculated.

However, this method is complex and requires extensive data relating to fleet composition, which would need to be updated through the appraisal period. Therefore, a simplified approach is recommended and RomTAP provides for two options. The user can either make separate calculations of PM emissions and NO_x emissions, or base calculations on an aggregated cost of air pollution per vehicle type as set out in the 2019 Handbook on External Costs. The first approach is preferred, as the PM emissions can be costed separately for exhaust emissions in metropolitan, urban and rural areas, and non-exhaust emissions, and, more importantly it leads to a more accurate estimate which considers in the formula the travel speed. Similarly, NO_x emissions can be costed separately for urban and rural environments. The 2019 Handbook values should only be applied in the absence of a road transport model able to produce reliable estimates of e.g., travel speeds. An example of this would be the appraisal of a rail project with a rail only model, but with modal shift calculated using elasticities.

In years beyond the price base, both the average damage costs per pollutant and the aggregated air pollution costs are increased in line with GDP/capita with an elasticity of 0.8 applied.

Noise

If a project changes the volume of traffic on a road or rail line, then there may be an impact upon the population living nearby in terms of increased (or decreased) noise.

Noise can be defined as the unwanted sound or sounds of varying duration, intensity, or other quality that causes physical or psychological harm to humans. In general, two types of negative impacts of transport noise can be distinguished:

- Costs of annoyance: transport noise imposes undesired social disturbances, which result in social and economic costs such as restrictions on the enjoyment of leisure activities, discomfort, or inconvenience.
- Health costs: transport noise can also cause physical health damages. Hearing damage can be caused by noise levels above 85 dB(A), while lower levels (above 60 dB(A)) may result in nervous stress reactions, such as change of heartbeat frequency, increase of blood pressure and hormonal changes, increased risk of cardiovascular diseases and reduction in quality of sleep.

The scale of the impact varies depending upon the nature and the location of the project. There are four key factors that determine noise impact:

- Time of day – noise disturbance at night has a greater impact than during the day.
- Population density near the noise source – noise only impacts those who can hear it.
- Existing noise levels – depending upon traffic volume, speed, and vehicle type mix. The higher the existing background noise level, the lower the impact.
- Type of noise – intermittent noise can be more disturbing than constant background noise.

Additionally, there are mode specific factors that should be considered:

- Road – the noise level depends upon the type of vehicle, speed of vehicles, age of the vehicles, proportion of trucks, road surface conditions and gradient.
- Rail – the noise level depends upon the train speed, coach/wagon type, conditions of both track and wheels, type of brake, train length and the presence of noise walls. The most significant impact is from freight train movements at night.

It is also important to consider the impacts along alternative routes to the direct project corridor, for example, a new road or rail line may lead to high volumes of traffic, and thus a noise increase. However, if the new infrastructure is in a rural area and has removed traffic from an urban route the net impact may in fact be positive.

The change in vehicle kilometres which result from the project should be calculated and then monetised using unit cost rates. RomTAP provides annual unit costs (€/veh.km, €/pax.km and /tonne.km) of the impact of noise by mode, vehicle type and fuel type. If traffic data can be differentiated by urban, sub-urban and rural, adjustment factors are provided to reflect the different nature of traffic and population density in the regions.

In years beyond the price base, costs are increased in line with GDP/capita with an elasticity of 0.8 applied.

4.7.6 The Rule of Half (RoH)

The calculation of the value of user benefits follows economic theory of consumer surplus. As such, user benefits may vary depending on whether they are attributable to users of the existing route or infrastructure, users diverting from alternative routes or infrastructure or new users (also referred to as generated or induced traffic) who do not travel in the WOP case. Further benefits may be enjoyed by non-users from reduced external costs.

If benefits are defined as the difference in cost between the WOP and WP cases:

- Existing users are allocated the full value of any benefits they may enjoy in the WP case as compared to the WOP case.
- New users are allocated 50% of the benefits calculated for the existing users.
 - This is because some new users may decide to travel following a very small increase in benefits, while others will require a greater increase. By taking a 50% value of benefits, an average value is attributable to new users that approximates to the economic theory. This is referred to as “the rule of a half” (RoH) and is widely discussed in the literature - the interested reader may refer to the 2014 CBA Guide p89.
- For diverting users:
 - If the economic analysis is based on traffic forecasts from a network based multi-modal traffic model, then the actual costs of the users diverting from one mode to another will be known in both the WOP and WP cases. In this case, they are treated the same way as existing users and the full value of any benefits is included.
 - However, if a more simplified modelling approach is adopted, for example focussing only on the project corridor and/or only on the transport mode of the project, then the WOP costs of traffic diverting from an alternative corridor or alternative mode will not be known and the RoH should be applied (i.e., 50% of the savings enjoyed by the existing users).

Note also that:

- The RoH is only applied to the categories of benefits relating to user behaviour (perceived costs). For example, in the case of roads, this will generally comprise time and fuel costs.
- It is not applied to external costs where an increase in traffic leads to a corresponding increase in costs to third parties. For example, if building a new road results in a certain volume of induced traffic that is truly “new” rather than “diverted”, it will result in an increase in GHG emissions of 100% of the emissions caused by the new traffic.

Table 4.5. Application of the Rule of a Half to different categories of user; % of value of benefits applied

Benefit category	Existing users	Diverting users		New users
		WOP costs known	WOP costs unknown	
Value of time savings	100%	100%	50%	50%
Road vehicle operating cost savings – fuel component	100%	100%	50%	50%
Road vehicle operating cost savings – non-fuel component	100%	100%	100%	100%
Train operating cost savings	100%	100%	100%	100%
Safety benefits	100%	100%	100%	100%
Environmental benefits (GHG emissions, local air pollution, noise)	100%	100%	100%	100%

Source: JASPERS

4.7.7 Economic indicators

The incremental costs of a project are compared with the incremental benefits over a specified number of years (the “reference” period) to produce three¹⁶ indicators of economic performance. These are:

- The **net present value (NPV)** of the project. Future costs and future benefits are discounted to the price base year according to an annual discount rate. The sum of the discounted future costs and the sum of the future discounted benefits produce the present values (PV) of costs and benefits respectively. The NPV is the PV of the benefits minus the PV of the costs. A project that is economically “viable” will have an NPV greater than zero.
- The **economic internal rate of return (ERR)**. The ERR is the discount rate that would result in an NPV of zero. Thus, a project that is economically “viable” will have an ERR that is greater than the discount rate (3%)¹⁷.
- The **benefit-cost ratio (BCR)**. The BCR is the PV of benefits divided by the PV of costs. The BCR is expressed as a ratio and a project is considered economically viable if the BCR is greater than 1.0.

Note:

- Economic impacts can be positive or negative depending upon the nature of the project being assessed.
- However, in the calculation of the BCR, only investment, replacement and O&M costs are to be included on the costs side, and all impacts listed above on the benefit side, irrespective of their sign.
- In addition, a residual value (RV) may be included as a cost or a benefit, depending on the calculation procedure adopted (see section 4.7.4), i.e., on the benefit side in case the RV is determined as NPV of the remaining lifetime method and respectively on the cost side if determined based on the depreciation method.

The following table shows the calculation in Excel of the ENPV and ERR of a simple investment project with an appraisal period of 30 years, 2 years of construction and 28 years of operation.

Table 4.6. Sample calculations of ENPV and ERR

PV			Construction		Operation									
			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	...	Year 30		
Discount rate	3.0%		0	1	2	3	4	5	6	7	...	29		
Discount factor			1.000	0.971	0.943	0.915	0.888	0.863	0.837	0.813	...	0.424		
Costs (€m)	PVC	49.27	25	25										
Benefits (€m)	PVB	54.65			3	3	3	3	3	3	...	3		
ENPV	PVB-PVC	5.38	-25	-25	3	3	3	3	3	3	...	3		
EIRR		3.8%												

The discount rate is 3%. The undiscounted investment costs are €25m in each of years 1 and 2. The undiscounted benefits are €3m in each of years 3 to 30. The present value of costs is calculated in Excel as:

$$PVC = \text{SUMPRODUCT}(\text{Discount factor array}, \text{Costs array})$$

The present value of benefits is similarly calculated:

$$PVB = \text{SUMPRODUCT}(\text{Discount factor array}, \text{Benefits array})$$

¹⁶ There are other indicators, such as the first year rate of return, but they are less frequently used and are not required to be calculated.

¹⁷ For projects which are financed by International Financial Institutions (e.g., EIB), other rules may apply for the economic analysis, including higher hurdle rates.

The ENPV is calculated as:

$$\text{ENPV} = \text{PVB} - \text{PVC}$$

And the ERR is calculated as:

$$\text{ERR} = \text{IRR}(\text{ENPV array}).$$

In this example it can be seen that the ENPV is greater than zero and the ERR is greater than the discount rate. Thus, the project may be considered as good value for money.

4.7.8 Ranking and prioritising projects and options

When comparing options within a single investment proposal, usually the better performing option has both a larger ENPV and a larger ERR/BCR than the option performing less well. There might be, however, some (infrequent) cases in which, owing to the different scales of the options, one has a larger ENPV but a smaller ERR/BCR than the other. In such a case, it is suggested that the ERR/BCR is used because it would (usually) allow the promoter to save resources that could be reused for additional investments.

In ranking alternative projects from a group typically competing under budget constraints, the ENPV is also less relevant (because it is biased towards more expensive projects) and the ERR/BCR is the preferred indicator as well, provided that it can be calculated for all projects.

4.8 Overview of financial and economic outflows and inflows

The economic analysis (and the financial analysis where applicable) considers various outflows (costs) and inflows (benefits in the case of economic analysis, revenues in the case of financial analysis) associated with and generated by a project.

While the characteristics of inputs are consistent between the economic and financial analysis, the treatment of the data can vary. The table below summarises the key inputs to the analysis and whether they are included in the respective analyses.

Table 4.7. Summary of treatment of analysis inputs: included (Y) or not included (N)

	Economic analysis	Financial analysis
Investment costs	Y	Y
Operation & maintenance costs	Y	Y
Discount rates	Y (SDR)	Y (FDR)
User charges (fares, tolls)	N (transfer payment)	Y
Travel time savings	Y	N
Vehicle operating cost savings	Y	N
Safety benefits	Y	N
CO ₂ emissions	Y	N
Local air pollution	Y	N
Noise	Y	N
Subsidies & taxes	N (transfer payment)	Y
VAT	N	N

Source: JASPERS

4.9 Sensitivity and risk analysis

Project appraisal is a forecasting process and, as such, has inherent uncertainties. These uncertainties come from both data limitations in the existing situation, and uncertainties as to how aspects, such as

demand for travel, costs for infrastructure etc., will change over time. These uncertainties in the inputs to the appraisal process lead to uncertainty in the economic and financial appraisal output.

The sensitivity and risk assessment considers these uncertainties and their impact on the outcomes of both the economic and financial appraisal.

4.9.1 Sensitivity analysis

Sensitivity analysis entails a series of tests to establish which input variables have a significant impact on economic and financial appraisal outcomes. The sensitivity analysis considers the impact of changes in input variable value on output value of key performance indicators.

The economic analysis will have been undertaken assuming the most likely values for all the input variables. In the sensitivity analysis, changes +/- are made to the values of each of the key variables in turn. Typical variables tested include:

- Investment and maintenance costs;
- Traffic volume;
- Unit monetary values of benefit categories.

The impact on the economic indicators of changes to each variable is tested in turn using 1% change of the variable values..

The elasticity between the change in variable value and the change in performance indicator (usually ENPV) is calculated for each variable in order to identify critical variables.

A critical variable is defined as one for which a 1% change in value results in a change of 1% or more in ENPV. Switching values are then calculated for the critical variables to identify the points at which ENPV becomes zero, providing thus important information on the economic margins for e.g., cost overruns or demand risks. The closer to the base case values a switching value for a particular variable is, the higher the risk. This risk should be properly assessed, and appropriate mitigation measures should be included as part of the project preparation, implementation, or operation stage.

4.9.2 Scenario analysis

In the sensitivity analysis, variables are tested one by one. Scenario analysis involves combining critical (independent) variables to test extreme optimistic and pessimistic cases. The optimistic and pessimistic scenarios are defined by using the low/high values of the tested variables, within a realistic range. For example, a scenario analysis could test the impact on ENPV of high investment cost combined with low traffic.

In the current context of climate mitigation policies aimed at reaching a 90% reduction in the transport sector's GHG emissions by 2050, actions are being taken to shift more traffic towards low-carbon modes (e.g., rail), in addition to reduction of transport demand. Therefore, a decreased demand is expected for roads. Thus, it is strongly recommended for the analyst to include in the sensitivity analysis a scenario considering very conservative growth rates for road demand (see reference to the EC Sustainable and Smart Mobility Strategy¹⁸). This scenario should also include the policy scenario regarding the penetration rates of electric vehicles (see RomTAP - Sheet J. Road veh fleet – Adapted scenario.)

Undertaking the scenario analysis allows the analyst to assess the impact of multiple negative events on the project's economic viability. Projects that can withstand multiple negative impacts are likelier to be found economically justified ex-post.

¹⁸ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020SC0331&from=EN>

4.9.3 Risk analysis

A probabilistic risk analysis (for example using Monte Carlo analysis) is not generally required, but a qualitative risk analysis must nevertheless be carried out. Detailed guidelines on setting up a qualitative risk analysis are presented in the 2014 CBA Guide. In summary, the analysis should include:

- a list of adverse events to which the project is exposed;
- a risk matrix for each adverse event indicating:
 - the possible causes;
 - the link with the sensitivity analysis (if applicable);
 - the negative effects on the project;
 - the levels of probability of occurrence and severity of impact;
 - the risk level.
- an interpretation of the risk matrix;
- a description of mitigation and/or preventative measures for the main risks, indicating who is responsible for the applicable measures.

The list of adverse events could include (among others):

- demand risks (traffic higher or lower than forecast);
- design risks (site surveys, cost estimates, project design);
- administrative risks (delays obtaining permits, approvals);
- land acquisition risks (higher costs, delays);
- procurement risks (procedural delays);
- construction risks (cost over-runs, geological risks, climate risks, as identified in the Climate Change Vulnerability and Risk Assessment that has been separately prepared for the project, archaeological risks, contractor risks);
- operation risks (inadequate O&M, environmental changes);
- regulatory risks (changes in regulations);
- financial risks (availability of national financing for CAPEX and OPEX, increased financing costs, lower project revenues);
- management risks (weak management capacity of beneficiary);
- political risks (public opposition, policy changes).

For each risk identified, the following should be described:

- the cause (what events could trigger the occurrence of the risks);
- the consequence (what effect will the risk have on costs, benefits, implementation time, funding and financial sustainability);
- the risk owner (who is accountable and will manage it);
- the project stage at which risk occurs;
- the probability of the risk occurring (using the table below);

Table 4.8. Risk probability

	Likelihood	Probability
A	Very unlikely	0-10%
B	Unlikely	>10-33%
C	About as likely as not	>33-66%
D	Likely	>66-90%
E	Very likely	>90-100%

Source: 2014 CBA Guide

- the severity (using the table below);

Table 4.9. Risk severity

Meaning	
I	No relevant effect on social welfare, even without remedial actions.
II	Minor loss of the social welfare generated by the project, minimally affecting the project long run effects. However, remedial, or corrective actions are needed.
III	Moderate: social welfare loss generated by the project, mostly financial damage, even in the medium-long run. Remedial actions may correct the problem.
IV	Critical: high social welfare loss generated by the project; the occurrence of the risk causes a loss of the primary function(s) of the project. Remedial actions, even large in scope, are not enough to avoid serious damage.
V	Catastrophic: project failure that may result in serious or even total loss of the project functions. Main project effects in the medium-long term do not materialise.

Source: 2014 CBA Guide

- the risk level (the combination of the probability and the severity on a four-level scale: low, moderate, high, very high).

Table 4.10. Risk level

		Severity				
		I	II	III	IV	V
Probability	A	Low	Low	Low	Low	Moderate
	B	Low	Low	Moderate	Moderate	High
	C	Low	Moderate	Moderate	High	High
	D	Low	Moderate	High	Very high	Very high
	E	Moderate	High	Very high	Very high	Very high

Source: 2014 CBA Guide

Prevention and/or mitigation measures should be defined in accordance with the following table:

Table 4.11. Mitigation measures

		Severity				
		I	II	III	IV	V
Probability	A	Prevention or mitigation			Mitigation	
	B					
	C					
	D	Prevention			Prevention and mitigation	
	E					

Source: 2014 CBA Guide

The proposed mitigation measures should be reasonable and realistic and the entities responsible for implementing the mitigation measures should be clearly noted. At the level of the beneficiary, the units responsible for acting should be named. Furthermore, a detailed and realistic implementation plan for the mitigation measures, with their expected completion dates, should be provided, clearly indicating the measures that have already been implemented (if the case). The residual risks should reflect the effect of implementing the mitigation measures.

Finally, the beneficiary has to present a summary of the risk monitoring strategies it has in place to evaluate the correctness of the risk assessment and the appropriateness of the mitigation measures.

ANNEX I. PARAMETER VALUES FOR THE ECONOMIC ASSESSMENT OF TRANSPORT PROJECTS

AI.1. Database of parameter values

An Excel database of Transport Appraisal Parameter values, RomTAP, has been developed for use in the appraisal of transport projects in Romania. It is included as a separate Excel Annex to these Guidelines. The database consists of information sheets, calculation sheets and tables of parameter values.

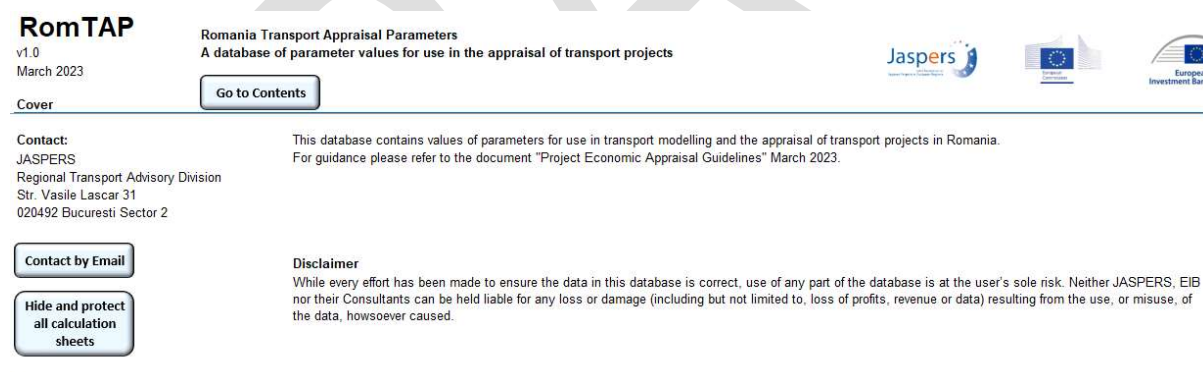
Some general principles of the database are as follows:

- Database worksheets are colour coded according to their category. Information sheets have grey tabs, calculation sheets have red tabs, tables of general parameter values are blue and tables of parameter values that relate to specific benefit categories are green.
- Each page has a header that includes the database name, version number and a link to the Contents page.
- Specific pages can be accessed using links on the Contents page or directly using page tabs.
- Some pages include default values (blue cells) that the user can over-ride (yellow cells).

The following sections describe each of the pages of the database.




AI.2. Cover

A **Cover** page presents information such as the database name, version number, ownership, description, disclaimer and JASPERS/EC/EIB logos. It includes buttons to navigate directly to the Contents page, to contact JASPERS, to unhide or hide all calculation sheets and to unprotect or protect cells.





AI.3. Contents

The **Contents** page is accessible either from a link on the **Cover** page or directly from a page tab. The **Contents** page lists the tab names of the various parameter value pages and includes a table title for each page. Links on the **Contents** page provide access to parameter value tables.

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Contents			
Category	Parameter group	Worksheet	Table title or page description
Information		Cover	Cover page
		Contents	Contents (this page)
		Sources	Details of data sources
		Changelog	Record of version numbers and changes
General	General parameters	A. General parameters	General parameters for setting values
		B. Annual Parameters	Annual economic parameters
		C. Conversion factors	Conversion factors from financial costs to economic costs
Infrastructure	O&M costs	D. O&M	Operation and maintenance costs by mode
Consumer / producer		E. Pax trip purpose	Trip purpose split by passenger mode
		F. Pax veh occupancy	Average number of passengers per vehicle by passenger mode
		G. Freight veh loading	Average load in tonnes per vehicle by freight mode
	Value of time	H. Pax VoT	Values of time per person by trip purpose and year




AI.4. Sources

Sources lists the various documents used to compile the database, with live links where available.

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Sources		Go to Contents	
The source of original data is noted on all pages of tables. Details of all sources are shown below.			
Abbreviated name	Category	Source name and link (where available)	Notes
CBA Guide	Primary reference	European Commission (2014) Guide to Cost Benefit Analysis of Investment Projects	
EAV	Primary reference	European Commission (2021) Economic Appraisal Vademecum 2021-2027	
Handbook on External Costs	Primary reference	European Commission (2019) Handbook on the External Costs of Transport	
JASPERS Rail Guidance	Primary reference	JASPERS (2017) Guidance on appraising the economic impacts of rail freight measures	
AECOM	Primary reference	AECOM (2014) Guide to Economic and Financial Cost Benefit Analysis and Risk Analysis	
CBR	Primary reference	EIB (2020) Climate Bank Roadmap 2021-2025	
	General	HEATCO (2006) Vol. 5. Proposal for Harmonised Guidelines	
	Annual parameters	Eurostat HICP	

AI.5. Changelog




The **Changelog** is a record of changes made to the RomTAP file with corresponding dates and version numbers.

RomTAP			
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Changelog		Go to Contents	
Version	Date	Log	
1.0.21	12/03/2023	Air pollution calcs P16: added value for IWT Noise calcs D175: modified label GHG calcs/GHG: added train and IWT emissions Fuel consumption calcs B42:D46: added HGV split Fuel consumption calcs rows 106:134: added aggregated calculations Fuel costs B165:G172: added aggregated fuel costs of road vehicles for rail projects Non-fuel calcs B77:1104: added aggregated calculations Non-fuel costs B26:E32: added aggregated non-fuel costs of road vehicles for rail projects GHG calcs B590:N618: added aggregated calculations GHG B553:G560: added aggregated GHG costs of road vehicles for rail projects	
1.0	13/03/2023	First release	

AI.6. General parameters

Table **A. General parameters** includes the default discount rates, reference period and price base year. In most cases the default values should be used. However, the user can enter alternative values to over-ride defaults where justified. The default financial discount rate (FDR) for projects financed under the 2021-2027 programming period is kept at 4%, the value used for the 2014-2020 programming period. The default social discount rate (SDR) is 3% in accordance with the EAV. A standard reference period (construction period plus operation period) of 30 years should be used. If the expected economic life of the asset is shorter or longer than 30 years, the appraisal period can be adapted accordingly, in

line with the recommendations provided in section 4.5.1 of the current guidelines. The default price base year to which all prices are adjusted is 2021.

<div> <div>RomTAP</div> <div> <div>v1.0</div> <div>March 2023</div> </div> </div> <div> <div>Romania Transport Appraisal Parameters</div> <div>A database of parameter values for use in the appraisal of transport projects</div> </div> <div>    </div>				
General parameters		Go to Contents		
Parameter	Parameter description	Default	Over-ride	Value used
FDR	Financial discount rate	4.00%		4.00%
SDR	Social discount rate (economic discount rate)	3.00%		3.00%
Reference period	Number of years in the appraisal period (construction period + operation period)	30		30
Price base year	The base year to which all prices are adjusted	2021		2021
Parameter	Source of default values, notes			
FDR	CBA Guide			
SDR	EAV p13			
Reference period	A standard reference period of 30 years should be used, unless the construction period is longer than 5 years, in which case the reference period could for example be set to (construction period - 5) + 30.			
Price base year	The default year is initially set to 2021, but may be reviewed by the Managing Authority and changed to a later year during the course of the programming period.			

AI.7. Annual parameters

Annual parameters are calculated to convert monetary values to the price base year.

Input data is held on sheet **B. Annual parameters** and includes the following:

- 2010 to 2021 recorded values from INSSE, 2022 to 2026 forecast values from CNSP and 2027 to 2030 JASPERS assumptions of engineering works cost indices used to adjust investment and O&M costs.
- 2010 to 2021 recorded values from CursBNR, 2022 to 2026 forecast values from CNSP and 2027 to 2030 JASPERS assumptions of EUR/RON exchange rates.
- 2010 to 2021 recorded values from Eurostat and 2022 onwards forecast values from EIU of Romanian real GDP/capita growth.
- 2010 to 2021 recorded values from Eurostat, 2022 to 2024 forecast values from ECB and 2025 to 2030 JASPERS assumptions of harmonised indices of consumer prices (HICP) in the euro area.
- 2010 to 2021 recorded values from Eurostat, 2022 to 2026 forecast values from CNSP and 2027 to 2030 JASPERS assumptions of harmonised indices of consumer prices (HICP) in Romania.

Data beyond 2021 may be updated by JASPERS as it becomes available.

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Annual parameters

User input (optional)

Engineering cost index, exchange rate, GDP/capita and HICP

Year	Engineering works cost indices	EUR/RON exchange rate	RO real GDP/capita growth	HICP € area	HICP RO
2010	115.600	4.2099			
2011	125.989	4.2379	5.00%	2.70%	5.80%
2012	133.591	4.4560	2.40%	2.50%	3.40%
2013	129.594	4.4190	0.60%	1.40%	3.20%
2014	128.448	4.4446	4.50%	0.40%	1.40%
2015	125.703	4.4450	3.70%	0.20%	-0.40%
2016	127.465	4.4908	3.50%	0.20%	-1.10%
2017	135.342	4.5881	8.80%	1.50%	1.10%
2018	155.338	4.6535	6.60%	1.80%	4.10%
2019	167.731	4.7452	4.30%	1.20%	3.90%
2020	169.338	4.8371	-3.10%	0.30%	2.30%
2021	189.764	4.9204	6.60%	2.60%	4.10%
2022	228.097	4.9300	5.30%	8.40%	12.00%
2023	251.591	4.9400	2.80%	6.30%	10.80%

Various calculations are carried out on the **Annual param calcs** sheet to produce different categories of escalation factors. These include the following:

Investment and O&M costs

- *Moving from a prior year to the price base year*

Investment costs are typically estimated in nominal prices, in local currency, in the year in which the cost estimate is prepared. To change the price base year for investment costs to the specified base year, the following approach is recommended:

Step 1: **Exchange rate conversion.** If the values are expressed in EUR, these should be converted to RON (using the average exchange rate applicable to that year).

Step 2: **Inflation adjustment.** Using the engineering works cost index, the unit value should be updated from the old to new price base year as follows:

New unit value = old unit value x (index value for updated price base year/index value for old price base year).

Step 3: **Exchange rate conversion.** The new unit values should be converted to EUR using the average exchange rate applicable to the new price base year.

- *Growth in real values over time (after the price base year)*

Such process is particularly important when the specific evolution of some costs is significantly different than the general inflation (consumer prices index), meaning that the related costs, in real terms, are evolving over time. To consider the costs increase in real terms after 2021, the following approach is recommended:

Step 1: **Exchange rate conversion.** If the values are expressed in EUR, these should be converted to RON (using the average exchange rate applicable to the base year).

Step 2: **Growth in real values.** The cost in RON corresponding to each year after the current base year, converted to the price base year as explained above (Step 1 and 2), should be multiplied by $(1+n)/(1+i)$, where n is the percentage change in the engineering works cost for the relevant year after 2021, and i is the percentage change in the Romanian consumer price index (HICP RO) over the same period for the relevant year after 2021. This calculation is performed as long as the engineering works cost index percentage change is different to that of the HICP RO.

Step 3: **Exchange rate conversion.** The new unit values should be converted to EUR using the average exchange rate for the relevant year.

The calculated annual cost escalation factors for investment and O&M costs for the selected price base year using the input data above are presented in Table B1. These are included as an output table as they may be required for use externally to RomTAP.

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Annual parameters

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Table B1. Annual cost escalation factors for investment and O&M costs

Year	Escalation factor to from	
	price base	price base
2010	1.64	0.00
2011	1.51	0.00
2012	1.42	0.00
2013	1.46	0.00
2014	1.48	0.00
2015	1.51	0.00
2016	1.49	0.00
2017	1.40	0.00
2018	1.22	0.00
2019	1.13	0.00
2020	1.12	0.00
2021	1.00	0.00
2022	0.00	1.07
2023	0.00	1.07
2024	0.00	1.06
2025	0.00	1.06
2026	0.00	1.06
2027	0.00	1.06
2028	0.00	1.06
2029	0.00	1.06
2030	0.00	1.06

Notes

Escalation factors are to be applied to investment and O&M costs in RON.

Economic Benefits

There are three categories of parameter values corresponding to the economic benefits in terms of converting the values to a base year and considering the growth in real values over time:

- parameter values dependent on GDP/capita (VoT and externalities, except for GHG emissions).
- parameter values dependent on fuel cost (e.g., VOC for petrol/diesel vehicles).
- CO₂ cost.

Parameter values dependent on GDP/capita (VoT and externalities except for CO₂ cost)

The parameter values for these benefits are typically estimated in nominal prices, in EUR, in the year for which values were calculated (usually 2010). To change the prior price base year to the current base year, the following approach is recommended and is applied internally in RomTAP.

Moving from one price base year to another

The parameter values included in RomTAP are all expressed in prices of the defined price base year. It is not generally necessary to change the price base year for these parameters. However, where alternate parameter values are being proposed (e.g., where better / more appropriate unit values have been identified), the project analyst may need to change the price base year of the new values to that of the defined price base year. In these circumstances the following approach is recommended:

Step 1: Exchange rate conversion. If the unit values are expressed in EUR these should be converted to RON (using the average exchange rate applicable to that year).

Step 2: Inflation adjustment. Using the appropriate national statistical index (HICP RO), the unit value should be updated from the old to new price base year as follows:

New unit value = old unit value x (index value for updated price base year/index value for old price base year).

Step 3: Real growth. The real value of the parameter in question is assumed to grow over time in line with GDP/capita, with an elasticity of 0.8 applied to all such parameters.

Step 4: **Exchange rate conversion.** The new unit values should be converted to EUR using the average exchange rate applicable to the new price base year.

Growth in real values over time

Throughout the appraisal period the unit values are expected to grow in real terms (i.e., inflation occurring after the price base year should be ignored), with an elasticity of 0.8 applied to the GDP/capita growth. The HICP RO values after the base year should not be considered in these calculations.

Parameter values dependent on fuel cost (e.g., VOC for petrol/diesel vehicles)

For this parameter, the values of the fuel element of the VOC are considered for the price base year and two scenarios: the Base scenario and the Adapted scenario, with growth rates defined in RomTAP. For both scenarios the fuel cost values for 2022 will be the average value from the Oil Bulletin, but with inflation (HICP RO for 2022) removed. These values are calculated internally in RomTAP.

For the non-fuel element of VOCs, the costs are converted to RON, inflation-adjusted, then converted back to EUR.

Unit CO₂ cost

EIB shadow cost of carbon in €/tCO₂e 2016 prices are to be used. They are converted to the price base year by applying the HICP euro area for inflation adjustment as the values are not specific to Romania. The unit costs for the rest of the reference period are estimated based on linear interpolation of the above defined unit costs. These values are calculated internally in RomTAP.

AI.8. Conversion factors

Sheet **C. Conversion factors** sets out conversion factors from financial to economic prices for various CAPEX and OPEX categories as defined in Table C.1 of the former EU Major Project Funding Application Form. All financial costs should exclude VAT.

Conversion factors are calculated based on the percentage cost of materials, skilled labour, unskilled labour, energy, and other costs of each category, as presented in the Romanian Prices Statistical Bulletin. The conversion factor for each of these categories is shown in the table below.

Conversion factor category	
Category	Value
Materials	1.00
Skilled labour	1.00
Unskilled labour	0.53
Energy	0.63
Others	1.00
Land acquisition	1.00

Source: pwc.com; AECOM p36-37, categories defined according to EU major project funding application form, Table C.1.

The conversion factor of 0.53 for unskilled labour is based on the calculation of the Shadow Wage Rate Factor (SWRF). This is derived from the unemployment rate U, income tax rate I, social security rate S and minimum wage W according to the following formula:

$$SWRF = (1 - U) * (1 - (I + S))$$

Shadow Wage Rate Factor (SWRF)	
Category	Value
Unemployment rate	5.60%
Income tax rate	6.50%
Social security	37.25%
Minimum wage	€ 466.23
SWRF	53.10%

Source: Eurostat, Romanian National Institute of Statistics

The conversion factor of 0.63 for energy was derived by JASPERS based on European Commission data (Weekly Oil Bulletin 2021), relating the Romanian price for fuel without taxes and duties and the pump price excluding VAT.




The percentage of conversion factor category for each cost category was estimated by JASPERS and is shown in the table below.

Percentage of conversion factor category for each cost category

Cost category		Conversion factor category					Total
		Materials	Skilled labour	Unskilled labour	Energy	Others	
CAPEX	Planning/design fees	16.75%	70.00%	0.00%	5.00%	8.25%	100.00%
	Land purchase	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
	Building and construction	47.21%	5.75%	13.41%	10.20%	23.44%	100.00%
	Plant and machinery or equipment	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
	Contingencies	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Price adjustment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Publicity	16.75%	70.00%	0.00%	5.00%	8.25%	100.00%
	Supervision during construction	20.10%	50.00%	0.00%	20.00%	9.90%	100.00%
	Technical assistance	20.10%	50.00%	0.00%	20.00%	9.90%	100.00%
OPEX	O&M	46.82%	5.59%	16.78%	10.20%	20.61%	100.00%

Source: JASPERS

The resulting final conversion factors to be applied are shown in the table below:

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Conversion factors			
Tables			
Table C1. Conversion factors from financial to economic prices			
Cost category	Conversion factor		
CAPEX	Planning/design fees	0.98	
	Land purchase	1.00	
	Building and construction	0.90	
	Plant and machinery or equipment	1.00	
	Contingencies	0.00	
	Price adjustment	0.00	
	Publicity	0.98	
	Supervision during construction	0.93	
	Technical assistance	0.93	
OPEX	O&M	0.88	

AI.9. O&M

Sheet **D. O&M** presents price base year values of operation and maintenance costs for road, rail, IWT and metro.

The values for roads are presented by type of road (based on data obtained from CNAIR Regional Directorate Cluj) and for tunnels (based on work carried out by ARUP), separately by road and lane kilometre for routine maintenance, periodic maintenance, and rehabilitation. Indicative intervention frequency is provided for periodic maintenance and rehabilitation. The tables below show the economic costs that should be used in CBA. (Financial costs are also presented in RomTAP Tables D1 and D2 but are not shown here.)

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O&M

Table D3. Road maintenance economic costs (€2021/road.km)

Road category	Routine maintenance			Periodic		Rehabilitation	
	Summer €/km	Winter €/km	Total €/km	€/km	Frequency years	€/km	Frequency years
2x3 Motorway	30,226	14,482	44,708	281,833	5	3,923,302	20
2x2 Motorway	21,983	10,546	32,529	205,034	5	2,853,326	20
Expressway/ 4-lane road	12,997	8,628	21,625	143,524	5	1,997,311	20
Road (AADT>=3500)	3,268	4,307	7,575	71,762	5	998,655	20
Road (AADT<3500)	3,268	4,307	7,575	71,762	10	998,655	30
Tunnel (twin bore >3km)			382,099				
Tunnel (twin bore 1-3km)			282,285				
Tunnel (twin bore <1km)			200,815				

Table D4. Road maintenance economic costs (€2021/lane.km)

Road category	Routine maintenance			Periodic		Rehabilitation	
	Summer €/km	Winter €/km	Total €/km	€/km	Frequency years	€/km	Frequency years
2x3 Motorway	5,038	2,414	7,451	46,972	5	653,884	20
2x2 Motorway	5,496	2,636	8,132	51,258	5	713,332	20
Expressway/ 4-lane road	3,249	2,157	5,406	35,881	5	499,328	20
Road (AADT>=3500)	1,634	2,154	3,788	35,881	5	499,328	20
Road (AADT<3500)	1,634	2,154	3,788	35,881	10	499,328	30
Tunnel (twin bore >3km)			95,525				
Tunnel (twin bore 1-3km)			70,571				
Tunnel (twin bore <1km)			50,204				

The costs of O&M for railways are presented in terms of line km and track km for the overall network and for single track and double track lines, subdivided into electrified and non-electrified lines. They are based on average values in Europe presented by UIC¹⁹, adjusted to account for wage rates in Romania²⁰. O&M costs are also included per track km of metro (based on Metrorex Line M2 data) and network km of IWT (based on research by CE Delft²¹).

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O&M

Table D6. Rail, IWT and metro economic O&M costs (€2021)

Mode	Category	Base unit	Component unit	Component factor	Base unit €1000/km per year	Component unit €1000/km per year
Rail	Network (total)	Line km	Track km	1	53.69	53.69
	Network (non-electrified)	Line km	Track km	1	45.37	45.37
	Network (electrified)	Line km	Track km	1	67.61	67.61
	Single track (total)	Line km	Track km	1	58.52	58.52
	Single track (non-electrified)	Line km	Track km	1	49.46	49.46
	Single track (electrified)	Line km	Track km	1	73.69	73.69
	Double track (total)	Line km	Track km	2	83.01	41.51
	Double track (non-electrified)	Line km	Track km	2	70.15	35.08
IWT	Double track (electrified)	Line km	Track km	2	104.53	52.27
		Network km	Network km	1	7.62	7.62
Metro		Track km	Track km	2	174.52	87.26

O&M costs beyond the price base year should increase in line with the forecast real growth in construction prices.

AI.10. Passenger trip purpose

Passenger trip purposes are presented in sheet **E. Pax trip purpose** in terms of percentages of passengers travelling for work, commuting and other purposes by car, bus, and train. The table is based on aggregated trip purposes presented in the AECOM guide.

¹⁹ UIC (2008) lasting Infrastructure Cost Benchmarking (LICB)

²⁰ The adjustment is based on the AECOM assumption that 40% of maintenance costs are wage related and that Romanian wages are 20% of average EU wages.

²¹ CE Delft (2019) Overview of transport infrastructure expenditures and costs, main report and EXCEL annex.

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Passenger trip purpose

Tables

Table E1. Passenger trip purpose

Mode	Trip purpose			Total
	Work	Commuting	Other	
Car	13.0%	33.0%	54.0%	100.0%
Bus	6.0%	21.0%	73.0%	100.0%
Train	4.0%	20.0%	76.0%	100.0%

AI.11. Passenger vehicle occupancy

Default average numbers of passengers per passenger vehicle are presented in sheet **F. Pax veh occupancy**. The user can enter over-ride values if more appropriate project specific data is available. Default car occupancy is taken from the AECOM guide. There is little data for bus occupancy, so the value in the table below is proposed until better information becomes available. (It is advised to provide local project specific values, where available, to over-ride this value). Default train and metro occupancies are average observed values.

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Passenger vehicle occupancy

Tables

Table F1. Number of passengers per vehicle

Mode	Default	Over-ride	Value used
Car	1.79		1.79
Bus	25.00		25.00
Train	80.90		80.90
Metro	360.00		360.00

AI.12. Freight vehicle loading

The default freight vehicle loadings in sheet **G. Freight veh loading** are based on values presented in recent studies. The user can over-ride this data with project specific values.

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Freight vehicle loading

Tables

Table G1. Number of tonnes per vehicle

Mode	Default	Over-ride	Value used
LGV	1.00		1.00
HGV1	5.00		5.00
HGV2	11.00		11.00
Train	650.00		650.00
IWT vessel	8250.00		8250.00

AI.13. Passenger value of time

Passenger values of time are presented in sheet **H. Pax VoT** by trip purpose and year in terms of price base year €. The values are aggregated from the AECOM guide and escalated to the price base year by converting from EUR to RON, increasing in line with Romanian inflation and GDP/capita with an elasticity of 0.8 applied, then converting back to EUR.

Growth beyond the price base is calculated in line with forecast growth in GDP/capita with an elasticity of 0.8 applied.

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Passenger VoT

Tables

Table H1. Passenger value of time by trip purpose and year (€2021/passenger hour)

Year	Work	Commuting	Other	Total
2021	15.96	6.49	5.44	6.83
2022	16.60	6.76	5.66	7.11
2023	16.94	6.89	5.78	7.25
2024	17.11	6.96	5.83	7.32
2025	17.28	7.03	5.89	7.40
2026	17.46	7.11	5.96	7.48
2027	17.63	7.18	6.02	7.56

AI.14. Freight value of time

In order to calculate time savings for freight, the recommended unit values shown in Table I1 of sheet **I. Freight VoT** should be used. Although the values quoted in this table are based on research undertaken in France, they are considered appropriate given the small differences in market value between countries for typical rail freight and given the broad range of value categories. They are held constant over time beyond the price base year.

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Freight VoT

Tables

Table I1. Freight values of time by commodity (€2021/tonne hour)

Commodity	Value of time (€/tonne.hour)
Freight with low added value (< €6,000/tonne), e.g. bulk, aggregates	0.00
Ordinary freight (€6,000 - €35,000/tonne)	0.23
Freight with high added value (> €35,000/tonne), e.g. parcels, refrigerated produce, combined traffic, ro-ro traffic	0.69

AI.15. Road vehicle fleet

The composition of the road vehicle fleet is presented in the sheet **J. Road veh fleet** by year from 2016 to 2070 for two scenarios: Baseline (following current trends, but assuming a ban on newly produced internal combustion vehicles after 2045) and Adapted (based on the Paris Agreement). The table shows the forecast percentage of cars, buses, LGVs and HGVs subdivided by type of fuel (petrol, diesel and electricity) in the Baseline scenario. A similar table shows the forecast fleet structure in the Adapted scenario.

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Road vehicle fleet

Tables

Table J1. Road vehicle fleet composition: Baseline Scenario (current trend)

	Car (petrol)	Car (diesel)	Car (electric)	Bus (diesel)	Bus (electric)	LGV (petrol)	LGV (diesel)	LGV (electric)	HGV (diesel)	HGV (electric)
2016	61.3%	38.7%	0.0%	100.0%	0.0%	19.0%	81.0%	0.0%	100.0%	0.0%
2017	58.0%	42.0%	0.0%	100.0%	0.0%	17.4%	82.6%	0.0%	100.0%	0.0%
2018	55.2%	44.8%	0.0%	100.0%	0.0%	15.8%	84.2%	0.0%	100.0%	0.0%
2019	53.2%	46.8%	0.0%	100.0%	0.0%	14.5%	85.5%	0.0%	100.0%	0.0%
2020	51.6%	48.4%	0.0%	100.0%	0.0%	13.2%	86.8%	0.0%	100.0%	0.0%
2021	50.2%	49.7%	0.1%	100.0%	0.0%	12.4%	87.6%	0.0%	100.0%	0.0%
2022	50.2%	49.7%	0.1%	100.0%	0.0%	12.4%	87.5%	0.1%	100.0%	0.0%
2023	49.7%	49.2%	1.2%	100.0%	0.0%	12.3%	86.9%	0.8%	100.0%	0.0%
2024	49.1%	48.6%	2.2%	100.0%	0.0%	12.2%	86.4%	1.4%	100.0%	0.0%
2025	48.6%	48.1%	3.3%	100.0%	0.0%	12.1%	85.8%	2.1%	100.0%	0.0%
2026	48.1%	47.6%	4.4%	100.0%	0.0%	12.1%	85.2%	2.7%	100.0%	0.0%
2027	47.5%	47.1%	5.4%	100.0%	0.0%	12.0%	84.7%	3.4%	100.0%	0.0%
2028	47.0%	46.6%	6.5%	100.0%	0.0%	11.9%	84.1%	4.0%	100.0%	0.0%

AI.16. Fuel costs

Costs per unit of fuel (price base € resource costs) are presented in sheet **K. Fuel costs** for the years 2010 to 2022 (actual values) and 2023 to 2070 (forecast values), for both the Baseline and Adapted scenarios. The observed costs of petrol and diesel are average annual values exclusive of tax for Romania extracted from the Weekly Oil Bulletin²². The observed cost for electric vehicles is based on Eurostat²³ household electricity prices for Romania, with an assumption that electric vehicles are charged 80% at private locations and 20% at public locations, where a markup of €0.10/kWh is incurred. The user can over-ride both these assumptions.

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Fuel costs

User input (optional)

EV assumptions

	Default	Over-ride	Value used
Household charging %	80%		80%
Public markup (€/kWh)	0.10		0.10

Source: base assumption

Baseline forecast prices assume short term fluctuations consistent with research carried out by Deloitte²⁴ and are held constant from 2026. Adapted scenario forecast prices follow the same profile to 2025. Thereafter, petrol prices are forecast to increase by 2.2% annually, diesel prices by 2.3% annually, while electricity prices are held constant.

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Fuel costs

Tables

Table K1. Fuel cost growth per year beyond observed data

Year	Baseline scenario			Adapted scenario		
	Petrol	Diesel	Electricity	Petrol	Diesel	Electricity
2023	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%
2024	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%
2025	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%
2026	0.00%	0.00%	0.00%	2.20%	2.30%	0.00%

Table K2. Baseline road vehicle fuel costs, resource cost average per year €2021

Year	Petrol €/litre	Diesel €/litre	Electricity		
			(household) €/kWh	(public) €/kWh	(inc. public) €/kWh
2010	0.523	0.552	0.085	0.185	0.105
2011	0.629	0.693	0.084	0.184	0.104
2012	0.681	0.760	0.077	0.177	0.097
2013	0.663	0.728	0.089	0.189	0.109
2014	0.641	0.694	0.091	0.191	0.111
2015	0.511	0.538	0.093	0.193	0.113
2016	0.453	0.468	0.090	0.190	0.110
2017	0.501	0.526	0.091	0.191	0.111
2018	0.573	0.628	0.098	0.198	0.118
2019	0.543	0.608	0.100	0.200	0.120
2020	0.434	0.475	0.104	0.204	0.124
2021	0.604	0.621	0.114	0.214	0.134
2022	0.928	1.014	0.168	0.268	0.188
2023	1.067	1.166	0.193	0.293	0.213
2024	0.960	1.049	0.174	0.274	0.194
2025	0.864	0.944	0.166	0.266	0.176

Aggregated fuel costs of road vehicles are included in a separate table for use in the assessment of rail projects. The costs are shown in terms of €/pax.km and €/ton.km for the Baseline and Adapted

²² https://energy.ec.europa.eu/data-and-analysis/weekly-oil-bulletin_en

²³ https://ec.europa.eu/eurostat/databrowser/view/NRG_PC_204_custom_807721/default/table?lang=en

²⁴ <https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/energy-resources/ca-en-energy-resources-industrials-o-g-price-forecast-report-Q2-fy23-aoda.pdf>

scenarios for the price base year and a custom year that can be specified on sheet **L. Fuel consumption**. These costs should be added to the aggregated non-fuel costs of road vehicles to give total road vehicle VOCs.

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Fuel costs

Table K4. Aggregated fuel costs of road vehicles for rail projects

		Baseline		Adapted	
		2021	2030	2021	2030
Car	€/pax.km	0.020	0.020	0.029	0.028
Bus	€/pax.km	0.006	0.006	0.009	0.009
LGV	€/ton.km	0.047	0.047	0.069	0.064
HGV	€/ton.km	0.018	0.018	0.027	0.027

AI.17. Fuel consumption

Sheet **L. Fuel consumption** presents the formulae and parameter values to be used to calculate the fuel consumption per kilometre for road vehicles. The formulae depend on speed and the user must therefore apply them according to modelled average link speeds. Sample calculations are presented for cars, buses, LGVs and HGVs by fuel type, sample speeds, sample years and alternative scenarios (Baseline and Adapted). Values are provided for all sample speeds. However, the calculations may present unreliable results for speeds greater than the maximum speeds specified in Table L1.

The formulae are based on WebTAG and the original data relates to UK fleet composition in 2015, but assumed representative of Romanian fleet composition in 2021. Note that HGVs are split into two categories – HGV1 (HGVs with 2 or 3 axles) and HGV2 (HGVs with 4 or more axles). The default split to be used is 34.8% HGV1 and 65.2% HGV2, based on proportions observed in the Romanian National Traffic Model. Note also that until more data becomes available, values for electric buses, electric LGVs and electric HGVs are adjusted from a speed of 80km/h to other speeds following a similar profile to that of electric cars.

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Fuel consumption and sample costs

Input data and formulae

Base data relates to the year: 2021

Table L1. Road vehicle fuel consumption: petrol and diesel fuelled vehicles (base data for year 2021)

Vehicle category	a	b	c	d	Min speed km/h	Av speed km/h	Max speed km/h	Sample calculations		
								Min speed l/km	Av speed l/km	Max speed l/km
Car (petrol)	0.451947	0.096046	-0.001094	0.000007	10	100	130	0.131	0.064	0.080
Car (diesel)	0.481913	0.069094	-0.000665	0.000005	10	100	130	0.111	0.060	0.075
Bus (diesel)	3.360187	0.295249	-0.003209	0.000024	12	80	85	0.540	0.231	0.232
LGV (petrol)	0.344348	0.193090	-0.003031	0.000020	12	90	120	0.188	0.083	0.114
LGV (diesel)	0.463485	0.113278	-0.001634	0.000014	12	90	110	0.134	0.083	0.105
HGV1 (diesel)	2.696285	0.143057	-0.001034	0.000011	12	80	85	0.357	0.166	0.168
HGV2 (diesel)	5.665597	0.294224	-0.001949	0.000012	12	80	85	0.745	0.283	0.279

Source: WebTAG Table A1.3.8, based on research carried out by Ricardo-AEA (2019)

Note: original data relates to UK fleet composition 2015, but is assumed representative of RO 2021. The minimum and maximum speeds delimit the range over which the curves are valid.

The default HGV split is HGV1 (2-3 axles) 34.8%, HGV2 (4+ axles) 65.2%, based on data from the National Transport Model.

Vehicle category	a	b	c	d	e	Min speed km/h	Av speed km/h	Max speed km/h	Sample calculations		
									Min speed kWh/km	Av speed kWh/km	Max speed kWh/km
Car (electric)	7.21215E-09	-2.58685E-06	3.39096E-04	-1.60095E-02	4.15865E-01	10	100	130	0.29	0.34	0.44
Bus (electric)					1.180	12	80	85		1.18	
LGV (electric)					0.259	12	80	120		0.26	
HGV (electric)					1.860	12	80	85		1.86	

Source:

Car - Ricardo-AEA (2015) Speed emission/energy curves for ultra-low emission vehicles

Bus, LGV - WebTAG Table A1.3.8

HGV - omev.se

Table L2. Fuel efficiency improvement per year from 2021

Scenario	Petrol	Diesel	Electric
Baseline	0.00%	0.00%	0.00%
Adapted	1.25%	1.30%	1.40%

Sample tables

Table L3. Road vehicle fuel consumption with fuel efficiency improvement applied

Scenario: Select a scenario from the drop-down list and, if required, enter a custom speed and custom year.
 Custom speed:
 Custom year:

				Speed (km/h)						
Year	Vehicle category		Unit	20	40	60	80	100	120	75
2021	Car	petrol	l/km	0.100	0.075	0.064	0.061	0.064	0.073	0.061
	Car	diesel	l/km	0.082	0.063	0.056	0.055	0.060	0.069	0.055
	Car	electric	kWh/km	0.212	0.171	0.211	0.276	0.340	0.403	0.259
	Bus	diesel	l/km	0.408	0.289	0.243	0.231	0.243	0.277	0.232
	Bus	electric	kWh/km	1.341	1.083	1.335	1.750	2.155	2.554	1.643
	LGV	petrol	l/km	0.158	0.112	0.087	0.080	0.089	0.114	0.080
	LGV	diesel	l/km	0.109	0.082	0.073	0.077	0.093	0.120	0.075
	LGV	electric	kWh/km	0.383	0.309	0.381	0.500	0.616	0.730	0.470
	HGV1	diesel	l/km	0.262	0.187	0.167	0.166	0.180	0.204	0.165
	HGV2	diesel	l/km	0.543	0.376	0.314	0.283	0.272	0.275	0.289
HGV	electric	kWh/km	1.426	1.151	1.419	1.860	2.291	2.714	1.747	
2025	Car	petrol	l/km	0.100	0.075	0.064	0.061	0.064	0.073	0.061
	Car	diesel	l/km	0.082	0.063	0.056	0.055	0.060	0.069	0.055
	Car	electric	kWh/km	0.212	0.171	0.211	0.276	0.340	0.403	0.259
	Bus	diesel	l/km	0.408	0.289	0.243	0.231	0.243	0.277	0.232
	Bus	electric	kWh/km	1.341	1.083	1.335	1.750	2.155	2.554	1.643
	LGV	petrol	l/km	0.158	0.112	0.087	0.080	0.089	0.114	0.080
	LGV	diesel	l/km	0.109	0.082	0.073	0.077	0.093	0.120	0.075
	LGV	electric	kWh/km	0.383	0.309	0.381	0.500	0.616	0.730	0.470
	HGV1	diesel	l/km	0.262	0.187	0.167	0.166	0.180	0.204	0.165
	HGV2	diesel	l/km	0.543	0.376	0.314	0.283	0.272	0.275	0.289
HGV	electric	kWh/km	1.426	1.151	1.419	1.860	2.291	2.714	1.747	

Note: the default HGV split is HGV1 34.8%, HGV2 65.2%, based on data from the National Transport Model.

Values are provided for all sample speeds. Note however that the calculations may be unreliable for speeds greater than the maximum speeds specified in Table L1 above.

Until more data becomes available, values for electric buses, LGVs and HGVs are adjusted from a speed of 80km/h to other speeds following a similar profile as for cars.

Table L4. Road vehicle fuel cost with cost growth and fuel efficiency improvement applied

Scenario:

			Fuel unit	Fuel unit cost					Speed (km/h)				
Year	Vehicle category			€	Unit	20	40	60	80	100	120	75	
2021	Car	petrol	l	0.604	€/km	0.060	0.045	0.039	0.037	0.038	0.044	0.037	
	Car	diesel	l	0.621	€/km	0.051	0.039	0.035	0.034	0.037	0.043	0.034	
	Car	electric	kWh	0.134	€/km	0.028	0.023	0.028	0.037	0.046	0.054	0.035	
	Bus	diesel	l	0.621	€/km	0.254	0.179	0.151	0.144	0.151	0.172	0.144	
	Bus	electric	kWh	0.134	€/km	0.180	0.145	0.179	0.235	0.289	0.342	0.220	
	LGV	petrol	l	0.604	€/km	0.095	0.068	0.053	0.048	0.054	0.069	0.049	
	LGV	diesel	l	0.621	€/km	0.068	0.051	0.045	0.048	0.058	0.075	0.046	
	LGV	electric	kWh	0.134	€/km	0.051	0.041	0.051	0.067	0.083	0.098	0.063	
	HGV1	diesel	l	0.621	€/km	0.162	0.116	0.103	0.103	0.111	0.127	0.102	
	HGV2	diesel	l	0.621	€/km	0.337	0.234	0.195	0.176	0.169	0.171	0.179	
	HGV	electric	kWh	0.134	€/km	0.191	0.154	0.190	0.249	0.307	0.364	0.234	
2025	Car	petrol	l	0.729	€/km	0.073	0.055	0.047	0.044	0.046	0.053	0.044	
	Car	diesel	l	0.836	€/km	0.069	0.053	0.047	0.046	0.050	0.058	0.046	
	Car	electric	kWh	0.169	€/km	0.036	0.029	0.036	0.047	0.057	0.068	0.044	
	Bus	diesel	l	0.836	€/km	0.342	0.241	0.204	0.193	0.203	0.232	0.194	
	Bus	electric	kWh	0.169	€/km	0.226	0.183	0.225	0.295	0.363	0.430	0.277	
	LGV	petrol	l	0.729	€/km	0.115	0.081	0.064	0.058	0.065	0.083	0.059	
	LGV	diesel	l	0.836	€/km	0.091	0.068	0.061	0.064	0.078	0.101	0.062	
	LGV	electric	kWh	0.169	€/km	0.065	0.052	0.064	0.084	0.104	0.123	0.079	
	HGV1	diesel	l	0.836	€/km	0.219	0.157	0.139	0.139	0.150	0.171	0.138	
	HGV2	diesel	l	0.836	€/km	0.454	0.315	0.262	0.237	0.228	0.230	0.242	
	HGV	electric	kWh	0.169	€/km	0.240	0.194	0.239	0.314	0.386	0.458	0.294	

Note: the default HGV split is HGV1 34.8%, HGV2 65.2%, based on data from the National Transport Model.

Values are provided for all sample speeds. Note however that the calculations may be unreliable for speeds greater than the maximum speeds specified in Table L1 above.

Until more data becomes available, values for electric buses, LGVs and HGVs are adjusted from a speed of 80km/h to other speeds following a similar profile as for cars.

AI.18. Non-fuel costs

The formulae and parameter values for consolidated road vehicle non-fuel costs (ownership costs) are presented for sample speeds in sheet **M. Non-fuel costs**. They depend on speed and the user must therefore apply them according to modelled average link speeds. Sample calculations are presented for cars, buses, LGVs and HGVs by fuel type for minimum, average and maximum speeds in price base €.

The original data is sourced from the AECOM guide, which itself is stated to be based on WebTAG, rebased to Romania 2010 prices using an adjustment factor from an unspecified source. The AECOM data has been further disaggregated by fuel type (using relationships observed in WebTAG) and rebased to the price base by applying Romanian inflation.

Non-fuel costs are held constant beyond the price base.

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Non-fuel road VOCs

Tables

Table M1. Consolidated road vehicle non-fuel costs 2021

Vehicle category	a €/km	b €/km	Min speed km/h	Av speed km/h	Max speed km/h	Sample calculations		
						Min speed €/km	Av speed €/km	Max speed €/km
Car (petrol/diesel)	0.018926	0.083783	10	100	130	0.03	0.02	0.02
Car (electric)	0.005486	0.083803	10	100	130	0.01	0.01	0.01
Bus (diesel)	0.144409	3.292666	12	80	85	0.42	0.19	0.18
Bus (electric)	0.043323	3.292666	12	80	85	0.32	0.08	0.08
LGV (petrol/diesel)	0.034189	0.223347	12	90	110	0.05	0.04	0.04
LGV (electric)	0.010257	0.223347	12	90	110	0.03	0.01	0.01
HGV1 (diesel)	0.031825	1.250690	12	80	85	0.14	0.05	0.05
HGV2 (diesel)	0.061924	2.410780	12	80	85	0.26	0.09	0.09
HGV (electric)	0.018577	2.410780	12	80	85	0.22	0.05	0.05

Aggregated non-fuel costs of road vehicles are included in a separate table for use in the assessment of rail projects. The costs are shown in terms of €/pax.km and €/ton.km for the price base year and a custom year that can be specified on sheet **L. Fuel consumption**. These costs should be added to the aggregated fuel costs of road vehicles to give total road vehicle VOCs.

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Non-fuel road VOCs

Table M2. Aggregated non-fuel costs of road vehicles for rail projects

		2021	2030
Car	€/pax.km	0.011	0.010
Bus	€/pax.km	0.007	0.007
LGV	€/ton.km	0.037	0.035
HGV	€/ton.km	0.009	0.009

AI.19. TOCs

Train operating costs are calculated separately for passenger trains and freight trains in sheet **N. TOCs**. For passenger trains, costs per train km are based on AECOM 2010 data, subdivided by type of train and energy, and adjusted to the price base year by applying the Romanian inflation rate. Freight train costs are based on JASPERS Rail Guidance, subdivided into hourly and kilometric cost components by type of train. The hourly cost component is adjusted to the price base by applying the Romanian inflation rate and the kilometric cost is adjusted according to energy market prices.

Passenger train operating costs are presented in RomTAP by train kilometre and passenger kilometre and either metric may be used. The costs remain constant beyond the price base year.

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Train operating costs

Table N1. Economic passenger TOCs: total TOC/train.km (€2021)

Year	Diesel trains						Electric trains					
	Locomotive hauled			New multiple unit			Locomotive hauled			New multiple unit		
	Inter-city	Inter-regional	Regional	Long distance	Regional	All	Inter-city	Inter-regional	Regional	Long distance	Regional	All
2021	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2022	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2023	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2024	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2025	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2026	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2027	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56
2028	18.29	15.82	10.20	9.07	8.53	7.21	13.61	11.74	8.33	8.25	7.56	7.56

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Train operating costs

Table N2. Economic passenger TOCs: total TOC/passenger.km (€2021)

Year	Diesel trains						Electric trains					
	Locomotive hauled			New multiple unit			Locomotive hauled			New multiple unit		
	Inter-city	Inter-regional	Regional	Long distance	Regional	All	Inter-city	Inter-regional	Regional	Long distance	Regional	All
2021	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2022	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2023	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2024	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2025	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2026	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2027	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093
2028	0.226	0.196	0.126	0.112	0.105	0.089	0.168	0.145	0.103	0.102	0.093	0.093

No operating costs are currently available for metro trains. For appraisal of metro projects, the operator should provide the applicable TOC data.

Freight train operating costs are presented for trains and tonnes by time and distance metrics and both metrics are to be used together i.e., the total TOC is the hourly cost plus the kilometric cost either per train or per tonne. The hourly costs remain constant beyond the price base year while the kilometric costs are adjusted in line with the Baseline and Adapted scenarios.

Table N3. Economic freight TOCs: total TOC/train.hour and train.km (€2021)

NB. These are NOT mutually exclusive. Use the cost per hour PLUS the cost per kilometre.

Year	€2021/train.hour						€2021/train.km			
	Block train		Wagonload train		Container train		Baseline		Adapted	
	Electric	Diesel	Electric	Diesel	Electric	Diesel	Electric	Diesel	Electric	Diesel
2021	459.21	491.44	509.52	558.51	423.70	457.85	3.51	5.02	3.51	5.02
2022	459.21	491.44	509.52	558.51	423.70	457.85	5.76	8.54	5.76	8.54
2023	459.21	491.44	509.52	558.51	423.70	457.85	6.62	9.82	6.62	9.82
2024	459.21	491.44	509.52	558.51	423.70	457.85	5.96	8.84	5.96	8.84
2025	459.21	491.44	509.52	558.51	423.70	457.85	5.37	7.95	5.37	7.95
2026	459.21	491.44	509.52	558.51	423.70	457.85	5.37	7.95	5.37	8.14
2027	459.21	491.44	509.52	558.51	423.70	457.85	5.37	7.95	5.37	8.29

Table N4. Economic freight TOCs: total TOC/tonne.hour and tonne.km (€2021)

NB. These are NOT mutually exclusive. Use the cost per hour PLUS the cost per kilometre.

Year	€2021/tonne.hour						€2021/tonne.km			
	Block train		Wagonload train		Container train		Baseline		Adapted	
	Electric	Diesel	Electric	Diesel	Electric	Diesel	Electric	Diesel	Electric	Diesel
2021	0.706	0.756	0.784	0.859	0.652	0.704	0.005	0.008	0.005	0.008
2022	0.706	0.756	0.784	0.859	0.652	0.704	0.009	0.013	0.009	0.013
2023	0.706	0.756	0.784	0.859	0.652	0.704	0.010	0.015	0.010	0.015
2024	0.706	0.756	0.784	0.859	0.652	0.704	0.009	0.014	0.009	0.014
2025	0.706	0.756	0.784	0.859	0.652	0.704	0.008	0.012	0.008	0.012
2026	0.706	0.756	0.784	0.859	0.652	0.704	0.008	0.012	0.008	0.013
2027	0.706	0.756	0.784	0.859	0.652	0.704	0.008	0.012	0.008	0.013

AI.20. IWTOCs

Inland waterway vessel operating costs are tabulated in sheet **O. IWTOCs** by year in price base € in terms of €/km, €/hour, €/tonne.km and €/tonne.hour for the Baseline and Adapted scenarios. The values are based on work carried out by Jacobs²⁵ and Panteia²⁶.

²⁵ JACOBS (2020) Improvement of Navigation Conditions on the Romanian-Bulgarian Common Sector of the Danube

²⁶ Panteia (2020) Cost figures for freight transport

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IWT vessel operating costs

Tables

Table O1. Baseline IWT vessel operating costs, resource cost average per year €2021

Year	€/km	€/hour	€/tonne.km	€/tonne.hr
2021	85.262	437.859	0.010	0.053
2022	99.386	510.396	0.012	0.062
2023	104.073	534.464	0.013	0.065
2024	100.480	516.012	0.012	0.063
2025	97.246	499.404	0.012	0.061
2026	97.246	499.404	0.012	0.061
2027	97.246	499.404	0.012	0.061
2028	97.246	499.404	0.012	0.061

Original data is subdivided into crew costs, fuel costs and other costs, escalated to the price base as follows:

- Crew cost: converted to RON, escalated in line with Romanian inflation and GDP/capita with an elasticity of 1.0, then converted back to EUR.
- Fuel cost: escalated in line with market prices.
- Other costs: converted to RON, escalated in line with Romanian inflation, then converted back to EUR.

Crew costs and other costs are held constant from the price base year while fuel costs are escalated according to the Baseline and Adapted scenarios.

AI.21. Road accidents

Accident costs are tabulated in sheet **P. Road accidents** by year, type of casualty and for material damage. The values are based on the 2019 Handbook on External Costs data for Romania, rebased to the price base year. In years beyond the price base, costs are increased in line with GDP/capita with an elasticity of 0.8 applied.

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Road accident costs

Tables

Table P1. Cost per casualty by year with elasticity to GDP/capita applied (€2021)

Year	Fatality	Serious injury	Slight injury	Damage only
2021	3,107,545	431,956	33,330	6,215
2022	3,232,997	449,394	34,676	6,466
2023	3,298,725	458,530	35,381	6,597
2024	3,332,145	463,176	35,739	6,664
2025	3,366,388	467,936	36,106	6,733
2026	3,401,462	472,811	36,483	6,803
2027	3,725,019	517,786	39,953	7,450
2028	3,802,450	529,385	40,848	7,617

A second table presents road accident rates in terms of the number of damage only accidents per million vehicle kilometres and injury accidents per million vehicle kilometres by type of road (motorway, national rural, national urban, regional rural, regional urban and local). The number of fatalities, serious injuries and slight injuries is also tabulated. The rates are based on data from 2007 – 2011 reported in the AECOM Guide and should be updated once suitable data is available. Accident rates are assumed to decline by a default rate of 0.5% per year, as infrastructure geometry, vehicle safety features and driver awareness improve.

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Road accident costs

Table P2. Accident rates by type of road

Year	Motorway					DN Rural						
	Damage only accidents per mln.veh.km	Injury accidents per mln.veh.km	Fatalities per accident	Serious injuries per accident	Slight injuries per accident	Damage only accidents per mln.veh.km	Injury accidents per mln.veh.km	Fatalities per accident	Serious injuries per accident	Slight injuries per accident	Damage only accidents per mln.veh.km	Injury accidents per mln.veh.km
2021	1.5300	0.0406	0.1495	0.3551	1.0000	2.2700	0.1325	0.1726	0.4841	1.1296	10.7300	0.7306
2022	1.5224	0.0404	0.1495	0.3551	1.0000	2.2587	0.1318	0.1726	0.4841	1.1296	10.6764	0.7269
2023	1.5147	0.0402	0.1495	0.3551	1.0000	2.2474	0.1312	0.1726	0.4841	1.1296	10.6230	0.7233
2024	1.5072	0.0400	0.1495	0.3551	1.0000	2.2361	0.1305	0.1726	0.4841	1.1296	10.5699	0.7197
2025	1.4996	0.0398	0.1495	0.3551	1.0000	2.2249	0.1299	0.1726	0.4841	1.1296	10.5170	0.7161
2026	1.4921	0.0396	0.1495	0.3551	1.0000	2.2138	0.1292	0.1726	0.4841	1.1296	10.4644	0.7125
2027	1.4847	0.0394	0.1495	0.3551	1.0000	2.2027	0.1286	0.1726	0.4841	1.1296	10.4121	0.7090
2028	1.4773	0.0392	0.1495	0.3551	1.0000	2.1917	0.1279	0.1726	0.4841	1.1296	10.3600	0.7054

A further table presents the costs of road accidents per injury accident and per million vehicle kilometres by type of road, again with annual reduction factors applied.

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Road accident costs

Table P3. Cost of road accidents, €2021 per injury accident and per million vehicle kilometres

Year	Motorway			DN Rural			DN Urban			DJ Rural		
	Cost of road injury accident	Cost of road injury acc. / mln.veh.km	Cost of all road accs. / mln.veh.km	Cost of road injury accident	Cost of road injury acc. / mln.veh.km	Cost of all road accs. / mln.veh.km	Cost of road injury accident	Cost of road injury acc. / mln.veh.km	Cost of all road accs. / mln.veh.km	Cost of road injury accident	Cost of road injury acc. / mln.veh.km	Cost of all road accs. / mln.veh.km
2021	657,511	26,695	34,171	789,337	104,587	104,587	629,753	460,097	460,097	651,911	191,923	191,923
2022	654,055	27,634	35,072	821,203	108,265	108,265	655,176	476,278	476,278	678,229	198,672	198,672
2023	697,962	28,055	35,456	837,898	109,914	109,914	668,496	483,531	483,531	692,017	201,698	201,698
2024	705,033	28,197	35,561	846,387	110,472	110,472	675,269	485,988	485,988	699,028	202,722	202,722
2025	712,278	28,344	35,672	855,085	111,050	111,050	682,208	488,527	488,527	706,212	203,782	203,782
2026	719,699	28,497	35,787	863,994	111,646	111,646	689,316	491,149	491,149	713,570	204,875	204,875
2027	788,159	31,051	38,305	946,180	121,654	121,654	754,886	535,179	535,179	781,447	223,242	223,242
2028	805,814	31,688	38,806	967,374	123,768	123,768	771,795	544,431	544,431	798,961	227,101	227,101

A final table presents road accident costs per passenger kilometre and tonne kilometre by year. This table is based solely on data in the Handbook on External Costs and may not, therefore, be fully consistent with the previous tables. These values should only be applied in the absence of a road transport model able to produce reliable estimates of e.g., vehicle kilometres. An example of this would be the appraisal of a rail project with a rail only model, but with modal shift calculated using elasticities.

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Road accident costs

Table P4. Road accident costs per passenger kilometre and tonne kilometre, €2021

Year	€/pax.km		€/tonne.km	
	Car	Bus	LGV	HGV
2021	0.095	0.018	0.580	0.009
2022	0.099	0.019	0.603	0.009
2023	0.101	0.019	0.616	0.009
2024	0.102	0.019	0.622	0.010
2025	0.103	0.019	0.628	0.010
2026	0.104	0.019	0.635	0.010
2027	0.114	0.021	0.695	0.011
2028	0.117	0.022	0.714	0.011

AI.22. Rail & IWT accidents

Rail and IWT accident costs are presented in two tables in sheet **Q. Rail & IWT accidents**. In the first they are expressed in terms of cost per million train kilometres, per level crossing, per rail network kilometre and per million IWT vessel kilometres. The table is based on injury accident rates in the AECOM guide and costs per casualty shown in Table P1 above.

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Rail & IWT accident costs

Tables

Table Q1. Cost of rail and IWT accidents, €2021

Year	Rail			IWT
	Cost per mln.train.km	Cost per level crossing	Cost per network.km	Cost per mln.ship.km
2021	37,802	21,438	30,244	3,748,717
2022	39,328	22,304	31,465	3,900,054
2023	40,128	22,757	32,105	3,979,343
2024	40,534	22,988	32,430	4,019,659
2025	40,951	23,224	32,763	4,060,968
2026	41,378	23,466	33,105	4,103,278
2027	45,314	25,698	36,254	4,493,594
2028	46,320	26,274	37,066	4,504,260

A second table presents rail and IWT accident costs in terms of passenger and tonne kilometres. These are based on the Handbook on External Costs.

Table Q2. Rail and IWT accident costs per passenger kilometre and tonne kilometre, €2021

Year	rail		IWT
	€/pax.km	€/tonne.km	€/tonne.km
2021	0.0017	0.0022	0.0006
2022	0.0018	0.0022	0.0006
2023	0.0018	0.0023	0.0006
2024	0.0018	0.0023	0.0006
2025	0.0019	0.0023	0.0006
2026	0.0019	0.0024	0.0007
2027	0.0021	0.0026	0.0007
2028	0.0021	0.0027	0.0007

AI.23. Noise

Noise costs based on the 2019 Handbook on External Costs are presented in sheet **R. Noise** by passenger kilometre, tonne kilometre and vehicle kilometre by type of vehicle (car, bus, LGV, HGV, train and IWT) and fuel (petrol, diesel and electricity) by year. In years beyond the price base, costs are increased in line with GDP/capita with an elasticity of 0.8 applied. The Handbook does not provide data for electric road vehicles. An assumption is made that they are 50% quieter than conventionally fuelled road vehicles.

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Noise costs

Tables

Table R1. Noise costs per passenger kilometre and tonne kilometre, €2021

Year	€/pax.km								€/tonne.km				
	Car (petrol)	Car (diesel)	Car (electric)	Bus (diesel)	Bus (electric)	Train (electric)	Train (diesel)	LGV (petrol)	LGV (diesel)	LGV (electric)	HGV (diesel)	HGV (electric)	T
2021	0.011952	0.013004	0.006239	0.005182	0.002591	0.009144	0.013250	0.066953	0.066953	0.033476	0.014657	0.007329	
2022	0.012434	0.013529	0.006491	0.005391	0.002696	0.009514	0.013785	0.069656	0.069656	0.034828	0.015249	0.007624	
2023	0.012687	0.013804	0.006623	0.005501	0.002750	0.009707	0.014066	0.071072	0.071072	0.035536	0.015559	0.007779	
2024	0.012816	0.013944	0.006690	0.005557	0.002778	0.009805	0.014208	0.071792	0.071792	0.035896	0.015717	0.007858	
2025	0.012947	0.014087	0.006759	0.005614	0.002807	0.009906	0.014354	0.072530	0.072530	0.036265	0.015878	0.007939	
2026	0.013082	0.014234	0.006829	0.005672	0.002836	0.010009	0.014504	0.073286	0.073286	0.036643	0.016044	0.008022	
2027	0.014327	0.015588	0.007479	0.006212	0.003106	0.010961	0.015883	0.080257	0.080257	0.040128	0.017570	0.008785	
2028	0.014647	0.015937	0.007646	0.006351	0.003175	0.011207	0.016230	0.082054	0.082054	0.041027	0.017963	0.008892	

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Noise costs

Table R2. Noise costs per vehicle kilometre, €2021

Year	€/veh.km											
	Car (petrol)	Car (diesel)	Car (electric)	Bus (diesel)	Bus (electric)	Train (electric)	Train (diesel)	LGV (petrol)	LGV (diesel)	LGV (electric)	HGV (diesel)	HGV (electric)
2021	0.021394	0.023277	0.011168	0.129553	0.064777	0.739783	1.071959	0.066953	0.066953	0.033476	0.161230	0.080615
2022	0.022525	0.024216	0.011618	0.134783	0.067392	0.769648	1.115235	0.069656	0.069656	0.034828	0.167739	0.083869
2023	0.022710	0.024709	0.011855	0.137523	0.068762	0.785295	1.137908	0.071072	0.071072	0.035536	0.171149	0.085574
2024	0.022940	0.024959	0.011975	0.138917	0.069458	0.793251	1.149436	0.071792	0.071792	0.035896	0.172883	0.086441
2025	0.023176	0.025215	0.012098	0.140344	0.070172	0.801403	1.161248	0.072530	0.072530	0.036265	0.174660	0.087330
2026	0.023417	0.025478	0.012224	0.141807	0.070903	0.809753	1.173347	0.073286	0.073286	0.036643	0.176479	0.088240
2027	0.025645	0.027902	0.013387	0.155296	0.077648	0.886779	1.284960	0.080257	0.080257	0.040128	0.193266	0.096633
2028	0.026219	0.028527	0.013686	0.158774	0.079387	0.906643	1.313743	0.082054	0.082054	0.041027	0.197596	0.098798

If a more detailed breakdown of costs is required, consolidated adjustment factors can be applied. These facilitate the conversion of the costs per vehicle kilometre to be adjusted to noise generated during the day and during the night in urban (average population density of 1,500 inhabitants per square kilometre), suburban (average population density of 300 inhabitants per square kilometre) and rural (average population density of less than 150 inhabitants per square kilometre) locations. The adjustment factors are based on the relative values presented in the AECOM Guide. They are applied by multiplying the per vehicle kilometre cost by the corresponding adjustment factor.

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Noise costs

Table R3. Consolidated adjustment factors

Vehicle type	Time of day	Location		
		Urban	Suburban	Rural
Car, bus, LGV	Day	3.72	0.53	0.05
	Night	7.43	1.06	0.11
HGV	Day	4.05	0.58	0.06
	Night	6.08	0.87	0.09
Pax train	Day	2.02	2.02	0.20
	Night	7.09	3.04	0.40
Freight train	Day	1.91	1.91	0.19
	Night	7.63	3.82	0.38

AI.24. GHG emissions

Greenhouse gas (GHG) emission costs are calculated in sheet **S. GHG** as costs per litre and kWh of fuel and energy consumed for Baseline and Adapted scenarios. Emission rates in terms of kg/litre and kg/kWh of CO₂ equivalent are based on values used in UK WebTAG. The rates for electricity are adjusted for Romania according to the relative grid emissions of the UK.

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GHG costs

Tables

Table S1. Emission rates 2021

Petrol kg/litre	Diesel		Electricity	
	Road kg/litre	Rail kg/litre	Road kg/kWh	Rail kg/kWh
2.071	2.420	2.669	0.392	0.363

Source: WebTAG Table A3.3; electricity emissions adjusted for RO grid factor

A table of emission rates presents GHG emissions by fuel type for the two scenarios, adjusted by the assumed annual fuel efficiency improvement.

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GHG costs

Table S5. GHG emission rates

Year	Baseline					Adapted				
	Diesel		Electricity			Diesel		Electricity		
	Petrol kg/litre	Road kg/litre	Rail kg/litre	Road kg/kWh	Rail kg/kWh	Petrol kg/litre	Road kg/litre	Rail kg/litre	Road kg/kWh	Rail kg/kWh
2021	2.071	2.420	2.669	0.392	0.363	2.071	2.420	2.669	0.392	0.363
2022	2.071	2.420	2.669	0.379	0.350	2.045	2.389	2.634	0.373	0.346
2023	2.071	2.420	2.669	0.365	0.338	2.020	2.357	2.600	0.355	0.329
2024	2.071	2.420	2.669	0.352	0.325	1.994	2.327	2.566	0.337	0.312
2025	2.071	2.420	2.669	0.338	0.313	1.969	2.297	2.533	0.320	0.296
2026	2.071	2.420	2.669	0.325	0.300	1.945	2.267	2.500	0.302	0.280
2027	2.071	2.420	2.669	0.311	0.288	1.920	2.237	2.467	0.286	0.265
2028	2.071	2.420	2.669	0.297	0.275	1.896	2.208	2.435	0.270	0.249

The cost per tonne of carbon (equivalent) emitted is adjusted from the 2016 data presented in the EAV to the price base year in line with euro area inflation.

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GHG costs

Table S4. Carbon cost €/tonne

Year	2016 €/tonne	2021 €/tonne
2020	80	86.1
2021	97	104.4
2022	114	122.7
2023	131	141.0
2024	148	159.3
2025	165	177.6
2026	182	195.8
2027	199	214.1
2028	216	232.4

The cost per tonne is applied to the emission rates to produce a table of annual costs by fuel type for the two scenarios.

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GHG costs

Table S6. GHG emission costs €/2021

Year	Baseline						Adapted					
	Diesel			Electricity			Diesel			Electricity		
	Petrol €/litre	Road €/litre	Rail €/litre	Road €/kWh	Rail €/kWh		Petrol €/litre	Road €/litre	Rail €/litre	Road €/kWh	Rail €/kWh	
2021	0.216	0.253	0.279	0.041	0.038	0.216	0.253	0.279	0.041	0.038		
2022	0.254	0.297	0.327	0.046	0.043	0.251	0.293	0.323	0.046	0.042		
2023	0.292	0.341	0.376	0.051	0.048	0.285	0.332	0.367	0.050	0.046		
2024	0.330	0.385	0.425	0.056	0.052	0.318	0.371	0.409	0.054	0.050		
2025	0.368	0.430	0.474	0.060	0.056	0.350	0.408	0.450	0.057	0.053		
2026	0.406	0.474	0.523	0.064	0.059	0.381	0.444	0.490	0.059	0.055		
2027	0.443	0.518	0.572	0.067	0.062	0.411	0.479	0.528	0.061	0.057		
2028	0.481	0.562	0.620	0.069	0.064	0.441	0.513	0.566	0.063	0.058		

Sample road vehicle GHG emission costs per vehicle kilometre at various speeds are tabulated for the Baseline and Adapted scenarios. Values are provided for all sample speeds. Note however that the calculations may be unreliable for speeds greater than the maximum speeds specified in Table L1.

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GHG costs

Table S7. Sample road vehicle GHG emission costs per veh.km, €2021 Baseline scenario
(Year and custom speed are selected on page L. Fuel consumption)

Year	Vehicle category	Unit	Speed (km/h)							
			20	40	60	80	100	120	75	
2021	Car	petrol	€/veh.km	0.022	0.016	0.014	0.013	0.014	0.016	0.013
	Car	diesel	€/veh.km	0.021	0.016	0.014	0.014	0.015	0.017	0.014
	Car	electric	€/veh.km	0.009	0.007	0.009	0.011	0.014	0.017	0.011
	Bus	diesel	€/veh.km	0.103	0.073	0.061	0.058	0.061	0.070	0.059
	Bus	electric	€/veh.km	0.037	0.030	0.037	0.048	0.059	0.070	0.045
	LGV	petrol	€/veh.km	0.034	0.024	0.019	0.017	0.019	0.025	0.017
	LGV	diesel	€/veh.km	0.028	0.021	0.018	0.019	0.023	0.030	0.019
	LGV	electric	€/veh.km	0.008	0.007	0.008	0.011	0.013	0.015	0.010
	HGV1	diesel	€/veh.km	0.066	0.047	0.042	0.042	0.045	0.052	0.042
	HGV2	diesel	€/veh.km	0.137	0.095	0.079	0.072	0.069	0.069	0.073
	HGV	electric	€/veh.km	0.058	0.047	0.058	0.076	0.094	0.111	0.071
2030	Car	petrol	€/veh.km	0.056	0.042	0.036	0.034	0.035	0.041	0.034
	Car	diesel	€/veh.km	0.053	0.041	0.037	0.036	0.039	0.045	0.036
	Car	electric	€/veh.km	0.015	0.012	0.015	0.020	0.025	0.029	0.019
	Bus	diesel	€/veh.km	0.266	0.188	0.158	0.151	0.158	0.180	0.151

GHG emissions from trains are tabulated in terms of kgCO₂/train.km and €/train.km.

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GHG costs

Table S10. Rail GHG emission rates (kg/train.km)

Year	Baseline						Adap					
	Pasenger trains			Freight trains			Pasenger trains			Freight trains		
	Intercity	Regional	Suburban	Intercity	Regional	Suburban	Intercity	Regional	Suburban	Intercity	Regional	Suburban
2021	33.44	21.36	15.43	4.86	3.28	2.37	17.58	6.05	33.44	21.36	15.43	4.86
2022	33.44	21.36	15.43	4.69	3.17	2.29	17.58	5.84	33.01	21.08	15.23	4.62
2023	33.44	21.36	15.43	4.52	3.05	2.21	17.58	5.63	32.58	20.81	15.03	4.40
2024	33.44	21.36	15.43	4.36	2.94	2.12	17.58	5.43	32.16	20.54	14.83	4.17
2025	33.44	21.36	15.43	4.19	2.83	2.04	17.58	5.22	31.74	20.27	14.64	3.96
2026	33.44	21.36	15.43	4.02	2.71	1.96	17.58	5.01	31.33	20.01	14.45	3.75
2027	33.44	21.36	15.43	3.85	2.60	1.88	17.58	4.80	30.92	19.75	14.26	3.54
2028	33.44	21.36	15.43	3.69	2.49	1.80	17.58	4.59	30.52	19.49	14.08	3.34

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GHG costs

Table S11. Rail GHG emission costs (€2021/train.km)

Year	Baseline						Adap					
	Pasenger trains			Freight trains			Pasenger trains			Freight trains		
	Intercity	Regional	Suburban	Intercity	Regional	Suburban	Intercity	Regional	Suburban	Intercity	Regional	Suburban
2021	3.49	2.23	1.61	0.51	0.34	0.25	1.83	0.63	3.49	2.23	1.61	0.51
2022	4.10	2.62	1.89	0.58	0.39	0.28	2.16	0.72	4.05	2.59	1.87	0.57
2023	4.71	3.01	2.17	0.64	0.43	0.31	2.48	0.79	4.59	2.93	2.12	0.62
2024	5.33	3.40	2.46	0.69	0.47	0.34	2.80	0.86	5.12	3.27	2.36	0.66
2025	5.94	3.79	2.74	0.74	0.50	0.36	3.12	0.93	5.64	3.60	2.60	0.70
2026	6.55	4.18	3.02	0.79	0.53	0.38	3.44	0.98	6.14	3.92	2.83	0.73
2027	7.16	4.57	3.30	0.82	0.56	0.40	3.76	1.03	6.62	4.23	3.05	0.76
2028	7.77	4.97	3.59	0.86	0.58	0.42	4.09	1.07	7.09	4.53	3.27	0.78

GHG emissions from IWT vessels are tabulated in terms of €/ship.km.

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GHG costs

Table S12. IWT GHG emission costs (€2021/veh.km)

Year	Baseline	Adapted
2021	3.84	3.84
2022	4.51	4.45
2023	5.18	5.05
2024	5.86	5.63
2025	6.53	6.20
2026	7.20	6.74
2027	7.87	7.28
2028	8.55	7.80

A final table presents aggregated GHG costs of road vehicles for use in the assessment of rail projects. The costs are shown in terms of €/pax.km and €/ton.km for the price base year and a custom year that can be specified on sheet L. **Fuel consumption.**

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GHG costs

Table S13. Aggregated GHG costs of road vehicles for rail projects

		Baseline		Adapted	
		2021	2030	2021	2030
Car	€/pax.km	0.008	0.019	0.008	0.016
Bus	€/pax.km	0.002	0.006	0.002	0.005
LGV	€/ton.km	0.019	0.047	0.019	0.038
HGV	€/ton.km	0.007	0.019	0.007	0.017

AI.25. Air pollution

An assessment can use either combined local Air Pollution tables or separate PM and NOx tables, but should not use both.

Local air pollution costs in sheet T. **Air pollution** based on the 2019 Handbook on External Costs are presented by passenger kilometre, tonne kilometre and vehicle kilometre by type of vehicle (car, bus, LGV, HGV, train and IWT) and fuel (petrol, diesel and electricity) by year. In years beyond the price base, costs are increased in line with GDP/capita with an elasticity of 0.8 applied. The Handbook does

not provide data directly for electric road vehicles, but includes data from COPERT that enables an estimate to be made. The 2016 cost of air pollution created by electric cars is about 16.7% that of conventionally fuelled cars, while that of electric LGVs is about 7.8%.

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Air pollution costs

Tables

Table T1. Total air pollution costs per passenger kilometre and tonne kilometre, €2021

Year	€/pax.km							€/tonne.km				
	Car (petrol)	Car (diesel)	Car (electric)	Bus (diesel)	Bus (electric)	Train (electric)	Train (diesel)	LGV (petrol)	LGV (diesel)	LGV (electric)	HGV (diesel)	HGV (electric) Tra
2021	0.006004	0.010761	0.000700	0.010430	0.000000	0.000105	0.004736	0.077591	0.069758	0.001717	0.010394	0.000000
2022	0.006246	0.011196	0.000728	0.010851	0.000000	0.000110	0.004927	0.080723	0.072574	0.001787	0.010813	0.000000
2023	0.006373	0.011423	0.000743	0.011072	0.000000	0.000112	0.005028	0.082364	0.074049	0.001823	0.011033	0.000000
2024	0.006438	0.011539	0.000750	0.011184	0.000000	0.000113	0.005079	0.083199	0.074800	0.001841	0.011145	0.000000
2025	0.006504	0.011657	0.000758	0.011299	0.000000	0.000114	0.005131	0.084054	0.075568	0.001860	0.011259	0.000000
2026	0.006572	0.011779	0.000766	0.011417	0.000000	0.000115	0.005184	0.084929	0.076356	0.001880	0.011377	0.000000
2027	0.007197	0.012899	0.000839	0.012503	0.000000	0.000126	0.005677	0.093008	0.083619	0.002058	0.012459	0.000000

AI.26. PM

An assessment can use either combined local Air Pollution tables or separate PM and NOx tables but should not use both.

PM emissions include both exhaust and non-exhaust PM₁₀ emissions. PM₁₀ particle mass includes both fine (below 2.5 µm) and coarse (between 2.5 and 10 µm) fractions of airborne particulate matter.

The formulae for the calculation of exhaust PM emissions are presented in sheet **U. PM** in terms of grams per kilometre by vehicle category for selected years, based on WebTAG. The formulae depend on speed and the user must therefore apply them according to modelled average link speeds. The tables present an indication of the valid speed ranges to which the formulae apply and sample calculations for minimum, user selected average and maximum speeds.

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PM costs

Tables

U1. Exhaust PM emissions parameter values (g/km)

----- Sample calculations -----														
Vehicle category	Year	a	b	c	d	e	f	g	Min speed km/h	Av speed km/h	Max speed km/h	Min speed g/km	Av speed g/km	Max speed g/km
Car (petrol)	2021	3.49805E-03	7.77435E-04	9.61460E-06	-4.39934E-07	9.00841E-09	-9.01603E-11	3.51205E-13	10	100	130	0.00119	0.00088	0.00170
	2026	2.37907E-03	6.22316E-04	5.75809E-06	-3.38664E-07	6.56547E-09	-6.29354E-11	2.48291E-13	10	100	130	0.00089	0.00059	0.00133
	2031	1.87287E-03	7.30685E-04	4.20501E-06	-3.16769E-07	5.84546E-09	-5.34376E-11	2.11583E-13	10	100	130	0.00093	0.00062	0.00137
	2036	1.46718E-03	7.81656E-04	3.15823E-06	-2.89409E-07	5.15983E-09	-4.54318E-11	1.79833E-13	10	100	130	0.00094	0.00063	0.00135
	2041	1.38804E-03	7.90451E-04	2.98054E-06	-2.84695E-07	5.04002E-09	-4.40038E-11	1.74032E-13	10	100	130	0.00094	0.00064	0.00134
Car (diesel)	2021	1.20402E-02	1.60286E-02	-2.36830E-04	2.22606E-06	-7.84992E-09	4.19675E-11	-9.09955E-14	10	100	130	0.01508	0.01016	0.01432
	2026	1.52400E-02	6.62689E-03	-1.19539E-04	1.61873E-06	-1.32114E-08	7.21654E-11	-1.58695E-13	10	100	130	0.00710	0.00343	0.00425
	2031	1.61936E-02	7.62913E-03	-8.81647E-05	1.61086E-06	-1.65000E-08	8.77966E-11	-1.28419E-13	10	100	130	0.00617	0.00344	0.00460

Values for intermediate years may be interpolated, while values for years beyond 2041 should be held constant.

A separate table presents non-exhaust PM emissions from tyre wear and brake wear by vehicle category and type of road.

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PM costs

U2. Non-exhaust PM emissions (g/km)

Vehicle category	Urban			Rural			Motorway		
	Tyre wear	Brake wear	Total	Tyre wear	Brake wear	Total	Tyre wear	Brake wear	Total
Car	0.00874	0.01168	0.02042	0.00680	0.00553	0.01233	0.00579	0.00136	0.00715
Bus	0.02118	0.05360	0.07478	0.01739	0.02714	0.04453	0.01398	0.00844	0.02242
LGV	0.01380	0.01822	0.03202	0.01074	0.00862	0.01936	0.00915	0.00212	0.01127
HGV1	0.02074	0.05100	0.07174	0.01739	0.02714	0.04453	0.01398	0.00844	0.02242
HGV2	0.04707	0.05100	0.09807	0.03824	0.02714	0.06538	0.03149	0.00844	0.03993

A final table presents the costs that are to be applied per tonne of PM exhaust emissions in metropolitan, urban and rural areas, and PM non-exhaust emissions. It is noted that the metropolitan area applies to

cities larger than 0.5 million inhabitants These costs are extracted from the 2019 Handbook on External Costs data annex for Romania, adjusted to the price base. In years beyond the price base, costs are increased in line with GDP/capita with an elasticity of 0.8 applied.

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PM costs

U3. PM costs per tonne, €2021

Year	PM exhaust			PM non-exhaust
	Metropolitan	Urban	Rural	
2021	345,984	111,936	53,424	20,479
2022	359,951	116,455	55,581	21,306
2023	367,269	118,822	56,711	21,739
2024	370,990	120,026	57,285	21,959
2025	374,803	121,260	57,874	22,185
2026	378,708	122,523	58,477	22,416
2027	414,732	134,178	64,039	24,548
2028	424,022	137,183	65,174	25,008

AI.27. NOx

An assessment can use either combined local Air Pollution tables or separate PM and NOx tables but should not use both.

The formulae for the calculation of NOx emissions are presented in the **V. NOx** sheet in terms of grams per kilometre by vehicle category for selected years, based on WebTAG. The formulae depend on speed and the user must therefore apply them according to modelled average link speeds. The tables present an indication of the valid speed ranges to which the formulae apply and sample calculations for minimum, user selected average and maximum speeds.

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NOx costs

Tables

V1. NOx emissions parameter values (g/km)

Sample calculations														
Vehicle category	Year	a	b	c	d	e	f	g	Min speed km/h	Av speed km/h	Max speed km/h	$L = (a + bv + cv^2 + dv^3 + ev^4 + fv^5 + gv^6) / v$ Min speed g/km	Av speed g/km	Max speed g/km
Car (petrol)	2021	-2.75193E-02	1.33465E-01	-1.22195E-03	-1.06496E-05	4.74778E-07	-4.36986E-09	1.40097E-11	10	100	130	0.11786	0.08239	0.10960
	2026	1.44527E-02	9.30617E-02	-1.22404E-03	1.02637E-05	2.53074E-09	-4.06549E-10	1.71088E-12	10	100	130	0.08329	0.05242	0.06047
	2031	1.90129E-02	8.71269E-02	-1.27847E-03	1.71942E-05	-1.28595E-07	5.94541E-10	-1.16260E-12	10	100	130	0.07784	0.05064	0.05577
	2036	1.65523E-02	8.80483E-02	-1.30898E-03	1.81086E-05	-1.42748E-07	6.92865E-10	-1.42287E-12	10	100	130	0.07829	0.05071	0.05549
	2041	1.58203E-02	8.83983E-02	-1.31651E-03	1.81986E-05	-1.43564E-07	6.97134E-10	-1.43228E-12	10	100	130	0.07850	0.05072	0.05545
Car (diesel)	2021	1.84399E+00	9.33174E-01	-1.40679E-02	9.53669E-05	4.88229E-07	-8.14384E-09	3.94983E-11	10	100	130	0.98684	0.56732	0.94345
	2026	1.44917E+00	7.23815E-01	-1.06833E-02	7.47048E-05	2.44334E-07	-4.94166E-09	2.60799E-11	10	100	130	0.76957	0.42799	0.70238
	2031	1.05910E+00	4.80768E-01	-6.91525E-03	4.86027E-05	1.55917E-07	-1.79185E-09	1.81340E-11	10	100	130	0.52961	0.28593	0.46586

Values for intermediate years may be interpolated, while values for years beyond 2041 should be held constant.

A second table presents the costs that are to be applied per tonne of NOx emission in urban and rural areas. These costs are extracted from the 2019 Handbook on External Costs data annex for Romania, adjusted to the price base. In years beyond the price base, costs are increased in line with GDP/capita with an elasticity of 0.8 applied.

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NOx costs

V2. NOx costs per tonne, €2021

Year	NOx	
	Urban	Rural
2021	24,677	14,246
2022	25,673	14,822
2023	26,195	15,123
2024	26,460	15,276
2025	26,732	15,433
2026	27,011	15,594
2027	29,580	17,077
2028	30,243	17,460

ANNEX II. FINANCIAL ANALYSIS

The aim of financial analysis is to assess whether the proposed project needs co-financing from EU funds. If so, the analysis then determines the co-financing contribution and checks whether the EU support is appropriate, whether the proposed project investment option is financially sustainable during the construction and operation phases, and/or whether there are adequate commitments to ensure its sustainability.

In practice, it means that the financial analysis should answer the following questions:

- What is the project financial profitability?
- What will be the EU contribution?
- How will the project be financed?
- What is the national capital profitability?
- Will the project be financially sustainable?

Taking into consideration the above, the following sequence of steps is recommended:

- Setting assumptions for the analysis;
- Determination of all cash flows for each year of analysis (calculation of project financial inflows and outflows);
- Calculation of financial indicators for the entire investment (C) (net present value – FNPV(C) and profitability or rate of return – FRR (C).);
- Calculation of co-financing contribution from EU funds;
- Calculation of financial indicators for the national capital (K) (net present value – FNPV(K) and profitability or rate of return – FRR(K)). For most projects (C) and (K) calculations are not required (see Table 4.2);
- Verification of the project financial sustainability.

Annex II.1. Assumptions and parameters

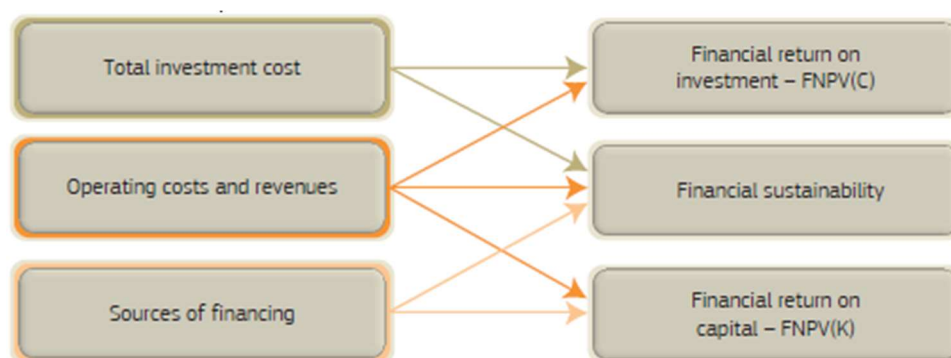
The following assumptions and parameters will be considered and presented in the financial analysis:

- The financial analysis will be carried out using the Discounted Cash Flow (DCF) method. An appropriate Financial Discount Rate (FDR) is adopted to calculate the present value of the future cash flows. The financial discount rate reflects the opportunity cost of capital. For the 2021-2027 programming period, the same FDR considered for the 2014-2020 programming period, respectively 4%, is to be used for transport sector projects in Romania.
- Only cash inflows and outflows are considered in the analysis. Depreciation, reserves, price and technical contingencies, and other accounting items which do not correspond to actual flows are disregarded.
- As a general rule, the financial analysis should be carried out from the point of view of the infrastructure owner. If, in the provision of a general interest service, the owner and operator are not the same entity, a consolidated financial analysis, which excludes the cash flows between the owner and the operator, should be carried out to assess the actual profitability of the investment.
- The financial analysis will be carried out considering the same appraisal period as the one in the economic analysis (see section 4.5.1 for details), and it should be clearly indicated.
- The financial analysis will be carried out in constant prices considering the same price base year as the one in the economic analysis (see section 4.5.3 for details), and it should be clearly indicated.
- The analysis should be carried out net of VAT, both on purchase (cost) and sales (revenues), if it is recoverable by the project promoter. If it is not the case, the VAT should be included.

- Direct taxes (on capital, income or other) are to be considered only for the financial sustainability verification and not for the calculation of the financial profitability, which is calculated before such tax deductions.
- All other input data and assumptions for the analysis must be coherent with the economic analysis data and transport forecasts (in particular, traffic forecast).

The structure of the financial analysis and the elements to be included are presented in the figure and table below, sourced directly from the 2014 CBA Guide:

Figure All.1. Structure of the financial analysis



Source: 2014 CBA Guide

Table All.1. Elements to be included in the financial analysis

	FNPV(C)	SUSTAINABILITY	FNPV(K)
Investment costs			
Start-up and technical costs	-	-	
Land	-	-	
Buildings	-	-	
Equipment	-	-	
Machinery	-	-	
Replacement costs	-	-	-*
Residual value	+		+
Operating costs			
Personnel	-	-	-
Energy	-	-	-
General expenditure	-	-	-
Intermediate services	-	-	-
Raw materials	-	-	-
Other outflows			
Loan repayments		-	-
Interests		-	-
Taxes		-	
Inflows			
Revenues	+	+	+
Operating subsidies		+	
Sources of financing			
Union assistance		+	
Public contribution		+	-**
Private equity		+	-
Private loan		+	

* Only if they are self-financed by the project revenues. Otherwise, if new sources of financing (either equity or debt) are needed to sustain them, these sources must be displayed within the outflows at the time they are disbursed.

** Operating subsidies shall not be accounted in order to avoid double counting with the operating costs outflow.

Source: 2014 CBA Guide

All.2. Financial cash flows

The financial analysis considers the financial flows of the project during construction and during operation. Financial flows should be determined for the WOP and WP scenarios for the purpose of further calculation of incremental flows used in the calculation of financial indicators and specification of the amount of the financial contribution from EU funds.

The cash flows to be included in the financial analysis are:

- Investment costs
- Operation and maintenance costs
- Revenues
- Residual value
- Source of financing.

The elements which constitute the investment and O&M costs are the same as the ones considered in the economic analysis (see sections 4.7.3 and 4.7.4), only that financial flows will be considered. The residual value can be calculated using either the net present value of the cash flows over the remaining lifetime of the project beyond the end of the reference period, or the depreciation method (see section 4.7.4).

Project revenues

The project revenues are defined as the '*cash in-flows directly paid by users for the goods or services provided by the operation, such as charges borne directly by users for the use of infrastructure, sale or rent of land or buildings, or payments for services*'.

Project revenues should include all revenues from all sources such as:

- Road tolls;
- Concessionaire payments, for example for the operation of road service areas;
- Rail track access charges;
- Ticket fares e.g., for public transport modes, where applicable.

Transfers or subsidies (e.g., transfers from state or regional budgets) and other financial income must not be considered revenues and included in the financial analysis as they are not directly attributable to the project operations. Though, they should be included in the sustainability analysis.

Sources of financing

The main sources of financing in the EU co-financed context can be:

- Union assistance;
- national public contribution (including, always, the counterpart funding from the OP plus additional grants or capital subsidies at central, regional or local government level, if any);
- project promoter's contribution (loans or equity), if any;
- private contribution (e.g., under a PPP, (equity and loans)), if any.

All.3. Project financial profitability

Generally, the calculation of the financial indicators on entire investment and national capital is not required (see Table 4.2). However, in case there is a specific need for these indicators to be calculated on a particular project, the instructions below apply.

This point of the analysis involves calculation of financial indicators for the project, based on which the profitability assessment is performed. Two basic groups of indicators are distinguished:

- Profitability indicators for the entire investment (project costs) – the so-called (C) indicators.
- Profitability indicators for the national capital – (K) indicators.

Financial indicators are calculated in the same way as economic indicators but using the financial cash flows. They include:

- Net present value (FNPV) which is the sum of the discounted financial flows of the project.
- Internal rate of return (FRR), defined as the discount rate that results in an FNPV equal to zero.

Details on the elements to be included in the calculations of the financial indicators for both the entire investment (C) and national capital (K) are provided in table AII.1 above.

Firstly, a consolidated analysis should be carried out to calculate the overall investment profitability. For a project to require contribution from EU Funds, the FNPV (C) should be negative and the FRR(C) should be lower than the financial discount rate used in the analysis. If a project has high financial profitability (e.g., the FRR(C) is significantly higher than the FDR), the investor can implement the project without EU support. Generally, transport projects are non net-revenue generating projects and therefore the FRR(C) will be negative.

Sample calculations of the profitability indicators for the entire investment are presented in the table below, sourced directly from the 2014 CBA Guide.

Table AII.2. Sample calculations of FNPV (C) and FRR (C)

	Years							
	1	2	3	4	5-9	10	11-29	30
Total revenues				11,598	...	12,011	...	12,222
Residual value								4,265
Total inflows	0	0	0	11,598	...	12,011	...	16,487
Total operating costs				5,561	...	5,662	...	5,713
Initial Investment	8,465	75,176	42,890					
Replacement costs						11,890	9,760	
Total outflows	8,465	75,176	42,890	5,561	...	17,552	...	5,713
Net cash flow	-8,465	-75,176	-42,890	6,037	...	-5,540	...	10,774
FNPV(C)	- 34.284							
FRR(C)	1.4%							

A financial discount rate of 4 % has been applied to calculate this value.

Source: 2014 CBA Guide

Secondly, to check that any profit generated by EU support is not unduly high, the return on capital is calculated as well.

Sample calculations of the profitability indicators for the national capital are presented in the table below, sourced directly from the 2014 CBA Guide.

Table All.3. Sample calculations of FNPV (K) and FRR (K)

	Years							
	1	2	3	4	5-9	10	11-29	30
Total revenues				11,598	...	12,011	...	12,222
Residual value								4,265
Total inflows	0	0	0	11,598	...	12,011	...	16,487
Public contribution	3,148	27,956	15,950					
Private equity	1,085	9,632	5,495					
Loan repayment (including interest)					1,789	1,789	1,789	
Total operating & replacement costs				5,561	...	17,552	...	5,713
Total outflows	4,233	37,588	21,445	5,561	...	19,341	...	5,713
Net cash flow	-4,233	-37,588	-21,445	6,037	...	-7,329	...	10,774
FNPV(K)	11,198							
FRR(K)	5.4 %							

The loan is here an outflow and is only included when reimbursed. In this example, it is assumed to be paid back in ten constant payments starting in year 5.

In this example, replacement costs are self-financed with the project revenues. Accordingly, they are treated as operating costs.

Source: 2014 CBA Guide

All.4. Funding gap calculation

The funding gap is to be calculated in the same manner as for the 2014-2020 programming period. The steps are shown in the table below. We note that the majority of transport projects are non net-revenue generating projects, and therefore for subsectors which are not revenue generating (e.g., untolled roads), the funding gap calculation is not required and is set to 100%. All transport projects that are revenue generating require a funding gap calculation.

Table All.4. Funding gap calculation

	Main elements and parameters	Value	
1	Reference period (years)		
2	Financial discount rate (%) ⁽¹⁾		
	Main elements and parameters	Value Not discounted	Value Discounted (Net Present Value)
3	Total investment cost excluding contingencies		
4	Residual value		
5	Revenues		
6	Operating and replacement costs		
Pro-rata application of discounted net revenue⁽²⁾			
7	Net revenue = revenues – operating and replacement costs + residual value = (5) – (6) + (4)		
8	Total investment cost – net revenue = (3) – (7)		
9	Pro-rata application of discounted net revenue (%) = (8) / (3)		

* Where VAT is recoverable, the costs and revenues should be based on figures excluding VAT.

⁽¹⁾ Preferably in real terms.

⁽²⁾ This does not apply: 1) for projects subject to the rules on State aids in the meaning of Article 107 of the Treaty (see point G1); and 2) if the sum of the present values of operating and replacement costs are higher than the present value of revenues the project is not considered as revenue generating, in which case items 7 and 8 can be ignored and pro-rata application of discounted net revenue should be set at 100%.

All.5. Financial sustainability of the project

The project is financially sustainable if there are sufficient funds to cover the expenses during the construction stage and the operation stage. The aim of the financial sustainability check is to demonstrate that the project beneficiary will be able to bear all financial expenditures required to maintain the operational services throughout the reference period. All costs need to be included, such as routine O&M costs and rehabilitation costs.

A project beneficiary must prove or show clear commitment that it has sufficient financial resources that will consistently match disbursements in the years to come to ensure an adequate level of service of the infrastructure. Revenues must be sufficient to cover O&M expenditures or supplemented with operational subsidies. Cumulated undiscounted net cash flows must be non-negative for all years of the reference period. In the case of non-revenue generating projects, it must be indicated how costs will be covered with a clear commitment of the beneficiary/operator to provide adequate funding from other sources to ensure the sustainability of the project.

Details on the elements to be included in the financial sustainability analysis are provided in table All.1 above.

Sample calculations performed for the financial sustainability analysis are presented in the table below, sourced directly from the 2014 CBA Guide.

Table All.5. Sample calculations for the financial sustainability analysis

	Years							
	1	2	3	4	5-9	10	11-29	30
Sources of financing	8,465	75,176	42,890					
Total revenues				11,598	...	12,011	...	12,222
Total inflows	8,465	75,176	42,890	11,598	...	12,011	...	12,222
Initial investment	8,465	75,176	42,890					
Replacement costs						11,890	9,760	
Loan repayment (including interest)					1,789	1,789	1,789	
Total operating costs				5,561	...	5,662	...	5,713
Taxes				604	...	-733	...	651
Total outflows	8,465	75,176	42,890	5,561	...	19,341		5,713
Net cash flow	0	0	0	6,037	...	-7,329	...	6,509
Cumulated net cash flow	0	0	0	6,037	...	20,726	...	133,835

The cumulated cash flow should be zero (or positive) during the construction phase

Financial sustainability is verified if the cumulated net cash flow row is greater than zero for all the years considered.

ANNEX III. PROJECT COMPLETION REPORT

The MA requires that a Project Completion Report (PCR) is undertaken for selected projects. The PCR should be a brief document (ca. 10 pages) and be completed about 1 year after the opening of the project.

The main aims of the Project Completion Report are:

- (i) to understand whether the basis on which the project was approved proved correct;
- (ii) to check whether the expected benefits materialised; and
- (iii) to see what lessons, if any, may be drawn which may be applicable to other projects under development.

The PCR should contain the following sections:

- (i) **Project concept.** This should review the development of the project concept, what was the need for the project, what objectives were set for it, whether it was included in relevant transport programmes/masterplans or operational programmes. It should conclude whether the project was correctly established and whether the project objectives were clearly stated.
- (ii) **Project development.** The PCR should critically review the project development stages, commenting on the appropriateness of e.g., demand analysis, options analysis, financial analysis, economic analysis, risk analysis, selected design.
- (iii) **Project Implementation.** The PCR should discuss whether: the management of the project during implementation was of good quality; the required periodic monitoring reports were timely and of good quality; any issues relating to quality of completed works were noted; the project outturn costs met the costs outlined at design stage; and whether there were any slippages to schedule. The PCR should discuss changes to the project during implementation; the extent to which such changes affected time or budget; whether variations to contract could have been anticipated in advance; whether active value for money management was evident during construction phase. The PCR may also discuss whether there were any design changes during implementation, whether all contractual obligations were met and whether there were any contractual claims made / outstanding.
- (iv) **Post-opening performance.** This section of the PCR should review whether the listed project objectives were met, whether forecast traffic volumes were achieved (if not detailing what went wrong and any lessons to be learnt for appraisal of similar projects going forward). The section may also comment on whether there have been any safety issues in early operational stage (and if so, what is being done to correct them), and detail any actions needed to ensure that forecasted benefits materialise.