Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Renewably mobile

Marketable solutions for climate-friendly electric mobility

Renewably
mobile

Imprint

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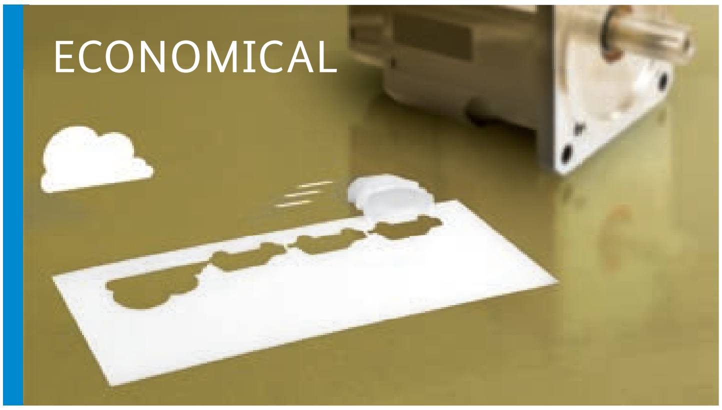
Electric vehicles and wind or solar generated electricity are ideal partners—emission-free mobility. When we use electricity from renewable sources for our mobility, climate protection is always onboard as well.

Electric mobility has to contribute to the protection of resources and the environment in a comprehensive way. Therefore, in the manufacturing and disposal of the vehicles and their parts, as many components as possible must later be reusable or recyclable.

The transition to electric mobility does not happen overnight. To offer an attractive range of vehicles, new marketing concepts need to be developed, which make the environmental benefits of such cars a central consideration.



Electric vehicles are extremely efficient. Due to the high degree of efficiency of their engines, much more of the energy they use is converted into motion than in traditional combustion engines.

Contents

Electric mobility at a glance

Federal Environment Ministry objectives

Funding priorities and projects

Why are we focusing on electric mobility?

In order to prevent any serious consequences of climate change, global warming needs to be restricted to 2°C above preindustrial levels. According to the Intergovernmental Panel on Climate Change, greenhouse gas emissions must be reduced by up to 85 percent, however at least by a minimum of 50 percent, compared to 2000 levels in order to achieve the two-degree target.

What does that mean for Germany? Assuming there is uniformity across the board, that means assuming there are the same emissions per capita across all countries worldwide, even conservative estimates suggest there needs to be a reduction of greenhouse gases of more than 80 percent compared to 2005 (see Figure 1a). This is a fixed objective of the Federal Government.

The extent of the required reductions makes it clear that all CO_2 producing sectors, including transport, need to make an equal contribution to this. If the number of cars on the road is similar in 2050 to the numbers seen today, then the CO_2 emissions of cars will need to be reduced from 221 g CO_2 per kilometers travelled in 2005 to a maximum of 43 g CO_2 per kilometers by 2050 based on calculations by the Federal Environment Ministry (see Figure 1b).

How can we reach this goal? It is essential that the coming years see greater progress in terms of improving the efficiency of conventional drives or by using biofuels instead. However this is not enough to achieve the targets set for 2050. The calculations show that the right upper emissions limit needed to reach the two-degree target of 43 g CO_2 per kilometers per car can only be achieved if at least two-thirds of all journeys are emission-free, most easily achieved by making them in pure electric and plug-in vehicles. Fuel cell vehicles with hydrogen based on renewable energy could also help contribute to meeting the targets, but the issue here is the high primary energy consumption related to the production of hydrogen and the low overall energy efficiency (see Figure 2). ■

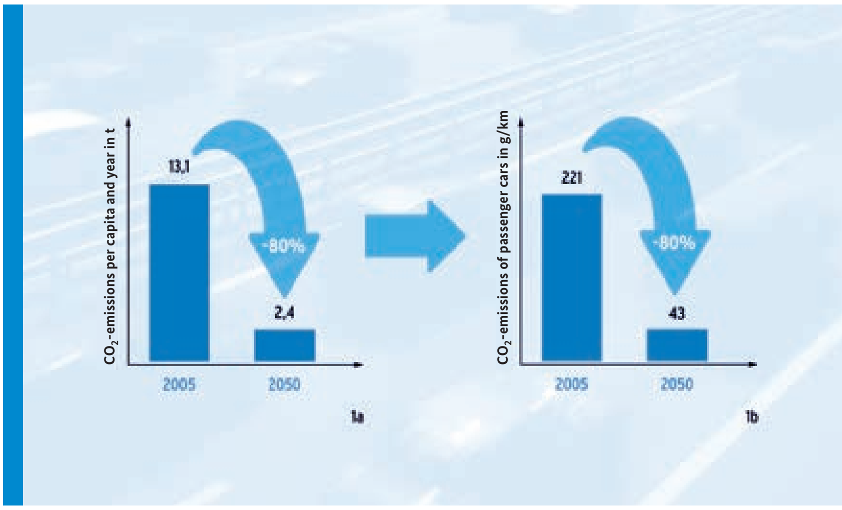


Figure 1 a and b: Required reduction of CO_2 emissions in Germany in order to limit global warming to two degrees by 2050. The models are based on calculations that take into account various factors such as population growth or changes in the number of vehicles currently in use. Figure 1a shows the required reduction of CO_2 emissions per capita, Fig. 1b shows the required reduction in terms of CO_2 emissions of cars.

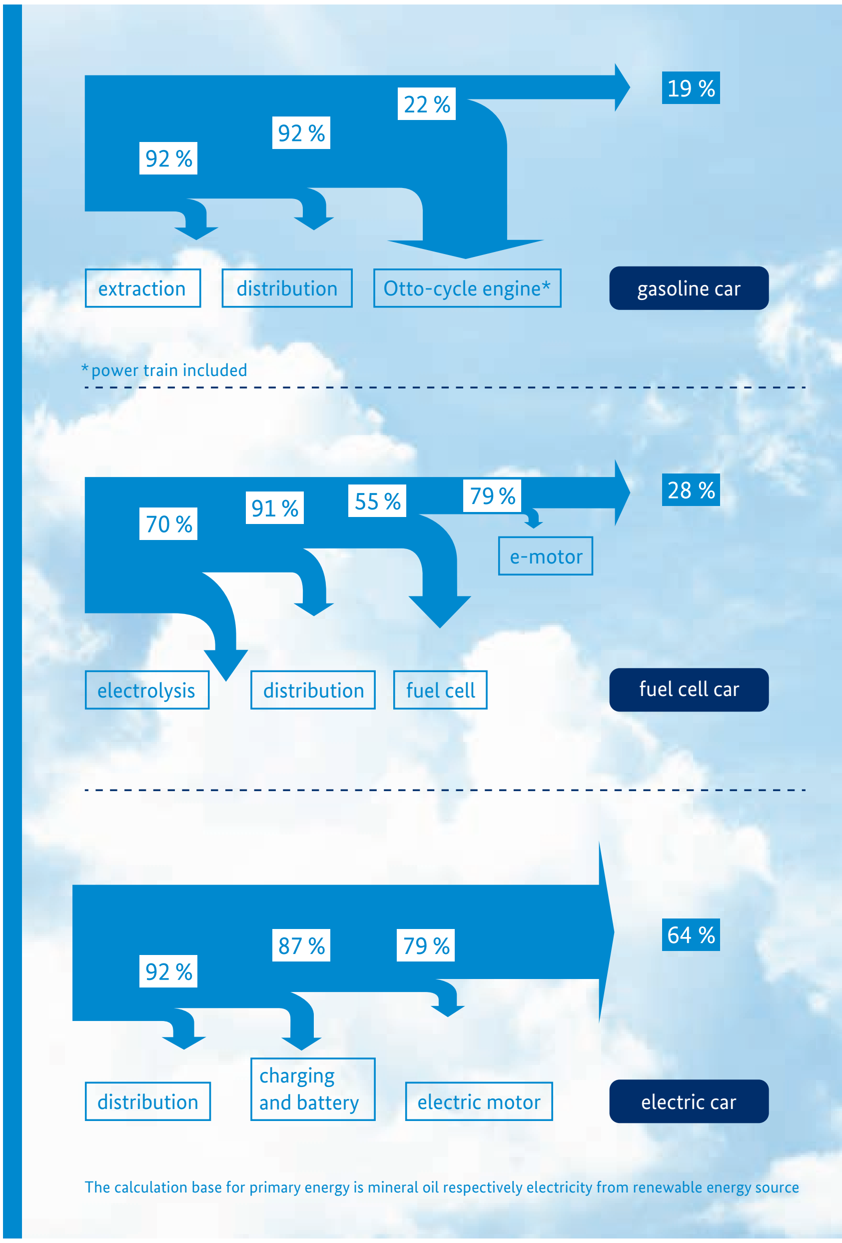


Figure 2: The energy efficiency shows what proportion of the supplied primary energy is converted into movement.
As an example, it is only 22 percent for petrol engines. If losses are taken into account with respect to the supply of fuel, then in actual fact only 19 percent of the output energy is used for the vehicle's kinetic energy.

With an energy efficiency of approximately 79 percent, an electric motor is very efficient. However, when using hydrogen to supply electricity to the vehicle, this advantage is significantly diminished by the upstream electrolysis process, compression, distribution and conversion into electricity. As a result, fuel cell vehicles have a total energy efficiency of just 28 percent. On the other hand, electric cars only have small losses in the upstream energy chain, meaning therefore that 64 percent of primary energy is converted into kinetic energy.

What is electric mobility as defined by the Federal Government?

The objective stated by the Federal Government is to introduce one million electric vehicles to Germany's roads by 2020 as well as six million electric vehicles by 2030. But what exactly are electric vehicles within the meaning of this objective?

BEV: Pure electric vehicles are fitted solely with an electric motor and receive their energy from a battery located within the vehicle which is charged via the power grid. The battery can store recovered braking energy (recuperation). In addition, pure electric vehicles no longer require a transmission system. Given that battery-operated vehicles are referred to in English as "Battery Electric Vehicles", the abbreviation BEV has in the meantime also been adopted into the German language.

REEV: Given that batteries with larger capacities are still relatively expensive, many manufacturers have fitted pure electric vehicles with an additional range extender (REEV = "Range Extended Electric Vehicle") which extends the vehicle's range. The range extender is a small combustion engine with a generator that only starts up when the battery power is running low. It provides additional power to the battery but does not actually propel the vehicle directly. The latter point here demonstrates a major difference compared to electric hybrid propulsion.

PHEV: A hybrid vehicle combines an electric and conventional propulsion and energy system (HEV = "Hybrid Electric Vehicle"). The vehicle is fitted with a combustion engine as well as an electric motor. If a larger battery is used which can be charged via the power grid, then this is referred to in English as a plug-in hybrid electric vehicle, or a PHEV. Only those PHEVs which can be charged via the power grid are defined by the Federal Government as electric vehicles. PHEVs and REEVs are therefore relatively similar. Both versions have the advantage that all daily journeys can be covered purely on electricity and in an emission-free manner, but it is also the case

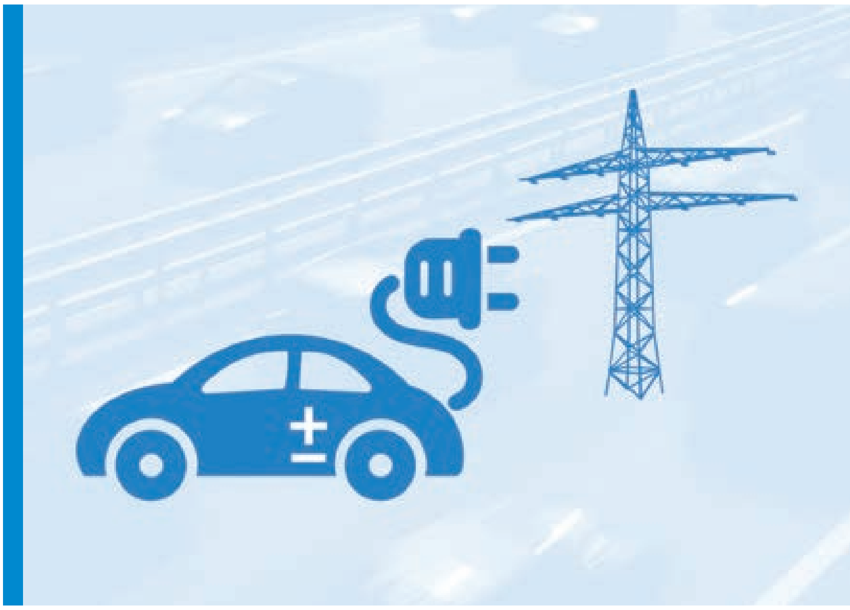


Figure 3: Electric mobility, according to the Federal Government, includes all vehicles that are powered by an electric motor and mainly draw upon the power grid for their energy, that means they are recharged externally. These include BEVs, REEVs and PHEVs.

that longer distances do not pose a problem either. Thanks to advances in battery technology, it should be possible to increase the proportion of electric vehicles even more in the future.

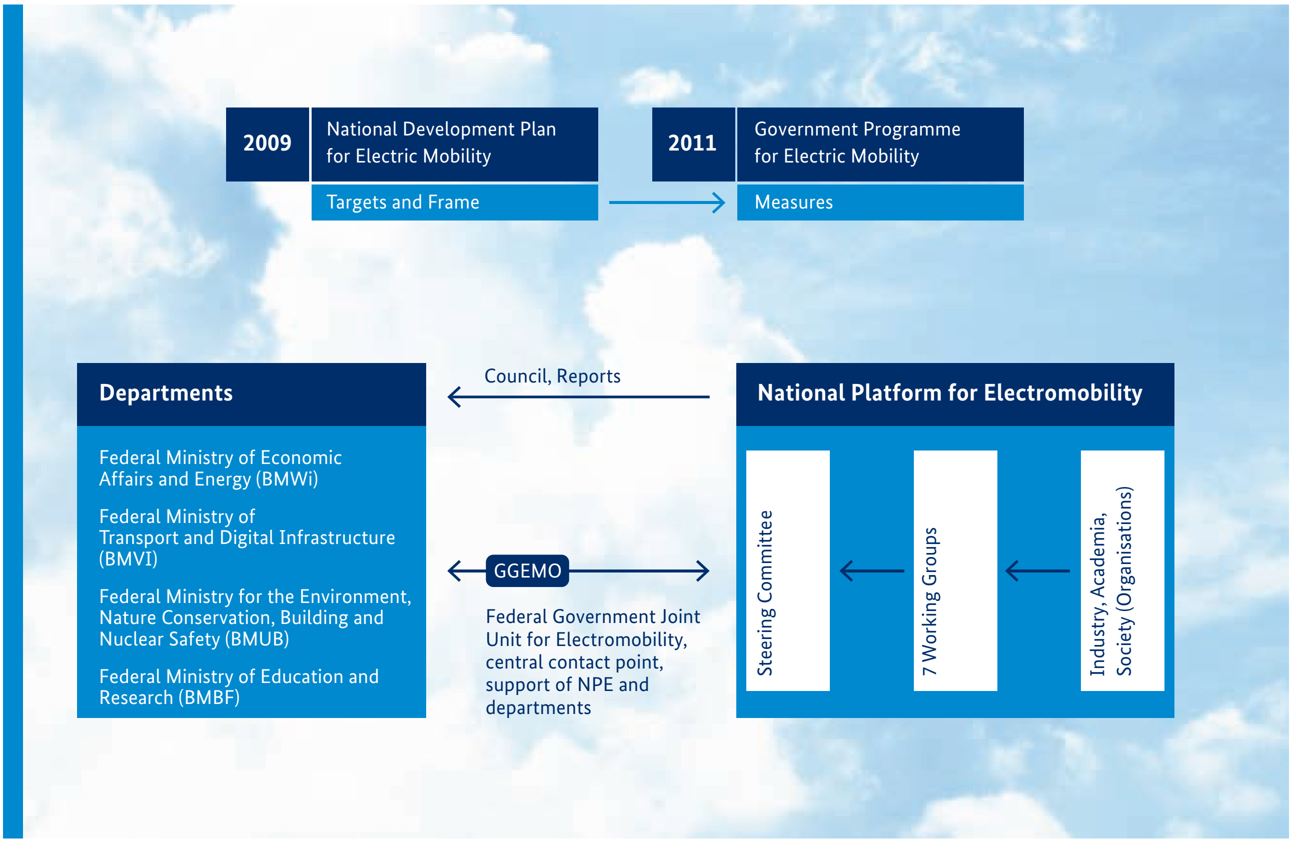
The Federal Government's definition for electric mobility therefore includes all vehicles

- that are powered by an electric motor and
- mainly draw upon the power grid for their energy, that means they are recharged externally.

This interpretation of the term electric vehicle, which is as closely related to power as "fuel", was selected for good cause. This is due to the fact that, if the entire energy chain is taken into account, only electricity offers efficiency benefits in terms of energy efficiency and, provided it comes from renewable energies, helps to significantly reduce the CO_2 balance (see chapter "Why are we focusing on electric mobility?"). In addition, electricity already provides a useful infrastructural base, which is not available for other energy sources. As an example, fuel cell vehicles with hydrogen which are driven by an electric motor require an energy source which can only be produced and transported with a high level of energy expenditure according to the state of the art. This significantly impairs the total energy and CO_2 balance. Furthermore, the creation of hydrogen infrastructure across the entire country would be costly. The further development of fuel cell technology is nevertheless beneficial as its advantages in terms of range and storage capabilities are undisputed. As a result, the Federal Government has established a funding programme which is independent of electric mobility; the "National Hydrogen and Fuel Cell Technology Innovation Programme". ■

Electric mobility: Who is who and who does what?

As part of its Integrated Energy and Climate Programme in 2007, the Federal Government declared the funding of electric mobility to be a key component for climate protection. In November 2008, a number of specific measures were discussed with representatives from industry, research and politics as part of the National Strategy Conference. The "National Development Plan for Electric Mobility" was finally adopted in 2009, the objective of which was to turn Germany into a lead market for electric mobility. The target is for there to be a million electric vehicles on German roads by 2020. The four Federal Government ministries responsible for electric mobility, the Federal Ministry of Economic Affairs and Energy (BMWi), the Federal Ministry of Transport and Digital Infrastructure (BMVI), the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Federal Ministry of Education and Research (BMBF), have intensified their support for electric mobility and are funding a number of different research projects. In May 2010 the Federal Chancellor established the „National Platform for Electric Mobility" (NPE). This was made up of a number of representatives from industry, science, politics and civil society who drafted a number of recommendations for further steps and measures. The Federal Government specified the National Development Plan and built on the main recommendations from the National Platform in its "Government Programme for Electric Mobility" in May 2011.



National Development Plan for Electric Mobility (NEP). The Federal Cabinet adopted the National Development Plan for Electric Mobility (NEP) in August 2009. The National Development Plan for Electric Mobility (NEP) sets out a number of objectives and frameworks which should be achieved within ten years thanks to major advances in battery technology and grid integration, as well as market preparation and the introduction of electric vehicles. A major component of this is the linking of electric mobility with renewable energies.

Government Programme for Electric Mobility. Adopted on 18 May 2011, the Government Programme for Electric Mobility stipulates a number of further measures and frameworks which should help contribute to the objective of making Germany a leading provider and market for electric mobility. This includes, for example, stipulating the provision of 1 billion euros worth of funding for research and development within this field, as well as establishing regional Showcase Regions and developing technical Lighthouse Projects. The Government Programme therefore brings together the various future activities of the Federal Government within the field of electric mobility and heralds the second phase of the National Development Plan for Electric Mobility. Thanks to the Government Programme, the Federal Government reaffirms its objective of a million electric vehicles by 2020 and also sets the objective of six million electric vehicles by 2030.

Joint Unit for Electric Mobility (GGEMO). Since February 2010, the Joint Unit for Electric Mobility (GGEMO) has acted as the single point of contact and secretary to the Federal Government for tasks within the field of electric mobility, as well as a service provider and secretary to the National Platform for Electric Mobility (NPE). It supports in particular cooperation with the Electric Mobility Steering Group as well as exchanges with the National Platform for Electric Mobility (NPE).

National Platform for Electric Mobility (NPE). The National Platform for Electric Mobility is an advisory body to the Federal Government and brings together key players from industry, science, politics and civil society for strategic dialogue. The main topics regarding the issue of electric mobility are dealt with in seven working groups, with approximately 20 high-ranking representatives, and recommendations are made regarding the implementation of the National Development Plan and the Government Programme for Electric Mobility. The working groups are coordinated by a Steering Committee which includes the chairs of the working groups and representatives from the Federal Government. ■

← **Figure 4:** Overview of task distribution of the various Federal Government institutions within the area of electric mobility: the Steering Group, the National Platform for Electric Mobility (NPE) and the Joint Unit for Electric Mobility (GGEMO) work together in order to implement the National Development Plan for Electric Mobility (NEP) and the Government Programme for Electric Mobility, both of which set objectives, frameworks and measures for the various activities of the actors involved.

A driving force for Germany. Electric mobility as active climate protection

Climate change and the depletion of fossil fuel resources will greatly change our mobility patterns. If we do not want to have to say goodbye to driving our own car, we must give it a set of “new wheels”. No reason to wave goodbye to it! Cars do have a future, but what might this future look like? How will we travel by car in the future? And where will our energy come from?

Individual transport will indeed come in many different, guises in the future; electric drive vehicles will certainly be one of these. Electric mobility offers us the chance to change the way we move from A to B in a sustainable way—towards a more eco-friendly, targeted mobility. It will make the transition from a fossil fuel to a post-fossil fuel mobility culture that focuses on clean, safe, local energy sources much easier.

Our planet’s population will continue to increase—as will the need to transport goods and people. At the same time, oil reserves are running out, and the various derivatives used as fuel are becoming increasingly expensive for end consumers. Not forgetting the CO_2 emissions that are causing our climate system to change. In view of this scenario, electric mobility can make a significant contribution to the move towards the use of alternative energy sources in the transport sector. However, this requires the power for electric vehicles to originate from wind, sun and other renewable energy sources, as this is the only way to come a huge step closer to achieving the zero-emissions goal and the phasing-out of fossil fuels.

In view of these facts, what will our everyday driving experiences look like in the future?

Electric vehicles will be firmly established in our every-day lives. The car that an ordinary commuter will have in their garage may be different to a conventional car with a combustion engine in terms of design and electronics. However, the current disadvantages of electric vehicles will no longer be an issue, as technological innovations and redesgined operating environments will have made electric mobility user-friendly. Commuters will not have to spend more money on buying a car, nor will this car be considerably heavier than today’s car due to a large battery, nor will their driving comfort be restricted in any way due to a limited range. Optimised vehicle designs and the use of lightweight construction methods throughout are one way of achieving the above.

Public and company vehicle fleets as well as the majority of vehicles for passenger and goods transport will also run on electricity, or be able to do so as and when required. Besides the various present-day microcars, there will be different vehicle types to meet the wide range of individual mobility requirements. In short, future users will be able to choose the right vehicle, whatever their respective needs.

For many city dwellers, for example, the "all-purpose vehicle" still commonplace today will be a thing of the past. Such vehicles were often purchased with long-distance journeys in mind, which were then undertaken very rarely. The emission-free, battery-operated micro-car has therefore become a useful alternative for many city dwellers. They use electric scooters and bicycles or the largely electrically powered public transport system if they have shorter journeys to make.

And if they do have to travel greater distances on a daily basis, there are a number of alternatives. Besides plug-in hybrid vehicles with a wide range there is access to many car sharing providers, whose offer of environmentally friendly vehicles includes cabriolets, sports cars and vans. The batteries of these cars are charged whilst being driven itself, namely by using induction systems which are embedded in the road surface over several kilometers. The time-consuming search for charging points located outside a driver's known environment is also something long past as the network of charging points has been expanded to offer nationwide coverage, and drivers can find out where they are whenever they need to via their on-board satellite navigation system.

The overall quality of life, especially in urban areas, has become much better thanks to less direct emissions: less exhaust fumes, less particulates and less noise, which will make a huge difference, particularly in the megacities.

Electric vehicles will also make a significant contribution to grid stability. For example, the battery of an electric vehicle, parked either in a garage or somewhere else, owned by a commuter is used to store energy generated from renewable energy sources, but it can also feed this energy back into the grid if necessary. This intelligent grid integration ensures that fluctuating energy sources such as clean wind and solar energy can also be used efficiently during times of surplus.

The current problem of insufficient electricity storage capacities will no longer be a problem. This integration of private cars into the power supply is controlled in a user-friendly way by state-of-the-art technology. In fact, the traditional plug will often also be surplus to requirements, thanks to the highly efficient wireless charging technologies that have become the norm. Long charging times that require careful routing and timing no longer need to be factored in. The car will have undergone a metamorphosis, from mere mode of transport to a tool that serves the ecologically sensible management of our energy usage. All of its components are recycled, of course, and environmentally friendly materials and processes have become the norm in automotive construction.

The unique and innovative state-of-the-art technology required for the system to run smoothly has given German automotive manufacturers and automotive industry suppliers a competitive edge on the international market. Germany's comprehensive, sustainable approach has turned out to be a particular strength.

Overall, as a clean, efficient, resource-compatible and above all user-friendly solution, the (electric) car has a secure future in Germany. ■

CLEAN

Electric vehicles and wind or solar generated electricity are ideal partners—emission-free mobility.

Developing the traditional combustion engine further is an important step towards reducing CO_2 emissions, but on its own, it will never suffice to provide climate-friendly transport. Although modern cars with combustion engines are becoming more efficient in terms of technology, and individual fuel consumption is going down, these advances are offset by the fact that globally, the number of vehicles on the road as well as the distances travelled are on the increase. The number of cars worldwide is expected to double by 2030. If it does so without a substantial proportion of low-emission or emission-free vehicles, CO_2 emissions are expected to soar once again, leading to a respective impact on the climate. Oil reserves are also finite and the market price will continue to rise in the long-term.

Electric vehicles are the obvious solution. However, only if the electricity used by these vehicles is generated from renewable sources, such as wind power or solar energy. This would make them true zero-emission vehicles that contribute to environmental and climate protection. Increasingly, the “green” image of electric vehicles will also become an incentive to purchase, and correspondingly provide the manufacturers with a competitive advantage. In addition, the use of electric vehicles not only reduces greenhouse gas emissions but also nitrogen oxide, particulate and noise pollution.

Few people are aware of the fact that the continuously increasing proportion of renewable energy input into the power grids calls for intelligent grid management and storage technology solutions. The energy generated from wind and solar power is subject to strong fluctuations and at peak times, there may be excess energy which cannot be fed into the energy market due to lack of storage capabilities. This is, for example the case at night, when wind turbines rotate heavily due to strong winds whilst power consumption goes down to a minimum. This renewably-generated electricity could be used to charge the batteries of electric vehicles parked at the time but connected to the grid to function as flexible “current collectors”.

The use of sophisticated technology ensures that the electric vehicle’s owner can easily and conveniently control charging times, for example via an online user interface. All the user has to do is enter the command “Charge battery fully by 7 am tomorrow”; and the technology does the rest. Feeding emission-free renewable energies into the system will become easier with every single one of such decentralised and time-sensitive charged electric vehicle batteries used.

They can be connected to the power grid with “intelligent” plugs. However, inductive, also known as wireless, charging will also soon be possible. Wireless charging systems are convenient and support the use of fluctuating energy sources: a driver assistance system (similar to current automatic parking aids) will automatically position the vehicle correctly above the coil of a wireless charging point when you drive your car into a garage or a car park and connect it to the power grid for you. Most vehicles are usually parked for 23 of each day’s 24 hours. The convenience increases the time vehicles are connected to the grid and thereby the options available for storing renewable energies at the best point in time. ■

ECO-FRIENDLY

is dealing with resources in a way that also takes the past and the future into account.

Many electric car components require raw materials that are increasingly becoming scarce on the global market, and correspondingly more expensive, particularly lithium, cobalt and rare earths. Given that no vehicle lasts forever or is immune to wear and tear, it is important to ensure during the manufacturing process that its individual components can be recycled or reused for other purposes (second life) later on. This reduces our dependence on key raw materials, helps to protect the environment, saves money—and therefore helps to give manufacturers a competitive edge. Electric vehicles are particularly suitable for comprehensive closed loop recycling management in the automotive industry, as so many of their components either needed redesigning or had to be designed from scratch specifically for their new purpose.

In order to efficiently recycle materials from electric vehicles, we need new manufacturing methods and smart designs. On the basis of an ecological overall concept for energy and material flows, various substances whose recycling will soon become a priority can be identified at an early stage. It is also a good idea to develop collection and return concepts in order to meet the objective of a maximum recovery rate.

Another option is reusing individual components in other areas of application. This might for example apply to older batteries that no longer meet the energy storage requirements of electric cars, yet are still effective enough to be used to capacity for other purposes. All of this requires sophisticated testing methods which can be used to analyse the aging behaviour and condition of individual components to determine the best time for their replacement. The removal or replacement of such recyclable or reusable components must also be accomplished with as little effort as possible. Again this must be taken into account during the vehicle manufacturing process.

Linking product development and recycling processes is also of strategic importance for German car manufacturers and automotive industry suppliers, as it is to their advantage and has already had a positive impact on costs whilst also benefiting their future competitiveness. ■

ECONOMICAL

means using energy effectively and converting all of it into propulsion.

Electric vehicles are extremely efficient. Thanks to the excellent energy efficiency of their engines, a far greater amount of generated energy is converted into propulsion than in a traditional combustion engine. On the other hand, the heavy weight of the traction batteries and the limited range of the vehicles represent new challenges for the manufacturers.

Electric motors utilise over 90 percent of energy input, whereas combustion engines utilise less than 40 percent. In electric vehicles, a proportion of the energy lost during braking can also be recovered by means of modern technology to be fed back into the battery. This efficiency advantage is particularly useful in urban traffic, where frequent braking and accelerating are the norm.

Electric mobility leads to innovation. In order to continue to improve the economy of electric vehicles—and thereby their range, carbon footprint and efficiency—some of the issues that need to be resolved are reducing the vehicle weight and optimising the ancillary components. One way to achieve this is lightweight construction with materials based on natural fibres. Thermal management, that means controlling thermal flows inside the vehicle, also offers scope for further improvement in order to increase the overall efficiency. Innovations such as these, resulting in efficient and long-lasting technologies, can subsequently also be utilised in cars with combustion engines, benefiting both the environment and the driver's wallet.

Bridging technologies help with the transition to electric mobility. These include various plug-in hybrid vehicle (PHEV) concepts, such as range extended electric vehicles (REEV), that means vehicles with hybrid drive whose batteries can also be charged via the power grid. Energy efficient drive components and intelligent operating strategies can ensure that these vehicles also produce only minimal CO_2 emissions. This hybrid form of "classic" car and electric vehicle can help to encourage users who expect a long-distance vehicle range to accept electric mobility. On the other hand, many users will make the experience that they can actually make most of their journeys in pure electric mode: More than two-thirds of all cars on German roads are driven less than 40 kilometres a day. ■

PRACTICAL

Ready for everyday use:
The right electric vehicle, whatever the needs.

The transition to electric mobility is a process that will not take place over night. For a start, despite their benefits in terms of energy efficiency, electric vehicles are initially more expensive to buy than cars with combustion engines. A sensible first step to make electric mobility key to road traffic is therefore to provide funding for pioneering vehicle fleet projects. In this field, the lower operating costs already compensate a considerable proportion of the initial investment, even today. The more the benefits of electric vehicles become apparent in these areas of application, the more acceptance they will find from private buyers.

One vehicle fleet area that electric mobility is perfect for is urban goods traffic. Transport companies or mobile service providers tend to benefit more from switching to fuel-efficient electric vehicles as the conditions are well-suited to electric mobility: If the vehicles are not in use, they are parked in depots or company car parks, making it easy to implement a bundled charging infrastructure. The daily routes of urban delivery service operators are also quite regular and can already easily be covered with the ranges offered by today's electric vehicles.

Many people use their cars mainly for urban commuting; the shorter range of electric cars is therefore of no real consequence to them. Another advantage is the fact that electric vehicles help to reduce the noise and air pollution levels in densely populated urban areas. And, not least, the noticeably more affordable way of "filling up" already helps to compensate the higher purchase price, even today. Vehicles with a range extender offer longer ranges, that means they are more like the all-purpose car we know today. They are fitted with a small-scale combustion engine that supplies the battery with power when necessary, but the majority of journeys can be driven in pure electric mode using renewable energy straight from the socket.

Controlled charging can make a significant contribution to power grid stability and optimum renewable energy use. People who prefer to travel by bus, train or plane can also simply share an electric car with others by registering for a car-sharing scheme. They can then choose the type of vehicle that is most suitable for their travelling plans that day—anything from a compact car to a van. New service models such as the purchase of "mileage" in kilometres, or the leasing of batteries can contribute to making electric mobility marketable. Designing customised, attractive offers is one element of new marketing concepts that focus on the environmental benefits. ■

What are the Electric Mobility Lighthouse Projects?

Since 2012, the Federal Government has selected several extraordinary projects, which deal with topics that are particularly relevant for research and development, as so-called Lighthouse Projects. The following topics have been identified as being particularly significant:

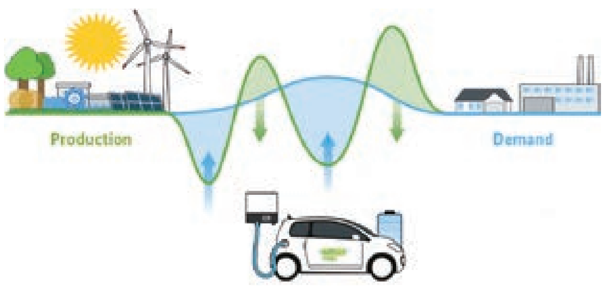
- Drive technology and lightweight construction
- Energy systems and energy storage
- Information and communication technology
- Charging infrastructure and grid integration
- Mobility concepts
- Recycling and resource efficiency

With the creation of Lighthouse Projects, the BMUB, in accordance with the government programme and the suggestions of the National Platform for Electric Mobility, supports the bundling of the resources of industry and science on such key topics, which contribute notably to the overall goal to develop Germany into the leading provider and leading market for electric mobility.

The selection of a project to be a Lighthouse Project should be considered a "seal of approval" for particularly important innovations, which make a significant contribution to technological progress or cost reduction in electric mobility. Additionally, the BMUB expects that the results of the selected projects will help to exploit the potential of positive environmental and climate effects of electric mobility particularly well. As such, Lighthouse Projects act as role models. Their activities are expected to have an impact not only on the regional but also on the national and international scientific community.

Various scientific institutions, numerous SMEs and large companies cooperate in the Lighthouse Projects. The application-oriented projects will help to harness the innovative potential of Germany's industry and researchers more effectively and swiftly. With their thematic focus and the integration of top-level research, the Lighthouse Projects are intended to garner high prestige for German industry and research. This makes the Lighthouse Projects highly useful strategically as well.

Currently, 15 projects have been awarded the "Lighthouse" seal of approval (http://www.erneuerbar-mobil.de/mediathek). Four of them came out of the BMUB's funding programme Renewably Mobile:



Focus: Charging infrastructure and grid integration

Lighthouse Project: Intelligent connection of electric vehicles to the grid in order to provide system services — INEES
The INEES project aims to integrate electric mobility in the electricity market in an intelligent way. It investigates how a pool of electric vehicles can provide operating reserves and other system services for the energy industry. An overall system developed for that purpose will be tested in a fleet trial with 20 vehicles (see page 46).

Lighthouse Project: Interoperable inductive charging — InterOp
An important prerequisite for unrestricted access to electric mobility is the interoperability of charging systems, in other words, that every electric vehicle can be charged at any charging unit completely automatically and efficiently. The InterOp project is developing such interoperable inductive charging systems for the street and the vehicle side and their functionality is being proven in a fleet trial in public and semi-public spaces (see page 60).

Focus: Mobility concepts

Lighthouse Project: Electric mobility for heavy commercial vehicles to reduce their environmental impact on densely populated areas — ENUBA 2
The main objective of the project is the development of a comprehensive road freight transport system based on electric, contact wire-based heavy goods vehicles. This is a promising approach to the necessary reduction of long-distance haulage CO_2 emissions (see page 30).

Focus: Recycling and resource efficiency

Lighthouse Project: Recycling of lithium-ion batteries — LithoRec II
The project focuses on the examination of the entire recycling process chain from battery and cell deactivation to battery disassembly and the grinding and separation of the individual material fractions. The translation of the developed procedures into a pilot plant represents an important step towards the financially viable recycling of lithium-ion traction batteries in Germany (see page 86). ■

What are the Showcase Projects for Electric Mobility?

The Federal Government, in coordination with the National Platform for Electric Mobility, has begun to set up regional Showcases for Electric Mobility to make it possible for the citizens to see and experience the full breadth of electric mobility. This way, an innovative programme was created, which connects the areas of energy supply, electric vehicles and traffic systems across different systems.

These regional Showcases function as proving grounds and research laboratories in order to find answers to as yet unresolved issues such as infrastructure requirements or user acceptance level. At the same time, they provide scope for experimentation, for demonstrating German technology expertise and putting it to the test, and for trying out regional implementation concepts and evaluating their practicability and environmental impact. The Showcases for Electric Mobility are an amalgamation of the commitment of industry, scientific research, public funding programmes and local communities to finding sustainable electric mobility solutions for Germany.

An expert jury selected large-scale regional demonstration and pilot projects that bundle and clearly demonstrate—also internationally—the most innovative elements of electric mobility at the point where energy system, vehicle and transport system meet as Showcases.

In April 2012, the Federal Government decided to fund the following four Showcases:

- Living Lab BW Electric Mobility (Baden-Württemberg)
- International Showcase Electric Mobility (Berlin/Brandenburg)
- We're Switching to Electric Horsepower (Lower Saxony)
- Elektric Mobility connects (Bavaria/Saxony)

The Government will provide a total of 180 million euros of public funding for the four Showcases; the BMUB will contribute 25 million euros to this sum. Additionally, the projects are co-financed by the participating companies and the federal states, so that the funding has a significant leverage effect. The BMUB funding priorities include the effects of electric mobility on climate and environment, as well as the coupling of electric vehicle use with renewable energies. For more detailed information, see:

http://schaufenster-elektromobilitaet.org/en/content/

schaufenster elektromobilität

Eine Initiative der Bundesregierung

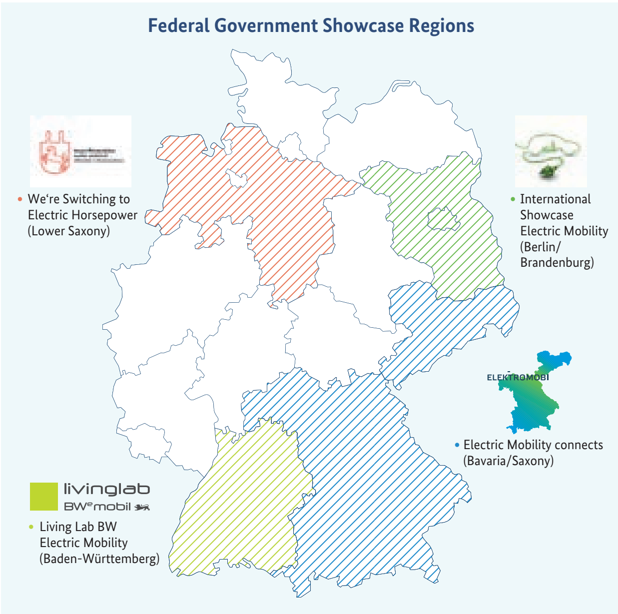
The Showcases in detail

Living Lab BW Electric Mobility (Baden-Württemberg)
As part of this Showcase Project, more than 2000 electric vehicles will be put on the road and more than 1000 charge points installed in the Stuttgart region and the city of Karlsruhe. More than 100 partners from industry, science and the public sector strive to test the technologies available today under day-to-day conditions and to develop feasible business models. A focus of the joint project is the integration of electric mobility in today's traffic system and the way we live.

International Showcase Electric Mobility (Berlin/Brandenburg)
This Showcase Project seeks to turn the capital city region into a place for the development, testing and implementation of electric mobility that is prominent beyond Germany. The focus on "driving, charging, storing and linking" represents the entire value creation chain of electric mobility. The topic "linking" plays an integral part in this. Transportation options such as local public mass transit or car sharing should be coordinated in an optimal way and connected to an intelligent electricity grid, which is primarily supplied with electricity from wind power plants in Brandenburg.

We're Switching to Electric Horsepower (Lower Saxony)
The Lighthouse Project is taking a holistic approach of electric mobility as a sustainable mobility concept for different user groups. In doing so, it is in line with the theme complex electric vehicle, energy system and traffic system. In the future, different industries should therefore work together more closely and technology transfer across industries should be increased. The legal framework should be developed further and adjusted to the new requirements. It is necessary to develop economically feasible mobility solutions in order to establish electric mobility successfully.

Electric Mobility connects (Bavaria/Saxony)
The federal states of Bavaria and Saxony illustrate that ELECTRIC MOBILITY CONNECTS in their joined Showcase Project Electric Mobility of the same name. The Showcase Project centres on the basic understanding that electric mobility represents far more than just an alternative propulsion technology. The projects can be subdivided into five sample foci: long-distance mobility, urban mobility, rural mobility, international connections, as well as education and continuing education. A strong industry, booming tourism and essential, international traffic hubs lead to a very high national and international prominence of the Showcase Project. ■



Results of the projects funded by the Stimulus Package II

Within the framework of the funding programme "Renewably Mobile" more than 100 companies and institutes will be supported with funding of about 250 million Euros in ambitious research and development projects (R&D projects) between 2009 and the end of 2016. The research findings from the projects on new charging methods and innovative vehicle concepts, which have already been completed, as well as the numerous electric vehicle fleets, are a testament to the programme's success. In order to tie in with these developments, the BMUB continues its funding programme for electric mobility uninterrupted. The supported projects, which are currently ongoing, are being presented in this brochure. Below, you will find an overview of what has been achieved in the first five key research topics so far.

Field tests electric mobility in car traffic
Extensive car traffic fleet trials were carried out in 12 projects. User survey and practical test results demonstrated that, in urban areas, electric mobility can already be designed in a way that makes it suitable for everyday use. Most of the participating users did not consider factors such as the limited range or charging times of pure electric vehicles as restrictive. Furthermore, the findings from the projects contributed to the development of affordable plug-in hybrid and electric vehicle concepts. The technical, economical and ecological effects of controlled charging were also examined in great detail. The project made it possible to improve the efficiency of the interaction between energy infrastructure and vehicle fleet. Wireless (inductive) charging was also an issue addressed by the funded projects. It was possible to develop procedures that achieve an efficiency rating of over 90 percent, compared to cabled (conductive) charging.

Field tests electric mobility in commercial traffic
Four projects focused on research into electric vehicles suitable for everyday use in a commercial environment under consideration of urban commercial traffic conditions. Besides the testing of electrified delivery vehicles in everyday operation, completely new vehicle concepts that take the requirements of distribution traffic and the particular properties of electric vehicles (range, charging times, charging spaces) into account were also developed and tested. The ENUBA project also focused on the development of a full, application-oriented contact wire-based HGV operating system for electricity powered road freight traffic. The feasibility of the whole concept, such as, for example, automated pantograph attachment and detachment or regenerative braking, which allows surplus electricity to be fed back into the grid, was demonstrated by means of operation on a test track. Another project, B-AGV, addressed the development and construction of battery electric heavy goods vehicles for transporting containers in commercial ports. A completely new kind of station was developed for the changing and charging of the huge batteries. The overall system was tested successfully in the port of Hamburg.

Hybrid buses for environmentally friendly public transport
A total of 50 hybrid buses was integrated into the regular scheduled bus services of 12 transport providers. The funding was linked to strict compliance with stringent environmental requirements in order to establish high environmental standards right from the outset, at the point of market launch. For example, the hybrid buses had to demonstrate an efficiency improvement of at least 20 percent compared to similar diesel buses as well as compliance with stringent noise and air pollution standards. They also had to have a closed-flow diesel particulate filter system fitted. A comprehensive accompanying programme verified compliance with various environmental criteria and monitored the efficiency and technical reliability of the hybrid buses during the commissioning phase.

BMUB electric mobility R&D project partners

Resource availability and recycling
The objective of the two projects carried out in this context, LiBRi and LithoRec, was the development and testing of recycling technologies for the lithium-ion batteries of electric vehicles. Both of the joint projects pursued a comprehensive approach—albeit with the focus on entirely different key aspects—that took the entire life cycle, from recycling-oriented initial design to technological processes, disassembly, material processing and metallurgical recovery as well as various recycling concepts into account. LithoRec included the development of a hydrometallurgical process that allowed the recovery of 85 to 95 percent of the lithium from the separated cathode material. The LiBRi project included the development of procedures for the disassembly and pretreatment of battery cells to make them safe for further processing and allow their introduction into existing pyrometallurgical processes—and therefore the recycling of essential raw materials such as nickel or cobalt. On the basis of experiments carried out on a laboratory or pilot plant scale, both projects also showed positive eco-balance results.

Accompanying scientific research
Several interdisciplinary research projects evaluated the ecological and economic effects of electric mobility in more detail. These projects also produced the first comprehensive analysis of the impact that an electric mobility system would have on emissions. In this respect, the interaction between vehicles that need electric power and the power plant fleet that is generating the current renewable and conventional energy mix played an important role. The microeffects at vehicle level were also examined in more detail, particularly which drive type and what form of usage is likely to be the most efficient, as well as the impact the various electric mobility development paths are likely to have on growth and employment. ■

Further project information and result reports:
www.erneuerbar-mobil.de/projekte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1 Funding priorities and projects
Effects of electric mobility on climate and environment

Provided they use electricity generated from renewable energy sources, electric vehicles could potentially significantly lower road traffic carbon emissions and their impact on local environments. Field tests in the areas of individual passenger as well as commercial transport provided important insights into the potential environmental benefits, technical maturity and user acceptance. These findings have made a major contribution to a targeted further development of the technology. The funding focuses on field testing various vehicle types such as pure electric vehicles or plug-in hybrid vehicles in everyday conditions. Besides insights into their impact on environment and climate, detailed information regarding user behaviour and preferences is also important in order to develop potential incentive measures and business models that serve the acceleration of market development. The project also entails accompanying research on the economical and ecological factors of electric mobility under consideration of the entire vehicle life cycle.

The funding is therefore used to focus on the following topics

- calculation of the energy required by electric and plug-in hybrid vehicles when in everyday use, in particular taking seasonal aspects into account,
- calculation of the annual electrically powered and combustion engine driven ratio of plug-in hybrid and range extender vehicles and the respective resultant CO_2 emissions,
- examination of various optimisation paths with regard to carbon emissions, energy efficiency and resource requirements (for example light construction),
- assessment of electric or plug-in hybrid drive user acceptance levels in terms of their everyday use,
- assessment of user preferences for the development of potential inventive measures,
- carbon footprint of different vehicle types and usage scenarios under consideration of the entire life cycle (Life-Cycle-Assessment LCA).

Joint project
Electric mobility for heavy commercial vehicles to reduce their environmental impact on densely populated areas – ENUBA 2

Project partners
Siemens AG, Munich
TU Dresden, Faculty of Transportation and Traffic Sciences

Duration
May 1, 2012 – December 31, 2014

ENUBA 2

Freight transport also has to contribute to achieving the target reduction levels for CO_2 emissions produced by the traffic sector, particularly in view of the fact that the levels of traffic related to freight transport are expected to grow considerably. Furthermore, a significant proportion of the local pollution (NOx, particulates, noise) in densely populated areas is caused by heavy goods vehicles. Improving the efficiency of combustion engines, increasing reliance on rail transport (existing rail network would require extensive expansion) or the use of biofuels (limited availability) are important building blocks, but they will not suffice to reduce emissions to the necessary extent.

These considerations were the starting point for the ENUBA project. A comprehensive concept for the use of electric power in road freight transport systems had been developed by September 2011, and various functional models or prototypes of central components and partial systems have been tested. Within the scope of the project, initial practical trials were carried out on a test track, and the technical feasibility of the concept was demonstrated: Electrically powered long-distance road freight transport with diesel-electric hybrid vehicles which obtain the electric power they need from an overhead wire is technically feasible and also makes economic as well as ecological sense. From May 2012 to April 2014, Siemens AG will be carrying out the follow-on project ENUBA 2 in cooperation with commercial vehicle manufacturers and the TU Dresden as joint accompanying research partners. The ENUBA technology is characterised by the integration of a comprehensive electrical system consisting of infrastructure, vehicles and management technology into an existing form of road transport whose routes, vehicles and traffic management technology must in turn meet specific requirements in order to ensure efficient road transport.

1 – Effects of electric mobility on climate and environment

The main objective of the joint project ENUBA 2 is the development of a comprehensive electrical, contact wire-based system for heavy goods vehicles suitable for long-distance use, as well as the exploration of concepts for other commercial vehicle classes. Provided energy from renewable sources is used, this can make a significant contribution to the reduction of traffic-related CO_2 and pollutant emissions. The R&D work focuses on the vehicle technology including pantograph, the overhead wire system and the energy supply, as well as the requisite infrastructure. The accompanying research addresses the analysis of all important traffic and energy related, ecological, economic and legal aspects relevant for the system's subsequent use in public spaces. In order to examine the functionality and reliability of the new vehicle and infrastructure systems, an articulated lorry will be equipped with the respective systems and thoroughly tested on a test track in a realistic test environment.

The ENUBA 2 project, which is also a Federal Government Lighthouse Project in the area of 'mobility concepts', aims to continue the testing and assessment of an innovative, eco-oriented road freight transport concept, thereby contributing considerably to the reduction of traffic-related emissions. ■

Joint project
Development of a battery-driven terminal truck and field test in a major German container handling environment – Terminal Truck

Project partners
Terex MHPS GmbH, Düsseldorf
HHLA Container-Terminal Altenwerder GmbH, Hamburg
Institute for Energy and Environmental Research (IFEU), Heidelberg
REFU Elektronik GmbH, Pfullingen
Hermann Paus Maschinenfabrik GmbH, Emsbüren
Neuss Trimodal GmbH, Neuss

Duration
June 1, 2012 – August 31, 2015

Terminal Truck

Germany's sea and river ports handle over 15 million TEU (1 TEU = 20-foot ISO container) a year. Heavy goods vehicles are employed to move each of these containers around the port area. Around the world, the most commonly used towing vehicles are special HGVs called terminal trucks. As these vehicles are currently diesel-fuelled, they are responsible for most of the pollutant and noise emissions in ports.

The Terminal Truck project, which involved five industrial partners and one environment institute, therefore focused on the development of a battery-electric terminal truck, including practical tests with a prototype in two German container terminals. Two such prototypes were developed, one where the traction battery is integrated into the truck and one where the battery is integrated into the trailer. As truck and trailer are frequentlyseparate, depending on the container transport method employed and the limited amount of space available in the actual truck, lithium-ion batteries had to be used for this version. The version with the battery integrated in the trailer relied on a lead-acid battery. Another focus of the trailer-based work is the development of a concept for an electric power train without torque converter transmission. The engine therefore has to cope with a wide rpm range, and electric engine and transmission combinations that can do so must be identified. At the same time, suitable concepts and strategies for the charging and / or changing of the traction batteries are being developed and tested.

Subsequent to the development and construction of the battery-electric prototypes, vehicle typical performance data as well as consumption and emission values will be evaluated in a field test under realistic conditions and compared with the respective properties of diesel-driven vehicles. The user acceptance level in terms of handling, performance, operational safety and reliability will also be assessed. Upon completion, the field test should supply the technical specifications that are a necessary

precondition for the market launch of sizeable vehicle fleets. At the same time, the environmental benefits of battery-electric power trains are evaluated within the scope of a comprehensive accompanying ecological research project.

A successful completion of the project would mean the potential realisation of the following advantages: Lower terminal truck energy costs (over 50 percent less compared to the standard electricity and diesel prices paid by the terminal operators), lower maintenance and repair costs, zero local pollutant emissions, significant reduction of acoustic emissions and reduction of CO_2 emissions along the entire emissions chain.

Assuming positive project results and economic viability, all existing diesel-powered port vehicles are to be successively replaced.

Beyond the use in commercial ports, the successful conclusion of this project with a respectively high cost savings potential as well as reduced exhaust and acoustic emissions also offers major scope for multiplication. For example, the project results can contribute to the electrification of other heavy goods vehicles used in further industries. The findings regarding driving performance, range, battery lifetime and environmental impact could also lead to a widespread use of battery-electric drives in series-produced vehicles. ■

Project
Reducing carbon emissions through the use of electric vehicles in commercial vehicle fleets – Ecargo

Project management
Volkswagen AG, Wolfsburg

Duration
October 1, 2012 – December 31, 2014

Ecargo

Many commercial enterprises and public institutions depend on large vehicle fleets. How these may be operated in a way that is economically viable as well as ecologically sustainable is an issue increasingly focused on. Particularly in view of rising fuel prices and also increasingly stringent ecological restrictions with regard to transport in inner city areas, alternative drive concepts could turn out to be a decisive factor in the long term when it comes to the economic success of companies in a competitive environment.

For several years now, the Volkswagen Group has included commercial vehicles in its focused research in the area of electric mobility. This has led to the development of an electricity-powered vehicle on the basis of the current Caddy, whose technical realisation was analysed in a previous research project supported by the BMUB. The current research project is based on the respective results. The investigations focus on the potential CO_2 reductions.

The overall result aims to show that particularly the use of commercial electric traction based vehicles in inner city areas can represent a high added value for companies and public institutions. Besides reduced carbon emissions, this additional value is to be represented by lower running costs.

The first part of the Ecargo project entails equipping 40 VW Caddys that feature the latest technology with an electric drive and subsequently carrying out an extensive fleet test. In this case, the fleet test, which is to run over a period of one year, will be carried out by users in various industries; the users will change every three months. More specifically, the users are to include companies that supply logistics, airport traffic, energy supply, catering, or reading services, as well as municipal utilities and transport operators, local police forces and communities. The scientific research accompanying the fleet trial will examine the potential for reducing CO_2 emissions in this way as well as noiseless vehicle opera-

tion in inner city areas, and also carry out an entire vehicle life cycle assessment (LCA). In addition, the project is expected to furnish insights into the user requirements in the various fields of application, and also into the vehicles' energy requirements.

The second part of the project deals with a commercial plug-in hybrid vehicle (PHEV) based concept. A plug-in hybrid power train is to be integrated into a VW Transporter. A complimentary concept for a vehicle that will be a sensible addition to an overall logistics concept will be designed on the basis of PHEV technology. Here, the focus will be placed particularly on construction issues and load capacity specifications such as, for example, the integration of the motor into the structure of the available space, and on what users require from a plug-in delivery vehicle. The aim is to demonstrate that efficient urban processes, as well as long-distance logistics processes that rely on electricity-powered commercial vehicles, are possible. For this purpose, the vehicle will be fundamentally redesigned. Subsequently, two vehicles will be constructed for test purposes and tested for six months in commercial applications within the VW Group. In the long term, the findings from this project can be used to adapt future electric commercial vehicle concepts to the individual requirements of various user groups in order to reduce emissions as well as costs. ■

Joint project
The impact of electric car sharing systems on urban mobility and environments – WiMobil

Project partners
BMW AG, Munich
DB Rent GmbH, Frankfurt am Main
DLR e.V. – Institute of Transport Research, Berlin
Universität der Bundeswehr München (the university of the German armed forces in Munich), Neubiberg
Berlin state government, Senate Department for Urban Development and Environment
City of Munich, Department of Public Order

Duration
September 1, 2012–August 31, 2015

WiMobil

In the past few years, 'new car sharing concepts' and 'electric mobility' have been the two main fields of innovation in the area of transport. They are the first step towards energy-efficient and emission-free mobility services in densely populated areas. The use of electric vehicles in flexible car sharing systems significantly lowers the car sharing users' threshold with regard to using an electric vehicle for the first time; in principle, this could work for 'everyone'. However, there are currently few scientific insights into the impact of electric vehicle car sharing systems, or rather the new, fully flexible car sharing systems, on mobility patterns on the one hand and the environment on the other.

The research project WiMobil focuses on the identification and quantification of the impact of electric vehicle car sharing systems on mobility patterns, traffic and environment. Three different methods are employed for this: The first entails the filing of vehicle usage data from a fully flexible and station-linked car sharing system in a central database (back end). The user data, such as collection and drop off locations, booking times or distances travelled, collected in this car sharing back end allows the identification of mobility patterns. The second entails user-related research away from the car sharing vehicles. Selected respondents record their daily journeys with a smartphone app and a GPS logger. This mobility tracking furnished exact information on daily journeys, the respective mode of transport chosen and also journey destinations. And the third entails direct customer interviews by means of an online questionnaire. This again features questions about the journeys they have made, as well as questions about general topics such as their personal mobility behaviour. It also takes socio-demographic data into account.

Additional tasks are the definition of typical user group characteristics and the computation of scenario-based forecasts of the effects of electric car sharing on the environment, public car parking facilities and the level

of motorisation. The two partner cities, Berlin and Munich, will examine and evaluate the results from a community perspective. The City of Munich's Department for Public Order is investigating the levers available to local communities when it comes to designing and steering the local use of car sharing and is currently drafting a respective field manual. The state government of Berlin is investigating the effects on urban parking facilities.

As the scientific partner, the DLR is responsible for concept design and data collection realisation. The Universität der Bundeswehr München (the university of the German armed forces in Munich) analyses the back end data, evaluates the total data collected with the various tools and carries out the computations. The industry partners BMW and DB Rent are contributing two different car sharing systems to the project. DriveNow stands for a new, flexible form of car sharing with the option of one-way journeys. Flinkster, on the other hand, is a classic, station-linked car sharing service. The two car sharing systems can be compared in order to research the respective electric mobility relevant effects. The field tests regarding user behaviour are being carried out in Berlin and Munich; the first data collection wave in Munich does not include any electric vehicles at all as this also allows the short-term effects of the introduction of electric vehicles to conventional car sharing fleets to be investigated. The outcome will be future electrified, flexible and station-linked car sharing concepts as well as hybrid solutions better suited to user requirements that will be integrated into urban transport infrastructures as a climate-friendly form of transport. ■

Project
Innovative drive concept for a plug-in hybrid with performance requirements of the premium car segment – Plug-In Hybrid

Project management
Volkswagen AG, Wolfsburg

Duration
January 1, 2014 – December 31, 2016

Plug-In Hybrid

Although purely electric vehicles can cover the average distances people drive, they are nonetheless perceived by the public as having a reduced range (150 kilometres per battery charge, for example) compared to vehicles powered by internal combustion engines. Due to this issue, more and more manufacturers are launching plug-in hybrid vehicles. By combining the electric propulsion system with an internal combustion engine, they combine the advantages of zero emission transportation over short distances with the option of a longer range.

Hybrid technologies have already been developed and tested in the past. In the area of plug-in technologies, the first vehicles are being integrated into the market as well. Essentially, there are two types of plug-in drive configurations. Parallel hybrids use either the combustion engine or a powerful electric motor in combination with a battery to power the vehicle. This has the advantage that both components can be less powerful because they can power the car simultaneously and thus complement each other. On the other hand, this design requires a transmission, which generates additional cost.

An alternative to this are series hybrid concepts. In this design, two electric motors are combined with a combustion engine. One electric motor acts as a generator and one as the actual motor that moves the car. The generator is powered by a combustion engine and provides the electricity for the main motor or charges the traction battery. It no longer has any mechanical connection to the actual drive shaft. This design does not require an elaborate transmission. However, the "daisy-chained" components usually also make this design less efficient than parallel hybrids.

The overall goal of the plug-in hybrid project is to investigate the potential of plug-in hybrid technologies for high performance vehicles in the premium car segment.

The technical limits need to be investigated and a sustainable concept for a plug-in hybrid power train that combines the advantages of parallel and series hybrid propulsion concepts needs to be developed. The new propulsion concept will also require the development of new vehicle and operation strategies and their implementation in a new drive control unit.

After the development of the components, a research vehicle based on the Audi A7 will be built, which can then be operated in a representative drive profile in order to gain practical experience in real-world vehicle operation. A significant component of the project is the investigation of the potential for the reduction of CO_2-emissions of the plug-in hybrid technology for vehicles with high system performance requirements.

In the long term, the findings and results of the project are to be used to take specific solutions to the production stage on the component level, which will combine the performance requirements and space restrictions in the premium vehicle segment. In doing so, both lowering emissions as well as a feasible cost level are a focus of considerations. The results can also help to prepare the development and introduction of production in series by juxtaposing the user requirements and product qualities of the vehicles. ■

Project
Making range extender concepts customer-oriented and affordable, and their everyday use as efficient as possible

Project management
Daimler AG, Stuttgart

Duration
October 1, 2012 – March 15, 2015

Customer-oriented range extenders

Vehicles with range extenders combine the advantage of emission-free local journeys with the comfort of an extended range. A relatively compact combustion engine, compared to those in conventional vehicles, augments the battery when it is low on power to ensure continued electricity-powered driving. In view of the fact that the quality and quantity of the energy storage capacities available for this purpose are not yet adequate, the planned development represents an important milestone with regard to the sensible and practical use of energy-efficient, low-emission vehicles both in urban as well as rural environments. Consequently, we could soon see electric vehicles that are not subject to a restricted range on our roads. Our traffic-related carbon and other pollutant emissions would be reduced. This would contribute to improving our quality of life, particularly in urban areas. However, vehicles with range extenders are currently still very expensive. The question is, what ranges do we really need to satisfy everyday requirements and what technical equipment (for example dimensions of the energy storage device, engine capacity) and concept is therefore truly necessary. The average German commuter travels around 30 kilometres a day, for example; the kilometres travelled per day are just as few in many commercial fleets.

The primary objective of the customer-oriented range extender concepts is therefore the improvement of individual mobility, to be achieved by means of a sustainable, affordable and technically mature vehicle concept to reduce urban pollutant and noise emissions. On the basis of previous respective work carried out by the Daimler AG, the project focuses on the development of a concept suitable for everyday use that provides an extended range compared to pure electric vehicles in addition to the use as ZEV (Zero Emission Vehicle).

Taking the previous range extender project carried out within the scope of the second Stimulus Package one step further, the current project examines the optimi-

sation of the vehicle components in more detail from the perspective of 'Optimum usability at affordable system cost'. Another issue is the necessary revision of the operating strategy of the range extender concept that is to be developed. In the course of this project, the functional but relatively expensive previous solution is to be developed further into a customer-oriented solution. A fundamental prerequisite for this is the identification of customer behaviour, which is accomplished through usability studies carried out in realistic conditions and involving customers with driving patterns that are as varied as possible. This allows the components to be developed in accordance with the needs of the so-called 95 percent customer.

The outcome of the project is to be the development of customer-oriented range extender concepts that meet ecological and economical customer requirements in the best possible way. The project therefore evidently contributes to ensuring the future competitive capabilities of the German automotive and automotive supplier industries. Furthermore, in Germany, the development and demonstration of the range extender concept is also of strategic importance for the further development of battery electric vehicles with a high level of user acceptance. ■

Project
Commuting and charging in Berlin – E-Berlin

Project management
AUDI AG, Ingolstadt

Duration
November 1, 2012 – September 30, 2014

E-Berlin

The use of electrified vehicles in urban areas harbours one of the biggest challenges of electric mobility. Although the use of low-emission electric vehicles would have the most positive impact in densely populated areas, the respective empirical values are currently insufficient. In order to broaden the extent of these findings, the project E-Berlin focuses on the testing of range extender vehicles by urban commuters in Berlin. The vehicles are made available to the respondents for a period of one year. The respondents work or live in the Quartier Potsdamer Platz in Berlin Mitte, the city centre.

The 24 range extender vehicles used in this study are Audi A1 e-trons. The commuters are testing two different versions. The main differences between the two versions lie in the thermal management of the passenger compartment and in adapted stability programmes, and also in various vehicle components such as the high voltage battery, a different vehicle structure at the vehicle rear as well as a range extender with different battery ratings. The analysis of the field test data—such as, for example, the amount of electricity-powered driving and the amount of combustion engine powered driving, and the impact of the seasons on the vehicles' energy management over a longer period of time—will provide some idea of the direction the technical developments for an urban use scenario should take. The test drivers' comments on satisfaction level and driving performance, and insights into user behaviour patterns complete the findings thus gained. To ensure reliable usability, the vehicle service and maintenance concept is also being developed further.

The vehicles are used mainly for commuting to and from work. This calls for the establishment of a charging structure that allows battery charging both at home as well as in the immediate vicinity of the respective workplace. Another important objective of the project is therefore the examination of legal and practical issues

related to charging points installed on dedicated parking spaces. The following aspects must be considered in this context: Permits for the installation of charging points, the avoidance of excessive costs in the case of leased car parking spaces, lacking connections to the power supply or electricity meters, as well as the financial investments required. The detailed analysis of these points is expected to allow the timely identification and overcoming of potential barriers that may be encountered in the course of a future charging infrastructure installation, and to contribute to the smooth implementation of electric mobility in densely populated areas.

Besides the gaining of insights into user profiles and potential changes in travelling behaviour, and into the compatibility of the vehicles with everyday requirements, the impact of the project's third focus, what are the potential non-monetary incentives, is also being examined. They are one way of making electric driving more attractive in future, and may support the market launch of such vehicles. Possible incentives are being allowed to use the bus lanes, or reduced car parking charges in special parking spaces designated as such in the inner city areas. The project is to include an assessment as to whether these privileges would be used in practice, and whether the respondents would actually consider them an added value. ■

2 Funding priorities and projects
Coupling to renewable energies and grid integration

The upstream value chain of energy impacts significantly on the carbon footprint of electric vehicles. Electric vehicles will certainly not be able to contribute to climate protection to the extent they could until the electricity used to power them is produced by renewable energy sources. At the same time, electric vehicles have an increasingly important role to play in the integration of fluctuating energies into the power grid. Used in large numbers, they can contribute significantly to power grid stabilisation by being available as a so-called shiftable load. That means that surplus energy which becomes available suddenly, for example when it is very windy, can be stored in the vehicle batteries.

In addition, electricity can also be fed back into the power grid as and when required. The funding hopes to contribute to the development of reliable methods to achieve this. In addition, further insights into inductive (wireless) charging are to be gained, including practical results, as successfully increasing the time the vehicles spend connected to the grid would make a flexible grid integration easier. Accompanying research activities are aimed at supplying additional insights into the economical and ecological aspects of charging procedures, customer needs and effects on the grid.

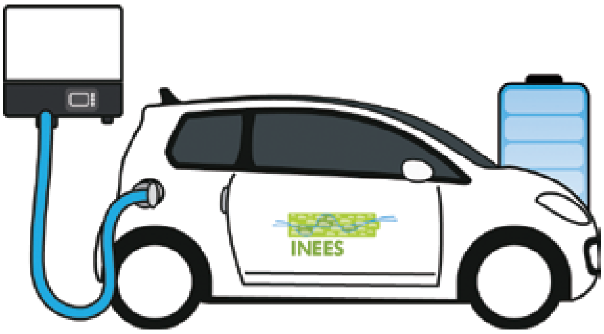
The funding is therefore used to focus on the following topics

- further development and testing of methods for coupling the use of electric mobility to the use of renewable energies,
- further development and testing of procedures for controlled charging and feedback of electric energy into the power grid,
- development and testing of wireless charging methods,
- fleet tests to validate the improved use of regenerative energy sources through the use of wireless charging in (semi-)public spaces,
- economic and ecological comparison of inductive and conductive charging, including potential business models,
- development of business models under consideration of ecological aspects such as controlled charging and the provision of energy supply services,
- analysis of controlled and wireless charging method grid impact and investigation of customer acceptance.

Joint project
Intelligent connection of electric vehicles to the grid in order to provide system services – INEES

Project partners
Volkswagen AG, Wolfsburg
LichtBlick SE, Hamburg
SMA Solar Technology AG, Niestetal
Fraunhofer Institute for Wind Energy and Energy System Technology, Kassel

Duration
June 1, 2012–May 31, 2015

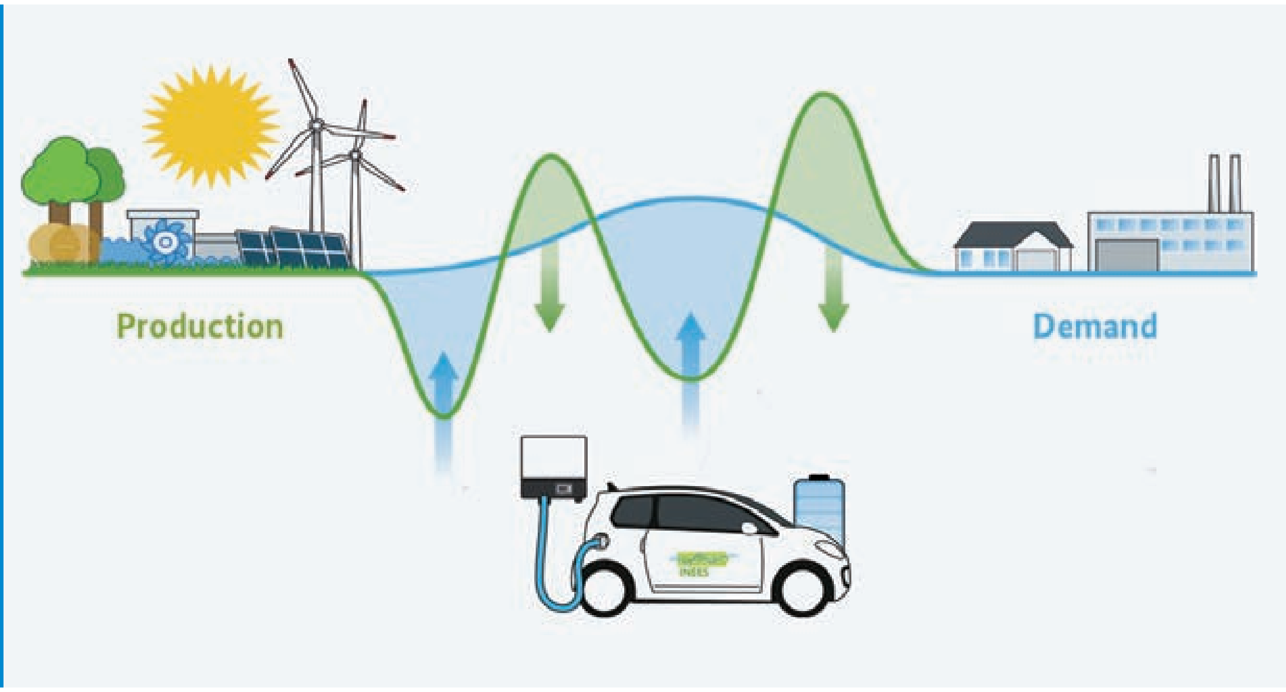


INEES

Balancing the power in the grid ensures that electricity consumers are supplied with precisely the amount of power they require, independent of the current load capacity and despite unforeseen events. Electric vehicles could store peak load electricity in their batteries and also feed it back into the grid. If they were linked to the balancing power market, they could therefore contribute to the stabilisation of the grid. Furthermore, this would generate income from the electricity market that could help to lower the cost of electric mobility, thereby making electric driving more attractive.

The objectives of the INEES project are the demonstration and testing of the technical and economical feasibility of a centrally managed electric vehicle pool participating in the balancing power market. A field test is to be carried out within the scope of the project in order to examine the respective technologies (bidirectional charging stations, communication infrastructure and battery-electric vehicles) and the associated business transactions and energy management benefits with the aim of arriving at conclusions regarding commercial viability and requisite framework conditions.

The overall system for the supply and marketing of balancing power from a pool of electric vehicles includes innovative components and processes, to be developed within the scope of INEES. In terms of the infrastructure, a three-phase, bidirectional DC charging station with a 10 kilowatt output suitable for commercial and home use will be constructed to allow rapid vehicle charging as well as the feeding in of stored energy into the grid (bidirectional connection). The electric vehicle pool will be directly accessed by means of a pool manager, as yet to be developed. This IT system will process the management signals from the grid operator and transmit the respective load request to the vehicles whilst ensuring that the balancing power contributed by the vehicles equals the supply on the balancing power market at all times yet also meets the vehicle users' mobility



requirements. This requires information interfaces involving both the pool manager as well as the vehicles and their users: The pool manager communicates the grid's power requirements to the vehicles via the vehicle interface and also exchanges vehicle-specific parameters. The user interface, on the other hand, serves the collection of data regarding the availability of surplus battery capacity for the supply of balancing power, taking the planned vehicle usage into account, and passes it on to the pool manager.

However, the balancing power market can only benefit effectively from these vehicles if the users share usage information, in particular details of when they plan to set off on their next journey and this journey's distance. To motivate them to do so, the user interface must be designed as user-friendly as possible. On the other hand, each user is given a financial incentive to make the battery of their vehicle available for energy management purposes.

A respective incentive system is being developed within the scope of the project.

The entire system is being tested over twelve months in the form a fleet test with twenty VW e-up! vehicles. The test monitors the functionality of the technologies and the energy management related business processes as well as the level of user acceptance. The accompanying research examines the impact of the pool operation on distribution networks. Final conclusions regarding mass market suitability, in particular also financial viability, as well as recommendations on balancing adaptation and standardisation, will be formulated on the basis of the experiences gained in the course of fleet operation and the results of the accompanying research. ■

Joint project
Real world test of the Energy Reforms – Smart-E

Project partners
RWE Effizienz GmbH, Dortmund
Energiebau Solarstromsysteme GmbH, Cologne
HOPPECKE Batterien GmbH & Co. KG, Brilon-Hoppecke
TU Dortmund University

Duration
May 1, 2013–October 31, 2015

Smart-E

Aside from the potential to enable zero-emissions mobility, electric mobility coupled with renewable energy sources offers the possibility to use intelligent charging systems to store peak load electricity from renewable sources at times when there is less demand. That requires an intelligent and efficient integration of electric vehicles into the electricity grid and the electricity market. Previous projects primarily investigated only technical aspects and functionalities for this.

As part of the research project Smart-E business models along the entire energy industry value chain are being developed and investigated bearing economic, energy law and regulatory aspects in mind. All steps of the process from power generation, transport, marketing and feeding power into the grid, to supply and billing are taken into account. The business models, which are to be developed, should combine privately used electric vehicles, decentralized power plants and stationary storage solutions with pay scale incentives and innovative products. For these pre-commercial business models, an intelligent charging system for the e-vehicles plays just as central a role as their combination with an optimisation of their own power consumption (in accordance with the wishes of the customers). Consequently, the goal is to develop pre-competition and mass-market-suitable business models for various market roles, some of which already function under the current regulatory conditions, while others will still require adjustments. So the objective is to identify, integrate and evaluate both economically as well as in terms of energy law those services that, given the current regulatory requirements, would be necessary for an electric mobility that is suitable for the mass market.

The business models, which are developed, will be tested in an 18-month field trial. To do so, no more than ten selected households will be equipped with photovoltaic systems or optionally with micro combined heat and power (micro-CHP) systems, energy storage systems and

Smart-Home-Packages. Additionally, the test households will be given an electric car with fast charging capability and a corresponding 11-kilowatt charging box for the home for the duration of the field test. All these innovative technologies are controlled according to demand via an energy management system. This means that the energy management system constantly optimises the customer's energy consumption within the household based on current energy prices and/or user behaviour.

Plant operators, electricity traders and electricity suppliers, consumers, energy logisticians as well as distribution grid and test point operators participate in this project. Therefore, the overarching objective is to develop approaches for a product implementation, which does not look at the individual process stages in an isolated way but instead analyse the integration of the individual market partners under the real world energy industry regulation, economic and regulatory conditions at the corresponding interfaces and to test if an implementation is feasible. This takes place within the framework of the field test, which is intended to prove that the individual predefined business models will work in the real world. ■

Joint project
Grid integration of electric mobility and renewable electrical infeeders using an intelligent local grid station – NEmo

Project partners
University of Wuppertal (UW)
SAG GmbH, Dortmund
Bilfinger Mauell GmbH, Velbert

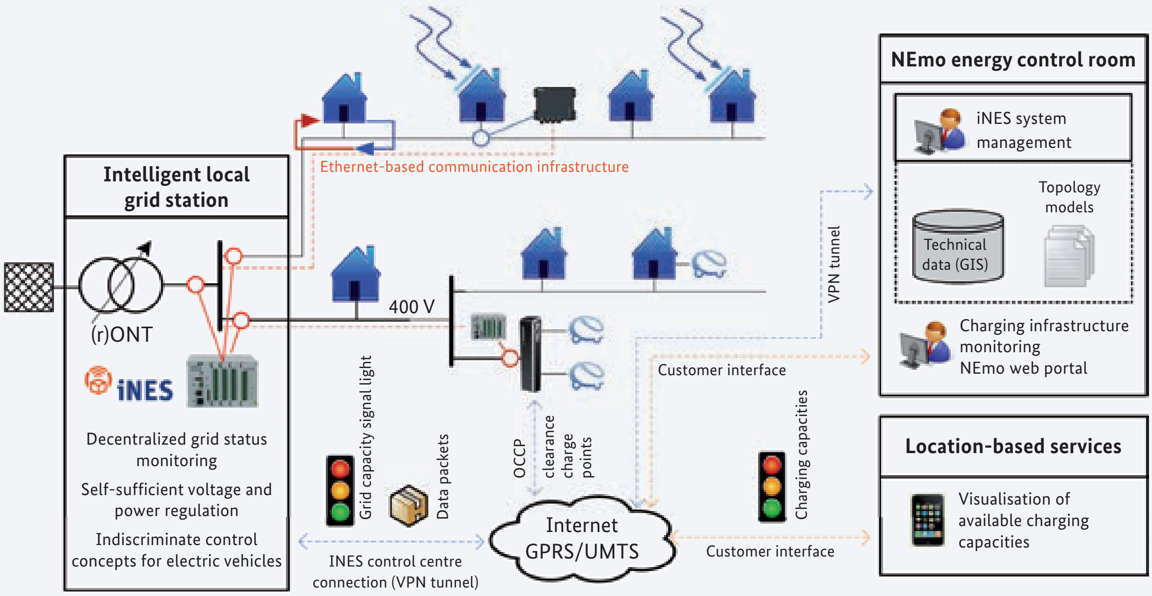
Duration
May 1, 2013–April 30, 2015

NEmo

Today's low voltage grids are not yet designed for heavy feeding of energy into the grid by decentralised energy sources (such as photovoltaic systems) or for connecting energy intensive consumers (such as electric vehicles). This can lead to temporary over-loading of the low voltage cables and so-called voltage range deviations, which, due to a lack of monitoring mechanisms, currently remain undetected and therefore also cannot be rectified. A grid expansion, which could also guarantee the transfer of these merely sporadically occurring high energy loads, would create significant cost. Intelligent monitoring and control systems, which can reliably locate and remedy the bottlenecks in the case of deviations, represent a sensible alternative in terms of cost efficiency.

For the implementation of such a system, controllable units in the grid are required. Due to their high charge capacity and the amounts of energy they require, electric vehicles are ideally suited to this purpose in technical terms. Controlling a charging station, however, can have significant consequences for the vehicle user since the charge time inevitably increases and the utilisability of the vehicle is thus impacted. In order to avoid discriminating individual users and to increase acceptance of such measures, special charging processes are therefore needed, which limit the negative effects to a minimum and distribute them fairly at the same time.

The objective of the project NEmo is the development and testing of an intelligent monitoring and control system for low voltage grids, which continually checks the state of the grid and locally and independently regulates the charging performance of electric vehicles from the local grid station, particularly in combination with decentralized power plants. An existing control algorithm serves as a basis. It is developed further to control the charging infrastructure and electric vehicles and complemented with a non-discriminatory charging concept. Furthermore, a special location-based service



Concept for an intelligent grid integration of electric vehicles

will be developed for consumers, which, among other things, will display the charging capacity available in the grid and can thus display the current utilisability of public charging stations.

Additionally, the automation system's operativeness will be verified in two test grids. The campus grid of the University of Wuppertal as well as the inner city grid of Wuppertal's municipal utility are available for that use. As a result, extensive practical experience can be gained in setting up intelligent monitoring and control systems for low voltage grids, which form the basis for an optimised grid integration of electric mobility in the future.

Four partners participate in the project. Apart from the overall project management, the University of Wuppertal is also responsible for the expansion of the calculation logic as well as the development and integration of the new charging processes. It will also conduct the two final field tests. Bilfinger Mauell GmbH in Velbert is responsible for determining and transferring the data, which is to be visualized for the location-based services and the adjustment of the existing hard and software to the newly developed extensions. SAG GmbH in Langen is in charge of data processing and the configuration of the test grids as well as adjustments to the facilities. As an associated partner, WSW Netz GmbH supports the implementation of the field test in their grid area. ■

Joint Project
Integration of electric mobility in smart grids – Well2Wheel

Project partners
HEAG Südhessische Energie AG (HSE), Darmstadt
Technische Universität Darmstadt
EUS GmbH, Holzwickede
Fraunhofer Institute for Structural Durability and System Reliability (LBF), Darmstadt
Frankfurt University of Applied Sciences

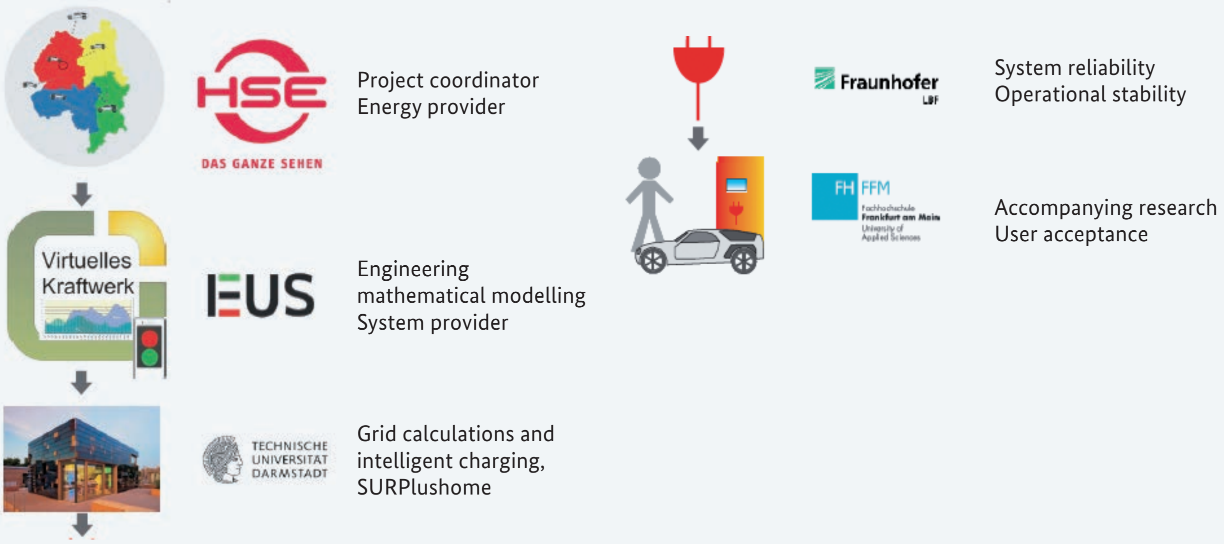
Duration
May 1, 2013–April 30, 2016

Well2Wheel

As renewable, fluctuating energies contribute an ever-growing share to the power generation, the demands on the electricity distribution grid, in terms of taking over system services for grid stabilization, grow as well. Aside from the traditional tools to control power generation and loads, energy storage in particular is gaining significant importance in this context. Electric vehicles can function as mobile storage units within the distribution grid and take over tasks related to voltage stability, service security and controlling power range. Prerequisite for this is the creation of an intelligent grid infrastructure for controlled charging of the vehicles.

The objective within the framework of the project Well2Wheel is to find a way to integrate electric mobility into the distribution grid as an active component and to control it beyond the limits of a grid operator. For this, we make use of existing infrastructure from the precursor project Web2Energy (virtual power plant, smart metre). As associated partners, the Chamber of Crafts Rhein-Main, the sanitation department of Darmstadt (EAD) and the Hessisches Immobilienmanagement (HI) (for the State Chancellery and the State Government of Hessen) contribute their electric vehicles to the project so that we have a fleet of 49 electric cars of various designs at our disposal. Specifically, they are 24 Opel Amperas, 2 Mitsubishi i-MiEVs, 6 Renault Kangoos, 7 eSmarts, one Nissan Leaf, 1 Tesla, 2 BMW i3s, 2 Govecs scooters as well as 4 Aixam Mega light lorries.

The focus of the project is on the technical integration of electric mobility in the virtual power plants of the distribution grid. For that purpose, an area of investigation was chosen, which is composed of five grid cells. A common communications standard for all grid cells will be established so that grid information about the optimal time to charge is accessible to the electric vehicle user without limitations.



Three different channels of information will be investigated more closely in the project: The direct communication with the vehicle, the communication with the charging point user via visual red-/green phases, and the communication with the vehicle user via text message and a web application. The project results contribute to improving the storage of short-term excess energy and to optimising the local consumption of regionally generated energy. As a result, the need for an expansion of the power grid can be reduced.

The real-world feasibility and user-friendliness of this approach will be investigated and improved, particularly for circular mobility, which means driving scenarios, where a driver always returns to his place of origin, as in the case of commuters. For that, a comprehensive user acceptance survey with about 100 participants will be conducted. Furthermore, the long-term wear and tear on charge points and charging devices due to mechanical, thermal and electrical stress will be investigated using modern sensor technology and a special testing setup. Additionally, the project has access to an energy efficiency house with integrated photovoltaics (The TU Darmstadt's surPLUShome). An electric mobility component will be added to that house. ■

Project website: www.well2wheel.de

Joint Project
Bringing together electric mobility and renewable energy for intelligent commercial traffic in rural areas through information and communication technologies – EMiLippe

Project partners
Kreis Lippe – the district administrator, Detmold
Phoenix Contact E-Mobility GmbH, Schieder-Schwalenberg
Herbert Kannegiesser GmbH, Vlotho
itelligence AG, Bielefeld

Duration
September 1, 2013–August 31, 2016

EMiLippe

The goal of the project is the development of an electric mobility system for commercial traffic in rural areas that makes optimal use of renewable energy. The concept considers the mobility requirements of companies with scattered facilities as well as associated companies that jointly use a vehicle fleet. Aside from industrial enterprises as the traditional "operators" of commercial traffic, other important stakeholders and network partners in the joint project are the public administration as well as research institutions.

The fleet of electric vehicles used for commercial traffic in rural regions should ideally be operated using self-generated renewable energy. That energy should come from the decentralized distribution grids (Micro-Grids) of the companies or optionally from regional utility companies.

The particular framework conditions of rural areas are more challenging in terms of availability of electric vehicles as well as the exchange of energy within the process chain from the power plants, and between them, all the way to the vehicles. On the basis of information and communication technologies (ICTs) a roaming concept will be developed, which is tailored to those requirements.

A control centre for the companies will be created to manage the vehicle fleets and flow of electricity. On the one hand, this control centre can record and optimise the different processes, on the other hand, it can serve the energy- and mobility requirements of the participating system partners. Due to the scalable design, the overall system for commercial traffic in rural areas becomes useable for different companies that operate jointly and for other networks of companies and public institutions with scattered sites.

The intelligent system will be connected to the infrastructure via products, which will be developed by the

participating companies. Those will be a renewable energy charge point (Phoenix Contact E-Mobility GmbH), an e-mobility energy parking space with renewable energy generation (Herbert Kannegiesser GmbH) and an electric car fleet and mobility management (itelligence AG). The mobility system, which will be newly-created from the prototypes of theses elements, will be tested and presented in a fleet test by the public institutions of the district Kreis Lippe, which is also in charge of the overall project coordination. Cost effectiveness, environmental impact and societal acceptance will be evaluated in study conducted alongside the project in order to explore impact and potentials for optimisation for commercial electric mobility in rural areas and to apply the findings to other regions. For accompanying research, technology development and to create test and demonstration systems, the project also includes the subcontractors Institute Industrial IT (inIT) of the Ostwestfalen-Lippe University of Applied Sciences, the Fraunhofer Application Center and the Ostwestfälisches Institut für innovative Technologien in der Automatisierungstechnik (OWITA GmbH).

Based on the findings and experiences of the project, especially the fleet test and the accompanying research, a legal and commercial manual will be created, which focuses on billing models. That manual will be another cornerstone to make the newly-developed system of commercial electric mobility transferrable from the representative regional background of Ostwestfalen-Lippe to other communities, regions and companies. ■

Joint project
The 3E-multi-family home –
own power generation, own consumption
and electric mobility – 3E MFH

Project partners
LichtBlick SE, Hamburg
ifeu – Institute for Energy and
Environmental Research, Heidelberg

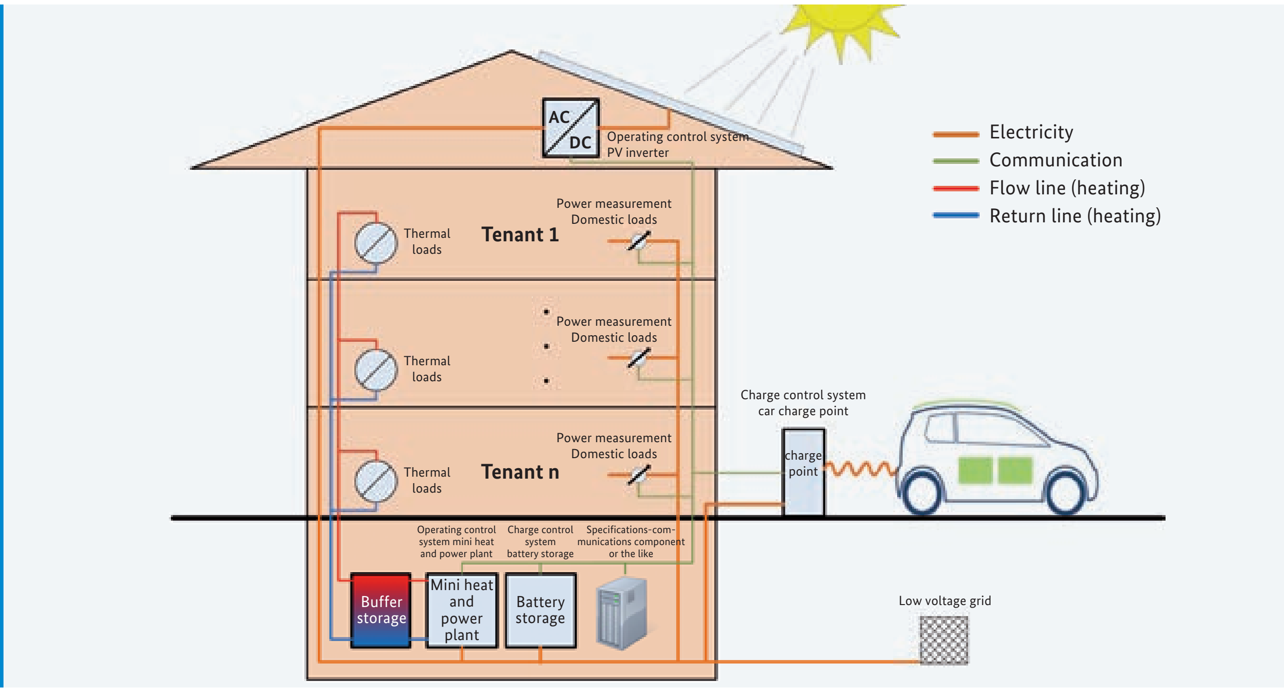
Duration
January 1, 2014 – December 31, 2016

3E MFH

Due to rising energy prices, generating your own electricity using photovoltaic systems and a combined heat and power plant are becoming economically more and more attractive for consumers. Even today, the bulk of new photovoltaic systems is installed for own consumption.

In the future, own consumption and electric mobility can be combined in a meaningful way. The system electric vehicle, charging infrastructure and power grid will be complemented with a local power plant. On the one hand, such a system–aside from optimising own power generation, own consumption and infeed–also has to consider mobility requirements. On the other hand, an intelligent way of charging creates the possibility to involve the vehicle battery as an additional, controllable consumer. Together, these components form a very flexible local system composed of decentralised power plants and storage.

Until now, to optimise such systems, research and development have focused on company car parks or single family homes. In the project 3E MFH, this complex decentralized energy system of the future is being tested in a multi-family home with a larger number of tenants for the first time. Photovoltaic systems as well as combined heat and power generation (mini heat and power plants or Mini-BHKW) will be used. Furthermore, a stationary storage battery will be installed, aside from the battery in the electric vehicle.
The project partner LichtBlick will integrate this overall system into the energy trade markets via the IT-platform SchwarmDirigent. This way, surplus power from the photovoltaic system, the BHKW and the batteries will be marketed in an optimal way. The procurement of additional electricity from the grid will also be optimised according to economic criteria. Via the product ZuhauseStrom, the tenants will be involved in the own consumption. The combination and energy economic optimization of an overall system composed of energy



providers and storage in a multi-family home can create incentives for investments in decentralised power plants, storage and electric mobility by offering attractive products and services. That way, the approach used in the project 3E MFH can contribute to accelerating the introduction of electric mobility in Germany if, thanks to their integration in the energy markets and the revenue generated as a result, the cost for the consumers can be reduced.

The project 3E MFH provides insights into a consumer-oriented configuration of energy-related products and services for the management of decentralised energy.

Furthermore, the project provides answers to ecological and energy business-related questions, which are investigated from the perspective of tenants, facility owners and pool operators. The yet unknown require-ments for charging the vehicle battery within the context of neighbourhood car sharing and the specific management of stationary energy storage solutions are being investigated as well.

The project partner ifeu will create an environmental performance evaluation of the system. Additionally, the relevance of this solution to the current and expected building stock will be investigated. More-over, it will be investigated if the system can be applied to single-family homes and what role it could play in a future energy system. ■

Joint Project
Smart parking solutions for parking
by the side of the road and at charge points
in the city of the future – City2.e 2.0

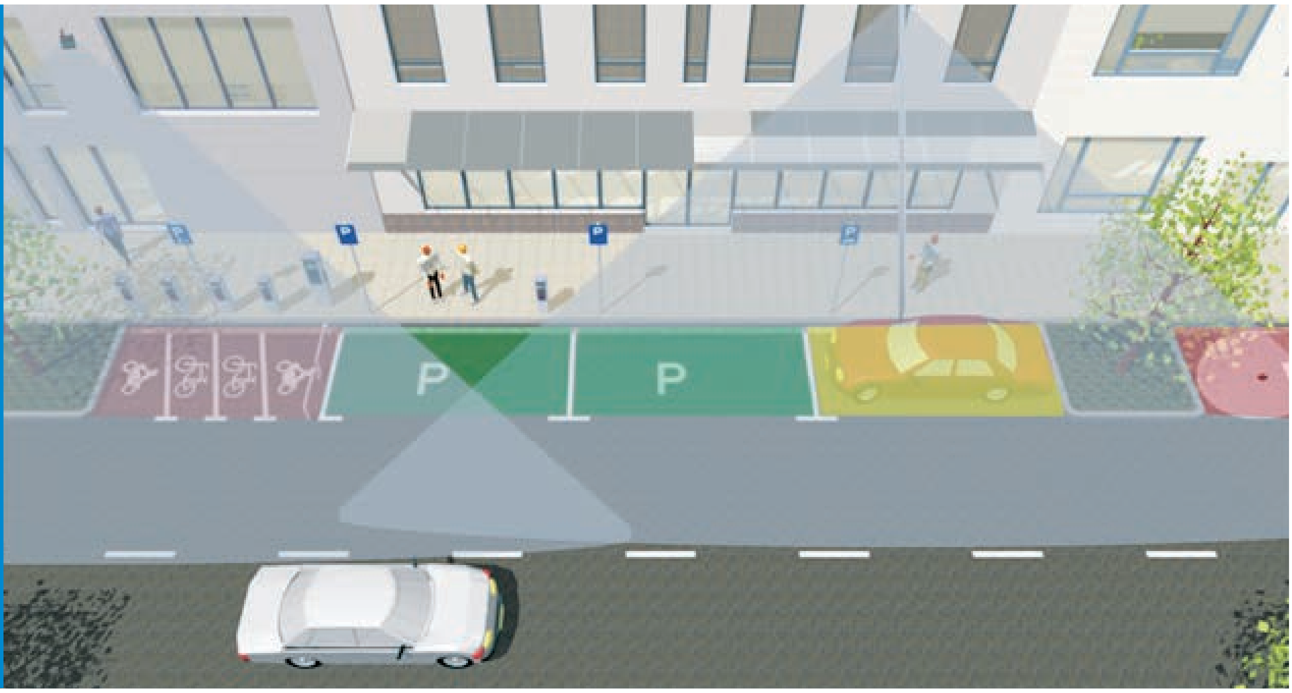
Project partners
Siemens AG, Berlin and Munich
Senate Department for Urban Development
and the Environment Berlin
VMZ Berlin Betreibergesellschaft mbH, Berlin
Institute for Climate Protection, Energy and Mobility-
Law, Economics and Policy (IKEM), Berlin
German Research Center for Artificial Intelligence
(DFKI), Kaiserslautern

Duration
January 1, 2014 – December 31, 2015

City2.e 2.0

A large part of the environmental pollution in urban areas is caused by motorised individual transport. The project City2.e 2.0 is therefore taking a holistic approach, which combines the successful expansion of electric mobility with a general reduction of traffic generated by the search for parking spaces, a more efficient use of the charging infrastructure capacity and an increased intermodality. One of the prerequisites for a broad acceptance of electric mobility is the establishment of a sufficient charging infrastructure in publicly accessible spaces. Furthermore, the driver always has to know the current availability of this infrastructure and its location in the city. The preceding project City2.e has shown that, due to the conduct of "kerbside parkers", a publicly accessible charging infrastructure can only be operated in an economically-viable way with significant subsidies. In order to increase the degree of capacity utilisation of the charge points, the parking period cannot exceed the charging period. Therefore an extended approach is necessary, which first and foremost includes the issues related to coordinating and controlling the parking and charging behaviour (reserving, finding/routing and paying). Furthermore, the numerous participating individual stakeholders (among them industry, operators, research institutions, utility companies and cities and municipalities) with their corresponding contributions have to be more closely tied into an overall system.

Smart parking solutions enable a demand-oriented use of the publicly available parking space by supporting a swift search for an available parking space and, if needed, one that is suitable for charging an electric car. Furthermore, smart parking solutions provide transparency in terms of parking space availability in the context of multimodal transportation. As a result, the traffic generated by the search for parking spaces will be reduced and the capacity utilisation of parking spaces and charge points optimised. The principal objective of the successor project City2.e 2.0 is the practical demonstration of an intelligent parking space monitoring and

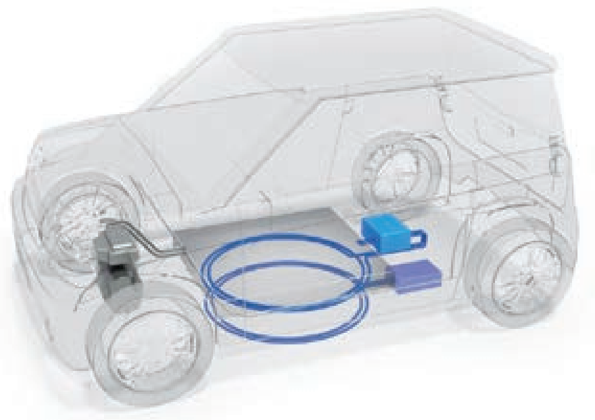


control system, which includes the parking spaces at charge points for electric vehicles in particular. This entails the development of a testing pattern for a powerful parking space detection as well as the development of a system architecture for the monitoring and control of the detected spaces. The focus will be on kerbside parking space and availability of charging infrastructure. The practical testing of the system will take place in Berlin's Steglitz and Friedenau-areas and will involve the Verkehrsinformationszentrale (VMZ) Berlin (the traffic information centre). By combining parking space sensor data, weather service information and self-learning models to develop individual operational profiles, it will be possible to better predict and control the demand for inner city parking and charging. The project also investigates the legal and economic framework conditions that are associated with this. Furthermore, an already existing mobility platform is to be expanded with multimodal services (car sharing, mass transit) as well as the integration of provider-independent smart routing to achieve better traffic coordination in large cities overall. ■

Joint project
Interoperable inductive charging – InterOp

Project partners
IPT Technology GmbH, Efringen-Kirchen
German E-Cars GmbH, Grebenstein
SEW-EURODRIVE GmbH & Co. KG, Bruchsal
Siemens AG, Munich
Paul Vahle GmbH & Co. KG, Kamen
E.ON New Build & Technology GmbH, Gelsenkirchen
DB FuhrparkService GmbH, Frankfurt am Main
StreetScooter GmbH, Aachen,
ifak Institut for Automation
und Kommunikation e.V., Magdeburg
EAI GmbH, Ilsenburg

Duration
November 1, 2012–October 31, 2015



InterOp

German commuters travel an average of 30 kilometres a day. The actual kilometres travelled per day are just as few in many commercial fleets and car sharing schemes. With ranges of up to 160 kilometres, electric cars already meet the majority of today's driving profiles without constant charging. The storage capacities of electric vehicle fleets are therefore available as a shiftable load for grid management. However, the precondition for this is controlled charging by means of connecting the vehicles to the internet and a charging infrastructure. The cars of the future will always and automatically be connected to the internet, thereby to the mobile communications network. If you want to ensure that vehicles are also automatically connected to the power grid, this requirement is best met through wireless charging.

The experiences gained in past fleet tests have shown that users tend to put off plug-in based charging until the last moment, or even sometimes to forget it entirely. Wireless charging, on the other hand, means that the vehicles are automatically connected to the grid, and are available as soon as they are parked. On average, this tends to be the case 23 hours a day. Even more intensively used car sharing or fleet vehicles still spend over 16 hours stationary. The operators of these vehicle fleets could benefit from offering grid stabilisation system services to the grid operators. The inductive charging of electric vehicles is therefore an important incentive for electric mobility.

If the majority of electric vehicles were charged by means of controlled charging, they could therefore contribute significantly to the stabilisation of the increasingly fluctuating loads supplied by power grids. Even the target figure of one million electric vehicles by 2020 could double Germany's entire pump storage capacity, providing the vehicles are available automatically, just like pump storage systems. In that case, the entire fleet would function as a virtual, decentralised storage power plant, from a network management perspective.

To allow the advantages of wireless charging to be used across the board, the use of all wireless charging points of all respectively equipped vehicles must be equally efficient and safe to use. This calls for charging point and vehicle interoperability. The project InterOp addresses this central task. The project partners can build on the experiences gained from three projects funded by the BMUB with the Stimulus Package II.

InterOp's main objectives are interoperability, safety and efficiency: Human and animal safety-critical events should be eliminated from all possible combinations of vehicles and charging points. In addition, the target of over 90 percent efficiency across the complete charging process and entire system should be reached. Although the principle of inductive energy transmission has been known for over 100 years, its application for electric cars in public spaces requires a fundamental redevelopment. As InterOp pursues mass market solutions, it strives for cost leadership from the outset and on each technology level. Wireless charging solutions can be expected to have a far greater cost reduction potential than cable-based solutions—not least through standardisation and automated mass production. Besides the above mentioned advantages, wireless charging offers freedom to the users (drivers); it is therefore decisive for the permanent introduction of electric mobility. ■

Joint project
Intelligent charging infrastructure and grid integration – INTELLAN

Project partners
BELECTRIC Solarkraftwerke GmbH, Kolitzheim
KISTERS AG, Gröbenzell
Elektrizitätswerk Mainbernheim GmbH, Mainbernheim
Lemonage Software GmbH, Dresden
Fraunhofer Institute for Solar Energy Systems ISE, Freiburg
Zittau/Görlitz University of Applied Sciences, Zittau
BELECTRIC Drive GmbH, Kitzingen

Duration
October 1, 2012–December 31, 2014

INTELLAN

The aim of the project is the development of an intelligent charging infrastructure that can be installed and easily operated anywhere. Such a network of charging stations should avoid a potential grid connection overload through intelligent local load management, and allow the integration of renewable energies. In this context, the focus is on the coordination of energy supply and demand. It is also connected to a building energy management system that involves other producers and consumers. Tests regarding the optimum use of locally produced regenerative energy in load management are being carried out at a solar carport with buffer battery.

Seven partners are involved in this joint project. BELECTRIC Solarkraftwerke GmbH manages the project and is responsible for developing the electrical and electronic engineering hardware, and will also develop the load management modes on the basis of their experience in the operation of electric systems. As the charging infrastructure supplier, BELECTRIC GmbH Drive will be developing the specifications, sales concepts and end customer pricing models for the charging current. BELECTRIC Drive hopes to couple photovoltaics with electric mobility to make eco-friendly mobility possible. The technical and economical feasibility of the applications developed will be tested in a municipal energy supplier environment at Mainbernheim power station. The power station will monitor the respective retroactions and how these impact on the electricity quality in low voltage grids. On the sales side, the company will design an easy to process billing concept for driving tariffs that makes it possible for energy customers to change between the company's own grid and other grids. These are to be supplied with a high proportion of power from renewable energy sources. The research carried out by the Fraunhofer Institute for Solar Energy Systems ISE creates the technical preconditions for an efficient and eco-friendly energy supply. In this project, the ISE develops and analyses innovative

communication and management concepts for electric vehicles and their interaction with building energy systems. KISTERS AG is developing the charging infrastructure's technology and commercial interface, which collects the charging data from the individual stations and makes it available to the linked billing system. KISTERS is also developing functions for the supply of balancing power and load management under consideration of the charging infrastructure's capacity potential.

Lemonage Software GmbH is developing the software for an embedded system that will be the basis for the charging cluster. Lemonage also supervises the linking of the other joint project partners' systems. Particularly important in this respect is the design of interfaces and new protocols that make it possible for the various systems to communicate with each other. The Zittau/Görlitz University of Applied Sciences is developing a design strategy for the integration and communication of charging boxes within a charging cluster with the aim of creating an economically realisable technical solution for larger charging clusters that is also capable of connection to non-local stations, similar to a network.

The results of the developed load management application are subsequently evaluated in terms of consumption optimisation, grid support and customer benefit by means of a fleet of electric vehicles. Various business models will be analysed in order to gain insights into the commercial aspects of charging infrastructures. ■

Project website: www.intellan.de

Joint project
Examination of the potentials of controlled charging using the full spectrum of options available for charging infrastructure to vehicle communication – Controlled Charging V3.0

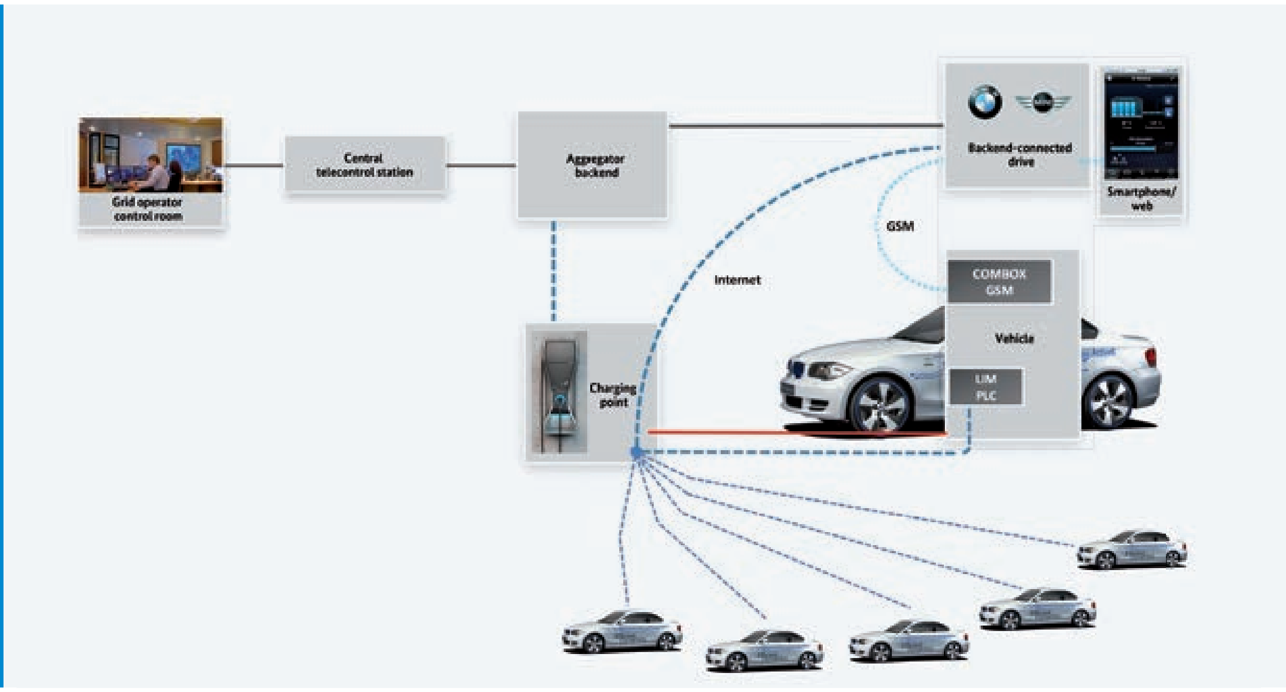
Project partners
BMW AG, Munich
EWE AG, Oldenburg
Clean Energy Sourcing GmbH, Leipzig
Fraunhofer Institute of Optronics, System Technologies and Image Exploitation (IOSB), Ilmenau
Ilmenau University of Technology
Chemnitz University of Technology

Duration
December 1, 2012–September 30, 2015

Controlled Charging V3.0

The objective of the research project is the identification of a technical and economical optimum for the charging of electric vehicles through intelligent energy management—which takes end consumer (vehicle user) requirements, temporal renewable energy availability fluctuations and infrastructure framework conditions into account. By exploiting all available regenerative energy resources subject to environment-related fluctuations, the charging of mobile energy storage capacities is to be carried out in such a way as to not restrict consumer mobility whilst also avoiding load peaks and allowing the existing infrastructure to be used to the greatest possible extent. Beyond this, the research focuses on how the individual charging processes in larger electric vehicle fleets can be bundled and subsequently managed in order to generate and therefore sell balancing power for grid stabilisation.

This requires the analysis of existing supply grid operator technical system requirements and their alignment with electric mobility systems. One major challenge here is the establishment of an information and communication technology network based on the current supply grid operator and balancing power provider structures to communicate with electric vehicles and back end systems. Besides the examination of the technical aspects, the project also examines the extent to which the current market regulations can support respective business models, or rather, the extent to which the regulations will need to be adapted. In a three-stage field test carried out between January 2014 and June 2015, ten users with a BMW ActiveE will test and experience both the charging technology as well as the accompanying business model first-hand as a ‘community’. In the third and final phase, it will hopefully be possible to use the vehicles in one particular section of one and the same local grid in order to carry out a “smart grid stress test” to test the supply grid load management functions.



The results will include conclusions regarding the balancing power potential of electric vehicle pools, their profitability perspectives and their feasibility within the scope of existing regulations, as well as recommendations regarding the redrafting of any regulations that might potentially be barriers. Besides a business model that focuses on the provision of secondary balancing power services, alternative utilisation options for the storage capacity of electric vehicles will also be examined.

The conclusions regarding the best possible information and operation design concepts will be completed by user research aimed at developing business model design recommendations that focus on maximum customer acceptance.

In addition, conclusions regarding the commercial benefits of the targeted integration of controlled charging into grid operation management at the transmission and supply grid level will be made, and statements regarding load stress prognoses for supply grids, control methods, grid analysis tools and dedicated profitability comparisons between conventional grid expansion and the approach of public / local load management systems expansion will be developed. ■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3 Funding priorities and projects
Market launch with ecological standards

Vehicle fleets are an electric mobility pioneer segment: Particularly fleet applications offer a high potential for the market launch of new vehicle technologies. Within the scope of the government programme for electric mobility, the Federal Government decided to acquire vehicles that produce less than 50 grammes of CO_2 emissions per kilometre for its vehicle fleet. Regional authorities, communities and also private vehicle fleet operators could take the initiative in the same way.

Vehicle fleet operators that test electric drive vehicles over a longer period of time and monitor the ecological benefits receive investment subsidies for the acquisition of electric vehicles under the funding programme. The practical tests are designed to make it possible to identify which vehicle fleet applications can be expected to show the biggest ecological benefit, particularly in the initial phase.

The funding is therefore used to focus on the following topics

- practical tests for the evaluation of market segments to identify initial commercial fields of application for electric vehicles (for example delivery services or car sharing fleets),
- analyses regarding the ecologically-oriented fleet management of various vehicle fleets.

Joint project
Electric vehicle fleets for the capital city region – InitiativE Berlin-Brandenburg

Project partners
Berlin Partner für Wirtschaft und Technologie GmbH, Berlin
DLR e.V., Berlin
X-Leasing GmbH, Munich

Duration
January 1, 2014 – December 31, 2016

InitiativE-BB

The objective of the project InitiativE Berlin-Brandenburg is to get more electric vehicles onto the roads of Berlin and Brandenburg. The focus will be on the use of up to 500 leasing vehicles from different manufacturers in vehicle fleets for different user groups and uses and their scientific monitoring.

The X-Leasing GmbH coordinates the acquisition of the vehicles and is the central organisation that processes the leasing of the vehicles. The joint project promotes the use of electric vehicles in companies and private institutions as well as public and semi-public institutions in the capital city region Berlin/Brandenburg. As a pioneer of innovative and sustainable mobility, the region represents a place, which is particularly suitable for the project. Furthermore, it is the largest real-world laboratory for electric mobility in Germany. With the largest number of vehicles and projects as well as a large network of public charging infrastructure, it is the leader among all German cities.

As the scientific project partner, the German Aerospace Center (DLR) tracks vehicle and user data over the course of the project. On that basis, it investigates the operating performance of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), the environmental impact on the region, and the economic viability of the use of electric vehicles from the perspective of the participating companies. The target groups will be informed about their options for using electric mobility and they will be encouraged to make use of electric vehicles and a corresponding charging infrastructure. From a scientific perspective, the primary goal of this broad field test is to gather vehicle-specific usage data that is relevant to the climate and the environment. That data will be analysed in terms of the potential to optimise CO_2-emissions, energy efficiency and the use of resources and recommendations for action will be derived from it.

The subsidised project InitiativE Berlin-Brandenburg will not merely make electric vehicles more affordable. The companies also get an analysis of the potential of electric mobility to reduce CO_2-emmissions, energy demand and of the local environmental impact of road traffic under real-world conditions. This allows them to draw direct conclusions about the profitability of the use of electric vehicles in their vehicle fleets. Furthermore, they profit from the synnergy effects with the international Showcase for Electric Mobility Berlin-Brandenburg, which is coordinated by the Berlin Agency for Electromobility (eMO) (see page 74).

The project is supported by the Vereinigung der Unternehmensverbände UVB in Berlin und Brandenburg (the association of company associations), the Handwerkskammer Berlin (chamber of crafts), the Berlin Chamber of Industry and Commerce (IHK Berlin) as well as the Motor Vehicle Guild and the Electrician's Guild of Berlin. Through these multipliers, their professional members can be reached directly. The leasing fleets are supposed to commence operations in Berlin and Brandenburg during the run of this project. The results are expected to contribute to making a realistic assessment of the potential for electric vehicles in commercial vehicle fleets in Germany and their contribution to climate protection as well enabling us to give recommendations to policy makers and companies for how the share of electric vehicles in vehicle fleets can be increased in the coming years. ■

Joint project
PREMIUM – Plug-in, range extender and electric vehicles in real-world mobility situations: Infrastructure, environmental conditions and market acceptance

Project partners
BMW AG, Munich
Alphabet Fuhrparkmanagement GmbH
Universität der Bundeswehr München
University of Duisburg-Essen (UDE)
University of Passau

Duration
January 1, 2014–December 31, 2016

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PREMIUM

Electrified propulsion is already being offered in various configurations today. The research project PREMIUM is investigating which one of them is most suitable to each of the individual needs of customers.

One million electric vehicles on Germany's roads—that is the Federal Government's goal for 2020. But in the end, the only one who can make electric mobility a success is the customer. Such success can only be achieved if electrified mobility concepts can be tailored specifically to the needs of different customer groups. The foundation for a higher market penetration of electric vehicles is now being laid by the project partners with their joint research project PREMIUM.

The research project will use different propulsion concepts ranging from battery electric vehicles (BEVs) as the most consequent form of electric driving, and range extended electric vehicles (REEVs) to plug-in hybrid electric vehicles (PHEVs). But which propulsion concept is the most suitable when the specific purpose, available charging infrastructure, charge time, battery cost, consumption and emissions are taken into account? And how can the individual parameters be tailored to the customer's needs in an optimal way? These are the questions that the consortium is investigating with a large-scale field test. For the first time, there will be a comprehensive examination of the entire spectrum of users: Aside from customer needs, the environmental-technological impact of electrically powered vehicles is being investigated for the entire range of potential customers ranging from private users and small-fleet users all the way to major corporate clients. Additionally, we will develop a projection for the energy and climate-policy impact of the one million electric vehicles that the Federal Government aims to have on the road by 2020.

In total, 360 customer vehicles will be used in the analysis of user behaviour, user acceptance and driving data. Aside from 60 private vehicles, 300 leasing vehicles

from various manufacturers in corporate vehicle fleets and from car sharing providers respectively, will be studied during the project duration of three years, as well.

A broad and solid foundation of real-life user data is indispensable so that automotive manufacturers can optimise the propulsion concepts to achieve the highest possible customer satisfaction. The “right” size of the battery, for example, is a question that we want to answer. The collected data will also give insights into what share of every day driving is done using electric propulsion versus an internal combustion engine. On that basis, taking into account the CO_2-emissions of electricity generation, it is possible to create a sustainability assessment for electric propulsion systems versus highly-efficient conventional vehicles.

More precise range projections can help fight so-called “range fear” for example the fear among consumers that an electric vehicle will not have sufficient range to get them to their destination. Current projections do not yet take the frequent stopping and starting at traffic lights or in stop-and-go traffic into account. That is despite the fact that such an operational profile can have a significant impact on the consumption of electricity. By taking the current traffic situation into account in the range projection, which is optimised for electric vehicles for the first time, the result should become more reliable and thus counteract the unease on the part of the users.

Joint project
Electric mobility in fleets – ePowered Fleets Hamburg

Project partners
hySOLUTIONS GmbH, Hamburg
Öko-Institut e. V., Berlin
Alphabet Fuhrparkmanagement GmbH, Munich

Duration
January 1, 2014– December 31, 2016

ePowered Fleets Hamburg

Numerous studies project that the use of electric vehicles in corporate vehicle fleets will have many advantages in the coming years compared to private use. Reasons for this development are that the problem of range restrictions of purely electric cars will be solved through the flexibility of a vehicle pool and the relativisation of the limited availability of public charging infrastructure through the installation of charging stations on the company premises. Furthermore, several analyses on the use of commercial fleet vehicles show that their usage patterns are characterised by routine use and daily driving distances that vary little. That leads to less usage conflicts and the fact that they become economically viable more quickly.

The objective of this project is the long-term every day use of up to 450 mass production electric vehicles in vehicle fleets as well as their scientific monitoring. The metropolitan region of Hamburg, which focuses strongly on commercial traffic in the area of electric mobility and is already using several hundred electric vehicles in fleets, is a particularly suitable region for the project outlined here. The intention is to include fleets of different sizes in the investigation. Fleets with more than 50 vehicles will be analysed, just as well as mid-size and smaller vehicle fleets. The premise is that in each case, only a part of the fleet will be replaced with electric vehicles.

A goal of the project is to gain insight into vehicle usage, acceptance and possible obstacles to electric vehicle use as well as economic attractiveness and the contribution of e-vehicles to reducing traffic-related greenhouse gas emissions.

The results will contribute to a realistic assessement of the potential of electric vehicles in commercial fleets in Germany and their contribution to climate protection. A central component of the project is the development of an information platform for companies, which

informs them about the suitability of electric vehicles for the use in fleets and which considers both ecological as well as economic parameters. The tool is intended to help reduce the existing informational deficit regarding electric mobility and to provide easy access to practical experience and the potential of electric mobility, particularly to SMEs. The focus of the first project phase is the identification of suitable fleets for the use of electric vehicles as well as the vehicle integration in the individual vehicle fleets. The goal is to have the first electric vehicles integrated into vehicle fleets as early as July 2014 and for the number of participating companies and the number of vehicles to expand in the subsequent months. The survey design of the accompanying scientific study will be developed simultaneously.
It will include suitable methods for tracking vehicle use as well as user acceptance. When the fleet use of electric vehicles begins, corresponding data will be recorded continually and in regular intervals.

Concurrently with the collection of data from the fleet vehicles during their real-world use, a model for profitability analysis (total cost of ownership/TCO-model) of the investigated fleet will be developed further and an information platform for companies will be created. ■

Joint project
Energetic behaviour, climate-ecological influence and user behaviour in new electric vehicle fleets – InitiativE-Baden-Württemberg

Project partners
DLR e.V., Stuttgart
X-Leasing GmbH, Munich

Duration
January 1, 2014–December 31, 2016

InitiativE-BW

The objective of the project is the analysis of realistic every day use of up to 300 production electric vehicles in fleets in different uses. The aim is to explore the potential for using electric vehicles in industry, commerce and private institutions as well as (semi-) public institutions and by private users in Baden-Württemberg. These target groups are to be informed about their options for making use of electric mobility and to be encouraged to acquire and use electric vehicles. The acquisition and leasing of vehicles are undertaken via the project partner X-Leasing GmbH.

In the project, user groups from industry, local craft guilds and interest groups will be approached in a targeted way. The goal is not to electrify large fleets but rather to identify different areas of application where electric vehicles could be used. The goal of the broadly dispersed and fragmented vehicle distribution is to win the vehicle users over as multipliers for those around them and to thus reach many different user groups through the use of vehicles with alternative propulsion systems. For that purpose, it is important to accompany the identified user groups during the introduction of the new technology to assure a successful transition and the positive experience associated with it, in order to engage other potential users as well.

The project focuses on the Federal State of Baden-Württemberg, particularly on the target regions Stuttgart, Karlsruhe, Mannheim, Freiburg and Lake Constance. In doing so, it picks up the local activities in the area of electric mobility such as the Showcase Project LivingLabBWe mobil or the leading-edge cluster Elektromobilität Süd-West as well as other regional projects in the state. For that, the project is supported and monitored by the Landesagentur für Elektromobilität und Brennstoffzellentechnologie e-mobil BW as an associated partner.

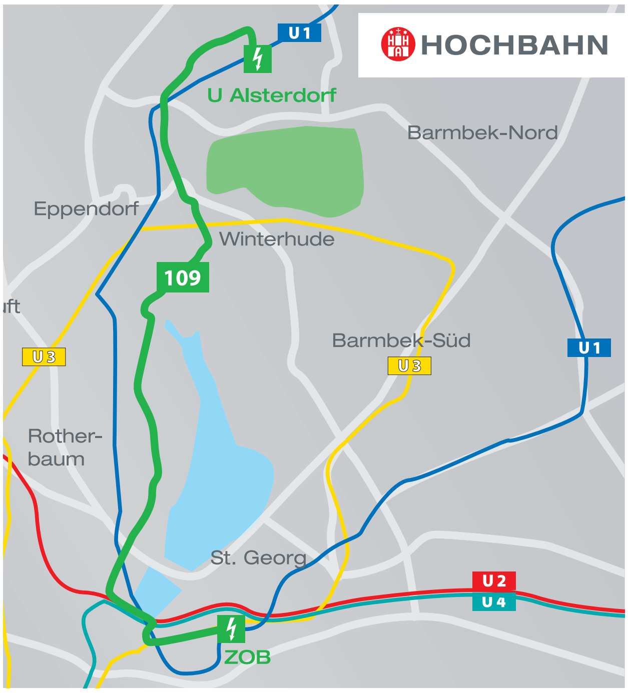
In cooperation with the partners, DLR will investigate the scientific issues related to energy demand, emissions, user behaviour, ways to optimise, and life-cycle analysis in a field trial within the project. For that purpose, the attitude towards the day-to-day use of electric mobility will be investigated in changing user groups and usage profiles by means of an extensive user survey.

In the accompanying research, a large number of the new vehicles will be equipped with the corresponding measuring technology and data about the day-to-day operation will be recorded and analysed. From the resulting findings, we will derive recommended actions to advance the development of electric mobility and to achieve the most ecologic and economic benefit possible in a targeted way. The energy-related behaviour will be analysed and used to determine the climate-ecological impact of the use of electric vehicles. Furthermore, a user survey will be conducted. The results will be used to generate a projection about whether the political target of one million electric vehicles by 2020 can be achieved or not. ■

Joint project
Hamburg Electric Bus Demonstration – Technical development and testing of plug-in and battery busses by the Hamburger Hochbahn AG – HELD

Project partners
Hamburger Hochbahn AG, Hamburg
Institut für Kraftfahrzeuge RWTH Aachen University

Duration
January 1, 2014–December 31, 2017



HELD

For several years now, the Hamburger Hochbahn AG has been testing hybrid busses in urban traffic and today they contribute to reducing emissions such as carbon dioxide, nitrogen oxides, soot, and noise caused by traffic. At this point, the vehicles have reached a degree of technical maturity, which, in the medium term, assures the degree of availability necessary for regular operation. Based on the experience from various field trials, the fuel savings can be up to 20 percent.

Given these facts, hybrid busses can contribute to climate protection and to improving air quality. At the same time, the electric propulsion systems have to be developed further in order to achieve completely emissions-free mass transit. The focus here is especially on the dense traffic in large cities, since that is where the pollution caused by burning fossil fuels has to be reduced most urgently. Based on the positive experience made so far with parallel hybrid busses, the current project entails further development of urban buses to plug-in hybrid busses and on to purely electric battery-powered busses.

The main objective of the HELD project is the use of three plug-in hybrid busses and three electric busses in regular line operations. The Hochbahn is responsible for the implementation of the fleet trials and will create the preconditions for the charging processes at bus stops as well as in the bus depots. The bus line number 109 (main train station–underground station Alsterdorf–main train station) was selected for the commercial use of the plug-in and battery busses. It runs for almost 10 kilometres and traverses the city centre with its high need for reducing noise and emissions. The map section above illustrates the path of the 109-line.

A system for recharging at the beginning of the route and at final stops will be used where energy will be provided via a pantograph with high charging capacity (up to 300 kilowatts). The introduction of the plug-in

hybrid and electric busses in regular line operations will make an important contribution to making local public mass transit even more environmentally friendly.

The Institut für Kraftfahrzeuge of RWTH Aachen University will scientifically accompany the fleet trial and analyse data obtained during the trial. The project is expected to generate insights about the day-to-day operation of the vehicles, their acceptance by mass transit users, about economic aspects compared to conventional busses, and about the reduction of local and global emissions. A close cooperation with the vehicle manufacturers will assure that further development of the technology is suitable to the needs of its users. The potential for expanding the use of electric vehicles within the Hochbahn network will also be explored and corresponding recommendations will be compiled. If the project is successful, the insights gained from the test of three plug-in hybrid and three electric busses in day-to-day operation can send a significant signal to other mass transit systems and municipalities. This can be another important contribution to increase the share of both low-emission as well as zero-emission electric vehicles in local mass transit in the coming years. ■

Project
Pilot test with three electric busses in line operations at üstra – zero emissions mass transit in Hannover

Project management
üstra Hannoversche Verkehrsbetriebe AG, Hannover

Duration
January 1, 2014–May 31, 2016

The circle line 100/200

Zero emissions mass transit Hannover

In this project, three electric busses with quick charge capability will be tested in a fleet trial on the üstra bus line 100/200, the so-called "sightseeing-line". The objective is to learn more about how greenhouse gas emissions can be reduced in local mass transit in the most economical way.

The representative circle-line, which runs through the entire inner city of Hannover, offers ideal conditions to achieve the target objectives and results, and to harness the environmental potential. Due to its large number of passengers, the short distances between bus stops and its route through the city centre of Hannover, the line offers optimal conditions for a trial with electric busses in line operation. In the process, opportunities for improvement will be identified, exploited and established. During the daytime, the line is served by 12-metre rigid busses in ten minute intervals. The total length of the line is 16 kilometres with a total of 42 stops and a total travel time of 53 minutes with 17,500 passengers per day.

Due to its circular path, there is only a single start/end point to the route, which is located at August-Holweg-Platz. One circular run requires about 25 kilowatt-hours of electricity. At the final stop, that amount of electricity has to be supplied to the vehicle within 6 minutes. This will be implemented using the overhead line system of the metro rail system using 680 volt and 500 ampere. This is an important component of the project. Starting in 2015, the electricity used for this purpose will come from zero-emission power generation.

The Hannover region has set itself the target to reduce its CO_2-emissions by 40 percent by 2020, compared to 1990. The pilot trial is very significant for the region because it is an opportunity to test very specifically to what extend the new technology can contribute to achieving the ambitious environmental goals of the region by combining üstra's bus network and the electricity supply of the metro rail system. Aside from the environmental impact, the project results

regarding market acceptance and economic viability of the project will be very significant in determining if electric busses will be a component of the mass transit system in the future. The project is supported by the associated project partners Region Hannover as the commissioning authority of local public mass transit and enercity Contracting GmbH, which will work on creating the recharging infrastructure for electric vehicles in Hannover.

The market readiness and readiness for mass production will be expedited by a close cooperation between service providers like üstra and the vehicle manufacturers. That way, the manufacturers will soon be able to offer reliable electric vehicles at marketable prices, which will be suitable to the respective needs of the different mass transit authorities. Aside from that, the service providers will get the opportunity to equip their fleets with environmentally friendly vehicles, whose extra cost will amortize due to energy savings throughout the vehicles' life cycles. ■

Joint project
Comprehensive analysis and evaluation of the environmental efficiency of electric and plug-in hybrid vehicles under everyday conditions using the example of vehicle fleet operation – Fleets Go Green

Project partners
Braunschweiger Versorgungs-AG & Co. KG, Braunschweig
imc Meßsysteme GmbH, Berlin
I+ME ACTIA GmbH, Braunschweig
iPoint-systems Gmbh, Reutlingen
Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM), Bremen
Lautlos durch Deutschland GmbH, Berlin
TU Braunschweig
TLK-Thermo GmbH, Braunschweig
Volkswagen AG, Wolfsburg

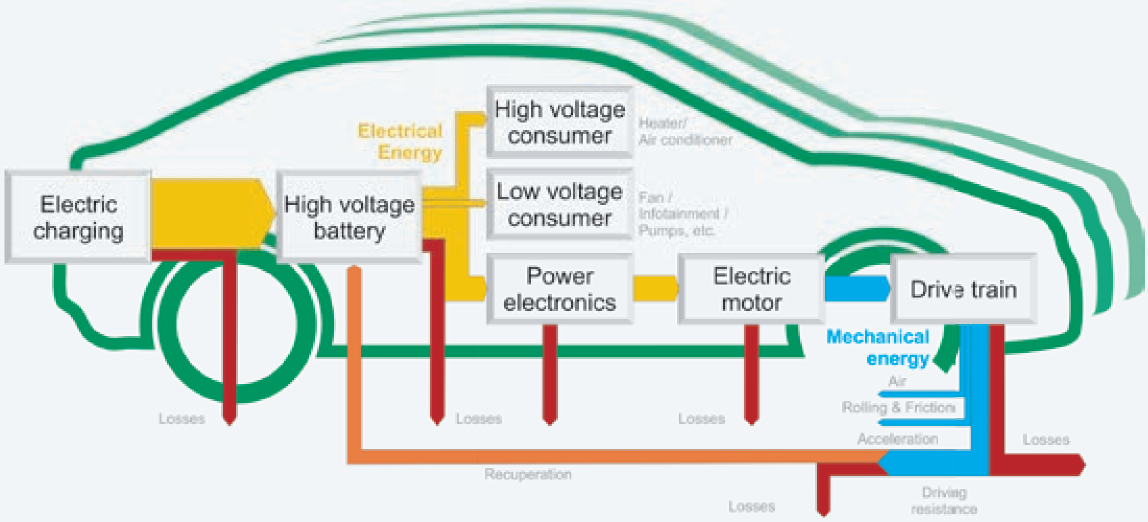
Duration
September 1, 2012–August 31, 2015

Fleets Go Green

Ensuring the efficient development and testing of electricity-powered vehicles requires the analysis of vehicle properties, routes driven, user behaviour and expectations, and vehicle design in accordance with the respective application profile. Various projects already comprehensively consider individual aspects of user and acceptance research, grid retroaction, and also carry out carbon footprint calculations. So far, however, there has been no single approach that carries out an integrated analysis and evaluation, that means an analysis and evaluation that covers all the aspects mentioned above, of the environmental impact of the use of electric and plug-in hybrid vehicle operation under realistic conditions. To what extent electric mobility can reduce the harmful environmental impact of everyday traffic can only be adequately analysed and evaluated through field tests.

The objective of the Fleets Go Green project is therefore the comprehensive environmental efficiency analysis and evaluation of electric and plug-in hybrid vehicle fleets operated in the long term and in everyday conditions.

For the application scenarios 'Werksflotte BS|Energy' and 'Pool-Konzept der Technischen Universität Braunschweig', the project partners BS|Energy and Lautlos durch Deutschland will acquire a total of 55 pure battery electric (BEV) or plug-in hybrid (PHEV) vehicles. These vehicles will be operated for 18 months to allow the collection of extensive data. On the basis of this data, the ecological and economical effects on the basis of various different usage profiles and the respective grid retroactions will be illustrated experimentally in a large-scale fleet test as well as with the aid of component and vehicle simulations. With its comprehensive approach, the project Fleets Go Green creates the requisite transparency for the exploitation of the ecological potentials



Schematic energy flow analysis of an electric vehicle fleet vehicle

of electric mobility for everyday fleet operation. The project entails a total of five modules. Module 1 encompasses the measuring of the energy requirement of the various vehicle components in fleet use, that means electric motor, power electronics and also secondary consumers are individually analysed. Component-specific energy consumption figures will be modelled, simulated and evaluated on the basis of the data collected. Module 2 will examine business model and segment-specific user acceptance drivers as well as the electric vehicle acquisition behaviour of fleet operators. Incentive mechanisms for eco-friendly driving and charging behaviour will also be examined in this context. The third module focuses on the interactions between the charging processes in the vehicle fleets used and the supply grid. Innovative concepts for the reduction of negative grid retroactions and the coupling of electric mobility to renewable energy sources will also be examined. Module 4 consists of an integrated ecological evaluation of the fleet operation and the analysis of the causal relationship of various factors. In the fifth module, recommended action plans for political and commercial decision-makers will be drawn up, for example in the form of advice on ecologically-oriented electric vehicle fleet management. With these results, the project provides an impulse for the large-scale introduction of electric vehicles in commercial fleets. ■

Project website: www.fleets-go-green.de

Joint project
Testing of electric mobility in fleet operation – carbon neutral deliveries in Bonn

Project partners
Deutsche Post AG, Bonn
Langmatz GmbH, Garmisch-Partenkirchen
RWTH Aachen University

Duration
July 1, 2012–December 31, 2016

Carbon neutral deliveries in Bonn

Future climate-friendly yet afffordable logistics services require new approaches. One of these approaches is electric mobility. However, there are still a number of challenges to be overcome before we will see major electricity-powered fleets on our roads. The first hurdle is the availability of electricity-powered commercial vehicles. Other aspects to be taken into account are the new characteristics of the electric vehicles (like range or charging times). Furthermore, infrastructure solutions suitable for major fleet use must be established in order to charge these vehicles. Currently, one electric car at a charging point is not a problem for any urban power grid. However, hundreds of commercial vehicles being charged at the same time would be. This scenario calls for intelligently managed and robust grids. This is the starting point for the project 'carbon neutral deliveries' in Bonn, which tests practicable solutions for delivery logistics based on electric mobility. The partner carrying out the practical testing is Deutsche Post AG. The Garmisch-Partenkirchen based Langmatz GmbH is also involved in the project. The company supplies the charging infrastructure. The idea behind intelligent management is that it helps to reduce the charging process impact on the supply grid down to a minimum. The third project partner is RWTH Aachen University. A team of researchers from three institutes (the E.ON Energy Research Center's Future Energy Needs and Behavior (FCN) and Power Generation and Storage Systems (PGS), and also from the Deutsche Post chair for the optimisation of supply chains will document the project and examine charging infrastructure and battery system issues as well as economic aspects.

The fleet test begins in 2013 with 79 electric vehicles used to deliver parcels in Bonn's city centre and both parcels as well as letters in the surrounding region. Even before the beginning of the project, Bonn already had one of the world's largest commercial electric vehicle fleets operated by one operator.

This fleet refuels with power from regenerative sources. The electric vehicles used in the project are small vans, transporters of up to 2.8 tons, and parcel delivery vehicles. The cars are manufactured by Iveco, Renault and Mercedes, although 20 StreetScooters are in use as well. Deutsche Post AG developed a pilot series of this new type of vehicle in cooperation with StreetScooter GmbH. If the vehicles and the charging technology meet expectations, the electric fleet will be expanded to 140 vehicles in two further project stages. The result would be that the city of Bonn and three sorting office branches in its surrounding areas will have switched fully to electricity-fuelled combined letter and parcel delivery as early as 2015.

As yet, there are no practical experiences in terms of running electric vehicle fleets of this size, which leads to a number of new, as yet unresolved issues such as: How can such a large number of electric commercial vehicles be charged? Is the current battery and drive technology already advanced enough for the vehicles to pass this long-term test—or is there a need for further development work? Do freezing conditions require the development of new charging strategies, as they affect the battery charging capacity—or the development of winter timetables? If all goes well, the approach can be transferred to other cities without any major adjustments as early as 2015. A great number of people can learn something from this project: Those involved in it as well as anyone else who has to undertake both urban and regional short-distance vehicle fleet journeys. ■

4 Funding priorities and projects
Resource availability and recycling

Electricity-powered vehicles and their components require some raw materials of which there are only limited supplies available, such as cobalt, rare earths or lithium. The identification of the raw material potential and the early development of a resource strategy are therefore vital for long-term industrialisation. The availability of the respective raw materials and, above all, their recovery be means of efficient recycling procedures must be ensured. The remanufacturing of batteries (second life) that no longer meet the requirements for vehicle use is also an important building block for the conservation of resources. Research projects that focus on various procedures of traction disassembly, separation and second life applications as well as recycling strategies are therefore also an important funding priority. Additional research is to be carried out with regard to logistics concepts for the collection, storage and re-input of battery and electric motor energy storage systems as well as the recycling of other materials they contain. And, not least, the exploration of alternative raw materials and their possible use is an important element of the funding programme.

The funding is therefore used to focus on the following topics

- continued research into hydro- and pyrometallurgic recycling procedures in existing pilot plants,
- establishment of pilot plants and research into li ion battery disassembly and component separation procedures,
- research into the remanufacturing (second life) of li ion traction batteries (for example establishment of life cycle, alteration mechanisms, second life applications),
- studies regarding the recycling of further materials (besides lithium) from batteries and electric engines,
- studies regarding the possible uses of the alternatives to the very limited natural resources.

Joint project
Recycling of lithium-ion batteries – LithoRec II

Project partners
Rockwood Lithium GmbH, Frankfurt
Audi AG, Ingolstadt
Electrocycling GmbH, Goslar
H.C. Starck GmbH, Goslar
Hosokawa Alpine AG, Augsburg
I+ME Actia GmbH, Braunschweig
Solvay Fluor GmbH, Hanover
TU Braunschweig
University of Münster
Volkswagen AG, Wolfsburg

Duration
July 1, 2012–June 30, 2015

LithoRec II

Although electric vehicles are still in the early stages of any large-scale market launch, it makes sense to address the issue of the recycling of lithium-ion batteries already in order to ensure the future competitiveness of the German automotive and automotive supplier industries. The electric mobility concept will not be fully mature, from an ecological point of view, until we have efficient recycling procedures in place. In addition, the recovery of lithium, cobalt, nickel and other raw materials is also of strategic importance for Germany to safeguard resource availability.

Due to the various materials used and the complexity of the traction batteries, the development of recycling procedures is an extensive effort that calls for interdisciplinary cooperation. Eight renowned industrial enterprises and two universities are cooperating in the joint project LithoRec II, which is also one of the Federal Government's Lighthouse Projects in the area of 'recycling and resource efficiency', to demonstrate the complete process chain from battery disassembly to the synthesis of battery material from recycled materials at pilot scale. Hydrometallurgic procedures are one method of achieving recovery rates that are as high as possible. This approach to the process also aims to ensure a high level of economic viability.

The fundamental mechanical and chemical procedures were already developed in a previous project. The first step basically consists of the disassembly of the casing and the electronic components, and their input into existing recycling cycles under consideration of a previously defined battery discharge state to ensure that the battery is safe to handle. Due to the different battery models and sizes, their disassembly is a complex effort. From a technical point of view, it is difficult to fully automate and therefore hardly likely to be economical. A hybrid approach (workstations with human as well as robot input), however, promises considerable efficiency potentials. The next step is the breaking up of the

individual modules or fuel cells. The machines for the hydrometallurgical recovery of active materials must be constructed in a way that takes particularly volatile substances and any energy potentially left in the batteries into account. The recovered active materials are mechanically separated and subsequently recycled. Electrocycling GmbH recovers especially aluminium and copper. A separate study addresses the recycling of the electrolytes (solvents and conducting salts). Several institutes at the TU Braunschweig are involved in the development and optimisation of the process.

Rockwood Lithium GmbH already employs its existing hydrometallurgical reprocessing plants to convert the remaining black active material powders into high-purity lithium oxide and transition metal salts. The recovered products are subsequently reused for the synthesis of new battery materials.

The construction of the pilot plant will demonstrate the technical and economic feasibility of lithium-ion traction battery recycling and optimise the respectively developed procedures. Vital safety aspects and the user-friendliness and easy maintainability of the components are also addressed to allow prompt industrial implementation as soon as larger quantities of the batteries become available in future. The ecological benefit of the recycling procedure is calculated with the aid of carbon footprint computation in accordance with ISO 14040 / 14044, which makes the comprehensive evaluation of the battery recycling procedure possible. ■

Project
Further and external use (second life) of lithium-ion traction batteries in mobile and stationary applications and investigation of possible business models – StaTrak

Project management
Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg

Duration
December 1, 2013–November 30, 2015

StaTrak

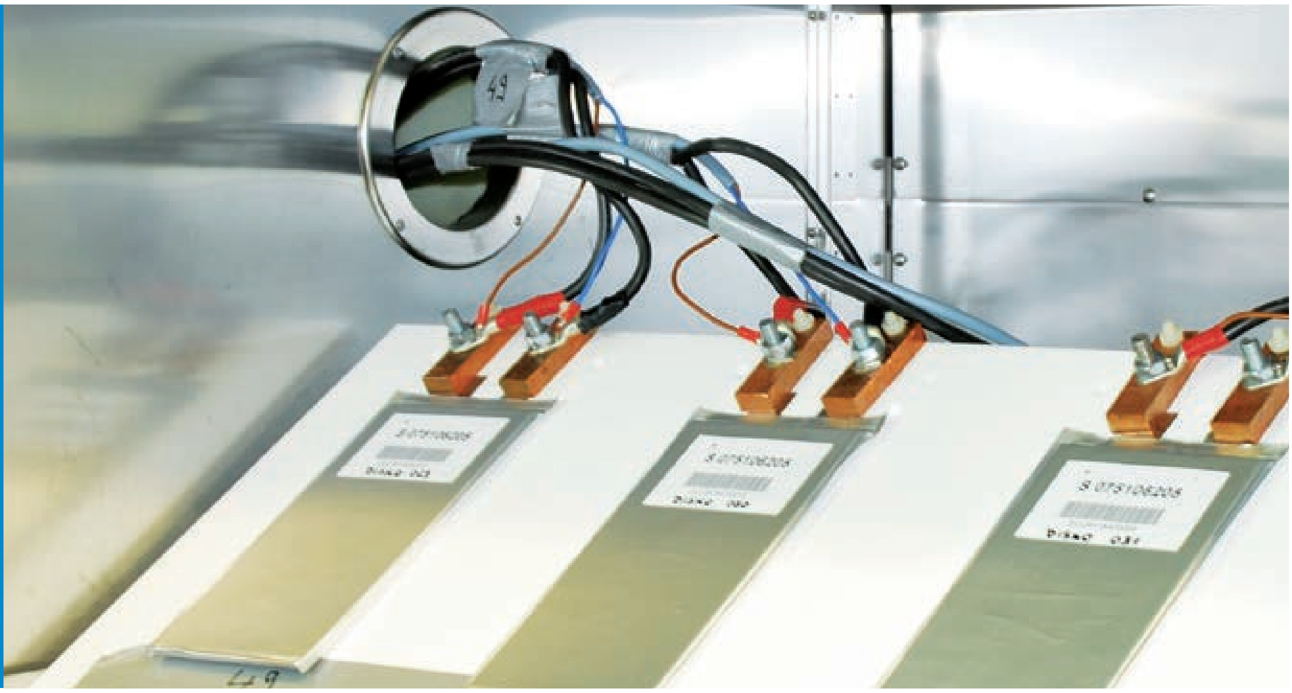
In the context of the Energy Reforms, the concept of electrically driven vehicles is becoming increasingly significant because they make it possible to use the renewable energy, which is generated, for transportation purposes. Aside from the application as a mobile storage solution, the lithium-ion battery is also gaining an ever growing market share as a stationary energy storage solution, to increase the own consumption of photovoltaic electricity, for example, and as a way to provide electricity grid services.

Rechargeable lithium-ion batteries are being used in electric mobility due to their high energy density. Therefore, the share of this technology for mobile applications will continue to grow in the global market. Naturally, the capacity and performance and thus the remaining life span of a battery decrease over time due to physical and electro-chemical processes within the battery cell. The so-called degradation sets in. As a result, the batteries become unfit for mobile use at some point.

But these aging batteries from traction applications still have a lot of potential for other applications. This is where the goal of the StaTrak project lies.

The aging battery modules from electric vehicles will be transferred to other, so-called second-life applications, which will be investigated systematically. A possibility are applications, which require less discharge currents, such as the use in work machines and the use as stationary storage solutions, for example.

For the investigation, the project uses lithium-ion battery cells with a characteristic cell chemistry used in the area of electric mobility. Based on the analysis of the degradation mechanisms of the cell, a mathematical model will be derived, which makes it possible to determine the process of cell aging. That model will comprise all dominant aging processes. The possibility of a lifespan prediction and a determination of the remaining value of a battery represent the basis for the



business model trade and rental, which will be investigated in this project. Within the StaTrak project, the focus is on stationary applications as energy storage solutions to increase the own usage of photovoltaic electricity as a form of second-life use. Additionally, the acceptance of a trade model among users will be surveyed. The reuse and secondary use of battery modules is a motivation for building standardised modules. This has a positive impact on the economic viability and the environment. Larger scale production of standardised modules is expected to lead to price reductions. Furthermore, electric mobility is promoted and, thanks to the reuse of the battery modules, their premature disposal and the waste generated by this are reduced.

The battery laboratory at Fraunhofer ISE will investigate the physical and electro-chemical mechanisms of the aging of lithium-ion batteries both in terms of time and charging cycles. In experiments, new cells will be subject to accelerated aging under precisely defined conditions and their capacity, resistance and performance will be measured. The resulting data can be used to develop models and simulation-based conclusions can be derived about life span, residual capacity and degradation mechanisms. ■

Joint project
Electric vehicle recycling 2020 –
Key component power electronics –
ElmoReL 2020

Project partners
Öko-Institut e. V., Darmstadt
Electrocycling GmbH, Goslar
PPM Pure Metals GmbH, Langelsheim
TU Clausthal, IFAD Institute of Mineral and Waste Processing, Waste Disposal and Geomechanics
Volkswagen AG, Wolfsburg

Duration
December 1, 2013–November 30, 2016

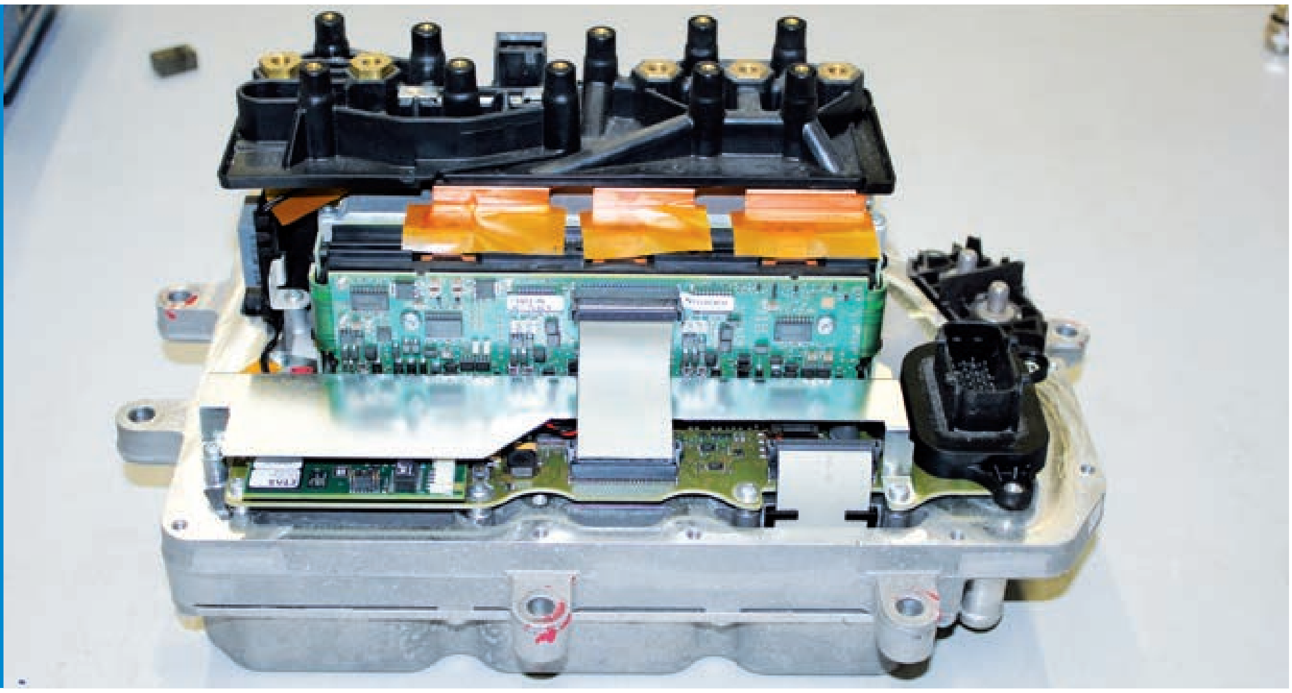
ElmoReL 2020

The power electronics are an essential component, which can have an important impact on functional attributes and cost structures of electric vehicles. Especially due to the numerous converters, the value creation share of the power electronics on the overall vehicle and thus the relevance of these resources will grow significantly. Currently, there is no optimised recycling process for the power electronics in electric mobility. Furthermore, the composition of the ingredients will change as the technology develops further. Therefore, flexible solutions are needed in the recycling process. Aside from a future use of gallium nitride, it is likely that power electronics will continue to contain precious metals like gold and silver as well as other technology metals like tantalum, indium or germanium.

For gallium and other technology metals, recycling processes currently only exist for production waste materials from the semiconductor and photovoltaic industry, where these materials exist in a concentrated and very pure form. The EU Commission considers the supply situation of many of these economically significant raw materials to be critical.

Hence the main objective of the project ElmoReL 2020 is the development of a recycling process for important ingredients of the power electronics of electric vehicles that is suitable to real-world needs. In doing so, we need to close the process technological gap between traditional electronic scrap recycling, which focuses on precious metals, and the hydro-metallurgical recovery processes from pre-concentrated high purity material from the semiconductor industry.

Because of the broad range of materials used in the power electronics in electric mobility and the general complexity of power electronics, the development of recycling processes is an extensive task, which requires the cooperation of different disciplines.



Therefore, research institutes and industrial companies have joined forces in the project ElmoReL 2020 to map out both the product level as well as the process chain from the dismantling of the power electronics to the supply of secondary materials.

Among the task foci of the project are, on the one hand, the analysis of possible ingredients of the relevant power electronics components and the investigation of ways to disassemble and mechanically process them (crushing, separation, classification). On the other hand, processes for hydro-metallurgical pre-concentration and a modification of the process for metallurgical refinement of the technology metals will be developed. The process developments will be accompanied by an evaluation of the economic feasibility. Another project goal is the creation of an environmental performance evaluation, including a critical review to prove the environmental advantages when compared to the extraction from fresh raw materials. To conclude the planned activities, the resource efficiency potential of recycling of power electronics from electric mobility will be reliably calculated both in Germany and on a global scale. With that, we will determine the possible contribution to alleviating supply shortages for predefined technology metals. With this focus, this interdisciplinary project will also make an important contribution to avoiding supply shortages of strategically important technology raw materials for the German economy. ■

Joint project
Demonstration plant for the zero-cost, resource efficient processing of disused li-ion batteries from electric vehicles – EcoBatRec

Project partners
Accurec Recycling GmbH, Mülheim a.d.R.
Research Chair for Process Metallurgy and Metal Recycling (IME),
RWTH Aachen University

Duration
May 1, 2012–September 30, 2015

EcoBatRec

As the degree of the success of electric mobility also depends very much on economical attractiveness for the vehicle owners, all economic factors including end-of-life costs must be taken into account. The selling prices of electric vehicles are strongly influenced by the battery module manufacturing costs, as they currently increase the overall price of the vehicle by as much as over 10,000 euros. According to a recent study by Roland Berger, at least 13 percent of the current battery costs are due to the raw materials used, whilst almost half of the costs are generated by cell production. This proportion of raw material costs will only increase once the cells are mass produced. Besides the impact of the cost of the raw materials on the battery module manufacturing cost, another cost factor that should not be ignored in view of the current market situation is the disposal costs, which depend on the manufacturer's level of product responsibility. Reducing the dependence on raw material imports as well as the costs can therefore only be realised through the closing of domestic material cycles.

The objective of the joint project EcoBatRec is therefore the development and testing of economically viable recycling technologies for the lithium-ion batteries of electric vehicles. In the course of the project, the two partners will consider the entire recycling process chain, from the characterisation and discharging of the batteries to their disassembly and the separation and grading of the individual material fractions, and also carry out research into new procedures for lithium recovery. In contrast to the Lithorec II project, the core of the EcoBatRec project is the development of a new process step called autothermal vacuum pyrolysis. It is hoped that this will make the application of new methods in the breaking up, grading, examination and separation of the individual material fractions possible.

A pilot plant will be constructed and operated for the mechanical disassembly, breaking up and grading processes. Two alternative methods for the recovery of lithium, carrier gas vaporisation and vacuum vaporisa-

tion, are to be examined. An economically extremely attractive recovery routine could be unlocked, especially if the recovery of metallic lithium is successful.

Overall, the main objective of the project EcoBatRec is therefore the recovery of valuable metal fractions at a reasonable, or at the least possible, cost. A considerable increase of the recovery rate for valuable materials with a high marketing potential (compliant with EU Directive EU / 66 / 2006 specifications), a reduction of the processing costs, a method that is particularly resistant against adverse factors (for example charging state) and influences (for example non-lithium batteries, mounted parts et cetera) and usability for all common lithium-ion cell types are all expected to contribute to this. In addition, the methods developed should also be marked by a high level of energy efficiency as the auto-thermal pre-treatment minimises the energy required for the necessary pyrolysis, the processing methods used are mostly mechanical to save energy, and the early separation of marketable product groups results in a highly concentrated electrode mass. A further project objective is the computation of a carbon footprint to confirm the environmental benefits compared to extraction from primary raw materials. ■

Project website: www.ecobatrec.de


CO_2

5 Funding priorities and projects
Accompanying scientific research

The BMUB has initiated several interdisciplinary research projects in order to be able to comprehensively evaluate the ecological and economic factors of electric mobility. For example, it must be examined whether certain mobility models (for example car sharing or multi-modal travelling) can be sensibly combined with electric mobility. To achieve this, the short- and long-term effects of mobility and vehicle purchasing behaviour must be studied empirically with the aid of user surveys and route protocols. The long-term impacts of growing numbers of electric vehicles on public low voltage grids must also be researched, including traffic shifting effects. And, not least, the contribution of electric mobility to long-term climate protection assuming various conditions and scenarios must also be examined. Ultimately, the results from the accompanying research can lead to the formulation of recommendations for political action and potential steering measures.

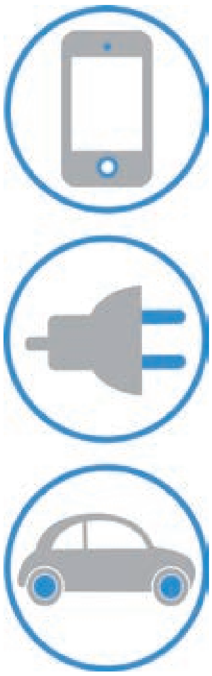
The funding is therefore used to focus on the following topics

- computation of the environmental impact reduction potential of electric vehicles that not only takes vehicle-related aspects but also interactions with the energy market into account,
- compilation and analysis of the findings from current fleet tests and application projects,
- development of scenarios regarding the contribution electricity-powered freight and public transport can make to climate protection,
- development and design of mechnisams for the integration of renewable energies and electric mobility into the distribution grids.

Joint project
App and Internet platform to support the decision making process for the purchase of electric vehicles – My E-Drive

Project partners
ifeu – Institute for Energy and Environmental Research, Heidelberg
Allgemeiner Deutscher Automobil-Club e. V. (ADAC), Munich

Duration
January 1, 2014–December 31, 2016



My E-Drive

The advantages and opportunities related to electric mobility in road traffic for society are known: Use of renewable energies in transportation, no local emissions and quiet propulsion.

When it comes to establishing electric vehicles in day-to-day mobility, it is the customers in particular, who have to be taken into consideration. They should be informed about the new vehicle concepts in a comprehensive way. The diversity of these concepts is growing with the various types, ranging from plug-in hybrids and vehicles with range extenders to purely battery-powered vehicles. The way in which vehicles are being used (distances driven, elevation profile, air conditioning and heating) and when they are charged where or if they can perhaps even feed electricity back into the grid, all of that will play an important role in the future. It has a big impact on the cost and the effects on the environment, which are related to various vehicle concepts.

Until now, many people only knew electric cars from the discussion in the media. But today, they are increasingly present in the market place. The vehicle concepts and models are diverse and pose many questions for potential buyers in their purchasing decision process:

- Is there an electric car that is suitable to my needs?
- Is it financially lucrative for me to purchase one?
- How clean is an electric car really?

Insecurity exists particularly when it comes to the limited range of purely battery-electric vehicles–the fear of standing by the side of the road with an empty battery continues to be significant. But time and time again, there is also criticism of the standardised energy-consumption and range figures given by the manufacturers, which do not take the use of air conditioning et cetera into account and which can deviate significantly in real-world use. The project My eDrive wants to provide potential buyers of electric vehicles

with a decision making aid to answer these questions. An integrated service, which includes a website and a smartphone app, is supposed to help a broad group of potential users of electric vehicles to select suitable models on the basis of their personal usage profile, taking realistic vehicle characteristics into account. Operating cost as well as the environmental performance are being considered in this. Based on tracking the user's individual travel route via the smartphone, the usage profiles can be entered in detail and can be further personalised. The technical attributes of the different electric vehicles will be modelled realistically in order to be able to make assessments about suitable electric vehicles that are realistic.

To live up to the high standards set by the project, a partnership between the scientific community and private organisations as been formed: The Institute for Energy and Environmental Research (IFEU) and the ADAC Technik Zentrum conduct the project jointly.

In the technical implementation, they are supported by Green&Energy GmbH, which has been working for several years on electric mobility and the options for letting a broad public experience this technology. IFEU contributes many years of experience in the environmental assessment of different vehicle concepts, ADAC possesses significant expertise, especially in the technical and economical assessment of vehicles. As a result, the project can profit not only from ADAC's vehicle database with technical data on more than 30,000 vehicle models but also the ADAC databases "Autotest" ("car test") and "Autokosten" ("car cost"). ■

Joint project
Scientific research with battery-electric and conventional vehicles to accompany the car2go share project

Project partners
Öko-Institut e.V. – Institute for Applied Ecology, Freiburg
The Institute for Social-Ecological Research, Frankfurt/Main

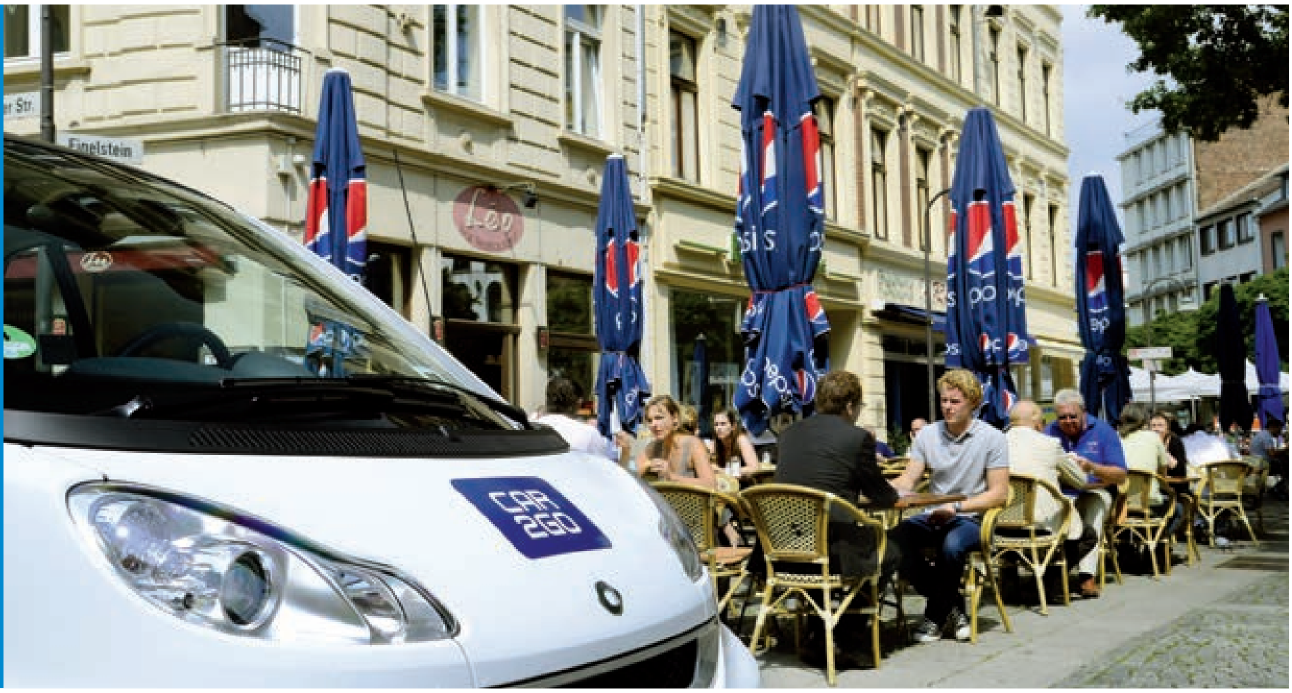
Duration
August 1, 2012–February 29, 2016

car2go share

Electric vehicles are currently still characterised by their high purchase price and limited range. Although, because of their high level of efficiency, the running costs of electric vehicles are considerably lower than those of conventional cars, they are currently still not a particularly economical option for anyone that drives only short distances due to the high initial purchasing price. Alternative usage concepts could therefore help to make climate-friendly electric mobility in urban areas more economical. In this context, flexible car sharing is a promising option. Compared to owning a car, a car sharing scheme offers users ecological and economic advantages as well as a high level of flexibility.

However, just how eco-friendly are electric vehicle car sharing concepts compared to schemes that rely on conventional cars? Who uses the vehicles, how are they used and how future-oriented are flexible car sharing concepts. The Öko-Institut e.V. Institute for Applied Ecology and the Institute for Social-Ecological Research will research these aspects over a period of 3.5 years, using the Daimler subsidiary car2go Deutschland GmbH, which is also a project partner, as an example.

The research project entails an empirical study of the short- and long-term effects of travelling behaviour. Interesting aspects in this context are how the car design impacts on user behaviour, whether users use their own vehicles in a different way, and also potential shifting effects, from public transport and cycling to car sharing. The analyses focus on the quantification of the environmental effects. The project also examines the appeal and acceptance of car sharing schemes as such, and the use of electric vehicles in such schemes. In this context, the project will also highlight the issue of how the changed usage characteristics of electric vehicles impact on the appeal of electric mobility. To achieve this, several user surveys will be carried out at two different car sharing scheme locations over a period of two years: In Cologne, car2go uses vehicles with combustion engines; the vehicle



fleet in Stuttgart will consist entirely of battery-electric vehicles. In addition to the car2go user surveys, one control group consisting of non-car sharing scheme participants will be interviewed in each location.

Another objective of the research project is the formulation of general statements on the usage potential of flexible car sharing concepts. To achieve this, typical user groups and the overall potential of flexible car sharing concepts in Germany and their potential for the avoidance of carbon emissions will be identified on the basis of scenarios that also take the results of the acceptance behaviour studies into account. During the course of the project, the research results will be presented and discussed in the form of stakeholder workshops. The result will be an overall evaluation of the use of electric mobility in flexible car sharing concepts from an ecological perspective, and an assessment of whether battery-electric cars can demonstrate their advantages over conventional cars when operated in car sharing concepts, and overcome their restrictive image. Furthermore, the project allows a long-term assessment of the use of electric vehicles in car sharing schemes in terms of suitability as a building block for multi-modal mobility concepts under consideration of market penetration and environmental benefits. ■

Project
Scientific support for the development of scenarios regarding the contribution electricity-powered freight and public transport can potentially make to long-term climate protection – E-Mob GV-öV 2050

Project management
Öko-Institut e.V. – Institute for Applied Ecology, Freiburg

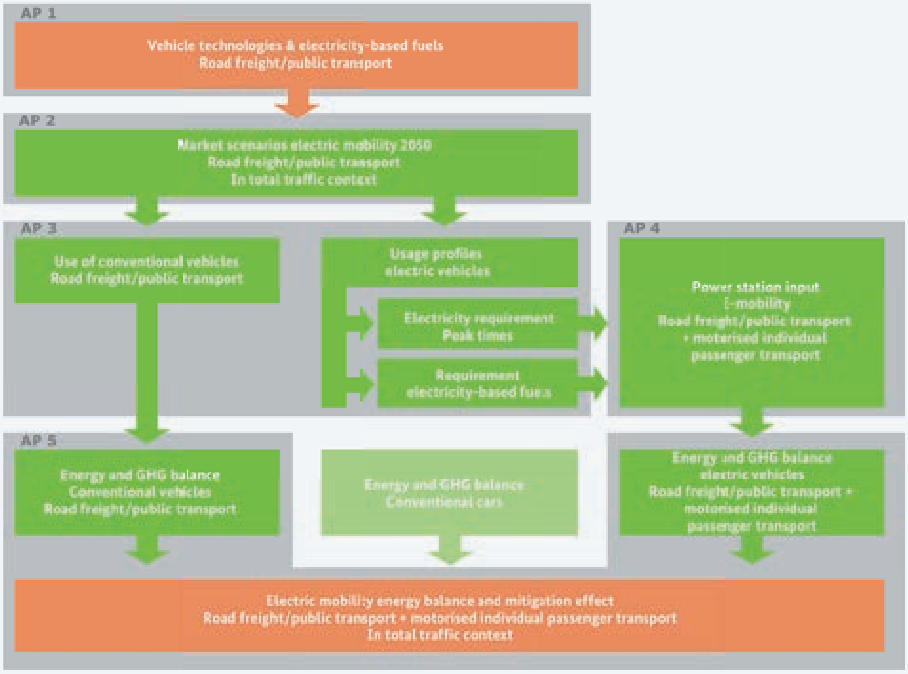
Duration
May 1, 2012–January 31, 2014

E-Mob GV-ÖV 2050

The increased use of electricity-powered vehicles in road traffic is an important building block for the achievement of the climate and energy policy goals set by the Federal Government for the transport sector. The coupling of electric mobility to renewable energies and their grid integration plays a particularly important role here. Rail traffic has already been dominated by electric drive technologies for some time now. However, the situation is different when it comes to road traffic: Although first practical experiences with light, (partially) electric commercial vehicles used for road freight traffic have been gained in several major cities in Germany, the fundamental transformation of the transport sector in line with the Federal Government's energy concept still requires considerable development efforts and change processes. The introduction of electric mobility is a particular challenge in the area of heavy goods vehicles.

Within the scope of the research project, public and freight transport electric drive concept development perspectives and the respective usage barriers will be examined with the aid of different scenarios up to 2050. Concurrently, a parallel project also funded by the BMUB will look at the long-term potentials of electric cars for individual passenger transport. The joint result will be a comprehensive picture of potential electric mobility developments up until 2050, and of the resultant demand for electricity. The respective scenario process will be co-designed and accompanied by experts as well as stakeholders.

Besides electricity-powered vehicles, another alternative to using electricity in the transport sector is the use of fuels generated by electric power—these are fuels for which the electricity is converted into hydrogen, methane or liquid fuels. In the event of the large-scale introduction of electric mobility as well as electrically-generated fuels to the transport sector, the demand for electricity can be expected to rise considerably. The exact contribution of electric mobility to the the mitigation of



CO_2 emissions therefore depends largely on the share of renewable energies in the energy sector. At the same time, the energy sector could potentially benefit from the contribution electric mobility could make to load management, as the sector will increasingly be subject to fluctuations due to the generation of power by means of renewable energy sources. The research project will therefore also address the reciprocal effects between increased demand for electricity and power generation.

This aims at the creation of potential electric mobility development scenarios up until 2050, and a quantification of the effects on energy consumption and greenhouse gas emissions. The results are also intended to serve as the basis for the design of political framework conditions for the targeted funding of electric mobility in the road freight and public transport sector. In addition, they should provide an idea of the extent to which renewable energies must be expanded by 2050 in order to supply the additional demand from the transport sector due to the increased use of electricity and electrically-generated fuels, and achieve a significant mitigation of greenhouse gas emissions.

The results are likely be published in the form of scientific papers in professional journals and popular scientific media and contributions to workshops and conferences. ■

Project
Electric bicycle use related shifting and climate effects – PEDELECTION

Project management
Braunschweig University of Art – Institute of Transportation Design (ITD)

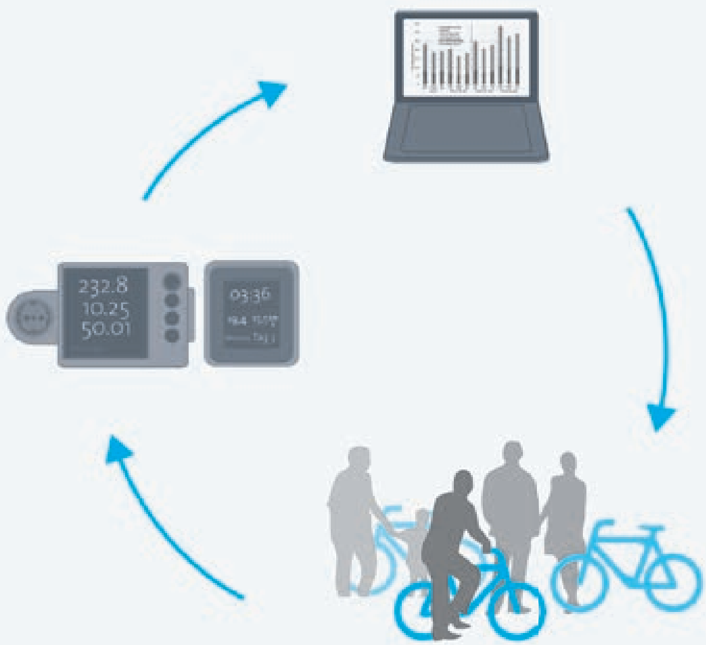
Duration
August 1, 2012–February 28, 2015

PEDELECTION

The positive market development in the pedelec (pedal electric bicycle) sector in recent years shows that these bicycles with electric pedalling support are a vehicle class that apparently already enjoys a positive image today, and is increasingly accepted by a steadily growing number of people. Due to the limited availability of parking spaces and restricted capacity for traffic, as well as the comparably short distances travelled daily by the residents, urban and densely populated areas are virtually predestined for pedelec use. If they are used for journeys which would otherwise be covered by car or moped, they contribute to the improvement of the urban climate. They can also make an important contribution to the transition towards electric and other, new forms of mobility.

So far, mobility research has paid only cursory attention to the pedelec, and if so mainly in the form of (commercial) fleet tests. Accordingly, there are still a number of unresolved issues regarding user profiles and behaviour within the scope of everyday use: For which everyday journeys do the users use the pedelec, and for which journeys do they refrain from usage? Why are certain journeys (not) undertaken by pedelec? Which modes of transport are replaced by the pedelec, and what is their eco-balance based on the actual usage behaviour?

The research project Pedelection will address these and other issues over the next few years. Between 2012 and 2015, the Institute of Transportation Design (ITD) will carry out a study regarding the everyday usage profiles and motives of private pedelec users in four German regions in cooperation with the Institute for Energy and Environmental Research Heidelberg (IFEU). In the sense of a general accompanying research project, the partners will examine the substitution and shifting effects (compared to other forms of transport such as cars, public trans port, other motorised two-wheeled vehicles, bicycles) due to the increasing use of pedelecs in the greater Munich and Frankfurt am Main areas as well as



the Oldenburg / Bremen and Wolfsburg / Hannover / Braunschweig regions. Based on the scenarios and data provided by the ITD, the IFEU will also carry out an environmental analysis which compares the situations prior and subsequent to the purchase of a pedelec. In contrast to previous research approaches, this is not a fleet test where the project participants supply the respondents with pedelecs. In fact, Pedelection will address ordinary people living ordinary 'busy lives' who have bought a pedelec for personal reasons. The study was designed by the scientists of the ITD in cooperation with the IFEU.

It encompasses the collection of both qualitative as well as quantitative pedelec (usage) data in the form of, for example, face-to-face interviews and online surveys but also with the aid of energy consumption and GPS loggers. The result is expected to identify the major barriers and drivers for pedelec use in Germany, and allow the formulation of political action plans for the best possible unlocking of the environmental benefits of pedelecs. ■

Project website: www.pedelection.de

Project
Effects of increasing numbers of electric vehicles on the quality of electric energy in public low voltage grids – ElmoNetQ

Project management
TU Dresden – Institute of Electrical Power Systems and High Voltage Engineering

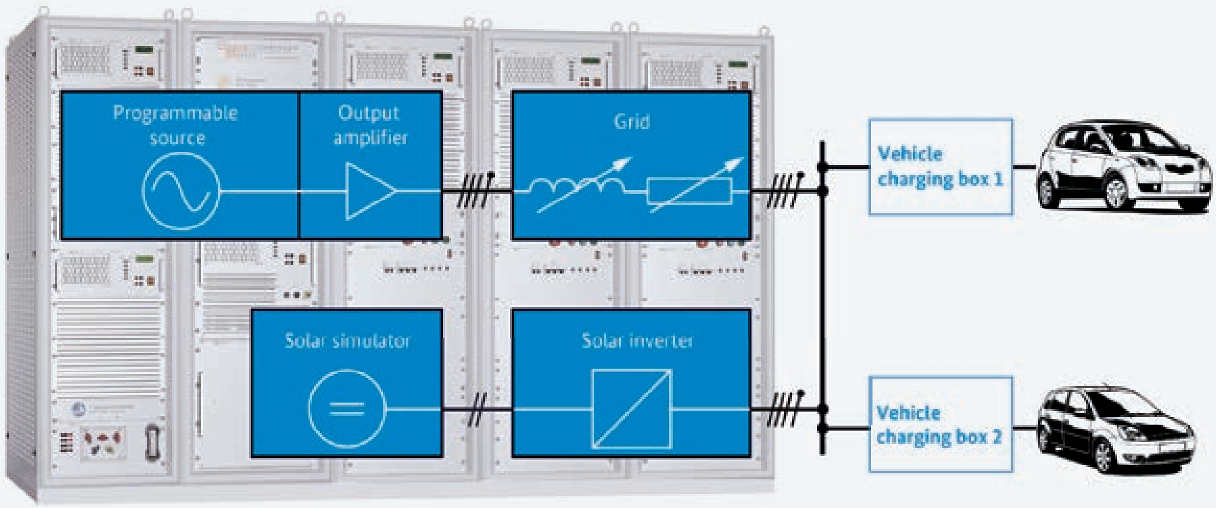
Duration
September 1, 2012 – August 31, 2015

ElmoNetQ

An adequate electricity and voltage quality is the fundamental basis for the smooth running of all devices and plants connected to the grid, from computers to photovoltaic systems. This quality is assured by many different specifications and standards. They have been continuously further developed over decades in order to keep the cost of this quality to a minimum and distribute it fairly amongst device manufacturers, grid operators and customers.

The future connection of increasing numbers of electric vehicles to the grid must on no account lead to either a legally not permitted reduction in quality or a disproportional increase in costs to ensure their grid-friendly integration. One such quality marker, for example, is voltage symmetry. If a certain value is exceeded, it can, for instance, accelerate the ageing of motors. Electric vehicles are often connected single-phase to the normal domestic electricity system and, if they are charged over several hours with a high current, cause a voltage dissymmetry that should not be ignored. This can be excacerbated by an adverse interaction with a simultaneously connected, single-phase photovoltaic system. Strategies must therefore be developed that allow the simultaneous operation of as many of these systems and devices as possible, and the maximisation of the load factor in the three-phase based grid infrastructure. This requires new technologies such as a dynamic adjustment of the charging process, for example to peak periods when there is a surplus of power generated by renewable energy sources, or the systematic analysis of vehicle-to-grid (V2G) input, because the grid-friendly integration of an increasing number of electric vehicles is an important precondition for the successful increase of electric mobility in Germany.

The ElmoNetQ project carries out a comprehensive analysis of the impact of electric mobility on public low voltage grid quality. To be able to construct representative grid models, the project will define probable



scenarios with regard to vehicle penetration, charging strategies, number and type of decentral power plants and grid structure. The model development will entail the experimental measuring of individual electric vehicle charging processes and their retroactive effects on the grid in a laboratory environment under various conditions. To verify the practical suitability of the models for the simulation of future scenarios, two specific charging scenarios will be measured at INNO-Park Kitzingen or the grid of Mainbernheim power station with the aid of real large-scale fleets, and compared to respective scenarios.

One important project result is the construction of a complex testing stand for the simulation of a low voltage grid (45 volt-ampere) with variable impedance as well as photovoltaic panels (10 watt) for the laboratory-based measurement of the separate and simultaneous operation of electric vehicles and power generation systems under realistic, reproducable changeable grid conditions.

There will also be a public-scientific discussion of the research results on an internet platform created especially for this purpose, including the publication of all of the electric vehicle charging process and photovoltaic inverter feed-in measurement data collected in the course of the project. And finally, recommendations for political action plans will be formulated on the basis of the simulation results for the defined future scenarios in order to optimise the grid integration of electric vehicles under consideration of the examined grid retroactions.

Joint project
Integration of renewable energies and electric mobility into the distribution grids — E3-VN

Project partners
TU Berlin, Workgroup for Infrastructure Policy (WIP)
BET Büro für Energiewirtschaft und technische Planung GmbH, Aachen

Duration
September 1, 2012–August 31, 2015

E3-VN

Besides the increased additional inflow of fluctuating energy from renewable sources, the envisaged expansion of electric mobility will also add to the pressure on German power distribution grids. The factors renewable energies and electric mobility therefore have a significant impact on power distribution grid management and expansion requirements. Electric vehicles are high-performance power consumers that are currently mostly charged uncontrolled. Initially, this makes the efficient use of the fluctuating power generated by renewable energy sources more difficult, although the pressures at distribution grid level will also continue to grow. In order to be able to counteract this in the long run, the extent to which the distribution grids should be expanded must be examined in more detail. In this context, the potential of alternative measures such as the implementation of allocation mechanisms for limited grid capacities is another factor to be considered. The precise nature of the regulatory preconditions that must be created for the controlled charging of electric vehicles and an adequate grid expansion must also be clarified.

The initial area of analysis addressed by the project E3-VN is therefore research into the best way to integrate electric mobility and renewable energies into the German distribution grids based on energy technical, energy management and institutional economic analyses under consideration of grid shortages and expansion costs. The local grid expansion requirements up until 2030 are to be identified on the basis of typical distribution grids illustrated by means of a load flow based grid model based on real grids and information gained from electric mobility expansion, energy and charging scenarios. The assessment is also to include forecasts of the distribution grid expansion costs. In addition, an economic analysis of tools for the allocation of limited distribution grid capacities such as pricing or randomly designated 'charging slots' is to be carried out.

There will also be a subsequent comprehensive examination of the extent to which allocation mechanisms for limited distribution grid capacities should be employed in the context of the integration of renewably energy reliant electric mobility into the energy system. In the area of storage technology, the joint project partners will be supported by the RWTH Aachen University's Institute for Power Electronics and Electrical Drives (ISEA).

In a parallel second analysis area, the project will examine the incentive and regulation approaches that stimulate and steer grid expansion under consideration of the integration of electric mobility and renewable energies. This will involve the thorough examination of various incentive and regulation approaches for distribution grids.

In this respect, the fact that the initial conditions and expansion requirements in the individual distribution grids are likely to be heterogenous must be taken into account. It must be analysed whether and how decentral information regarding the expansion requirements can be integrated into the regulation system in this context. On this basis, the project will examine what the current requirements are, and the available options for the further development of the German regulation system, especially the statutory incentive regulation (Anreizregulierungsverordnung, ARegV). ■

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