LICCER

LICCER Model Guidelines Report

Report Nr 4.1

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1 Introduction

Energy use and greenhouse gas (GHG) emissions associated with road transport system do not only take place during vehicles operation, but also in the life cycle of road infrastructure. That is, they also result from road construction and operation (including maintenance), and from demolition and waste processing of obsolete road infrastructure. These GHG emissions and energy use can be divided into direct and indirect ones. Direct GHG emissions and energy use originate from on-site processes during construction (e.g. earthworks), and operation (e.g. transport of resurfacing materials). Indirect GHG emissions and energy use relate to offsite production of materials and energy carriers used during construction and operation (upstream processes), and to demolition and waste processing of obsolete road infrastructure (downstream processes). To get knowledge of the total energy use and GHG emissions, i.e. both the direct and indirect ones, a life cycle perspective should be applied.

Several studies estimated the relation between energy use associated to road infrastructure (direct and indirect) and the energy use for the overall transport systems. The numbers vary widely between these studies, and go from a few percent up to a quarter for the share of infrastructure in the total energy used for road transport systems. Even though the exact energy use and GHG emissions for road infrastructure are not clear from the scientific literature, this energy use and GHG emissions should definitely not be neglected.

Legally required environmental assessment (EA) procedures, like strategic environmental assessment (SEA) and environmental impact assessment (EIA), should in principle cover all possible environmental impacts. This also includes energy use and greenhouse gas (GHG) emissions. Nevertheless, current practice shows that EAs often do not address direct and indirect energy use and GHG emissions related to road infrastructure (i.e. from construction and operation of road infrastructure) (Finnveden and Åkerman, 2011, Hildén et al. 2004).

The Institute of Environmental Management and Assessment (IEMA, 2011) states that ¨the EIA process should, at an early stage, influence the location and design of projects to optimise GHG performance and limit likely contribution to GHG emissions¨. Browning and Stewenson (2011) conclude that the greatest opportunity to reduce GHG emissions during the lifetime of infrastructure projects exists at the earliest stages (investment planning and selection of options).

Norway seems the only European country that systematically quantifies life cycle energy use and GHG emissions as part of the Cost Benefit Analysis (CBA) required for both SEA and EIA during Partial Municipal Master Planning of road infrastructure (when choice of road corridor is decided) (Kluts and Miliutenko, 2012). To this purpose, Norwegian road administration employs the EFFEKT model that assesses direct and indirect energy use and GHG emissions of road infrastructure based on a limited set of data reflecting Norwegian conditions in early stage of road infrastructure planning. There exist other models for quantifying energy use and GHG emissions related to road infrastructure, but the EFFEKT model is unique in covering both direct and indirect contributions, and calculating this from a limited set of data. The latter makes the EFFEKT model suitable for use in the early stages of road infrastructure planning when exact road designs are not yet known, but decisions about road corridor alternatives have to be taken.

Other European countries are also in need of a model enabling quantification of direct and indirect energy use and GHG emissions in the early stage of road infrastructure planning. Therefore the LICCER model has been developed, inspired by the EFFEKT model, but with higher flexibility towards different national contexts. In LICCER the user input road corridor alternatives to the model. The model quantifies energy use and GHG emissions for each alternative based on a set of algorithms and default data included in the model. Default data can be inserted for different countries. An additional value of the LICCER model that is tentatively quantifies the energy use and GHG emissions from traffic, in addition to that from the road infrastructure.

The LICCER model is designed for generating information supporting the early stage of decision-making of road infrastructure. An obvious dilemma in the early stage planning of roads is the fact that much information and quantitative data about given road corridor alternatives do not yet exist. Nevertheless accurate estimates of the energy consumption and GHG emissions are needed. This dilemma was carefully discussed at the 2nd LICCER workshop. The overall recommendation from participants was to aim for a model with simplicity and a limited number of required data inputs, without compromising the need for accuracy and robustness. In order to achieve this, the user is recommended to spend more efforts for infrastructure-heavy road projects (e.g. project with a high share of tunnels, bridges, and earthwork). While, for less infrastructure-heavy projects the input parameters can be neglected or taken into account by use of default values that are predefined in the model. That is, LICCER can be used with a limited set of data or, more precisely, without knowing yet how the planned piece of road infrastructure will exactly look. This enables a screening evaluation of the direct and indirect energy use and GHG emissions at the stage of the planning process where different road localisation options are assessed. However, the LICCER model can also be used later in the planning process, for example for optimization purposes, as more details about design and construction quantities are known.

Purpose of the Guide

By considering following issues, this guide aims to describe how the LICCER model can be used to integrate energy and climate in early planning of road infrastructure. The guideline is divided in two parts, presenting both:

i) When and why the model should be used related to the planning process (Chapter 2), and
ii) How the model should be used in practice (Chapter 3).

2 When and why to use the LICCER model

2.1 LICCER as a part of the decision making-process of roads

The decision on where to build a road and what road elements to use often takes place in several steps (see Table 1). In the project specific process the first stage involves decreasing the number of alternative road corridors (stage 2a). In the next step (stage 2b) a decision on one specific road corridor are based on these alternatives. The LICCER model is primarily developed for supporting decision-making in this second step (2b) where already preliminary information about the alternatives is known, e.g. length and type of road elements (i.e. roads, tunnels, bridges). The exact quantities and type of materials in the road elements, is often not yet known. The LICCER model therefore provides possible default design options and data for evaluating alternatives. These defaults can optionally also be specified and in that case the LICCER model would be suitable for decision-support related to the specific construction of road elements when the formal decision on road elements and design is taken (stage 3).

Before a decision on a plan or a project is approved, the European Union legally requires the performance of Environmental Assessments (EAs) to ensure that environmental implications are taken into account. With regards to the use of EAs, three main levels of decisions can be distinguished during transport planning process.

1) Choice of transport modality at the national level (SEA):

2) Choice of road corridor and construction type of a specific project (SEA/EIA):

3) Choice of specific construction type and design (EIA):

Table 1: General planning process and moments of decisions (based on Kluts and Miliutenko, 2012).

	Planning stage	Main task/decision	Impact Assessment
1	Modality – national	Is there need for a new infrastructure?	SEA
2	(a) Modality – project specific - many to a few alternatives	What are alternative solutions for solving mobility problems?	(SEA)
	(b) Localization / route of road corridor - few to one alternative	Where should the road be constructed? Choice of road corridor.	SEA/EIA
3	(a) Construction type	What specific type of construction of road elements (i.e. road, bridges, tunnels)?	EIA
	(B) Construction design	How should the construction be designed (choice of materials etc.)?	-

The LICCER model was originally developed to be integrated within EIA/SEA. However during the project the project team realized that the implementation could be done in a number of different ways. The LICCER project has identified three possible approaches to implementing the model results into the practice of supporting decision-making. These approaches should be considered as overall guidance. As specific practice varies between different countries, the model needs to be implemented specifically for and adapted to each countries transport planning process.

The three main approaches are as follow:

A. Integrated within the Impact Assessment process (SEA and/or EIA) as part of the impact analysis.

B. Integrated with the overall assessment. In such assessment all decision perspectives are gathered and evaluated; the socioeconomic perspective, the distributional perspective, and the goal-fulfillment perspective.

C. Integrated within the socio economical assessment, i.e. as a part of the Cost Benefit Calculations. The LICCER model present life cycle energy use and GHG emissions as input to the Cost Benefit Analysis (CBA). The LICCER model does not calculate the economic value of energy use and GHG emissions, only their physical units.

Figure 2 gives a schematic overview of the use of the LICCER model in the transport decision and planning process. In practice, the three processes A, B and C is somehow integrated. The overall assessment could for example be part of the CBA. The CBA could also be integrated within the EIA/SEA process. However, the different practices vary between countries. We have therefore here chosen to present it as three separate components of the decision support.

The different usages of the model have different benefits. For example, including the model within socio economic assessments possibly gives the model the best opportunity to influence the overall decision. On the other hand including the LICCER model within the Impact Assessments process provides opportunity both as decision support, but also as a tool to reduce energy use and GHG emissions of the road through mitigation measures within the design and construction phase.

Examples of possible mitigation measures that could be included in the EIA and later in the Environmental Management Plan (EMP) could be for example:

- Avoiding energy consuming locations within a road corridor (i.e. sites requiring a lot of soil stabilisation or heavy road structures).

- Development of lean constructions

- Decreasing transport distance to storage sites of material

- Reducing the energy use from lightning, ventilation and dewatering

- Dimensioning of the elements in order to decrease the future need for maintenance and reinvestments

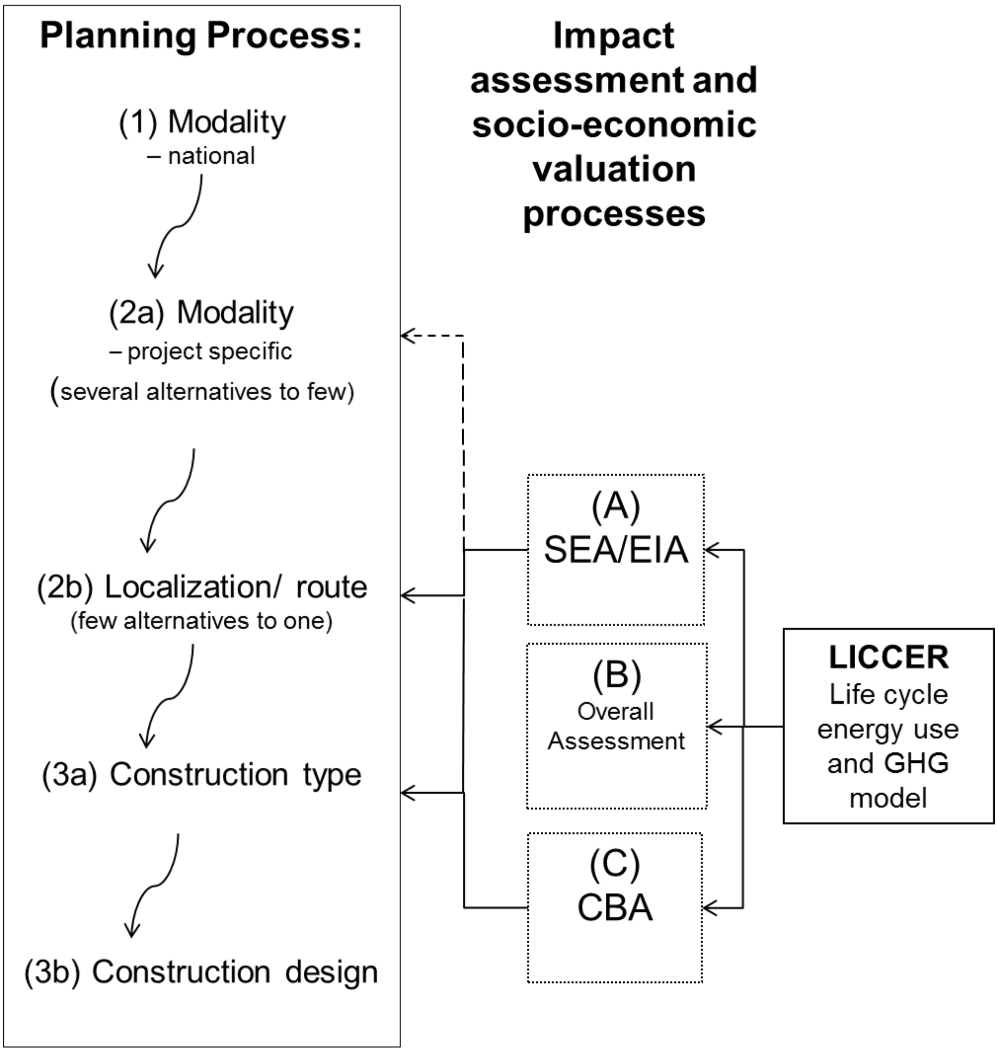


Figure 1: Suggested use (A, B and C) of the LICCER model in the transport decision and planning process

2.2 Illustration of the result from the LICCER model

The LICCER-model generates different types of output (see below). All LICCER-output results are expressed in annual energy consumption (GJ/year) and greenhouse gas (GHG) emissions (tons CO_2-e/year). The results are given using a functional unit representing 1 year of operation of a given road corridor between two locations, on average for the defined analysis time horizon with a defined traffic characteristic and road geometry, taking into account the service life of the different road infrastructure components. This means that the total contribution of the road infrastructure is allocated to one year of operation, and then the contributions from traffic on the road during one year is added to the allocated contribution from infrastructure.

The functional unit makes it possible for road planners to examine in a systematic and transparent way how each route or road corridor alternative performs regarding energy and GHG emissions, and what are the reasons for such performance profiles.

The LICCER model offers two calculation modes to analyse up to four road alternatives. Alternative 0 represents "Today's road" (i.e. an existing road) that often can still be used also in future, partly or as a whole, while the other three alternatives represent upgraded versions of today's road and/or new constructions in new routes (road corridors). In the Comparison mode, individual routes are compared against each other, with in principle Alternative 0 as the reference. If Alternative 0 or today's route is unable to carry the future traffic load, then Alternative 1 as one of the new routes is taken as the reference. In the Adding-Up mode, one new route (now containing in-series road sections) can be compared to Alternative 0 as reference. In this mode one can also do the analysis without a reference, and if so, one may or may not include Alternative 0 as one of the sections in a new route. This can be useful in situations where a part of today's road (to be specified in Alternative 0) is a candidate for inclusion in a new route alternative, therefore made up of sections.

The results of the model are presented in three different ways:

1. Individual presentation and breakdown of aggregated results for each alternative, separately (see example of results in figure 2 and 3).
2. Presentation and breakdown of aggregated results for each new alternative can be seen compared with the reference alternative, when the user has chosen the **'Comparison mode'** for analysis. This mode is to be chosen when alternative 1, 2 and 3 represent individual new alternative routes of the road corridor and each of them is to be compared with the reference (see example of results in figure 4 and 5).
3. Presentation and breakdown of aggregated results for the sum of a series of new alternatives can be seen compared with the reference alternative, when the user has chosen the **'Adding-Up'** for analysis. This mode is to be chosen when alternative 1, 2 and 3 are in-series sections of one new route of the road corridor, which is to be compared with the reference (see example of results in figure 6 and 7)

The model also provides presentation and breakdown of aggregated results showing the contribution of different material input types for road infrastructure and of different fuel types for traffic during operation (see example of results in figure 8 and 9). These results are reported both in the Comparison mode and the Adding-Up mode.

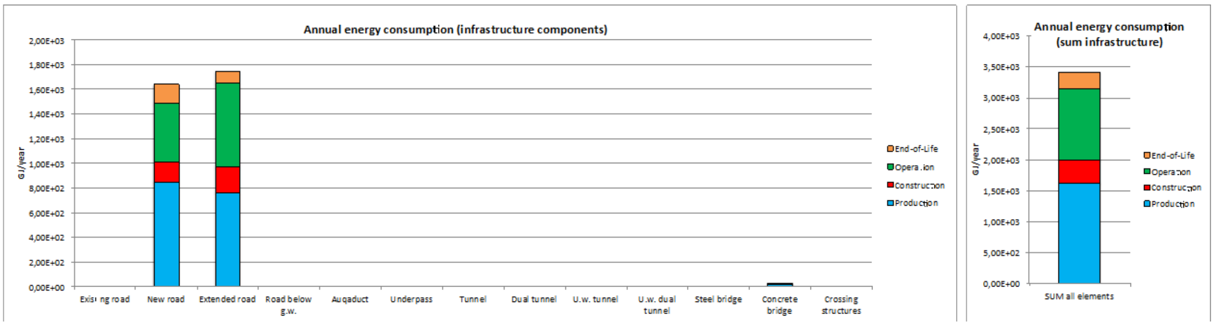


Figure 2: Annual energy consumption from road infrastructure elements in each of the four life cycle stages (Production, Construction, Operation and End-of-Life)

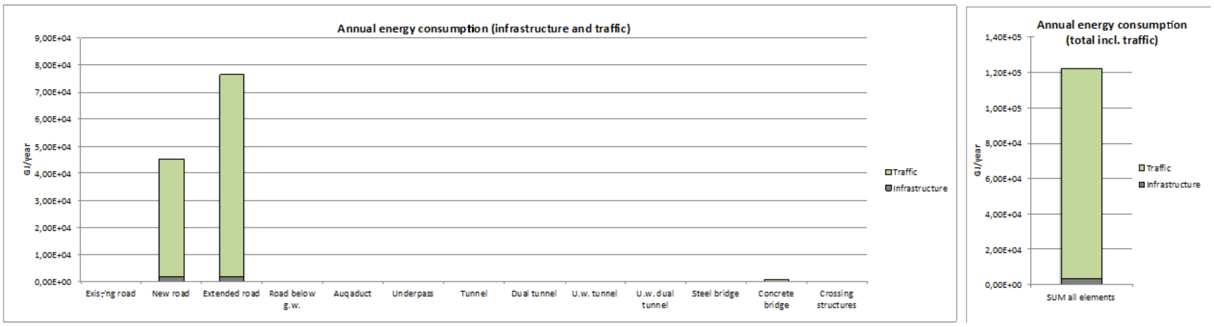


Figure 3: Annual energy consumption from road infrastructure elements and traffic

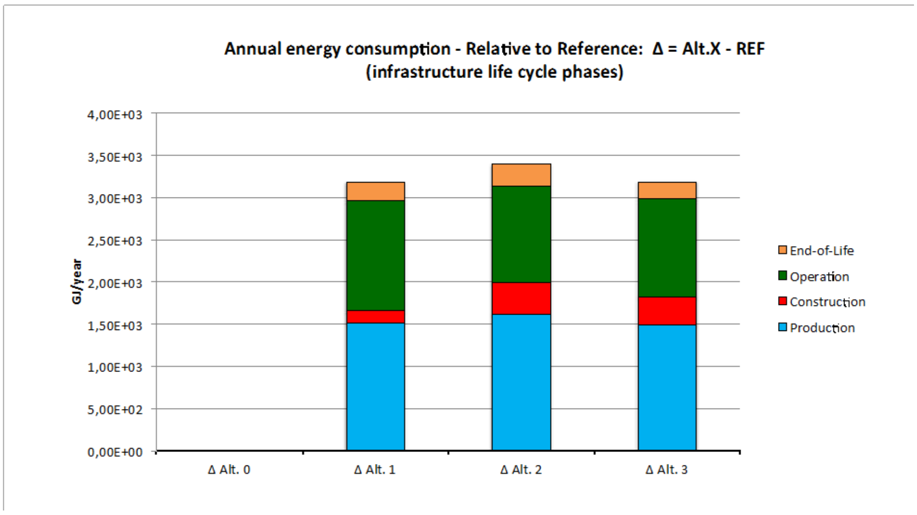


Figure 4: 'Comparison' mode - Annual energy consumption from road infrastructure, relative to a reference alternative

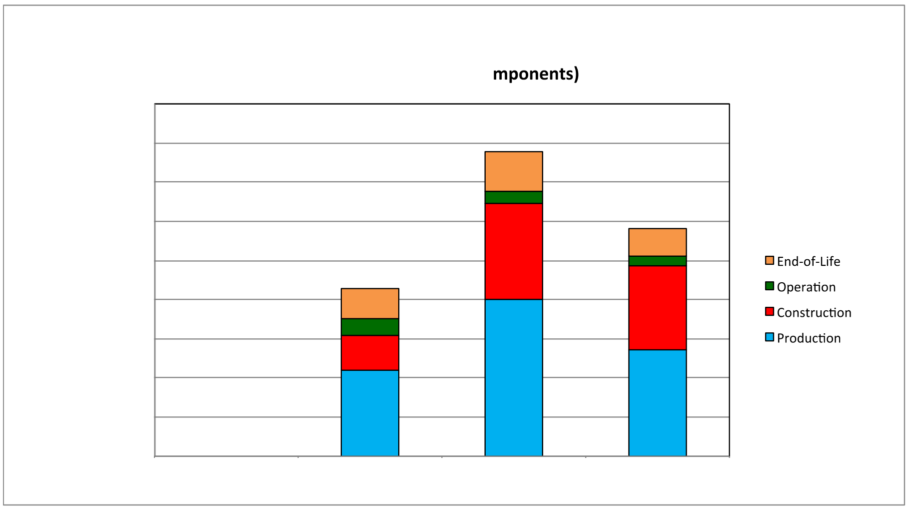


Figure 5: 'Comparison' mode - Annual GHG emissions from road infrastructure, relative to a reference

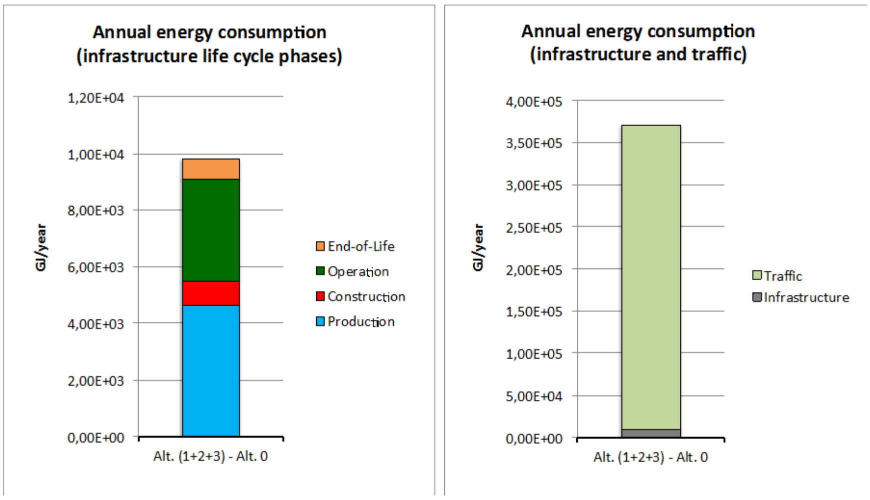


Figure 6: 'Adding Up' mode - Annual energy consumption from road infrastructure and traffic

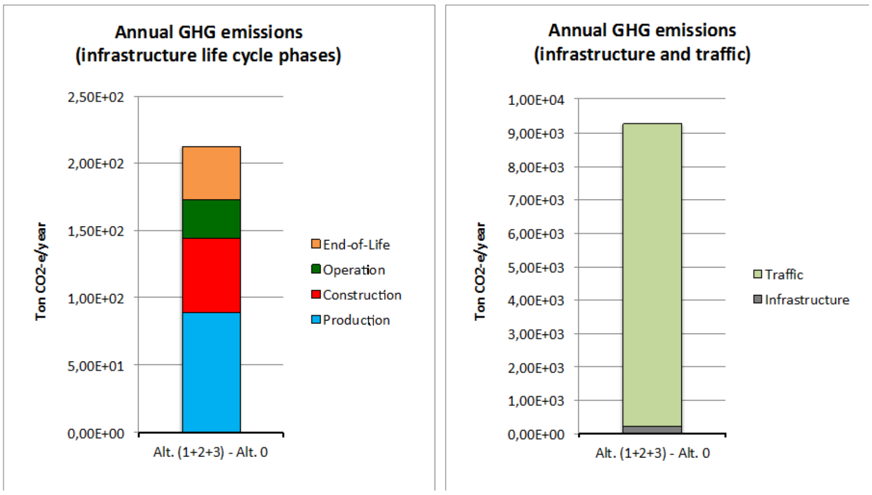


Figure 7: 'Adding Up' mode - Annual GHG emissions from road infrastructure and traffic

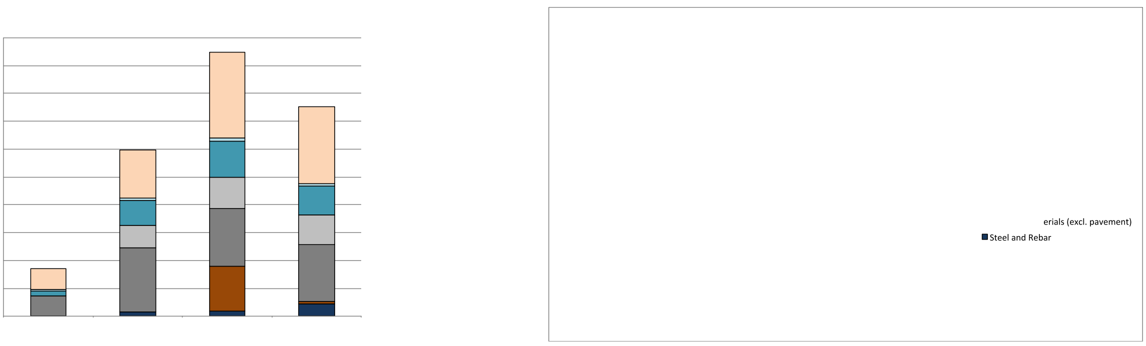


Figure 8: Annual GHG emissions and energy consumption from road infrastructure; contributions from different material input types

Figure 9: Annual GHG emissions and energy consumption from traffic; contributions from different fuel types

2.3 Application of LICCER model result

The different types of output from LICCER could be used with slightly different purposes within the transport planning process. The output presenting road infrastructure elements for each alternative (figure 2 and 3) can be used both for gaining overall knowledge about energy and GHG emission within the road infrastructure in general as well as for specific projects. In addition, this way of presenting the result gives important information on areas of improvements. That is, it can give input to the suggestions of suitable mitigation measure within the SEA/EIA process. Also the aggregated results in figure 9 and 10 provide valuable information for choosing mitigation measures.

The output of LICCER presented in the 'Comparison' mode (figure 4 and 5) is specifically intended to be used as a basis for choosing route corridor alternative.

The purpose of the adding up mode is to increase the flexibility of the LICCER model in practical use. The main benefits from using the 'Adding-Up' mode is that it is possible to analyse the sum of new road corridor alternatives that are located as number of in-series sections (successively following each other) on the way from “A” to “B”. This mode is intended for situations in which one new road corridor alternative in the project is not constant in its cross-section geometry along its whole length. For example, in a case where the number and width of lanes or depth of pavement layers varies, three different geometry conditions could be modelled as three in-series sections, together representing one new road corridor alternative. Similarly, two different geometry conditions could be modelled as two in-series section (leaving the third empty). And likewise, more than three in-series sections can be examined (if needed) by running the model in 'Adding-Up' mode in more than one analysis run. The comparison mode does not allow for modelling of a road corridor alternative with varying road cross-section geometry along its length. One can also use a defined part of an existing road as Alternative 0 in the 'Adding-Up' mode, and include this as one of the sections on the way from “A” to “B”. This is likely to be a common situation, since parts of an existing road may be used within a new road project.

3 How to use the LICCER model

3.1 Installing LICCER model

The LICCER model is developed as an MS-Excel tool. You need to have Microsoft Excel 2010 (or later version) installed at your computer in order to be able to use all functionalities of the model, such as the macros in the model.

The model is accompanied with two files:
'LICCER_D4.1_Guideline_Report.pdf' (current document) and
'LICCER_D4.2_Technical_Report.pdf'.

Please store these reports in the same folder as the one in which the Excel-file is stored containing the actual LICCER model. Only then it is possible to open both files directly from the link in the Excel model. Links to those reports are marked in red circle in Figure 10.

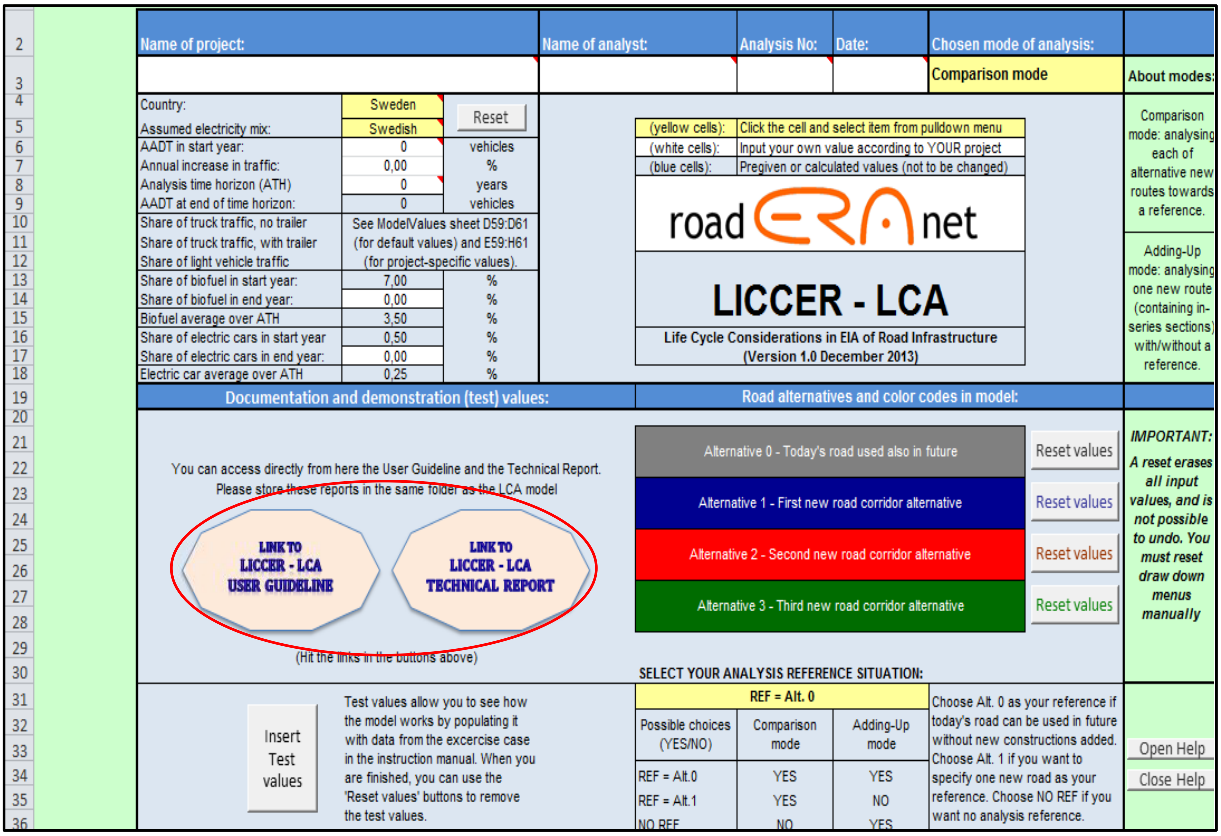


Figure 10: Part of first sheet of the Excel model (RoadDesign) with links to User Guideline and Technical Report (marked in red circle)

3.2 Overview of the LICCER model

The LICCER model consists of ten Excel sheets (Figure 11). Each Excel sheet is shortly elucidated in this section. A more detailed description of these Excel sheets is given in the sections below (Section 3.3 - 3.9). Some Excel sheets contain background information (i.e. 'Calculations' and 'DataSources' in Figure 11), and don't need to be opened by a user not interested in this type of information. Most Excel sheets need, or may need action from the user in order to run the LICCER model and see its results. This section also provides some general information, i.e. relevant for all Excel sheets, about how to navigate through the model.

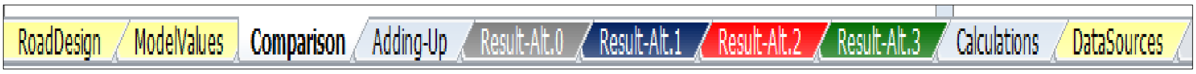


Figure 11: Sheets included in the LICCER model (as shown in Excel model)

'RoadDesign' sheet allows the user to fill in general information about the project and architecture of considered road corridor alternatives (Section 3.3).

'ModelValues' sheet consists of default values for service life, transport distances, fuel and material consumption, tunnel geometry, as well as cradle to gate energy use and GHG emissions of materials and energy carriers (Section 3.4).

'Comparison' sheet reports the difference (Δ) between each of the new alternatives (1, 2 and 3) and the reference alternative (0) in terms of GHG emissions and energy consumption (Section 3.5).

'Adding-Up' sheet shows the difference (Δ) between the sum of the different parts of road corridor and the reference alternative (0) in terms of GHG emissions and energy consumption (Section 3.6).

'Result-Alt.0', 'Result-Alt.1', 'Result-Alt.2' and 'Result-Alt.3' sheets show absolute results for each alternative, i.e. corresponding absolute contributions to annual GHG emissions and energy consumption of the main components and life cycle phases of the road infrastructure, and the annual total emissions and energy use of traffic on the road during operation (Section 3.7).

'Calculations' sheet shows underlying formulas and calculations of the model (Section 3.8).

'DataSources' sheet shows references to background data used in the model (Section 3.9).

The following buttons can be used while navigating through the sheets in the model:

'Expand' and 'Open help'	Opens hidden cells in order to insert the values in the model or see more detailed information.
'Collapse' and 'Close help'	Hides the cells
'Insert test values'	Populates the model with test values from a specific test case study (Section 4)
'Reset values' and 'Reset'	Removes the test values or values inserted by the user
'Print Results'	Prints out results

Please, note that there are four types of cells used in the model (explanation of each colour is also provided on top of the 'RoadDesign' and 'ModelValues' sheet):

(yellow cells):	Click the cell and select item from drop-down menu ('RoadDesign' sheet)
(white cells):	Input your own value according to YOUR project ('RoadDesign' sheet) appear in collapsed version only and represent more important variables ('ModelValues' sheet)

(blue cells):	Pregiven or calculated values (not to be changed) ('RoadDesign' and 'ModelValues' sheet)
(grey cells):	appear in expanded version and represent generally less important variables ('ModelValues' sheet)

To make it easier for the user to distinguish between alternatives/parts of the road, the model uses colour codes for each alternative/part of the road, depending on the chosen mode of analysis (see in Table 2).

Table 2: Colour codes for each alternative/part of the road depending on the chosen mode of analysis

Colour	Comparison mode	Adding-Up mode
Grey	Alternative 0 - Today's road used also in future	Alternative 0 - Today's road used also in future
Blue	Alternative 1 - First new road corridor alternative	Alternative 1 - First Section in new road
Red	Alternative 2 - Second new road corridor alternative	Alternative 2 - Second Section in new road
Green	Alternative 3 - Third new road corridor alternative	Alternative 3 - Third Section in new road

The tables included in the sections below (Section 3.3 - 3.9) provide a list of parameters included in the model. The following words are used in order to describe necessary actions to be performed by the user when filling in the data for the project:

SHOULD	Required input if the user wants these factors to be calculated as part of an analysis
MAY	Optional input, if more accurate value is available
SHOULD NOT	Absolutely prohibited input

3.3 RoadDesign

Figure 12 gives an overview of the 'RoadDesign' sheet (note that Figure 12 is an extended version of Figure 10). This sheet allows the user to enter general project input data and specification of alternative road designs.

The LICCER model enables input of up to 4 different alternatives for a given road project, of which Alternative 0 is normally the reference alternative, and representing continued use of today's road system.

In the rows corresponding to each alternative one defines which road elements this alternative consists of (e.g. plain roads, bridges or tunnels etc.), as well as what is the geometry and design of those elements.

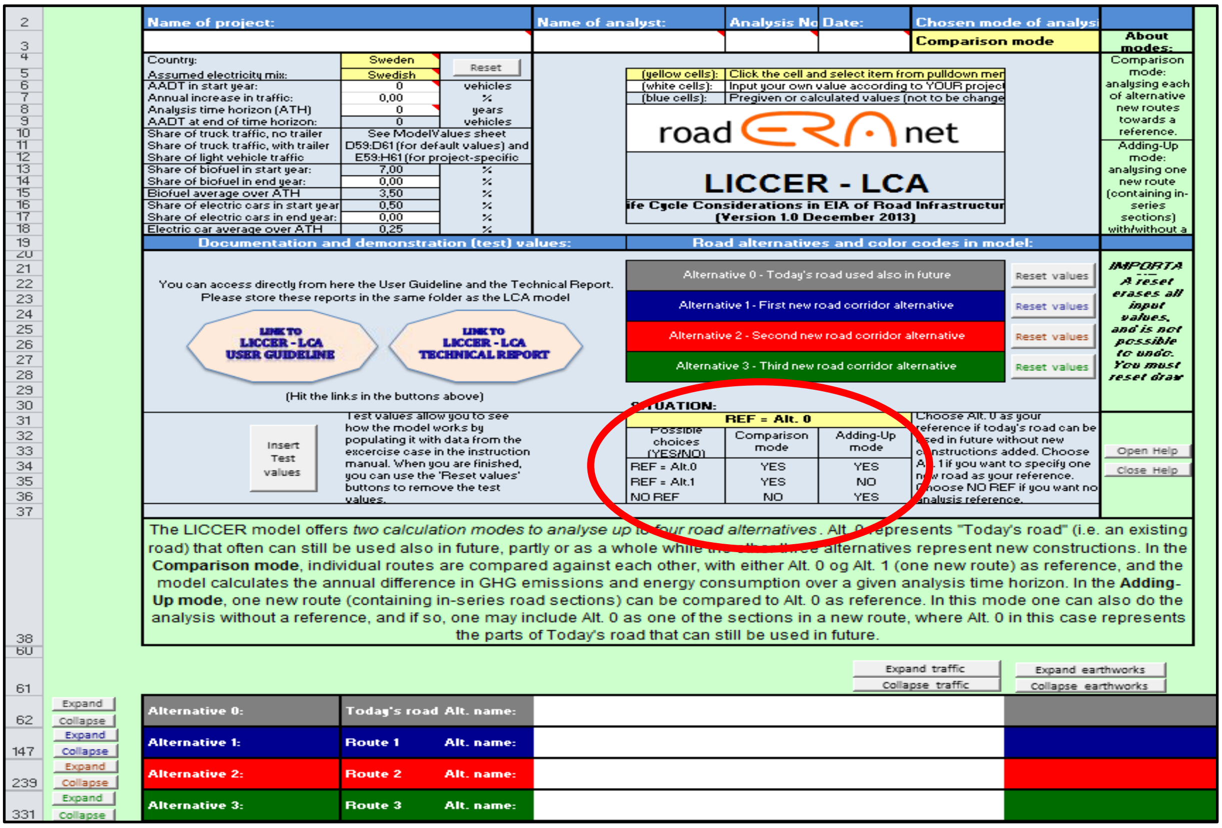


Figure 12: Part of 'RoadDesign' sheet

The sections below (Section 3.3.1- 3.3.4) provide a detailed description of the parameters included in the sheet 'RoadDesign'. Figures used in the sections below are images of the model sheets without values inserted. The example of the model with values inserted is shown in Section 4.

These parameters are subdivided into the following groups (that are covered in separate subsections):

1) **Project input data** (where the general information about the project should be inserted) (Section 3.3.1).

2) **Specification of input data for each alternative which is marked with a specific colour code** (Table 2 and Figure 12). Using 'Expand' button for each corresponding alternative, the user should specify the following information:
    a. road elements included in each alternative (Section 3.3.2)
    b. elements crossing the studied road alternative (Section 3.3.3)
    c. cross-section geometry of the road corridor (Section 3.3.4)

3.3.1 Project input data

The first part in the upper left corner of 'RoadDesign' is the table where project input data should be inserted (Figure 13).

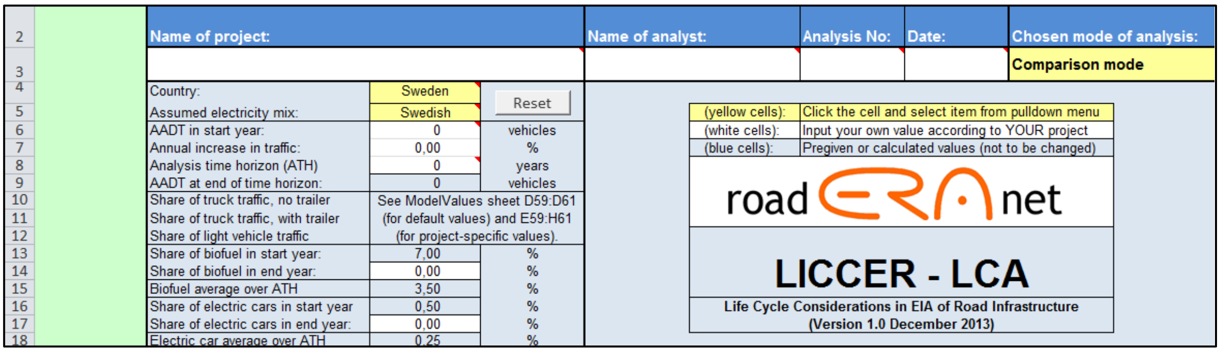


Figure 13: Project input data

As shown on Figure 13, the user should start by entering the following information:

- Name of project
- Name of analyst
- Analysis number (optional)
- Date
- Chosen mode of analysis:

The model can work in two modes, Comparison mode and Adding-Up mode, but only in one mode at a time. More details about interpretation of modes of analysis are described in the Technical report (Brattebø et al., 2013).

Cases when it is recommended to choose the Comparison mode: if you want to compare alternatives in parallel. Note that each road corridor alternative should consist of elements (roads, tunnels, bridges) of the same dimensions and type within the same alternative.

Cases when it is recommended to choose Adding-Up mode: if you want to analyse one road corridor that is made up of in-series sections.The analysis may consider a complex road corridor that consists of different types and dimensions of road elements (roads, tunnels, bridges, etc.). Thus in this mode you may specify each section independent of each other, for instance regarding number of lanes and width of the road, and then add them up (as one corridor).

⇒ *Note, that even though the model always shows results from both modes, only results of the chosen mode should be used. This is also clearly stated on the top of the results sheet for each respective mode.*

In Figure 12 you can also see an area (marked with a red circle in the centre of the screenshot) that refers to “Select your analysis reference situation”. This shows which reference situations the LICCER model can handle, in each of the two analysis modes:

- REF = Alt. 0 (Alternative 0, today’s road, is chosen as the reference)
- REF = Alt. 1 (Alternative 1, one of the new road corridor alternatives, is chosen as the reference)
- NO REF (No reference is defined, and the analysis is done without a reference)

Normally it is recommended to analyse new road corridor alternatives relative to the continued use of today's road (Alternative 0), and REF = Alt.0 should be selected (Figure 14). There may, however, be situations where today's road is not a realistic alternative in the future, for instance when it cannot handle the future design traffic without road extension or significant infrastructure upgrading. In such situations one cannot include Alternative 0 in the analysis, on an equal basis as other (new) road corridor alternatives, since in the LCA terminology it cannot fulfil the same functional unit as the other alternatives. Therefore, the user of the LICCER model in such situations might want to select one of the new alternatives as reference, against which other new alternatives are compared. If so, this new reference will be Alternative 1 (Figure 15). The Comparison mode does not allow for an analysis without a reference.

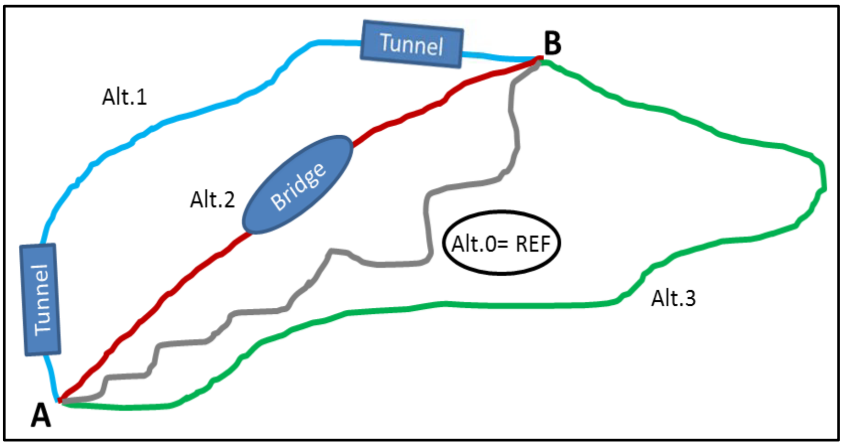


Figure 14: Illustration of alternatives considered in Comparison mode where Alt.0, existing road, is used as Reference (marked with black circle)

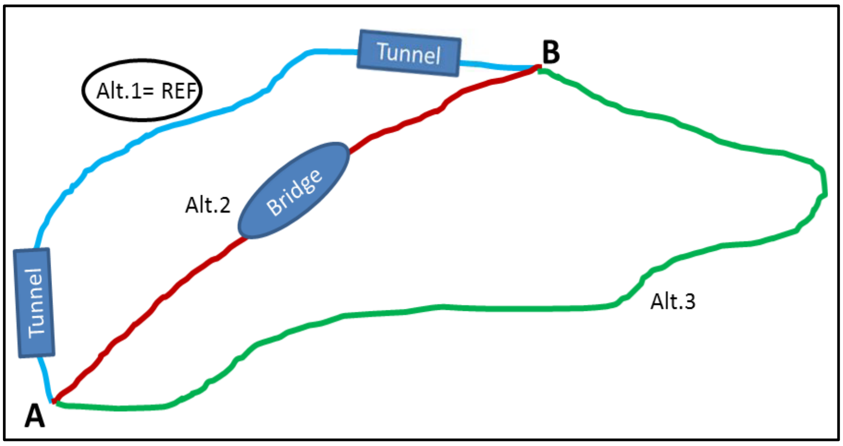


Figure 15: Illustration of alternatives considered in Comparison mode where Alt.1, new road, is used as Reference (marked with black circle)

The Adding-Up mode allows for selecting Alternative 0 as reference or analysing without a reference. When Alternative 0 is chosen as reference, the other alternatives (1-3) are to be seen as in-series section of one new road, which is compared to the Alternative 0 (Figure 16). Alternative 1 cannot be chosen as reference in the Adding-Up mode, since this here is only one of several sections of the new road. However, also in the Adding-Up mode the analysis can be carried out without the new road (made of section 1-3) being compared relative to a reference. In this case the new road can actually also include an existing road stretch as part of the new road. If so, Alternative 0 can represent this existing road stretch, which now becomes Section 0 of the new road, together with the other new sections (1-3).

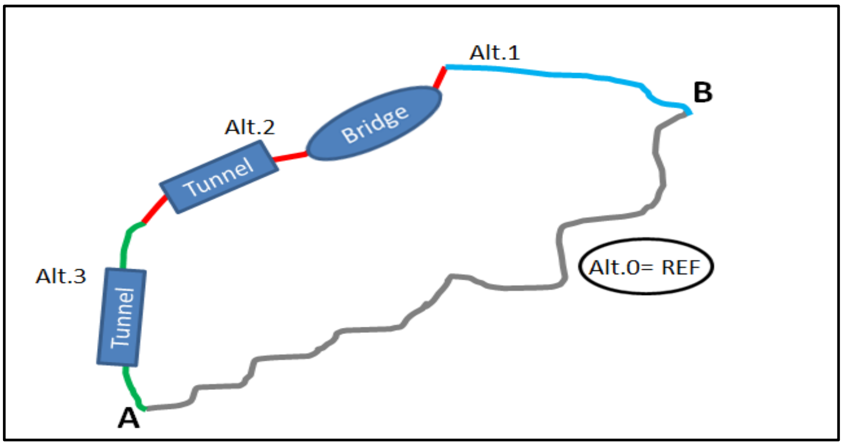


Figure 16: Illustration of alternatives considered in Adding-Up mode where Alt.0, existing road, is used as reference (marked with black circle)

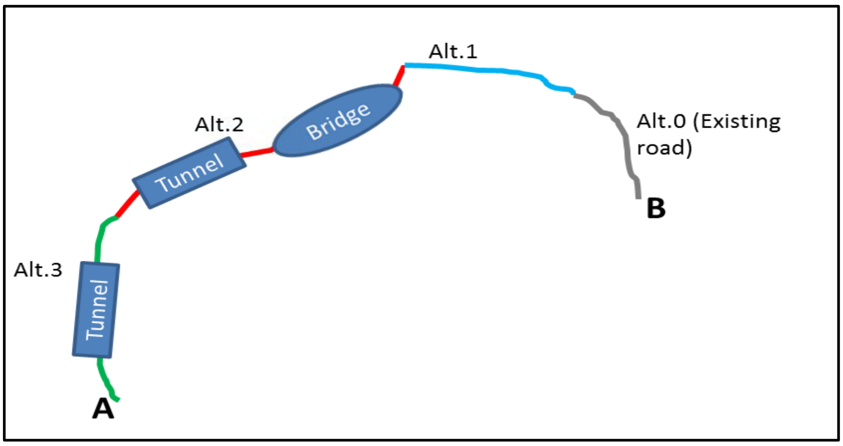


Figure 17: Illustration of alternatives considered in Adding-Up mode where Alt.0, existing road stretch, is used as another section of the road (No Reference is considered in this case)

Providing the situation specific for the project, the user should choose an analysis reference situation (Alt.0, Alt.1 or NO REF) from a drop-down menu in row 31.

Each parameter for the project input data (rows 4:18 in Figure 13) is described in the tables below.

Table 3: List of parameters that SHOULD be inserted into the model (project input data)

Parameter	Comment
Country	Choose from a drop-down menu a country where the project is performed. Note that the choice of country is of importance for determination of country-specific default values used in the model. At the moment, those default values are provided for Norway and Sweden.
Assumed electricity mix	Choose from a drop-down menu assumed electricity mix. The choice of electricity mix is of importance for determination of default values for GHG emissions and energy use

AADT in start year	Insert Average Annual Daily Traffic (AADT) in start year, which is expected traffic on road after the project is constructed (measured as quantity of vehicles).
Annual increase in traffic	Insert percentage (%) of annual increase of expected future traffic on road after the project is constructed
Analysis time horizon (ATH)	Insert Analysis time horizon (ATH), which is the time horizon over which annual energy consumption and greenhouse gas emissions are calculated for expected future traffic on road after the project is constructed. Example: ATH=20 years.
Share of biofuel in end year	Insert assumed share of biofuel in the end year of your chosen analysis time horizon (ATH) ⇒ *Scenarios with default values for Sweden can be found in Hansson, J. and Grahn, M., 2013. Utsikt för förnybara drivmedel i Sverige. Uppdatering och utvidgning av studien Möjligheter för förnybara drivmedel i Sverige till år 2030 av Grahn och Hansson, 2010. IVL Rapport B2083. Göteborg, Sweden: IVL Svenska Miljöinstitutet AB.*
Share of electric cars in end year	Insert assumed share of electric cars in the end year of your chosen analysis time horizon (ATH) ⇒ *Scenarios with default values for Sweden can be found in Hansson, J. and Grahn, M. (2013) (as provided in the previous row).*

Table 4: List of parameters that MAY be updated (project input data)

Parameter	**Comment**
Share of truck traffic, no trailer	Default national value is provided in the model in 'ModelValues' (cell ModelValues!D59). If the user does not want to use national default values, project-specific input may be inserted in cell ModelValues!E59.
Share of truck traffic, with trailer	Default national value is provided in the model in 'ModelValues' (cell ModelValues!D60). If the user does not want to use national default values, project-specific input may be provided in cell ModelValues!E60.
Share of light vehicle traffic	Default national value is provided in the model in 'ModelValues' (cell ModelValues!D61). If the user does not want to use national default values, project-specific input may be inserted in cell ModelValues!E61.
Share of biofuel in start year	Default national value is provided in the model in 'ModelValues' (cell ModelValues!D63). If the user does not want to use national default values, project-specific input may be inserted in cell ModelValues!E63.
Share of electric	Default national value is provided in the model in 'ModelValues'

cars in start year	(cell ModelValues!D64). If the user does not want to use national default values, project-specific input may be inserted in cell ModelValues!E64.

Table 5: List of parameters that SHOULD NOT be changed (project input data)

Parameter	**Comment**
AADT at end of time horizon	This value is calculated based on AADT in start year, Annual increase in traffic and Annual time horizon (previously filled in by the user).
Biofuel average over ATH	This value is calculated as an average between share of biofuel in start year and share of biofuel in end year (previously filled in by the user).
Electric car average over ATH	This value is calculated as an average between share of electric cars in start year and share of electric cars in end year (previously filled in by the user).

3.3.2 Design of elements along the road corridor alternative

Having provided general input data for the project, the user should fill in data for specification of design for each road corridor alternative which is marked with a specific colour code (Table 2).

First of all, the user should specify detailed information about the road elements included in each alternative or section of the road (Figure 18).

147	Expand Collapse	**Alternative 1:**	**Route 1**	**Alt. name:**							
148		**Elements along this road corridor alternative:**	No. of elements of this type within the alternative	Sum length of elements of this type within the alternative	Share length with road lighting	Share length with side guardrails	Side guardrail type	Share length with center guardrail	Center guardrail type	Volume of concrete use per m length	Total fuel used for earthwork (excavation & transportation)	Tunnel walls and lining method
149		Variable name:	N_E	L_{TOT}	SHL_{LG}	SHL_{SG}		SHL_{CG}		$Q_{CON-OTH}$	$Q_{DIE-TEUD}$	
150		Unit:	(#)	(m)	(0-100 %)	(0-100 %)	(type)	(0-100%)	(type)	(m3/m)	(m3 total)	(type)
151		Existing road (EXR)	0	0	0,0							
152		New road (NR)	0	0	0,0	0,0	None	0,0	None		0,00	
153		Extended road (ER)	0	0	0,0	0,0	Steel	0,0	None		0,00	
154		Road below groundwater (RBG)	0	0	0,0	0,0	None	0,0	None	0,0	0,00	
155		Auquaduct (AD)	0	0	0,0	0,0	None	0,0	None	0,0	0,00	
156		Underpass (UP)	0	0	0,0			0,0	None	0,0	0,00	
157		Tunnel (T)	0	0	0,0			0,0	None		0,00	Please select
158		Dual Tunnel (DT)	0	0	0,0			0,0	None		0,00	Please select
159		Underwater tunnel (UWT)	0	0	0,0			0,0	None		0,00	Please select
160		Underwater dual tunnel (UWDT)	0	0	0,0			0,0	None		0,00	Please select
161		Steel bridge or overpass (SB)	0	0	0,0			0,0	None		0,00	
162		Concrete bridge or overpass (CB)	0	0	0,0			0,0	None		0,00	
163		Total length of all elements (L_{TOT})		0								

Figure 18: Specification of elements along the road corridor alternative (Alternative 1 as an example)

Please, press ‘Expand’ button in order to open rows with necessary parameters for each alternative. Note that in order to see parameters that should be entered for traffic and earthworks data, you need to use buttons ‘Expand traffic’ and ‘Expand earthworks’ respectively.

Using ‘Expand traffic’ button, you will see parameters that should be inserted only if the element serves traffic from outside. Some parameters under ‘Expand earthworks’ button should always be inserted. These are: ‘Soil stabilization method’ and ‘Total volume of soil stabilized’ (Table 6). Other parameters should be inserted only if ‘Total fuel used for earthwork (excavation & transportation)’ is not specified before.

Table 6: List of parameters that SHOULD be inserted into the model (design of elements along the road corridor alternative)

Parameter	**Comment**
No. of elements of this type within the alternative	Insert the number of elements (i.e. B151:162 for Alternative 1) included in the analyzed alternative. Just write ‘0’, if some of those elements are not included.
Sum length of elements of this type within the alternative	Insert the total length of each element included in the alternative. Just write ‘0’, if some of those elements are not included. Note that this input is important as all material consumption will be based on these values.
Share length with road lighting	Insert the share of road (in %) that is supplied with lighting. Just write ‘0’, if there is no lighting for some of the road elements
Share length with side guardrails	Insert the share of road (in %) that is supplied with side guardlines (assuming one guardline on each side of the road). Just write ‘0’, if there are no side guardrails for some of the road elements. The guardrails can be specified only for the following elements: New road (NR), Extended road (ER), Road below groundwater (RBG), Aqueduct (AD).
Side guardrail type	Choose from a drop-down menu the type of side guardrail (concrete or steel). If ‘None’ is chosen, then no material consumption will be attributed to this guardrail. The type of guardrails can be chosen only for the following elements: New road (NR), Extended road (ER), Road below groundwater (RBG), Aqueduct (AD).
Share length with center guardrail	Insert the share of road (in %) that is supplied with center guardlines (assuming two guardrails in the central reserve). Just write ‘0’, if there are no center guardrails for some of the road elements.
Center guardrail type	Choose from a drop-down menu the type of centre guardrail (concrete or steel). If ‘None’ is chosen, then no material consumption will be attributed to this guardrail.
Volume of concrete use per m length	Insert volume of concrete use per m length for the following elements: Roads below groundwater level, Aqueducts and Underpasses. It is expected that reinforced concrete will be used in significant quantities per meter of road length for these road elements. However, such elements are less common in several countries, have a variety of designs and it is difficult to provide generic default methods for calculation of the quantities of reinforced concrete consumed. If you have such elements in your road project, please estimate the volume of reinforced concrete.

Total fuel used for earthwork (excavation & transportation)	Insert values here if you can estimate the total fuel (m3 diesel) used for earthwork (machinery for excavation and uploading of soil and rock masses as well as diesel for transport of the masses). Fuel used for soil stabilization is not included here. If you don't have this information, then please put '0' in this cell and give your inputs on excavated soil and rock amounts in columns L:S. ⇒ *Note, that if you insert this value here, then you don't need to fill in the information in columns L:S (Share length of simple excavated soil in earthworks, Volume of simple excavated soil per m length, Total volume of simple excavated soil in earthwork, Share length of excavated ripped soil in earthworks, Volume of excavated ripped soil per m length, Total volume of excavated ripped soil in earthworks, Share length of blasted rock in earthworks), which are explained more in detail further in this table.*
Tunnel walls and lining method	Choose from a drop-down menu tunnel walls and lining method for the following elements: Tunnel (T), Dual Tunnel (DT), Underwater tunnel (UWT), Underwater dual tunnel (UWDT)
Parameters that should be inserted after pressing the button 'Expand earthworks'	
Volume of simple excavated soil per m length	Insert volume of simple excavated soil per m length for all road elements except tunnels, if 'Total fuel used for earthwork (excavation & transportation)' is not specified before. In case of tunnels, it is calculated based on Tunnel cross-section variables (with default values provided in ModelValues!rows 88:109 for Alternative 1).
Share length of excavated ripped soil in earthworks	Insert percentage (%) of road length that includes excavated ripped soil in earthworks, if 'Total fuel used for earthwork (excavation & transportation)' is not specified before.
Volume of excavated ripped soil per m length	Insert volume of excavated ripped soil per m length for all road elements except tunnels, if 'Total fuel used for earthwork (excavation & transportation)' is not specified before. In case of tunnels, it is calculated based on Tunnel cross-section variables (with default values provided in ModelValues!rows 88:109 for Alternative 1).
Share length of blasted rock in earthworks	Insert percentage (%) of road length that includes blasted rock in earthworks, if 'Total fuel used for earthwork (excavation & transportation)' is not specified before.
Volume of blasted rock per m length:	Insert volume of blasted rock per m length for all road elements except tunnels, if 'Total fuel used for earthwork (excavation & transportation)' is not specified before. In case of tunnels, it is calculated based on Tunnel cross-section

	variables (with default values provided in ModelValues!rows 88:109 for Alternative 1).
Soil stabilization method	Choose from a drop-down menu the method used for soil stabilization**.** If you choose ‘None’, then no material consumption will be attributed to soil stabilisation.
Total volume of soil stabilized	Insert your best estimate of the total volume (m3) of soil subject to the given stabilization method.
Parameters that should be inserted after pressing the button ‘Expand traffic’	
Length of this element that also serves traffic from outside:	If the element serves traffic from outside, insert the length of that stretch of road (in m). ⇒ *A part of each element in a new road project may also serve traffic from outside, i.e. if such traffic enters or leaves our project's road "system" in addition to the traffic on the whole length of our project. If so, the use of materials and energy and the GHG emissions due to infrastructure investments in our project will have to be partly allocated to the traffic from outside. Please enter the length of each element where such traffic from outside occur.*
Quantity of traffic from outside:	If the element serves traffic from outside, insert the quantity of that traffic (in AADT). Use the expected average value of the time horizon in your analysis.

Table 7: List of parameters that SHOULD NOT be filled in the model (design of elements along the road corridor alternative)

Parameter	Comment
Share length of simple excavated soil in earthworks:	This value is calculated on the basis of share length of excavated ripped soil in earthworks and share length of blasted rock in earthworks (filled in by the user).
Total volume of simple excavated soil in earthworks	This value is calculated on the basis of values previously filled by the user (volume of simple excavated soil per m length and length of the road element).
Total volume of excavated ripped soil in earthworks	This value is calculated on the basis of values previously filled by the user (volume of excavated ripped soil per m length and length of the road element).
Total volume of blasted rock in earthworks	This value is calculated on the basis of values previously filled by the user (volume of blasted rock per m length and length of the road element).

3.3.3 Design of elements crossing the road alternative

Elements crossing the road corridor alternative, as considered in this model, are permanent structures that cross our road corridor. These structures have to be built or rebuilt as a consequence of the implementation of our project. For instance, these are an overpass/flyover (bridge structures of different designs) made of concrete or steel, an underpass or a large intersection of any kind. These structures may consume significant amounts of pavement, concrete, steel and diesel used in earthworks on the site (Figure 19).

The user can also include other types of elements (not included in the model) under 'Other' (Figure 19).

164		**Elements crossing this road corridor alternative:**	Total paved surface area	Total reinforced concrete use	Total construction steel use	Total diesel use in earthworks
165						
166		Units:	(m2)	(m3)	(tons)	(m3)
167		Steel Overpass/Flyover	0	0,0	0,00	0,00
168		Concrete Overpass/Flyover	0	0,0		0,00
169		Large intersection	0	0,0		0,00
170		Other	0	0,0		0,00

Figure 19: Specification of elements crossing the analysed road alternative

If you have crossing structures of a significant size occurring in this road corridor alternative, you should estimate their total quantity of paved surface area, reinforced concrete use, construction steel use and diesel use in earthworks (Table 8). Crossing structures of smaller size may be neglected.

Table 8: List of parameters that SHOULD be inserted into the model (design of elements along the road corridor alternative)

Parameter	Comment
Total paved surface area (m2)	If you have crossing structures of a significant size occurring in this road corridor alternative, you should estimate the total paved surface area. Just put '0', if the element is not included in the analyzed alternative.
Total reinforced concrete use (m3)	If you have crossing structures of a significant size occurring in this road corridor alternative, you should estimate the total use of reinforced concrete. Just put '0', if the element is not included in the analyzed alternative.
Total construction steel use (ton)	If you have a Steel Overpass/Flyover crossing the road corridor alternative, you should estimate total construction steel use (ton). Steel use should not be estimated for other types of elements crossing the road alternative.
Total diesel use in earthworks (m3)	If you have crossing structures of a significant size occurring in this road corridor alternative, you should estimate total diesel use in earthworks (m3). Just put '0', if the element is not included in the analyzed alternative.

3.3.4 Cross-section geometry of the road corridor

Specific cross-section geometry should be specified for each road element included in the road alternative (Figure 20).

171	**Cross-section geometry of the road corridor:**	Single width of lanes etc.	No. of lanes etc. in parallel	Total width of lanes etc.	Subbase layer material	Subbase layer height	Base layer material	Base layer height	Pavement layer material	Pavement layer height
172	Variable name:	W_i	N.	W_{TOT}		H_{SBL}		H_{BL}		H_{PV}
173	Unit:	(m)	(#)	(m)	(type)	(m)	(type)	(m)	(type)	(m)
174	**Existing road:**									
175	Driving lanes (DL)	0,00	0	0,00					User defined	0,000
176	Hard shoulders (HS)	0,00	0	0,00					User defined	0,000
177	Central reserve incl. guardrail (CR)	0,00	0	0,00					User defined	0,000
178	Cycling/pedestrian lanes (CPL)	0,00	0	0,00					User defined	0,000
179	Soft shoulders incl. guardrail (SS)	0,00	0	0,00						
180	Road ditch (RD)	0,00	0	0,00						
181	**New road:**									
182	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	User defined	0,000
183	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	Default mix	0,000
184	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	User defined	0,000
185	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	User defined	0,000
186	Soft shoulders incl. guardrail (SS)	0,00	0	0,00	None	0,000	None	0,000		
187	Road ditch (RD)	0,00	0	0,00						
188	**Extended road:**									
189	Driving lanes (DL)	0,00	0	0,00	100% Aggregate	0,000	User defined	0,000	Default mix	0,000
190	Hard shoulders (HS)	0,00	0	0,00	100% Aggregate	0,000	User defined	0,000	Default mix	0,000
191	Central reserve incl. guardrail (CR)	0,00	0	0,00	100% Aggregate	0,000	User defined	0,000	Default mix	0,000
192	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	100% Aggregate	0,000	User defined	0,000	Default mix	0,000
193	Soft shoulders incl. guardrail (SS)	0,00	0	0,00	None	0,000	100% Aggregate	0,000		
194	Road ditch (RD)	0,00	0	0,00						
195	**Road below ground water:**									
196	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
197	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
198	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
199	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
200	**Auquaduct:**									
201	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
202	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
203	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
204	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
205	**Underpass:**									
206	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
207	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
208	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
209	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
210	**Tunnel:**									
211	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
212	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
213	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
214	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
215	**Dual tunnels:**									
216	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
217	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
218	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
219	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
220	**Underwater tunnels:**									
221	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
222	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
223	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
224	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
225	**Underwater dual tunnels:**									
226	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
227	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
228	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
229	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
230	**Steel Bridges:**									
231	Driving lanes (DL)	0,00	0	0,00					None	0,000
232	Central reserve incl. guardrail (CR)	0,00	0	0,00					None	0,000
233	Cycling/pedestrian lanes (CPL)	0,00	0	0,00					None	0,000
234	**Concrete Bridges:**									
235	Driving lanes (DL)	0,00	0	0,00					None	0,000
236	Central reserve incl. guardrail (CR)	0,00	0	0,00					None	0,000
237	Cycling/pedestrian lanes (CPL)	0,00	0	0,00					None	0,000

Figure 20: Specification of the cross-section geometry of the road corridor

Note, that you don't need to insert any values for these elements in the table, if you wrote '0' in a column on 'Sum length of elements of this type within the alternative' for elements not included in your analyzed road corridor (Table 3).

Table 9: List of parameters that SHOULD be inserted into the model (cross-section geometry)

Parameter	Comment
Single width of lanes etc. (m)	Insert single width of lanes for each of the variables included in the studied road element. Just put '0' if some of those variables are not included in the analysed road element.
No. of lanes etc. in parallel	Insert number of lanes for each of the variables included in the studied road element. Just put '0' if some of those variables are not included in the analysed road element.

Subbase layer material	Choose a subbase layer material from a drop-down menu for each road element (except existing road, tunnels and bridges). If you choose 'None', then no material consumption will be attributed to subbase layer. If you choose 'User defined', then you need to specify this layer (% of aggregate/gravel, sand and soil) in ModelValues sheet (cells: ModelValues!E74, ModelValues!H74)
Subbase layer height (m)	Insert height of a subbase layer for each road element included in the studied alternative (except existing road, tunnels and bridges).
Base layer material	Choose a base layer material from a drop-down menu for each road element (except existing road and bridges). If you choose 'None', then no material consumption will be attributed to base layer. If you choose 'User defined', then you need to specify this layer (% of aggregate/gravel, bitumen and sand/soil) in ModelValues sheet (cells: ModelValues!E79, ModelValues!F79, ModelValues!H79)
Base layer height (m)	Insert height of a base layer for each road element included in the studied alternative (except existing road and bridges).
Pavement layer material	Choose a pavement layer material from a drop-down menu for each road element. If you choose 'None', then no material consumption will be attributed to pavement layer. If you choose 'User defined', then you need to specify this layer (% of aggregate/gravel, bitumen and concrete) in ModelValues sheet (cells: ModelValues!E70, ModelValues!F70, ModelValues!G70)
Pavement layer height (m)	Insert height of a pavement layer for each road element included in the studied alternative.

Table 10: List of parameters that SHOULD NOT be filled in the model (cross-section geometry)

Parameter	Comment
Total width of lanes	This value is calculated on the basis of values previously filled in by the user (i.e. single width of lanes multiplied by a number of lanes).

3.4 ModelValues

'ModelValues' sheet consists of default values for service life, material consumption and other background data (Figure 21).

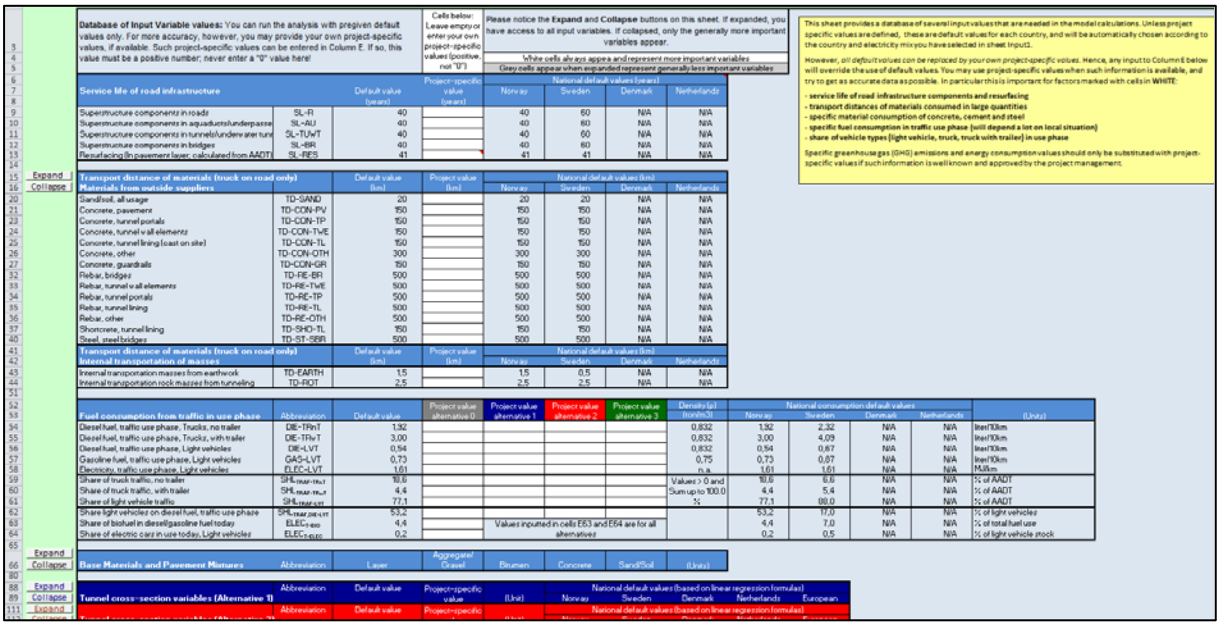


Figure 21: Part of 'ModelValues' sheet

The present version of the LICCER model hosts country-dependent default values for Sweden and Norway. You can run the analysis with pregiven default values only. Column D shows which default values are used in the model calculations. This column automatically picks up the correct default values for a given road project, according to which country is chosen in cell C4 in the RoadDesign sheet. For more accuracy, however, you may provide your own project-specific values, if such values are available and if you prefer not using default values. Such project-specific values can be entered in Column E. This is particularly of interest for the cells in white colour, which represent parameters that might potentially influence the results significantly. Note that if you enter any value in 'Project value' (grey or white cells in column E), it will overwrite the default value that is automatically given in column D. This value inserted in column E must be a positive number. "0" value should be never entered here, in-stead leave the cell open.

Default values are included for the following variables:

- **Service life:**

  Assumed service life for main components if road infrastructure.

- **Transport distances:**

  Default values for assumed transport distances for transportation of materials: from suppliers and internal transportation of masses.

- **Fuel consumption from traffic in use phase:**

  Fuel consumption from traffic (divided per types of vehicles), as well as shares of vehicle types.

- **Base material and pavement mixes:**

Values for material mix used in layers for road construction (Aggregate/Gravel, Bitumen, Concrete, Sand/Soil).

Note that if more project specific information is available, those values may be entered only in grey cells. Blue cells should not be changed.

- **Tunnel cross-section variables:**

  Variables used for linear regression function that calculates the cross-section area and arch length of any tunnel on the basis of its total width. On this basis the LICCER model calculates the volume and masses of rock that must be blasted and transported away per unit length of a tunnel. This is also the basis for estimation of the consumption of input resources for making the tunnel (e.g. explosives, electricity, diesel, PE foam, concrete, shotcrete and rebar).

- **Specific material consumption:**

  Consumption of main types of materials, electricity and fuel during production, construction, operation and end-of-life of infrastructure elements.

- **Emission data (GHG emissions and energy):**

  Specific factors of greenhouse gas emissions and total energy consumption per unit of resource input for materials, electricity and fuel.

3.5 Comparison

The sheet 'Comparison' reports the difference (Δ) in terms of GHG emissions and energy consumption between each of the new alternatives and the chosen reference alternative (Figure 22). Hence, when REF = Alt.0, alternative 1, 2 and 3 are analysed against alternative 0 (Figure 14), and when REF = Alt.1, alternative 2 and 3 are analysed against alternative 1 (Figure 15). **No values should be changed or inserted here!**

In 'Comparison' sheet you can see graphs for the following results:

i) Annual GHG emissions and energy consumption - Relative to Reference: Δ = Alt.X – REF (infrastructure life cycle phases)

ii) Annual GHG emissions and energy consumption- Relative to Reference: Δ = Alt.X - REF (sum infrastructure)

iii) Annual GHG emissions and energy consumption- Relative to Reference: Δ = Alt.X - REF (infrastructure and traffic)

iv) Annual GHG emissions and energy consumption - Relative to Reference: Δ = Alt.X - REF (total incl. traffic)

v) Annual GHG emissions and energy consumption from infrastructure, by material type (Absolute values)

vi) Annual GHG emissions and energy use from traffic, by fuel type (Absolute values)

Note, that the graphs look empty if no values are inserted in the model (as in Figure 22). The bars in the graphs appear as soon as the user inserts values in the model (Section 2.2 and Section 4).

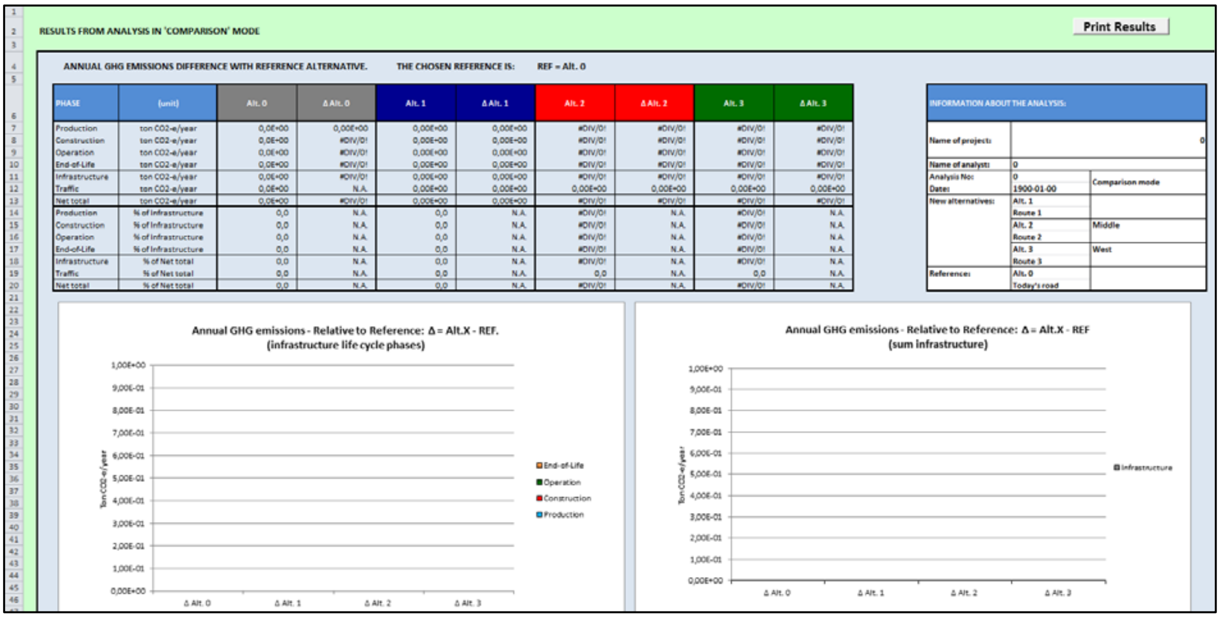


Figure 22: Part of 'Comparison' sheet

The results will have a meaning only if the chosen mode of analysis is Comparison mode (Section 3.3.1). In case you are looking at the results sheet that does not correspond to the chosen mode, the message will appear on top of the sheet that you should check another mode (red text in Figure 23).

3.6 Adding-up

The sheet 'Adding-up' shows the difference (Δ) between the sum of in-series sections of a new road corridor alternative and the reference alternative in terms of GHG emissions and energy consumption (Figure 23). Hence, when REF = Alt.0, the sum of 1, 2 and 3 are analysed against alternative 0 (Figure 16). In the NO REF situation the results represent the absolute sum of all sections included in the new road, i.e. 1, 2 and 3, as well as 0 if this is assumed to represent a stretch of an existing road that will be a part of (a section) of the new road alternative (Figure 17). **No values should be changed or inserted here!**

In 'Adding-up' mode you can see graphs for the following results:

i) Annual GHG emissions and energy consumption (infrastructure life cycle phases);

ii) Annual GHG emissions and energy consumption (sum infrastructure);

iii) Annual GHG emissions and energy consumption (infrastructure and traffic);

iv) Annual GHG emissions and energy consumption (net total)

v) Annual GHG emissions and energy consumption from infrastructure, by material type (Absolute values)

vi) Annual GHG emissions and energy consumption from traffic, by fuel type (Absolute values)

The graphs look empty if no values are inserted in the model (as in Figure 23). The bars in the graphs appear as soon as the user inserts values in the model (Section 2.2 and Section 4).

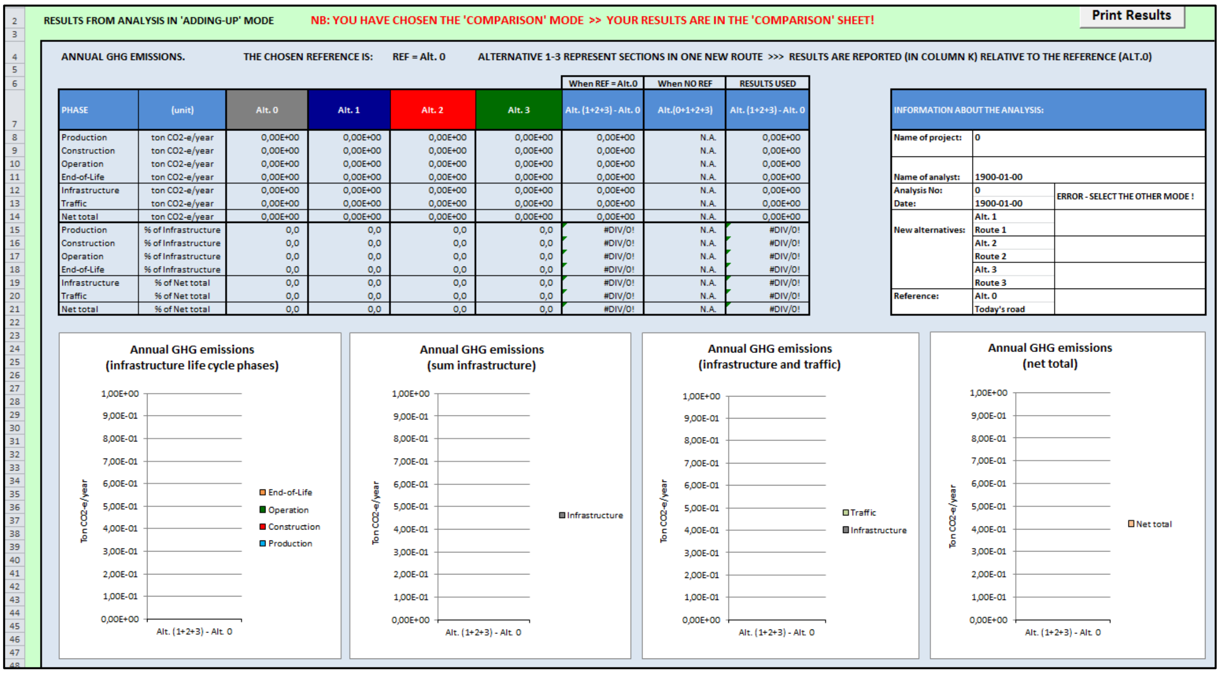


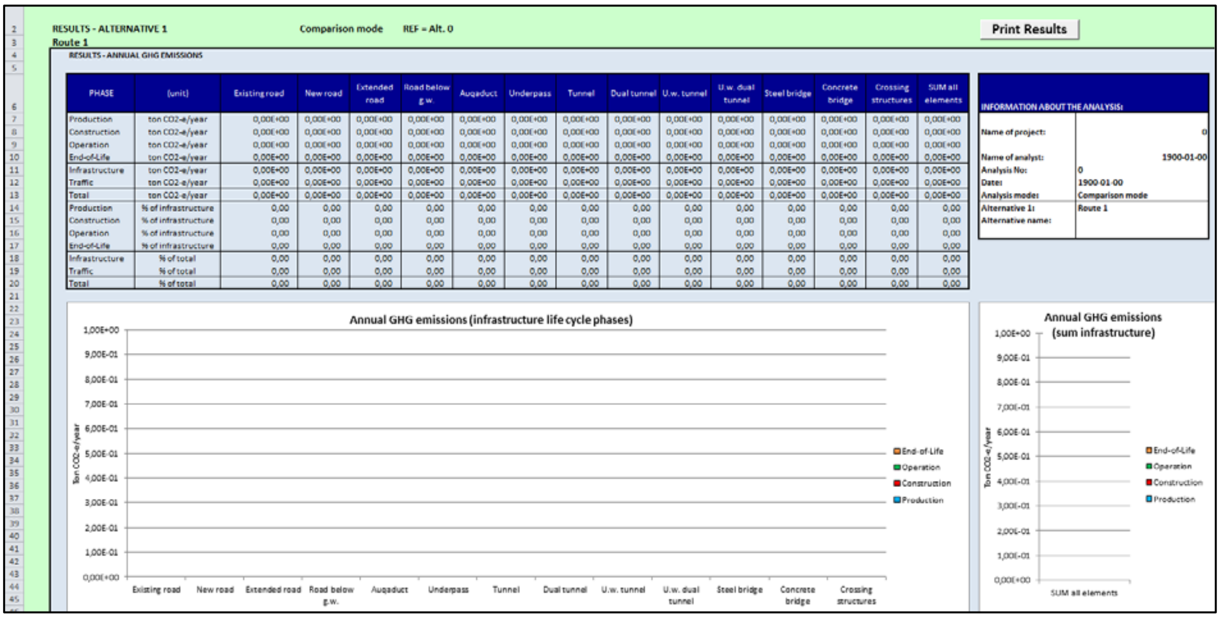
Figure 23: Part of 'Adding-up' sheet

Note that results will have a meaning only if the chosen mode of analysis is Adding-Up mode (Section 3.3.1). In case you are looking at the results sheet that does not correspond to the chosen mode, the message will appear on top of the sheet that you should check another mode (red text in Figure 23).

3.7 Result- Alt.0, Result- Alt.1, Result- Alt.2, Result- Alt.3

The sheets ‘Result-Alt.0’, ‘Result-Alt.1’, ‘Result-Alt.2’, and ‘Result-Alt.3’ show absolute results for each alternative, i.e. corresponding absolute contributions to annual GHG emissions and energy consumption of the main components and life cycle phases of the road infrastructure and traffic on the road during operation (Figure 24). **No values should be changed or inserted here!**

The graphs look empty if no values are inserted in the model (as in Figure 24). The bars in the graphs appear as soon as the user inserts values in the model (Section 2.2 and Section 4).

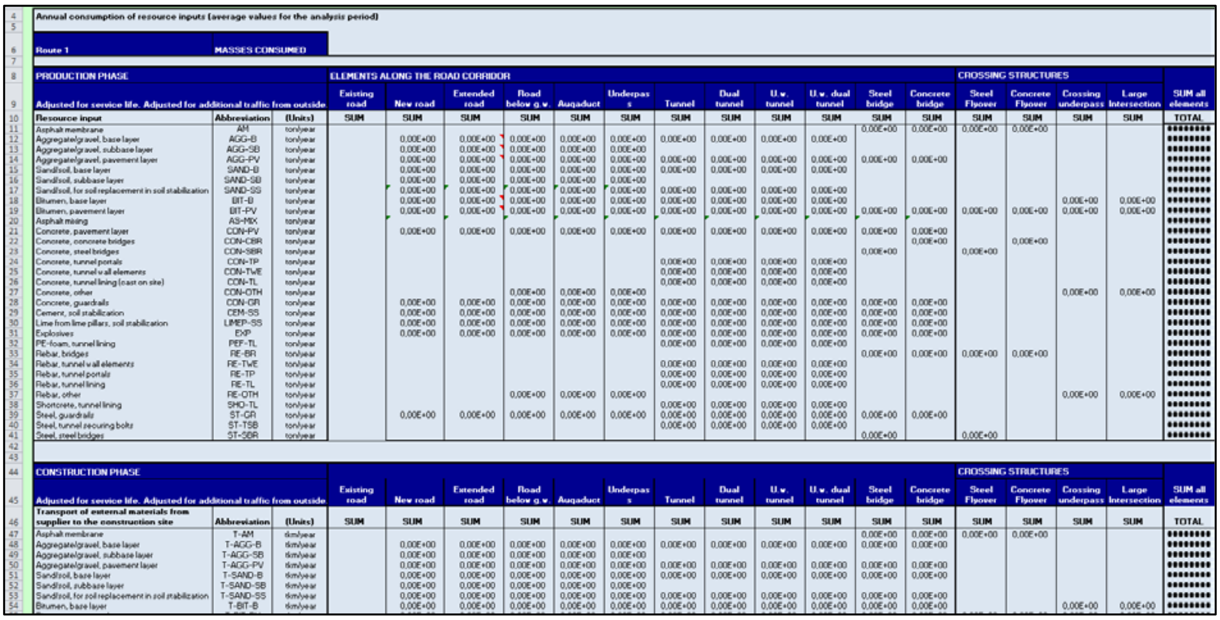


PHASE	(unit)	Existing road	New road	Extended road	Road below g.w.	Auqaduct	Underpass	Tunnel	Dual tunnel	U.w. tunnel	U.w. dual tunnel	Steel bridge	Concrete bridge	Crossing structures	SUM all elements
Production	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Construction	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Operation	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
End-of-Life	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Infrastructure	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Traffic	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Total	ton CO2-e/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Production	% of infrastructure	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Construction	% of infrastructure	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Operation	% of infrastructure	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
End-of-Life	% of infrastructure	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Infrastructure	% of total	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Traffic	% of total	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	% of total	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Figure 24: ‘Result-Alt.1’ sheet

3.8 Calculations

The sheet ‘Calculations’ shows the underlying calculations behind the aggregated results for each alternative separately (Figure 25). **No values should be changed or inserted here!**



Annual consumption of resource inputs (average values for the analysis period)

Route 1	MASSES CONSUMED

PRODUCTION PHASE			ELEMENTS ALONG THE ROAD CORRIDOR												CROSSING STRUCTURES				
Adjusted for service life. Adjusted for additional traffic from outside.			Existing road	New road	Extended road	Road below g.w.	Auqaduct	Underpasses	Tunnel	Dual tunnel	U.w. tunnel	U.w. dual tunnel	Steel bridge	Concrete bridge	Steel Flyover	Concrete Flyover	Crossing underpass	Large Intersection	SUM all elements
Resource input	Abbreviation	(Units)	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	TOTAL
Asphalt membrane	AM	ton/year											0,00E+00	0,00E+00	0,00E+00	0,00E+00			########
Aggregate/gravel, base layer	AGG-B	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Aggregate/gravel, subbase layer	AGG-SB	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00											########
Aggregate/gravel, pavement layer	AGG-PV	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Sand/soil, base layer	SAND-B	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Sand/soil, subbase layer	SAND-SB	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00											########
Sand/soil, for soil replacement in soil stabilization	SAND-SS	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Bitumen, base layer	BIT-B	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					0,00E+00	0,00E+00	########
Bitumen, pavement layer	BIT-PV	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	########
Asphalt mixing	AS-MIX	ton/year																	########
Concrete, pavement layer	CON-PV	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Concrete, concrete bridges	CON-CBR	ton/year												0,00E+00		0,00E+00			########
Concrete, steel bridges	CON-SBR	ton/year											0,00E+00		0,00E+00				########
Concrete, tunnel portals	CON-TP	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Concrete, tunnel wall elements	CON-TWE	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Concrete, tunnel lining (cast on site)	CON-TL	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Concrete, other	CON-OTH	ton/year				0,00E+00	0,00E+00	0,00E+00									0,00E+00	0,00E+00	########
Concrete, guardrails	CON-GR	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Cement, soil stabilization	CEM-SS	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Lime from lime pillars, soil stabilization	LIMEP-SS	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Explosives	EXP	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
PE-foam, tunnel lining	PEF-TL	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Rebar, bridges	RE-BR	ton/year											0,00E+00	0,00E+00	0,00E+00	0,00E+00			########
Rebar, tunnel wall elements	RE-TWE	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Rebar, tunnel portals	RE-TP	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Rebar, tunnel lining	RE-TL	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Rebar, other	RE-OTH	ton/year				0,00E+00	0,00E+00	0,00E+00									0,00E+00	0,00E+00	########
Shortcrete, tunnel lining	SHO-TL	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Steel, guardrails	ST-GR	ton/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Steel, tunnel securing bolts	ST-TSB	ton/year							0,00E+00	0,00E+00	0,00E+00	0,00E+00							########
Steel, steel bridges	ST-SBR	ton/year											0,00E+00		0,00E+00				########

CONSTRUCTION PHASE															CROSSING STRUCTURES				
Adjusted for service life. Adjusted for additional traffic from outside.			Existing road	New road	Extended road	Road below g.w.	Auqaduct	Underpasses	Tunnel	Dual tunnel	U.w. tunnel	U.w. dual tunnel	Steel bridge	Concrete bridge	Steel Flyover	Concrete Flyover	Crossing underpass	Large Intersection	SUM all elements
Transport of external materials from supplier to the construction site	Abbreviation	(Units)	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	SUM	TOTAL
Asphalt membrane	T-AM	tkm/year											0,00E+00	0,00E+00	0,00E+00	0,00E+00			########
Aggregate/gravel, base layer	T-AGG-B	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Aggregate/gravel, subbase layer	T-AGG-SB	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00											########
Aggregate/gravel, pavement layer	T-AGG-PV	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Sand/soil, base layer	T-SAND-B	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Sand/soil, subbase layer	T-SAND-SB	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00											########
Sand/soil, for soil replacement in soil stabilization	T-SAND-SS	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00					########
Bitumen, base layer	T-BIT-B	tkm/year		0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00			0,00E+00	0,00E+00	########

Figure 25: Part of the ‘Calculations’ sheet

3.9 DataSources

The sheet 'DataSources' shows references to background data used in the model (Figure 26). **No values should be changed or inserted here!**

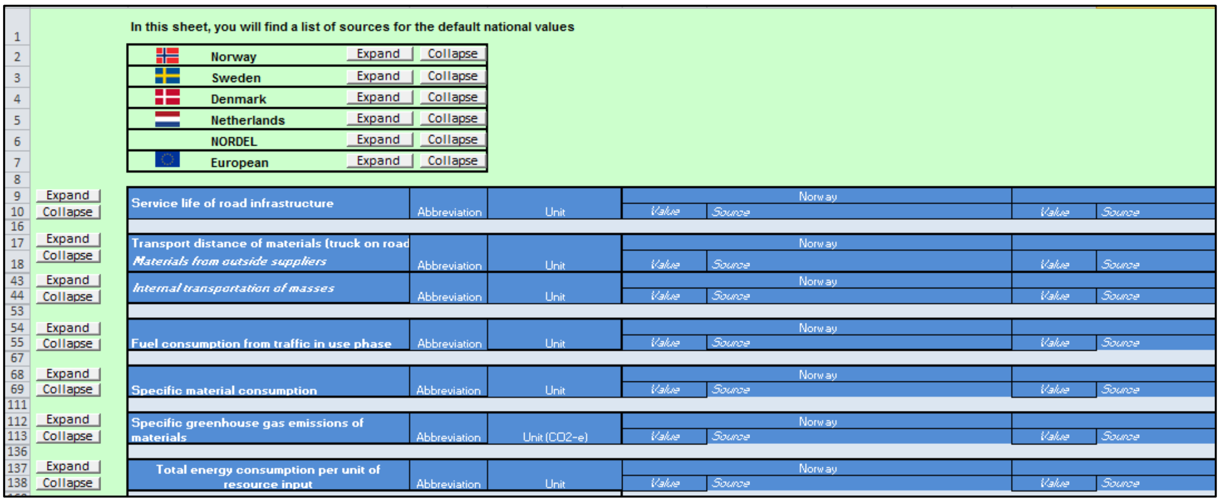


Figure 26: Part of the 'DataSources' sheet

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4 Illustrations/example

This section contains a guided tour to illustrate the use of the LICCER model. This tour shows an example of a case study described more in detail in the case study report by Liljenström et al. (2013).

The project chosen for the case study is the on-going reconstruction project on road 55, between Yxtatorpet and Malmköping in south-eastern Sweden. This project is chosen as it includes both widening of an existing road and construction of new road sections and bridges, which allows for testing many of the features in the LICCER-model (Liljenström et al. 2013).

The following road corridor alternatives were analysed in the case study (Figure 27):

- Alternativ Väst (Alternative West)= Alternative 3
- Alternative Mitt (Alternative Middle)= Alternative 2
- Förbättringsalternativ (Improvement Alternative)= Alternative 1

The case study also included assessment of Alternative 0, which is a reference alternative to which the other alternatives are compared. This alternative includes those changes to the transport system which are predicted to take place if no bigger investments or reconstruction projects are taking place (Swedish Road Administration, 2006).
Note that the results with the final version of the model are slightly different from results in the case study report, since an earlier version of the model was used for the case study report.

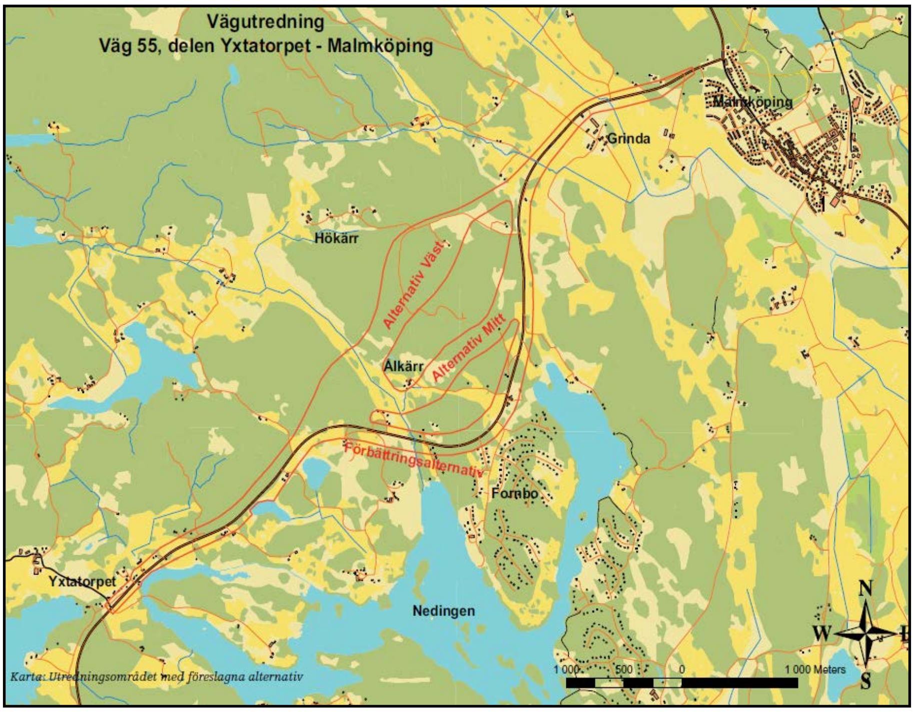


Figure 27: Map showing the location of the alternatives analysed in the case study (Swedish Road Administration, 2006)

Step 1: Open the Excel file with LICCER model and open sheet 'RoadDesign'. Please, press 'Insert Test values' button in the sheet 'RoadDesign'. These values will allow you to see how the model works by populating it with data from a specific case study.

Please note, that the ‘Insert’ button does not automatically update a couple of parameters used for the case study, so these parameters should be inserted manually for each alternative. Updates that should be made manually for Alternative 3 will be shown in the steps below and Table 11 on page 38. Table 11 also shows needed updates for other alternatives considered in the case study (as described in Step 4).

Step 2: Go to the first table in ‘RoadDesign’ and inspect the project input data that should be filled by the user (white cells) together with some pregiven or calculated values (marked with a red square in Figure 28). Make sure that the chosen mode of analysis is ‘Comparison mode’, the country is ‘Sweden’ and assumed electricity mix: ‘Swedish’.

Go down to the row 31 and select your analysis reference situation (as described in Section 3.3.1). Make sure that Alt.0 is selected as a reference situation from the drop-down menu (marked with red circle in Figure 28).

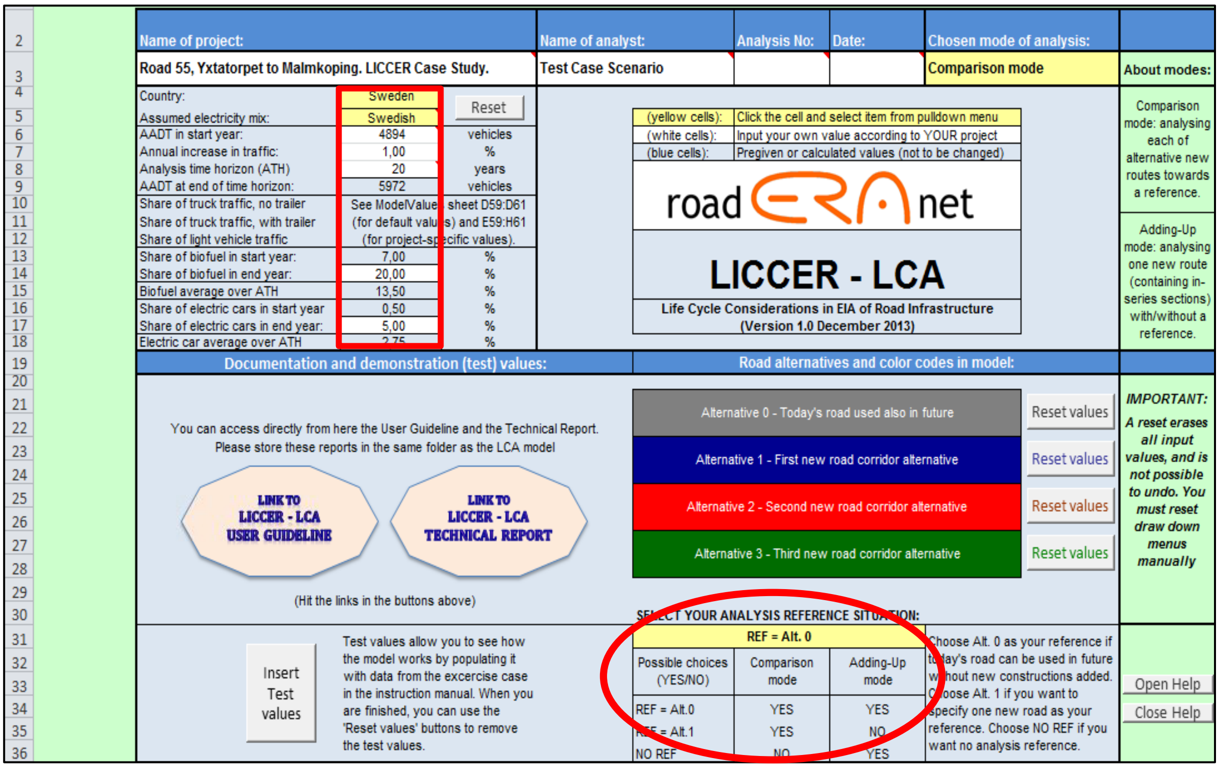


Figure 28: Project input data (case study)

Step 3: Scroll down the sheet ‘RoadDesign’ and with the help of ‘Expand’ button inspect input data needed for each alternative which is marked with a specific colour code: Alternative 1- blue, Alternative 2- red, Alternative 3- green, and Alternative 0- grey.

Using ‘Expand’ button, take a closer look at Alternative 3 (Figure 29), where the following variables are specified:

1) road elements included in the analysed road corridor alternative (their length, lighting during operation, guardrails, earthworks during construction, stabilization etc.)

2) elements crossing this road corridor alternative

3) cross-section geometry (i.e. number and width of lanes, height of layers) of the elements included in the road corridor.

62	Alternative 0:	Today's road	Alt. name:	Continuing use of current road
147	Alternative 1:	Route 1	Alt. name:	Improvements
239	Alternative 2:	Route 2	Alt. name:	Middle
331	Alternative 3:	Route 3	Alt. name:	West

332	Elements along this road corridor alternative:	No. of elements of this type within the alternative	Sum length of elements of this type within the alternative	Share length with road lighting	Share length with side guardrails	Side guardrail type	Share length with center guardrail	Center guardrail type	Volume of concrete use per m length	Total fuel used for earthwork (excavation & transportation)	Tunnel walls and lining method
333	Variable name:	N_E	L_{TOT}	SHL_{LG}	SHL_{SG}		SHL_{CG}			$DIES_{EARTH}$	
334	Unit:	(#)	(m)	(0-100 %)	(0-100 %)	(type)	(0-100%)	(type)	(m3/m)	(m3 total)	(type)
335	Existing road (EXR)	0	0	0,0							
336	New road (NR)	1	2979	0,0	64,0	Steel	64,0	Steel		221,30	
337	Extended road (ER)	1	3794	26,4	11,0	Steel	11,0	Steel		0,00	
338	Road below groundwater (RBG)	0	0	0,0	0,0	None	0,0	None	0,0	0,00	
339	Auquaduct (AD)	0	0	0,0	0,0	None	0,0	None	0,0	0,00	
340	Underpass (UP)	0	0	0,0			0,0	None	0,0	0,00	
341	Tunnel (T)	0	0	0,0			0,0	None		0,00	Please select
342	Dual Tunnel (DT)	0	0	0,0			0,0	None		0,00	Please select
343	Underwater tunnel (UWT)	0	0	0,0			0,0	None		0,00	Please select
344	Underwater dual tunnel (UWDT)	0	0	0,0			0,0	None		0,00	Please select
345	Steel bridge or overpass (SB)	0	0	0,0			0,0	None		0,00	
346	Concrete bridge or overpass (CB)	1	21	0,0			0,0	None		45,00	
347	Total length of all elements (L_{TOT})		6794								

348	Elements crossing this road corridor alternative:	Total paved surface area	Total reinforced concrete use	Total construction steel use	Total diesel use in earthworks
349					
350	Units:	(m2)	(m3)	(tons)	(m3)
351	Steel Overpass/Flyover	0	0,0	0,00	0,00
352	Concrete Overpass/Flyover	0	0,0		0,00
353	Large intersection	0	0,0		0,00
354	Other	0	0,0		0,00

These elements are permanent structures that cross our road corridor, which have to be built or rebuilt as a consequence of the implentation of our project. Typical such are an overpass/flyover (bridge structures of different designs) made of concrete or steel, an underpass or a large intersection of any kind, which consume significant amounts of pavement, concrete, steel and diesel used in earthworks on the site. If you have crossing structures of a significant size occuring in this road corridor alternative, you should estimate their total quantity of paved surface area, reinforced concrete use, construction steel use and diesel use in earthworks. The estimated values can be inputs to cells C314:F317. Crossing structures of smaller size may be neglected.

355	Cross-section geometry of the road corridor:	Single width of lanes etc.	No. of lanes etc. in parallel	Total width of lanes etc.	Subbase layer material	Subbase layer height	Base layer material	Base layer height	Pavement layer material	Pavement layer height
356	Variable name:	W_i	N_n	W_{TOT}		H_{SBL}		H_{BL}		H_{PV}
357	Unit:	(m)	(#)	(m)	(type)	(m)	(type)	(m)	(type)	(m)
358	Existing road:									
359	Driving lanes (DL)	0,00	0	0,00					User defined	0,000
360	Hard shoulders (HS)	0,00	0	0,00					User defined	0,000

Figure 29: Alternative 3 (case study)

Please check if the following values are specified for Alternative 3:

> *Alternative 3 consists of a new road, extended road and concrete bridge. This is marked with '1' in column C and corresponding length of those elements is inserted in column D: 2979 m of new road, 3794 m of extended road, and 21 m of concrete bridge. About 64 % of new road and about 11 % of extended road will have steel side guardrails and steel centre guardrails. About 26,4 % of extended road will have road lighting. Due to geological conditions, it is expected that about 221,3 m3 of diesel will be used for earthworks (excavation and transportation) for new road construction. About 45m3 diesel fuel will be used for earthworks on the bridge. All these parameters are marked with red squares in Figure 30.*

331	Alternative 3:	Route 3	Alt. name:	West						
332	Elements along this road corridor alternative:	No. of elements of this type within the alternative	Sum length of elements of this type within the alternative	Share length with road lighting	Share length with side guardrails	Side guardrail type	Share length with center guardrail	Center guardrail type	Volume of concrete use per m length	Total fuel used for earthwork (excavation & transportation)
333	Variable name	N_E	L_{TOT}	SHL_{LG}	SHL_{SG}		SHL_{CG}			$DIES_{EARTH}$
334	Unit	(#)	(m)	(0-100 %)	(0-100 %)	(type)	(0-100%)	(type)	(m3/m)	(m3 total)
335	Existing road (EXR)	0	0	0,0						
336	New road (NR)	1	2979	0,0	64,0	Steel	64,0	Steel		221,30
337	Extended road (ER)	1	3794	26,4	11,0	Steel	11,0	Steel		0,00
338	Road below groundwater (RBG)	0	0	0,0	0,0	None	0,0	None	0,0	0,00
339	Auquaduct (AD)	0	0	0,0	0,0	None	0,0	None	0,0	0,00
340	Underpass (UP)	0	0	0,0			0,0	None	0,0	0,00
341	Tunnel (T)	0	0	0,0			0,0	None		0,00
342	Dual Tunnel (DT)	0	0	0,0			0,0	None		0,00
343	Underwater tunnel (UWT)	0	0	0,0			0,0	None		0,00
344	Underwater dual tunnel (UWDT)	0	0	0,0			0,0	None		0,00
345	Steel bridge or overpass (SB)	0	0	0,0			0,0	None		0,00
346	Concrete bridge or overpass (CB)	1	21	0,0			0,0	None		45,00
347	Total length of all elements (L_{TOT})		6794							

Figure 30: Elements along Alternative 3 (case study)

Information about diesel consumption used in earthworks is not available for extended road, but the total length of road where rock blasting occurs (40%) and how much rock is blasted per meter (193 m^3/m), as well as amount of simple excavated soil moved per meter (66m^3/m) is known. In order to see these parameters, you need to press the button 'Expand earthworks', and the new columns and rows will appear (marked with a red square in Figure 31).

Share length of simple excavated soil in earthworks	Volume of simple excavated soil per m length	Total volume of simple excavated soil in earthworks	Share length of excavated ripped soil in earthworks	Volume of excavated ripped soil per m length	Total volume of excavated ripped soil in earthworks	Share length of blasted rock in earthworks	Volume of blasted rock per m length	Total volume of blasted rock in earthworks	Soil stabilization method	Total volume of soil stabilized	Tunnel walls and lining method
SHL_{ES}	Q_{ES}	Q_{TOT-ES}	SHL_{ERS}	Q_{ERS}	$Q_{TOT-ERS}$	SHL_{BLR}	Q_{BLR}	$Q_{TOT-BLR}$		$SOIL_{STAB}$	
(0-100%)	(m3/m)	(m3)	(0-100%)	(m3/m)	(m3)	(0-100%)	(m3/m)	(m3)	(type)	(m3)	(type)
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	L-C Columns	30205	
60,0	66,0	150242	0,0	0,0	0	40,0	193,0	292897	L-C Columns	3925	
60,0	66,0	0	0,0	0,0	0	40,0	193,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	

Figure 31: Earthworks in Alternative 3 (case study)

In case Alternative 3 is chosen, LC-columns will be used for stabilization of new road and extended road and concrete mass piles- for stabilization of bridges. About 30205 m3 of soil is stabilized during construction of a new road and about 3925 m3 of soil will be stabilized during construction of extended road. These parameters are visible after pressing the button 'Expand earthworks' (marked with a red square in Figure 32).

Share length of simple excavated soil in earthworks	Volume of simple excavated soil per m length	Total volume of simple excavated soil in earthworks	Share length of excavated ripped soil in earthworks	Volume of excavated ripped soil per m length	Total volume of excavated ripped soil in earthworks	Share length of blasted rock in earthworks	Volume of blasted rock per m length	Total volume of blasted rock in earthworks	Soil stabilization method	Total volume of soil stabilized	Tunnel walls and lining method
SHL_{ES}	Q_{ES}	Q_{TOT-ES}	SHL_{ERS}	Q_{ERS}	$Q_{TOT-ERS}$	SHL_{BLR}	Q_{BLR}	$Q_{TOT-BLR}$		$SOIL_{STAB}$	
(0-100%)	(m3/m)	(m3)	(0-100%)	(m3/m)	(m3)	(0-100%)	(m3/m)	(m3)	(type)	(m3)	(type)
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	L-C Columns	30205	
60,0	66,0	150242	0,0	0,0	0	40,0	193,0	292897	L-C Columns	3925	
60,0	66,0	0	0,0	0,0	0	40,0	193,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	Please select
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	
100,0	0,0	0	0,0	0,0	0	0,0	0,0	0	None	0	

Figure 32: Soil stabilization in Alternative 3 (case study)

Note that there are no elements crossing this road corridor alternative. Consequently, all the values in that table are '0' (rows 348:354).

The new road and concrete bridge will have 3 lanes (3,4 meters each), extended road will have 2 lanes (3 meters each). Please check the thickness and types of materials used for Subbase layer, Base layer, and Pavement layer under corresponding cells (marked with red squares in Figure 33).

365	**New road:**									
366	Driving lanes (DL)	3,40	3	10,20	100% Aggregate	0,420	User defined	0,150	Default mix	0,080
367	Hard shoulders (HS)	1,00	2	2,00	100% Aggregate	0,420	User defined	0,150	Default mix	0,080
368	Central reserve incl. guardrail (CR)	1,75	1	1,75	100% Aggregate	0,420	User defined	0,150	Default mix	0,080
369	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
370	Soft shoulders incl. guardrail (SS)	1,50	2	3,00	None	0,000	100% Aggregate	0,650		
371	Road ditch (RD)	0,50	2	1,00						
372	**Extended road:**									
373	Driving lanes (DL)	3,00	2	6,00	100% Aggregate	0,420	User defined	0,150	Default mix	0,080
374	Hard shoulders (HS)	1,00	2	2,00	100% Aggregate	0,420	User defined	0,150	Default mix	0,080
375	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
376	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
377	Soft shoulders incl. guardrail (SS)	1,50	2	3,00	None	0,000	100% Aggregate	0,650		
378	Road ditch (RD)	0,50	1	0,50						
379	**Road below ground water:**									
380	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
381	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
382	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
383	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
384	**Auquaduct:**									
385	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
386	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
387	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
388	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
389	**Underpass:**									
390	Driving lanes (DL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
391	Hard shoulders (HS)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
392	Central reserve incl. guardrail (CR)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
393	Cycling/pedestrian lanes (CPL)	0,00	0	0,00	None	0,000	None	0,000	None	0,000
394	**Tunnel:**									
395	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
396	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
397	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
398	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
399	**Dual tunnels:**									
400	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
401	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
402	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
403	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
404	**Underwater tunnels:**									
405	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
406	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
407	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
408	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
409	**Underwater dual tunnels:**									
410	Driving lanes (DL)	0,00	0	0,00			None	0,000	None	0,000
411	Hard shoulders (HS)	0,00	0	0,00			None	0,000	None	0,000
412	Central reserve incl. guardrail (CR)	0,00	0	0,00			None	0,000	None	0,000
413	Cycling/pedestrian lanes (CPL)	0,00	0	0,00			None	0,000	None	0,000
414	**Steel Bridges:**									
415	Driving lanes (DL)	0,00	0	0,00					None	0,000
416	Central reserve incl. guardrail (CR)	0,00	0	0,00					None	0,000
417	Cycling/pedestrian lanes (CPL)	0,00	0	0,00					None	0,000
418	**Concrete Bridges:**									
419	Driving lanes (DL)	3,40	3	10,20					Default mix	0,080
420	Central reserve incl. guardrail (CR)	1,75	1	1,75					Default mix	0,080
421	Cycling/pedestrian lanes (CPL)	0,00	0	0,00					None	0,000

Figure 33: Cross-section geometry of the road corridor of Alternative 3 (case study)

Note that one type of material chosen in several cells is called 'User defined'. 'User defined' layer (% of aggregate/gravel, bitumen and sand/soil) can be specified in 'ModelValues' sheet. For instance, cells: ModelValues!E70, ModelValues!F70, ModelValues!H70 (marked with a red square in Figure 34). So in order to see what types of material is specified under 'User defined', you need to open sheet 'ModelValues'. The user can also change and modify the 'User defined' values.

		Expand							
66	Collapse	**Base Materials and Pavement Mixtures**	Abbreviation	Layer	Aggregate/ Gravel	Bitumen	Concrete	Sand/Soil	(Units)
67					(%)	(%)	(%)	(%)	%
69		Default mix	PV1	Pavement	94,00	6,00	0,00	0,00	%
70		User defined	PV2	Pavement	94,10	5,90	0,00	0,00	%
72		100% Aggregate	SB1	Subbase	100,00	0,00		0,00	%
73		100% Sand	SB2	Subbase	0,00	0,00		100,00	%
74		User defined	SB3	Subbase	80,00	0,00		20,00	%
76		Default mix	B0	Base	99,50	0,50		0,00	%
77		100% Aggregate	B1	Base	100,00	0,00		0,00	%
78		100% Sand	B2	Base	0,00	0,00		100,00	%
79		User defined	B3	Base	97,90	2,10		0,00	%

Figure 34: Specification of 'User defined' layers in 'ModelValues' sheet (case study)

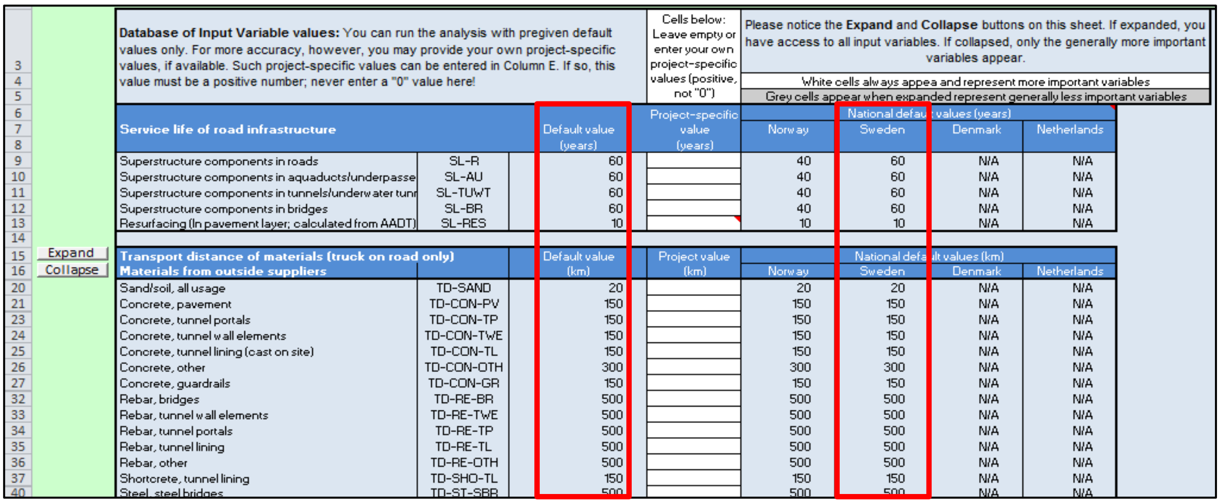
Step 4: Having finished looking through all the parameters inserted for Alternative 3, you can also check parameters for other alternatives: Alternative 0, Alternative 1, and Alternative 2.

As noted before, some of the values need to be inserted manually. Please make sure that all parameters are updated for other alternatives (as described in Table 11).

Table 11: List of parameters that should be manually updated for each alternative considered in the case study

Cell	Needed update for the case study
Alternative 0:	
No changes needed	
Alternative 1:	
D151 (Sum length of elements of this type within the alternative)	0
H153 (Share length with center guardrail)	100
I153 (Center guardrail type)	Steel
U153 (Soil stabilization method)	LC columns
X153 (Length of this element that also serves traffic from outside)	7574
Y153 (Quantity of traffic from outside)	1104
F193 (Subbase layer material)	100% Aggregate
Alternative 2:	
I244 (Center guardrail type)	Steel
I245 (Center guardrail type)	Steel
U244 (Soil stabilization method)	LC columns
U245 (Soil stabilization method)	LC columns
Y244 (Quantity of traffic from outside)	1104
Y245 (Quantity of traffic from outside)	1104
K276 (Pavement layer height)	0,08
K277 (Pavement layer height)	0,045
Alternative 3:	
Y336 (Quantity of traffic from outside)	1104
Y337 (Quantity of traffic from outside)	1104
X336 (Length of this element that also serves traffic from outside)	2979
X337 (Length of this element that also serves traffic from outside)	3794
U336 (Soil stabilization method)	LC-Columns
U337 (Soil stabilization method)	LC-Columns
V336 (Total volume of soil stabilized)	30205
V337 (Total volume of soil stabilized)	3925
M337 (Volume of simple excavated soil per m length)	66
R337 (Share length of blasted rock in earthworks)	40
S337 (Volume of blasted rock per m length)	193

Step 5: Go to the next sheet 'ModelValues' and inspect the default values used in the project. Note that since the chosen country is Sweden, Swedish default values were chosen for this exercise (marked with a red square in Figure 35).



Database of Input Variable values: You can run the analysis with pregiven default values only. For more accuracy, however, you may provide your own project-specific values, if available. Such project-specific values can be entered in Column E. If so, this value must be a positive number; never enter a "0" value here!

Cells below: Leave empty or enter your own project-specific values (positive, not "0")

Please notice the **Expand** and **Collapse** buttons on this sheet. If expanded, you have access to all input variables. If collapsed, only the generally more important variables appear.

White cells always appear and represent more important variables

Grey cells appear when expanded represent generally less important variables

Expand | Collapse

Service life of road infrastructure		Default value (years)	Project-specific value (years)	National default values (years): Norway	Sweden	Denmark	Netherlands
Superstructure components in roads	SL-R	60		40	60	N/A	N/A
Superstructure components in aquaducts/underpasse	SL-AU	60		40	60	N/A	N/A
Superstructure components in tunnels/underwater tunr	SL-TUWT	60		40	60	N/A	N/A
Superstructure components in bridges	SL-BR	60		40	60	N/A	N/A
Resurfacing (In pavement layer; calculated from AADT)	SL-RES	10		10	10	N/A	N/A

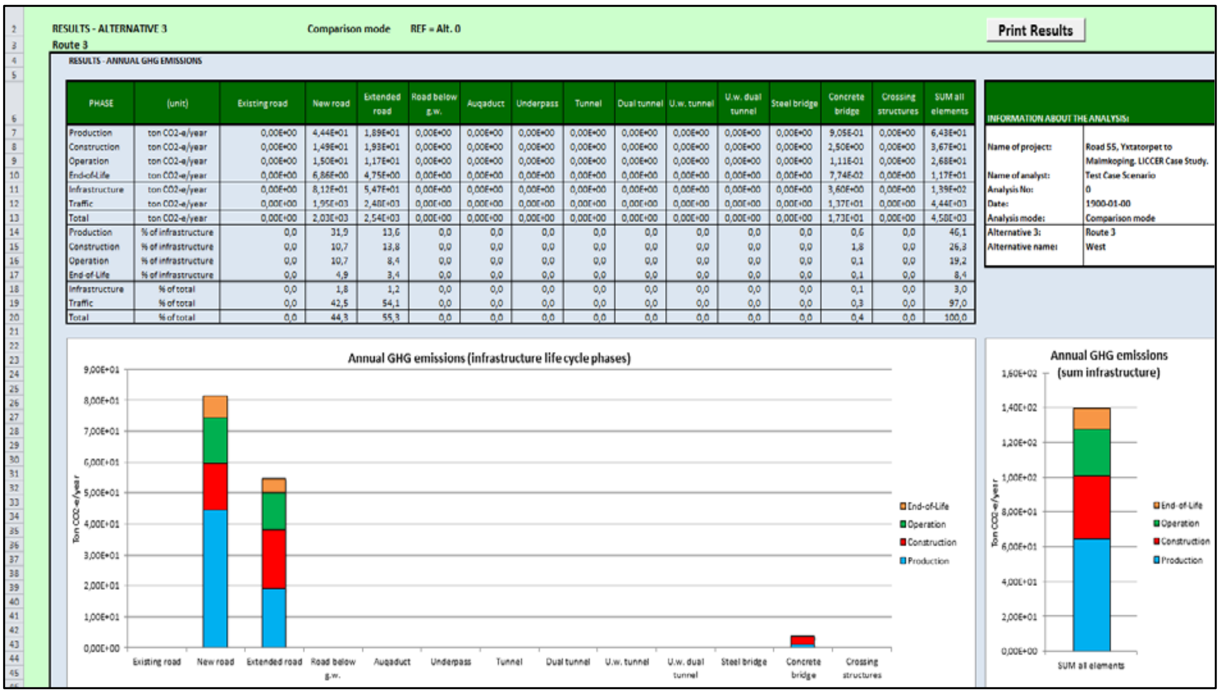
Transport distance of materials (truck on road only) Materials from outside suppliers		Default value (km)	Project value (km)	National default values (km): Norway	Sweden	Denmark	Netherlands
Sand/soil, all usage	TD-SAND	20		20	20	N/A	N/A
Concrete, pavement	TD-CON-PV	150		150	150	N/A	N/A
Concrete, tunnel portals	TD-CON-TP	150		150	150	N/A	N/A
Concrete, tunnel wall elements	TD-CON-TWE	150		150	150	N/A	N/A
Concrete, tunnel lining (cast on site)	TD-CON-TL	150		150	150	N/A	N/A
Concrete, other	TD-CON-OTH	300		300	300	N/A	N/A
Concrete, guardrails	TD-CON-GR	150		150	150	N/A	N/A
Rebar, bridges	TD-RE-BR	500		500	500	N/A	N/A
Rebar, tunnel wall elements	TD-RE-TWE	500		500	500	N/A	N/A
Rebar, tunnel portals	TD-RE-TP	500		500	500	N/A	N/A
Rebar, tunnel lining	TD-RE-TL	500		500	500	N/A	N/A
Rebar, other	TD-RE-OTH	500		500	500	N/A	N/A
Shortcrete, tunnel lining	TD-SHO-TL	150		150	150	N/A	N/A
Steel, steel bridges	TD-ST-SBR	500		500	500	N/A	N/A

Figure 35: 'ModelValues' (case study)

Note that except 'User defined' values for mixes of base, subbase and pavement, no project-specific values were inserted in this sheet. This means that the model will use default values for this case study.

Step 6: Have a look at sheets 'Result-Alt.0', 'Result-Alt.1', 'Result-Alt.2' and 'Result-Alt.3'. These sheets show absolute results for each alternative separately (Section 3.7).

Check and analyse results for each alternative (Alternative 0, Alternative 1, Alternative 2, and Alternative 3. Results for Alternative 3 are shown in Figure 36.



RESULTS - ALTERNATIVE 3 Comparison mode REF = Alt. 0

Route 3

Print Results

RESULTS - ANNUAL GHG EMISSIONS

PHASE	(unit)	Existing road	New road	Extended road	Road below g.w.	Auqaduct	Underpass	Tunnel	Dual tunnel	U.w. tunnel	U.w. dual tunnel	Steel bridge	Concrete bridge	Crossing structures	SUM all elements
Production	ton CO2-e/year	0,00E+00	4,44E+01	1,89E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	9,05E-01	0,00E+00	6,43E+01
Construction	ton CO2-e/year	0,00E+00	1,49E+01	1,93E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,50E+00	0,00E+00	3,67E+01
Operation	ton CO2-e/year	0,00E+00	1,50E+01	1,17E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,11E-01	0,00E+00	2,68E+01
End-of-Life	ton CO2-e/year	0,00E+00	6,86E+00	4,75E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,74E-02	0,00E+00	1,17E+01
Infrastructure	ton CO2-e/year	0,00E+00	8,12E+01	5,47E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,60E+00	0,00E+00	1,39E+02
Traffic	ton CO2-e/year	0,00E+00	1,95E+03	2,48E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,37E+01	0,00E+00	4,44E+03
Total	ton CO2-e/year	0,00E+00	2,03E+03	2,54E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,73E+01	0,00E+00	4,58E+03
Production	% of infrastructure	0,0	31,9	13,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	46,1
Construction	% of infrastructure	0,0	10,7	13,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,8	0,0	26,3
Operation	% of infrastructure	0,0	10,7	8,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	19,2
End-of-Life	% of infrastructure	0,0	4,9	3,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	8,4
Infrastructure	% of total	0,0	1,8	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	3,0
Traffic	% of total	0,0	42,5	54,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	97,0
Total	% of total	0,0	44,3	55,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	100,0

INFORMATION ABOUT THE ANALYSIS:	
Name of project:	Road 55, Yxtatorpet to Malmkoping. LICCER Case Study.
Name of analyst:	Test Case Scenario
Analysis No:	0
Date:	1900-01-00
Analysis mode:	Comparison mode
Alternative 3:	Route 3
Alternative name:	West

Figure 36: 'Result-Alt.3' sheet (case study)

Step 7: Have a look at the sheet 'Comparison' (Section 3.5 and Section 2.2). Remember that the 'Comparison' mode of analysis was chosen in the beginning. Look at the graphs in 'Comparison' sheet and compare alternatives in terms of their contribution to annual GHG emissions and energy use (Figure 37).

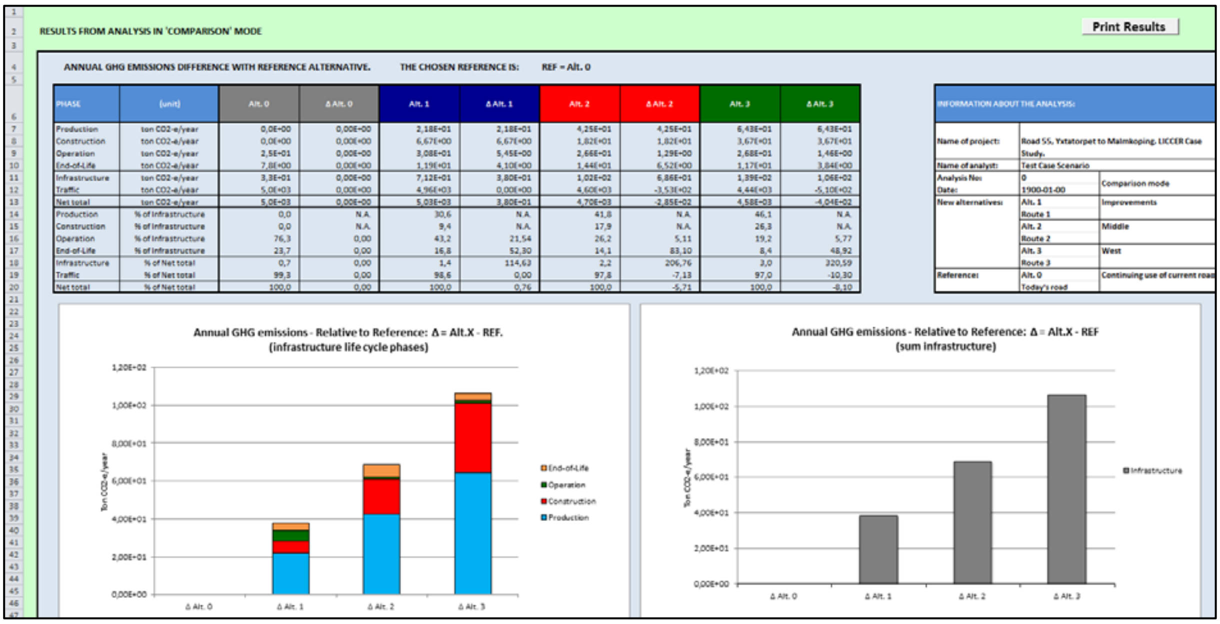


Figure 37: Part of 'Comparison' sheet (case study)

Step 8: Have a look at the sheet 'Adding-Up (Section 3.6 and Section 2.2). Note that since 'Comparison' mode was chosen, and you are comparing different alternatives with each other, the message 'NB: YOU HAVE CHOSEN THE 'COMPARISON' MODE >> YOUR RESULTS ARE IN THE 'COMPARISON' SHEET!' appears on top of this sheet (Figure 38). This means that you should not use results from this sheet.

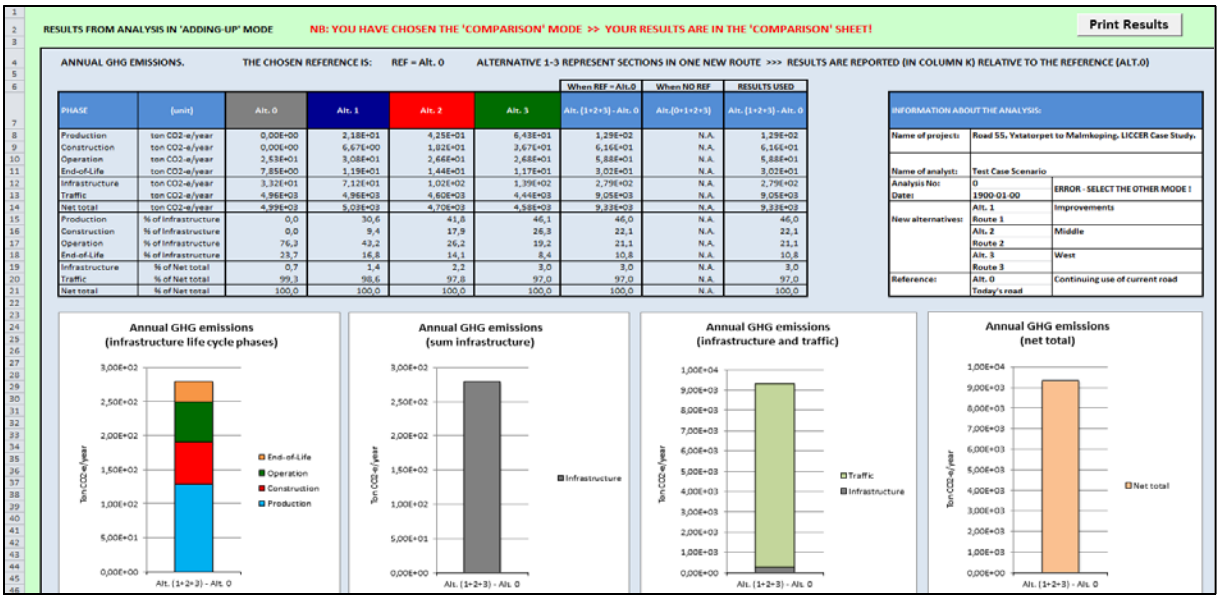


Figure 38: Part of 'Adding up' sheet (case study)

Step 9: Have a look at the underlying calculations used in this model in the sheet ‘Calculations’ (Figure 39 and Section 3.8).

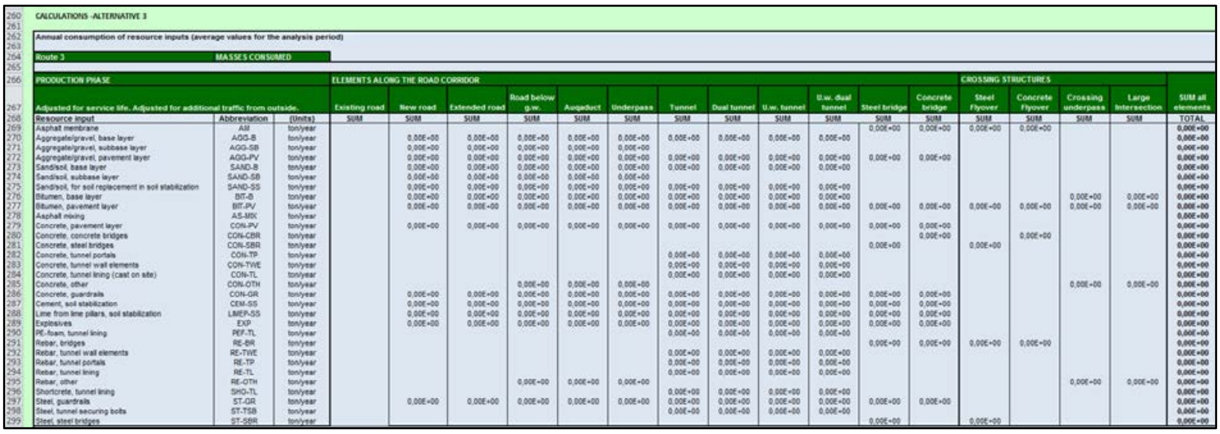


Figure 39: Part of ‘Calculations’ sheet (case study)

Step 10: Have a look at ‘DataSources’ sheet (Figure 40). Note that ‘Sweden’ was chosen as a country for this case study. You can find here a list of sources for the default national values in Sweden (using ‘Expand’ button).

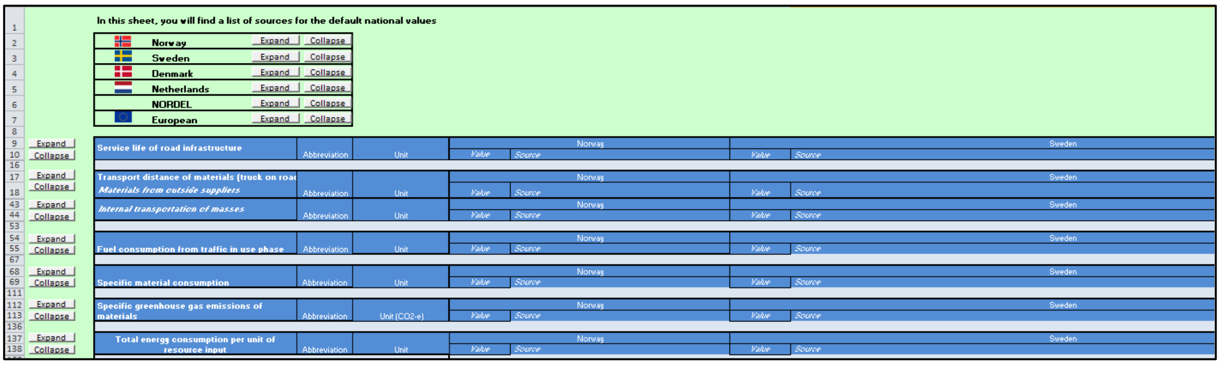


Figure 40: Part of ‘DataSources’ sheet (case study

When you are finished, you can use the 'Reset values' buttons to remove the test values.

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