Statens vegvesen

profu CHALMERS UNIVERSITY OF TECHNOLOGY

Ferjefri E39

Current and future options for a fossil free E39-highway

Highway route E39

The E39-highway runs along the western coast of Norway; from Kristiansand in the south to Trondheim in central Norway - a distance of 1100 km. E39 passes some of Norway's main connection points Ålesund, Bergen and Stavanger. There are also seven ferry connections and approximately 85 tunnels along the route. E39 runs through six counties; Vest-Agder, Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal and Sør-Trøndelag, with a total population of 1.8 million people. Located along the road are more than half of Norway's energy intensive industry, and primary products such as oil, gas, fish are landed and processed in the area. The economy in the region is growing and so will most likely the E39 road traffic.

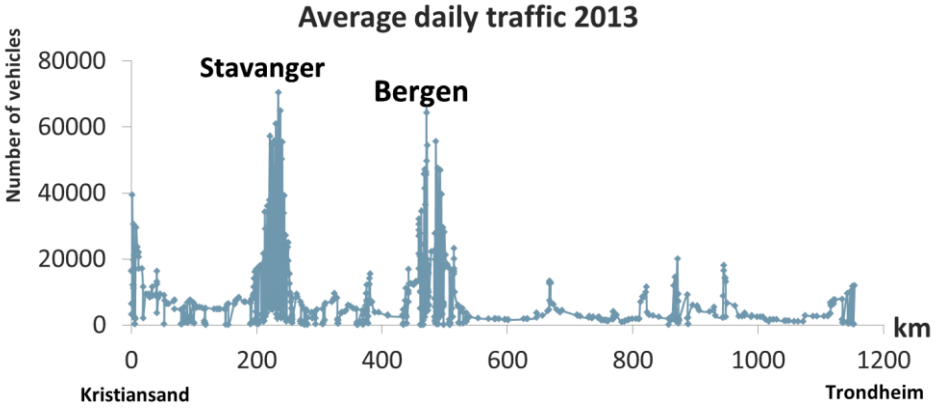
Traffic Flow

The annual road traffic volumes for E39 has been estimated to 2600 million vehicle kilometers for 2013, which corresponds to 6% of the Norwegian road traffic volumes. Heavy vehicles (heavy trucks and buses) are responsible for 12% of the traffic, and light vehicles (light trucks and private cars) thus for 88%. There are large geographical variations in the traffic intensity along E39, from less than 1000 to more than 70 000 vehicles per day. The heaviest traffic is of course around the biggest cities, such as Stavanger and Bergen, where E39 is used for short trips in city areas.

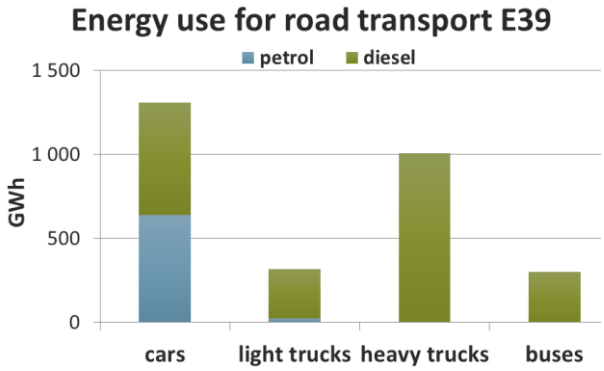
Energy use

For the annual road traffic volumes of 2600 million vehicle kilometers, approximately 70 million liters of petrol and 230 million liters of diesel are used per year. Those figures are based on assumptions about the average fuel consumption and the fuel distribution between vehicle types, given in the table below.

	Fuel consumption (l/100km)		Fuel distribution (%)	
	Petrol	Diesel	Petrol	Diesel
Light vehicles				
Cars	8.6	6.6	36%	46%
light trucks	9.7	7.8	1%	17%
Heavy vehicles				
Heavy trucks	-	43	0%	77%
Buses	-	43	0%	23%



Electric vehicles and gas buses, account for approximately 1.4% of the Norwegian vehicle fleet in 2013, and have been neglected. The share of biofuels in road transport was 4% in 2013.



The yearly energy use for road transport along E39, expressed in TWh, is approximately 2.9 TWh, assuming an energy content in diesel and petrol of 9.77 and 9.06 kWh/l, respectively.

CO_2 emissions

Direct CO_2 emissions from road transportation on E39 are estimated to 0.73 Mton. Thus, on average, a light vehicle emits 180 gCO_2/km and a heavy vehicle 1000 gCO_2/km. The CO_2 emissions from E39 accounts for 7% of the Norwegian and 23% of the regional road traffic CO_2 emissions.

CO_2 reduction strategies

Norway has a target to cut the CO_2 emission from the transport sector with 2.5-4 million tons by 2020, and a long term target of a carbon neutral transport sector by 2050. Preliminary calculations of some possible CO_2 reduction strategies show that there is a great potential for CO_2 reductions from E39.

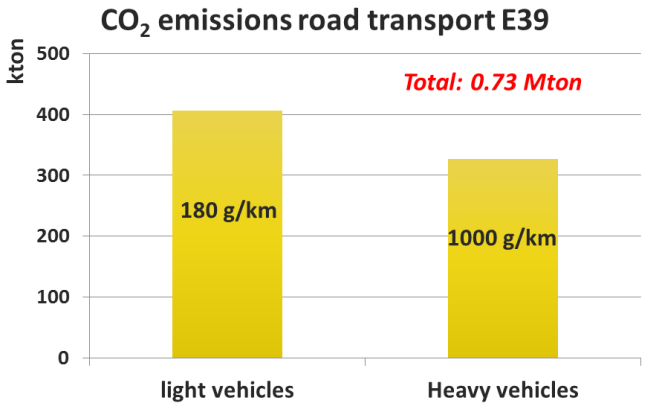
Biofuels has, based on two biofuel scenarios presented in a report by *Statens Vegvesen, Avinor* together with others, a potential to reduce the CO_2 emissions from E39 road transport by 2030 with 16% in a low ambition scenario, and 50% in the high ambition scenario, assuming zero emissions from biofuels. For E39 this would mean a reduction of ~120-370 kton. Today, if well to wheel emissions are considered, the effect will be smaller. In the future, there will be a strong competition for biofuels from other sectors, such as the heat sector. A change to hybrid electric vehicles could results in a 30% energy savings per kilometer, and potentially reduces CO_2 emissions with ~220 kton.

In order to reach low or zero emission, a transition to electricity or hydrogen is most likely needed. An electrification of E39 could imply electric cars, fuel cells, conductive or inductive charging from the road (for example overlines or ground-level supply). A transition to electric vehicles will not only reduce the emissions, but also substantially decrease the energy use. A complete electrification of E39 would result in energy savings of ~50% per vehicle kilometer.

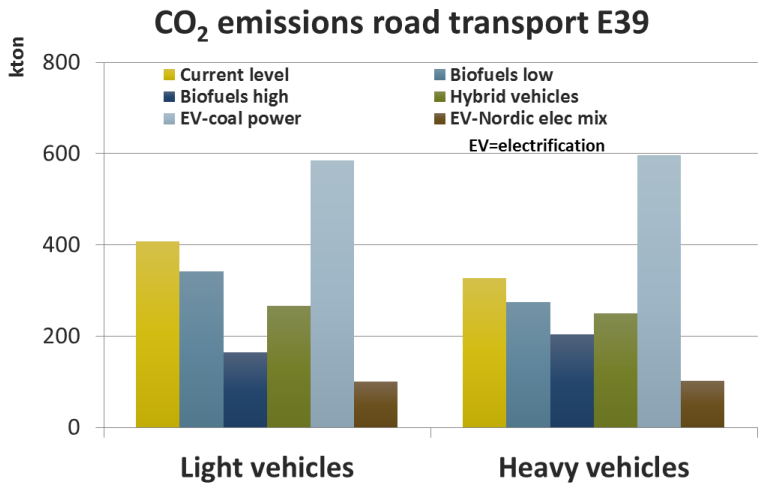
Possible CO_2-reduction Strategies

Strategy	CO_2-reduction (%)	kton
Biofuels	**16-50**	**120-370**
Hybrid EV	**30**	**220**
Electrification	**75-95**	**530-700**

The CO_2 emissions, when electrifying E39, depend on the method that is applied, for example looking from a marginal or average perspective, and geographical boundaries. If it assumed that the increase in electricity demand through the electrification of E39 is supplied by coal power there will, of course, be a significant increase of CO_2 emissions.



Coal power may be considered as the short-term marginal electricity supplier in the short-run in the North European electricity system. However, also if we apply a marginal perspective, the issue is not that simple especially if the time perspective is long. Rather the climate impact is determined by a mix of generation technologies, including investments in new technologies, also in a marginal perspective. Furthermore, it is highly likely that the future climate impact of electricity will be reduced significantly as a consequence of stringent energy and climate policies.



In this project, detailed model studies of the European and Nordic electricity systems will be performed in order to further investigate the (climate) impact of an electrification of E39.

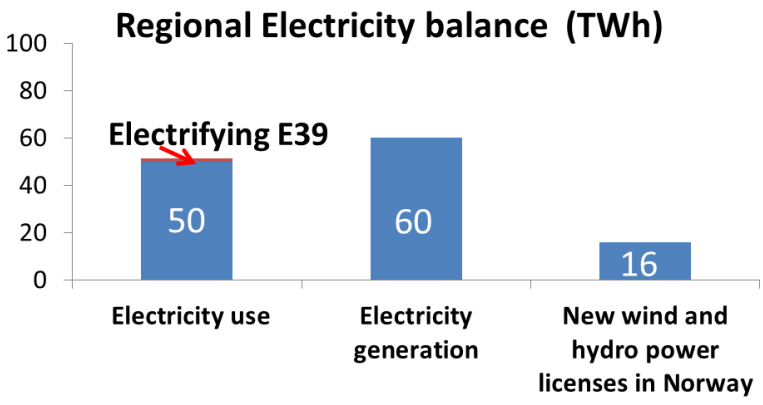
Regional Electricity Balance

A change of fuel in the transport sector or electrifying a road may also have an impact on the regional energy system. The electricity generation in the E39-region (consisting of six counties) is approximately 60-75 TWh per year, depending mainly on if it is a wet or a dry year. The electricity use in the region is 50 TWh per year, which means that the region has a surplus of electricity. Almost all of the electricity (~95%) is today generated by hydro power.

Wind power is, however, rapidly growing in the area and reached 490 MW of installed capacity, producing approximately 1.1 TWh, in 2012. Additionally installations in Norway of ~16 TWh of wind and hydro power have been approved by the Norwegian Water Resources and Energy Directorate. But in 2014, only 0.6 TWh of hydro and wind power was built in Norway. Thus, the electricity demand for road traffic at E39 if electrifying (~1.5 TWh) is on a yearly basis small compared to the total amount of generated electricity.

Electrifying the transport sector will thus have a minor influence on the total national use of electricity when considering the yearly average. But there are both local and time variations, which could impose a challenge on the electricity system, in the form of specific power peaks. Such implications have not yet been studied.

The aim is to use the Chalmers energy systems models to investigate how the E39 can interact with the electricity generation system including import and export of electricity to neighboring regions. The future role of E39 in the energy system system will depend on investments in transmission capacity (e.g. to UK and continental Europe) as well as demand side management in industry and buildings.



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