Are electric vehicles the mode of the future? Potentials and environmental impacts

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Press inquiries:
Phone: +49 761 45295-22
Email: presse@oeko.de

Public Relations & Communications Department
Mandy Schossig
Phone: +49 30 405085-334
Email: m.schossig@oeko.de

Germany is looking to have one million electric vehicles on the road by 2020. This is the target set by the German government in its National Electromobility Plan of August 2009, in accordance with which a number of promotion programmes have been set up.

Yet many questions concerning the environmental and climate benefits of electric mobility remain to be clarified, as do issues of market potentials and user acceptance. The Oeko-Institut has conducted research into these and other matters: this paper presents the key findings on the private and commercial use of electric vehicles and on resource efficiency.

Research question: Acceptance and private use

What is the potential of electric vehicles for private users?

In 2020 two-thirds of people buying a new car would opt for an electric vehicle (battery electric vehicles or a plug-in hybrid car). This was the finding of a car-buying simulation performed in conjunction with a survey of more than 1,500 purchasers of new cars carried out by the Institute for Social and Ecological Research (ISOE). Depending on the vehicle class concerned, between 12 and 25 percent of interviewees would choose an all-electric model. The survey showed that the smaller the desired car, the larger the number of people who go for the electric version (minis: 25 percent; small cars: 20 percent; compact class/vans: approx. 12 percent). By 2030 acceptance also rises for the larger classes – the reason being technical progress and falling prices.

Electric vehicles meet the everyday requirements of passenger vehicle use for the majority of users. The biggest damper on the purchase of new battery electric passenger vehicles is their restricted range of about 160 kilometres. This renders such vehicles insufficient for special journeys such as holidays or weekends away: on average twelve such journeys (six outward and six return trips) are undertaken each year. Alternative mobility options for "long journeys" – perhaps involving the use of public transport or a hire car – are therefore essential to the acceptance of electric vehicles.

Research question: Market potential and electricity demand

How many electric vehicles can be realistically expected by 2020 / 2030 and what effect will this have on electricity demand?

Germany could have up to six million electric vehicles on its roads by 2030. In 2020 there might perhaps be half a million, equivalent to about 1.3 percent of all passenger vehicles in Germany. According to modelling carried out by the Oeko-Institut, the million mark could be passed in 2022. The vast majority of these electric vehicles will be of the plug-in hybrid type. If the number of electric vehicles on the roads were to rise to nearly six million by 2030, such vehicles would account for 14 percent of all passenger vehicles. However, in terms of the total distance driven, electric vehicles are predicted to account for only 0.8 percent in 2020 and eight percent in 2030. This is because battery electric vehicles cover on average 8,000 kilometres per year – 40 percent less than conventional cars. In addition, plug-in hybrids travel only two-thirds of their distance driven in electric mode.

Electricity demand in 2030 will be increased by around eleven terawatt hours (TWh) as a result of electric mobility. This is equivalent to around two percent of Germany's total electricity consumption at present. Unless battery charging is managed, this will produce undesirable additional spikes in the need for power generation at times of day at which electricity demand is already high. To avoid excessive demand peaks and the accompanying need for expensive peak load power plants, battery charging would have to be managed in a way that shifts charging to lower-cost periods when demand is lower or wind energy input is high. However, this would involve making greater use of CO_2-intensive, coal-fired power plants that are harmful to the climate: such plants underpin the baseload power supply in Germany, especially at night. In the modelling for 2030, 40 percent of the additional electricity needed for electric cars would come from lignite, while 35 percent would come from hard coal and 5 percent from natural gas power plants. Just under 20 percent of the electricity for electric vehicles could come from renewable sources that were not previously usable.

Research question: Climate change mitigation
To what extent can electric mobility help to mitigate climate change?

If the use of renewable energies continues to rise in future, it is clear that there will frequently be situations in which more wind is blowing than is being used at that moment. This “unusable” renewable energy would be surplus. If electric vehicles could charge their batteries at these times, this would be a particularly efficient way of using renewable electricity for driving. However, in the Oeko-Institut’s model calculations the surplus renewable energy available in 2030 is insufficient to meet the additional demand for electricity for electric vehicles. Without further expansion of renewable energies, the CO_2-intensity of the additional electricity that electric mobility would require would therefore far exceed the average value for the German electricity mix (see above).

Expansion of electric mobility thus needs to go hand in hand with the development of further capacity for generating electricity from sun, wind and water, on top of the German government’s existing development plans for renewable energy. This is essential if the electricity needed by electric vehicles is to be emissions-free. Under such conditions, CO_2 emissions could be cut by 0.6 million tonnes in 2020 as a result of electric mobility. In 2030 the saving would be as high as 5.2 million tonnes by comparison with a scenario without electric vehicles. This is equivalent to a reduction in the CO_2 emissions of passenger vehicles of 0.6 percent by 2020 or six percent by 2030.

In the short to medium term, conventional cars continue to have the greatest potential for mitigating climate change: if their efficiency increases as expected, around a quarter of the CO_2 emissions of all passenger vehicles on the road could be removed by 2030.

Research question: Resource requirement
How does electric mobility alter global resource requirements?

The expansion of electric mobility in German will have significant consequences for the need for important and in some cases critical – i.e. rare – metals. This may lead to shortages of some of the metals that are particularly important for the manufacture of electric cars – for example, copper for the entire manufacturing process, lithium and cobalt for battery production, rare earths such as neodymium, praseodymium, dysprosium and terbium for electric engines and indium, gallium, germanium, gold, silver, platinum and palladium for other components such as power electronics. The rise in demand is most striking in the case of dysprosium: without countermeasures, electric mobility applications alone will in 2030 need 482 percent more of the metal than is currently produced for all applications. In addition, electric mobility competes with other applications of rare metals such as wind turbines, which need dysprosium for the manufacture of neodymium-iron-boron magnets. Similar considerations apply to gallium, which is used in photovoltaics and LEDs as well as in electric mobility.

Research question: Resource efficiency and recycling
What strategies are needed to resolve possible resource shortages?

Two key strategies are needed to alleviate medium- and long-term supply shortages. Firstly, resources must be used more efficiently and where possible replaced by other technologies. For example, types of engine that do not require the use of rare earths should be refined and brought to market.

Secondly, recycling strategies for rare earths and other critical metals must be developed in order to prevent shortages in the long term. While established recycling processes exist for copper and precious metals, recycling loops for rare earths, indium and other special metals still need to be researched and developed.

In addition it is essential to identify and tap new deposits, especially of rare earths, to avoid critical situations such as can arise if extraction is restricted almost entirely to one country. Exploitation of these deposits should be governed by environmental mining standards in order to limit environmental damage, especially in the mining of rare earths.

Research question: Commercial use of electric vehicles
What are the potentials of electric vehicles for commercial use or as company cars?

The Oeko-Institut has investigated the potential for the commercial use of electric vehicles in two accompanying research projects involving surveys and evaluation of real driving data. The results show that acceptance within the business community is growing and that environmental aspects are playing an increasingly important role in the procurement of fleet vehicles.

Service and fleet vehicles – growing acceptance
Environmental aspects are becoming increasingly important in the procurement of fleet vehicles, as a survey of some 30 commercial fleet operators shows. Around a fifth of respondents were prepared to allow for additional costs of between ten and 20 percent for good environmental performance. Nevertheless, total vehicle costs are still the main purchasing criterion.

While the total costs – investment and operating costs combined – of battery electric vehicles are at present around half as much again as those of conventional cars, they will fall steadily over the next twenty years. In 2030 electric vehicles actually have a cost advantage over those powered by a combustion engine in most vehicle classes. With the average commercial vehicle covering around 13,000 kilometres per year, the lower operating costs of electric vehicles are particularly advantageous.

In the best-case scenario, involving emissions-free electricity generation from additional renewable energies, almost one million battery electric vehicles in 2030 could reduce the CO_2 emissions of all the passenger vehicles on the roads by almost 0.75 million tonnes (or one percent). Around 14 percent of the electric vehicles would be deployed in commercial fleets.

Company cars – potential for mitigating climate change
A fifth of company car users at SAP AG would choose an electric vehicle – this was the finding of a survey of staff who took part in the Future Fleet project. Over a six-month period 500 employees covered 90,000 kilometres in 27 electric cars. The basic acceptance of electric vehicles as company cars is there, but expectations of their range, charging time and purchase price are not yet being met. For example, only a quarter of respondents were prepared to pay more than for a conventional car, around 66 percent expected a range of over 200 kilometres and almost half wanted the battery to be fully charged within an hour.

In the field trial participants saved around a fifth of the CO_2 emissions that petrol-powered vehicles would have produced. If SAP were to switch its vehicle fleet to plug-in hybrid vehicles by

2030, CO_2 emissions could be reduced by almost fifty percent. Extrapolated to Germany as a whole, electric company cars could by 2030 cut around 40 percent of the greenhouse gas emissions that a purely petrol-powered fleet would produce.

Details of the research projects – approaches and methodology

OPTUM: Optimising the environmental benefit of electric vehicles – integrated analysis of vehicle use and energy management

In cooperation with the Institute for Social and Ecological Research (ISOE), the OPTUM project explored ways of maximising the potential of electric vehicles for reducing greenhouse gas emissions in Germany. The research project was funded by the German Environment Ministry (BMU).

Research methods:

> The ISOE and the Oeko-Institut surveyed around 1,500 respondents to simulate the purchase of new cars, taking into account eight important factors such as vehicle properties, vehicles types, purchase costs, fuel costs, etc. The researchers combined the resulting information with data from the transport survey “Mobilität in Deutschland”, which asked 77,000 people from 26,000 households about their everyday driving habits.
>
> With the aid of this information on acceptance and driving behaviour and the support of a group of stakeholders representing industrial, political and environmental organisations, the experts drew up a scenario for the market penetration of electric mobility in Germany to the year 2030. Using electricity demand profiles based on a per-hour resolution, the Oeko-Institut’s electricity market model PowerFlex was used to identify the effects on the electricity market and the CO_2 balance of electrically powered vehicles.

Link to the OPTUM study

OPTUM Resources: Resource efficiency and resource-policy aspects of the electromobility system

This study, which formed part of the OPTUM project, investigates the resource-policy aspects of electric mobility. The aim of this joint project of the Oeko-Institut, Daimler AG, Umicore and TU Clausthal was to identify bottlenecks and possible weaknesses in the resources required for electric mobility and develop timely solution strategies such as recycling.

Research methods:

> The calculations according to various scenarios – innovation scenario, recycling scenario, substitution scenario – were based on the global market scenarios of McKinsey (2009) for the development of electric mobility. These scenarios were combined with detailed data on the quantities of the priority metals needed for the main components of the different vehicle propulsion systems (hybrid, plug-in, range-extender, battery electric, fuel cell) used in electric mobility. The analysed data for the specific resource requirements of the relevant components was discussed with external experts in special workshops.

Link to the OPTUM Resources study

E-mobility: Analysis of the potential environmental benefits of greater use of small battery electric vehicles

With the support of Daimler AG the Oeko-Institut has explored the use patterns and market potential of small electric vehicles for private and commercial use. The project was funded by the German Federal Ministry of Transport, Building and Urban Development (BMVBS).

Research methods:

The Oeko-Institut analysed the data of real driving profiles of passenger vehicles for private ("Mobilität in Deutschland 2008" – see OPTUM) and commercial ("Kraftfahrzeugverkehr in Deutschland 2002") use in order to identify possible areas of use for battery electric vehicles. The assessment of the future acceptance of electric vehicles was based on the findings of a survey of more than 30 fleet operators who were asked about their vehicle fleets and purchasing criteria and on the empirical results of the fleet trial "E-Mobility Berlin" on real user behaviour. For the commercial arena the researchers devised a model for comparing the cost-effectiveness of electric vehicles with that of conventional cars over time. By combining these components they drew up a market scenario for the period 2010 – 2030 and calculated the effects on the electricity market and the CO_2 balance of commercial electric mobility.

Link to the E-mobility study

Future Fleet: CO_2 reduction potentials through the use of electric vehicles in company car fleets

On the basis of the example of 27 battery electric cars in the passenger vehicle fleet of the software developer SAP, the Oeko-Institut – in cooperation with the ISOE, Mannheim University and the energy supplier MVV – investigated the potential of electric vehicles as company cars. The research was funded by the German Environment Ministry (BMU).

Research methods:

In a field trial at SAP AG the Oeko-Institut analysed automatically registered usage data and charging information on the electric vehicles in the study. This data, together with information from a survey of participants in which they were asked about their driving habits and the use of the electric vehicles, was used to identify the potential for the use of electric vehicles as company cars and the resulting impact on greenhouse gas emissions. Figures were calculated for the SAP company and extrapolated to Germany.

Link to the Future Fleet study

For further information see the Oeko-Institut's brochure "Autos unter Strom" (in German only), produced as part of the OPTUM project.

Contacts at the Oeko-Institut

For the potentials and greenhouse gas balance of electric mobility:

Florian Hacker and **Peter Kasten**
Staff researchers in the Infrastructure & Enterprises Division
Oeko-Institut, Berlin office
Tel.: +49 30 405085-373 and -349
Email: f.hacker@oeko.de and p.kasten@oeko.de

For the interaction between electric mobility and the electricity market:

Charlotte Loreck
Staff researcher in the Energy & Climate Protection Division
Oeko-Institut, Berlin office
Tel.: +49 30 405085-337
Email: c.loreck@oeko.de

For resource aspects of electric mobility:

Dr. Matthias Buchert
Head of the Infrastructure & Enterprises Division
Oeko-Institut, Darmstadt office
Tel.: +49 6151 8191-147
Email: m.buchert@oeko.de

The Oeko-Institut is a leading European research and consultancy institute working for a sustainable future. Founded in 1977, the Institute develops principles and strategies for realising the vision of sustainable development globally, nationally and locally. The Institute has locations in Freiburg, Darmstadt and Berlin.