LICCER

LICCER Final Report

Report Nr 6

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1 Introduction

European National Road Administrations (NRAs) agreed in 2006 to progressively share their road research priorities and open up their research budgets. This has resulted in two European Framework Projects (ERA-NET ROAD I from 2006 to 2009 under FP6, and ERA-NET ROAD II from 2009 to 2011 under FP7), and a number of transnational calls for projects and programme calls (road ERA net, 2013).

Since 2011, a cross-border funded research program “Sustainability and Energy Efficient Management of Roads” has been running (Call 2011: ENR – Energy; co-funded by Denmark, Germany, Ireland, Netherlands, Norway, Sweden and United Kingdom). Overall aim of this research programme is to improve common understanding, and enhance implementation of sustainable developments in European road networks by taking an integrated and life cycle approach related to road infrastructure and traffic. Four research projects were selected for funding (road ERA net, 2013):

- SUNRA (**SU**stainability for **N**ational **R**oad **A**dministrations): Developing and testing a rating-system framework supporting NRAs with identifying how they can contribute to sustainable development.
- CEREAL (**C**O_2 **E**mission **RE**duction in ro**A**d **L**ifecycles): Developing and testing a model for computation of CO_2 emissions of pavement construction, maintenance and rehabilitation works to support NRAs - and contractors - in their efforts to reduce CO_2 emissions from traffic.
- LICCER (**LI**fe **C**ycle **C**onsiderations in **E**IA of **R**oad Infrastructure): Developing and testing a model to assess life cycle energy and greenhouse gas emissions of road infrastructure in support of early stage decision-making in transport planning process.
- MIRAVEC (**M**odelling **I**nfrastructure influence of **R**o**A**d **V**ehicle **E**nergy **C**onsumption): Determining the most important road infrastructure characteristics influencing vehicle energy consumption as basis for recommendations to pavement and asset management systems.

This report focuses on the LICCER-project, and makes some final reflections looking back over the whole project. Like the other projects, LICCER started in January 2012 and ended in December 2013. Partners from four countries participated in the LICCER-project (Sweden, Norway, Denmark, the Netherlands).

Last LICCER-coordinator was José Potting (KTH Royal Institute of Technology, Sweden) / Wageningen University, the Netherlands). Coordinators at the start of the project were Susanna Toller and Göran Finnveden (both at that time KTH Royal Institute of Technology, Sweden). Other partners were Helge Brattebø (NTNU, Norway), Harpa Birgisdottir (Harpa Birgisdottir Consulting, Denmark), and Kristina Lundberg (Ecoloop, Sweden). Other team-members involved in the actual work were Ingeborg Kluts and Roel van Oirschot (Wageningen University), Reyn O’Born and Ole Magnus Iversen (NTNU), Carolina Liljeström and Sofiia Miliutenko (KTH). Susanna Toller remained unofficial team-member after her job-change to Swedish national road authority in December 2012.

Other LICCER-reports already discuss in detail the development and use of the LICCER-model (Brattebø et al., 2013a/b; Liljeström et al., 2013; Lundberg et al., 2012/2013; Kluts and Miliutenko, 2012; Potting et al. 2013). This report does not intend to repeat what already can be read in those reports, but wants to provide a quick retrospective of the project activities, and discuss some main results in relation to the other “Call 2011: ENR – Energy” projects as a basis to identify directions for further work.

Chapter 2 briefly summarizes backgrounds of the LICCER-project. Chapter 3 gives an overview of project-activities and project-outputs. Chapter 4 concludes with an outlook to follow-up work related to the LICCER project.

2 Backgrounds to LICCER project

LICCER started in January 2012 with the aim to develop a model for Life Cycle Assessment of road infrastructure that can be used within the Environmental Assessment process in the early stage of the transport planning process. This aim has during the project, in response to stakeholder input and review of national transport planning processes, been modified. The aim of the LICCER model therefore changed into developing a model for assessment of life cycle energy and greenhouse gas (GHG) emissions of road infrastructure. The model-results that can be used in the early stage decisions of the transport planning process. The LICCER-project has in practice thus focused on life cycle energy and GHG emissions as indicators for broader life cycle environmental impacts, whereas the model-results were anticipated to feed in the transport planning process also via other ways than as part of environmental assessments only.

Transport planning processes are roughly similar across European countries, notably the countries explicitly covered in the project (Sweden, Norway, Denmark and the Netherlands). There are though also differences in the exact national procedures and environmental assessments required (see Kluts and Miliutenko, 2012: Miliutenko et al., to be submitted). As one of the stakeholders pointed out, however, environmental assessments may not be the only and most appropriate way of including life cycle consideration in the transport planning process, amongst others because the environmental assessment framework puts specific (legal) requirements on the life cycle assessment. The LICCER project identified three approaches for including life cycle considerations in the transport planning process. These were (see Lundberg et al., 2013):

- Integrated in the environmental assessment (EA) (i.e., strategic environmental assessment (SEA) or environmental impact assessment (EIA)).
- Integrated in an overall environmental assessment that documents and valuates a wide range of impacts serving all decision perspectives (i.e. socioeconomic perspective, distributional perspective, and goal-fulfilment perspective).
- Integrated in the socio economical assessment, i.e. Cost Benefit Calculations and/or Cost Benefit Analysis (CBA).

As already indicated, the LICCER-model intends to provide support in the early stage of transport planning, but this still needed closer specification for serving as an adequate basis for the model design. The LICCER-team therefore had reiteratively in-depth discussions, internal and with relevant stakeholders (e.g. in 2 LICCER-workshops in May 2012 and September 2013), where the LICCER-model could be most relevant in the transport planning process.

Rough localization of a new road, i.e. from many to a few road corridor alternatives, is decided in early planning where more specific information about the planned road infrastructure is still absent. This advocates a simple and consequently crude modelling, probably with archetype designs of different road elements (i.e. roads, bridges and tunnels). The uncertainty in generated modelling-results may be adequate in this planning stage where considerations of life cycle energy and GHG emissions still play a minor role. Road infrastructure planners typically prefer more robust information, however, when the decision is made from a few alternative road corridors to one preferred road corridor. In this stage also some project-specific information is available, or can be logically deduced, since the selected road corridor alternatives set the length of a road and the need for tunnels or bridges within an alternative (even though the decision for a tunnel or bridge is formally taken later in the planning process).

The LICCER-model focuses on supporting decision-making from a few alternatives to one preferred road corridor. The model-user in principle only needs to provide the type of details typically known in this stage (i.e. expected type, length and cross-section geometry with width, depth and height of road elements). The LICCER-model next calculates with help of default values the life cycle energy and greenhouse gas emissions of the involved road corridor alternatives. The LICCER-model also provides the option, however, to insert project specific data if available (i.e. replacing default data). This makes the model also suitable for decision support later in the planning process, like when formal decision on type and design of road elements is taken (e.g. bridge or tunnel, and/or concrete or steel bridge). Figure 1 gives an overview of the modelling structure as presently followed in the LICCER-model.

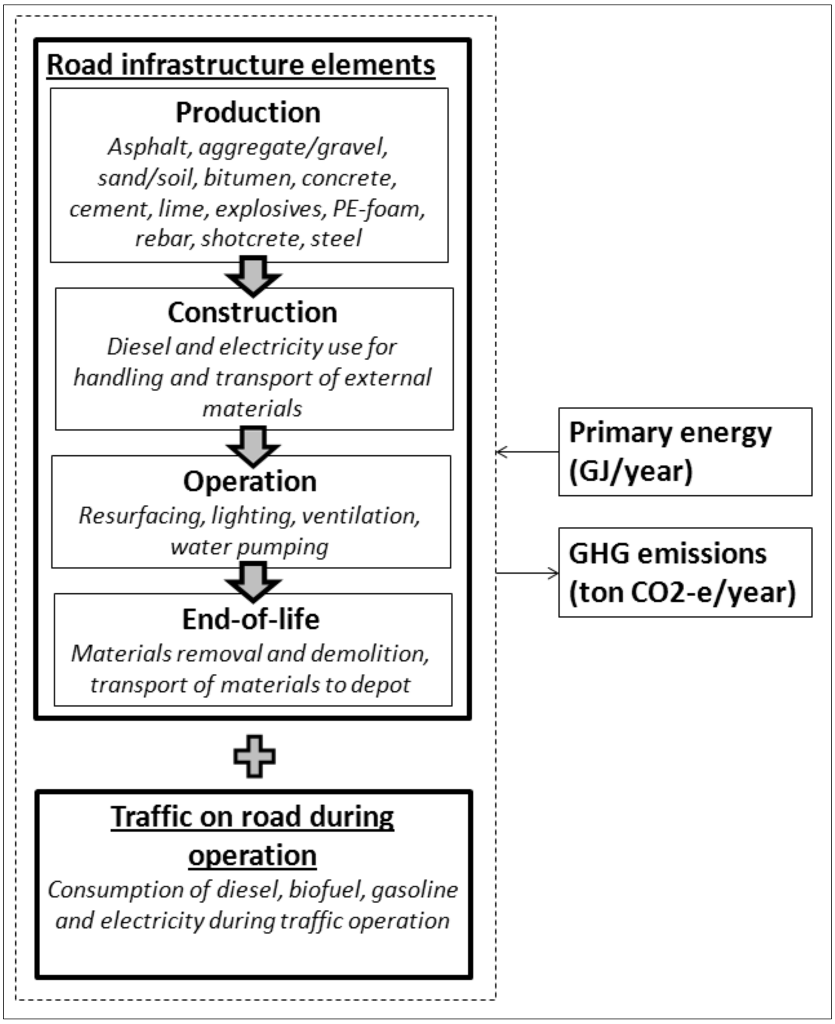

Figure 1: Simplified system boundaries in the LICCER model

The LICCER project initially aimed to develop a modular model based on existing tools and methodologies for Life Cycle Assessment of road infrastructure. The developed model does not follow a modular approach, however, but fully integrates modelling of road elements (i.e. road, bridges and tunnels). Also, existing LCA tools for road infrastructure, applicable for use in early stage planning and in different countries, according to the needs of the LICCER project, were not really available. Hence, the LICCER team had to develop a new model fairly much from scratch, despite taking inspiration from a few existing models such as the EFFEKT model already used in Norway.

Moreover, although not anticipated in the initial project-plan, the developed LICCER-model tentatively quantifies the energy use and GHG emissions from (the change in) traffic, in addition to that from the road infrastructure. This model extension is a deliverable feature beyond what is required according to the LICCER contract, and was incorporated in the model in response to discussions at the first LICCER-workshop where external stakeholders emphasized the dominance of traffic compared to road infrastructure. The LICCER framework and model are described in detail in Brattebø et al. (2013a), whereas Lundberg et al. (2013) provide information about when and how to practically use the model.

3 LICCER-activities and project-outputs

The LICCER-project team started its activities formally per January 2012. One of the first substantial activities was making an overview of the road infrastructure planning process, the role of environmental assessments in that, and the role of life cycle considerations in those environmental assessments.

Kluts and Miliutenko (2012) started with a comparison and benchmarking for Sweden and the Netherlands by means of an extensive literature study, evaluation of Swedish and Dutch environmental statement reports, and in-depth interviews with Swedish and Dutch stakeholders (representatives from NRAs, consultancy firms and researchers). The results for Netherlands and Sweden have been presented for verification at the first LICCER workshop, whereas at the same time input has been acquired about the road infrastructure planning processes in Norway and Denmark. The additional input for Norway and Denmark has been used to extend Kluts and Miliutenko (2012) into an overview integrating the transport planning process for the four involved countries. The results have been presented at several conferences (see Appendix 1), and is processed into a paper to be submitted to a peer reviewed scientific journal (Milieutenko et al., to be submitted).

The first LICCER-workshop took place on 9 May 2012 on the premises of KTH Royal Institute of Technology in Stockholm, Sweden. Excluding the LICCER-team (7), the workshop counted 22 participants from Sweden (16), Norway (2), Denmark (3), and the Netherlands (1). Participants represented NRAs, consultancies and researchers. Discussed were the possibilities of incorporating life cycle considerations within the transport planning process, and how to make the LICCER-model most beneficial. See the 'Report from first workshop' (Lundberg et al. 2012), and the previous chapter for directions taken in the LICCER-project.

The LICCER-team came again together on the 10 May, the day immediately following the first LICCER-workshop. The team-meeting proceeded from discussions and results of the day before in outlining the model-structure, and distributing between partners the work needed to arrive at the actual LICCER-model. The partners started their work on the actual work in the months, i.e. summer and early autumn 2012, following the first LICCER-workshop and team-meeting. The team met again on 24-25 October 2012 in Trondheim to discuss progress of the model-development, and further work needed on model-development and other project-deliverables (notably guidelines report and technical report for the LICCER model).

It was also decided in the team-meeting in Trondheim to distribute a bèta-version of the model to representatives of NRAs, and to have meetings with those representatives in late autumn 2012 / early winter 2013 to check whether the anticipated LICCER-model complied with their expectations (see Appendix 1 for presentations at meetings). The outcomes of those meetings have been used to further tailor the development of the LICCER-model according to stakeholder needs. Also instrumental in the further development the LICCER-model were presentations of the model-outline at international conferences (see Appendix 1).

The full LICCER-model has been reported in detail for the first time in the internal 'LICCER model technical report' (Brattebø et al., not published). This internal report, which was released in June 2013, was an interim-deliverable as required in the LICCER-contract. This internal report served for a next check with stakeholders about the relevance and quality of the LICCER-model. It has been distributed, together with a draft-version of the 'LICCER model guidelines report' (Lundberg et al. 2013), to the invitees of the second LICCER workshop.

The second LICCER-workshop took place on 17 September 2013, again on the premises of KTH Royal Institute of Technology in Stockholm, Sweden. This second workshop focused on a last testing and discussing of the relevance and applicability of the LICCER-model. The workshop-participants worked with the LICCER-model, with a guided tour through the model and with the examination of an exercise on a partly implemented case study. This case study had been performed by Liljenström et al. (2013) during summer, and represented in itself a test of the LICCER-model, but was also used as a basis for the workshop-exercise (modified in Lundberg et al., 2013). The second workshop was visited by 12 external participants, unfortunately mainly representing Sweden (10) and further by one Norwegian and one Danish representative. The workshop-participants were in general positive about the LICCER-model, and provided important input to make a final version of it (Potting et al., 2013).

Similar as after the first LICCER-workshop, the LICCER-team again met the day immediately following the second LICCER-workshop (i.e. 18 September 2013). The results of the second LICCER-workshop were discussed, and a timeline was set for finalising the LICCER-project. The LICCER-model, external 'LICCER model technical report' (Brattebø et al., 2013a) and 'LICCER model guidelines report' have been finalised with the feedback of the invitees and participants of the second LICCER-workshop. The final model has been used in a second case study, started after the second LICCER-workshop (Brattebø et al., 2013b).

All together the LICCER project has resulted in the following required deliverables:

1. Lundberg, K. and S. Toller (2012): *Report from first workshop. Report no 1.*

2. 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).*

3. Potting, J., H. Birgirsdottir, H. Brattebø, C. Liljenström, K. Lundberg, S. Miliutenko, R. O'Born, S. Toller (2013): *Report from second workshop. Report nr. 3.*

4.1 Lundberg, K., S. Miliutenko, H. Birgirsdottir, S. Toller, H. Brattebø and J. Potting (2013): *LICCER model guidelines report*. Report nr. 4.1.

4.2 Brattebø, H., R. O'Born, S. Miliutenko, H. Birgirsdottir, K. Lundberg, S. Toller and J. Potting (2013): *LICCER model technical report. Report nr. 4.2.*

5.1 Liljenström, C. (ed.), S. Miliutenko, H. Brattebø, R. O'Born, H. Birgirsdottir, K. Lundberg, S. Toller and J. Potting (2013): *LICCER Model Case Study Report. Application of the LICCER-model to a Swedish road section between Yxtatorpet and Malmköping. Report 5.1*

5.2 O'Born, R., H. Brattebø, O.M. Iversen, C. Liljenström, S. Miliutenko, H. Birgirsdottir, K. Lundberg, S. Toller and J. Potting (2013): *LICCER Model Case Study Report – Application of the LICCER-model to a Norwegian road section crossing the Oslo fjord. Report nr. 5.2*.

6 Potting, J. H. Birgirsdottir, H. Brattebø, I. Kluts, C. Liljenström, K. Lundberg, S. Miliutenko, R. O'Born, R. Oirschot, S. Toller, R. van Oirschot (2012): *LICCER Final report. Report nr. 6.*

Appendix 1 lists all additional, but non-contractual outputs from the LICCER-project. The LICCER-team plans to also make a couple of scientific publications from the project-results. These are not yet included in Appendix 1.

Appendix 1 also lists all face-to-face exchanges with stakeholders as part of the LICCER-project, or as spin-off from the LICCER-project (e.g. presentations at international conferences). It can be seen from above activity-report and from Appendix 1 that there has been an intensive interaction with stakeholders in order to tailor the LICCER-model and other LICCER-outputs to the extent possible to stakeholder-demands. These exchanges also represent dissemination activities of the LICCER-project to the outside world.

4 Discussion and conclusions

LICCER is a model to assess life cycle energy and greenhouse gas emissions of road infrastructure. The results can be used in the early stage of the transport planning process, when the decision is made from a few alternatives to one preferred road corridor. The model-user in principle only needs to provide the type of details typically known in this stage (i.e. type, length and cross-section geometry of road elements). The LICCER-model next calculates with help of default values the annual cumulative energy (consumption and greenhouse gas emissions of the involved road corridor alternatives.

The LICCER-model was tested and discussed by the participants in the second LICCER-workshop for the models applicability and relevance of its results (see also above). Applicability and relevance were likewise demonstrated in two case studies. The two case studies also brought to light that the greenhouse gas emissions and energy use related to the change in traffic between road corridor alternatives by far exceeded the greenhouse gas emissions and energy use from road infrastructure. Since both case studies assumed the same number of vehicle across alternatives, it was largely the difference in road length that decides whether the one road corridor alternative performed better than another. This suggests that road infrastructure planners do not need information at all about energy use and greenhouse gas emissions from road infrastructure for making a decision from a few alternatives to one preferred road corridor. This might be true if there is a significant difference in road length between road corridor alternatives, but comparison with the LICCER-model remain relevant for alternatives that do not significantly differ in road length. It should also be noted that (1) the LICCER-model was in both case studies tested for traffic-intensive situations, and (2) fuel use efficiency was kept the same over the whole analysis period, i.e. 20 years in the Swedish case and 40 years in the Norwegian case, whereas the efficiency is likely to increase over the coming decades, (3) the share of bio-fuelled and electrical vehicles was kept the same over the whole analysis period, while their share is likely to increase over the coming decades, (4) the LICCER-model is limited to energy use and greenhouse gases only, while infrastructure may be more important than the change in traffic in other impact categories. All four contribute to the dominance of the change in traffic over road infrastructure, where the middle two clearly represent uncertainties leading to an overestimate in both case studies. Dominance in both case studies of change in traffic, i.e. difference in road length times vehicles, over road infrastructure in comparing energy use and greenhouse gas emissions of alternatives nevertheless is an important learning from the LICCER-project. One first has to make the analysis, however, before being able to draw the preliminary conclusion. Note that above discussion does not refer to absolute traffic. but to the ***change*** in traffic between a given road corridor alternative compared to the reference situation.

The LICCER-model also provides the option to insert project specific data if available (i.e. replacing default data). This makes the model also suitable for decision support later in the planning process, like when formal decision on type and design of road elements is decided (e.g. bridge or tunnel, and/or concrete or steel bridge). Two projects financed under Call 2011: ENR – Energy, i.e. CEREAL and Miravec, can contain additional details not included in the LICCER-model. The CEREAL-model may provide extra detailed information about road restoration, while the Miravec-model may inform about specific road pavement design curbing energy use. The three models together form a strong combination supporting the work of NRAs. One direction for future work may be integration of these three models.

The LICCER-model is less suited for rough localization of a new road, i.e. when the decision is made from many to a few alternative alternatives. Hardly any information is available in this very early planning stage. This asks for a simpler and consequently cruder model than LICCER with archetype designs of road elements (i.e. roads, bridges and tunnels). KlimaKalkyl in Sweden, and EFFEKT in Norway may fulfil that role. Another direction for future work may be to extend the LICCER-model to also include archetype road elements.

The countries involved in the LICCER-project, notably Sweden, Norway and the Netherlands, already have adopted national models for decision-support in the transport planning process. These models range between very simple and very detailed, consequently supporting different types of decisions along the transport planning process. The involved countries are presently reflecting on the added value of LICCER (and CEREAL, Miravec and SUNRA), and whether and how it can be used in combination with their already adopted tools. Any decisions in this direction would likely benefit from a carrying out a more elaborate testing of the LICCER-model and the other tools, on more road cases, in order to synthesize information and giving recommendations on further developments and/or combinations of tools.

The LICCER model only covers a smaller number of impact categories that is normally asked for in LCA standards, i.e. energy and GHG emissions. In future, as NRAs will be probably expected to pay increasingly attention to life cycle environmental impacts from road infrastructure, beyond energy and GHG emissions. Hence, a future possible extension of LICCER would be to develop a model that also includes other resource consumption categories and environmental impact categories, e.g. in line with what is already recommended in Product Category Rules (PCRs) for road infrastructure.

Road infrastructure planning goes along with deciding about huge amounts of money. Cost considerations therefore play an important role in the transport planning process. A last direction for further work in integration of cost considerations in the LICCER-model, or even more radically, integration of the LICCER-model and cost benefit analysis.

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Appendix 1: LICCER-outputs

Reports

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Toller, S. (2012): Presentation to the reference group of the LICCER project, 9 May 2012, Stockholm (Sweden).

Toller, S. (2012): Presentation to PEB members and participants of the SUNRA project, 14 May 2012, London (United Kingdom).