July 2012
ISSN 1863-2009

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

eco@work

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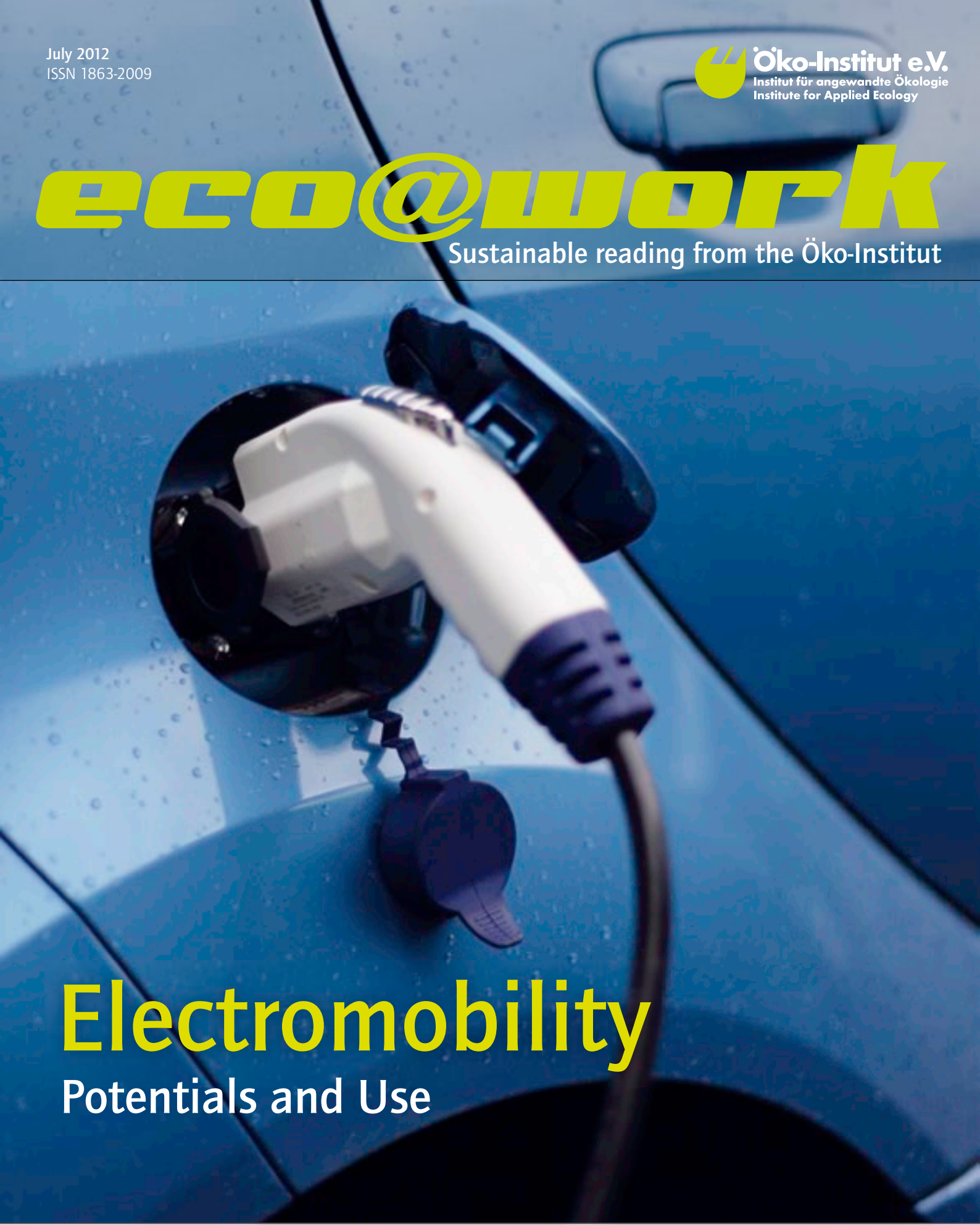


Electromobility

Potentials and Use

Ask the Expert
Professor Armin Reller
talks to eco@work

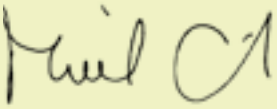
Travel electric!

Electromobility is a much debated, if not to say controversial issue at present. And yet electric travel has been around for some time. As a passionate fan of railways, I know – and I'm sure I don't need to tell you – that trams, trains and in some places even buses are powered by electricity. These public transport modes are seen as an environmentally friendly alternative to "personal motorised transport" – in other words, to the car. Does this latter option also have the potential to become more climate-friendly in future? That's a question which has long been the subject of research at the Oeko-Institut. We have conducted various studies which explore how – despite the steady increase in the volume of traffic over many years – personal mobility can be maintained in a climate-smart manner.

Over the past year, however, some of our work has taken a slightly different turn and has focused on a vision for the future of transport: electromobility. What is its potential? How much acceptance is there among private and business car-drivers, and how much scope does it genuinely offer to reduce greenhouse gas emissions? These questions have been explored in three projects at the Oeko-Institut. In this issue of eco@work, we are pleased to give you an overview of the findings of these studies and of other analyses which investigate resource-related aspects of electromobility.

As always, we are keen to share the full range of our research with you. We also invite experts from outside the Oeko-Institut to have a say in eco@work. This time, it is once again the turn of specialists from the private sector and researchers from universities in Germany and China who present their views on the headline topic of this e-paper. Read on to find out more.

We hope you enjoy reading this issue of eco@work. We wish you a pleasant and restful summer and a safe journey – by rail? – to your chosen holiday destination!



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Imprint

eco@work – July 2012, Published by: Öko-Institut e.V.

Edited by: Mandy Schossig (mas), Christiane Weihe (cw)

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Design/Layout: Tobias Binnig, www.gestalter.de

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Account Details for Donations: Sparkasse Freiburg – Nördlicher Breisgau,
Bank Code No.: 680 501 01, Account No.: 2 063 447
IBAN: DE 96 6805 0101 0002 0634 47, BIC: FRSPDE66
Donations are tax-deductible for German income tax purposes.

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"At some point, it will no longer be viable to extract the remaining resources"

They contain lithium and cobalt, indium and gallium, copper and gold. The manufacture of electric vehicles relies on numerous raw materials as inputs. These include critical metals such as the rare earths neodymium, praseodymium and dysprosium, which are used in electric engines. Resource expert Professor Armin Reller from the University of Augsburg spoke to eco@work about resource availability, resource and recycling strategies and substitution options.

Professor Reller, which raw materials needed to manufacture electric vehicles are already in short supply?
There are currently problems with dysprosium, a rare earth element. This is partly due to competition from other technologies, such as wind energy. Rare earths are currently used in around one-sixth of wind energy systems.

Where does Germany import these resources from?
It varies. A great deal of the lithium which is used to manufacture batteries for electric vehicles is obtained from South America, specifically from Bolivia, Argentina and Chile. More than 90 per cent of rare earths, on the other hand, are imported from China. However, Australia and the US are now keen to increase their output of rare earths once more. The US plans to reopen the mine in Mountain Pass in California, for example. It's possible that these measures will lead to a decrease in the price of rare earths again, but they won't enhance sustainability in this sector.

So what needs to be done to increase sustainability?
We need comprehensive resource and recycling strategies which map out ways of extracting and producing these resources with minimal environmental and social impact and aim to close the substance cycle. Starting with the development of a technology, it is essential to consider what will happen once the product has reached the end of its life, and what options then exist for recovering the inputs.

How far have we progressed with regard to recycling?
A great deal is already being done to recycle battery packs and engine blocks. They are collected and reprocessed, and the metal parts are recovered and reused. The challenge is this: an electric vehicle contains a great many metals, but often in very small quantities. But the advantage of metals is that they don't break down. In other words, they can be recycled as many times as you like.

Does this apply to rare earths as well?
Broadly speaking, yes. They can be reused over and over again. But here, we have a different problem. The chemical composition of the rare earths is very similar, making them very difficult to separate chemically. This means that they are also very difficult to process.

What challenges exist in the search for possible substitutes?
A great many factors must be considered. For example, copper is a conductive material and could easily be replaced by aluminium. However, using aluminium is more complex and expensive, and copper is also easier to recycle. Generally speaking, it is important not only to consider the substance itself but also its active form and the function that it fulfils – the conductivity of aluminium is a good example. Problems invariably arise when specific physical properties are required, such as magnetic properties.

What do you expect from future resource strategies?
What I want is a workable toolbox for meaningful, future-proof and sustainable management of the resources we have available. For example, I think it would be entirely justified for the EU to intervene by adopting regulations in cases where recycling is not economically viable because primary production is cheaper and easier. In my view, there is far too strong a focus on profitability. We now need to start investing in the future and take a long-term view by developing practical solutions for the key future-oriented technologies and their resource needs. We should also consider that at some point, it will simply no longer be viable to extract the remaining resources.

Professor Reller, thank you for talking to eco@work.
The interviewer was Christiane Weihe.

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Professor Armin Reller, Chair of Resource Strategy at the University of Augsburg, talks to eco@work.


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The vital partner: renewable energies

What can electromobility do for the climate and environment?

Electric vehicles are highly efficient. They produce no exhaust gases and can be powered by renewable energies. There's no doubt that electromobility offers a great many benefits. But what can it do for the climate and the environment, especially once usage figures start to rise? This question has been explored in depth by the Oeko-Institut, with a focus on the sources of the drive energy, load management and vehicle construction.

A major plus point for electric propulsion systems is that they are much more efficient than the combustion engine, achieving efficiency rates of around 90 percent. What's more, if the drive energy is generated from renewable sources, an electric vehicle produces zero emissions while on the move. That's one of the reasons why Florian Hacker, an electromobility expert and researcher at the Oeko-Institut, is convinced that electric vehicles offer great potential for more sustainable mobility. "But can this potential be fully exploited? That's the question – and it will depend to a large extent on whether the right frameworks are in place," he explains. As part of the OPTUM project – the name stands for "Optimising the environmental benefit of electric vehicles" – the Oeko-Institut conducted an in-depth analysis of the market potential of electrically driven cars and their impacts on electricity demand and climate protection.

"If we genuinely want to put up to six million electric vehicles on Germany's roads by 2030, this will bring about an additional electricity demand of approximately 11 terawatt hours, corresponding to roughly 2 per cent of Germany's current total electricity consumption," says Florian Hacker. Meeting this demand from conventional power plants would drive up CO_2 emissions – even though electric vehicles produce zero emissions. If more electric cars are to improve the climate balance sheet, more renewable energies will also be required.

However, the surplus renewable energy which is likely to be available as a result of the German government's expansion goals to 2030 could well be insufficient to meet the additional demand for electricity for electric vehicles, according to model calculations by the OPTUM project, which is funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. "There is a frequent assumption that these cars can be charged from the power generated from renewable sources, such as wind energy, that is surplus to requirements as a result of the expansion of renewables, but this is unlikely to be the reality," says Florian Hacker. At the same time, a system of load management which shifts battery charging to lower-cost periods, rather than at peak periods in the evening when demand for electricity is high, would involve making greater use of coal-fired power plants that are harmful to the climate, as these plants underpin the baseload power supply in Germany, especially at night. "Our model calculations show that just under 20 percent of the additional electricity required in 2030 to power electric vehicles could come from renewable sources that were not previously usable," says the Oeko-Institut's expert. "A further 5 percent would come from natural gas power plants, but the lion's share of the power – a total of 75 percent – would have to come from CO_2-intensive, lignite- and coal-fired power plants that are harmful to the climate." (For more information about this topic, see Box on electromobility and emissions trading.)

Renewables: a key role

Due to the additional electricity demand generated by a growing number of electric vehicles on our roads, additional renewable energies have a vital role to play in achieving a healthy environmental and climate balance sheet. "The further expansion of renewables is essential, on top of the German government's existing development plans for renewable energy, if the target proposed for electromobility is to be achieved with no climate impact," says Florian Hacker. If additional renewable energies are used, CO_2 emissions could be cut by 0.6 million tonnes in 2020 as a result of electric mobility, and 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 6 percent. "It's crucial that we generate the amount of additional electricity from renewables that is needed to match the extra vehicles' consumption," says Florian Hacker. "The point in time when the electricity is fed into the grid will then no longer matter – even if this means that an electric vehicle is occasionally powered by "grey" electricity."

When considering the climate potential of electromobility, however, it is important not to lose sight of one key aspect: the ongoing potential to make conventional propulsion systems even more efficient – whether this is achieved with improved engine technology, the use of lighter materials, or less powerful vehicles. "In the short to medium term, conventional cars offer even greater potential for mitigating climate change and reducing environmental impacts than electromobility," says Florian Hacker. "If the efficiency of petrol-driven cars increases, around a quarter of the CO_2 emissions of all passenger vehicles on the road could be removed by 2030. But to achieve long-term climate goals, alternatives such as electric propulsion systems are urgently needed."

Climate potential in corporate fleets

The use of electric vehicles in corporate fleets also offers major potential to reduce emissions. In Germany, approximately 60 percent of newly registered passenger cars are company cars. In the "Future Fleet" project, the Oeko-Institut investigated the potential environmental benefits of electrically powered company cars. As part of the project, the Institute for Social-Ecological Research (ISOE) analysed the usage behaviour and the acceptance of electrically powered vehicles among the company workforce at SAP AG (for more information, see the article "A building block that fits – electromobility from the consumer's perspective", p. 8). In addition, the Oeko-Institut focused on the climate change mitigation potential of electromobility in the corporate sector and the scope for reducing emissions here. The analysis showed that if company vehicles were powered from renewable sources, a substantial impact could be achieved: the Oeko-Institut found that if the analysed potentials for SAP AG are used to make projections for the usage of electric company vehicles in Germany as a whole, approximately 40 percent of the greenhouse gas emissions of company cars could be saved by 2030 compared to a conventionally powered car fleet. "Due to long journeys frequently being made, it is necessary – particularly in the case of company cars – for battery electric vehicles to be supplemented by plug-in hybrids to fully tap the GHG mitigation potentials," says Florian Hacker.

Resources and recycling

Energy for propulsion systems and emissions are not the only factors of relevance to electromobility's environmental balance sheet, however. The design and construction of engines, battery packs and power electronics also play a key role, as do the raw materials (inputs) used. Manufacturing the very powerful batteries needed in electric vehicles requires critical raw materials such as lithium and cobalt. Recycling processes are already being developed for these inputs, supported by eco-audits undertaken by the Oeko-Institut (see Box: Recycling lithium-ion batteries). However, electric engines also require key resources, such as rare earths like neodymium and dysprosium. So anyone wishing to drive electromobility towards a sustainable future must consider the need for environmentally compatible production of these rare inputs and investigate substitution and recycling options (see the interview on page 3 for an in-depth discussion of this issue).

Powering electromobility towards a positive future in the private and commercial sectors and maximising its climate and environmental potential will pose major challenges for all stakeholders – in research and development, business and politics. But Florian Hacker is convinced that with concerted and coordinated efforts from all stakeholders, the potential afforded by electric mobility can be utilised for everyone's benefit: "We know that the road towards a more sustainable future is not an easy one," he says. "But if everyone puts their shoulders to the wheel, electromobility can make a major contribution here."

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Recycling lithium-ion batteries

Options for recycling lithium-ion batteries from electric vehicles have a key role to play in ensuring that electromobility maintains a healthy environmental balance sheet. After all, if electric vehicles achieve the desired market penetration, large quantities of old battery packs will inevitably accumulate – and these contain key metals such as cobalt, nickel and lithium.

As part of the LiBRI and LithoRec projects, the Oeko-Institut undertook comprehensive environmental impact assessments for two recycling processes for the recovery of cobalt, nickel and lithium which are currently undergoing research and development. The main focus of the LiBRi project, coordinated by Umicore, is on a pyrometallurgical method for recycling the batteries, whereas the LithoRec project, coordinated by Braunschweig University of Technology (Technische Universität Braunschweig), is developing and testing a hydrometallurgical process. The results of the environmental impact assessments show that there are clear environmental benefits from battery pack recycling; they also provide useful feedback for the processes themselves.

Electromobility and emissions trading

There is a close connection between electromobility and carbon trading in the power generation industry. This is because the electricity needed to power electric cars is subject to emissions trading unless it is generated from renewable sources. As things stand, any increase in the number of electric vehicles would have a direct impact on the carbon markets. If demand for electricity from conventional power plants increases, this drives up demand for emission allowances, which in turn increases the costs for industrial enterprises which are subject to carbon trading.

For Europe, however, carbon emissions from power generation have been capped until 2020, with further reductions envisaged thereafter. This means that emissions cannot rise while the cap remains in force – and it also requires emissions to be avoided elsewhere. The question which arises, then, is who bears the political responsibility for additional emissions, especially if, over the long term, the demand for electricity and for electric vehicles increases the demand for emission allowances. If the responsibility for transport-related emissions is placed on the shoulders of the participants in emissions trading, there is a risk that the cap will soften. In reality, however, the cap needs to be lowered even further in order to achieve long-term climate goals, so safeguarding a supply of electricity from additional renewable energies for electric vehicles is recommended as a matter of urgency. These energy sources do not require any emission allowances, so there is no need to worry about price hikes – and no justification for a softening of the cap.

A building block that fits – Electromobility from the consumer's perspective

Good for a spur-of-the-moment trip to the country today and a reliable commute to the office tomorrow, while remaining affordable and minimising environmental impacts: today's transport options have to satisfy often very exacting demands. Freedom and flexibility, in particular, have become the expected norm. On the face of it, electric vehicles – with their limited range and long charging times – seem to fall short of these expectations. But take a second look, and it's clear that they are in perfect harmony with consumers' mobility behaviour and needs.

Take a closer look at Germans' mobility and it quickly becomes apparent that consumers are not using the constant flexibility that many claim they need. This is revealed by the Oeko-Institut's analysis of data from the "Mobility in Germany" (MiD) survey of travel behaviour, conducted in 2008, as part of the OPTUM project. Over the course of a year, the project surveyed 77,000 people from 26,000 households about their day-to-day mobility behaviour, collecting information about timings, routes and the modes of transport used. "If we look at the results of the analysis, we have to ask ourselves: do we really need so many cars?" says Peter Kasten from the Oeko-Institut. "More than one third of the cars remain parked during working days; on Saturdays, the figure rises to 44 percent, and on Sunday, a full 63 percent of cars sit on the drive." And even if they are taken out for a spin, the distances driven are generally very short: 80 percent of them are driven less than 50 km a day, and an astonishing 95 percent are driven less than 100 km a day. "Electric vehicles – despite their more limited range and long battery charging times – are already a good fit for our daily travel behaviour," Peter Kasten concludes. "But we shouldn't forget the longer journeys that are taken less regularly – such as holiday travel." In the experts' view, these longer distances will require alternative mobility strategies – perhaps involving the use of a hire car or public transport. "And of course, plug-in hybrids also offer potential in this context," says Peter Kasten.

So car owners could in fact meet their daily mobility needs very easily with electric modes of transport. But the question is: do they want to? A conjoint analysis conducted by the Institute for Social-Ecological Research (ISOE) investigated levels of acceptance in order to provide some answers. The analysis consisted of a simulation of car purchases based on various criteria such as costs, performance and CO_2 emissions for various vehicle types and categories. In all, 1487 people between 18 and 82 years of age who were planning to buy a new car in the next two years participated in the survey – which revealed that there is great potential for electric vehicles now and in future. Depending on the specifications chosen – such as the vehicle's performance and features – between one sixth and one quarter of respondents, on average, said that they would choose a fully electric vehicle now, and two-thirds of respondents reported that they would opt for electric mobility (battery-powered or plug-in hybrid) by 2020. The analysis revealed a high level of acceptance for the "mini" category in particular, but the ISOE survey also showed that acceptance of larger vehicle classes is likely to increase by 2030. This is based on the expectation of price decreases and technological advancements.

The commercial sector, too, is sending out positive signals about electric vehicles, according to Oeko-Institut researchers working on the project "Accompanying research for E-Mobility Berlin" (Begleitforschung E-Mobility Berlin). The environmental performance of vehicles is becoming increasingly significant in the commercial procurement of service or fleet vehicles, according to the Oeko-Institut's survey of more than 30 fleet operators. Around a fifth of those surveyed stated that they are willing to accept up to 20 per cent higher costs for the "green operation" of their passenger car fleet. Nonetheless, the combination of purchase and operating costs remains the key criterion in commercial procurement – but even this might not put electromobility at a disadvantage over the long term. "The cost disadvantage of electric vehicles compared with conventional propulsion will decrease over time," explains Peter Kasten. "Indeed, we assume that in 2030 electric vehicles will even have a cost advantage in most vehicle categories compared to vehicles powered by internal combustion engines."

Commercial sector: potentials

The commercial sector already offers potential for electromobility, according to the "Future Fleet" study conducted by the Oeko-Institut in cooperation with the Institute for Social-Ecological Research (ISOE). Over a six-month period, the usage behaviour of company car drivers working for SAP AG was analysed. Data collection focused on when the electric vehicles were used, what journeys were made and what distances were travelled, when the vehicles were charged, and how long they took to charge. As part of the project, the acceptance of electrically powered vehicles among the company workforce at SAP AG was also analysed. A survey carried out by the ISOE among SAP employees found that the greatest barriers for users were the low range of electric vehicles and the significantly higher purchase costs. Even so, approximately a fifth of those surveyed can today envisage purchasing an electric company car in the next three years. "In order to cope with the lower range of electric vehicles, mixed fleets are an option," says Peter Kasten. "These could include conventional vehicles for longer journeys."

A spur-of-the-moment trip to the country today, a reliable commute tomorrow? The analyses conducted by the Oeko-Institut and its project partners show that the Germans' travelling habits are in perfect harmony with the options afforded by electromobility. Consumer acceptance, too, shows that electromobility offers significant potential. For Peter Kasten, one thing is certain: "Over the coming years and decades, consumers will increasingly discover what electromobility has to offer – especially if the existing obstacles, such as cost, can be overcome."

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