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Safe and sustainable Coastal Highway Route E39

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Abstract

The project "Coastal Highway Route E39" have a mandate to, investigate how infrastructure can exploit renewable energy to reduce environmental footprint. Three PhD projects were initiated on this subject at Chalmers University of Technology by Norwegian public road administration. Results in this paper conclude that (1) Life Cycle Assessment should have a geographical dimension with respect to assumptions and input data, (2) there are substantial potential to reduce the CO_2 emissions from the E39, especially when considering an electrification, and (3) the harvested energy from hydronic pavement system can be enough for maintaining ice-free roads in Nordic countries.

Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)

Keywords: LCA; LCCA; Electric roads; electricity system; CO_2 emissions; Hydronic asphalt pavement

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1. Introduction

The Norwegian coastal highway route E39, located on the west coast of Norway, connects Kristiansand in the south to Trondheim in central Norway - a distance of 1100 km. The route E39 runs through six counties with a total population of 1.8 million people (SSB, 2014). More than half of Norway's energy intensive industry is located along this road. The Ministry of Transport and Communications has given the project "Coastal Highway Route E39" a mandate to address challenges, possible technological solutions and to investigate social and economic benefits of building fixed connection instead of using ferry connections (Statens Vegvesen, 2012). Examples of areas under investigation are how the infrastructure can be exploited to generate renewable energy and how the harvested energy can be used in order to reduce the ecological and environmental footprint of the road infrastructure.

In connection to the investigation of the future of the E39, twelve PhD projects have been initiated at Chalmers University of Technology by Norwegian public road administration (NPRA). The aim of this paper is to present some of the initial results from three of these projects: (1) Infrastructure performance viewer, (2) The E39 as a renewable European electricity hub, and (3) Safe and ice free roads using renewable energy.

The project "Infrastructure performance viewer" has a goal to support the Norwegian Public Road Administration (NPRA) in reducing the environmental impacts of their infrastructures, while increasing the safety as well as striving for optimized lifecycle costs. The project therefore aims to address the targeted areas by means of environmental life cycle assessment (LCA) and economic life cycle cost analysis (LCCA), and to investigate and visualize the LCA and LCCA performance of Norwegian roads. As part of this aim, understanding of the state-of-the-art LCA and LCCA can help to highlight what is the current practice in the field of road infrastructure, in order to identify the best practices in the application of combine LCA and LCCA as well as to identify knowledge gaps so as to understand how these can be reduced in the future.

The project "The E39 as a renewable European electricity hub" has the aim to investigate the possibility of a transition to alternative fuels including electrification of vehicles, and how E39 can interact with the electricity generation system in the region. The development of infrastructure in the region, will most likely increase the road traffic on E39 (Nilsen, 2014). The current fuel supply to the Norwegian road transport is mainly from fossil fuels, with a small contribution of biofuels, gas and electricity (5.4%). The CO_2 emissions from E39 accounts for 7% of the Norwegian road traffic (Fridstrøm and Alfsen, 2014), but without any fuel shift there will most likely be an increase in this share due to increased transportation work. An increase of CO_2 emissions is in conflict with the Norwegian long term target of a carbon neutral transport sector by 2050 (Norwegian Ministry of Environment, 2008). The possibility of a transition to alternatives fuels, such as electricity, and the possible challenges and impacts that could have on the regional electricity system, is discussed in this paper.

The third project, "Safe and ice free roads using renewable energy", investigates the possibility of utilizing harvested solar energy to de-ice road surfaces during winter to increase road safety. It is well known that driving on a slippery surface could be considered unsafe due to that drivers might lose control of their vehicle. Accidents are more likely when there is a sudden change in the surface friction and this is more common in some sections of roads such as slopes, curves, bridges and near stretches of water. A traditional method, to mitigate the problem of slippery road conditions, is to spread salt and sand on the roads. However, consumption of salt for winter maintenance in the Scandinavian countries is over 0.6 million ton and the amount of sand 1.7 million ton (Knudsen et al., 2014). Considering this high amount of salt and sand consumption along with the negative impacts of salt on the environment and the durability of infrastructures in a road (Fay and Shi, 2012, Liu et al., 2007), there is a need for alternative solutions to mitigate icy conditions on road surfaces. This alternative could be to use a hydronic pavement (HP) combined with a seasonal thermal energy storage (STES).

The aim of this paper is to give an insight into the project "Coastal Highway Route E39" by exemplifying with some results from the three abovementioned PhD projects as well as to provide a discussion on what implications these results will have for the E39 project.

2. Infrastructure performance viewer

The evaluation of large-scale infrastructural projects from a sustainability perspective is a complex task, but still of high importance. It is complex due to the possible high impacts from the infrastructure project on resources use, energy use, stakeholders involved, as well as the economic and environmental impacts (Bohne, 2007, Flyvbjerg, 2014). These complexities have been recently addressed in an EU founded project entitled LCE4ROADS[1] (Zukowska et al., 2014, Cerezo et al., 2014). Therefore, such large scale infrastructures must be planned, built and maintained with the aim to be as sustainable as possible while supporting the national and regional economic viability, environmental protection, increase social welfare, generate and secure jobs, as well as being secure (European Commission, 2011, IPCC, 2014, Garbarino et al., 2014). In doing so, the engineering solutions should encounter the present social and economic demands within the environmental framework conditions including a complex ecosystem without jeopardizing future generations' needs (Brundtland, 1987, Ainger and Fenner, 2014).

Route E39 is an example of a new large-scale infrastructural project, for which, its sustainability performance is an important part of it. This PhD project focuses on evaluation of economic and environmental performance of Norwegian roads by means of environmental life cycle assessment and economic life cycle cost analysis.

Among various methodologies, LCA and LCCA have become a major part of investment decision-making to assist in selection of infrastructural solutions (Girmscheid, 2008). So far, there are a number of studies using LCA and/or LCCA that investigate various aspects of environmental and/or economic performance of road infrastructures. In this regard, some studies reviewed state-of-the-art LCA of roads (Santero et al., 2011b, Santero et al., 2011a), and they stated the best practice and what the knowledge gaps are in the field of LCA. However, no study could be identified in the literature that reviewed the current state of works combining LCA and LCCA of roads in order to highlight the challenges and knowledge gaps in using these methods together. It is therefore important to review existing research in the domain of LCA and LCCA in favor of pinpointing lessons to be learned and where it is essential to perform further developments in the aforementioned topics. This procedure can be helpful to reduce the iteration of some fundamental errors and bring a better understanding about the ongoing research in the areas of combined LCA and LCCA.

2.1. Lessons learned from literature

Transparency is crucial in the LCA analysis (ISO, 2006). Different applied data, system boundaries, and functional units in the scope of a LCA study can lead to different end results (Santero et al., 2011b). This could in a comparative study consequently give a certain study an advantage over some other studies and may show complete opposite results in another case. Hence, transparency in LCA, as required by the EN 15804:2012+A1:2013 (CEN, 2013), is important in order to assess and apply the outcome of the LCA analysis. In addition, limitations and recommendations should be addressed at the end of each LCA study, to highlight and inform the future users of data to show what the accuracy level of the results are (ISO, 2006).

It is necessary to include more environmental indicators rather than only one or two indicators commonly used in the LCA of roads. Most LCAs of roads studies global warming potential (GWP) and cumulative energy demand (CED) which were in the target and scope of the studies (Zhang et al., 2010, Liu et al., 2014, Wang and Chong, 2014, Lidicker et al., 2013, Giustozzi et al., 2012, Robinette and Epps, 2010). However, making decisions only based on one environmental impact category can lose the potential of fairness in the results because there are other impact categories than GWP and CED (like acidification potential, eutrophication potential, abiotic depletion potential, etc.). In fact, the selection of few environmental indicators might lead to an outcome with sub-optimization of environmental benefits and neglecting potential trade-offs. Thus, selection of environmental indicators should be done wisely (using e.g. guidelines, standards etc.) to cover important environmental indicators that are influential to the final decisions.

There exist various uncertainties in the LCA and LCCA, which some can be handled well with better: data sampling, methods of calculation, robustness of scoping, and other indispensable improvement. For instance, having more data sampling and/or use of different mathematical methods might help to reduce the uncertainty of input data variations (Zhang et al., 2010, Noori et al., 2014, Heravi and Esmaeeli, 2014). However, some other future related uncertainties exist that are outside the control of LCA and LCCA practitioners; e.g. impacts from natural disasters and climate changes, impacts from user behavior, changes in legislations and many others. Hence, it is essential to discuss

[1] http://www.ecolabelproject.eu/

these uncertainties with relevant experts in order to better estimate or verify the magnitude of changes This may also help to enhance the robustness of underlying assumptions within the scope of analysis (ISO, 2008).

As a road connects different places, the assumptions and input data may vary depending on geographical location. It is therefore important that both the LCA and LCCA have a geographical dimension in assumptions and input data. This is especially obvious when it comes to parameters such as type and amount of construction material, traffic volume, climate zone, axle load etc.

3. The E39 as a renewable European electricity hub

The annual road traffic volumes for the E39 has been calculated to be 2,600 million vehicle kilometers for 2013 (7% of the Norwegian road traffic volumes), based on data for E39 collected by NPRA. Heavy vehicles (heavy trucks and buses) are responsible for on average 12% of the vehicle kilometers and light vehicles (light trucks and private cars) thus for 88% (Statens Vegvesen, 2015). There are large geographical variations in the traffic intensity along the E39, from, on average, less than 1,000 to more than 70,000 vehicles per day. The heaviest traffic is of course around the biggest cities, such as Stavanger and Bergen, where the E39 is used for short trips around the city areas. The traffic peaks and the geographical variations in traffic volumes will have implications for electrification strategies of the transport sector, such as charging infrastructure, further discussed by Taljegard et al. (2015).

A fuel consumption model was developed within this project (Taljegard et al., 2015), and the annual secondary energy supply for the E39 has been calculated to be 2.9 TWh. Direct CO_2 emissions from road transportation on the E39 has been estimated to 750 kton for year 2014, assuming a CO_2 emission factor of 2.54 kg/l of diesel and 2.36 kg/l of petrol. Yet, the emissions from E39 will, based on a transport modelling analysis performed by Nielsen et al. (Nilsen, 2014), increase in a business as usual scenario by 90% to year 2060 if the project “Coastal Highway Route E39” is realised. Thus, it is of great importance to investigate and analyze alternative scenarios which can reduce emissions while providing the necessary infrastructure service. The initial work has focused on analyzing potential for reduction in CO_2 emissions and the change in energy demand from different fuel shifts.

3.1. CO_2 reduction strategies for the route E39

In the future, there will be a strong competition for biofuels from other sectors, such as the heating sector. Grahn et al. (2009) show in a global energy system modeling study, taking into account global potential and the competition for bioenergy from other sectors, that only parts of the transport sector could be covered by biofuels. To what extent, biofuels have a potential to reduce the CO_2 emissions from the E39 road transport can be estimated by using a Norwegian scenario study by Avinor et al. (Avinor, 2010). In that study, two scenarios for 2030 were presented. The low ambition scenario was characterized mainly by a biofuel blending of 20% for road vehicles in 2030 (5% for railway) and the high ambition scenario was defined by a major introduction of E85 and a biofuel blending of 40% in 2030 (50% for railway), made possible by a switch to second generation biofuels. Applying those two scenarios to the E39-case gave a 16% and a 50% decrease in CO_2 emissions, respectively, assuming net zero CO_2 emissions from biofuels. For the E39, this would mean a reduction of ~120-370 kton CO_2/yr compared to 740 kton/yr emitted today, as seen in Fig 1.

A change to hybrid electric vehicles, such as plug-in-hybrids, could technically reduce the energy needed per vehicle kilometer with 30%, and then potentially reduce CO_2 emissions from E39 by approximately 220 kton/yr for the E39. However, in order to reach low or zero emissions of CO_2, a more complete transition to electricity or hydrogen seems to be required. Electrification of the E39 could imply electric cars, fuel cells, conductive or inductive charging integrated in the road infrastructure (for example over-headlines or ground-level supply). In summary a transition to electric vehicles will have, in the long term perspective, the potential to reduce the CO_2 emissions by almost zero percent (see section 3.2 for a detailed discussion on CO_2 emissions when electrifying E39), and decrease the energy use with up to 50% per vehicle kilometer, as can be seen in Fig. 2.

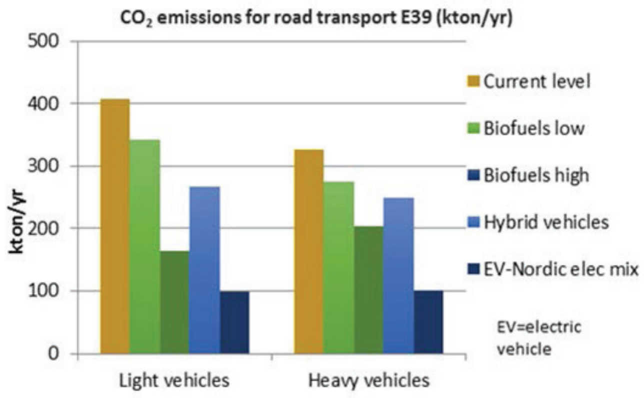

Fig. 1. CO_2 emissions when applying different possible reduction strategies.

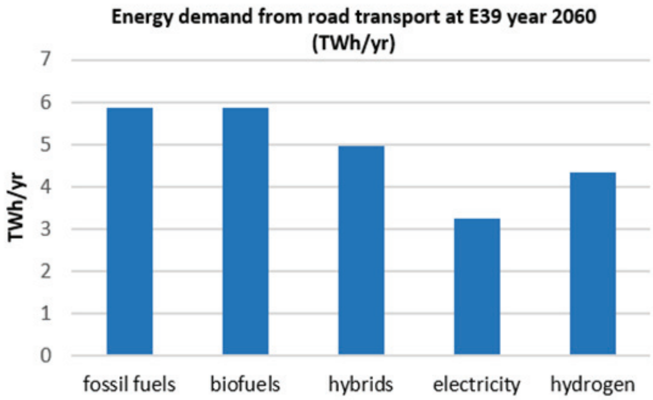

Fig. 2. Energy demand for different future vehicle technologies in 2060 (TWh/yr).

3.2. Regional Electricity Balance in the E39-region

If electrifying E39, the electricity demand for the road traffic (~1.5 TWh) is on a yearly basis small compared to the total amount of generated electricity in the E39-region, which is approximately 60-75 TWh per year depending mainly on if it is a wet or a dry year (SSB, 2013). The electricity use in the region is on average 50 TWh per year, which means that, looking in the past, the region has generally been a net exporter of electricity. Almost all of the electricity (~95%) is today generated by hydro power. Wind power is, however, growing in the E39-region (including six counties) and reached 490 MW of installed capacity, producing approximately 1.3 TWh, in 2012 (SSB, 2013). Additionally, installation of ~16 TWh of wind and hydro power have been approved by the Norwegian Water Resources and Energy Directorate (2014). But in 2014, only 0.6 TWh of new hydro and wind power was built in Norway (Norwegian Water Resources and Energy Directorate, 2014).

The electricity generated in Norway is traded on a common electricity market, called Nordpool, with Denmark, Finland and Sweden, with each country divided into a number of price areas. Thus, the change in CO_2 emissions which can be associated with an electrification of E39 depends on the method of calculating these emissions (marginal or average perspective) and under what time frame. In a marginal, short-term perspective (i.e. long enough for a change in the energy balance but too short for including the effect from investments in new electricity generation or an upgrade of existing capacity), an increased demand for electricity in the E39-region will be met by existing capacities in the European electricity system, which at the moment is likely to be electricity from coal or lignite power plants. But in a marginal, long-term perspective (i.e. long enough for investments in new energy technologies or an upgrade of the existing power technologies), the climate impact is determined by the development of the electricity system in Europe, i.e. investments in new and existing capacity. In a European context, the CO_2 emissions from centralized electricity generation is governed by the EU Emissions Trading System (EU-ETS) which specifies a cap of emissions which give the price of the emission allowances. Although, EU-ETS allowance prices have been low over several years, if the emission trajectory defined in the EU energy and climate roadmap are followed, the allowance prices will reach levels that will prevent investments in any CO_2 emitting technology to meet an increase of electricity demand from E39. Thereby a transition to electricity for road transport at E39 would mean, in the longer-term perspective, a substantial decrease in CO_2 emissions (see is also assumed in Fig. 1). Yet, detailed model studies of the European and Nordic electricity systems is needed in order to investigate the full emission impact from an electrification of E39. In summary, electrifying the transport sector will have minor influence on the total national use of electricity when considering the yearly average electricity supply. But there are both local and time variations in the use of electricity generation, which could impose a challenge on the electricity system, in the form of specific power peaks. The energy dynamics of traffic flows along E39 has been studied further by Taljegard et al. (2015).

4. Safe and ice free roads using renewable energy

The main goal in this PhD project is to investigate hydronic pavement (HP) systems using renewable energies to remove snow and ice from road surfaces, similar to the concept presented by Adl-Zarrabi et al. (2014) concerning E39. The HP system which is introduced here, has the same characteristics; i.e. it is integrated with energy harvesting. The HP system consists of embedded pipes in the pavement layer of a road in order to harvest solar energy during warm days, store the thermal energy and release it during snowy days to keep the road ice and snow free. The HP system works by circulating a fluid inside the embedded pipes. This fluid may be brine, oil or glycol-water (ASHRAE, 2003). Figure 3 gives a schematic model of a HP system.

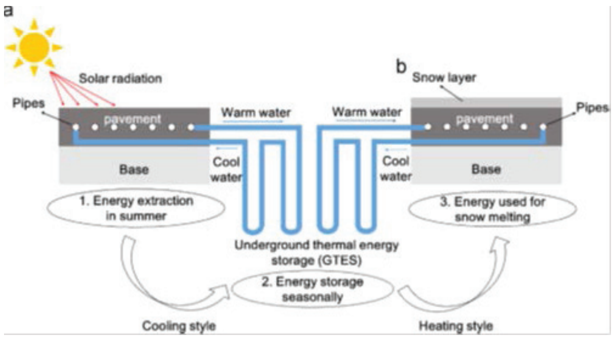

Fig. 3 (a) Harvesting Energy during summer (b) releasing energy during winter (Pan et al., 2015).

There has been a number of experimental studies which have demonstrated the possibilities of harvesting energy from pavement solar collectors. In a work by Loomans et al. (Loomans et al., 2003), an asphalt collector in the Netherlands was studied during summer months with an average air temperature of 14 °C. They found that the energy efficiency was around 30%; i.e. of the incoming solar heat on the pavement surface, nearly 30% could be harvested. Furthermore, the temperature of the fluid in pipes was around 20 °C during energy harvesting. Results of another study, which was done for an inland climate with an annual mean temperature of 4.8 °C, showed that a heat flux of about 150 W/m^2 would be possible to obtain from solar asphalt collectors during summer days (Gao et al., 2010). Moreover, Kovacs and Wahlgren (2012) in their study about integrating harvesting technologies for renewable energy into bridge constructions, concluded that it is possible to harvest energy via pavement collectors in the E39 corridor; however, they did not present any quantitative results regarding harvesting energy.

Harvesting heat via asphalt solar collector will decrease the asphalt pavement temperature. Reduction of pavement temperatures will make the pavement withstand permanent deformations like rutting thereby extend the life time of the asphalt pavements (Xu and Tan, 2015). Another advantage of cooling down road surfaces via the HP would be to mitigate the effects of urban heat islands (UHI) (Santamouris, 2013). UHI is referred to as areas of a city which is considerably warmer than its surrounding areas.

4.1. Energy harvesting

Considering the abovementioned literatures, it is possible to calculate the amount of harvested energy based on the assumption that nearly 30% of the incoming solar radiation on a horizontal surface could be transformed to usable heat. By using the hourly mean value of global radiation the harvested heat during a certain time period could be calculated. This was done for the climate of Gothenburg during three summer months. The results reveal that more than 140 kWh/m^2 of solar energy could be harvested during summer.

4.2. HP design

Piping is considered as one of the important parts in the construction of the HP system. Piping includes selection of pipe material and its size and position inside the pavement. Steel, iron, copper and plastic are some materials which may be used in the HP system (ASHRAE, 2003). The position of pipes includes the distance of the pipes from each other and the depths of the pipes from the surface of the pavement. Pan et al. (2015) in their literature review on HP systems concluded that as the size of the pipes gets larger and the pipes are installed closer to each other and to the road surface, the efficiency of the HP system will increase i.e. the HP system will enable to melt snow and ice more quickly. However, it should be taken into account that if the pipes are installed in shallow depth of the pavement, the risk of pipe damage will increase. Therefore, it is advised to put the pipes deeper than 50 mm (Van Vliet et al., 2005). However, deeper embedded pipes will decrease the efficiency of snow melting for a HP system. To increase the efficiency, a recommended design method is to increase the thermal conductivity of the pavement (Hall et al., 2012). Higher thermal conductivity of the pavement leads to an increased heat transfer rate from pipes to the road surface. In a study by Dehdezi (2012), it was found that the installation of pipes deeper in the pavement would reduce the risk of reflective cracking in the pavement as well as enabling future rehabilitation of the pavement without damaging the pipe network.

4.3. An example of the design of HP system

As mentioned above there are a number of parameters like the asphalt pavement materials and the spacing of embedded pipes which could affect the efficiency of the HP system. In order to investigate how these parameters influence, the efficiency of a HP system, calculations based on a finite element method were performed using COMSOL Multiphysics (COMSOL, 2015).

This analysis studies what the effect of buried depth and the distance between two pipes had on the snow melting process in the simulated HP. The calculation results are shown in Table 1. The results in Table 1 indicate that, the effect of the pipes distance is higher than the depth of the pipes. For example, considering a pipe depth of 78 mm, the increase in the distance between pipes from 200 mm to 320 mm could result in about 170% increase in the time which is required to remove snow from the road surface. However, considering a fixed distance of 200 mm, 260 mm and 320 mm between pipes while changing the pipe depth from 60mm to 96 mm, the time required to remove all snow from the road surface increases about 50%, 31% and 16% respectively. Considering the obtained results, it is advisable from an enhanced heat transfer aspect to embed the pipes with a distance less than 200 mm and in depth lower than 78 mm.

Table 1. The time required to remove all snow from the road surface in the simulated HP system depending on pipe position

	Pipe Distance (mm)		
Buried Depth (mm)	200	260	320
60	10 hr	16 hr	25 hr
78	10 hr	18 hr	27 hr
96	15 hr	21 hr	29 hr

4.4 HP storage interaction

To design a seasonal thermal energy storage (STES), it is required to have a HP system surface model. In design of a STES, the rapid changes of the surface conditions, like changes in solar radiation, could usually be neglected because the changes takes place in time steps of seconds to minutes. This short timespans as well as the thermal lag created by the heat capacity of the pavement structure and the working fluid in pipes, will delay and dampen the effects of changes at the surface of the pavement. The literature review revealed that there are a number of models available (Pan et al., 2015) for estimating the heat fluxes at a pavement surface during snow/ice melting. In this paper the ASHRAE method (ASHRAE, 2003) was used as a base method because it is one of the most established methods in the industry for designing HP system. The ASHRAE model is used with the exception that surface evaporation have not been incorporated. The inaccuracy caused by this simplification is small compared to other simplifications made. The calculated heat fluxes is presented in Fig. 4a. Since heat flux above 500 W/m^2 occurs rather rarely and that there is a need for a more stable model considering the dampening effect, a new model was created in this study to simplify the heat flux into heat pulses for a seasonal storage.

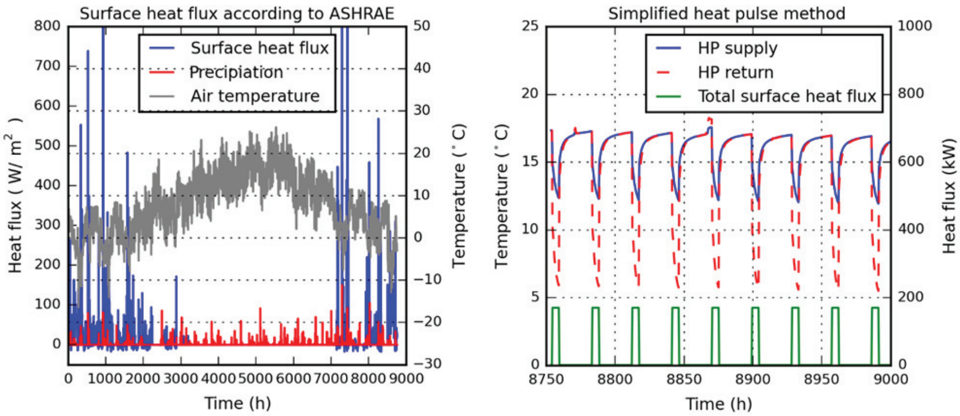

Fig. 4 (a) Surface heat fluxes for a HP based on ASRAE; (b) Simplified method there heat pulses could be seen for a climate in Gothenburg seen as well as the temperature of the working fluid in the HP.

The fluctuating heat demand generated by the ASHRAE model was transformed into periodic heat pulses with approximatively the same energy demand using a constant heat flux of 170 W/m^2. It was assumed that the heat pulses last for 12 hours since that was representative for a major weather event like a snow fall. This was repeated 42 times each winter which corresponds to an energy demand of 75 kWh/m^2 for each year, see Fig. 4b. This results were used as input data in a TRNSYS thermal energy storage model (Klein et al., 2010). The calculated return and supply temperatures of the storage could be seen in Figure 4b and there is a trend of decreasing temperatures in the thermal storage. The results indicates that it is possible to design a sustainable HP system connected only to a seasonal thermal energy storage, charged with harvested solar energy. This study has found that it would be possible to harvest about 141 kWh/m^2 while the energy need is only 75 kWh/m^2. However, further research is needed in order to: validate the simplified surface model; incorporate a model for energy harvesting and study the losses and long term changes in the STES.

5. Discussion and conclusion

In this paper the initial results from three PhD projects are presented of which all are investigating possibilities to increase the environmental performance of road infrastructures. The main conclusion will be presented in this section; further results and conclusion could be found in the separate sections.

Infrastructure performance viewer: From the literature survey on LCA/LCCA methodologies, it is concluded that understanding of current environmental and economic impacts assessment can help in gaining knowledge of present practice in the domain of LCA and LCCA of roads as well as highlighting areas that require further improvement. The literature review identified important factors when it comes to set up LCA and LCCA. Among other findings the geographical dimension must be considered when setting up LCA and LCCA for road due to variations and complexity of parameters. Therefore, it is vital to be aware of crucial parameters (like uncertainties, impact categories, system boundaries etc.) and transparently built and document inventories to bring clarity in the results.

The E39 as a renewable European electricity hub: From the work so far in this PhD project, it is concluded that electrifying the traffic on E39 will have a minor influence on the total regional use of electricity when considering the yearly average Norwegian electricity supply. But there might be significant local and time variations in the potential power demand, which could impose a challenge on the electricity system in the form of specific power peaks, and that will be further studied in this PhD project. Yet, the transformation of both the transportation sector and the electricity system offers potentially interesting links with possibilities for integrating the generation and use of electricity so as, for example, make better use of variable renewable electricity generation such as wind power. This can give different actors, like NPRA, a new role when road infrastructures, like E39, combines wind power and energy storage devices and interacts with the surrounding electricity generation system, by for example exporting electricity during high market prices and using or storing during low market prices. Further work will use models to investigate how an electrified E39 can interact with the electricity generation system, including import and export of electricity to neighboring regions.

Safe and ice free roads using renewable energy: Considering the HP system, it is concluded that it is possible to harvest renewable solar energy during hot periods, save it and release it to melt ice during cold periods. The optimum usage of the harvested energy depends on the pipe positions in the system. It was found that the efficiency of snow melting will be higher if the pipes are placed closer to each other and also closer to the road surface. However, the depth of pipes should be chosen with regard to the risk of pipe damage due to traffic load.

The project “Coastal Highway Route E39”, which aims at creating a ferry free highway from Kristiansand to Trondheim, will need to address a vast number of technical challenges especially since it aims at reducing the environmental impact of roads. Regarding the second aim it has been found, by the three presented PhD projects, that there are knowledge gaps which needs to be filled, before that aim of a road with reduced environmental impact could be reached. It is by using joint research projects and collaboration between researchers that these gaps could be found and addressed. It might not be the work of the researcher to solve the problem, nevertheless by identifying them half the work is done. The project “Coastal Highway Route E39” gives the possibility to let researcher and designer collaborate and together shape the new E39 and overcoming technical challenges.

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