Policy Design and Environmental Benefits of Electric Vehicles

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The interest in electric vehicles (EVs) has increased over the last decade mostly due to the pressing environmental problems. EVs are considered to be environmentally benign and to have the potential to contribute remarkably to GHG emission reduction. However, since the total driving costs of electric vehicles are still significantly higher than those of gasoline or diesel cars, see Fig. 1, different policies and measures are needed to foster their market introduction. As Fig. 1 clearly shows fuel cell vehicles (FCV) and battery electric vehicles (BEV) are by far most expensive.

Currently, a broad portfolio of monetary and non-monetary policy measures exists which is able to increase the attractiveness of EVs as well as their competitiveness in the market. However, they are not able to ensure realization of their full environmental benefits. In this context it has to be borne in mind that the final goal of transport electrification is not just to increase the number of EVs but to reduce GHG emissions and air pollution.

The core objective of this work is to show that promotions strategies for EVs have to depend on the energy used for electricity generation and hydrogen production.

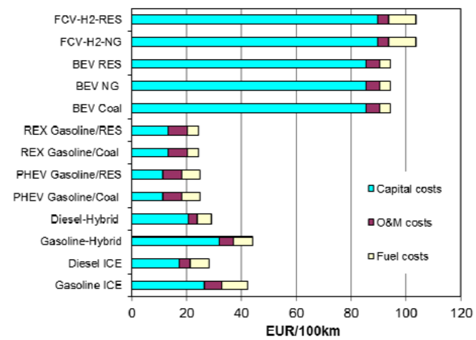

Figure 1. Total specific cost per 100 kilometre driven (EUR/100km) in 2014

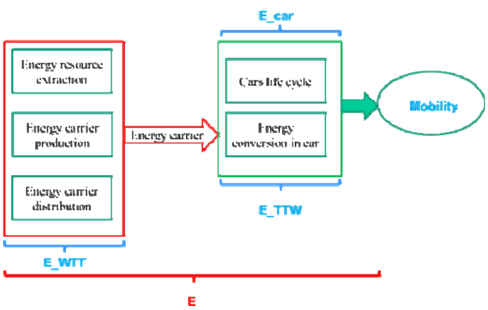

Figure 2. Method of approach for the environmental assessment of GHG emissions

METHOD

The method of approach applied in this article is based on research published in Ajanovic and Haas, 2015. In our work we conduct a comprehensive environmental investigation, and provide recommendations for promotion policies for electric vehicles. We have estimated environmental benefits of different types of electric vehicles (battery electric vehicles (BEV), hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), range extenders (REX) as well as fuel cell vehicles (FCV)).

Electric vehicles could be more or less environmental friendly technology depending on the carbon-intensity of electricity used. We analyze the whole well-to-wheel (WTW) emissions related to the provision of the energy service mobility including also the embedded life-cycle emissions of the car. Figure 2 shows the basic method of approach used in this paper. Total emissions of passenger car mobility (E) can be very different depending on the energy and material flows in the well-to-tank (WTT) part of the energy supply chain, the efficiency of the energy use in cars (in the tank-to-wheel (TTW) part), as well as emissions associated with the car production and scrappage.

ENVIRONMENTAL ASSESSMENT

The environmental benefits of electric vehicles could be very different depending on type of car, as well as energy mix for generating electricity used in cars. Figure 3 shows CO_2 emissions per 100 km driven for the whole energy supply chain and for various types of EVs in comparison to gasoline and diesel cars. Power of all analyzed cars is 80 kW. We have used average data for EU-15 (for data and basic assumptions see Ajanovic/Haas, 2016)).

It is obvious that all types of EVs contribute to CO2 emission reduction in the TTW part of the energy supply chain. The largest reduction in total CO2 emission could be reached with BEV powered by electricity from renewable energy sources (RES) – wind or hydropower – and FCV powered by hydrogen produced from RES. For all BEVs and FCVs TTW-fuel emissions are zero. To harvest the full environmental benefits of rechargeable EVs and to contribute effectively to heading toward sustainability in transport, it is most important to ensure that EVs use to a large extent electricity from renewable energy sources (RES). Unfortunately, this is currently not specified in policies for the promotion of EVs. Consequently, in most European countries the full potential of GHG emission reduction due to EVs cannot be reaped. If old coal power plants are used for electricity generation, total emissions from EVs could be even higher than those of conventional cars.

THE ENVIRONMENTAL RELEVANCE OF EVS PROMOTION POLICIES

To foster market introduction of EVs different policies and measures are implemented worldwide. The use of electric vehicles in Europa is directly or indirectly promoted by various regulations and strategies, such as:

- Directive 2009/28/EC (Directive, 2009), which states that 10% of the energy used in transport must be provided by renewable sources by 2020;
- The EC regulation 443/2009 (EC, 2009), which imposes reductions in average emission levels for vehicle manufactures, setting objectives of 130 gCO_2/km for 2015, and 95 gCO_2/km for 2020;
- The European strategy (EC, 2010) which establishes as priorities the development of electric vehicles that are at least as safe as conventional ones, a European standard for charging points, a public charging network, a smart grid and research programs for the safe recycling of batteries (Perdiguero and Jimenez, 2012).

In addition to these measures which are set at the EU level, there are different national/local supporting measures implemented in various countries with the goal to make electric vehicles more attractive. These measures can be divided in two categories: monetary (such as financial incentives, tax relief, exemption from tolls, free parking, etc.) and non-monetary (such as use of bus lanes, availability of suitable charging options, permission to enter city center and zero emission zones, etc.) measures (Kilian, 2012, Ajanovic, 2015). Yet, the core question is whether these strategies really lead to reduction of GHG emissions.

A comprehensive overview on current financial incentives and taxation in European countries is given by Ajanovic and Haas, 2015. This survey reveals that there is no country whose financial incentives on federal level depend on the source of electricity or on the specific CO_2 emissions of electricity generation. Depending on the average electricity-specific emission factors BEVs could have very different CO_2 emissions per km driven in different countries. Hence, from a static point of view – looking at the current electricity generation mix and the resulting average CO_2 emissions in the countries analyzed only in Norway, Sweden and France, the use of BEVs can significantly reduce GHG emissions, see Fig. 4.

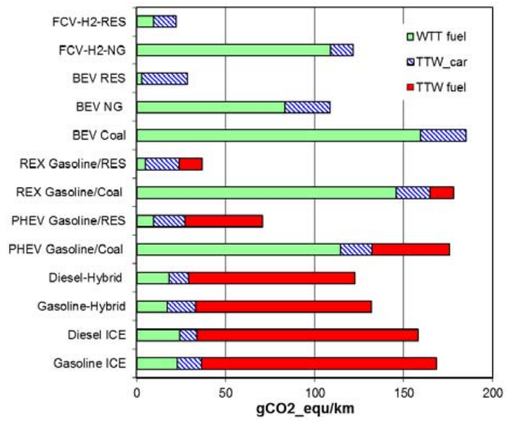

Figure 3. CO_2 emissions per km driven in for various types of EV in comparison to conventional cars, in 2012 (power of car: 80kW)

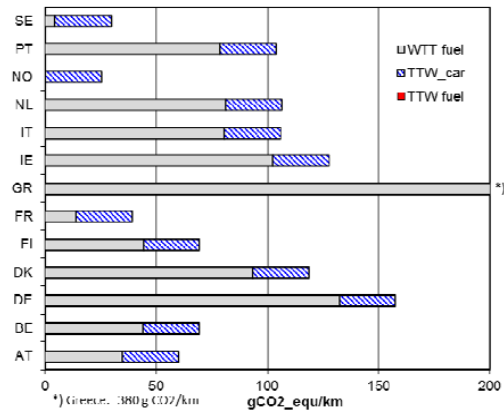

Figure 4. CO_2 emissions per km driven for BEV powered by grid electricity in different countries

Due to the fact that most of the promotion measures for EVs currently implemented are not sustainable in the long run, new policies will be needed. Most important is that future promotion strategies depend on the carbon content of the electricity used and its dynamic development. Moreover, CO_2-based fuel- and registration taxes would be very important complementary policy tools. Furthermore, indirectly, all measures supporting an increase in the use of RES lead to the reduction of electricity-specific CO_2 emission factors, and consequently, to a better environmental performance of EVs.

CONCLUSIONS

The major conclusions of this work are:

(i) To harvest the full potential of GHG reduction of rechargeable EVs it is most important to ensure that these EVs are using electricity from RES;
(ii) Yet, promotion policies implemented so far in almost all countries do not properly address the aspect of the source of electricity generation, and, consequently, have not yet led gain the full GHG emission reduction potential of electric vehicles.
(iii) In the future all promotion strategies should depend on the carbon content of the electricity used.
(iv) Only in countries with a high share of RES in the electricity mix, e.g., by certificates ensuring the source of electricity, significant positive effects of EVs on the environment can be expected.

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Bergen Overview (continued) (Environmental Considerations)

Norway is also in the rather special situation that virtually all of its electric power comes from renewable sources, with 98% from hydro power. As a token of what hydro power has meant for the economic development of the country for a period of more a century, and for the general welfare of its people, a monument in the form of a turbine wheel that had been running for almost 50 years in a local hydro power station was donated by the regional power company. BKK, to NHH. It was handed over by the CEO of the company, Jannicke Hilland, to NHH's Rector, Frøystein Gjesdal, in a ceremony on Monday morning outside the main building. Originally, this initiative was taken by NHH-Professor of Environmental Economics and Chair of the Conference Programme Committee, Gunnar Eskeland.

Bergen Conference Sessions and Seminars

In parallel with the Council meeting on Sunday, three pre-conference seminars were arranged. Professors Georg Erdman and Markus Graebig from Berlin Technical University started up in the morning with a workshop on Enhancing academic presentation skills, followed by Professor Sebastian Schwenen from Munich University on Capacity markets, and finally, Fereidoon Sioshansi from Menlo Energy Economics on the Future of utilities – utilities of the future. The seminars had 40-70 participants throughout the day, a remarkable turnout on a sunny and pleasant Sunday in Bergen!

With over 600 conference attendees, the capacity of the largest auditorium of NHH was exceeded by some 100. Instead of restricting the number of participants to the maximum capacity of the auditorium, and thus losing valuable contributions from speakers and authors of papers, the organizers decided to video transfer the plenary sessions over to an adjacent auditorium. Technically, this worked quite well and only positive feedback was received. For the dual plenaries and concurrent sessions, capacity of auditoriums and other conference functions was sufficient.

The plenary and dual-plenary sessions spanned a wide area of current energy and environmental economics and policy issues. The titles of these sessions were as follows: Energy and environmental policy formation in an uncertain world; Technological change and energy in transport; Business strategies in an uncertain world; Petroleum market fundamentals and risks, Energy and the economy; Institutional investors and the energy sector; Gas: Russia and European markets, Financial aspects of power markets; In the aftermath of Paris. All sessions were very well attended and there were lively discussions, within the panels and between the audience and the panels.

Seminars and sessions were well attended throughout the conference

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