LICCER

Report from second workshop

Report Nr 3

October 2013

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Deliverable Nr 3 – Report from second workshop

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Introduction

The LICCER project aims at developing a model for quantifying life cycle energy use and greenhouse gas emissions in the early stage of road infrastructure planning. This stage involves decisions on road corridor localization of the new road infrastructure and/or on how to increase the capacity of existing infrastructure. The LICCER model focus on energy use and greenhouse gas emissions may in the future be extended to include also other environmental impacts.

A draft-version of the LICCER model was available at the time of the second LICCER workshop. This second workshop took place on 17 September 2013 on the premises of KTH Royal Institute of Technology, Stockholm (Sweden). Appendix 1 gives an overview of the workshop programme. The LICCER workshop was targeted at participants from National Road Administrations (NRAs), researchers, consultants and other potential users of the LICCER model. Appendix 21 contains the list of participants of this second LICCER workshop.

Aim of the second workshop was to test and discuss relevance and applicability of the LICCER model. To this purpose, a pre-structured exercise with the LICCER model was prepared giving workshop participants a unique opportunity to get a hands-on introduction to the preliminary model, at the same time providing the LICCER team with some first valuable information about the relevance and applicability of the LICCER model that afterwards were closer discussed in the plenary discussion (see Appendix 1 for the workshop-programme).

This report provides all relevant materials used and produced at the second LICCER workshop. The slides of all presentations are included in the Appendices 5-9. Appendix 4 contains the answers to the pre-structured exercise, and Appendix 3 contains the exercise itself. Chapter 4 contains the main conclusions of this second workshop, while Chapter 3 summarises the results of the plenary discussion. Chapter 2 gives a short overview of the LICCER project up to now.

Not included in this report, but used at the second workshop, are the 'LICCER model Technical report' (Brattebø et al. 2013), the 'LICCER model guidelines' (Lundberg et al. 2013), and a draft version of the LICCER model populated with exercise input data. These reports can be obtained on request.

The LICCER project duration: 01/01/2012– 31/12/2013

Coordinator: José Potting, KTH Royal Institute of Technology (Sweden) / Wageningen University (the Netherlands) (previous coordinators: Susanna Toller and Göran Finnveden, KTH Royal Institute of Technology, Sweden)

Other team members: Helge Brattebø, NTNU (Norway), Harpa Birgisdottir, Harpa Birgisdottir Consulting (Denmark), Kristina Lundberg, Ecoloop (Sweden).

LICCER project up to now

The LICCER project started in January 2012 with the aim to develop a model for Life Cycle Assessment (LCA) of road infrastructure that can be used within an Environmental Impact Assessment (EIA) process in the early stage of transport planning. The life-cycle model was intended to focus on energy use and greenhouse gases, but would consider the option to include also other environmental impacts. It was expected that the model would be built in Excel using a modular framework that will consist of modules for plain roads, bridges and tunnels including supporting components. The aim and focus of the LICCER project has been adjusted slightly, as will be elucidated in this chapter.

The work within the LICCER project is planned through five work packages (WPs). Figure 3 presents the different WPs and how they are organised within the project. WP1 and WP2 are being performed throughout the whole project while WP3, WP4 and WP5 are being performed by the corresponding partners in parallel.

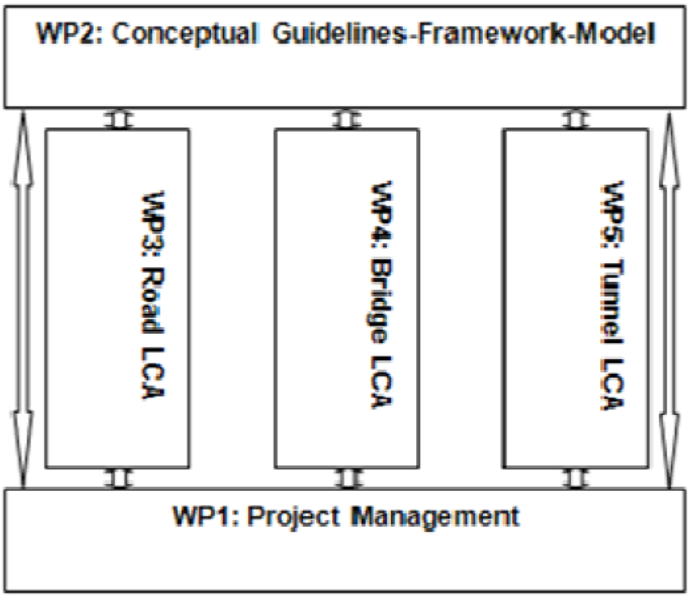


Figure 1: Organisation of work packages in the LICCER project

The work in the LICCER project started with making an overview of the road infrastructure planning process and the use of Environmental Assessments in Sweden, Norway, Denmark and the Netherlands. Kluts and Miliutenko (2012) collected in-depth information, through literature search and open interviews. The results from the literature and interviews were verified with information in environmental assessment reports, and by asking Swedish and Dutch participants in the first LICCER workshop for their expert feedback. Participants from Denmark and Norway were obviously also asked for their feedback on the results for Sweden and the Netherlands, but additionally requested to give input for extending the overview to Norway and Denmark (Lund and Toller, 2012). This facilitated completing the overview of the road infrastructure planning process and the use of Environmental Assessments in the 4 countries mentioned (Miliutenko et al., to be submitted).

The overview of the road infrastructure planning process and the use of Environmental Assessments was the basis for a closer discussion with the participants about the specific aim and focus of the LICCER project. The LICCER model development has, as a result of this discussion, been further confined to:

- Life cycle energy use and greenhouse gas emissions (i.e. leaving inclusion of other environmental impacts in the model to a follow-up project)
- Focusing on road corridor localization where decisions are taken about the length and composition of road elements (road, bridges and tunnels)
- Flexible specification of road elements (i.e. user-defined specification of how much of different pre-defined road elements are part of alternative road corridors in a new road project; the energy use and greenhouse gas emissions from the pre-defined road element can be calculated using default input values as basis, but the LICCER model provides the possibility for providing more precise project specific values)
- Tentative inclusion of energy use and greenhouse gas emissions from traffic movement
- Default model values to be based on national databases.

During the course of the LICCER model development also the initially intended modular framework has been changed into a fully integrated modelling or road elements (i.e. roads, tunnels and bridges). Figure 2 gives an overview of this integrated framework. Brattebø et al. (2013) contains closer details about the LICCER model development and its technical backgrounds. A draft version of the model was tested and discussed during the second LICCER workshop about which this report gives an overview.

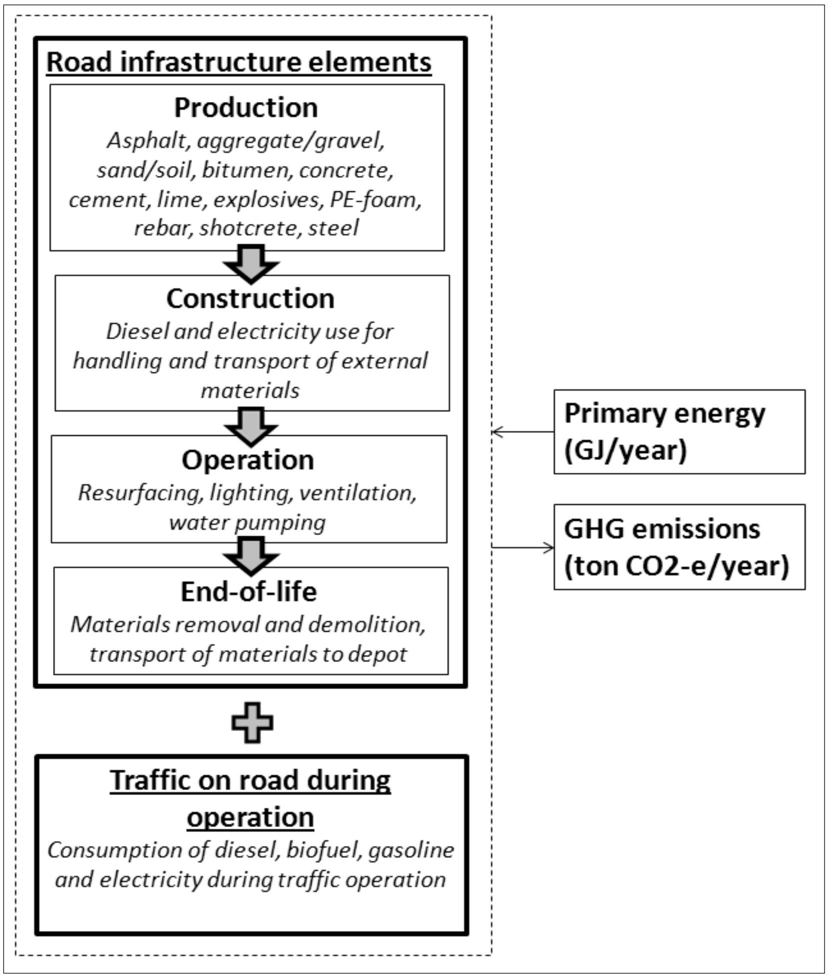


Figure 2: Integrated framework for the LICCER model

The first LICCER workshop also discussed how life cycle energy use and greenhouse gas emissions are best to be used for decision support in the early stage of road infrastructure planning process. Figure 3 compares the road infrastructure planning processes in Sweden, Norway, Denmark and the Netherlands. The Netherlands makes use of a Strategic Environmental Assessment (SEA), while the other countries are bound to an Environmental Impact Assessment (EIA) for road corridor localization. It was suggested that life cycle energy use and greenhouse gas emissions can be included in these SEA/EIA, but also separately from these, as stand-alone or as part of a Cost Benefit Analysis.

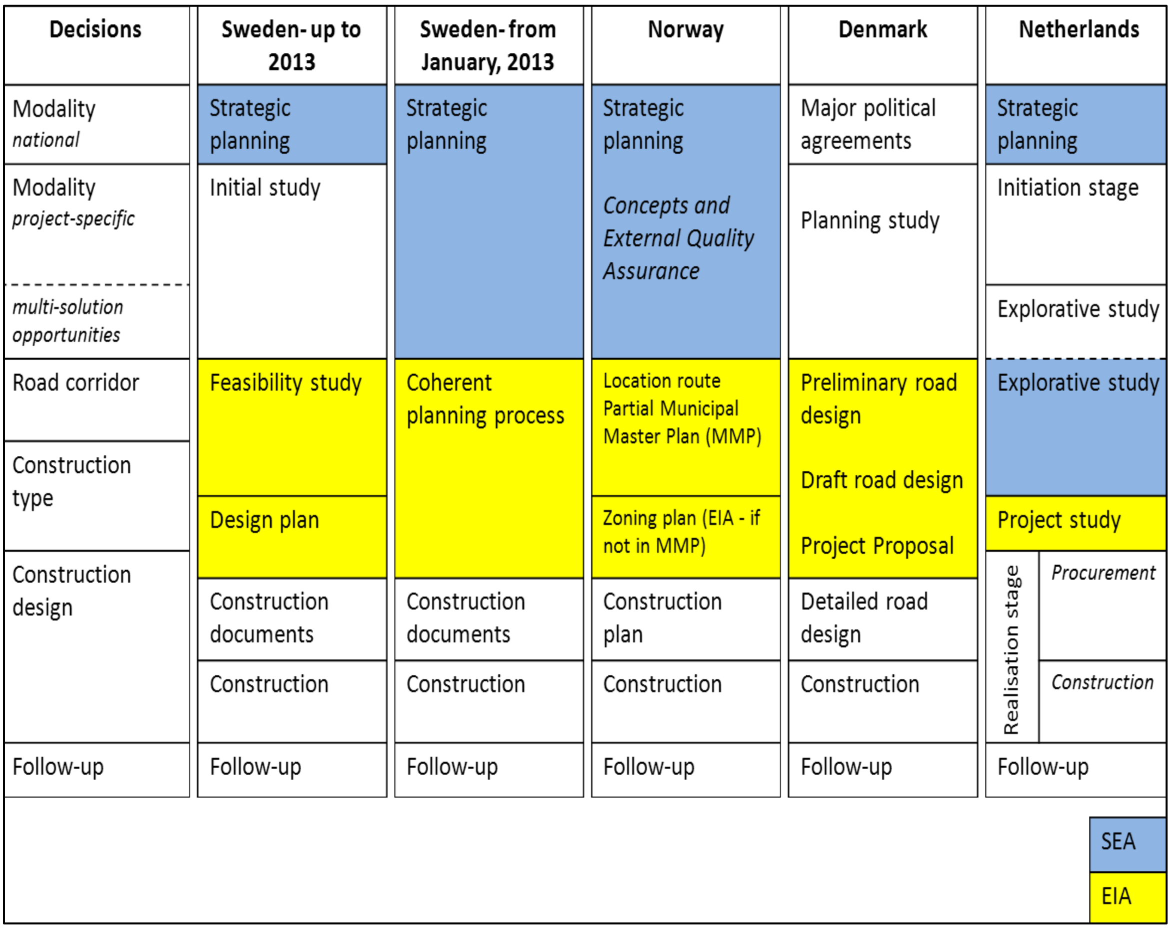


Figure 3: Comparison of road infrastructure planning in the Netherlands, Sweden, Denmark and Norway (Miliutenko et al., submitted)

The 'LICCER model guidelines report' (Lundberg et al. 2013), from which the draft has been distributed to the participants of the second LICCER workshop, further elaborates on the aim and use of the model. It discusses the different types of LICCER model output in relation to the type of information needed in different stages of the road transport planning process, with a specific focus on its use for supporting decisions about road corridor localization.

Workshop discussion and results

The relevance and applicability of the LICCER model was discussed as part of the interactive pre-structured exercise and during the plenary discussion. The main results of these discussions are reflected here according to subject (i.e. do not chronologically reflect the course of discussions).

One of the workshop participants expressed during the plenary discussion her surprise about the easiness of using the model without having seen it before, and without having read any documentation. This experience was confirmed by most of the other workshop participants. Also the LICCER-team observed remarkable little need for assistance from the participants during the exercise. One workshop participant, working within the research department at a national road authority, stated that the model was easy indeed for users familiar with Life Cycle Assessment (LCA) and/or life cycle thinking (which basically applied to the majority of workshop participants). However, he doubted whether colleagues from other departments within national road administration would be able to easily use the model. This was answered by a counter-question whether the LICCER model needs to be easy enough for users without LCA competence, as some LCA knowledge maybe should be required in road planning teams.

There are two angles to the question whether the LICCER model needs to be easy enough for users without LCA competence, i.e. (1) whether the model output or also (2) the underlying calculation principles should be easy enough to comprehend without LCA competence. The first angle was not further discussed at the workshop, but the LICCER team is of the opinion that the model output should in principle be understandable without LCA competence. Road planning teams without LCA expertise should thus be able to comprehend the model output results. For good understanding of the underlying calculation principles on the other hand, the second angle, some knowledge of LCA methodology may be expected. Also inputting data and running the LICCER model may require some LCA competence. The workshop participants agreed some LCA competence is needed to understand the context of using the LICCER model, and for inserting specific values into the LICCER model. When national road administrations lack internal LCA competence, they can contract an expert with LCA competence, similar as experts are contracted for other types of information during the road infrastructure planning process.

Another workshop participant, also from a national road authority, pointed after the workshop to the trade-off between how easy a model is to use and the robustness of the results it generates. He stipulated that national road authorities need robust data to support road infrastructure planning, and this typically means less relevance for easier = simpler models.

A workshop participant, working within the procurement department at a national road authority, considers the LICCER model particularly useful for road corridor localization. A simpler type of model, e.g. Klimakalkyl, is needed in the earlier stages of the road infrastructure planning where you want to decide whether some road has to be (re-)build at all (no project information available yet). The Klimakalkyl models adds that for such decision only the share of roads, bridges and tunnels is of interest. Klimakalkyl, a model presently being developed for Swedish trafikverket, calculates energy use and greenhouse gas emissions for archetype bridges and tunnels. These archetype roads, bridges and tunnels are based on (statistical) analysis of roads, bridges and tunnels in existing studies. LICCER initially also intended to take a similar approach, which is already used in the Norwegian EFFEKT method, but reconsidered this after learning the unfeasibility to obtain this type of information for the other countries in the LICCER project. It would be interesting, however, to later explore integration of the Klimakalkyl archetypes in the LICCER model (in a follow-up project thus).

The availability of input data needed to run the LICCER model was questioned as part of the exercise. Workshop participants considered the input data to run the LICCER model in general as easily to possible accessible or to estimate. The detailed results from the completed questions in the exercise are included in Appendix 3. Note that Appendix 3 contains valuable comments related to specific data items. Here is a snapshot of some plenary comments:

- Updated Annual Average Daily Transport (AADT) may be hard to find
- Specification of the share of biofuel may depend on who provides the information. This can lead to misuse, which may be avoided by proposing a default value. The presently included default value is based on statistics.
- There are two ways for calculating excavated soil etc. This needs to be better explained in the model.
- Transport distances of materials are considered difficult to estimate as they depend on local conditions as well as the contractor's solutions. Transport distances may in some cases nevertheless be important for the results.

Several project specific data are hardly available in the early stage of road infrastructure planning. It was a common understanding across workshop participants that it is therefore important to have as good as possible (national) default data in the LICCER model. This default data should preferably be approved by the transport administration. Sweden, Norway and the Netherlands have approved sets of default data. Some of this data are taken from licensed databases (e.g. EcoInvent), however, which prevents its inclusion in the LICCER model (national road authorities and other models, e.g. Klimakalkyl struggle with the same problem). The LICCER model, as to be delivered at the end of the LICCER project, will contain to the extent possible approved data for Sweden and Norway, but licensed data in those national sets will be replaced by non-licensed data from another source. The LICCER model will contain data references, or explanations where own data is produced, so that the user can judge whether the included data are relevant to use.

It was put forward that the LICCER model user needs to understand if for example a 5% difference in results between road corridor alternatives is in fact a significant difference. Some form of uncertainty analysis would be good, but would make the model more complex to use. It should also be noted, that the importance of data items may differ across projects, countries, questions etc. The workshop participants nevertheless considered it useful to highlight important data items in the LICCER model. This applies both to input data mandatory to run the LICCER model, as well as to data that optionally can be made project specific. The LICCER team recognized this suggestion and will try to see how the model can better highlight what are the (commonly) important input items.

The LICCER model assumes for all road corridor alternatives, including the reference alternative, the same Annual Average Daily traffic (AADT). One of the workshop participants alerted the LICCER team to the fact that the reference alternative may not always have the capacity for hosting the expected future AADT. The LICCER team afterwards discussed this issue extensively before arriving at a solution that will be implemented in the LICCER model.

The LICCER model presently produces absolute results in the tables and bar diagrams. Some workshop participants like to also have percentage results, particularly for the comparison of alternatives. It was suggested that the bar diagram output, which presently contain absolute results, could be modified to reflect percentage results. That is, the Y axis unit could be changed into percentage and the bars could represent the difference to the reference alternative that would then be taken as 100% (similar as in SimaPro). It was questioned during the workshop, however, whether this would lead to meaningless results. The impact of the production phase in the reference alternative is zero, after all, as per definition the reference alternative refers to the unchanged situation where nothing is produced. The LICCER team therefore decided to include percentage results in the tables.

Some Environmental Product Declarations do not allow presentation of results summed over the product's life cycle (in order to avoid bias from differences in data quality). This conflicts with the summed stacked bar presentations as included in the comparison mode output of the LICCER model. There is, however, no conflict with the ISO-standard in which comparison of summed results are allowed.

One of the workshop participants asked after the difference between comparison and adding up mode output of the LICCER model. The difference became clear after explaining that there sometimes is a need to distinguish between different sections of one road corridor alternative. The adding up mode output is meant for that situation. This needs to be clarified better in the LICCER model, e.g. by not using alternatives for naming the different sections. The LICCER team will reconsider the naming used in comparison and adding up.

Concluding remarks

The participants of the second LICCER workshop were dominated by participants from Sweden (see Appendix 2). Participation from Norwegians, Danes and Dutch were under-represented. The workshop has nevertheless provided the LICCER team with valuable input to improve and finalise the LICCER model itself, the ‘LICCER model technical report’ and the ‘LICCER model guidelines report’. Draft versions of these deliverables have also been distributed to other invitees for this second workshop in order to get additional feedback.

Final versions of the LICCER model, technical and guidelines report are to be delivered before the end of 2013, but will first become publically available after approval of ERA-NET ROAD (the body funding the LICCER project).

References

Brattebø, H., R. O'Born, S. Miliutenko, H. Birgirsdottir, K. Lundberg, S. Toller and J. Potting (2013): *LICCER model technical report.* Report nr. 2 (internal report). ERA-NET ROAD, Stockholm (Sweden).

Fms-KTH (2011): Life Cycle Considerations in EIA of Road Infrastructure. Application Form (AF) - Part A. ERA-NET ROAD, Stockholm (Sweden).

Kluts, I. and S. Miliutenko (2012): *Overview of road infrastructure planning process and the use of Environmental Assessments in the Netherlands and Sweden.* TRITA-INFRA-FMS 2012:6, ISSN 1652-5442. Environmental Strategies Research – fms, KTH Royal Institute of Technology, Stockholm (Sweden).

Lundberg, K., S. Miliutenko, H. Birgirsdottir, S. Toller, H. Brattebø and J. Potting (2013): *LICCER model guidelines report*. 4.1 (draft). ERA-NET ROAD, Stockholm (Sweden)

Lundberg, K. and S. Toller (2012): *Report from first workshop.* Report nr. 1. ERA-NET ROAD, Stockholm (Sweden).

Miliutenko, S., I. Kluts, K., Lundberg, S., Toller, H., Brattebø, H., Birgisdottir and J. Potting (to be submitted): Inclusion of life cycle considerations in road infrastructure planning processes: the example of Sweden, Norway, Denmark and the Netherlands. *To be submitted*.

Appendix 1: Programme of the 2nd LICCER-workshop

Date: 17 September 2013
Place: Seminar room 4055, Drottning Kristinas väg 30 (L-building), KTH Royal Institute of Technology in Stockholm, Sweden.

9.45 Reception with coffee

10.00 Opening, outline of the project and the day
José Potting (WU/KTH)

10.45 Overview of the model
Helge Brattebø (NTNU)

11.15 Interactive exercise
Sofiia Miliutenko (KTH), all participants

12.30 Lunch at ¨Syster och Bror¨

13.30 Interactive exercise (continuation)
Sofiia Miliutenko (KTH), all participants

14.45 Coffee break

15.00 Plenary discussion about sense, possibilities and limitations
Kristina Lundberg (Ecoloop)

16.00 Concluding remarks
Harpa Birgisdottir

16.15 Closing & Drinks

Appendix 2: Participants of the 2nd LICCER-workshop

Ali Azhar Butt	KTH	Sweden
Andreas Öman	WSP	Sweden
Anna Björklund	KTH	Sweden
Annelie Carlson	VTI	Sweden
Bob Hamel	NPRA	Norway
Carolina Liljenström	KTH	Sweden
Hanna Eklöf	Trafikverket	Sweden
Harpa Birgisdottir	Harpa Birgisdottir Consulting	Denmark
Helge Brattebø	NTNU	Norway
Henrik Fred Larsen	DRD	Denmark
Ida Sjöberg	Tyrens	Sweden
José Potting	WU	Netherlands
Kristina Lundberg	Ecoloop	Sweden
Larissa Strömberg	NCC	Sweden
Lennart Folkeson	VTI	Sweden
Nicklas Magnusson	Tyrens	Sweden
Reyn O Born	NTNU	Norway
Sofiia Miliutenko	KTH	Sweden
Susanna Toller	Trafikverket	Sweden
Åsa Lindgren	Trafikverket	Sweden

Appendix 3: Interactive exercise

LICCER workshop exercise – Workshop, Stockholm September 17, 2013

LICCER Workshop Exercise

Aim of the exercise: to demonstrate the LICCER model and to get feedback on how easy it is to use and how relevant information it provides with regards to the position in the planning process.

- **Name (optional):**____

- **Affiliation (optional):**____

Note that we will not distribute or refer to your answers individually.

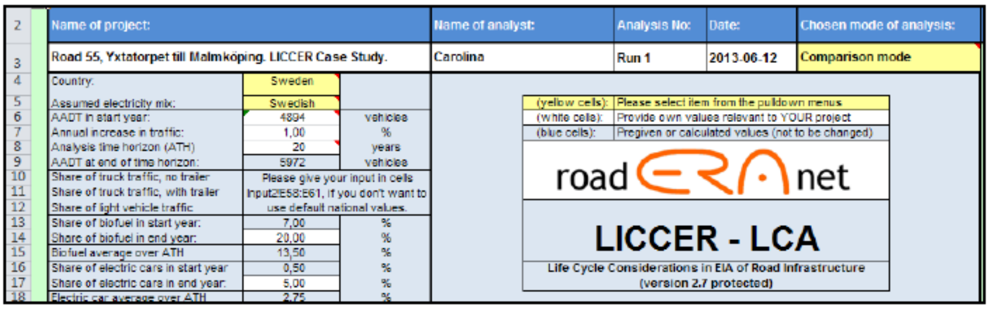
- **Please indicate to which stakeholder group(s) you belong:**

Stakeholder group	Mark this field
Competent authority	
Property owner	
Research & Development	
Consultancy	
Contractor	
Other, namely _______________	

- Are you involved in decisions on choice of road corridor?
  - Yes
  - No
  - Sometimes
  - Comment:____
    ____
    ____

Step 1: Open the Excel file with LICCER model and open sheet ¨*Input1*¨. This sheet allows the user to enter project input data and specification of alternatives.

A. Go to the first table in Input1 and inspect the project input data that should be filled by the user (white cells) together with some pregiven or calculated values (blue and yellow cells) in rows 2:18 (see Figure below). Don't bother at this stage if the values are not precise.



	Name of project:			Name of analyst:	Analysis No:	Date:	Chosen mode of analysis:
3	Road 55, Yxtatorpet till Malmköping. LICCER Case Study.			Carolina	Run 1	2013-06-12	Comparison mode
4	Country:	Sweden					
5	Assumed electricity mix:	Swedish					
6	AADT in start year:	4894	vehicles				
7	Annual increase in traffic:	1,00	%				
8	Analysis time horizon (ATH)	20	years				
9	AADT at end of time horizon:	5972	vehicles				
10	Share of truck traffic, no trailer	Please give your input in cells Input2!E58:E61, if you don't want to use default national values.					
11	Share of truck traffic, with trailer						
12	Share of light vehicle traffic						
13	Share of biofuel in start year:	7,00	%				
14	Share of biofuel in end year:	20,00	%				
15	Biofuel average over ATH	13,50	%				
16	Share of electric cars in start year	0,50	%				
17	Share of electric cars in end year:	5,00	%				
18	Electric car average over ATH	2,75	%				

(yellow cells):	Please select item from the pulldown menus
(white cells):	Provide own values relevant to YOUR project
(blue cells):	Pregiven or calculated values (not to be changed)

road ERA net

LICCER - LCA

Life Cycle Considerations in EIA of Road Infrastructure (version 2.7 protected)

B. Make sure that the chosen mode of analysis is ¨Comparison mode¨ (row 3), the country is ¨Sweden¨ (row 4) and assumed electricity mix: ¨Swedish¨ (row 5).

Please answer Question #1:

What type of the input data that you have just seen (rows 4:18) is easily accessible, according to your experience (for example, already used in economic evaluations, feasibility study etc.) when the decision on road corridor is taken?

Please mark in the table below

Variable name	Easily accessible	Could probably be obtained but I am not sure	No, I don't think so	I don't know	Comments
AADT in start year *(for the analysed project)*					
Annual increase in traffic *(for the analysed project)*					

Share of biofuel in end year *(general for the country)*					
Share of electric cars in end year *(general for the country)*					

Step 2: Scroll down the sheet ¨*Input1*¨ and inspect input data needed for each alternative which is marked with a specific colour code: Alternative 1- blue (row 43), Alternative 2- red (row 169), Alternative 3- green (row 295), and Alternative 0- grey (row 421).

Note that some input values for Alternative 3 are missing (rows 299, 300, 309, 322, 329, 375). You will have a chance to insert them later during the workshop exercise. Input values for Alternative1, 2, and 0 have been already inserted in the model.

Take a closer look at Alternative 2 (rows 170:251), 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.) (B170:Y184)
2) elements crossing this road corridor alternative (B185:K191)
3) cross-section geometry (i.e. number and width of lanes, height of layers) of the elements included in the road corridor (B192:K251).

Note that alternative 2 consists of new road, extended road and concrete bridge. This is marked with ¨1¨ in column C (C173, C174, C183).

169	Alternative 2:	1B	Alt. name:	Middle						
170	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	Total fuel used for earthwork (excavation & transportation)	Share length of simple excavated soil in earthworks
171	Variable name:	N_E	L_{TOT}	SHL_{LG}	SHL_{SG}		SHL_{CG}		DES_{EARTH}	SHL_{ES}
172	Unit:	(#)	(m)	(0-100 %)	(0-100 %)	(type)	(0-100%)	(type)	(m3 total)	(0-100%)
173	New road (NR)	1	2579	0.0	40.7	Steel	100.0	Steel	99,08	60.0
174	Extended road (ER)	1	4434	22.6	11.3	Steel	100.0	Steel	170,35	70.0
175	Road below groundwater (RBG)	0	0	0.0	0.0	None	0.0	None	0,00	100.0
176	Auguaduct (AD)	0	0	0.0	0.0	None	0.0	None	0,00	100.0
177	Underpass (UP)	0	0	0.0			0.0	None	0,00	100.0
178	Tunnel (T)	0	0	0.0			0.0	None		100.0
179	Dual Tunnel (DT)	0	0	0.0			0.0	None		100.0
180	Underwater tunnel (UWT)	0	0	0.0			0.0	None		100.0
181	Underwater dual tunnel (UWDT)	0	0	0.0			0.0	None		100.0
182	Steel bridge or overpass (SB)	0	0	0.0			0.0	None	0,00	100.0
183	Concrete bridge or overpass (CB)	1	21	0.0			100.0	Steel	0,81	75.0
184	Total length of all elements (L_{TOT})		7034							

Please answer Question #2:

A. What type of the project specific input data that you have just seen (rows 170:184) can be easily estimated for the analysed project, according to your experience (for example, if it has already been estimated in economic evaluations, feasibility study etc.) when the decision on road corridor is taken?

Please mark in the table below

Variable name	Yes, I can make a good estimate	Not sure, but maybe possible	No, I don't think so	I don't know	Comments
Share length with road lighting (E:170)					
Length and type of guardrails(F170:I170)					
Fuel used for earthworks during construction (J:170)					
Simple excavate soil in earthworks (share length and volume) (K170:M170)					
Excavated ripped soil in earthworks (share length and volume) (N170:P170)					
Blasted rock in earthworks (share length and volume) (Q170:S170)					
Type and volume/area of soil stabilization method (T170:U170)					
Volume of concrete used in concrete constructions (V:170) *(only for road below groundwater, aqueducts and underpasses)*					
Type of tunnel walls and lining method for tunnels (W:170)					

B. Some parts of the road project may serve extra traffic from outside, in addition to the traffic within our project. New road infrastructure on such parts of the road project will contribute to the overall energy consumption and GHG emissions; however, these contributions should only partly be allocated to our project. In case the new road serves extra traffic from outside, a part of the contributions to energy consumption and GHG emissions should also be allocated to the outside system.

So is it possible to estimate the quantity of extra traffic that is served from outside and the length of road that serves that traffic (X170:Y170)?

i. Yes, I can make a good estimate

ii. Not sure, but maybe possible

iii. No, I don't think so

iv. I don't know

v. Comments:____

____

Step 3: Go to the next sheet ¨Input2¨.

The Input2 sheet provides national default values and a possibility to insert project-specific values if available (service life, transport distances, etc…). The national default values will be used by the model if there are no project-specific values inserted. If project-specific values are inserted (in pink or white cells), then they will be used by the model.

3 4 5	**Database** - default and optional project specific values. Please notice that the model will work without any of your own project specific values, by using the default values that are preset for each country. However, if you estimate and enter your own project specific values, your model will calculate more accurate results. This is particularly of interest for the cells in PINK color. And if you enter a value in Column E, this value must be a positive number. Never enter a "0" value here!			Cells below: Leave empty or enter project specific values (positive, not "0")	**Please notice the color codes in these input tables:** Pink (More important variables): Please input project specific values if available White (Less important variables): Input project specific value for maximum accuracy					
6 7 8	**Service life of road infrastructure**		Default value (years)	Project value (years)		National default values (years)				
						Norway	Sweden	Denmark	Netherlands	Other
9	Superstructure components in roads	SL-R	60			40	60			
10	Superstructure components in aquaducts/underpasses	SL-AU	60			40	60			
11	Superstructure components in tunnels/underwater tunnels	SL-TUWT	60			40	60			
12	Superstructure components in bridges	SL-BR	60			40	60			
13	Resurfacing (In pavement layer; calculated from AADT)	SL-RES	10			10	10			
14										
15 16	**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	Other
17	Aggregate/gravel, all usage except pavement asphalt	TD-AGG	5			10	5			
18	Asphalt membrane	TD-AM	500			500	500			
19	Asphalt, pavement (incl. bitumen and aggregate)	TD-AST-PV	5			20	5			
20	Sand/soil, all usage	TD-SAND	10			10	10			
21	Concrete, pavement	TD-CON-PV	300			300	300			
22	Concrete, bridges	TD-CON-BR	300			300	300			
23	Concrete, tunnel portals	TD-CON-TP	100			100	100			
24	Concrete, tunnel wall elements	TD-CON-TWE	300			300	300			
25	Concrete, tunnel lining (cast on site)	TD-CON-TL	100			100	100			
26	Concrete, other	TD-CON-OTH	100			100	100			
27	Concrete, guardrails	TD-CON-GR	100			100	100			
28	Cement, soil stabilization	TD-CEM-SS	100			100	100			
29	Lime from lime pillars, soil stabilization	TD-LIMEP-SS	300			300	300			

Please answer Question #3:

A. Would the type of information below be available for a specific project at the stage of choosing road corridor? Please mark in the table below:

Variable name	Yes, project-specific data are available	No, Project-specific data are not available	I would prefer to use national default values	I don't know	Comments
Service life (B7:K13)					
Transport distances (B15:K50)					
Fuel consumption (B53:L64)					
Base material and pavement mixes (B66:I79)					
Tunnel cross-section variables (B89:K109)					
Specific material consumption (B112:L164)					
Emission data (GHG emissions and energy) (B166:L214)					

B. Do you think this method of providing input data in **Input 1** and **Input 2** will give the user sufficient flexibility with respect to large variation of road projects, as well as access and variability of data?

i. Yes

ii. No

Please explain why: ____

iii. I don't know

iv. Comment:____

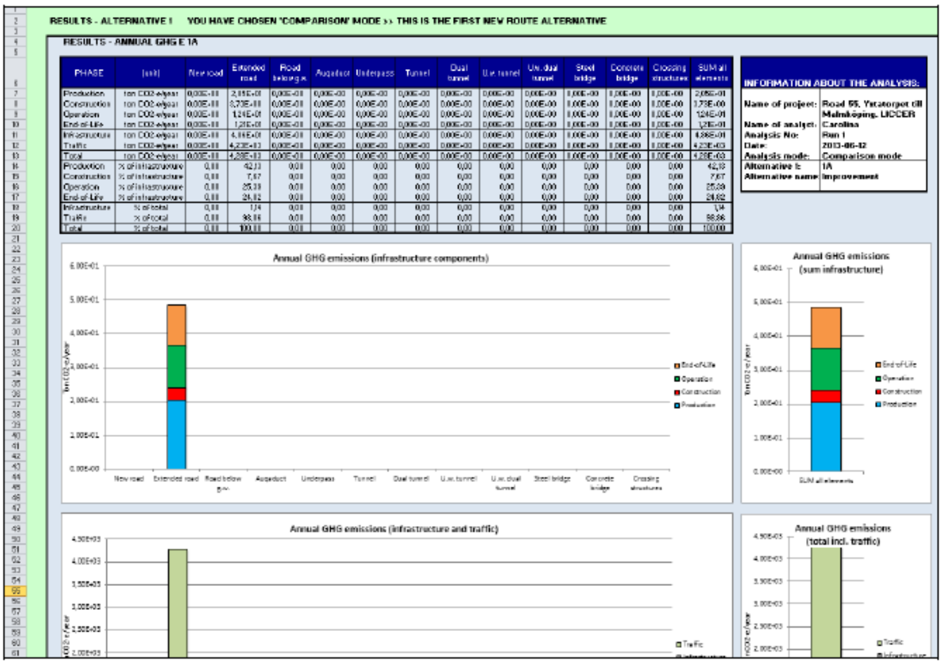
Step 4: Have a look at sheets ¨*Result Alt 1*¨, ¨*Result Alt 2*¨ and ¨*Result Alt 0*¨. Note that the sheet ¨Results Alt3¨ is empty, as no input data have been filled in yet. But we will do it later during the exercise.

In ¨Result Alt X¨ sheet you can see:

i) the relative importance of each life-cycle phase

ii) the difference between energy and GHG emissions,

iii) the role of traffic versus road infrastructure



Please answer Question #4:

A. Is this type of information relevant in decision-making?

a. Yes

b. No

Please explain why:

____

____

____

c. I don’t know

d. Comment:____

____

____

B. Are the graphs easy to read and understand?

a. Yes

b. No

Please explain why:

____

____

____

c. I don't know

d. Comment:____

____

____

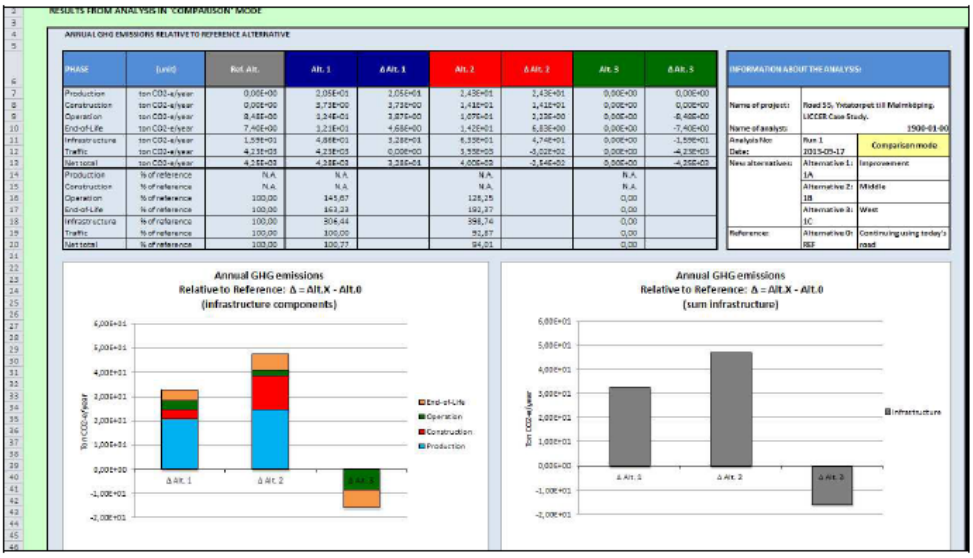
Step 5: Have a look at the sheet ¨*Comparison*¨ (note that we have chosen ¨Comparison¨ mode of analysis). Don't bother about Alternative 3, as data have not been inserted yet.

In ¨Comparison¨ sheet you can see:

i) the differences between each of the alternatives,

ii) the difference between energy and GHG emissions,

iii) the role of traffic versus road infrastructure



Please answer Question #5:

A. Is this information relevant for your organization and decision-making?

a. Yes

b. No

Please explain why:

____

____

____

c. I don't know

d. Comment:____

____

____

B. Are the graphs easy to read and understand?

a. Yes

b. No

Please explain why:

____

____

____

c. I don't know

d. Comment:____

____

____

Step 6: Have a look at the sheet ¨*Calculations*¨

In ¨Calculations¨ sheet you can see:

i) The underlying calculations behind the aggregated results

ii) The most important factors of each alternative, regarding energy and GHG emissions.

1								
2	CALCULATIONS - ALTERNATIVE 1							
3								
4	Annual consumption of resource inputs (average values for the analysis period)							
5								
6	1A	MASSES CONSUMED						
7								
8	PRODUCTION PHASE			ELEMENTS ALONG THE ROAD CORRIDOR				
9	Adjusted for service life. Adjusted for additional traffic from outside.			New road	Extended road	Road below g.w.	Auqaduct	Underpass
10	Resource input	Abbreviation	(Units)	SUM	SUM	SUM	SUM	SUM
11	Asphalt membrane	AM	ton/year					
12	Aggregate/gravel, base layer	AGG-B	ton/year	0,00E+00	5,78E+02	0,00E+00	0,00E+00	0,00E+00
13	Aggregate/gravel, subbase layer	AGG-SB	ton/year	0,00E+00	6,84E+02	0,00E+00	0,00E+00	0,00E+00
14	Aggregate/gravel, pavement layer	AGG-PV	ton/year	0,00E+00	4,39E+02	0,00E+00	0,00E+00	0,00E+00
15	Sand/soil, base layer	SAND-B	ton/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
16	Sand/soil, subbase layer	SAND-SB	ton/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
17	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
18	Bitumen, base layer	BIT-B	ton/year	0,00E+00	3,58E+00	0,00E+00	0,00E+00	0,00E+00
19	Bitumen, pavement layer	BIT-PV	ton/year	0,00E+00	1,97E+01	0,00E+00	0,00E+00	0,00E+00
20	Concrete, pavement layer	CON-PV	ton/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
21	Concrete, concrete bridges	CON-CBR	ton/year					
22	Concrete, steel bridges	CON-SBR	ton/year					
23	Concrete, tunnel portals	CON-TP	ton/year					
24	Concrete, tunnel wall elements	CON-TWE	ton/year					
25	Concrete, tunnel lining (cast on site)	CON-TL	ton/year					
26	Concrete, other	CON-OTH	ton/year			0,00E+00	0,00E+00	0,00E+00
27	Concrete, guardrails	CON-GR	ton/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
28	Cement, soil stabilization	CEM-SS	ton/year	0,00E+00	7,13E-04	0,00E+00	0,00E+00	0,00E+00
29	Lime from lime pillars, soil stabilization	LIMEP-SS	ton/year	0,00E+00	5,40E+00	0,00E+00	0,00E+00	0,00E+00
30	Explosives	EXP	ton/year	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
31	PE-foam, tunnel lining	PEF-TL	ton/year					
32	Rebar, bridges	RE-BR	ton/year					
33	Rebar, tunnel wall elements	RE-TWE	ton/year					
34	Rebar, tunnel portals	RE-TP	ton/year					
35	Rebar, tunnel lining	RE-TL	ton/year					
36	Rebar, other	RE-OTH	ton/year			0,00E+00	0,00E+00	0,00E+00
37	Shortcrete, tunnel lining	SHO-TL	ton/year					
38	Steel, guardrails	ST-GR	ton/year	0,00E+00	3,49E+00	0,00E+00	0,00E+00	0,00E+00
39	Steel, tunnel securing bolts	ST-TSB	ton/year					
40	Steel, steel bridges	ST-SBR	ton/year					

Please answer Question #6:

Are the underlying calculations easy to follow?

a. Yes

b. No

Please explain why:

____

____

____

c. I don't know

d. Comment:____

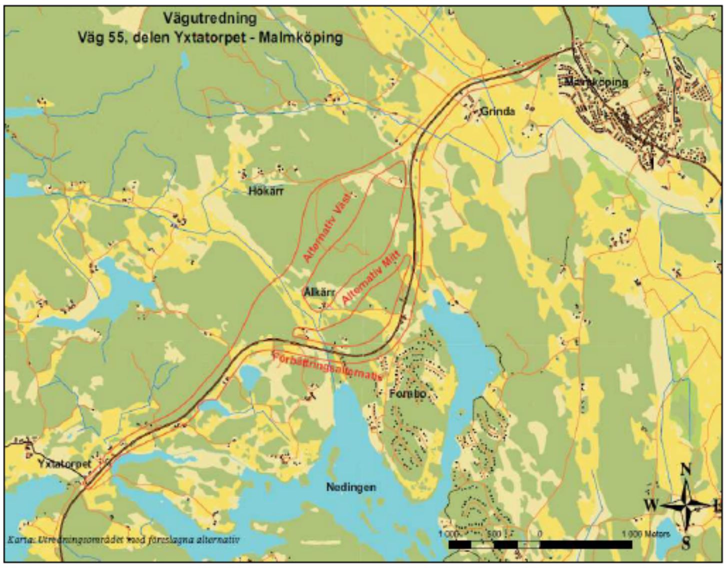
____

____

Step 7: Inserting new inputs values for Alternative 3

Please **insert the data** for Alternative 3 (sheet ¨ Input1¨, rows 295:377) according to the following information:

*Alternative 3 will consist of **2979 m** of **new road**, **3794 m** of **extended road**, and **21 m** of **concrete bridge**. See in the map below, where Alternativ Väst=Alternative 3 (Alternative Mitt=Alternative 2, Förbättringsalternativ= Alternative 1).*



*The **new road** and **concrete bridge** will have 3 lanes (3,4 meters each), **extended road** will have 2 lanes (3 meters each).*
*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.*

*Information about diesel consumption used in earthworks is not available for **extended road,** but the **share length requiring excavation of simple soil (45,5%) and amount of soil moved per meter (66m3/m) is known. As well, the total length of road where rock blasting occurs (40%) and how much rock is blasted per meter (193m3/m)** is known.*

*In case Alternative 3 is chosen, **LC-columns** will be used for **stabilization of new road and extended road** and **concrete mass** for **stabilization of bridges**.*

Having filled data for alternative 3, please check the results again (in sheet ¨Result Alt 3 ¨ and sheet ¨Comparison¨).

<u>Step 8:</u> Additional reflections on the use and usefulness of the LICCER model

Please think of answers to Questions #7 and #8:

Question #7

Is the model easy to use? :

a) Yes

b) Not completely, needs more adjustments, Please specify:

____

____

c) I don't know

d) Comment:______________________________________

____

____

Question #8

Will the model be useful for you? (Please, choose from below):

a) Yes, as it is

b) Yes, but with modifications. Please specify:

____

____

c) Not for me but for someone else in my organization or another organization. Please specify:

____

____

d) Comment:______________________________________

____

____

Appendix 3: Answers to interactive exercise

General feedback

- ALCA or CLCA? Important to distinguish
- The user should be very clearly notified about the static nature of inputs in the model and that they should be encouraged to change them if they have better values. The user should very clearly be told the implications of this on the results and that these values represent average values over the period

➢ **Please indicate to which stakeholder group(s) you belong:**

Stakeholder group	**Mark this field**
Competent authority	Iiii
Property owner	
Research & Development	Iiiii
Consultancy	Iiiii
Contractor	
Other, namely _______________	Student (ii)

Are you involved in decisions on choice of road corridor?

- **No – All said no**
- **Comment:** Trafikverket decides about the choice of corridor, but I am not involved in this decision. It is done at the planning department at Trafikverket._

Question #1:

What type of the input data that you have just seen (rows 4:18) is easily accessible, according to your experience (for example, already used in economic evaluations, feasibility study etc.) when the decision on road corridor is taken?

Please mark in the table below

Variable name	Easily accessible	Could probably be obtained but I am not sure	No, I don't think so	I don't know	Comments
AADT in start year *(for the analysed project)*	iiiii	iiiii		Iii	- Trafikverket has the data - AADT data is often old and outdated
Annual increase in traffic *(for the analysed project)*	iiiii	ii	i	iii	- Always political discussion on whether to allow it to increase, thus uncertain (STA) - Trafikverket makes prognoses on this future traffic information - AADT data is often old and outdated - Probable increase in traffic due to new development (PhD student)

Share of biofuel in end year *(general for the country)*		iiiii	ii	iiii	- Could be difficult to find numbers in % but this info is included in economic models; thus using these models to find background data possible (STA) - Need to rely on national data for that (KTH) - Trafikverket makes prognoses on this future traffic information but this is dependent on political decisions and how biofuel is planned for use - User should be recommended to work on scenarios for this (KTH) - There is a risk of misuse of the model in this section by using unrealistic development of renewable fuels (KTH)
Share of electric cars in end year *(general for the country)*		iiiii	iii	Iiii	- Trafikverket says it is not directly known about this but should be able to do given future projections - Dependent upon market intervention by authorities - Electrification of vehicles is not a certain decision, but is presumably a product of future demand for decreased CO2 emissions

Suggested to check the following source: http://www.hbefa.net/e/index.html

Question #2:

What type of the project specific input data that you have just seen (rows 170:184) can be easily estimated for the analysed project, according to your experience (for example, if it has already been estimated in economic evaluations, feasibility study etc.) when the decision on road corridor is taken?

Please mark in the table below

Variable name	Yes, I can make a good estimate	Not sure, but maybe possible	No, I don't think so	I don't know	Comments
Share length with road lighting (E:170)	iiii	iiii		ii	- Might be estimated based on previous projects - Qualified guess
Length and type of guardrails(F170:I170)	iiiii	iiiiii		i	- Might be estimated based on previous projects
Fuel used for earthworks during construction (J:170)	ii	iiIiii	i	i	- Might be estimated based on previous projects - Available if sources are open enough
Simple excavate soil in earthworks (share length and volume) (K170:M170)	iii	iiii	i	ii	- Might be estimated based on geological info - If sources are open enough - How much is reused within project? - Ongoing project Geokalkyl does this with GIS data and soil info, etc **(Mention this in the guidelines)**
Excavated ripped soil in earthworks (share length and volume) (N170:P170)	i	iii	iii	iii	- Might be estimated based on geological info - If sources are open enough - Ongoing project Geokalkyl does this with GIS dara and soil info, etc
Blasted rock in earthworks (share length and volume) (Q170:S170)	i	iiii	i	iiii	- Might be estimated based on geological info - Ongoing project Geokalkyl does this with GIS dara and soil info, etc - Available if sources are open enough

Type and volume/area of soil stabilization method (T170:U170)		iiii	ii	iiii	- Might be estimated based on geological info - Depends on how early the model is used. Field data will help - Depends on some extent by choice of solution
Volume of concrete used in concrete constructions (V:170) *(only for road below groundwater, aqueducts and underpasses)*	iiii	ii		iii	- Might be estimated based on geological info - Due to changing policy and introducing design build contracts, this wil. be more of guess work in the future, The NRAs are not specifying technical solutions
Type of tunnel walls and lining method for tunnels (W:170)	iii	ii		ii	- Might be estimated based on geological info - Due to changing policy and introducing design build contracts, this wil. be more of guess work in the future, The NRAs are not specifying technical solutions. However, some default values might be good enough - May vary gratly by rock type (think of "Hallandsås")

A. So is it possible to estimate the quantity of extra traffic that is served from outside and the length of road that serves that traffic (X170:Y170)?

i. Yes, I can make a good estimate - iiiiii
ii. Not sure, but maybe possible - iiii
iii. No, I don't think so -
iv. I don't know - ii
v. Comments;
   - There are tools to estimate
   - It depends on the situation, for example only one contributing road? That is not difficult. If a road network, equacity (sic), is affected and it is much more complex to make the allocation estimations. There are special "traffic models" for this

Question #3:

A. Would the type of information below be available for a specific project?

Please mark in the table below:

Variable name	Yes, project-specific data are available	No, Project-specific data are not available	I would prefer to use national default values	I don't know	Comments
Service life (B7:K13)	iiii	ii	iiii	i	- Estimated - National data should be used in such early stages
Transport distances (B15:K50)	i	iiiiiii	iiii		- Dependent on contractor - Not available in early planning stages
Fuel consumption (B53:L64)		iiii	iiii	i	- It might be unknown at this level without contractors being known yet

Base material and pavement mixes (B66:I79)	iii	iiiii	iii	i	Not available in early planning stages
Tunnel cross-section variables (B89:K109)		iiii	ii	iiiii	Not available in early planning stages
Specific material consumption (B112:L164)		iiiiii	iii	ii	Not available in early planning stages
Emission data (GHG emissions and energy) (B166:L214)		iiiii	iiiii	i	Not available in early planning stages

B. Do you think this method of providing input data in **Input 1** and **Input 2** will give the user sufficient flexibility with respect to large variation of road projects, as well as access and variability of data?

i. Yes - iiiiiiiii
ii. No

Please explain why:
Yes, choice between project specific and national data makes the model flexible

iii. I don't know - i
iv. Comment:
   a. Very happy with the flexibility shown in the model. Comparable models DO NOT provide such flexibility and quickly become obsolete as a result
   b. At the moment, yes. But would like to use it more. Would be interesting to know the sources of your data
   c. Much of this info is not considered at this early planning stage (before they make a road plan), I think.

Question #4:

A. Is this type of information relevant in decision-making?

a. Yes - iiiiiiiii
b. No

Please explain why:
- It is refreshing to see the relative importance both between the different stages in infrastructure and between traffic an infrastructure
- However, the decision-maker should all the time be aware that LICCER is ONE of all the other aiding tools used in decision-making

c. I don't know
d. Comment:
   - Yes, tells where improvements can be made
   - Yes, traffic is very important when deciding what infrastructure to use
   - Yes, but only with reliable data. At the decision process we might not be ready to consider this info
   - Possible to have more contribution analysis?
   - Hmm…. A ¨No¨ answer would question all LICCER project…

B. Are the graphs easy to read and understand?

a. Yes - iiiiiiiiiii

b. No

Please explain why:

____

____

____

c. I don’t know

d. Comment

- o Might be nice to have process contribution included
- o It is a bit difficult to see which processes contribute to what
- o Requires undertaking of lifecycle concepts of course

Question #5:

A. Is this information relevant for your organization and decision-making?

a. Yes - iiiiiiiiii
b. No - i

Please explain why:

- o No, not involved in planning process
- o Yes, during the choice of road corridor. It would be desirable to use it even at an earlier stage

I don’t know

c. Comment:

____

____

____

B. Are the graphs easy to read and understand?

a. Yes - iiiiiiiii

b. No - i

Please explain why:

- o No, traffic as the critical factor? Length of road?
- o Yes, they give simple overview

c. I don’t know

d. Comment:

- o It’s good that the relative changes are also shown as percentages in the table
- o I would like to see a sorting function so you can see the order of intensity in order to see where action can make a difference
- o The grey bars are not useful
- o Operation should be also called ¨Operation and maintenance¨. It should be also explained somewhere that traffic is NOT included in ¨Operation and maintenance.¨

Question #6:

Are the underlying calculations easy to follow?

a. Yes - iiiii

b. No – Iiii

Please explain why:

- No, to follow the calculations you need togo bak to the cells that are referred to in the functions and it is complicated. Also, some columns are hidden
- No, need to see the technical report
- Yes, but I want to see more transparency in the calculation
- No, hidden columns, long equations; will be better once user is more known with LICCER

I don't know

c. Comment:

- The cells in the input sheet could be named to make it easier (very time consuming – Reyn)
- Abbreviations are a bit confusing
- Lots of data, but it's necessary and is presented in an ok way
- I didn't have time to check the calculations.
- Possibly you could think of adding some type of **uncertainty** in those given default values, for instance add reference to literature, other models etc.

Question #7

Is the model easy to use? :

a) Yes – Iiiiiii

b) Not completely, needs more adjustments, Please specify: - iii

- The model requires a lot of inputs and may not be time for filling all of them in; maybe possible to enter share of the different elements (bridge, road, etc) for a faster calculation (with default values)
- Each column should have a link to an explanation of what it means
- Considering I have not seen the user manual or technical report, I am still able to navigate through the model easily. If there is documentation that explains the modelling principles and structure, then reading them will make it that much easier for someone with LCA background and general model experience. It should not be used by someone who does not have an understanding of LCA or an understanding of infrastructure
- It's difficult to answer as it depends on the experience. But I think that it can be learned quite quickly.
  Depending on user's ambitions, different quantity and quality of input data will be needed. Good that default values are given, but nothing is said about their uncertainty or ¨official¨ status.

c) I don't know

d) Comment:

- Link LICCER to klimakalkyl
- Havent been using it that long but feel like I understand it already
- Maybe adding error messages when data is forgotten would be useful
- Easy to make mistakes when including the data

Question #8

Will the model be useful for you? (Please, choose from below):

a) Yes, as it is - ii
b) Yes, but with modifications. Please specify: - i

- Transparency with data, emission factors, so the results may be compared to other LCA tools

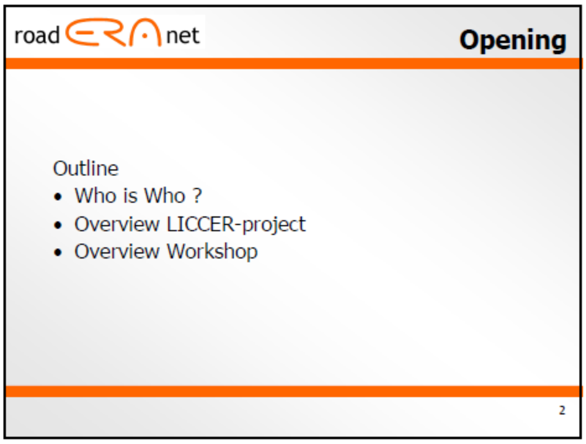
c) Not for me but for someone else in my organization or another organization. Please specify*:*
- iiii

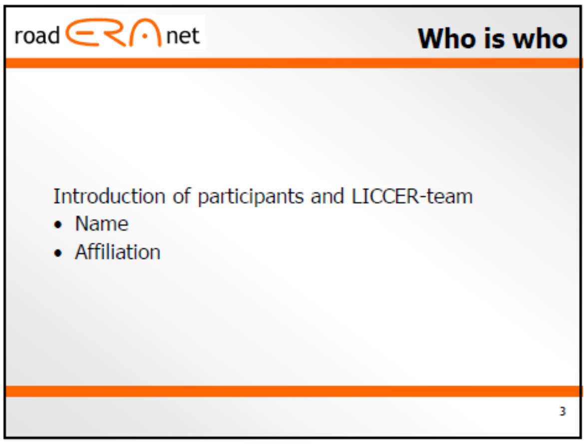
- Should be useful but has to be fitted into the process and it has to be clear how it complements other models that are used
- Road planning sections when choosing alternatives, Other sections when considering new measures
- The tool is useful for Trafikverket, but it would be better if it were also suitable for earlier stages- for prioritizing of measures

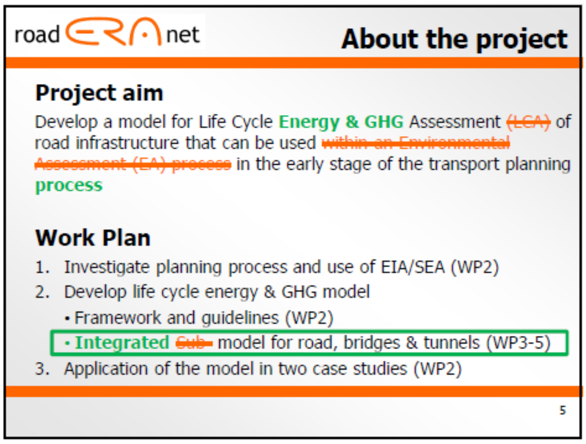
d) Comment:

- Cannot give a straight answer, must use the model more
- I would love to see an educational version of the model that could be used as a simulation for civil engineer students in the classroom to test and learn about LCA, preferably as part of a course in road construction. Could it be possible to get funding to plan something like this?
- In case the user inserts a very incredible value, the tool should put a ¨warning¨ or similar
- Would it possible to add guidelines in the model (as clickable explanations) and avoid paper guide? Many users ignore written ¨user's guides¨.
- It would be good if you could compare alternatives with each other, and not just with the 0-alternative. This might be especially relevant in case 0-alternative is modified over time (small updates happen even in 0-alternative)
- Write somewhere about the context in which LICCER will be used, and that LICCER is only one of the tools that can be used
- Describe LICCER's role in the EIA process, e.g. limitation that many other important environmental aspects are not included in LICCER.
- Feels like it's too detailed data to be relevant at the planning stage, it is meant to be used in

Appendix 4: Opening *(José Potting)*







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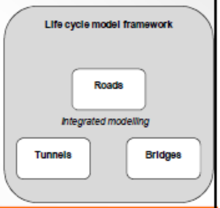
Model development

- Focusing on decision-support for road localisation/route
- Following ISO 14044 for LCA
- Limited to life cycle energy & GHG's
- Elaborated from (less flexible) Norwegian EFFEKT
- Integrated modelling of road elements
- Flexible specification of road elements
- Tentative inclusion vehicle movement
- Default (national) databases



7

road ERA net

Further activities

1. Testing and fine-tuning LICCER model and user guidelines
   - 2nd Workshop (today)
   - Case studies for Norway and Sweden (D5)
2. Release final version guidelines & external model report (D4)
3. Release final version of LICCER model

8

road ERA net

Workshop aim

To test and discuss relevance and applicability of the LICCER-model

- Model exercise
- Plenary discussion

Trust. Understand.Commit. 9

road ERA net

Workshop programme

10.00 Opening, outline of project and day (*José Potting, WU/KTH)*

10.45 Overview of the model (*Helge Brattebø , NTNU)*

11.15 Interactive exercise (*Sofiia Miliutenko, KTH) all participants)*

12.30 Lunch at "Syster och Bror"

13.30 Interactive exercise (*Sofiia Miliutenko, KTH; all participants)*

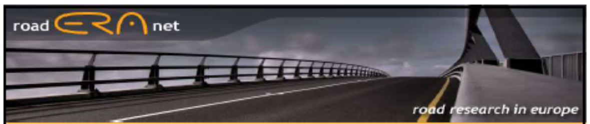
14.45 Coffee break

15.00 Plenary discussion on sense, possibilities & limitations (*Kristina Lundberg, Ecoloop)*

16.00 Concluding remarks (*Harpa Birgisdottir, HP Consulting)*

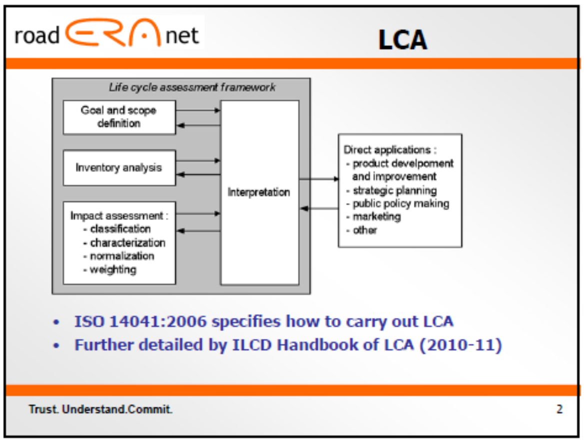
16.15 Closing & Drinks

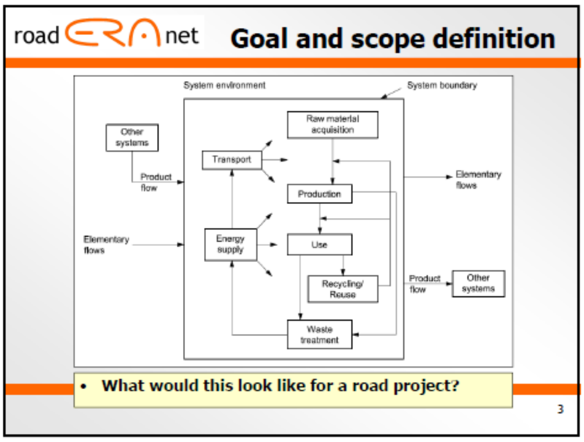
Trust. Understand.Commit. 10

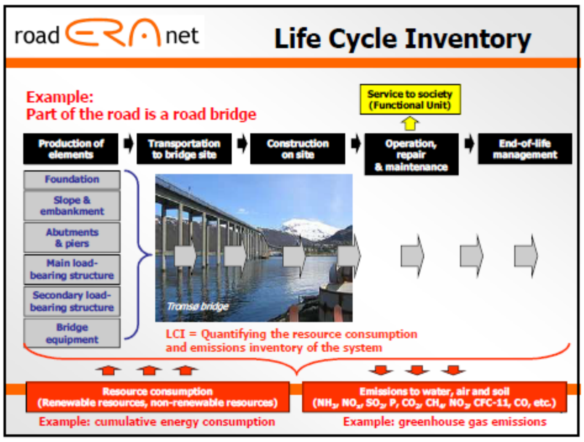


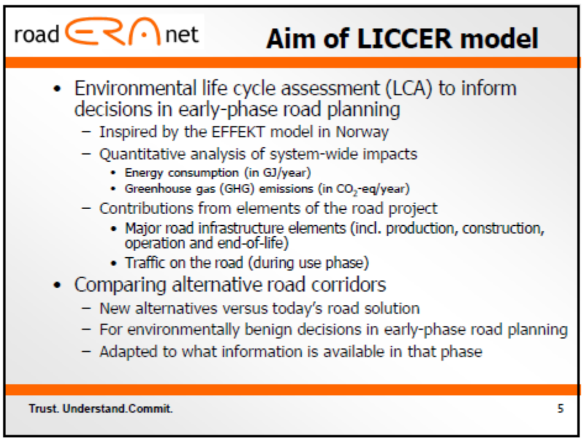
Thank you and enjoy !

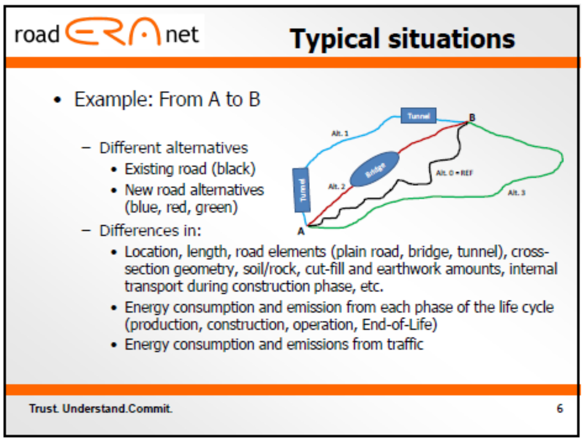
Appendix 5: Overview of the model *(Helge Brattebø)*





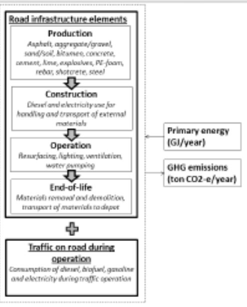






road ERA net

LICCER system definition



- We quantify the consumption of materials and energy inputs
  - For given route alternatives
  - With a given analysis time horizon and service life values
  - Finding the yearly consumption of each material and energy input
    - For road infrastructure elements during all phases of the life cycle
    - For traffic during operation
  - Then calculating the yearly
    - Cumulative primary energy use (GJ/year)
    - Greenhouse gas emissions (ton CO_2-eq/year)

road ERA net

Main elements of a road

Elements along a road corridor:

- New road (NR)
- Extended road (ER)
- Road below groundwater (RBG)
- Aqueduct (AD)
- Underpass (UP)
- Tunnel (T)
- Dual Tunnel (DT)
- Underwater tunnel (UWT)
- Underwater dual tunnel (UWDT)
- Steel bridge or overpass (SBR)
- Concrete bridge or overpass (CBR)

road ERA net

Crossing elements

Elements crossing a road corridor:

- Steel Overpass/Flyover
- Concrete Overpass/Flyover
- Underpass
- Large intersection

road ERA net

LICCER scope

- What is accounted for, and where in the system?
  - Elements along the road corridor
  - Elements crossing the road corridor
  - Traffic

		Elements along the road corridor				Elements crossing the road corridor		Traffic
Input type	Unit	New road, Extended road	Aqueduct, Underpass, Road below groundwater	Tunnel, Dual Tunnel Underwater tunnel, Underwater dual tunnel	Steel bridge or overpass, Concrete bridge or overpass	Steel Flyover, Concrete Flyover	Crossing underpass, Large intersection	
Asphalt membrane	ton							
Aggregate, gravel	ton							
Sand/soil	ton							
Bitumen	ton							
Concrete	ton							
Cement in soil stabilization	ton							
Lime in soil stabilization	ton							
Explosives	ton							
PE-foam	ton							
Rebar	ton							
Shotcrete	ton							
Steel	ton							
Diesel	m^3							
Electricity	kWh							
Biofuel	m^3							
Gasoline	m^3							
Transport of materials	tonkm							

road ERA net

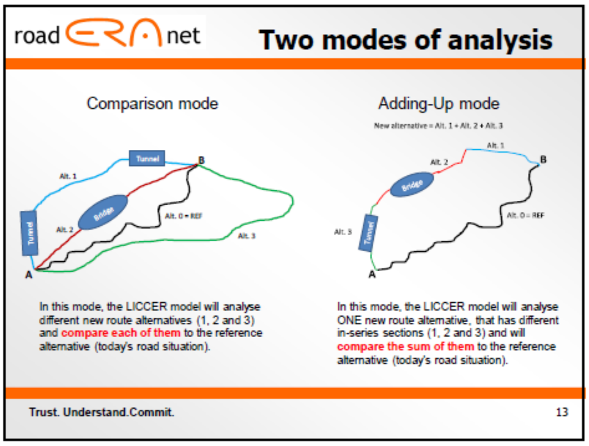
Example of inputs

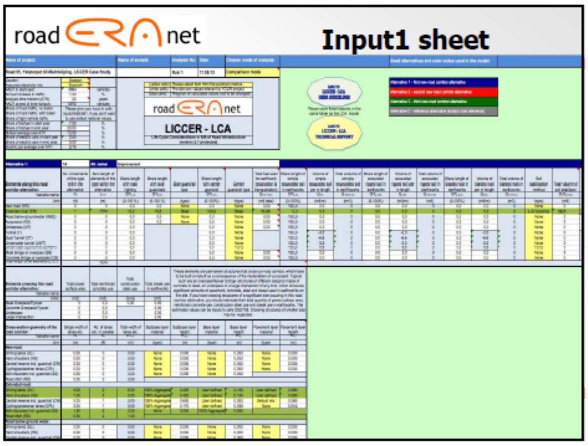
- Inputs related to the road infrastructure
  - Number and length of road elements of given types (road, tunnel, bridge, underpasse, etc.)
  - Road width and number of lanes
  - Pavement, base and sub-base layer height and material type
  - Share length including lighting, side and centre guardrails
  - Earthworks volumes and fuel used for earthworks
  - Soil stabilization methods
  - Tunnel walls and lining methods
  - Concrete use (in road below groundwater, underpass, aquaduct)
  - Paved area, concrete use and diesel in earthworks use for crossing structures (overpass, underpass, large intersection)

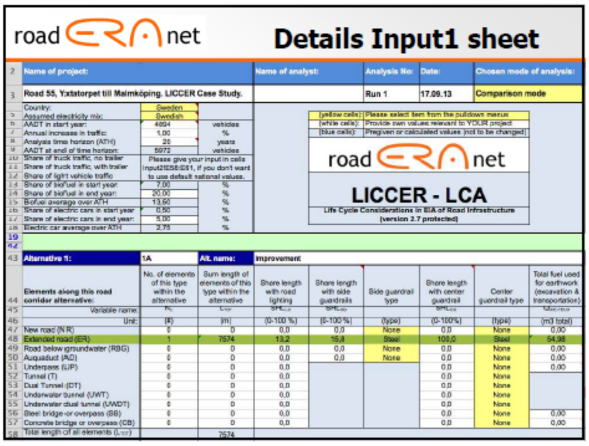
road ERA net

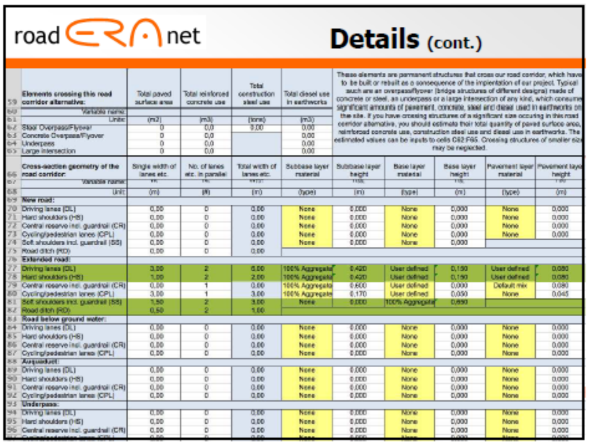
Example of inputs (cont.)

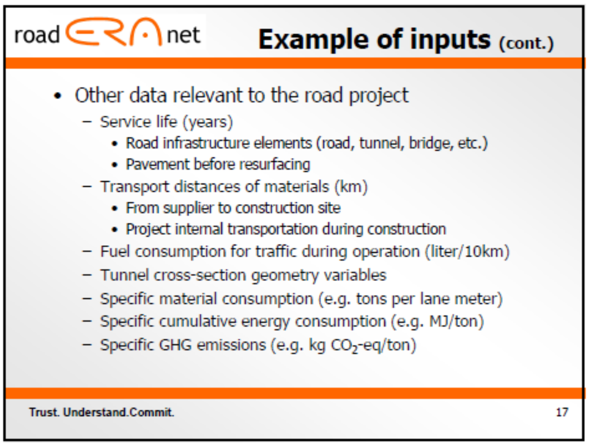
- Inputs related to traffic during operation
  - Traffic volume
    - AADT in start and end year of analysis time period
    - Share of traffic by vehicle type
    - Share of biofuel in gasoline/diesel
  - Types of vehicles
    - Trucks with trailer
    - Trucks without trailer
    - Electric powered light vehicles
    - Diesel powered light vehicles
    - Petrol powered light vehicles
  - Quantity and length of traffic from outside


road ERA net
Two modes of analysis
Comparison mode
Adding-Up mode
New alternative = Alt. 1 + Alt. 2 + Alt. 3
Tunnel
Bridge
Alt. 1
Alt. 2
Alt. 3
Alt. 0 = REF
A
B
In this mode, the LICCER model will analyse different new route alternatives (1, 2 and 3) and compare each of them to the reference alternative (today's road situation).
In this mode, the LICCER model will analyse ONE new route alternative, that has different in-series sections (1, 2 and 3) and will compare the sum of them to the reference alternative (today's road situation).
Trust. Understand.Commit.
13


road ERA net
Input1 sheet
LICCER - LCA


road ERA net
Details Input1 sheet
Name of project:
Name of analyst:
Analysis No:
Date:
Chosen mode of analysis:
Road 55, Yxtatorpet till Malmköping. LICCER Case Study.
Run 1
17.09.13
Comparison mode
LICCER - LCA
Life Cycle Considerations in EIA of Road Infrastructure
Alternative 1:
Alt. name:
Improvement
Elements along this road corridor alternative:


road ERA net
Details (cont.)
Elements crossing this road corridor alternative:
Cross-section geometry of the road corridor:
New road:
Extended road:
Road below ground water:
Aquaduct:
Underpass:


road ERA net
Example of inputs (cont.)
Other data relevant to the road project
Service life (years)
Road infrastructure elements (road, tunnel, bridge, etc.)
Pavement before resurfacing
Transport distances of materials (km)
From supplier to construction site
Project internal transportation during construction
Fuel consumption for traffic during operation (liter/10km)
Tunnel cross-section geometry variables
Specific material consumption (e.g. tons per lane meter)
Specific cumulative energy consumption (e.g. MJ/ton)
Specific GHG emissions (e.g. kg CO_2-eq/ton)
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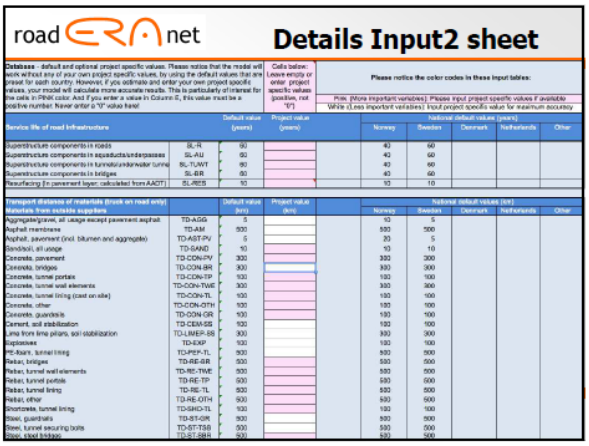
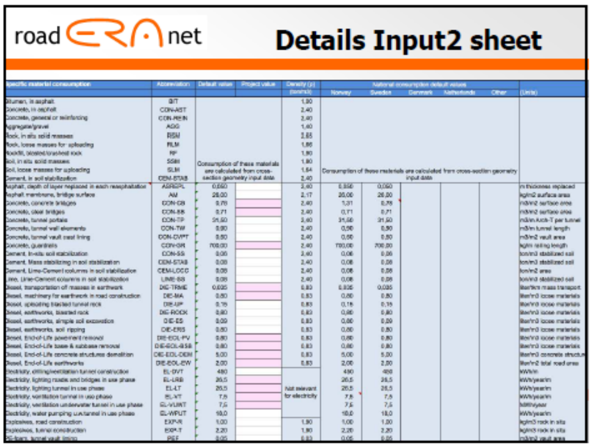
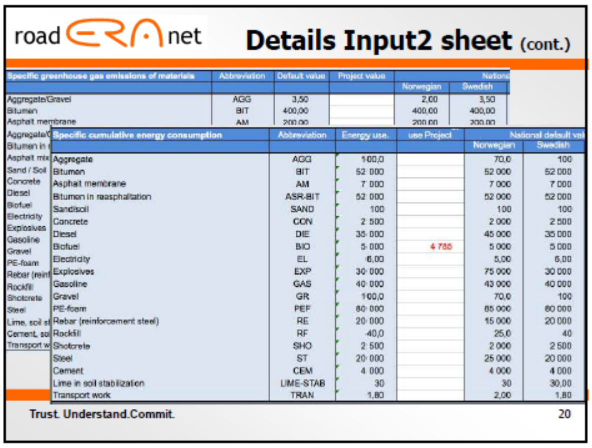
17

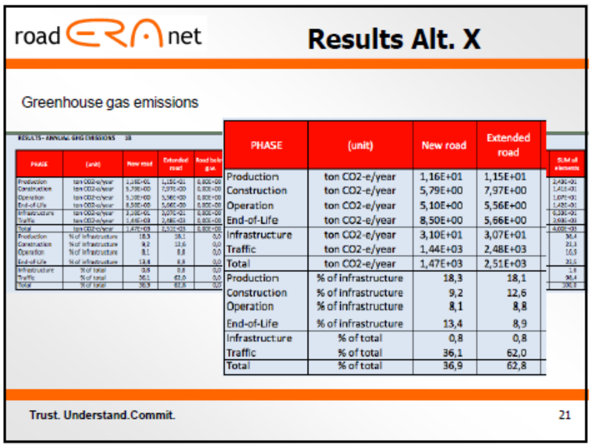

road ERA net
Details Input2 sheet
Service life of road infrastructure
Transport distances of materials (truck on road only)



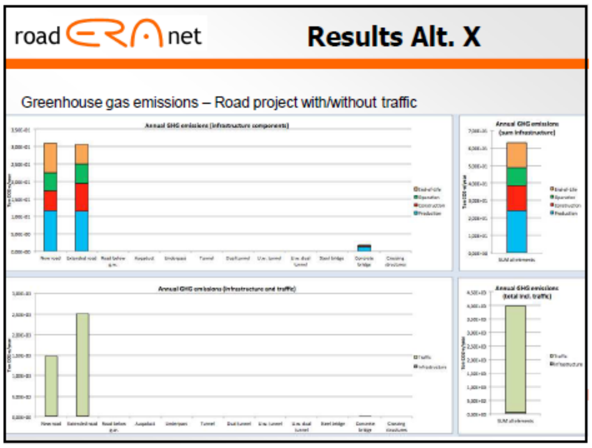


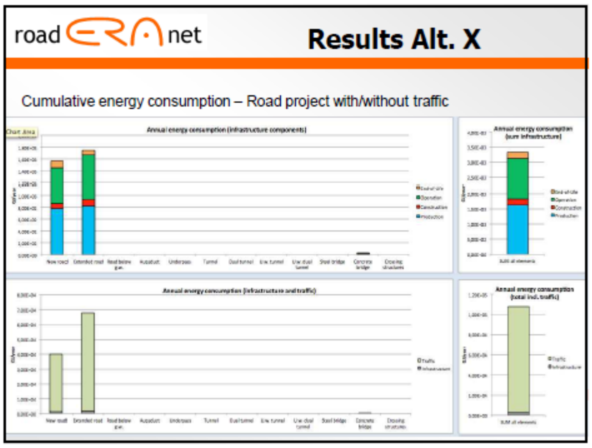
Specific greenhouse gas emissions of materials	Abbreviation	Default value	Project value	Norwegian	Swedish
Aggregate/Gravel	AGG	3,50		2,00	3,50
Bitumen	BIT	400,00		400,00	400,00
Asphalt membrane	AM	200,00		200,00	200,00

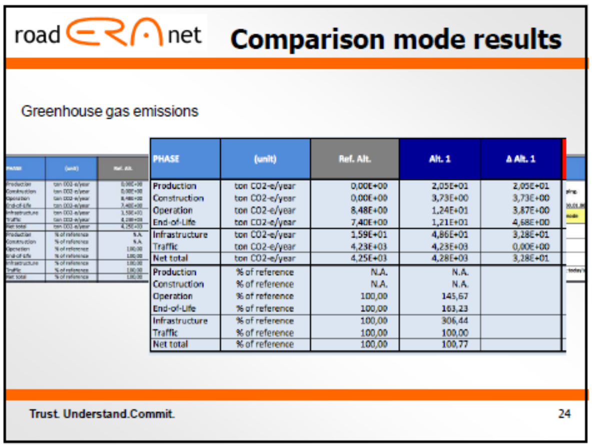
Specific cumulative energy consumption	Abbreviation	Energy use.	use Project	Norwegian	Swedish
Aggregate	AGG	100,0		70,0	100
Bitumen	BIT	52 000		52 000	52 000
Asphalt membrane	AM	7 000		7 000	7 000
Bitumen in reasphaltation	ASR-BIT	52 000		52 000	52 000
Sand/soil	SAND	100		100	100
Concrete	CON	2 500		2 000	2 500
Diesel	DIE	35 000		45 000	35 000
Biofuel	BIO	5 000	4 786	5 000	5 000
Electricity	EL	6,00		5,00	6,00
Explosives	EXP	30 000		75 000	30 000
Gasoline	GAS	40 000		43 000	40 000
Gravel	GR	100,0		70,0	100
PE-foam	PEF	80 000		85 000	80 000
Rebar (reinforcement steel)	RE	20 000		15 000	20 000
Rockfill	RF	40,0		25,0	40
Shotcrete	SHO	2 500		2 000	2 500
Steel	ST	20 000		25 000	20 000
Cement	CEM	4 000		4 000	4 000
Lime in soil stabilization	LIME-STAB	30		30	30,00
Transport work	TRAN	1,80		2,00	1,80



PHASE	(unit)	New road	Extended road
Production	ton CO2-e/year	1,16E+01	1,15E+01
Construction	ton CO2-e/year	5,79E+00	7,97E+00
Operation	ton CO2-e/year	5,10E+00	5,56E+00
End-of-Life	ton CO2-e/year	8,50E+00	5,66E+00
Infrastructure	ton CO2-e/year	3,10E+01	3,07E+01
Traffic	ton CO2-e/year	1,44E+03	2,48E+03
Total	ton CO2-e/year	1,47E+03	2,51E+03
Production	% of infrastructure	18,3	18,1
Construction	% of infrastructure	9,2	12,6
Operation	% of infrastructure	8,1	8,8
End-of-Life	% of infrastructure	13,4	8,9
Infrastructure	% of total	0,8	0,8
Traffic	% of total	36,1	62,0
Total	% of total	36,9	62,8

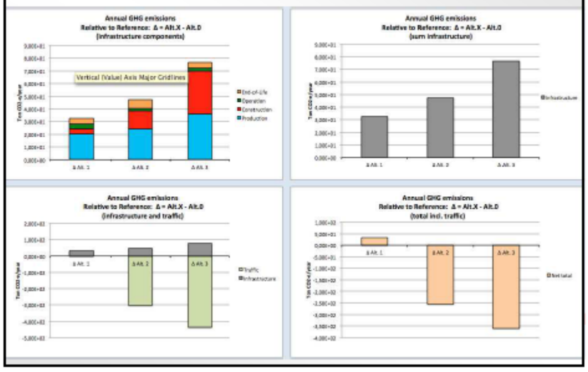




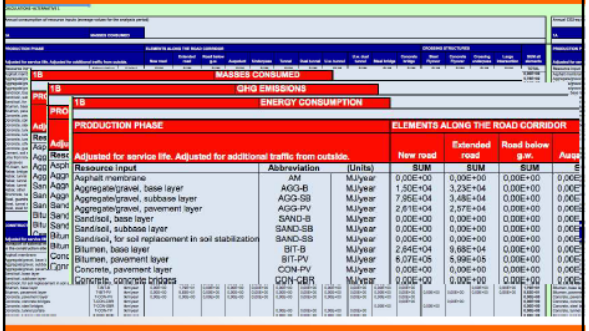


PHASE	(unit)	Ref. Alt.	Alt. 1	Δ Alt. 1
Production	ton CO2-e/year	0,00E+00	2,05E+01	2,05E+01
Construction	ton CO2-e/year	0,00E+00	3,73E+00	3,73E+00
Operation	ton CO2-e/year	8,48E+00	1,24E+01	3,87E+00
End-of-Life	ton CO2-e/year	7,40E+00	1,21E+01	4,68E+00
Infrastructure	ton CO2-e/year	1,59E+01	4,86E+01	3,28E+01
Traffic	ton CO2-e/year	4,23E+03	4,23E+03	0,00E+00
Net total	ton CO2-e/year	4,25E+03	4,28E+03	3,28E+01
Production	% of reference	N.A.	N.A.	
Construction	% of reference	N.A.	N.A.	
Operation	% of reference	100,00	145,67	
End-of-Life	% of reference	100,00	163,23	
Infrastructure	% of reference	100,00	306,44	
Traffic	% of reference	100,00	100,00	
Net total	% of reference	100,00	100,77	

Comparison results (cont.)



Calculations sheet



PRODUCTION PHASE			ELEMENTS ALONG THE ROAD CORRIDOR			
Adjusted for service life. Adjusted for additional traffic from outside.			New road	Extended road	Road below g.w.	Augu…
Resource input	Abbreviation	(Units)	SUM	SUM	SUM	S…
Asphalt membrane	AM	MJ/year	0,00E+00	0,00E+00	0,00E+00	[illegible]
Aggregate/gravel, base layer	AGG-B	MJ/year	1,50E+04	3,23E+04	0,00E+00	[illegible]
Aggregate/gravel, subbase layer	AGG-SB	MJ/year	7,95E+04	3,48E+04	0,00E+00	[illegible]
Aggregate/gravel, pavement layer	AGG-PV	MJ/year	2,61E+04	2,57E+04	0,00E+00	[illegible]
Sand/soil, base layer	SAND-B	MJ/year	0,00E+00	0,00E+00	0,00E+00	[illegible]
Sand/soil, subbase layer	SAND-SB	MJ/year	0,00E+00	0,00E+00	0,00E+00	[illegible]
Sand/soil, for soil replacement in soil stabilization	SAND-SS	MJ/year	0,00E+00	0,00E+00	0,00E+00	[illegible]
Bitumen, base layer	BIT-B	MJ/year	2,64E+04	9,68E+04	0,00E+00	[illegible]
Bitumen, pavement layer	BIT-PV	MJ/year	6,07E+05	5,99E+05	0,00E+00	[illegible]
Concrete, pavement layer	CON-PV	MJ/year	0,00E+00	0,00E+00	0,00E+00	[illegible]
Concrete, concrete bridges	CON-CBR	MJ/year	0,00E+00	0,00E+00	0,00E+00	[illegible]

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Follow-up work

- Feedback to be taken into consideration when fine-tuning and adjusting the model
- Final choice of default values (Sweden, Norway) in agreement with national road administrations
  - Service life and transport distances
  - Specific material consumption values
  - GHG emission coefficient values
  - Cumulative energy consumption coefficient values
- LICCER model deliverable by 31.12.2013

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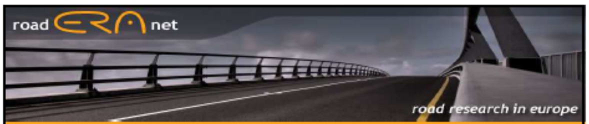
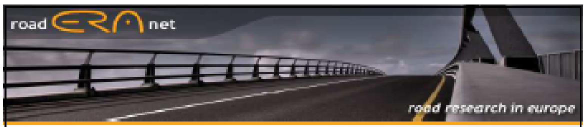


Thank you for your attention

Helge Brattebø
helge.brattebo@ntnu.no
Tel: + 47 95022976

Trust. Understand.Commit.

Appendix 6: Interactive exercise *(Sofiia Miliutenko)*



LICCER Workshop exercise

September 17, 2013
Stockholm, Sweden

Sofia Miliutenko

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road ERA net

Aim

- To **demonstrate** the **LICCER model** and to get **feedback** on **how easy** it is to use and how **relevant information** it provides with regards to the position in the planning process.

Trust. Understand.Commit. 2

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road ERA net

Organization of the exercise

Steps	Time duration	Start time
Short introduction slides about the case study and instructions for the exercise	10 min	11.15
Step 1, Step 2, Step 3 (performed together)	20 min	11.25
Discussion and feedback after Step 1, 2, 3	15 min	11.45
Step 4	15 min	12.00
Discussion and feedback after Step 4	10 min	12.15
Lunch	1 hr	12.30
Step 5, Step 6	20 min	13.30
Discussion and feedback after Step 5, 6	15 min	13.50
Step 7	15 min	14.05
Discussion and feedback after Step 7	10 min	14.20
Step 8	15 min	14.30
Coffee break	15 min	14.45
Plenary discussion (that will start with discussion and feedback after Step 8)	1 hr	15.00

Trust. Understand.Commit. 3

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road ERA net

Documents

- Excel file with the model (saved on your laptops)
- workshop survey and exercise (printed and distributed by us)
- User guideline (printed distributed by us)- optional

Trust. Understand.Commit. 4

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road ERA net

Case study

Reconstruction Yxtatorpet-Malmköping

- Section of road 55 (ca.100 km SW from Stockholm)
- Feasibility study considered three alternatives:
  I. Improving existing road (7,5 km)
  II. New road & bridges middle (6,9 km)
  III. New road & bridges west (6,6 km)

Trust. Understand.Commit. 5

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road ERA net

Excel file

- Slightly modified for the exercise, so the values are not exactly the same as used in Carolina's master thesis (as well as the results are different)
- This case study inolves comparing alternatives, using "Comparison mode"

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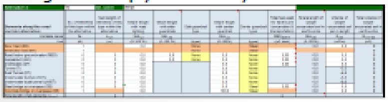
road net

Excel model

- Green rows (made only for the exercise, will be removed in the final version of the model)

- Orange cells: empty cells where you have to insert data



- Meaning of all the other colors is explained on top of each sheet.

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road net

Before you start…

- Specific results are not so important, what is important is your ideas on how to improve the model
- You don't need to fill in anything in the Excel model in the **first 6 steps**, just try to answer the questions (relevant to your background).
- If you think that some information is difficult to answer, just mark "I don't know"
- **Step 7:** you will need to insert some values in the Excel model

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road net

Step 1,2,3
(20 min)

Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break

road net

Discussion and feedback after Step 1, 2, 3

Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break

road net

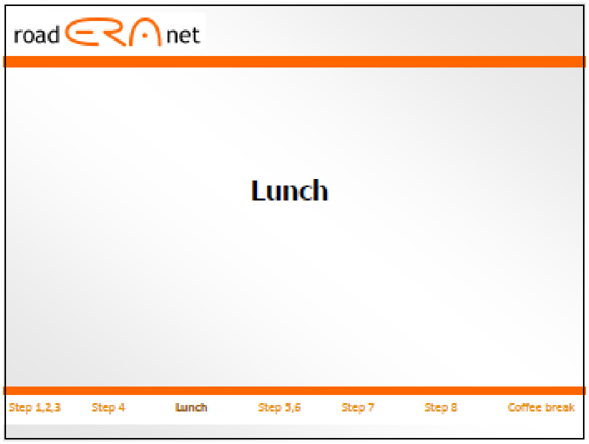
Step 4
(15 min)

Step 1,2,3 **Step 4** Lunch Step 5,6 Step 7 Step 8 Coffee break

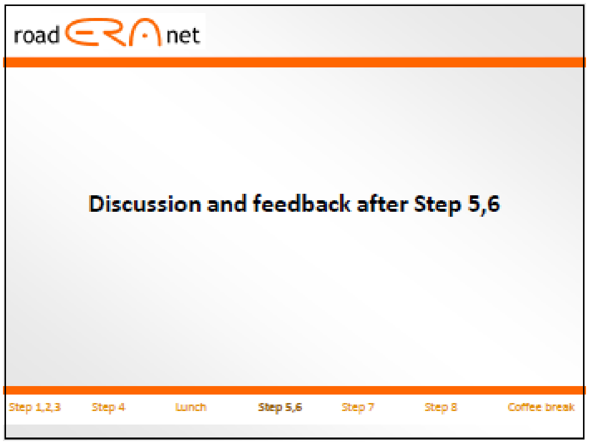
road net

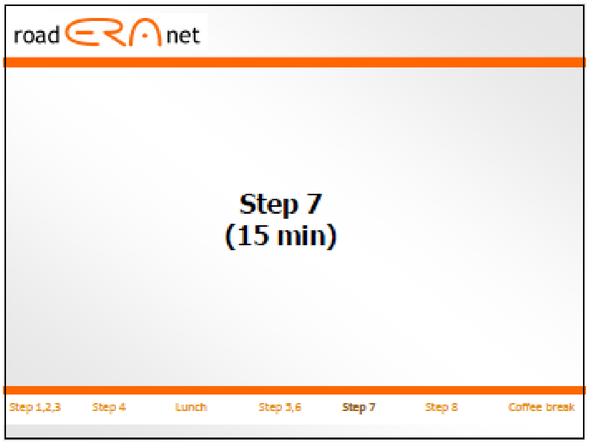
Discussion and feedback after Step 4

Step 1,2,3 **Step 4** Lunch Step 5,6 Step 7 Step 8 Coffee break

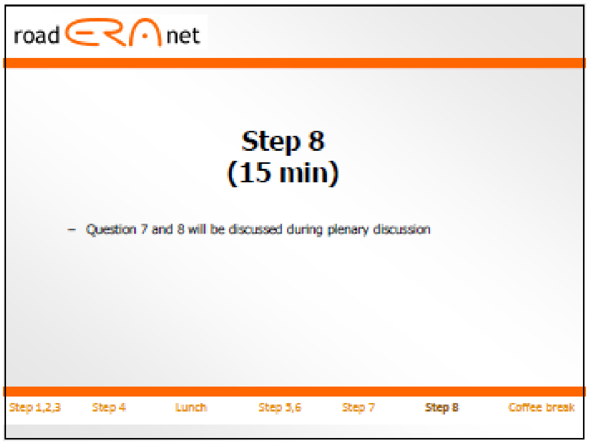

road ERA net
Lunch
Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break

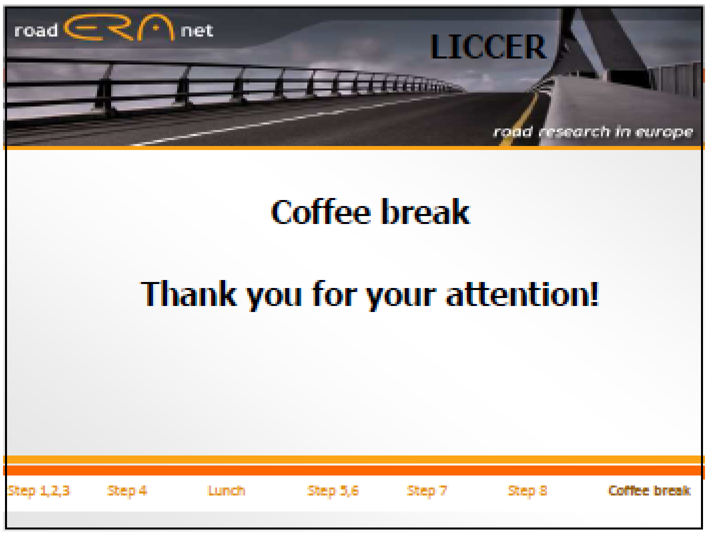

road ERA net
Step 5, 6
(20 min)
Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break


road ERA net
Discussion and feedback after Step 5,6
Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break


road ERA net
Step 7
(15 min)
Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break


road ERA net
Discussion and feedback after Step 7
Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break


road ERA net
Step 8
(15 min)
– Question 7 and 8 will be discussed during plenary discussion
Step 1,2,3 Step 4 Lunch Step 5,6 Step 7 Step 8 Coffee break


road ERA net
LICCER
road research in europe
Coffee break
Thank you for your attention!
Step 1,2,3
Step 4
Lunch
Step 5,6
Step 7
Step 8
Coffee break

Appendix 7: Plenary discussion *(Kristina Lundberg)*

road ERA net

road research in europe

LICCER workshop
Plenary discussion

17.09.2013
KTH Sweden

Kristina Lundberg

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road ERA net — **Plenary discussion**

LICCER,
just another model.....

2

---

road ERA net

... or finally a model that interlink knowledge and function as decision support in practice

Trust. Understand. Commit.

3

---

road ERA net — **Plenary discussion**

Supply of and demand for science

		Demand: Can User Benefit from Research? YES	Demand: Can User Benefit from Research? NO
Supply: Is Relevant Information Produced?	NO	Research agendas may be inappropriate.	Research agendas and user needs poorly matched; users may be disenfranchised.
	YES	Empowered users taking advantage of well-deployed research capabilities.	Unsophisticated or marginalized users, institutional constraints, or other obstacles prevent information use.

(Sarewitz and Dilling, 2007)

4

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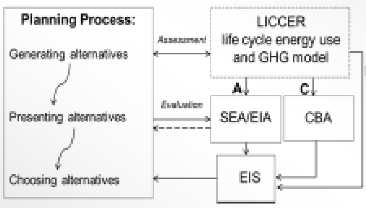
road ERA net — **Plenary discussion**

- Different uses i.r.t planning process
  - EIA, CBA or as a parallel process?



5

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road ERA net — **Plenary discussion**

Themes to discuss

Is relevant information produced

- About the model
- Different modes/ways of presenting results

Can user benefit from research?

- Model implementation
- Different uses in relation to the transport process

6

road ERA net

Plenary discussion

- About the model
  - User-friendliness/easy to use/flexibility?
  - Data availability and license?
  - Transparency of data and calculations
  - Developments in research needed?

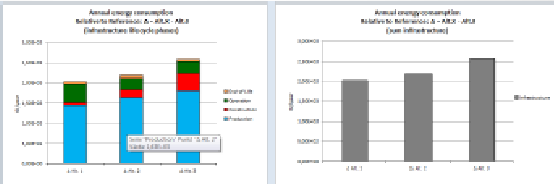
road ERA net

Plenary discussion

- Different ways of presenting result
  - Does it fit its purpose?

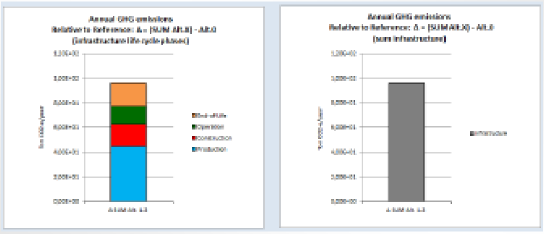
road ERA net

'Comparison' mode



road ERA net

'Adding-Up' mode



road ERA net

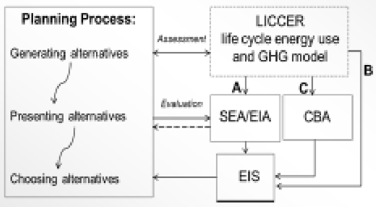
Plenary discussion

- Model implementation
  - Benefits for your organization? / useful for you?
  - Who are going to be the users?
  - Model & data maintenance (role national administrations)
  - Hindrances for implementing the model in your organization as a tool for choosing alternative
  - To what extent is LICCER useful also for later stage of the planning process

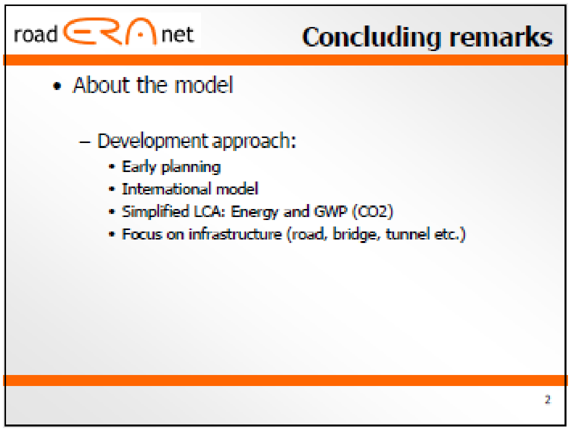
road ERA net

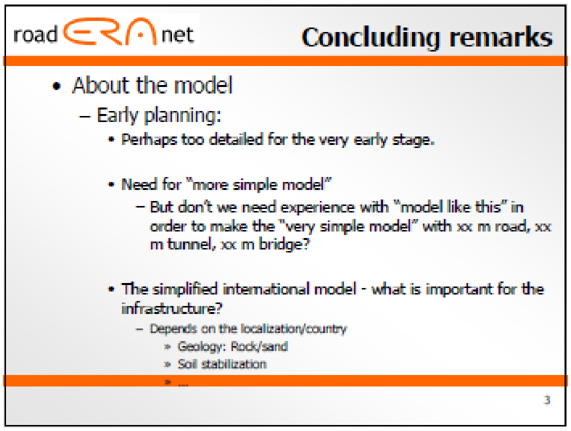
Plenary discussion

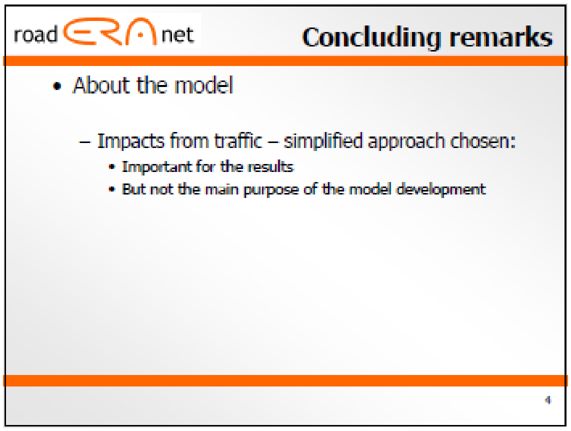
- Different model uses i.r.t planning process
  - EIA, CBA or as a parallel process?

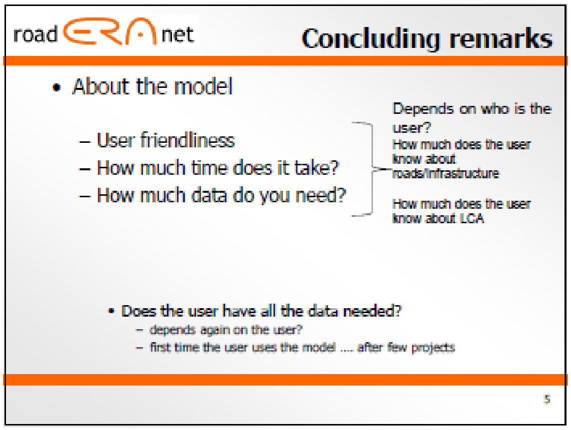


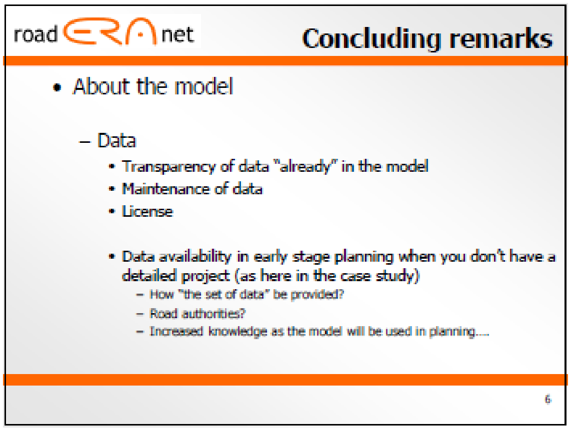
Appendix 8: Concluding remarks *(Harpa Birgisdottir)*











Concluding remarks

- About the model
  - Results
    - More figures
    - Different levels – simplified and more detailed….

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Concluding remarks

- Different model uses i.r.t planning process
  - EIA, CBA or as a parallel process?
  - Different model outputs i.r.t. planning process?

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Concluding remarks

- Model implementation in your organization?
  - Who is the user?
    - Is it necessary that the one working on the dimensioning of the infrastructure should be able to do the modeling?
    - Or can we accept that a person that has some knowledge on LCA is involved?

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Feedback

- Lot of valuable feedback already
- Exercise questions
  - Important feedback in the finalization
  - Please hand in what you have today
  - If you have additional feedback, please hand in by email latest **October 7th.**
- Other feedback
  - To the model
  - To the guideline
  - To the technical report

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Timeplan for the project

- Work finalized in the end of the year 2013
  - Model
  - Guideline for the model
  - Technical report
  - Case studies
- Public available when approved by the PEB
  - Winter/Early spring 2014

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