ENVIRONMENTAL RESEARCH
MOBILITY CONCEPTS
FLEET TRIALS
ELECTROMOBILE CITY
USER ACCEPTANCE
INTEGRATION
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INFRASTRUCTURE
DATA ANALYSIS
INNOVATION
TRAFFIC CONCEPTS

REPORT OF RESULTS

ELECTROMOBILITY MODEL REGIONS 2009–2011

Model Regions Electromobility

Funded by:
Federal Ministry of Transport, Building and Urban Development

Coordinated by:
NOW National Organisation Hydrogen and Fuel Cell Technology

REPORT OF RESULTS

ELECTROMOBILITY MODEL REGIONS 2009–2011

FOREWORD
REPORT OF RESULTS
ELECTROMOBILITY
MODEL REGIONS

The world of mobility is constantly changing. The best example of this is the rapid development of the automobile over the past 125 years since its patenting by Carl Benz. Today, new challenges are arising to which we must find answers. We have come to the important realisation that in the context of climate change and finite resources, our mobility must become significantly more environmentally and climate friendly.

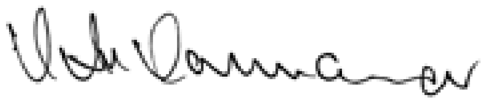
Innovations play a decisive role in solving the key challenges of the future – also where mobility is concerned. That is why we are focusing on new technologies such as alternative drives. Electromobility presents us with a great opportunity that we want to fully exploit. Whether battery-electric-operated with electricity from renewable sources, hydrogen and fuel cells, or a combination of drives: electromobility is a promising and climate-friendly alternative to the combustion engine.

New opportunities are also emerging for our economy. Our automobile sector is already the global market leader. It remains for us to use these competencies in order to become the market leader in the area of new efficient and sustainable technologies as well. Based on the results of the "National Platform for Electromobility", in which industry, science, politics, trade unions and a multitude of other stakeholders are bundling their resources, we have set ourselves the goal of making Germany the leading market and lead supplier for electromobility in our "Government programme for electromobility".

Electromobility has to be suitable for daily use, and one of the most essential levers for this is the "Electromobility in Model Regions" programme. Financed with 130 million euros, you are now reading the programme's report of results. A key focus of our efforts was to examine and promote the practical feasibility of electromobility in a variety of applications. To this end, with close cooperation between politics, industry and science, a broad spectrum of electric vehicles were tested in eight model regions until the end of 2011. The programme comprises over 200 individual projects, the implementation of which involved towns, administrations, local bus and public transport companies, public services, car manufacturers and numerous suppliers. Test drivers covered several million kilometres with over 2,000 electric vehicles. In addition, large hybrid bus fleets and the most comprehensive e-carsharing project in Europe were put in place. The experiences garnered from all the projects show that we are already now seeing important successes on the road to market preparation of electromobility. In the model regions in particular, the first positive results were obtained in economic terms, where close partnership structures between participants were created. In addition, it was possible to set up an infrastructure to meet demand, already comprising almost 1,100 charging stations with over 1,900 charging points.

The established structures now must be made permanent through, among other initiatives, the new funding programme "Showcase Electromobility", which builds upon the successful model regions approach in a concentrated way. The showcases are self-contained electromobility regions, in which the areas of energy, vehicle and transport management are to be integrated with their innovative technologies and solutions in an overall electromobility system.

I am delighted about the success of our funding programme so far and am firmly convinced that together with our partners from politics, industry and science, we will reach our ambitious targets in electromobility.



Dr. Peter Ramsauer
Federal Minister of Transport, Building and Urban Development

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FOUR QUESTIONS TO STATE SECRETARY RAINER BOMBA

>>1 WHAT IS SPECIAL ABOUT THE FUNDING PROGRAMME "ELECTROMOBILITY IN THE MODEL REGIONS"?

For me, the unique feature of the programme is the introduction of new technologies in everyday transport. It is about finding out where the advantages of electromobility – technical, environmental, societal and commercial – can be best applied. Our experience is that battery-electric mobility will not just emerge on its own – because it does not fulfil the customer needs of today in every circumstance. There will be no "iPhone moment" for the electric car. The conventional combustion engine is simply a much too comfortable solution – but it's not the best. And so we must discover the areas in which electromobility satisfies customer needs – and also the areas in which it lives up to its environmental claim to reduce CO_2 transport emissions. This is the core of the model regions – to test how energy, infrastructure, vehicles and customers fit together for commercially viable applications of battery-electric mobility in the future.

A second aspect is networks. No one can manage or implement these complex systems alone. The model regions have contributed to these networks: between the experts, which is to say the automobile industry and infrastructure, but especially between industry and the public sector as well – in regional structures on federal, state and local administration levels.

>> **2** WHY THE REGIONAL APPROACH? IS THERE NOT A DANGER OF 'DOUBLING' THE FIELD TESTS?

This was a criticism made at the beginning, which has not proved to be valid. This is not only because there are only a few key players who were involved, but a whole array of industrial companies, which of course are based in the regions. That means that the programme could include the entire technological diversity that occurs in Germany, especially where SMEs are concerned. In addition, the implementation of electromobility is tied to the specific location. The model regions have different experiences with supposedly the same approach, because of different existing local conditions. One could say that the decentralised approach is in fact one of the programme's strengths.

>> **3** WILL THERE BE PRIVATELY OWNED ELECTRIC CARS BY 2020?

Yes – because the development of battery costs shows that by 2020 the compact city vehicle with zero-emissions and a range of 100–150 kilometres can be an option for private users. Even with certain extra costs, one should not underestimate the customer base which is prepared to take on these additional costs. Yet it is clear that in the end only a part of the mass market of vehicle mobility can be covered in Germany. How large this share will become is difficult to predict, as the transport in Germany outside certain population centres is characterised by long routes which have to be overcome. The model regions have also shown – surprisingly for us – that public reaction in rural regions is unexpectedly high. This was the case in the operation of commuter vehicles.

>> **4** IN HINDSIGHT, WHAT SCENARIOS HAVE SHOWN THE GREATEST POTENTIAL FOR THE FIRST COMMERCIAL USE OF ELECTROMOBILITY?

The question is always, what does "commercial" mean? What interests us is the question of where could battery-electric mobility be relevant in the mass market – also with regards to environmental goals. Experience shows that electric vehicles for business use are already an attractive option. We must therefore particularly strengthen the area of fleets, be they car-sharing or business fleets, in companies or within local administrative structures. These will, in my view, be the initial markets for these vehicles. We should not however, forget about the mass market and the private customer – we must similarly also unlock this potential. Another promising area includes the efficiency improvements and fuel savings in public transport with hybrid buses – also as a bridge towards zero-emissions technology with fuel cells. Great energy-saving potential awaits discovery here, which can be tapped into relatively quickly. Electromobility convinces us not least through its many applications – and I look forward to using those possibilities in the future.

RAINER BOMBA, STATE SECRETARY AT THE FEDERAL MINISTRY OF TRANSPORT, BUILDING AND URBAN DEVELOPMENT

OVERVIEW

This overview is divided into five sections that build on one another (see fig 1): The brief summary is followed by a description of the concept and strategy of the "support programme for electromobility in the model regions". The results from the model regions over the past two years have also been presented and structured according to areas of operation. A conclusion can be drawn from the findings in these three areas. The overview ends with the prospects for the future development of electromobility.

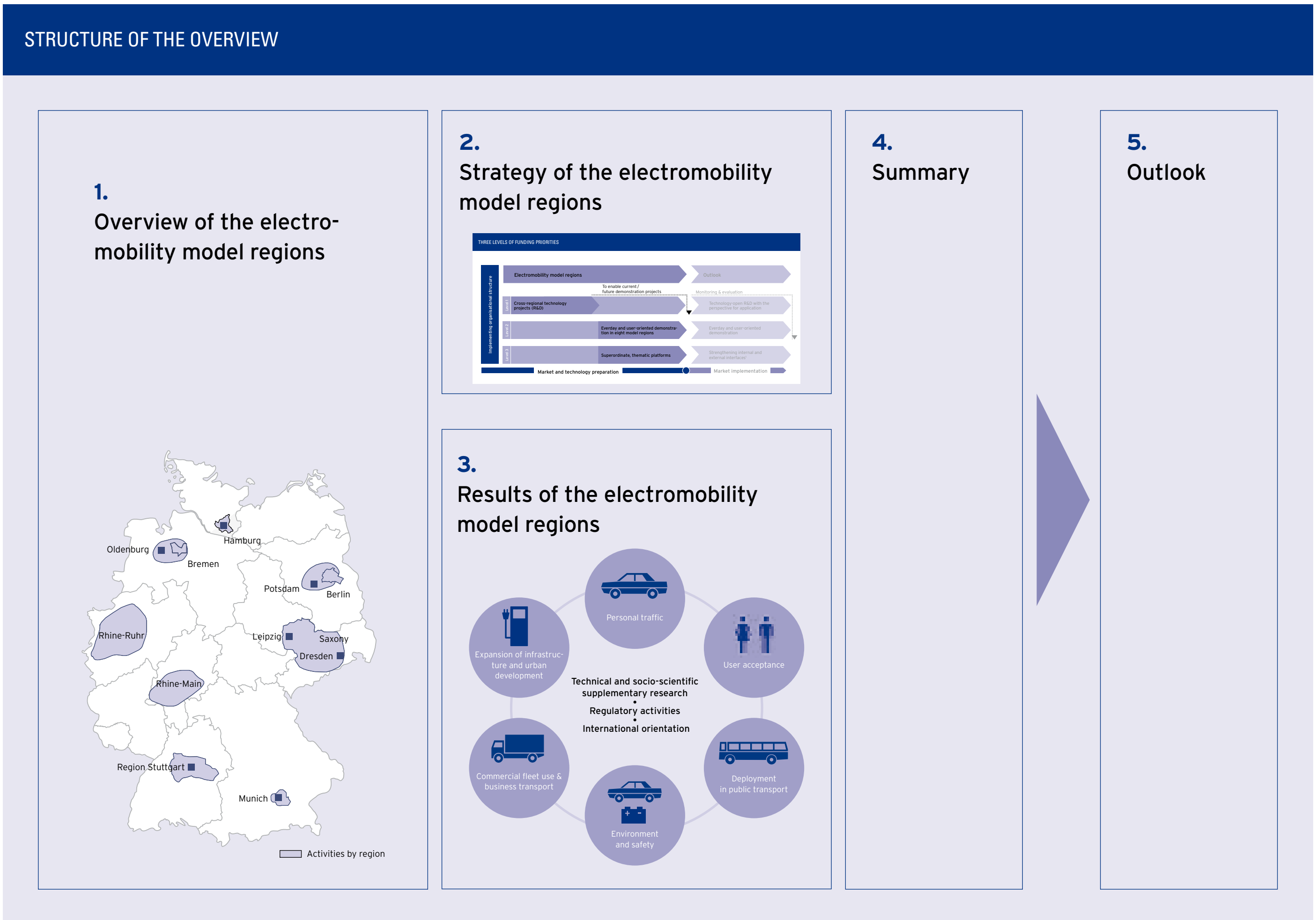


FIGURE 1

>> 1. THE MODEL REGIONS. AN OVERVIEW OF ELECTROMOBILITY

Against the background of the global climate change and the increasing shortage of fossil fuel resources, electric-driven vehicles – powered by electricity from renewable energy sources – offer a possible solution for the sustainable provision of mobility. Industrialised countries such as the US, Japan or France, but also China, are already very much involved in the development of this innovative sector, which combines ecological, technological and not least economic perspectives. For Germany, one of the leading nations in the conventional automobile manufacturing industry, investment in electromobility also means ensuring the future viability of one of the country's most important industries.

The federal government intends to establish and further develop Germany's role as a lead market for electromobility. It plans that by 2020, a million electric vehicles will be driving on our streets. The federal government is promoting this development through targeted programmes. With this purpose, the Federal Ministry of Transport, Building and Urban Development (BMVBS) has introduced the support programme "Electromobility in the Model Regions". This supplements the "National Innovation Programme for Hydrogen and Fuel Cell Technology" (NIP), which was launched in 2006. Together, these two successful programmes cover the application of the key areas of development in the electromobility sector: battery and fuel cell technology.

The support programme was launched using funds from the economic stimulus package II at the time of the global economic crisis. From 2009 to 2011, the development of electromobility in Germany was supported with a total of 500 million euros. The "Electromobility in the model regions" programme was a key component as it was funded with approx. 130 million euros. In a period of economic difficulty, the programme helped the industries involved, as well as the scientific institutions and local municipalities, to move ahead with innovative developments in the field of sustainable mobility.

GOALS OF THE SUPPORT PROGRAMME

The basic idea behind "Electrobmobility in the model regions" is that the introduction of electromobility must be considered in a larger context. In practical terms, this means the development of a completely new, very different mobility system that will secure mobility for the economy and society long term. Electromobility will play a key role in fulfilling different mobility needs. In order to continue to stimulate this development, which has already been initiated, and promote it long-term, the support programme is pursuing the following goals.

Goals of support programme for the market and technological preparation of electromobility

- Technologically open research and development (R&D) for battery-powered electric vehicles
- Everyday, user-oriented trials
- Integration in mobility, spatial and urban development
- Local networking between agents from the relevant industries, science and the public sector
- Results-oriented exchange on umbrella platforms

Electromobility is developing in coordinated, locally-based processes. For this reason, the project support programme takes a regional, yet comprehensive cluster approach. For a period of two years, eight model regions joined forces to create a regional innovation network for a long-term, nationwide innovation process to prepare for market entry and develop the technological aspects of electromobility.

In connection with this, electromobility was perceived as a more extensive development of mobility in general. For this reason, the needs and experience of the individual projects were incorporated conceptually into the mobility, spatial and urban planning.

In addition, key issues drawn from all of the supported projects were worked on in seven umbrella platforms. Numerous companies and research institutions worked in close cooperation on these platforms, an approach that is unique among the project support programmes to date. As a result, a large number of concrete recommendations for action to promote the further development of electromobility in different areas of operation could be recorded.

THE EIGHT BMVBS MODEL REGIONS

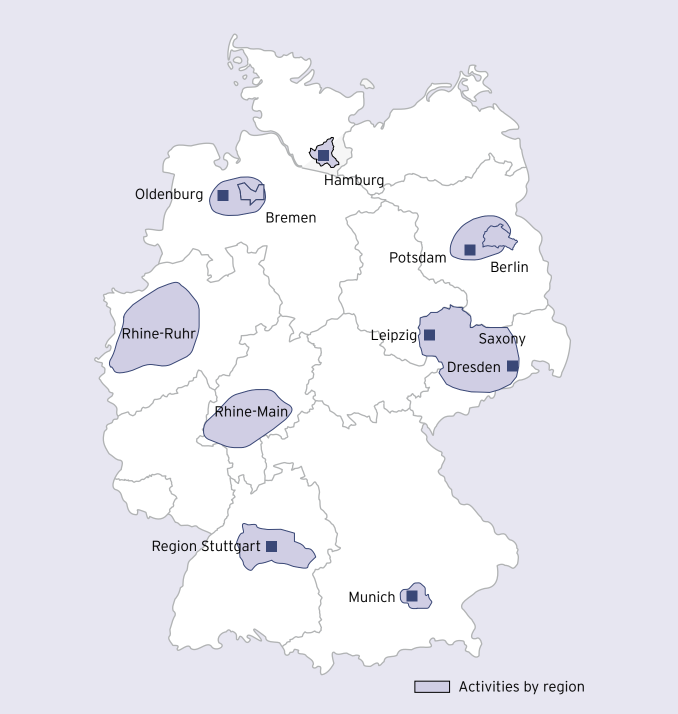


FIGURE 2

SUCCESS OF SUPPORT PROGRAMME: FACTS AND FIGURES

With regard to the vehicles in operation, the wide range of topics and the diversity of the partners involved, "model regions electromobility" was the most significant German support programme for battery-electric mobility in the context of the second economic stimulus package.

Model regions in figures: the programme

- Overall investments to the sum of around 300 million euros: funding provided by the government to the sum of around 130 million euros with private industry contributions of at least the equivalent value
- 220 project partners involved, approx 150 of them from the sectors automobile manufacturers, component manufacturers and suppliers, energy supply companies, logistics and transport
- Key focus on private sector: approx 70% of the funding went to private companies, 43% to SMEs
- In six content-based platforms, project partners from the sector operative implementation met regularly in order to present and exchange experience. In this way, the largest available database on the topic of electromobility in Germany was created. The seventh platform was responsible for the overall programme communication.

Model regions in figures: vehicles, infrastructure and users

- A total of 2,476 electric vehicles were in operation in the model regions: 59 buses, 243 utility vehicles, 881 cars, 693 two-wheelers & scooters and 600 pedelecs were systematically integrated into the transport system with the goal of analysing project-specific themes. The total distance travelled by the electric vehicles overall in the eight model regions is well in excess of 2.2 million kilometres.

- Experience drawn from the real operation of prototypes and pre-production models made a significant contribution to further market and technological developments. The first series-production vehicles from German manufacturers will be on the market in 2012.

- Approximately 70 demonstration projects with different vehicle fleets were spread among the sectors individual transport, commercial transport and public transport.

- A charging infrastructure was set up. This includes far in excess of 1,100 charging stations with 1,935 charging points in public, semi-public and private locations.

- Energy efficiency: with the deployment of hybrid buses, more than 90,000 litres of diesel could be saved during the project period. This is equivalent to approx. 270 tons of the greenhouse gas CO_2.

- Use of renewable energy: when using a charging current from renewable energy sources, CO_2 emissions between 16 and 29 gCO/km were generated in the model regions, depending on the vehicle category.

- Safety: the safety documentation of the deployed vehicles showed that during operation no malfunctions or shortcomings could be ascertained that might represent a danger for the user. 90% of all the defects identified had technical-mechanical causes that could be rectified by the manufacturers during the course of the programme. Approximately 30% of them were not specific to electric vehicles.

- Within the framework of the socio-scientific supplementary research, more than 20 companies and scientific institutions have acquired data on the topic of user acceptance in all the model regions, using a standardised dataset.

- Approx. 2,300 user surveys have been carried out on themes such as expectations (around 800 surveys), first impressions (around 1,000 surveys) and experience with electromobility (around 500 surveys).

>> 2. MODEL REGIONS ELECTROMOBILITY – THE STRATEGY

The National Electromobility Development Plan is now to a large extent outdated. Figure 3 shows an overview of the structuring aspects of the programme strategy. The strategy concept has been divided into three levels: the cross-regional technology programme, the trials in eight model regions and the platforms dealing with umbrella topics. These three levels of the programme will be implemented using a comprehensive organisational structure, comprising of local and key elements.

CROSS-REGIONAL TECHNOLOGY PROJECTS

Initially, when the support programmes were launched, only a few electric vehicles were available. It was ascertained at a very early stage that further development and investment was needed in the challenging area of vehicle technology. In order to press ahead with technological developments and avoid bottlenecks in the operation of vehicles used for trials, cross-regional projects were supported in the field of technologically-open research and development. These projects were dedicated to the following topics:

- Hybridisation in the heavy goods vehicle sector as well as rail transport operations and local public transport
- Technological development and testing of two-wheelers
- Fleet tests with vehicles
- Realisation of innovative vehicle concepts using electromobility concepts
- Development and testing of electric-driven sports cars
- Establishment of battery centres
- Innovative inductive energy supply systems in the public traffic sector, on streets and railway lines.

EIGHT MODEL REGIONS

In order to optimally prepare for a successful market launch, it was necessary to set up trials in the model regions to test the vehicles in everyday use, as well as from a user perspective. For this purpose, a nationwide competition was organised and eight model regions were selected from among 130 entries. The following metropolitan and expansive regions were chosen:

- Hamburg
- Bremen / Oldenburg
- Berlin / Potsdam
- Rhine-Ruhr
- Saxony
- Rhine-Main
- Region Stuttgart
- Munich

Tailored to meet local needs, it was possible to optimally incorporate the application-based research and development in these model regions. This took place within the regions, in each case with different emphasises and a large number of different protagonists.

For the purpose of market and technological preparation, all the local and regional parties involved who were to play a decisive role in the future market success were brought together. This also meant that existing networks and co-operations could be used effectively.

THREE LEVELS OF FUNDING PRIORITIES

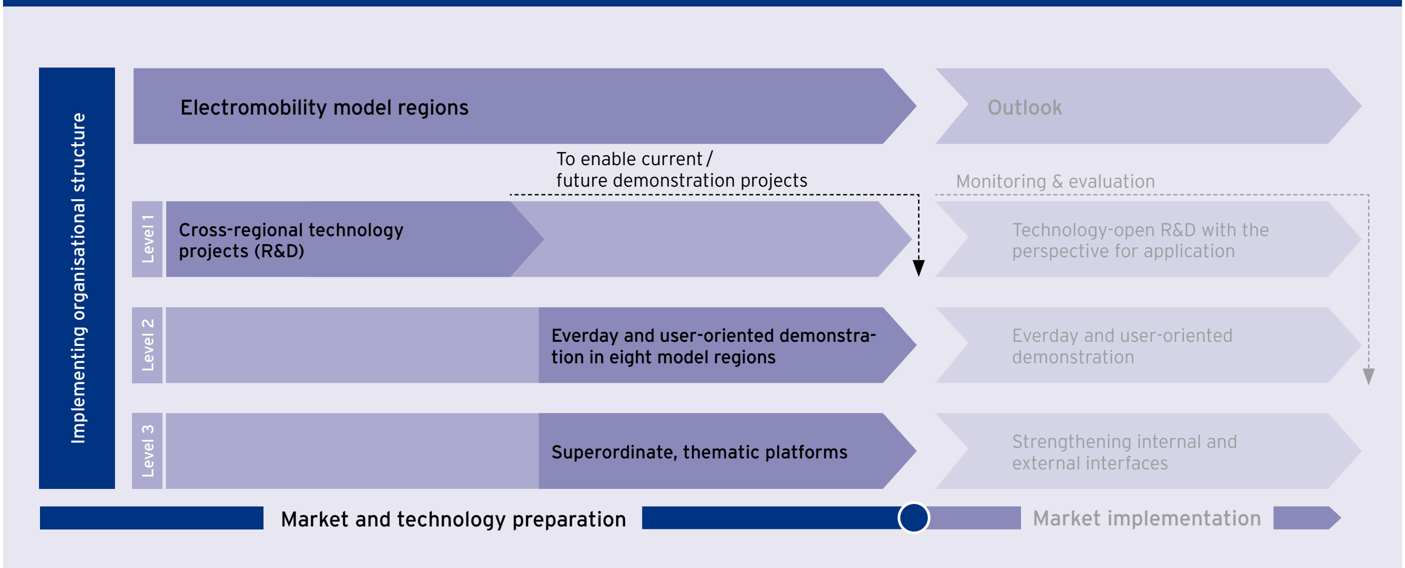


FIGURE 3

Typical composition of the project consortiums

- Agents: vehicle manufacturers, component developers, cross-regional energy supply companies and regional public utility companies as installers and operators of charging infrastructure, service providers, public authorities
- Transport carriers: bus and rail applications, cars, utility vehicles incl. heavy load applications, two-wheelers

The individual projects are characterised by different goals, for example:

- Set-up and development of infrastructure, allowing for open, non-discriminating access
- Analysis of the regionally diverse (electro-)mobility performance in everyday situations
- Networking of the different applications and users: integration of electric vehicles into intermodal transport (e.g. linking road and rail) and mobility services (e.g. carsharing), private and business-related mobility patterns, as well as commercial and delivery traffic
- Consideration of specific city and urban planning aspects to enable the initiation of comprehensive transport concepts
- Development and analysis of the business models of regional companies and organisations, e.g. collaboration between the local energy suppliers and local public transport companies and fleet operators.

SUPERORDINATE THEMATIC PLATFORMS

Of the previously-mentioned seven platforms, six were responsible for processing content-based issues. The seventh platform focused on the overall communication within the programme. The task of all the platforms was to respond to questions affecting all areas and to ensure an exchange of information between the model regions, in order to identify best-practice cases and avoid duplication of work. In this respect, a key measure was on one hand the direct exchange of experience between the project partners in the eight model regions and the BMVBS (Federal Ministry of Transport, Building and Urban Development). On the other hand, a long-term networking system for all parties involved was initiated at the same time. The platforms were able to draw on a diverse range of data from all the model regions, ranging from the user survey to individual measurement data from the vehicles. This data was usually provided and prepared by the participating partners, companies and research institutes involved.

PARTNER STRUCTURE OF THE PLATFORMS

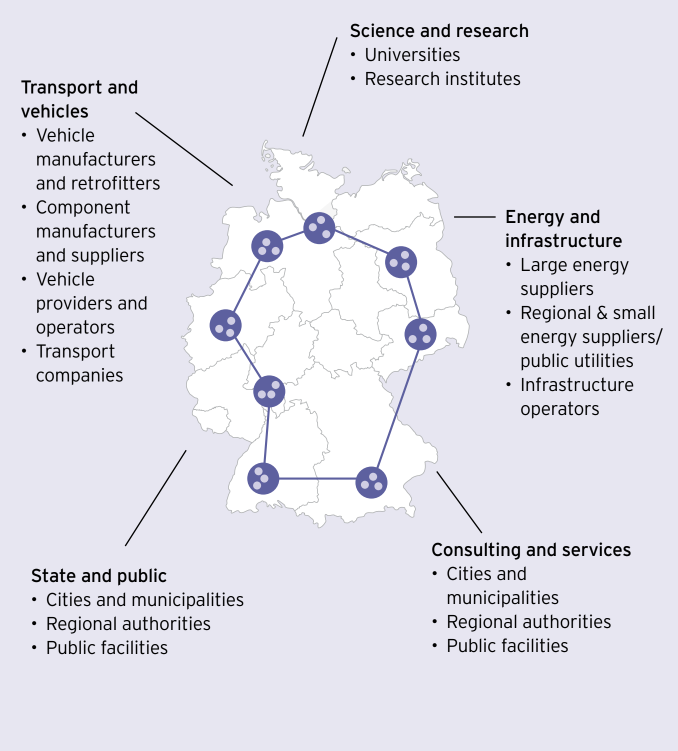


FIGURE 4

The group of participants in the platforms in figure 4 reflects the structure of the project networks in the model regions. Together, representatives from business, science and research as well as the public authorities concerned themselves with the current and future challenges posed by electromobility.

Figure 5 shows the network of superordinate thematic platforms. The platforms were divided into three main areas of focus: innovative drives bus, innovative drives car and transporter as well as infrastructure. These topics were supplemented by the following overlapping topics: regulatory framework, socio-scientific supplementary research, supplementary research environment and supplementary research safety. These themes were worked on in different constellations: by one platform or several simultaneously. There was a regular exchange of information and experience, or the topics were examined in-depth by work groups.

CROSS-LINKING OF THE PLATFORMS

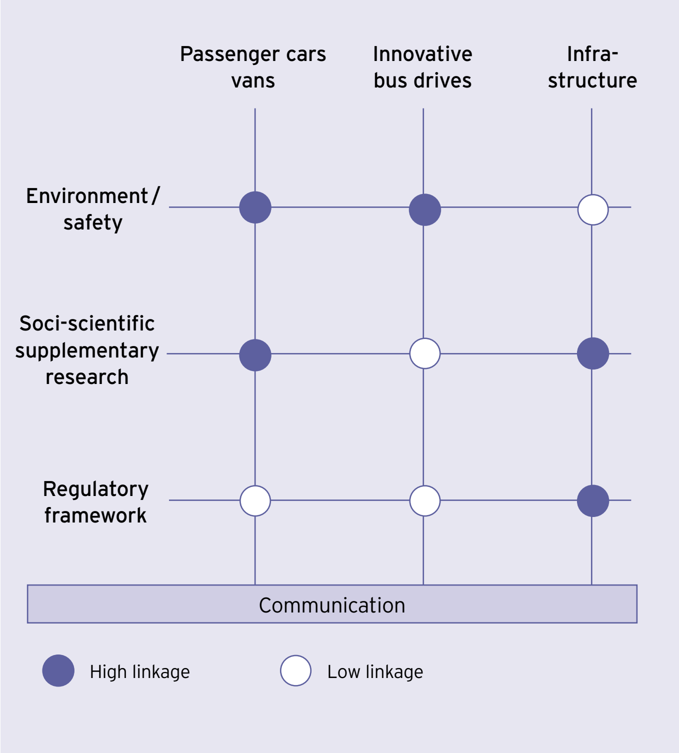


FIGURE 5

IMPLEMENTATION OF ORGANISATIONAL STRUCTURE

In order to implement the main area of focus with its three programme levels (see fig 3), existing organisational units were integrated into a structure and new ones were created (see fig 6).

The BMVBS developed and took overall responsibility for the support programme and also ensured the content-based coordination with other federal government activities, anchoring them in a political context. In the process, the federal government took responsibility for the content-based determination of the main area of focus in the electromobility sector and formed the interface with the National Platform Electricmobility.

The NOW GmbH (National Organisation Hydrogen and Fuel Cell Technology) was responsible for the programme management and the overall coordination of the model regions. This included the content-based preparation for the project selection based on the main areas of focus compiled by the BMVBS and the subsequent concretisation of project drafts from the industry, scientific institutions and local municipalities, together with the regional project coordination centres. In addition, NOW initiated and coordinated the seven umbrella platforms and assisted the individual projects and network schemes with the implementation.

IMPLEMENTING ORGANISATIONAL STRUCTURE

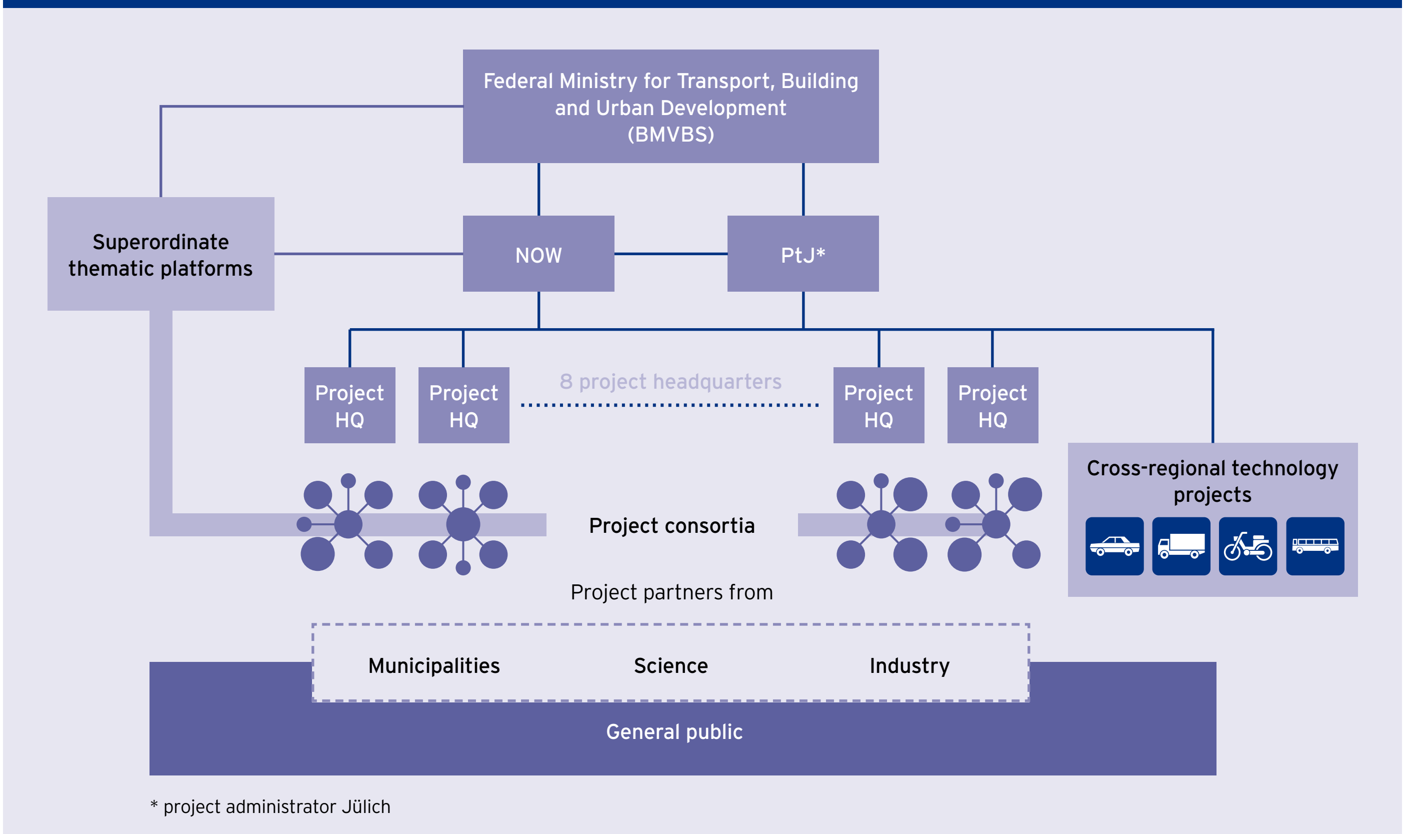


FIGURE 6

Following the project selection and handover by the BMVBS and NOW, the project administrator Jülich (PtJ) provided the project partners with administrative support in filing an application. In addition, they issued a letter of intent and later the official notifications regarding funding. The lead partner was also responsible for the administration of the funds, providing support with the completion of projects and the invoicing at the end of each respective project.

The organisation and implementation of the projects in the eight model regions was carried out by regional coordination centres, which were also funded by the programme. The coordination centres were set up with agents that have strong roots in the region, from the sectors business development, public utility companies, energy agencies and other public-private partnerships. In this way, local and regional participation could be guaranteed quickly and the regional responsibility for the implementation of the programme could be strengthened. The regional coordination centres quickly became competent in putting regional agents in contact with one another and bringing together project consortiums.

>> 3. MODEL REGIONS ELECTROMOBILITY – THE RESULTS

In view of the economic significance, the effective implementation structure, the number of vehicles deployed, the infrastructure installed, the wide range of themes and the diversity of the partners involved, at the end of 2011 the model regions electromobility represented the most extensive German support programme for battery-electric mobility. This meant that in the last two years, valuable insights could be gained regarding the further development of electromobility.

ECONOMIC SIGNIFICANCE

The BMVBS support programme "Electromobility in the model regions" was launched at the time of the global economic crisis in 2008/2009 using funding from the economic stimulus package II. Although the economy was unstable at this time, it was possible to win partners who were willing to implement the programme. In addition to this, the programme triggered positive economic stimulus overall, for example through the support given to German manufacturers for the development of vehicles, some of which are already being promised for 2012.

In the course of the long-term move towards a successful market development and mass market (see fig. 7), it has been possible to achieve a large number of positive economic effects in the past two years as a result of the support programme:

- The innovation chain of the participating companies was supported by providing compensation for the cuts in the research and development budgets in 2009.
- By bridging funding gaps in the early product cycle phases, an important contribution towards market preparation was made, for example, in the case of new products with high of social benefit level, which are at the same time a high financial risk for the manufacturers and operators.
- The demand for electromobility in the form of fleet operation was strengthened by motivating a large number and diverse range of industrial partners to participate (approx.150 private sector companies of different value-added levels and sizes from a total of 220 participating partners).
- In the future-oriented sector electromobility, key competencies (e.g. in the case of suppliers of power components and systems) were developed for different partners.
- By setting up regional networks, sustainable structures for future collaborations were created.
- Initial business models were developed and tested.
- Experience gained though everyday operations and the provision of target-group-specific information for users and operators formed a basis for future investment decisions and triggered an initial buying interest in the (test-) vehicles, not only among the investors.

IMPLEMENTATION PROCESS

The participants perceived the organisational implementation of the support programme to be successful and helpful in achieving the goals. This was ascertained in the independent evaluation of the programme. Following small delays at the beginning of the implementation, partly caused because structures needed to be set up, the central and organisational structures have proved to be valuable.

The project funding and subsidies for the support programme "Electromobility in the model regions" was awarded in four stages (cf. fig 8). The call for declarations of interest, the submission of project drafts and the concretisation and planning in 2009 was followed by the formal application a year later. On the basis of a letter of intent, the project ensured that the partners were able to begin work quickly. In this way, it was guaranteed that the project partners would receive securities in advance to cover the anticipated R&D investments. Parallel to this process, the compilation and delivery of the notifications of funding was made throughout

INNOVATION CHAIN TO THE MASS MARKET

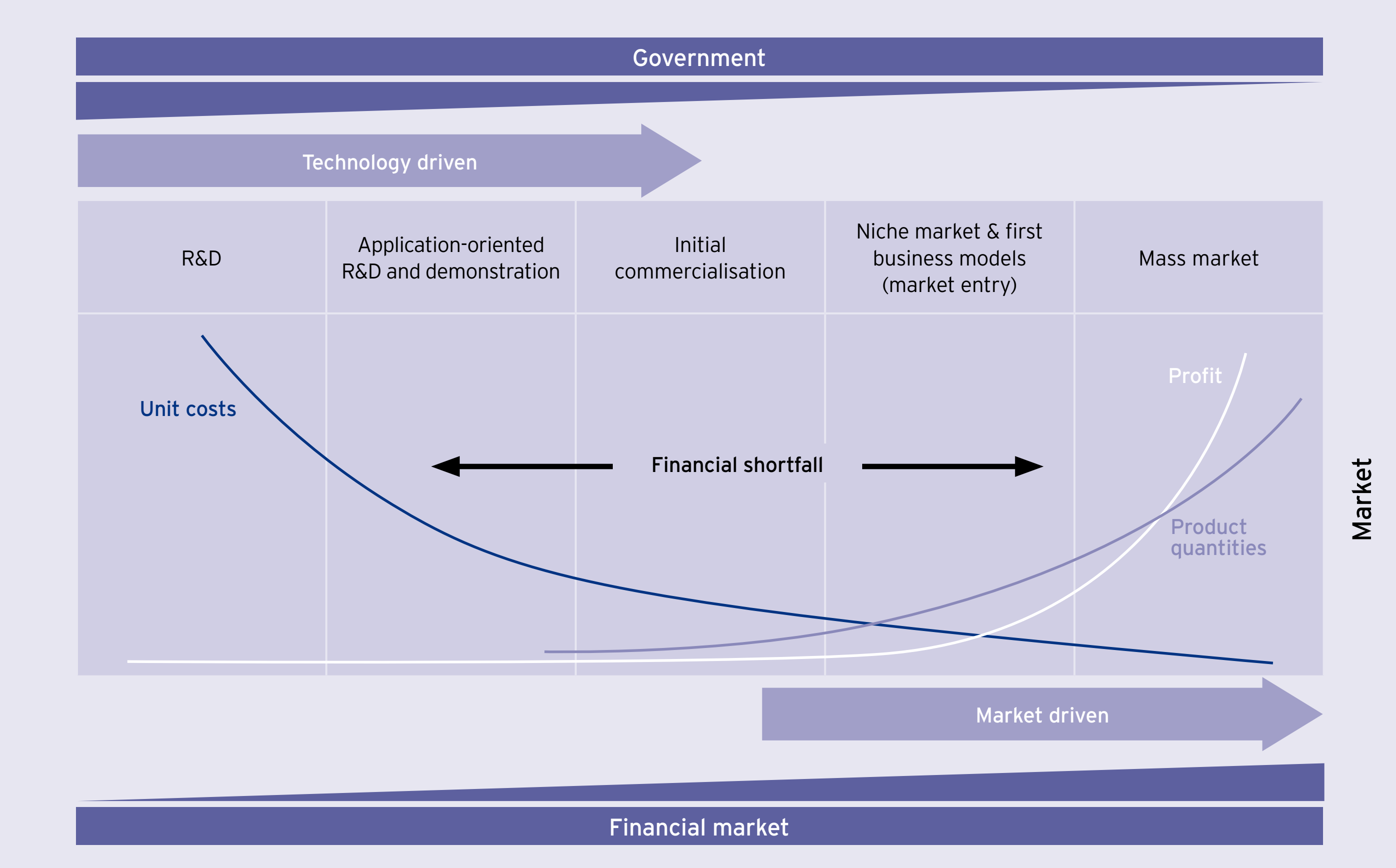


FIGURE 7

FUNDING APPROVALS AND DRAWING ON FUNDS

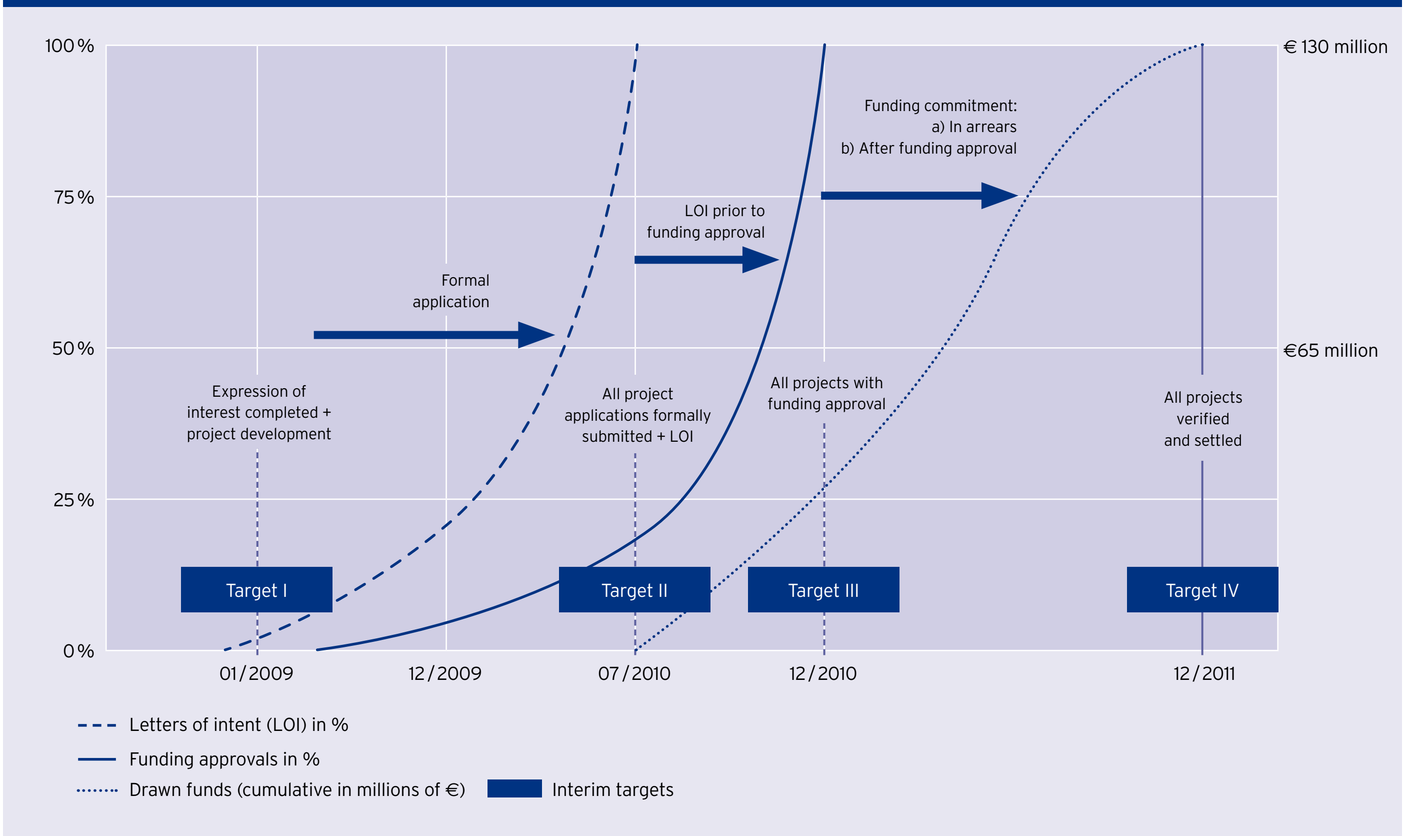


FIGURE 8

2010, as planned. This meant that the funds were also tied to the projects submitted. This process was completed by the end of the year as planned. Since mid 2010, the funds commitment has been in line with the funds outflow, according to the original planning. The target value for 2010 was even exceeded with approx. 50 million euros funds commitment by the end of the year. The call for funds was implemented by the end of 2011.

VEHICLE USE AND INFRASTRUCTURE DEVELOPMENT

The key components of the areas of operation described in the next section were the vehicles deployed and the charging infrastructure that had been set up. The following overview provides information about both categories. Within the projects, it was possible to test 2,476 vehicles from five vehicle segments in different fields of operation in a way that was diverse and relevant to everyday life. The trials included hybrid and all-electric vehicles. In addition, 1,935 charging points were set up. A differentiation was made here between publicly accessible, semi-public and private charging points.

The positive experience made with the vehicles in operation shows that the right basic strategic approach is being taken with these measures. Although with regard to the technical operations, there were individual cases of the technology causing problems (for example in the areas of infrastructure and vehicle technology), the majority of these cases were recognised and to some extent remedied during the project period. Yet these trials in everyday conditions cannot be considered complete. There are diverse reasons why further analysis and optimisation is needed. The tested vehicles showed that there is a need for technical modifications, for example, in winter operation and with regard to the range, the increase in efficiency, the improvement of the vehicle quality and in the area of maintenance and service.

The demonstration projects have also shown that it is not sufficient to replace conventional vehicles with electric vehicles as a response to the current transport development. In future there will be an increasing need to work on more long-term solutions and to tackle them in good time: funding of the local public transport system, a stronger network between private transport, local public transport and rail transport for longer distances, as well as different forms of carsharing.

INTERIM CONCLUSION: MODEL REGIONS ELECTROMOBILITY – A MODEL FOR THE FUTURE

Overall, the BMVBS support programme electromobility can be perceived as a success. In addition to the important data regarding the deployment of vehicles, the work in the model regions led to utilisable and sustainable knowledge based on a wide range of experience of all the parties involved. The open approach to technology and the ongoing, moderated networking of all participants, with the project headquarters on a regional level and

VEHICLES IN THE MODEL REGIONS
RESULTS OF THE PROJECT CONSORTIA

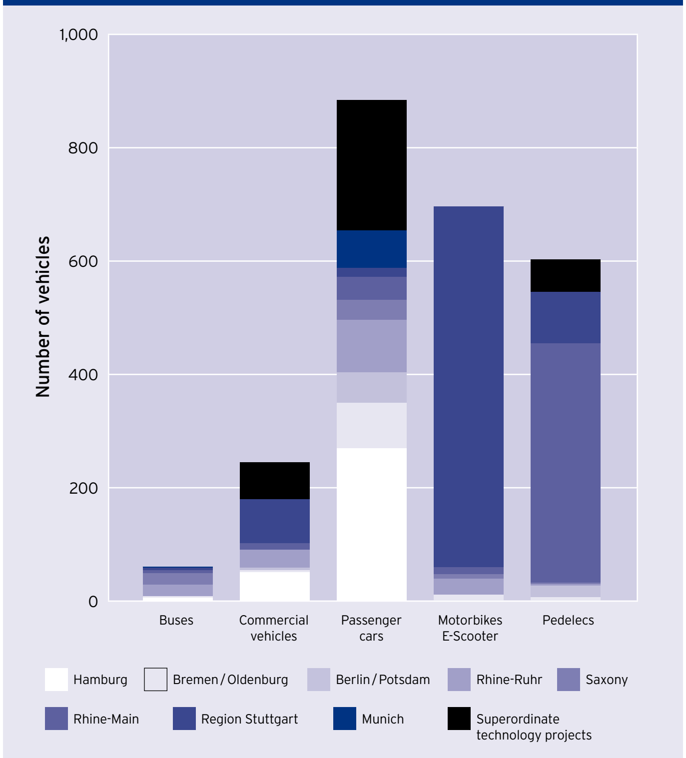


FIGURE 9A

CHARGING POINTS IN THE MODEL REGIONS
RESULTS OF THE PROJECT CONSORTIA

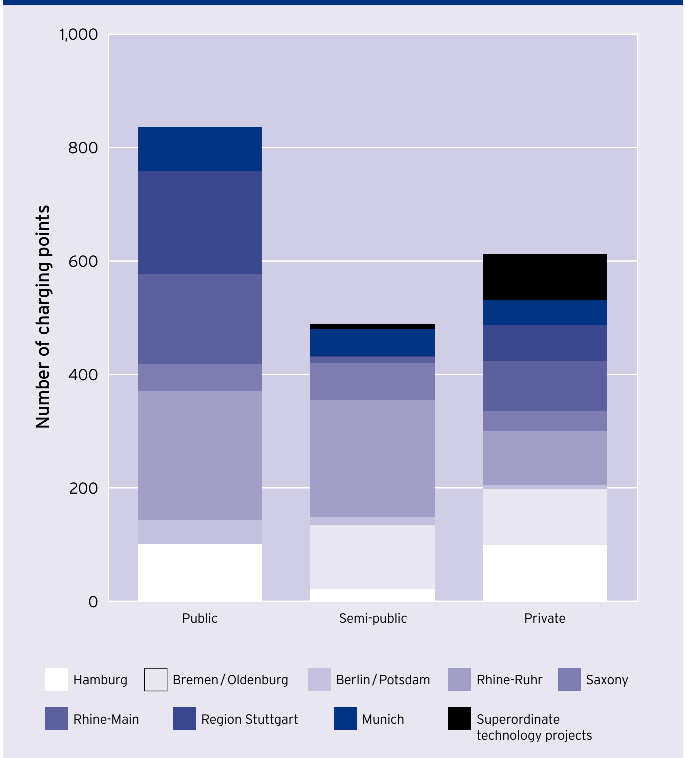


FIGURE 9B

the platforms on a national level acting as umbrella organisations, can be evaluated as particularly successful. The proximity of the agents involved, as well as their spirit of collaboration made it easier to generate a higher level of media and public attention and also to supply these with information.

RESULTS ACCORDING TO AREAS OF ACTIVITY

In the following chapter, the results of the programme have been structured according to six areas of activity.

Electromobility in private transport

In the sector private transport, a large number of vehicles, together with the corresponding infrastructure, were deployed in cooperation with manufacturers, operators and infrastructure partners. A total of 881 vehicles were in operation in the model regions. The goal was primarily to test battery-powered vehicles in the everyday private transport sector.

In addition, the testing of two-wheelers (motorbikes or e-scooters) and electric bikes was a further element of the trials. Due to the advanced marketability level of these vehicles, the task was primarily to test a range of new applications for them and in this way to explore their scope for mobility concepts. Some examples were the integration of pedelecs and e-scooters in the ranges offered by car-sharing fleets and their deployment as low cost commuter vehicles for mid-range distances between 5 and 15 km, which not everyone can manage easily. In the model regions for example, local municipal facilities and commercial enterprises were found, which were prepared to deploy pedelecs as company vehicles or as commuter vehicles for the journey to and from work for a trial period.

Approximately 250 drivers are using the vehicles daily, either privately and / or for business journeys. In addition, numerous people were able to gain a first impression of electromobility. In the context of the socio-scientific supplementary research, a central data platform was made available for evaluation purposes and all the relevant user data was collected here. At the same time, the suitability of the electric vehicles for daily use in company fleets was tested.

The findings of the socio-scientific supplementary research show that there will not be a more extensive private use of electric vehicles until the medium term. As they do not yet cover long distances and due to the length of the charging time, electric vehicles are more suited to city and commuter journeys. A surprising aspect was the positive feedback regarding the use of electric vehicles in rural districts. The reasons for this are the availability of private parking spaces with a private power supply connection and the easier scheduling of the commuting distances, which are also generally within the range of one charging cycle.

OVERVIEW OF AREAS OF ACTIVITY

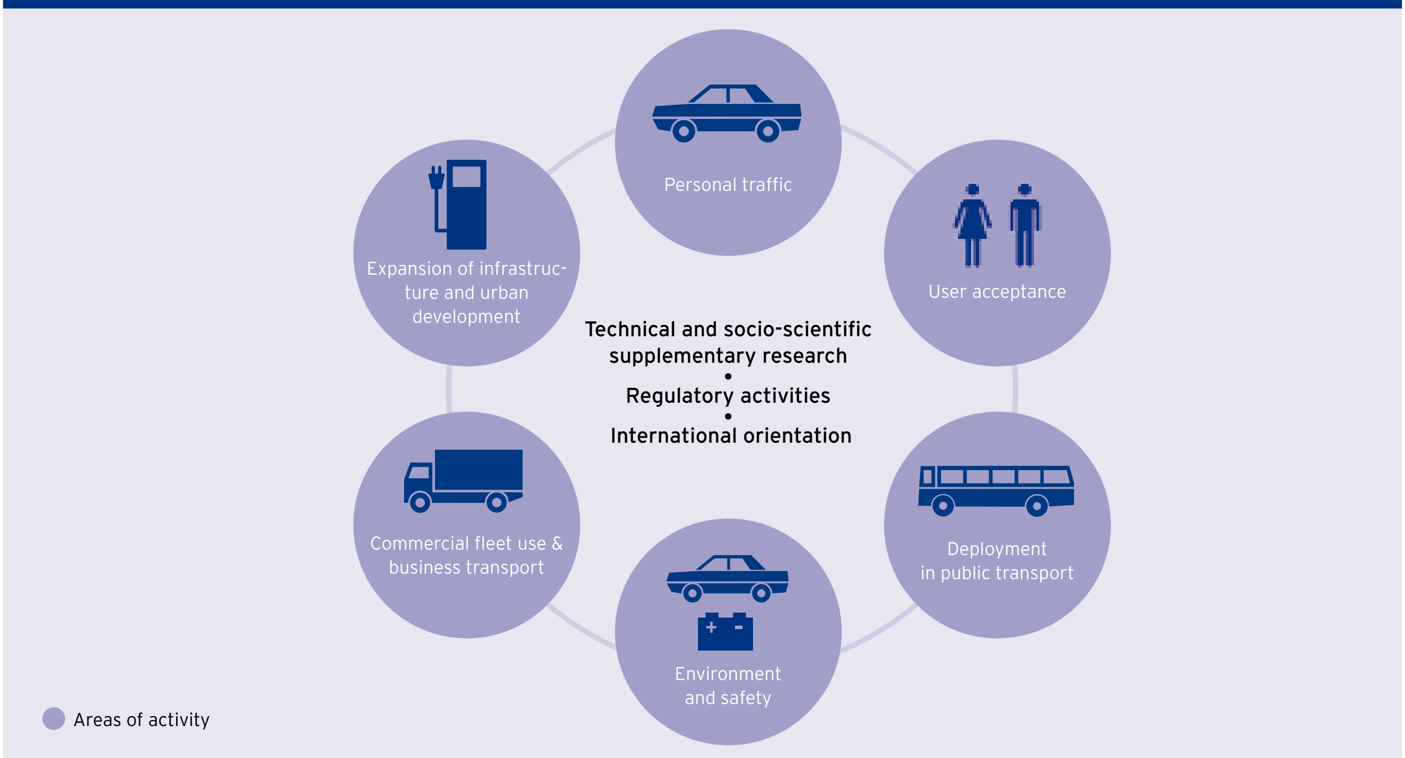


FIGURE 10

One hurdle is the fact that the purchasing costs are still high. Different forms of carsharing, organised as a neighbourhood concept for example, could help to deal with this aspect more quickly.

Special attention should also be paid to a further result of the user survey, which could have a big impact on the development of a battery-electric concept in the private sector: the survey respondents perceived the integration of electric vehicles in more broad-based mobility concepts to be a positive future development, for example, in combination with local public transport, as part of a carsharing concept or as an intermodal approach. The electric vehicle is therefore not only seen and accepted as a further development for the conventional private vehicle but also as part of a sustainable mobility chain.

Electric two-wheelers are to a large extent ready for the market and are for many users already a potential option due to the generally lower costs involved. This is backed up by the user acceptance surveys that were carried out in the context of the socio-scientific supplementary research. The expectations that the users have of electric vehicles are primarily driving pleasure, environmental friendliness, suitability for everyday use and easy operation. According to the available data, this applies much more to two-wheelers than cars or utility vehicles.

Use in public transport

The project consortiums in this sector concerned themselves primarily with the deployment of hybrid buses in urban traffic. A total of 59 hybrid buses with innovative drives were in operation in the model regions. They travelled a distance of almost one million kilometres and were in operation for more that 50,000 hours in total. The average distance travelled daily by the hybrid buses was approximately 200 kilometres, which is almost equivalent to that of the conventional buses. This also applies to the average daily period of use of 14 hours, which is only slightly below the usual values for diesel buses. The cross-regional platform "innovative drive bus" provided a comprehensive analysis of these trial operations. The collaborative results of this platform make it possible to systematically evaluate the practical feasibility and climate protection benefits of these platforms for the first time.

The deployment of hybrid buses in urban traffic is generally perceived to be very positive. Following an introductory phase, with 70–80%, the availability levels in the trial projects came close to that of the conventional buses (approx. 95%). The buses showed considerable energy-saving potential (up to 19%) with subsequent environmental benefits. Acceptance of the technology is increasing among the transport companies. Initial programmes for the initial and further training of the staff were set up and implemented. It was also possible to set up the first service and maintenance facilities aimed at meeting the specific needs of hybrid buses and these could also be integrated into the daily operations.

The energy savings are still less than the theoretical saving potential. According to the previous status of the analysis, this is the result of different factors, for example company management, air conditioning, route characteristics and a limited comparability of the vehicles. The manufacturers are aware of these issues and have incorporated them into their optimisation measures. In addition, the findings are helpful in the implementation of improved measures.

Nevertheless: Due to the reduction of diesel consumption achieved in comparison to the non-hybrid buses during the course of the project in the model regions electromobility, it was possible to avoid emissions of 270 tons of the greenhouse gas CO_2. This is equivalent to approx. 90,000 litres of diesel. In addition to the analyses and evaluations of the vehicle technology and the operating performance, in the context of the platform, analyses were also made regarding the acceptance and perception of the hybrid technology. Both the bus drivers and the participating transport companies, as well as passengers and passers-by were questioned. The recorded results show that hybrid buses were evaluated positively in general.

In terms of positive environmental impact, even greater potential can be ascribed to all-electric buses. There is, however, still considerable need for development. The buses are currently available in the size of midi-buses. The first models for public service buses have now been announced. When and to what extent the public service buses can be replaced by all-electric buses still requires research.

One example of the innovative technological developments in the public transport sector are the new, inductive energy supply systems for buses and trains that no longer require elaborate overhead wiring and allow for a contact-free charging procedure. Initial projects were launched in the model regions to explore this aspect. More information is available in the third section of this report.

In the field of rail traffic applications, the retrospective hybridisation of diesel carriages was tested. The areas of operations are the non-electrified routes. This technology promises considerable energy saving potential and an increase in efficiency and opens up new perspectives for marketing, in particular in countries where the majority of the rail traffic is not electric.

Industrial fleet operation and commercial transport

According to the results available, it seems that inner city industrial fleet operation is an important area of operation for electric vehicles. For fleet operators, the deployment of electric vehicles is financially viable at an earlier stage than for private customers. This area of operation could speed up the further development of electromobility considerably. This is on the one hand due to the easier scheduling and the consistency of company journeys. These make it possible to match the regular travel and charging operations with the vehicle range. Hence shorter distances become less important. For this reason, the fleet operators also only require public charging points in exceptional cases, as has been shown by the trial operations. A further reason: in fleet operations, specialised vehicles can be deployed much more efficiently than in the private sector. Hence, electric vehicles could be used for inner city short-distance traffic and supplemented by conventional vehicles for long distances. In another area, the introduction of battery-driven vehicles is already showing benefits. The parcel delivery services in large cities, for example, are already covering distances of between 80 and 120 km per day – sometimes only 40 km, depending on the route. In this context, 100 stop-and-go processes could be recorded. In this case, electric vehicles can take complete advantage of their saving potential because they start without any power loss and in addition regain momentum with every brake application.

In the trial projects for commercial use, a range of very different vehicle types was deployed. Depending on the company, these were smaller and medium-sized cars but also two-wheelers, especially pedelecs. The vehicles were deployed, for example, in customer service or were on the road on behalf of the local municipalities. Although a period of becoming familiar with the vehicle was usually necessary, in order to break down any barriers and trigger enthusiasm among potential drivers, the response of the users and the fleet operators was for the most part positive.

Larger utility vehicles were also in operation in the model regions. The deployment of hybridised or all-electric utility vehicles has even proved to be of particular interest to commercial contractors. In the transporter sector, users from retail, the trades and messenger services were addressed. The market situation was assessed with view to the refitted vehicles and pre-production or small batch series. The main focus was on medium-heavy trucks with hybrid drive as well as the battery-electric sector that includes small or medium-sized transporters such as the Renault Kangoo or the Vito E-CELL by Mercedes-Benz. In total, 243 utility vehicles were deployed including special vehicles such as hybrid-driven refuse collection vehicles, which were also tested in everyday conditions. In the case of these vehicles, which have high fuel consumption levels in stop-and-start operations, the consumption could be minimised by a third. In addition, the noise emissions were reduced by 15 dB(A).

Parallel to these findings in the sectors cars and two-wheelers, the battery-electric driven utility vehicles can already be efficiently deployed. Although the high investment costs are still an obstacle in the development of commercial operations, in addition to the previously-mentioned benefits, other benefits of electromobility in this sector have been revealed, ones that are economically calculable. These include, for example, the possibility to also deliver goods at off-peak times and to residential areas with noise restrictions. The extension of this scope for utilisation alone could justify use of the new technology. This also applied to potential access restrictions in inner cities ("environmental zones").

For business-related operation in particular, the economic viability is a decisive criteria. Based on the further development, it will become more evident in which commercial fields of operation the best use can be made of electric vehicles in a way that has the greatest economic benefits, in particular with regard to smaller companies without much scope for investment. It is therefore necessary to modify introduction strategies very specifically to suit the respective companies and the vehicles in use. The "Handbook for Fleet Operators", which can be considered to contain key findings made in the context of the platform activities, outlines the practical approach taken to effectively integrate electromobility into commercial fleets of up to 100 vehicles. A five-phase procedure has been presented, which can apply equally to both closed vehicle fleets operated by companies and local municipalities as well as open fleets operated by carsharing or rental car operators. The phases are as follows:

1. Analysis of vehicle fleet
2. Electromobilisation scenarios for the vehicle fleets
3. Test phase with electric vehicles
4. Acquisition management
5. Training of employees and implementation

The staff training in particular proved to be an important aspect of the fleet trials. In principle, it is wise and conducive to achieving results if all the staff are generally informed about electromobility and its scope for utilisation and benefits, in addition to the specified safety instructions and training, and if the acquired vehicles are also presented and their special features highlighted. The user surveys have also shown that the majority of the responses of the drivers, once they have changed to an electric vehicle, are very positive and remain positive when the vehicles are used for longer.

Development of infrastructure and urban development

In addition to the technical features of the different charging units for the public, semi-public and private sectors, the individual projects focused on themes such as infrastructure development, specification of location, legal business aspects and access and invoicing modalities.

DIFFERENTIATION OF CHARGING STATIONS ACCORDING TO TYPE AND LOCATION

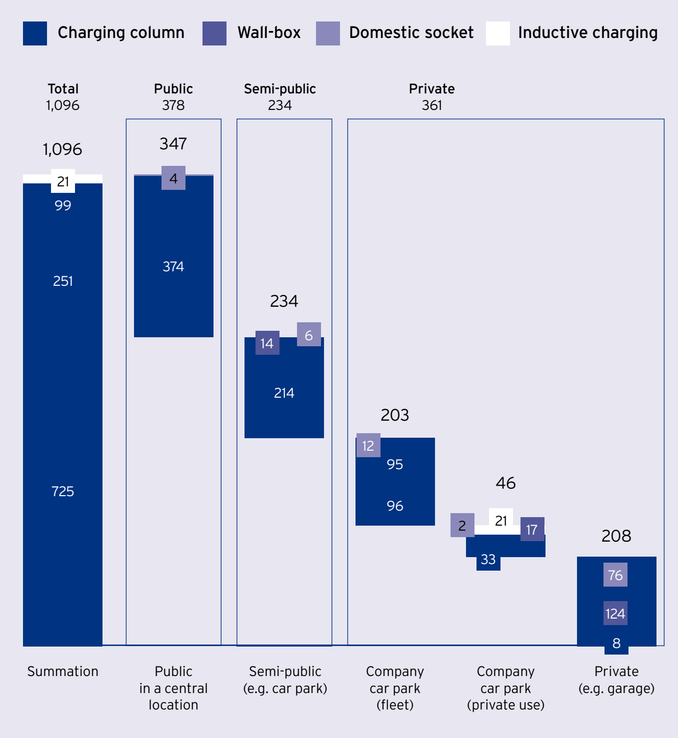


FIGURE 11

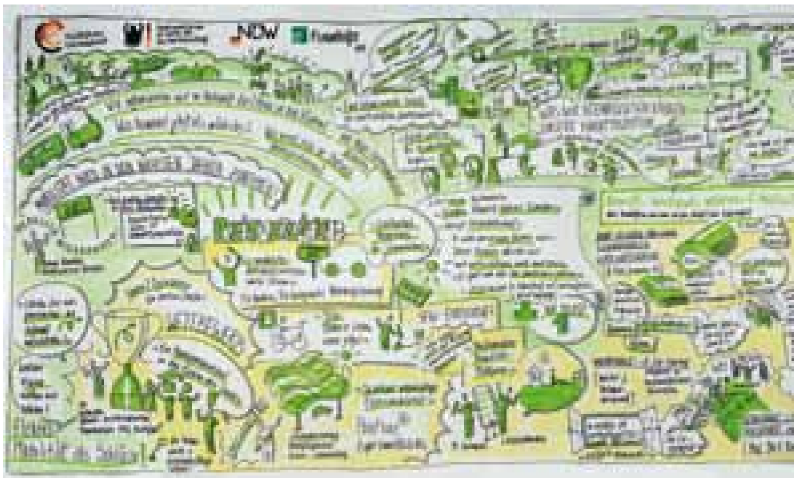
A total of 1,096 charging stations were planned and installed in the model regions; of these 378 were public, 234 semi-public and 484 private charging stations (see fig. 11). These also include more than 20 non-contact, inductive charging points that function without charging cables. In general, several charging points were installed per charging station. This has resulted in a total of 1,935 charging points.

It is evident that the public charging infrastructure has not been developed to the extent that was originally planned in 2009. In addition to a shift of emphasis to the semi-public sector and the good usability of the private infrastructure (including wall-boxes), the costs in the public sector for the installation and maintenance of charging columns were underestimated prior to the project launch and the anticipated levels of revenue were overestimated. The search for prospective business models is still underway. An insight into the complex nature of the infrastructure development is provided by the publication "Scenarios of infrastructure development for electromobility – results from the expert workshops facilitated by the infrastructure platform".

When planning the public charging stations, there were frequently difficulties and delays involved in the cooperation of local municipalities and applicants. Decisive guidelines and solutions were worked on in the infrastructure platform – in close collaboration with public authorities and private industry. The resulting publication "Guidelines for practical implementation – development of a publicly accessible charging infrastructure for authorising bodies and applicants" ensures more transparency in the fields of planning, authorisation and technical implementation and the best-practice case studies from the model region projects provide valuable assistance here.

Although no comprehensive needs assessments or continuous analyses of the intensity of use within the complete infrastructure are available yet, it is already clear that during the demo projects, sufficient infrastructure was available or had been set up. There are still uncertainties with regard to the needs-based instalment and development of the (public) infrastructure. However, in this area, the model regions were able to test initial analysis methods with regard to the assessment of needs and choice of location. Initial data on charging characteristics and a potential comparison with the availability of electricity from renewable energy sources was generated.

In the long term, a fast standardisation of the charging procedure and the sockets would be desirable in order to enable a standard charging procedure throughout Europe to be implemented so as not to be at a disadvantage in comparison to the Asian and US markets.



Among the challenges posed by the installation of public charging points was the development of sustainable access and billing systems. A large number of these were tested in the model regions and different technologies were used. The types of contract, pricing and payment options were particularly complex: a wide range of models was tested, from more long-term contracts with invoices, to flatrates and one-time transactions with debit card payment options. One successful example is the combination of "park & charge", which was developed in the model region of Rhine-Main.

How electromobility can enhance modern urban development is also a topic dealt with by the platform socio-scientific supplementary research. The most important tool for the working group was the city survey. In order to develop a more comprehensive understanding of the requirements and plans of the cities in the electromobility sector, the Fraunhofer IAO institute conducted a written survey as well as supplementary in-depth interviews, based on guidelines, with representatives from selected cities in the eight model regions.

The survey findings show: the three key topics in the electromobilty sector that require more commitment on the part of the cities are environment, transport and economy. In addition to climate policy goals, it is above all important to not only reduce the air pollutant emission but also the noise levels locally.

An upswing of alternative transport concepts is associated with the topic electromobility. This also means: electromobility is not perceived as the only solution for all transport problems but is viewed in a differentiated way as a technology with special potential to create a shift in the private transport sector and also to reduce the traffic levels. The potential for this is provided for example by linking the electromobility concept to the local public transport system and to carsharing models. One anticipated benefit is an increase in the quality of the location, both as a commercial and a residential location. In addition, the image of the cities and their role model function should be mentioned here.

In order to establish a well-functioning charging structure it is necessary to primarily develop private and semi-private charging stations. The development of a public charging infrastructure should however be integrated into the city and should be installed at important intersections and connecting points, as well as serve to supplement the private and semi-public charging stations. The main focus here is on parking garages, P&R parking spaces and junctions such as railway stations.

When the first electric vehicles are deployed in the cities, this will primarily be in the context of vehicle fleets and services on offer to tourists. Initial concepts for the introduction of electromobility are frequently promoted in connection with existing development plans in the transport and environment sector. Further information on the city survey can be found in the second part of the report.

The competition "Vision – Electromobile City of the Future" provided new insights, as did the conference of the same name held on 7th and 8th September 2011 at BMVBS in Berlin. Based on the four categories – intelligent e-mobility, integrated urban infrastructure, electromobile urban design and life in an electromobile city – the speakers presented their visions, from the present day through to 2050. During the two-day conference, an impressive overall view emerged: the vision "Electromobile City of the Future" (see fig 12).

FIGURE 12: GRAPHICAL PROTOCOL OF THE CONFERENCE "VISION: ELECTROMOBILE CITY OF THE FUTURE"

Environment

The main focus of the assessment was on the actual energy consumption of the vehicles and the comparison of their environmental impact (CO_2 emissions) with conventional vehicles.

In addition, the remaining vehicles were summarised in three more or less homogenous groups: minis / micro-cars and small cars, compact and medium sized and lightweight utility vehicles.

For the entire duration of the journeys the data is based on, an average energy consumption of 18.4 kWh / 100 could be ascertained: 17.2 kWh / 100 km for minis / microcars and small cars, 16.9 kWh / 100km for compact and medium-sized cars and 30.4 kWh / 100 km (1 kWh corresponds to 0.102 l diesel equivalent (DKeq) and 0.112 l gasoline equivalent (OKeq)) for the lightweight utility vehicles. The consumption levels of the vehicles selected for comparison with combustion engines ranged from 3.2 to 6.7 l / 100 km combined or between 3.4 and 8.3 l / 100 km in urban traffic. The recorded consumption levels for the electric vehicles reflect the current status of technical development and can be evaluated as indicators for the near future. It should be taken into account that in the case of electric vehicles, these are primarily pre-production series and retrofitted vehicles. It is anticipated that further optimisation measures will be implemented in the course of a market launch. In addition, it should be noted that the available figures hardly include any winter operations with additional energy consumption for heating.

DR. ANDREAS SCHEUER (PARLIAMENTARY STATE SECRETARY, BMVBS) AT THE BMVBS OPEN DAY

The detailed evaluation of the individual journeys generated the following overall results with regard to the driving distance, overall driving distances and charging loads and performance. Every second journey was less than 3.6 km and every ninth journey more than 30 km. The average driving distance was approx. 7.3 km. Half of the journeys did not last more than 11 minutes while almost 90% of the journeys did not last longer than half an hour.

The average journey duration was approx. 17 minutes. The average quantity of electricity used per charging process was 3.5 kW or less in half of the cases and in 10% of the cases 14.6 kWh or more. The average charging quantity was 5,5 kWh. In half of the cases, the vehicle was charged for 75 minutes, while in 10% of the cases, the charging process lasted 3.5 hours or longer. The charging processes lasted 2.5 hours on average. Using this existing database as a starting point, it can be concluded that the distances travelled by the vehicles do not indicate any constraints for everyday use.

In order to assess the impact of the vehicles on the climate it is necessary to make a differentiated analysis of the emissions caused by the electricity generation and the consumption of the vehicles themselves. For this purpose, three different regenerative electricity approaches, electricity generated according to the German power generation mix 2010 and electricity from additional coal and gas-based sources (so-called "merit order" electricity) were selected. The results showed that the CO_2 emissions on the basis of coal and gas-based electricity are much worse than those of the conventional vehicles (approx. 270 to 485 gCO_2 / km in the case of coal-based electricity and between 106 and 191 gCO_2 / km in the case of gas-based electricity, depending on the vehicle category). The CO_2 emissions caused by electric vehicles on the basis of the current power mix are more or less comparable to those of the best conventional vehicles in each of the respective segments (131 to 236 gCO_2 / km according to the power mix 2010 and between 104 and 217 gCO_2 / km in cities for conventional vehicles, well-to-wheel-assessment).

The CO_2 emission levels of the electric vehicles are lower in comparison to standard vehicles. If one adds the regenerative electricity levels, in an inner city traffic comparison for example, the positive climate assessment of electric vehicles is considerably better than that of conventional vehicles, for minis / microcars with a factor 6 to 7 (104 to 16 gCO / km), for compact and medium-sized cars with a factor of 9 (144 to 16 gCO / km) and for lightweight utility vehicles with a factor of 7 (217 to 29 gCO / km).

If one considers the overall situation up until 2020, not a great deal of change in the CO_2 emissions can be expected due to the low number of electric vehicles on the roads. In addition, regenerative electricity continues to produce low emissions while the fuel mix only shows moderate improvements of about 10% because the percentage of fossil fuel-based electricity generation has hardly changed. The additional fossil fuel-generated electricity, however, is provided more and more frequently by gas-fired power plants. In the case of purely gas-based electricity generation on the other hand, relatively high emission levels are generated in the conventional vehicle sector.

The picture could change considerably in 2030 and the years that follow. It is anticipated that regenerative fuels will clearly dominate the mix (according to the goals set by the federal government it will make up about 55% in 2030). In this way, the CO_2 levels will be reduced step by step. Electricity drawn from other sources will be primarily from gas power stations and will to some extent even be produced regeneratively. In contrast to this, after 2030 there will be a significant increase of CO_2 emissions in the fossil fuel-based upstream chain of the fuel production for conventional vehicles, which can only be correspondingly reduced by the supply of regenerative fuel.

To sum up, it can be recorded that electric vehicles will primarily have a positive effect on the environment in connection with the development of renewable energy concepts and the use of regenerative electricity. This is the goal when supplying the electric vehicles in general and in the model regions it is backed up by the stringent requirements imposed on the certification of the charging electricity, set up in collaboration with the energy suppliers and manufacturers. New technologies, which for example enable controlled charging in the case of an excess supply of regenerative electricity, can provide additional scope here. This particularly applies in the light of the considerable increase in the number of electric vehicles after 2030.

Other aspects analysed in the context of this supplementary research were the effects of electromobility on traffic-related noise, harmful substances and particle emissions as well as eco-balance issues. The detailed evaluation can be found in the section "supplementary research environment" as part of the platform reports.

Safety

Another aspect of the research focused on the safety of the electric vehicles deployed in the model regions. The aim was to ensure the safety of operation and the safety of the battery and high-voltage systems installed in the vehicles deployed in the trials. In addition, the results of all the supplementary safety analyses as well as the vehicle and system documentations were compiled and evaluated, and scope for improvement was determined. In addition, during the trial period, cases of dysfunction or breakdown were determined and analysed in the projects. These reports and findings can contribute to the establishment of standards – on an international level too.

All of the manufacturers who participated in the analysis fulfil the safety requirements and have completed the safety documentation. In addition, some manufacturers have carried out comprehensive tests, in some cases with extensive, cost-intensive trials, although these were not required due to the small number of vehicles in operation, many of which were included on the basis of individual vehicle approvals.

The technical standard of the vehicles deployed in the model regions was consistently very high. The monitoring of the dysfunctions did not reveal any defects or mistakes that made it necessary to discontinue operations completely or that might have represented a potential danger to the user. There were no cases of people being endangered. About 30% of the documented dysfunctions were due to operating errors (e.g. errors when starting the vehicle) or general vehicle errors that have nothing to do with the special features of the electric vehicles. The operating errors are often due to the different users. The manufacturers could sometimes remedy technical errors during the running of the programme. A continuation and extension of the analyses in the context of future trial programmes is recommended.

User acceptance

During the model region programme, users from all of the projects that had participated in the platform socio-scientific supplementary research were questioned. In the context of this platform, at the beginning of 2010, with the help of more than 20 scientific institutions as well as social scientists working for the automobile manufacturers and energy suppliers, a joint set of standard questions about user expectations and user acceptance was compiled. This set of questions was then integrated into the project-specific surveys once it had been put into practice. The surveys (ideally) were carried out at three specified times: before the

use of the electric vehicle (expectations of electric vehicles and electromobility: T0-questionnaire), after a period of use of up to three months (first impressions of the electric vehicle and electromobility: T1-questionnaire) and finally after at least three months (more long-term experience with the electric vehicle and electromobility: T2-questionnaire). In total, about 2,300 valid surveys allocated to identical users were carried out (T0-questionnaire: approx. 800 participants, T1-questionnaire: approx. 1,000 participants, T2-questionnaire: approx. 500 participants).

In order to promote a better understanding of the findings, the mixture of participants in the survey will be briefly presented here: the persons questioned are primarily male (83% in the T2-questionnaire) and have an above-average level of education. The average age of the participants was 40. The participants in the fleet trials use their vehicles frequently: the vehicles were used at least once a week however more than 30% of the participants in the T2-questionnaire used their vehicles daily or almost daily.

The results show that the respondents had positive expectations of electromobility at the beginning of the trials: they presume that the electric vehicles will inspire them and that they are environmentally-friendly, beneficial in everyday life and easy to operate. The anticipated vehicle features reflect a realistic level of knowledge among the future users. The positive carbon footprint levels are important to the future users. However, the availability of green electricity is viewed critically. The drivers of electric two-wheelers have more positive expectations with regard to the ease of use, environmental friendliness and the suitability of the vehicles for everyday tasks.

During the utilisation of the vehicles, their features were also evaluated positively overall. The ease of operation in traffic and when charging the vehicle, as well as the driving pleasure, acceleration and low driving noise is appreciated by the users. This means that the participants experience driving pleasure with their electric vehicles, a fact that is also reflected in the large number of positive responses to the question about levels of enthusiasm. On the other hand, the respondents feel some catching up needs to be done in the areas of charging infrastructure and when questioned further they state that they would like to see a further development of the public and semi-public charging options. The private users were satisfied with the current charging possibilities at home. Throughout the project, the perception of electromobility as an environmentally-friendly alternative remained constant during the period of use and the high levels of enthusiasm for the vehicle are even greater after longer vehicle use than at the time of the preliminary questionnaire. The majority of respondents expressed a high level of interest in electromobility and plan to inform themselves about the topic in the future. The commercial users perceive the image generated for their company by the electric vehicles to be very positive and this aspect offers electromobility a great deal of scope here.

However, very few people could imagine completely replacing a conventional vehicle with an electric vehicle. The limited range, (charging time, battery capacity) is and remains a strong barrier – even if the vehicles can meet the demands of everyday journeys. The purchasing costs of electric vehicles are also viewed very critically and from a user perspective this is also a major reason for currently not considering purchasing an electric vehicle.

The number of people interested in electric vehicles and electromobility, however, increases slightly during the project after longer periods of use and the survey has shown that private users show slightly more interest than commercial users. With regard to possible financing models, long-term users prefer a one-off purchasing price (car users would like a price of approx. 20,000 euros, two-wheeler users a price of approx. 2,000 – 2,500 euros). Soft incentives, as opposed to monetary payments or additional benefits, are currently not able to compensate the high purchasing costs of the electric vehicles. An open-mindedness towards new, more complex business, for example, a cost calculation according to time and distance is (still) not very advanced. Yet the future potential of electromobility overall is considered to be very high, above all in the context of new mobility concepts. However, the future viability of electric vehicles is perceived more in terms of their integration in carsharing models, rental concepts or local public transport.

The published initial interim analyses of the user surveys in the model regions issued by the Federal Ministry for Transport, Building and Urban Development entitled: "What do future users expect of electric vehicles?" provides a good insight into the results of the preliminary survey. In addition, the results of an expert workshop comprising members from the platform socio-scientific supplementary research were used for the development of the roadmap "customer acceptance", which illustrates a potential way forward towards an electromobile future with a focus on the user perspective until 2020. A publication has also been issued on this topic.

The "eTrust – vision statements and strategies for the future of electromobility" study, which was recently commissioned and conducted on behalf of NOW GmbH, shows that in future it would be advantageous if potential users and purchasers became more involved in the early stages of the vehicle development as well as in the development of future business models and mobility strategies. Apparently, electric vehicles are intuitively compared to familiar conventional cars, which are flexible enough to be used equally for travel, excursions and shorter city trips. With the current status of technology, the electric vehicle still cannot hold its own in this comparison. In addition to the basic further development of the technologies, two different approaches could increase preference for electromobility: on the one hand, it is important to access new forms of mobility and in this way also new usability patterns, while on the other hand electric vehicles with a unique utilisation profile and their own design should be developed.

As a basis for this at the current point in time and status of development, different forms of user potential for electric-powered vehicles could be identified in the model regions. It was discovered that there are considerable differences in the user evaluations for different types of vehicle and areas of operation. Different services, which were tested in the model regions, meet the very differentiated demand.

- Commercial customers are a driving force for electromobility, for example operators of delivery vehicles, service vehicles or fleets for hire
- Another target group is the commuters with daily travel distances of about 100 kilometres and private charging possibilities
- There is already scope for collective use; the issue of how to manage the charging procedure is still a challenge, as are questions concerning the economic viability and protection against vandalism
- In principle, it proved to be realistically possible to integrate the electric vehicles in classical carsharing concepts; however further trials are necessary before the vehicles can be considered suitable for everyday use

INTERNATIONAL FOCUS OF THE PROGRAMME

In the course of the programme, the international cooperation, which was not previously intended to be a key topic, became increasingly important. This is due to the great importance of electromobility on an international level, especially in markets such as Asia and the US. There are different support programmes in these countries too, which are comparable to the activities in Germany. On a European level, it is important that the countries active in the electromobility sector (including France, Austria) share information. Hence as a first step, two main areas of focus for international and European exchange were defined,

DR. PETER RAMSAUER, FEDERAL MINISTER FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT AND MEMBER OF THE GERMAN BUNDESTAG, AND WAN GANG, CHINESE MINISTER OF ECONOMY AND TECHNOLOGY

which could be expanded to include more in-depth programmes dealing with themes and co-operations.

International cooperation: on an international level the current focus is on the exchange with China. Building on a joint declaration of intent signed by the Federal Minister Dr. Peter Ramsauer and the Chinese Minister of Science and Technology (MOST) Wan Gang, the German-Chinese cooperation was strengthened in the sectors energy efficiency and future technology. A key aspect of this declaration is collaboration in the electromobility sector aimed at examining the scope of fuel cells and batteries. This will take place in the context of a broad-based exchange between three German-Chinese model cities and regions. In Germany these are the model regions Hamburg, Bremen / Oldenburg and Rhine-Ruhr while in China they are Wuhan / Central China, Dalian / North China and Shenzhen / South China. The details of these collaborations have been specified in individual agreements between the regions.

Within the scope of the cooperation schemes, for example between the model regions Rhine-Ruhr and Wuhan, initial successes have been achieved with the help of the support programme. This cooperation builds on existing team efforts by the "German-Chinese Sustainable Fuel Partnership – GCSFP" and is intended to secure the cooperation long-term.

In practical terms, it was agreed that there would be an intensive exchange of information and experience concerning electromobility concepts, as well as trial and pilot projects. The individual areas of activity are the exchange of experience regarding the performance of electric vehicles in trial runs, concepts for charging infrastructure, vehicle and battery safety and transport and mobility concepts. Through meetings and specialist workshops in Germany and China, it was possible to build on the existing co-operation.

Cross-border traffic: the model region of Stuttgart is actively involved in the German-French fleet trials, which have the goal of analysing the aspect of cross-border electromobility. This project "CROME – CROss-border Mobility for EVs" will take place in the context of the German-French working group electromobility and are based on a resolution made by the German-French Council of Ministers. Funded by the Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Federal Ministry of Economics and Technology (BMWi), the vehicle fleets for cross-border journeys and the development of a mutually compatible charging infrastructure close to the border on the German and the French side, is being supported. The goal is to identify challenges arising from different requirements on each side of the border, such as charging plugs or protocols and billing systems. This is followed by the development of joint solutions that make cross-border electromobile traffic possible. Funded partners on the German side are the companies Daimler, Porsche, EnBW, Bosch and Siemens as well as the Karlsruhe Institute of Technology (KIT). These companies draw on the experience gained in their activities in the model region of Stuttgart. In addition there are also plans to deploy vehicles from the model region in this project too in the future. On the French side, the project will be funded by the Ministry for Environment, Sustainability, Transport and Residential Construction, the Ministry for Economics, Finance and Research as well as the Agency for Environment and Energy and in the context of the support programme "investissements d´avenir" (investments in the future). The participating companies on the French side are EDF, Schneider Electric, PSA Peugeot Citroën and Renault.

>> 4. CONCLUSION

The integrated activities of the eight model regions proved to be the most important support programme introduced by the federal government for everyday and user-oriented trials in the area of battery-electric mobility. All five overall goals of the support programme "Electromobility in the model regions" were achieved:

- Technologically open research and development (R&D) for battery-electric vehicles
- Everyday use and user-oriented trials
- Integration in mobility, spatial and urban development
- Local networking of agents from the relevant industries, scientific institutions and the public authorities
- Results-oriented exchange in umbrella platforms

The strategy of the model region approach with its three different levels has proved its worth in view of the detailed and significant results. The overall theme-based technology projects generated new vehicle developments including corresponding proof of their practical viability. The numerous regional trials led to a networking of the significant parties involved and to a sustainable build up of knowledge. In total, approx. 220 partners in approx. 70 project consortiums committed themselves to the project. In the cross-sector platforms, the findings of the decentral groups were presented and grouped together – a unique approach to date. For most of the analyses, the data used was collected in all the model regions and systematically consolidated by renowned research partners. The programme was successfully coordinated by the BMVBS as the responsible body on a federal level, with NOW in charge of programme management and PtJ responsible for the administrative implementation of the programme as well as the consultant for all legal issues concerning funding and support.

More than 2,400 deployed vehicles and almost 2,000 charging points (at more than 1,000 charging stations) made the programme visible to the public and attracted a great deal of attention. Overall, the acceptance of electromobility has increased considerably in all the model regions as a result of this.

The technical standard of the vehicles deployed in the model regions was constantly very high. Vehicle breakdowns resulted primarily from operating errors or technical errors that could be remedied by the manufacturer during the programme. Detailed analyses of the deployed vehicles show that they are generally not subject to restrictions in everyday use. The average fuel consumption values in real operations were 18.4 kWh / 100 km. Depending on the vehicle category (minis/ microcars and small cars, compact and medium-sized cars and lightweight utility vehicles) consumption values were generated between 16.9 and 30.4 kWh / 100 km (1 kWh corresponds to 0.102 l diesel equivalent (DK) and 0.112 l petrol equivalent (OK).

If and to what extent electric vehicles can relieve the burden on the climate is, as to be expected, dependent on how the electricity used is generated. The carbon footprint varies very strongly, in fact to the disadvantage of the electric vehicles, if one bases the calculations on coal and gas-generated electricity. On the basis of the current fuel mix 2010 this is comparable with conventional vehicles. With regenerative electricity the climate balance is improved – depending on the vehicle class and operation profile – by the factor 6 to 9. For the future, one can assume that there will be a continuous decrease in the burden on the climate resulting from the implementation of electric vehicles. Important factors here are the number of vehicles and the percentage of renewable energy in the German power mix.

Important insights can be gained in all the areas of activity (private transport, public transport, infrastructure and urban development, environment and safety and user acceptance).

Commercial traffic has turned out to be the first potential profitable field of application for electromobility. This field of application can be a significant catalyst for the development of electromobility.

In terms of private use, electric vehicles will not establish themselves to a greater extent until the mid-term. Initial fields of application in the private sector are city and commuter traffic. The positive response to electromobility in rural regions was surprising. In this area, different approaches to the new mobility structure will be developed in the mid term. The deployment of hybridised buses in the local public transport system has already proved to be successful. In general, the operators have evaluated the trial runs as positive. Due to a continuous increase in the availability (70 to 80% towards the end), the vehicles deployed could generate considerable energy savings (up to 19%) as well as substantial environmental benefits. Initial programmes for initial and further training were set up and implemented.

During the course of the programme it became evident that sufficient infrastructure had been set up. There are still uncertainties regarding the needs-related instalment and development of the (public) infrastructure both on a local municipal level and a private-commercial level. The programme already included initial proposals for solutions. In addition to the development of a public infrastructure, the semi-public infrastructure received a great deal of attention because it is able to combine the benefits of the public and private charging infrastructure. The private infrastructure is differentiated according to the type of charging (charging column, wall-box or plug socket) and also very much according to the type of use (fleet management or private parking space). Further developments in the sectors standard charging, rapid charging and inductive charging were discussed in depth. It was possible to gather initial data on the charging performance and to calculate a possible comparison with the availability of electricity from renewable energy sources.

In the context of the socio-scientific supplementary research, an extensive database on the theme of electromobility was compiled. The users have very realistic expectations of electromo-

DR. KLAUS BONHOFF, NOW, AND DR. VEIT STEINLE, BMVBS

bility and the vehicles, including their specific characteristics, are also evaluated positively after a longer period of use. The image gain was an additional motivation for the acquisition of an electric vehicle – from the perspective of a commercial user.

The "roadmap customer acceptance" compiled by the umbrella platform socio-scientific supplementary research highlights a potential path towards an electromobile future, in the period leading up to 2020, which focuses on the user perspective.

>> 5. OUTLOOK

The federal government (BMWi, BMVBS, BMBF and BMU) joint support programme "Showcase for Electromobility" (Schaufenster Elektromobilität), draws on the experience from the model regions. The showcases comprise of self-contained electromobility regions, in which the areas "energy, vehicle and transport", as well as their innovative technologies and solutions, are incorporated and implemented in the overall electromobility system. By spring 2012, three to five of the showcases will be selected in a competition. The support guidelines for the showcase programme, dated 28.10.2011, should be referred to for details.

In addition to the showcases, the research programme will also be continued. The main focus of the BMVBS is on the practical everyday viability and user-friendliness of electromobility. Due to the successes described in the overview, the BMVBS will continue to work on these themes. For this purpose, in July 2011 the BMVBS published the electromobility support guidelines. During 2011, the first new support consortiums began their work based on this approach.

As a result, the everyday and user-oriented trial using a comprehensive cluster approach will be continued in the "Showcases for Electromobility", complementary to the BMVBS support measures. The formation of consortiums with a high level of participation on the part of industry and a technologically-open approach will be continued in the same form. In future, the support will aim to close (industrial) financial gaps in research and development and make them independent of cyclical fluctuations.

In this case, it will also be very important to ensure that the project consortiums are designed in accordance with regional strategies. The development of showcases originating from the eight model regions should be supported.

RAINER BOMBA, STATE SECRETARY AT THE FEDERAL MINISTRY OF TRANSPORT, BUILDING AND URBAN DEVELOPMENT

Theme-based platforms play a key role in the presentation and grouping together of the results gained on a decentralised level. Possible themes for the overall collaboration are the continuation of the socio-scientific supplementary research, the further development of internationalisation activities and the processing of questions concerning the topics of regulatory framework, safety, environmental aspects, the increased incorporation of electromobility in the public transport system, the infrastructure and integrated mobility concepts. It is worthwhile assessing the cross-section cooperation on key issues from the perspective of the supplementary research. Measures that draw the attention of the project partners to the required active participation in the platforms when they apply, are already in the pipeline.

The platform findings should be incorporated to a greater extent in the National Platform for Electromobility. In addition, the platforms can serve as valuable interfaces for future showcases.

The established organisational structures should be continued on a permanent basis. This applies on the one hand to the well-established partners BMVBS, NOW, PtJ as well as the regional project coordination centres and on the other hand also to the project consortiums comprising of project partners from industry, science and the public authorities.

The duration of the programme will be adapted in response to the fact that more time is needed for the development of technologies and mobility concepts. In future, an additional monitoring of the projects should continue to improve the quality of the results; this applies equally to the regular comparison with the milestones, which in future is to be carried out in collaboration with the project partners.

The central data monitoring of the vehicle operations as well as the installation and expansion of the infrastructure throughout all of the model regions is to be intensified. In connection with this, further data should be integrated – for example user acceptance or environmental data from real operations. The findings can then be assessed together with the specified programme milestones and the reports of the federal government and the National Platform for Electromobility. Subsequent projects can be reorganised on this basis if necessary.

RECOMMENDATIONS FOR THREE KEY COMPONENTS OF THE PROGRAMME FROM THE FIELDS OF ACTIVITY

Vehicles, infrastructure, users

In the vehicle sector it will be necessary to develop the number of vehicles in operation to fit with the target of making Germany the lead market. In addition, the scope of electromobility should be clearly expanded in integrated transport concepts. There should be a particular focus on linking public and private transport.

Further measures in the area of vehicle applications:

- Car: active discussions about market launch instruments such as the local municipal acquisition initiative
- Innovative drive bus: incorporation of further manufacturers, recording of experience, long-term testing of the previously deployed vehicles, support of technical development scope, analysis of all-electric buses and innovative power transmission systems
- Heavy goods applications: incorporation of additional manufacturers, recording of experience, long-term testing of the previously deployed vehicles, support of technical development scope
- Utility vehicles and city logistics: development of transport applications, if possible integration in city logistics systems
- Rail applications: further development of key aspect and preparation of commercial applications, incorporation of additional manufacturers and agents

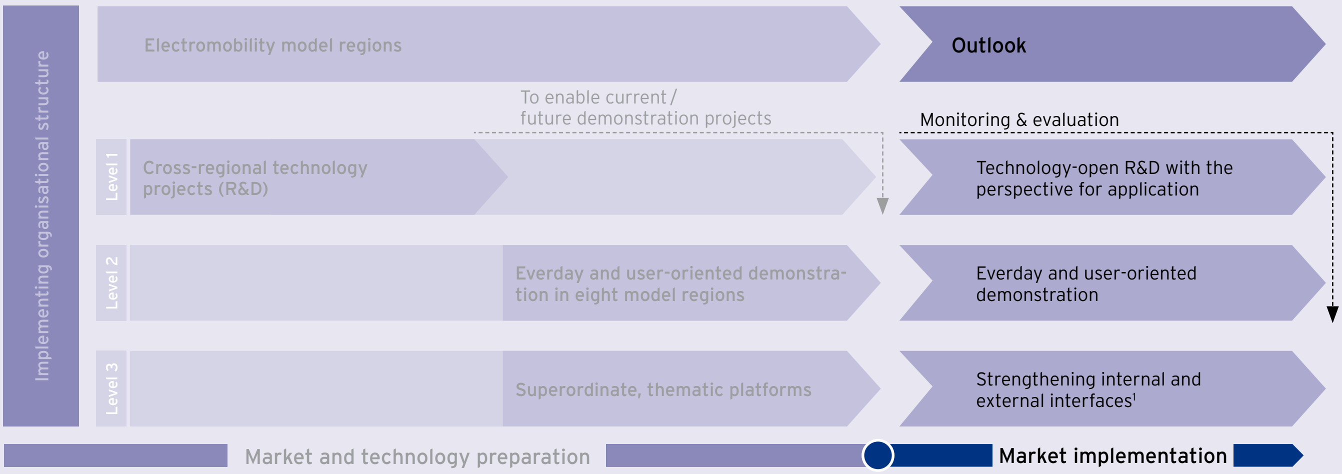
In the sector infrastructure, in future the needs-related and appropriate development of an infrastructure will become an important issue, together with the issue of how to find the best possible funding. A key area of activity for the energy supply will be the intelligent incorporation of renewable energy sources. The practical viability of a controlled charging process should also be considered.

In the area of technology, in addition to clarification of safety issues, the focus will be on the technologically open further development of a non-discriminating charging infrastructure and in particular the progress made regarding rapid charging and inductive charging developments.

Access and billing systems should be harmonised and standards for cross-border traffic should be found. Questions concerning the urban planning integration of the infrastructure must be answered.

From a user and operator perspective, a transition from a technologically-driven programme to a market responsive programme is required. In some areas the user and operators still need to be more deeply involved vehicle, mobility and infrastructure developments. For this purpose, the socio-scientific supplementary research must take a new approach. The local municipalities can also contribute towards making electromobility customer and operator friendly, by incorporating these in the future urban and transport planning.

THREE LEVELS OF FUNDING PRIORITIES



[1] Interfaces: internal work groups, cross-area supplementary research, National Platform Electromobility/Showcases, internationalisation

>> 6. PUBLIC RELATIONS 2010/2011 SELECTED HIGHLIGHTS

04/2010

AMI LEIPZIG

Trade fair opening: Minister of Transport Dr. Peter Ramsauer opens the AMI in Leipzig. The Citysachs of the model region of Saxony in which he arrives in also gets used on site to accept funding applications.

HANOVER TRADE FAIR/GERMAN-JAPANESE ECONOMIC FORUM: NOW SPEAKS ON THE PROGRAMME AND TECHNOLOGIES

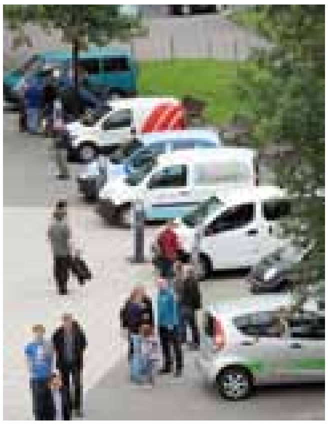
Electromobility in its full scope: "Electromobility is battery and fuel cell". It was under this theme that NOW presented itself as the point of contact for specialists and the public at the Hanover Fair.

06/2010

LAUNCH EVENT OF THE MODEL REGION BREMEN/OLDENBURG

Project kick-off: The electromobility model region of Bremen/Oldenburg officially gets started. The Personal Mobility Center will, among other things, develop future scenarios in regard to vehicles and mobility concepts.

FEDERAL MINISTER DR. PETER RAMSAUER IN AN ELECTRIC HYBRID BUS FROM THE LEIPZIG TRANSPORT AUTHORITY.



EVENT ENSURES GREAT PUBLICITY FOR THE RHINE-RUHR MODEL REGION

"ELECTRONAUTS" TAKE OFF IN THE STUTTGART REGION MODEL REGION

JOINT TRADE FAIR STAND OF ALL MODEL REGIONS

07 / 2010

ROLLING MODEL REGIONS

Pioneers: A moped invasion takes place on 4 July in Stuttgart – in the Schlossplatz the largest German electric fleet, comprising 500 electric mopeds, are handed over to test customers. NOW and the project headquarters of the region of Stuttgart model region participate as part of a large city festival.

ELECTROMOBILE / BEMOBILITY – THE MODEL BERLIN / POTSDAM

Field trial: With 18 Toyota Prius plug-in hybrid vehicles, the German Railways (DB) wants to facilitate the entry of its customers into electromobility – in terms of both carsharing and fleet use. Dr. Veit Steinle, Department Manager at the BMVBS gets a personal impression of the charging infrastructure and driving comfort.

08 / 2010

OPEN DAY AT THE TRANSPORT MINISTRY

Driving pleasure: German federal ministries invite citizens to take a tour. At the Transport Ministry, surrounding streets were of course also involved. Together with the CEP, NOW offers short spins in hydrogen vehicles, and interested guests can also test electric mopeds. The response is huge: the open days illustrate people's deep interest in future-oriented mobility concepts.

MODEL REGION RHINE-RUHR ON ITS MARKS

Press: Dr. Veit Steinle, BMVBS, together with other experts, provides answers to questions from journalists concerning the electromobile structures that will be established in the region.

MEMBER OF THE PRESS AT THE OPENING OF THE PERSONAL MOBILITY CENTER IN MODEL REGION OF BREMEN / OLDENBURG

STATE SECRETARY RAINER BOMBA AT THE BMVBS OPEN DAY

09 / 2010

TRANSPORT ASSOCIATION IN THE RHINE-RUHR MODEL REGION

Transport association: Ten transport companies from the region present the largest hybrid bus fleet to date as part of the Rhine-Ruhr Transport Association (VRR – Verkehrsverbund Rhein-Ruhr) at an event attended by State Secretary Rainer Bomba.

MINI-E FLEET IN THE MUNICH MODEL REGION

Presentation: In the Munich model region 40 drivers are happily about to test their Mini E's. The BMW Group, Siemens and the Stadtwerke München (Munich public utilities) celebrate as part of a ceremony on the Odeonsplatz with political figures from federal, state and city level including Parliamentary State Secretary Dr. A. Scheuer.

NOW CONFERENCE CLEAN MOBILITY INSIGHTS

The future now: Electromobility is battery and fuel cells – under the auspices of Transport Minister Peter Ramsauer, the NOW together with partners from NIP as well as the model regions present the first comprehensive status reports. Special attention is paid to the theme of international exchange of knowledge, the current technology status as well as European exchange of experiences with respect to market preparation and introduction concepts. Renowned experts make presentations from all sectors. The Fuel Cells and Hydrogen Joint Undertaking and the European Hydrogen Association are conference partners. The two-day programme rounded off with a conference dinner and a Ride-and-Drive opportunity for conference-goers. With 230 participants from industry, science and politics, the booked-out event attracted a high-level of publicity.

CLEAN TECH WORLD, BERLIN

Common exhibition stand: NOW is represented, together with the CEP and the eight model regions, at the first conference to be held in Berlin's Tempelhof airport. Aside from the opportunity to experience electromobile diversity, the event focuses on the best environmental technologies in Germany. The Clean Tech Media Award, for which Dr. Bonhoff is a jury member, takes place for the third time as part of the event.

11 / 2010

MULTIPLIER EVENT IN RHINE-MAIN MODEL REGION

Electromobile: With a kick-off event in Offenbach on the Main river, the Rhine-Main model region shows just how many applications can already become reality in the electromobility area. Alongside the vehicles, representatives from politics, business and trade associations also made their contribution. State Secretary Rainer Bomba is convinced of the benefits of electromobility and affirms, along with Hessen's Minister for Economy and Art, Eva Kuhne- Hörmann, the goal of the Federal Government to bring one million electric vehicles onto German roads by 2020.

DR. PETER RAMSAUER, FEDERAL MINISTER FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT

JAN MÜCKE, PARLIAMENTARY STATE SECRETARY AT THE TRANSPORT MINISTRY OPENS THE DEVELOPMENT CENTRE FOR BATTERIES IN ZWICKAU

02 / 2011

PORSCHE E BOXSTER HANDOVER IN STUTTGART REGION MODEL REGION

Electromobile sports car: With the rollout of the E Boxster, Dr. Ing. h.c. F. Porsche AG, Stuttgart, marks the beginning of a field trial within the large-scale initiative: "Electromobility Model Region Stuttgart". Together with Stefan Mappus, Porsche Chair of the Management Board, Matthias Müller is the first to take to the wheel of this silent research sports car. Also impressed with the vehicle are Dr. Veit Steinle, Head of Department at the Federal Ministry for Transport, Building and Urban Development (BMVBS), Dr. Klaus Bonhoff, Spokesperson and Managing Director (Chair) of NOW GmbH National Organisation Hydrogen and Fuel Cell Technology (NOW) as well as Dr. Walter Rogg, Managing Director of the Stuttgart Region Economic Development Corporation (WRS).

04 / 2011

HANOVER FAIR / MOBILITEC

Visibility: Following last year's positive response, NOW presents itself at the common hydrogen / fuel cells exhibition stand as well as, for the first time, at MobiliTec. Together with partners from both programmes (National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) and Electromobility Model Regions of the Federal Ministry of Transport, Building and Urban Development), information on implemented demonstration projects and participants is displayed over almost 170 square metres. With 13 international flagship trade fairs, the 2011 Hanover Fair brings together key industrial technologies. State Secretary Rainer Bomba (BMVBS), EU Commissioner Günther Oettinger as well as many more guests visit the fair and discuss, together with Dr. Klaus Bonhoff, NOW, the status quo as well as other projects.

HOPPECKE BATTERY TEST CENTRE

Opening ceremony: Hoppecke together with the Parliamentary State Secretary Jan Mücke (BMVBS) launches the new battery research and development centre. It provides 1,500 square metres of space for conducting experiments, prototype-building and tests in comprehensively-equipped laboratories and workshops.

POLITICAL EXCHANGE AT THE MOBILITEC (HANOVER FAIR)

PARTICIPANT AT WORK ON THE GRAPHICAL PROTOCOL AT THE "VISION – ELECTROMOBILE CITY OF THE FUTURE" CONFERENCE.

RAINER BOMBA (STATE SECRETARY AT THE FEDERAL MINISTRY FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT) AND DR. KLAUS BONHOFF (MANAGING DIRECTOR (CHAIR) NOW) CONGRATULATE THE WINNERS OF THE "VISION – ELECTROMOBILE CITY OF THE FUTURE" COMPETITION.

05 / 2011

MODEL REGION HAMBURG

Electromobile green capital: The Parliamentary State Secretary Enak Ferlemann (BMVBS) assesses funded projects in the Hamburg model region; a vehicle convoy through the city demonstrates the spectrum of the electric fleet (busses and cars) already in operation as well as the charging infrastructure.

06 / 2011

H2EXPO

International Conference: In Hamburg, NOW participates in the conference and trade fair for hydrogen, fuel cells and electric drives. The Hamburg model region is represented with its own exhibition stand. Dr. Klaus Bonhoff, NOW, outlines the overall programme through panel discussions and presentations. Further information and talks are offered at the exhibition stand at the accompanying fair.

07 / 2011

JOURNALISTS' WORKSHOP

Exchange: Together with the eight model regions, NOW hosts a journalists' workshop in the Heinrich Böll Foundation in Berlin. Under the heading: "Electromobility – quo vadis? The concept of model regions at the interface of technology, politics and industry" and in cooperation with the F.A.Z., leading journalists from the Spiegel, Zeit and Wirtschaftswoche are invited, among others, to discuss developments and perspectives with Parliamentary State Secretary Jan Mücke (BMVBS) and Chair of the NOW Advisory Board Prof. Werner Tillmetz at the technology journalism forum. WWF, the Boston Consulting Group and Frauhofer IFAM also present their views on the topic. Test drives round off the diverse workshop programme.

08 / 2011

TAKE TWO: OPEN DAYS AT THE BMVBS

A free pass: The model regions as well as the CEP hydrogen fleet are again represented in 2011 at the NOW exhibition stand during the Open Days of the Federal Transport Ministry. Vehicles are test-driven by visitors and experts are on hand for explanations of the technology.

09 / 2011

INTO THE FUTURE

Vision: Together with the Federal Transport Ministry and the Fraunhofer IAO, NOW hosts the "Electromobile city of the future" conference in the BMVBS. At numerous talks, visitors learn about various developments and visions for the future in electromobility. Prior to this a competition was tendered. The aim was to present ideas in four future areas, in which current developments and trends are further developed.

CLEAN TECH MEDIA AWARD

Green carpet: The Clean Tech Media Award is conferred in the European Green Capital of Hamburg. Dr. Klaus Bonhoff is once again present as a member of the jury and esteemed expert for assessing future-oriented ideas. At the accompanying exhibition in the Hamburger Curiohaus, guests from the worlds of politics, media and industry learn about the model region concept as well as hydrogen / fuel cell issues at the NOW exhibition stand. Electric vehicles are available for shuttle service.

JOURNALISTS' WORKSHOP AT THE HEINRICH-BÖLL FOUNDATION IN BERLIN

11 / 2011

ELECTROMOBILITY IN THE MODEL REGIONS – RESULTS AND OUTLOOK

Results conference: The Transport Ministry hosts the presentation to the public of valuable insights following two years of hard work in the model regions. Experts from all countries and platforms get involved in the two-day event in Berlin. The active participation of State Secretary Rainer Bomba, Andreas Scheuer as well as Enak Ferlemann demonstrates the political relevance of the topic of electromobility. The fully-booked conference is accompanied by a press conference. A further highlight is a convoy, displaying the range of all electric vehicles in the programme, travelling from the Ministry to the event location. Leading regional representatives from the model regions, who also participate in the podium discussion, travel in the convoy.

RAINER BOMBA (STATE SECRETARY AT THE FEDERAL MINISTRY FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT) OPENS THE CONFERENCE

PARLIAMENTARY STATE SECRETARY ENAK FERLEMANN (BMVBS) HELD THE CLOSING SPEECH AT THE EVENT

CORINNA WOHLFEIL OF GERMAN BROADCASTER N-TV, MODERATED THE ROUNDS OF TALKS, WHICH INCLUDED THE TOPICS OF INTERNATIONAL COOPERATION AND USER-ORIENTED DEMONSTRATIONS UNDER EVERYDAY CONDITIONS

A CONVOY OF MORE THAN 30 VEHICLES – FROM COMPACTS TO SPORTS CARS AND TRANSPORTERS TO BUSES – MADE ITS WAY THROUGH BERLIN TO THE CONFERENCE LOCATION, LEAD BY STATE SECRETARY RAINER BOMBA, MINISTERS FROM THE MODEL REGIONS AND THE FEDERAL MINISTRY FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT

STATE SECRETARY DR. ANDREAS SCHEUER, TOGETHER WITH THE FEDERAL MINISTER FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT IN THE DISCUSSION "ROLE OF THE REGIONS"



OVER 400 PARTICIPANTS ATTENDED THE FULLY-BOOKED "ELECTROMOBILITY IN MODEL REGIONS – RESULTS AND OUTLOOK" CONFERENCE WHICH BOASTED MORE THAN 30 TALKS AND LECTURES

STEFAN SCHMITT (LEFT), HEAD OF THE UNIT "INNOVATIONS FOR SUSTAINABLE MOBILITY, ELECTROMOBILITY" IN THE ROUND OF TALKS

AS PART OF THE CONFERENCE, RAINER BOMBA, STATE SECRETARY AT THE FEDERAL MINISTRY FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT, AND DR. KLAUS BONHOFF (LEFT), MANAGING DIRECTOR (CHAIR) OF THE NATIONAL ORGANISATION HYDROGEN AND FUEL CELL TECHNOLOGY (NOW) WHICH IS RESPONSIBLE FOR THE IMPLEMENTATION OF THE ELECTROMOBILITY MODEL REGION PROGRAMME, PRESENTED THE REPORT OF RESULTS OF THIS PROGRAMME – HERE TO (FROM LEFT TO RIGHT) HARRY VOIGTSBERGER, MINISTER FOR ECONOMICS, ENERGY, BUILDING, HOUSING AND TRANSPORT IN THE STATE OF NORTH RHINE-WESTPHALIA, HARTMUT FIEDLER, STATE SECRETARY IN SAXONY'S MINISTRY OF ECONOMICS, LABOUR AND TRANSPORT, AND MICHAEL BODDENBERG, HESSIAN STATE MINISTER FOR FEDERAL AFFAIRS.

THE HEAD OF THE CONVOY OF ELECTRIC VEHICLES AS IT PASSES BERLIN'S VICTORY COLUMN

>> PLATFORMS

CONTRIBUTION BY MANAGING DIRECTOR OF NOW DR. KLAUS BONHOFF

THE SUCCESSIVE REMODELLING OF THE TRANSPORT SECTOR – THE MODEL REGION APPROACH PROVES SUCCESSFUL

The transport sector will undergo a transformation. On the one hand, mobility is one of the basic needs of modern economies yet on the other hand it is important to master the challenges posed by energy, climate and industrial policies. Electromobility – the electrification of the power train using hybrid technologies such as battery or fuel cell powered all-electric vehicles – is particularly important in this context. It enables the production of emission-free vehicles and provides an opportunity to promote the development of renewable energy for use in the transport sector. It is not until the entire scope of electromobility, which is diverse in terms of its technological aspects, is transformed into marketable products in the different areas of application (road, rail, air, water) that the long-term social goals can be achieved. Cars, buses, trains and other modes of transport are feasible without the use of fossil fuels.

The scope and potential, but also the challenges posed by battery-powered electromobility, was the main focus of the Federal Ministry of Transport, Building and Urban Development (BMVBS) programme "electromobility in model regions" from 2009 to 2011. It was essential to demonstrate how the overall system – infrastructure, vehicle and user – could be implemented in an everyday environment – with view to the technological aspects and the preparation for the market launch. The task was to test this overall system in individual projects. However, another important goal was the networking of the players involved – from industry, science and the public sector. With superordinate theme platforms as well as regional project coordination offices in the eight model regions, the collection and presentation of significant findings ensured a results-oriented exchange of experience. In addition, the programme was able to gain economic momentum as companies could continue to work on innovative developments with the financial support of the German federal government.

The goal is to continue to utilise the findings and structures gained in the model region programmes, in accordance with the overall measures implemented by the federal government and hence achieve the common goal of the National Platform for Electromobility (NPE), to make Germany the leading market and leading provider in the field of electromobility. The platforms in particular can contribute their findings from the past two years and can, in the future, serve as interfaces for the concepts presented.

DR. KLAUS BONHOFF, MANAGING DIRECTOR OF NOW GMBH

>> 01 INFRASTRUCTURE

OUTLINE

The introduction of electromobility is not only limited to the deployment of electric-drive vehicles but is also very much characterised by the need to develop a charging infrastructure. The way in which these two main aspects interlock is reflected in the composition of the project consortia in the model regions. As a result, the development of a charging infrastructure is an issue that is constantly dealt with in the projects, and is usually implemented in cooperation with an energy provider. Hence, whenever vehicles are included in a project, it is necessary to develop the charging infrastructure in at least one of the following sectors: public, semi-public or private.

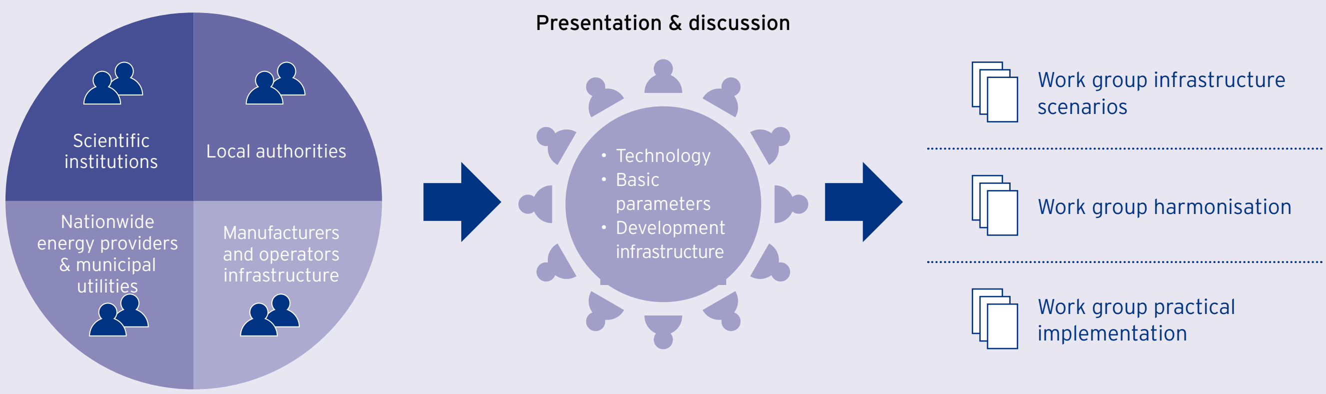
The platform infrastructure serves the project partners as a joint panel for the exchange of different experiences, with the aim of establishing a solid foundation for the further development of the infrastructure and avoiding duplicate work.

Since its establishment in 2009, the coordination of the platform infrastructure has been the responsibility of the NOW GmbH. A small group of approx. 30–40 regular participants has materialised from the large number of sporadic members and interested parties. These participants meet regularly to discuss specific topics, frequently with the support of guest speakers.

The participants are primarily representatives of the project partners in the model regions and include local municipalities, scientific institutions, municipal works, nationwide power supply companies and manufacturers and operators of charging infrastructure. The project partners present the technical developments in status reports, which are then discussed together. Furthermore, in 2010 and 2011 quantitative and qualitative monitoring of the charging infrastructure development was conducted and the results were presented and discussed at regular intervals.

In addition, at the platform symposiums work groups were set up in order to examine special issues in more depth and collaborate in developing end products. The work groups include the infrastructure scenario group (AG Infrastrukturszenarien), the harmonisation group (AG Harmonisierung) and the practical implementation group (AG Praxis). The infrastructure scenario group developed scenarios for the future establishment and further development of the charging infrastructure. The harmonisation group compiled a report on infrastructure concepts and the business model "park & charge". A policy paper on non-discriminatory access to the public charging infrastructure is currently still being worked on. In the third work group, the practical implementation group, practical implementation guidelines were created for the establishment of a publicly-accessible charging infrastructure for authorizing agencies and candidates. After completing these practical implementation guidelines, this group will work on developing a concept for the standard (online) presentation of the charging infrastructure, in order to achieve a better overview and subsequently higher levels of user-friendliness.

STRUCTURE OF THE PLATFORM INFRASTRUCTURE



Sporadic members & interested parties	30–40 regular participants	Temporary work groups for different topics
2009–2011	Every 3 months	Ø 6 months

FIGURE 1

As it pursues common themes, the platform infrastructure is closely interwoven with the platform regulatory framework and for this reason these two platforms have been holding joint meetings since January 2011. The aspects discussed include the provision of suitable park and charge options in city centres with specific signage, the modification of urban planning laws to incorporate the changes in mobility, as well as regulatory terms and conditions for the public and private charging infrastructure.

MILESTONES

Between 2009 and 2011 eight symposiums were organised by the platform infrastructure (11/2009, 03/2010, 05/2010, 07/2010, 01/2011,03/2011, 06/2011, 09/2011). Four of these were joint symposiums held together with the platform regulatory measures.
In the course of these symposiums, more than 30 lectures were given on the following key topics:

- Project status reports on individual topics
- Exchange of information with the projects from other sectors, e.g. BMWi and BMBF
- Exchange of insights and experience with hardware and software for the charging infrastructure
- Demands made of the charging infrastructure
- Rapid charging and inductive charging

Infrastructure monitoring
Activity
- **03 / 2010 – 09 / 2011** biannual inquiry about monitoring the development of the infrastructure

Contents
- Presentation of the results during the platform symposiums and in the programme reports

Infrastructure scenarios
Activity
- **03 / 2010 – 04 / 2011** Development of infrastructure scenarios in a group of 34 participants in three workshops including the textualisation by an editorial team.

Contents
- Three scenarios with the following focus: stricter CO_2 standards, a regulated infrastructure as well as electromobility concepts with no additional costs

Business model "park&charge"
Activity
- **02–03 / 2011** Evaluation of experience with the business model "park&charge" within a group of 7 participants

Contents
- Exchange of experience from different projects in four model regions

Handbook for operators of vehicle fleets and fleet management
Activity
- **03 / 2011 – 02 / 2012** Collection of contributions for the "handbook for operators of vehicle fleets and fleet management" within a group of 10 participants

Contents
- Experience of fleet deployment in all eight model regions, concerning infrastructure and charging

Policy paper on non-discriminatory access
Activity
- **03 / 2011 – 11 / 2011** Development of policy paper
- Discussion and exchange within a group of 17 participants

Contents
- Models illustrating the different kinds of access to the charging infrastructure, including evaluation according to eight different parameters

Guidelines for practical implementation
Activity
- **03-11 / 2011** Compilation of text contributions within a group of 20 participants, with subsequent textualisation by an editorial team

Content
- Establishment of guidelines for practical implementation to help the development of a public charging infrastructure, using best-practice examples from the model region projects

RESULTS

INFRASTRUCTURE MONITORING

The regular request for data concerning more than 30 projects, which have been developing and implementing infrastructure in the context of the programme, provided an insight into the developments in the model regions. This infrastructure monitoring was implemented on four occasions between 2010 and 2011. The most recent data request was made in September 2011, in close collaboration with energy suppliers (EWE, RWE) and consultants (TU Berlin, KEMA). The projects were asked to provide data on diverse attributes of the infrastructure (per charging station) and vehicles. A total of 941 charging stations and 1,711 charging points were evaluated. A distinction was made between public, semi-public and private charging infrastructures, analogue to the categories specified by the National Platform for Electromobility. In the context of the programme, the relationship between public, semi-public and private charging stations is approximately 40:20:40, however this does not reflect the actual frequency of use.

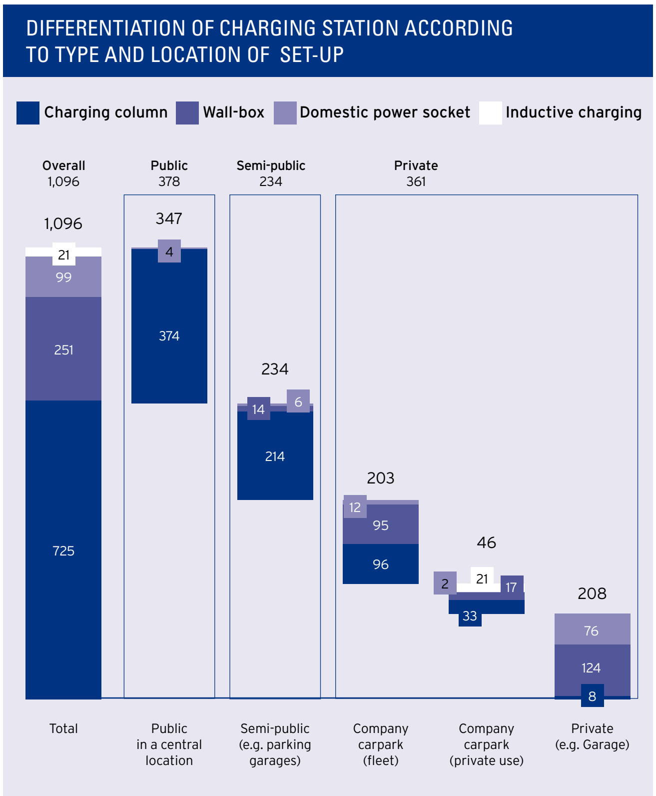


FIGURE 2

In these sectors, a distinction was made between the types of charging station. The public infrastructure in the projects comprises primarily of charging columns. Regarding the average ratio of approx. 30% conventional domestic power sockets or wall boxes, it can be ascertained that the value fluctuates according to the specific category of location. While in the central, public and semi-public locations, the conventional power socket or wall-box hardly plays any role at all, the reverse is true of the private parking spaces (garages). It is interesting that in the private sector of the model region projects, approximately half of the fleet operators use private charging columns while the rate of the privately used company parking spaces is sinking. Overall, the wall-box solution plays a more significant role for commercial and company-operated vehicles, while the private users rely on the domestic power socket.

It can be determined that for the duration of the project, the extent of the public infrastructure set up was lower than had been planned in 2009. There are many reasons for this. Initially, instead of creating a new public charging infrastructure it was possible to make use of the existing infrastructure, due to the "park&charge" concept. In addition, it became clear that the use of a private charging infrastructure and appropriate wall-boxes is sufficient and also uncomplicated. Last but not least, the public infrastructure development was slowed down by the fact that there was still no clarity with regard to a suitable business model, because in the course of the programme the commercial operators had to counter-finance the charging infrastructure by at least half. There are also uncertainties in terms of municipal planning, which slow down the development of a public infrastructure. In order to continue developments, best practices are required above all, ones in which the selection and analysis of the location for the urban and traffic planning, the authorisation procedures and respective contact persons, the future appearance, safety issues and funding will be presented in detail and will potentially serve to aid the establishment and development of the infrastructure.

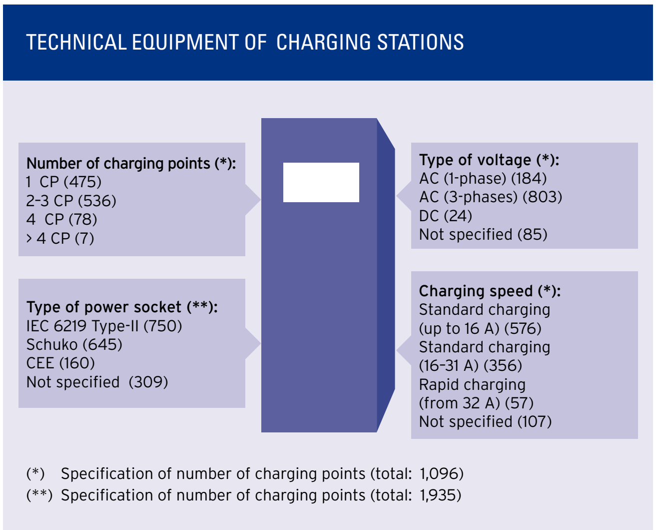


FIGURE 3

The charging stations in the various model regions have each been equipped with different technology. For example, they differ in terms of the number of charging points, the type of power sockets as well as the type of voltage and the charging speed (see figure 3).

DIFFERENT ACCESS AND BILLING SYSTEMS IN THE MODEL REGIONS

Access type (*)(**)	RFID (591), powerline (156), code (127), mobile communication (93), PIN (11), other (188), not specified (65)
Type of contract (*)	Contract for longer periods (467), still being developed (273), one-time transaction (39), not specified (317)
Pricing (*)	Still being developed (326), flatrate (177), quantitative single-level price (128), time-related, single-level price (34), not specified (431)
Payment options (*)(***)	Still being developed (240), payment by bank transfer on receipt of invoice (164), direct debit (154), cash (17), EC-card (9), other (22), not specified (546)

(*) Specification of number of charging stations
(**) 135 charging stations feature 2 different types of access
(***) 56 charging stations feature 2 different payment options

FIGURE 4

In the model regions, a large number of access and invoicing systems are being tested, of which several are still being developed (see fig. 4). The type of access to the charging column was clearly specified during the runtime of the project. In addition, a tendency towards more long-term contracts is developing. However, with regard to the types of contract and price-fixing, as well as payment options, there is a need for action and further development.

MANUFACTURERS AND OPERATORS OF INFRASTRUCTURE IN THE PROGRAMME

Manufacturer (*):	Operator (*):
Mennekes (206)	**RWE (161)**
RWE (161)	**Vattenfall (104)**
Langmatz (133) Siemens (77)	**EnBW (89)**
EBG Lünen (76)	**SWM (73)**
Bosch	Stadtwerke Düsseldorf
Schletter	Stadtwerke Leipzig
Keba	E.ON
NKT Cables	EWE
Bosecker	Hamburg Energie
Walther	DREWAG
Numerous other manufacturers	SWB
	Numerous public services and other operators

(*) Specification of number of charging stations

FIGURE 5

A large number of different manufacturers and operators have committed themselves to this programme, aimed at establishing an infrastructure. The main parties involved have been listed in figure 5, in descending order according to the number of charging stations.

To sum up, one could say that a great deal of positive insight and knowledge was gained in the model regions with regard to the development and operation of all three of the charging infrastructure options.

TECHNICAL DEVELOPMENTS

When the programme was launched, and hence the platforms too, the main focus was on setting up a public and semi-public charging infrastructure in the form of charging columns. In the course of time, it became clearer that several different charging systems are materialising, as the requirements for fast and uncomplicated vehicle charging can be met in very different ways. When it comes to the development of a charging infrastructure, there are already different charging systems available, which are not only limited to standard charging options (alternating current charging systems). Rapid charging, and in future inductive charging, is becoming increasingly attractive. In the context of the infrastructure planning it is therefore necessary to carefully evaluate which technology can be implemented at which location. Platform participants exchanged information in the form of regular status presentations, although occasionally there was also contentious debate.

In the model region projects, most of the charging infrastructure that was set up was in the public and semi-public sector, in the form of charging stations with a charging capacity of 3.7–22 kW. Hence three-quarters of the electric vehicles were refuelled using a standard charging procedure. In the private sector most of the vehicles were also fuelled using standard charging.

In addition to the utilisation of domestic power sockets, the charging infrastructure has been upgraded or supplemented in the form of wall boxes. One important insight gained from this is that the improper use of a domestic power socket when charging electrical vehicles can be dangerous for the user. As a result, initial services are being developed, which provide a safety check of the existing electrical infrastructure of users and operators, before the electric vehicle is used for the first time.

Standard charging
Different types of plugs can be used for standard charging in the model regions (see fig 3).

The most frequently used plugs are the shockproof plugs and the IEC 6219 type 2 plugs (also called "Mennekes plugs"). In addition, the CEE plug is used. Overall, the plug that is most frequently implemented is the IEC 6219 type 2 plug, as well as the shockproof plug. The IEC 6219 type 2 plug is a model that has been designed and further developed, in particular, to meet the new demands of the electromobility sector, which is increasingly becoming more significant. As a result, in the course of time, the German manufacturers have also agreed to use the plug IEC 6219 type 2 as a common standard for charging systems and hence they are operating in accordance with the European Automobile Manufacturer's Association (ACEA) specifications. However, an agreement must still be made on an international level.

Rapid charging

There is no clear boundary between standard charging and rapid charging. Any charging capacity that exceeds 32A can be classed as rapid charging. Furthermore, when it comes to rapid charging, with regard to the type of voltage a differentiation is made between AC and DC charging, although because of the technology currently available and the safety regulations, only conduction is used to transmit electricity. The standardisation of plugs will also play a role in future developments.

The CHAdeMo plug is primarily used for the DC rapid charging and the IEC 6219 type 2 for the AC rapid charging. CHAdeMo is a charging system developed in Japan, which is based on direct current voltage. In Germany an additional plug, the Combo plug, is being developed for rapid charging. This represents the further development of the IEC 6219 type 2 plug. The main benefit of rapid charging is the reduction of the charging time, but also the reduction of the vehicle weight as the charger is outside the vehicle. In the model regions, only a small section of the charging infrastructure comprises rapid charging options. This is being tested in eight projects in five model regions.

Induction charging

According to analyses by the Technical Inspection Authority TÜV Süd, inductive charging "represents a future alternative for charging e-vehicles in the public, urban sector [...]". The advantages of inductive charging over conductive charging systems are the increase of energy efficiency, being able to do without cables in public spaces, the automatic charging process, improved user acceptance due to more ease of use, a more frequent and longer coupling with the electricity network, as well as an improved integration in the power grid. In general, the establishment of an "almost invisible" charging infrastructure for the public space is of particular interest with regard to urban furniture and the cityscape. However, the benefits must be weighed up against the costs of upgrading the streets and carparks with induction loops. In addition, international standardisation is a basic prerequisite for expanding the technology to cover all areas. The feasibility and efficiency must be tested further and compared to the findings of the conductive charging system analyses. Inductive charging is currently being tested in the model regions Hamburg and Rhine-Main.

FINDINGS PROVIDED BY THE WORK GROUPS EVALUATING THE INFRASTRUCTURE IN DETAIL

WORK GROUP: INFRASTRUCTURE SCENARIOS

The platform infrastructure met for the first time at the end of 2009 and in view of the large number of different opinions regarding the charging infrastructure requirements, an initial target was set of compiling infrastructure scenarios.

There is still a great deal of uncertainty surrounding the various electromobility design parameters. This poses a challenge in particular for the partners involved in the construction of charging stations. In order to counteract uncertainties and the subsequent hesitation to set up the infrastructure, it seemed wise to present individual and possibly shared perceptions of what is required for setting up the infrastructure in the form of scenarios, and in this way to create a basis for further discussions.

The publication of "scenarios for the development of infrastructures for electromobility" was a result of these expert workshops. It contains three scenarios highlighting the following areas: "tighter standards", "regulated infrastructure" and "electromobility with no additional costs". In these scenarios, 20 influencing factors were evaluated in the areas "state influence", "charging infrastructure", "vehicle", "interfaces" and "customer".

The outcome shows similarities in all three scenarios with regard to the influence of the climate and fleet targets, the predictable network bottleneck, realistic minimal standards and the need for basic parameters set up by the state. In particular with regard to the form of organisation of the infrastructure, the assessments of the three groups of scenarios differ so strongly that three different solutions are envisaged: while the first scenario favours setting up the infrastructure via public-private partnerships, the second one is based on the concept of state regulation and the third on a competitive development in the free market.

	INFLUENCING FACTOR	SPECIFICATION		
STATE INFLUENCE	1. Regulation of charging / infrastructure	Free market	Regulating market	Development as PPP
	2. EC fleet targets (CO_2)	No tightening of targets	Moderate further development	Tightening of emission standards
	3. Environmental zones (local emissions)	No fast tightening of targets	Modest tightening	Drastic tightening
	4. Monetary & non-monetary funding instruments	Development of sponsorship promotion	Continuation of sponsorship	Cessation
INFRASTRUCTURE	5. Requirements of charging infrastructure	Simple technical solution	Mixture	Compl./high-end products & mW services
	6. Dense charging infrastructure (public)	Continuation of status	High density	Technological progress
	7. Dense charging infrastructure (semi-public)	Niche	Medium density	Technological progress
	8. Dense charging infrastructure (domestic)	Continuation of status/main focus on density	Enlargement of fleet to include private use	
	9. Realisation of inductive charging	No inductive charging possible	Will be introduced soon (2015)	Will be introduced long-term (after 2020)
	10. Distribution network	No bottlenecks until 2020	Initial bottlenecks 2012	Bottleneck after 2015
	11. Intelligent charging management (ICM)	No ICM	ICM from 2015	ICM from 2020
VEHICLES	12. Cost-delta	1	1.2	1.5–1.7
	13. Assertion of engine types	BEV	Mix	PHEV
	14. Development of battery technology	Conservative	Optimistic	
	15. Battery safety	Existent	Non existent	
INTERFACES	16. Standardisation (especially charging interface)	Rapid minimal-standardisation	Slow (until 2015 or 2020)	None
	17. Compatible access & billing models	Only minimal standardisation	Slow (until 2015 or 2020)	None
USERS	18. Use of public charging infrastructure	Intense use	Occasional use	None or only selected use
	19. Modification of mobility behaviour	No modification	Decline in attachment to cars	Emphasis on public transport
	20. Image of electromobility	Positive	Remains a niche	Negative image

— SCENARIO A — SCENARIO B — SCENARIO C

FIGURE 6

WORK GROUP: PRACTICAL IMPLEMENTATION

The task was to develop guidelines for practical implementation, as a continuation of the scenarios designed to minimise the hesitation of potential operators to set up an infrastructure. These guidelines were to include recommended action in the form of best practices based on initial project experience gained in the establishment of a publicly accessible charging infrastructure. The working group practical implementation was responsible for this task and commenced work in January 2011 with two goals: the compilation of the practical implementation guidelines "development of a publicly accessible charging infrastructure for authorising agencies and applicants" and in connection with this the (online) presentation of the charging infrastructure. The need for guidelines emerged as a result of the wide range of problems encountered by the project partners when setting up a public charging infrastructure within a group of 20 participants from the following institutions: TSB FAV, Freie Hansestadt Bremen, Wirtschaftsförderung Region Stuttgart, Stadt Stuttgart, RWE, SAENA, hySolutions, RheinEnergie, Stadtwerke Düsseldorf, Langmatz, DB Rent, ABGnova, InnoZ and Dornier Consulting Duisburg-Essen. Initially, the most recent insights and experience from the model regions was compiled and structured by dividing it into the topics planning, authorisation and technical realisation. Several sections of the practical implementation guidelines also refer to best-practice examples from the model regions. These are examples of concrete realisation that have proved to be particularly effective solutions for the questions and challenges that arose.

In addition to documenting the results and experience of the model regions and platforms in writing, the objective of the practical implementation guidelines is on the one hand to communicate the issues of infrastructure beyond the model regions and on the other hand to encourage the private sector and the municipalities to establish a charging infrastructure. As a result of the comprehensive presentation of the planning, authorisation, installation and operation of a publicly accessible charging infrastructure, the aim was to diminish inhibitions, while at the same time generating an awareness of the problems involved. Ideally, cities and municipalities should integrate electromobility into their mobility and urban development concepts now. In this way, a basis would be created for implementing electromobility as a component of these concepts, at the same time providing an opportunity for a chance for a systemic mobility strategy to be developed. In general, one could say that as a result of the current reticence in the public sector, the potential establishment of a charging infrastructure has shifted very much to the semi-public and private sector.

WORK GROUP: HARMONISATION

In the working group harmonisation, project partners with operational experience from four model regions came together and evaluated the business model "park & charge", based on the experience gathered in the projects. The partners' résumé states that with regard to public and semi-public parking spaces, time-based billing has many advantages over billing according to the energy quantity (see fig. 7).

In addition, in the working group harmonisation, different energy supply companies, together with a local representative, various representatives from scientific institutions and a consumer advisor, developed proposals for market models that could potentially provide non-discriminating access to charging infrastructure based on a user perspective. Particular attention was paid to infrastructure in public spaces here. The collaboration is exemplary for the goal of generating inter-agency results from the project and is implemented together with the supplementary research of the BMWi. The three market models that were developed in the working group differ with regard to the levels of regulation and are described according to eight aspects: "costs of charging infrastructure", non-discriminating access", technological innovation and cost efficiency", "spatial allocation and dimensioning", "transaction costs from a user perspective", "municipal issues", "international aspects" and "other".

FURTHER RESEARCH AND ANALYSIS REQUIREMENTS

In order to continue their activities, the participants in the platform infrastructure require a better understanding of the impact of electromobility on traffic and urban planning and vice-versa, in particular with regard to the demand-oriented development of additional infrastructure. In the process, it would be useful to update the practical implementation guidelines compiled by the working group practical implementation and to continue monitoring the infrastructure in the existing and new projects. For this purpose in particular, records of the intensity of use of the different kinds of infrastructures will continue to be made.

An interesting aspect for the platform infrastructure remains the developments in the area of business models and the operational and operator models. There may, for example, be a need for information with regard to the design of charging options for so-called parallel parking, service concepts such as safety checks before the initial use of electric vehicles and utilisation concepts in combination with public transport and car sharing.

In both sectors – transport planning and business models – the sharing of experiences with countries abroad is considered important. At the same time, the main focus it is not merely on the project development or the political groundwork. Instead, the dialogue partners hope that by exchanging operative solutions to specific questions they will benefit one another. For this reason, result reports, for example from Dutch and Scandinavian cities as well as the respective infrastructure operators, should be taken into account.

The project partners will keep a close eye on the technical developments, both in the sector rapid charging and induction charging, as well as solutions for controlled and bi-directional charging. In particular with regard to projects that are not part of the demo projects, safety and liability issues play a significant role. In addition, the online presentation of the publicly accessible charging infrastructure and user access via mobile end devices or other important information services are important future issues.

Furthermore, it will be necessary to develop commercial, municipal and operative fleets further and observe the subsequent impact on the charging infrastructure.

In the mid term, the practice guidelines are to be developed further and also updated to include new topics. If necessary, the data gained from the infrastructure monitoring (data request), as well as from the environmental platforms (charging measurements via data loggers), can continue to be collected and can in both cases be used for the further needs assessment of the charging infrastructure.

In the long run, in addition to keeping track of (new) technical developments, harmonisation – for example the access and billing systems – is an important field of activity. Furthermore, both national and international, innovative transport and mobility concepts will have reciprocal effects on the infrastructure. These interactions should be observed and a there should be active participation here.

COMPARISON OF BILLING OPTIONS

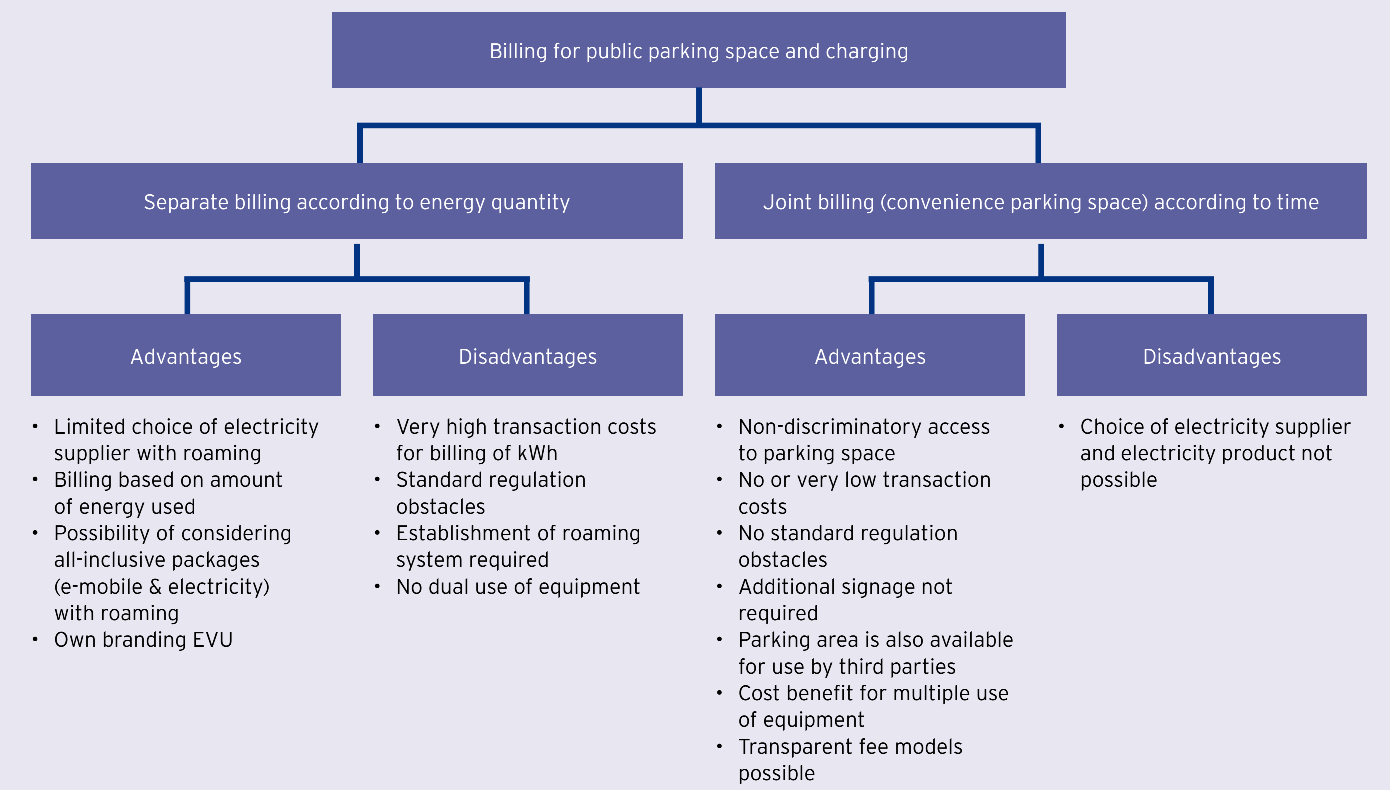


FIGURE 7: COMPARISON OF BILLING POSSIBILITIES BASED ON TIME AND AMOUNT OF ENERGY

>> 02 REGULATORY FRAMEWORK

BRIEF OUTLINE

The platform regulatory framework was set up at the end of 2009 and was managed by the BMVBS and coordinated by the NOW GmbH. On this platform, representatives of the 8 model regions, the municipalities in particular, universities, public utility companies, cross-regional energy supply companies and operators of charging infrastructure with a legal background worked in close collaboration.

The task of the platform was to identify the regulatory framework issues involved in preparing electromobility for the market and to collect and present possible approaches for the regions, to compile "best practices" and work on possible solutions.

The platform "regulatory framework" is closely interwoven with the platform "infrastructure" by the number of shared issues. As a result, joint meetings have been held since January 2011.

Up until the end of 2010, different topics were collected, which currently reflect open questions and obstacles that prevent action being taken in the model regions. It became evident that similar challenges are being faced in all the model regions with regard to the basic parameters. In fig 1 the topics are summarised according to the categories public space, infrastructure, vehicles and other. At the beginning of 2011, sponsors were found in the model regions for each individual topic in order that one main agent could be defined. This was because although the model regions were faced with similar challenges, the regional solutions were very different. The goal was to compile these.

The inquiries about the various issues led a collection and consolidation into four main topics and the associated sub-topics, as follows:

Identification
- The charging infrastructure during the charging process
- The vehicles
- The parking space, in particular the signage of the charging points. Please see transport communiqué, booklet 5 2011 (15.03.2011)

Incentive measures for electromobility
- Authorisation of bus lanes for electric vehicles
- Special lanes
- Free parking in city centres
- Authorisation of electric vehicles for entry into environmental zones
- Transferable licence plates
- Making pedestrian areas accessible for electric vehicles
- Public procurement initiative

Electromobility and the city
- Electromobility and living, e.g. parking space charters
- E-carsharing
- Combi-ticket models for public transport / e-carsharing / pedelec use

SPONSORSHIPS, NEED FOR ACTION, REGULATIVE LAW

Public space	Infrastructure			Vehicle					Other		Topics
Parking	Guidelines concession (PF IS)	Identification infrastructure	Non-discriminatory access (PF IS)	E-carsharing	Public transport	Pedelecs	Public acquisition	Identification	Incentive measures	Electromobility and city	Identified need for action
HH	BP HH SN	BO	HH	RM	RR HH	RM	RR	MUC STU	BO	RR MUC STU	Sponsorships

Abbreviations:
Hamburg = **HH**; Bremen / Oldenburg = **BO**; Berlin / Potsdam = **BP**; Rhine-Ruhr = **RR**; Saxony = **SN**; Rhine-Main = **RM**; Stuttgart = **STU**; Munich = **MUC**; platform infrastructure = **PF IS**

FIGURE 1

Transport safety

- Noise emission, sounds
- Danger to persons with visual impairment

Other topics such as the drafting of practice guidelines for the development of the infrastructure and the discussion of the "non-discriminatory access" were identified and passed on to the platform infrastructure to be worked on further.

MILESTONES

In the period from 2009–2011, the platform regulatory framework organised six symposiums, of which four were joint meetings with the platform infrastructure. In the course of the symposiums, more than 25 lectures were held on four main topics as well as project status reports on individual topics.

Symposium 1: Workshop June 2010
Discussion and exchange on the following topics:
- Is a charging column an autonomous piece of equipment in the street or an end device of a supply line.
- Length of parking time: only for parking procedure or longer
- Exclusion of user group privileges
- Awarding of special rights of use for setting up the infrastructure

Symposium 2: Meeting for project coordination centres December 2010
- Compilation of regulatory law topics via the project coordination centres
- Identification of topics from the sectors public space, infrastructure, vehicles, finances, other
- Allocation of sponsorships

Symposium 3: Platform symposium January 2011
- Presentation of topics from the model regions: non-discrimination / green electricity, parking, concessions, evaluation sheet for charging locations
- Inclusion of further divisions of the BMVBS with special discussions on the following points
  - Parking: transport communiqués, signalling of the charging process
  - Distinguishing of electric vehicles with a blue sticker
- Discussion incentives: Bus lanes, environmental zones, pedestrian zones, lanes for Pedelecs, combi-ticket models, transferable licence plates, public acquisition

Symposium 4: Platform symposium March 2011
- Presentation of findings from the E-trust study taking into account the aspects infrastructure and regulatory law.
- Discussion publication of transport communiqué
- Topics of meeting: approval of bus lanes, licence plates for electric vehicles, lifestyle and mobility
- Identification of new topics: noises and driving school
- Collection of questions from the sector regulatory framework with regard to the planned handbook "fleet operators and fleet management"

Symposium 5: Platform symposium June 2011
- Approval of bus lanes for electric vehicles
- Identification (charging infrastructure, electric vehicles, signage)
- Traffic safety with the main focus on noise made by electric vehicles
- E-carsharing
- Discussion of questions concerning regulatory laws and integration in the handbook "fleet operators and fleet management"

Symposium 6: Platform symposium September 2011
- Discussion about further development of the platform regulatory framework
- Presentation and discussion about approaches suggested by the model regions
  - Initial approaches in Hamburg to incentive systems
  - Identification and signage
  - State ordinance in Bremen with regard to non-discriminatory charging infrastructure, legal duty to maintain safety
- Presentation of potential identification for electric vehicles

In the course of the six symposiums, the platform served the project partners as a joint panel for exchanging information about the different kinds of local experience. Positive networking and lively exchange were established among the participants and the publicly accessible information such as the traffic communiqué and the state ordinances and regulations was provided.

In addition, there was an exchange of information with the group "law" from the projects e-energy and ICT on the theme of non-discriminating access to the charging infrastructure from the perspective of the user and the electrical supply companies. With regard to transport, non-discrimination is an important concern. Mobility obstacles in particular should be avoided. A further topic is the question of whether or not it would make sense to view the charging infrastructure as part of the energy network, in order establish a system-compatible link between electromobility and the energy sector.

RESULTS

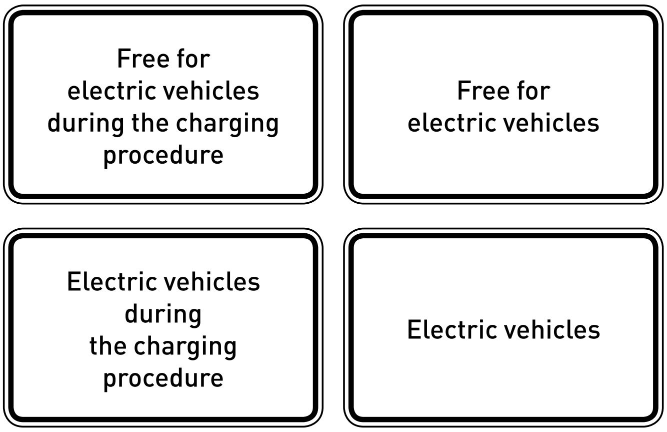
IDENTIFICATION OF PARKING ZONES

The work carried out by the platform regulatory law has generated initial concrete results. The BMVBS has subsequently issued a corresponding traffic communiqué, booklet 5 2011 (from 15.03.2011), on the subject of signage for parking zones for electric vehicles. Hence national standards are available for the signage of parking spaces for electric vehicles.

The traffic communiqué publication also includes supplementary signs, which can be implemented in connection with the symbols 314 (parking space), 315 (parking on pavements) and 286 (restricted parking):

- Positive signage: parking space (314) and parking on pavements (315) + supplementary signs
- Negative signage: restricted parking (286) + supplementary signs

Hence the supplementary signage for the parking zone can be as follows:



A survey was carried out in the model regions and used as the basis for a discussion about the use of signage. The result shows that signage is currently being used in three model regions and for the most part positive signage is being implemented. In one model region the signage has been implemented in connection with the symbol 1052-33 (car park ticket). In the other model regions, alternative signage is also used as a supplementary symbol or no signage has been used whatsoever. Other alternatives to the signage introduced are usually signs that can be distinguished through colour or that have been labelled using symbols.

In principle, in addition to signage, the identification of the parking space is also recommended in order to achieve a greater visibility for electric vehicles.

Based on the data collected in the context of the platform infrastructure, an additional picture emerges regarding the identification of the electricity charging parking space (see fig 2), especially with regard to the charging stations. In the analysis, 378 public sector charging stations were examined in the model regions. The results show that signage has been used for approx. 70% of the electricity charging parking spaces, in the form of signs, symbols on the ground or a combination of both.

IDENTIFICATION OF ELECTRICITY CHARGING PARKING SPACE

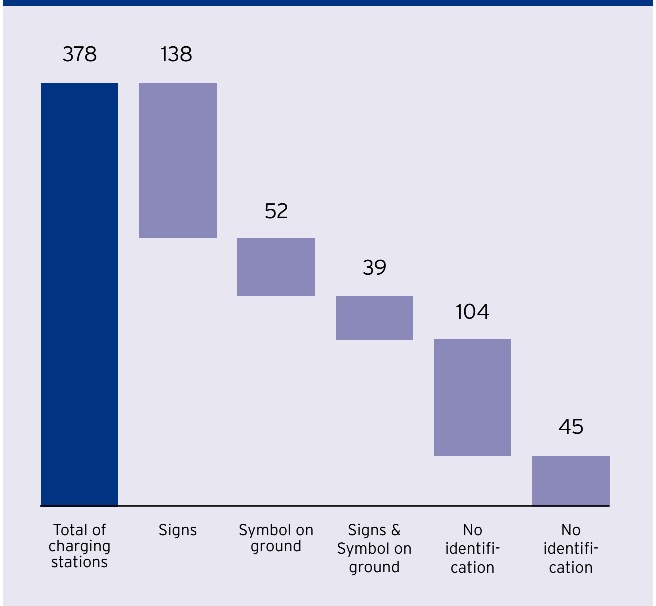


FIGURE 2

Parking as well as "charging" the vehicle is a transport-related action and is therefore considered an issue of public use according to § 7 clause 1 FStrG (Federal Highways Act). The "charging" does not mean that the vehicle is no longer defined as transport and does not divest it of its purpose as a means of transport. Correspondingly, the driver does not require a special use permit for charging the car in the highway ancillary facilities, which according to § 1 clause 4 no. 5 FStrG are an integral part of the highway.

IDENTIFICATION OF THE CHARGING INFRASTRUCTURE DURING THE CHARGING PROCESS

With regard to monitoring the authorisation to park using the sign "free for electric vehicles during the charging procedure" and "electric vehicle during the charging procedure", there are still aspects that have not been clarified in practice. As there is no distinct signal given by the charging infrastructure to indicate that the charging procedure has been completed – regardless of the technical feasibility of such an indicator either on the vehicle or the infrastructure, which still has to be clarified – a monitoring on the part of the regulatory agency can only be based on a visual inspection and the execution of discretionary power and requires that the regulatory agency staff are instructed accordingly. This is an adequate solution in particular with view to the low number of incidents. Possible law enforcement deficits must be accepted in the test phase. In addition, the municipalities in principle have the chance to specify special parking spaces for electric vehicles.

In this context, the Bremen-Oldenburg state ordinance was presented. It makes the awarding of concessions contingent on the charging station giving a signal at the end of the charging procedure. However, the technical feasibility of this specification is a matter of dispute among the partners in the model regions. A lively discussion was sparked among the participants and there is a need for further solutions in the future.

IDENTIFICATION OF THE VEHICLES

The identification of vehicles is not yet a great problem in need of urgent regulation as the level of vehicle density is low. An easily manageable process is required for the identification of electric vehicles, one that is not bureaucratic, is completely secure in terms of data protection and guarantees that the law enforcement staff and other road users are able to recognise the identification.

In view of the different types of electric vehicles, ranging from hybrid and plug-in to the pure battery-electric and fuel cell powered electric vehicles, it must be clarified which vehicles receive a form of identification.

So far, e-vehicles have been entitled to a green sticker as an entry permit into the environmental zones. In light of this, a variety of identification stickers should be avoided. Whether or not identification is required for safety reasons still needs to be assessed.

Emergency rescue services have the safety data of all vehicles at their disposal. As a result, the platform voted unanimously that identification cannot be dependent on the presentation of a green electricity contract, particularly for reasons of non-discrimination and feasibility. The platform's proposal envisages that the encoded vehicle classification be included in the vehicle documents as a tie-in for the identification. However, currently the vehicle classification (car, two-wheeler etc.) is not encoded in the vehicle documents. Instead, the classification is linked to the drive system. A vehicle classification would need to be regulated by EU law.

In principle, a system-compatible combination of electromobility with electricity generated by renewable energy is considered necessary for political reasons in order to ensure the acceptance of electromobility.

INCENTIVE MEASURES

With regard to the incentives, in two meetings and a special telephone conference, the possibility of opening bus lanes for electric vehicles was discussed and in some cases there was controversial debate. This led to a presentation of the existing international solutions, for example in Norway and Sweden. There are further examples of approaches taken in California (USA) and Australia with special lanes for fully occupied vehicles, in other words with 2–3 persons in addition to the driver (so-called commuter lanes or high occupancy lanes), as well as for hybrid vehicles.

On the other hand, representatives of the model regions took a critical view of the option of opening up the bus lanes to electric vehicles. They felt that public transport could be disadvantaged due to the capacity constraints on the bus lanes, the lack of technical feasibility and the clash of different transportation policy goals. This was increased by the difficulty in differentiating between vehicles with an electric power system and those with conventional combustion engines or plug-in hybrids, when they are operated in combustion mode.

If necessary, further scope for the use of bus lanes and special lanes could be envisaged for delivery vehicles and taxis, in the interest of efficient route planning and due to the fact that telematics equipment has already been installed.

The range of opinions presented here has not yet been substantiated by scientific analysis and practical testing. The theme of completely separate lanes for electric vehicles has also not yet been discussed.

The model region Hamburg presented the example of a planned designation of free parking spaces for electric vehicles, as a best-practice scenario. In this case, a free-parking sticker is being introduced and is available for drivers of cars with a carbon emission of less than 120 g / km², allowing them free parking for two hours in the Hamburg city centre. The plan is to evaluate the model every two years and reduce the threshold level for the CO_2 emissions step-by-step. However, the compatibility with § 6a of the German Road Traffic Act (StVG) has not yet been evaluated conclusively.

The basic parameters for public acquisition on a local municipality level were also discussed. In addition, the federal government acquisition initiative, which has already been published in the government programme, was presented. The goal is to define standard rules of acquisition and work tools for the federal government, the states and local authorities.

ELECTROMOBILITY AND THE CITY

In the sector electromobility and the city, further measures for the implementation of innovative mobility concepts with regard to the infrastructure were discussed, above all with view to the promotion of e-carsharing and the installation of suitable e-carsharing stations in public streets. Carsharing, with a range of services that provide an alternative to owning a car (above all due to the wide range of vehicles available for both long-distance and local transportation), reduces the pressure on parking spaces. At the same time, carsharing can serve as a supplementary aspect for e-vehicle users, for example, by giving them access to a suitable vehicle for long distances or transport purposes quickly and easily. In addition, electric vehicles can be incorporated into carsharing fleets, especially since electric vehicles are particularly suitable for fleet operation (standard fleet management, establishment of charging infrastructure in the specified parking spaces).

With regard to carsharing, the possibility of modifying the parking space regulations was also discussed. The parking space factor for conventional car-mobility is 1.5 parking spaces per housing unit, hence the carsharing concept allows for a lower parking space factor, e.g. 1.2 parking spaces per housing unit.

On this basis, it is important to analyse whether or not the car parking regulations should allow for e-carsharing spaces in future. This topic has not been discussed conclusively and it should therefore continue to be explored in more depth.

Additional requirements for the charging infrastructure were also discussed and intelligent solutions for parking and charging were developed. The possible self-commitment of the energy supply companies to only offer green electricity at the public charging columns was discussed. Other developments came to light, which showed a need for criteria when issuing a tender for the reorganisation of a charging infrastructure and / or charging columns. The example of the model region Hamburg is given here. The awarding of a concession for setting up charging columns is linked, among other things, to the supply of regenerative electricity, non-discrimination and its compatibility with the cityscape.

TRAFFIC SAFETY

In the sector traffic safety, in particular the themes of noise and the endangerment of persons with visual impairments were discussed. With regard to the noise emission of electric vehicles, the key message is that not only electric vehicles have low noise levels but also all the new conventional vehicle models with combustion engines. This theme should therefore be discussed in general in the context of traffic safety for vehicles.

Aspects such as the perceptibility of the particularly quiet electric vehicles also play a role here. Intelligent solutions should be developed, which warn unprotected road users appropriately, without eliminating the benefits of noise reduction. The experiences from the model region of Stuttgart show that in a project with 500 motorised two-wheeler drivers and 800,000 kilometres driven, there have been no incidents of noise-related accidents. On the other hand, an alternative, more long-term technical development should be kept in mind. It is conceivable that in the future, vehicles will communicate with one another and with their surroundings and in this way avert possible dangers caused by low levels of noise emission.

At present, the platform regulatory law has not ascertained any need for action. An eye should be kept on future developments, although the corresponding results from the R&D projects play a decisive role. In addition, in the context of the platform, representatives of local municipalities have ascertained that the demands made of the very limited public road space in the cities often compete with one another. In these areas, a preferential treatment of electric cars will be a further requirement that needs to be fulfilled in order to generate a balance of interests. This applies both to privileged treatment for stationary (parked) traffic as well as traffic in motion. The representatives of the local authorities expressed their concern that privileges granted too early, e.g. parking spaces kept free for electric vehicles in densely parked residential quarters without a visible demand that is comprehensible for the citizens could have a negative effect on the acceptance of electromobility.

NEED FOR FURTHER RESEARCH AND ANALYSIS

After the platform had dealt with this issue, a further need for discussion and research was identified. This includes the effects of electromobility on the (city) traffic. One of the particular issues here is how electromobility can be can be taken into account in urban development and planning. A key question in this context is: whether or not there will be more cars in the metropolitan area that take up the scarce parking space, particularly against the background that electric vehicles are used as short distance vehicles while conventional combustion vehicles are used for long distances. Traffic and urban planning aspects should also have a stronger impact on the infrastructure discussion. The following were listed as initial examples:

- Park & Ride with e-charging spaces – for the promotion of intermodal traffic chains with electric vehicles (also from the point of view of range).
- Bike & Ride with e-bikes or pedelecs requires possibilities at B&R stations for parking and loading that are secure against vandalism and theft.
- A special infrastructure for e-bikes, pedelecs and e-two-wheelers. These are currently being introduced in large quantities to the market. Due to the different speeds, safety issues must be considered – for example if these modes of transport are mixed with the purely muscle-driven bike traffic. There would be great potential for sustainable mobility if fast bike lanes could be constructed – at the same time there are also practical implementation issues, e.g. identification and legal designation
- Carsharing: identification of carsharing stations in the public road space
- Electromobility and living, scope for charging in densely populated city centre quarters.

Further important issues are the identification of the vehicles, in particular in the two-wheeler and hybrid sectors.

Other issues regarding the charging infrastructure in public spaces concern standardisation and safety, e.g. prevention, hazard control and liability issues in the case of e-accidents, charging cables as trip hazards in public space etc. as well as aspects linked to charging at the workplace.

>> 03 SOCIO-SCIENTIFIC SUPPLEMENTARY RESEARCH

BRIEF OUTLINE

The task of the platform, which is professionally co-ordinated by the Fraunhofer Institute for Systems and Innovation Research (ISI) in Karlsruhe, is to link the socio-scientific aspects of the individual projects in the model regions and relate them to one another, in order to create an overall picture. In terms of content, the platform focuses on two issues that are closely connected: on one hand the systematic determination of the requirements, needs and expectations, which the customers have of electromobility – both private and commercial – and on the other hand the analysis of regional perspectives, in other words the requirements, goals and challenges, from the perspective of the local municipalities.

The Stuttgart Fraunhofer Institut für Arbeitswirtschaft und Organisation (Fraunhofer IAO) is responsible for the key topic "electromobility and the city", while the Fraunhofer ISI is in charge of the analysis of customer acceptance as well as the overall coordination.

In a potential electro-mobile city or local municipality, both perspectives – that of the local municipalities and that of the users – must be combined, because only an electromobility concept that appeals to the customer has a chance to establish itself on the market. On the other hand, it is the regional terms and conditions in the local municipalities that define the parameters within which electromobility can develop. At the same time, electromobility has the potential to take an innovative approach towards the transport-political challenges that the local municipalities will be faced with, for example, those resulting from an increase in the population density in the cities, if these are taken into consideration in good time.

In order to achieve the above-mentioned goals, the Fraunhofer ISI manages a working group in the context of the platform project that includes participants from all of the model regions, which on the one hand collects the regions' customer research findings and on the other hand determines a standard data compilation of all the projects in the model regions, making it possible to carry out a cross-project data evaluation ("shared minimum data set"). Among the members of the working group are company representatives (e.g. from Daimler, EnBW), scientists from institutes (e.g. the German Aerospace Centre, InnoZ) and universities (e.g. the University of Duisburg-Essen, Frankfurt am Main University of Applied Sciences), as well as representatives of project coordinating headquarters.

MILESTONES

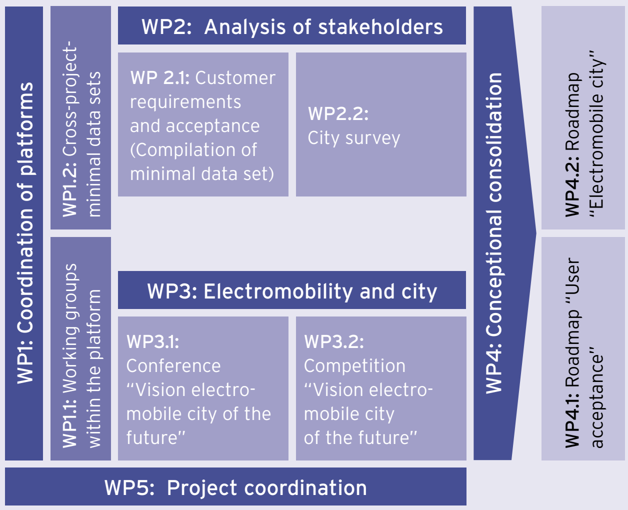


FIGURE 1

The work of the platform social sciences is divided into five work packages (WP), which correspond to the milestones. The first step involved setting up a working group together with the representatives of the projects in the model regions. This working group met six times in total during the project period, for the first time in May 2010 and provisionally for the last time in September 2011. A more detailed description of further packages can be found in the following section that deals with the findings of the platform.

The project is concluded with the compilation of roadmaps for the areas analysed. Services, products and technologies, but also requirements, performance parameters and planned measures can be incorporated into the roadmap and then linked to one another by paths of development, resulting in a more diverse range of applications for both the methodology and the document created. In order to create a roadmap, the parameters are determined in an initial step and the so-called architecture is specified. In steps 2 and 3, which will subsequently be linked to one another, technological or market-related developments are identified, analysed and evaluated. In step 4 their position on the roadmap is located in terms of content and time. Finally, step 5 involves the completeness and consistency analyses as well as the search for follow-up and cross-correlations, which define the paths of development within the roadmap. This is also followed by more detailed descriptions of knowledge development in the subsequent section.

RESULTS

CUSTOMER NEEDS AND ACCEPTANCE: THE STANDARD MINIMAL DATA SET

One of the main tasks of the project was the compilation of a standard data set on user awareness that covered all the projects in the model regions. The joint compilation of a questionnaire concerning a diverse range of projects with supplementary research on the user acceptance of electromobility in Germany is a completely new procedure. It provides a unique opportunity to gain cross-project as well as project-, regional- and vehicle-type specific insights and to view these in relationship to one another. The project goal was to question all the regular users of electric vehicles in the projects up to three times using an identical questionnaire ("minimal data set"), in order to guarantee that a comparison can be made between the data collected. This three-phase survey method is shown in the figure 2.

THREE-PHASE SURVEY DESIGN (T0-T1-T2)

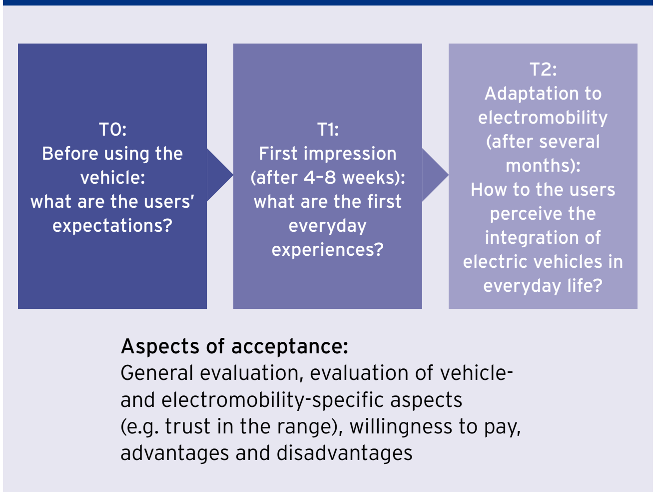


FIGURE 2

Using the minimal data set questionnaire, a total of 2,489 data sets could be compiled, hence generating a wealth of data from the projects. This is equivalent to 2,300 adjusted user surveys to determine the expectations T0 (approx 800 inquiries), the first impression T1 (approx 1,000 inquiries) and the experience with electromobility T2 (approx 500 inquiries). The results indicate that the participants in the fleet tests have positive expectations at the beginning of the tests – hence those interviewed presume that the electric vehicles will inspire them and that they are environmentally-friendly, beneficial in everyday life and easy to use. This appraisal is more pronounced among future two-wheeler users than car users, and private persons also have more positive expectations than commercial users. When it comes to the anticipated features of the vehicles, the future users reflect a realistic level of awareness: the expectations of the scope and charging time as well as the infrastructure available in the public space tend to be reserved. The technological sophistication of the vehicles with regard to service, safety/reliability and comfort is only anticipated to a limited extent. With regard to the costs, the participants have equally realistic perceptions, for example, they are often aware of the fact that the acquisition costs of the electric vehicles are comparatively high and the operating costs relatively low. On the other hand, the persons questioned had very positive expectations with regard to driving pleasure, vehicle noise and handling of the charging process.

This range of perceptions of electromobility becomes more stabilised during the participation in the programme, as is shown by the evaluation of the surveys made at the time of T1 and T2. The respondents see a need to catch up in the area of infrastructure, while the perception of electromobility as an environmentally-friendly alternative as well as the high level of enthusiasm for the vehicles becomes more stable. The majority of the participants in the survey expressed great interest in electromobility and plan to keep informed about the topic in the future – when the respective projects are over.

However, one encouraging aspect is that the percentage of persons who consider purchasing an electric vehicle increases considerably one they have started using such a vehicle. Yet it could be that the issue of whether or not someone is willing to replace their existing vehicle is not the crux of the matter: the survey participants evaluate the integration of electric vehicles in broader-based mobility concepts as being particularly innovative, e.g. in the context of local public transport, carsharing or intermodal approaches, however the persons questioned also see potential for electro-vehicles in the sectors of commercial or individual transportation.

>> 03 SOCIO-SCIENTIFIC SUPPLEMENTARY RESEARCH

ROADMAP CUSTOMER ACCEPTANCE

The roadmap deals with customer acceptance and describes the most important social trends, the subsequent demands made of politics, vehicles, infrastructure and future mobility services, as well as the subsequent recommendations for politics, industry and the municipalities as three superordinate approaches and allocates these to a respective timeframe. The timeframe has been specified as a period of ten years from the beginning of 2011 to the end of 2020. This ten-year period was divided up into five categories, which describe the current status in 2011, the short-term period until 2015 and the year 2015 itself as a "half-time" milestone, as well as the midterm period until 2020 and the year 2020 as a politically-motivated milestone in itself. The results will be disclosed in the publication "road-map of customer acceptance".

ELECTRIC VEHICLE CONFIGURATOR

In addition to the conceptual design and implementation of a web-tool for the ascertainment of customer needs and acceptance, in collaboration with the Fraunhofer ISI, the Fraunhofer IAO has conceived an analysis and information tool. It also serves to inform people who are not directly involved in one of the model region projects and / or do not yet have any experience with electric vehicles, about these vehicles and to question them about their expectations.

A web-based vehicle configurator has been developed as an online tool, which incorporates the demands made by private customers of electric vehicles (from mini vehicles to SUVs and vans) and enables a transparent comparison between electric vehicles and conventional Otto-engines and/or diesel-powered vehicles. Economics, comfort, marketing and environmental factors are taken into account here and presented to the user as a comparison. The total cost of ownership (TCO) is calculated based on respective norms such as DIN EN 60300-3-3 (guidelines for implementation of life-cycle costs). The TCO includes the acquisition costs, operating costs, maintenance costs and sales revenue. In order to calculate the values, an Excel-based calculation model has been set up.

The configuration options include the type of drive, performance, maximum speed and range. In addition to the configuration of the engine and vehicle concept, the configurator enables the user to define additional components on the exterior that are specific to electric vehicles (e.g. the positioning of the charging plug, the choice of horn etc.) and on the interior (e.g. the selection of the recuperation modus, the range indicator etc.) as well the desired ambience conditions (e.g. special access permits, infrastructure development, etc.). In addition to the description of factors related to the vehicles only, the vehicle configurator also serves to incorporate the needs of the user. In order to enable a standard evaluation of the data sets, the survey is based on the categories and questionnaires compiled for the accompanying research.

Following the content development, the software for the vehicle configurator was implemented during the time of the report and was tested and evaluated extensively. It is now available for recording user requirements and for the purpose of collecting data.

CITY SURVEY

The Fraunhofer IAO carried out a written survey in which they questioned people in the cities. In supplementary in-depth interviews based on guidelines, they also questioned selected representatives in the model regions in order to gain a more extensive understanding of the city-related needs and planning required in the sector electromobility.

The written questionnaire for the city-dwellers encompassed three areas: the technical and organisational structure, activities in the city and external collaboration and networking. The random selection of cities from the model regions was made in agreement with NOW as well as with the respective project coordination centres in the model regions. Written questionnaires were sent to 56 cities in the model regions. With 21 responses to the questionnaires, the return quota was just short of 38%. The structured in-depth interviews were conducted with a total of 11 representatives from the cities in the model regions. The selection was based on the regional distribution (one city per model region or two cities in the model regions spread over a larger number of municipalities) as well as initial insights gained from the written questionnaire and the number of specified activities, in order to identify potential best-practice examples. The interview partners were persons responsible for electromobility, in general from the Departments of Transport and Environment as well as from the business development sectors. The interviews sought to inquire about the motivation and role perception of the cities as well as responding to questions concerning the legal and regulative parameters. On the other hand, more in-depth inquiries focused on the activities of the cities in the sectors charging infrastructure, vehicles and concept development, as well as issues of networking and protagonists.

The findings from the city survey show how the motives that prompt the cities to become more active in the sector electromobility can be divided into the three areas: environment, traffic and commerce. In addition to the climate change goals, the main focus is above all on the reduction of local emissions (air pollutants and noise). In the transport sector, the theme of electromobility is seen in connection with an upswing of alternative transport concepts, although there are no expectations that electric-powered transport will be able to solve all of the traffic problems. A linking of electromobility with the local public transport and sharing concepts is viewed in a very positive light. A further motive that is mentioned is the improvement of the quality of the location both as a commercial and residential location. In addition, the image and the function of cities as role models is listed as a motive.

With view to the charging infrastructure, the development of the private and semi-public charging stations is considered to have priority. The development of the public charging infrastructure should be integrated into the city and located at important intersections and points of contact, as well as serving to supplement the private and semi-public charging stations. The main focus here is on multi-storey carparks, P&R parking spaces and stations, for example, where people change to trains or buses. When the first electric vehicles are deployed in the cities, this will be primarily in the form of fleets of cars as well as tourist services. The fleets of cars, which also play a particularly important role with regard to public relations, usually have a broad base – ranging from Segways, pedelecs and scooters to cars and utility vehicles.

The visibility of electromobility is important in the cities. Initial concept developments for the introduction of electromobility are frequently promoted in connection with existing development plans in the sectors transport or environment, while electromobility can be an important element here. The development of guidelines is perceived as a useful instrument, in order to establish a standard approach for example. The theme of networking is perceived by the cities questioned to be very important. The aim here is to link the individual protagonists (administration, energy providers / municipal utilities, companies, universities and research) in the city and on the other hand to connect them to other local municipalities and the local surroundings, to engage in exchange, learn from one another and develop concepts that extend beyond the boundaries of the city. The results are incorporated into a corresponding roadmap.

COMPETITION "VISION ELECTROMOBILE CITY OF THE FUTURE"

With funding from the Federal Ministry of Transport, Building and Urban Development (BMVBS), the Fraunhofer IAO organised an ideas competition "Vision electromobile city of the future". The goal was to encourage ideas that can make a contribution to designing the city of the future. For the time of its duration, from mid-May to the end of August 2011, the competition generated innovative ideas for the electromobile city. With more than 100 users registered on the competition web page and more than 270 comments, the competition site has developed into a platform for lively communication and exchange about ideas for the electromobile city of the future. Contributions could be made in the four areas "IN MOTION – intelligent, integrated e-mobility", "CHARGED – infrastructure integrated into the city", "CONSTRUCTED – electromobile city design" and "LIVED – life in the electromobile city". In each category, a specialist jury selected a winner according to the following criteria: novelty value and level of innovation, feasibility, ecological contribution, social benefit and level of specification of the idea. The winners were able to select prize money to the sum of 5,000 euros or a free two-year membership in an innovation network of the Fraunhofer Institute worth 30,000 euros.

CONFERENCE "VISION – ELECTROMOBILE CITY OF THE FUTURE"

On 7th and 8th September 2011 the BMVBS, together with NOW, invited people to the conference "Vision – Electromobile City of the Future" in the German Federal Ministry of Transport offices in Berlin, in order to highlight central issues concerning the city of the future. The Fraunhofer IAO was responsible for the contents of the programme. In addition to representatives of the model regions, who presented their results, speakers were invited to present German and international best-practice solutions, and together consider next steps and scope for the implementation of electromobility in Germany and worldwide and to discuss this with the audience. The two-day event was extremely well attended and provided deep insights into the visions of different industries and protagonists, in the context of the four topics determined at the same time as the above-mentioned competition. The winners of the four future competition areas were ceremoniously awarded their prizes and given the opportunity to present their contributions to a large audience.

MORE DEMAND FOR RESEARCH AND ANALYSIS

SECTOR CUSTOMER ACCEPTANCE

The fleet tests in the existing eight model regions have shown that the commercial use of electric vehicles in particular can represent an important primary market. As a rule, the commercial use generally envisages the integration of electric vehicles in a company fleet, which means that the specific strengths of both the electric and conventional vehicles can be taken advantage of (e.g. electric vehicles for the city and conventional cars for long distances). Commercial fleets are also particularly relevant because they frequently travel a large number of kilometres and with their combustion engines are responsible for a large amount of the local emission load. At the same time, commercial use as a rule also implicates a special challenge for user acceptance because the decision-makers and actual users are often not identical. Regulative incentive systems and an attractive environment – for example loading and parking opportunities – create interesting starting points for the introduction of regulations. However, there is currently a lack of interesting concepts and business models that could be analysed with view to their potential acceptance for vehicle fleets. It is necessary to close this gap and build on this by developing a comprehensive acceptance profile for the commercial use of electric vehicles too.

Another main focus of the acceptance analyses will be on twin-track vehicles. Electric vehicles can develop their environmental and economic potential – provided that the acquisition costs of electric vehicles decrease – in particular if they replace conventional cars and utility vehicles, and it is anticipated that the twin-track vehicles are better suited to this task. In addition to more detailed analyses of the available data and a continuation of the standard customer research, it seems wise to supplement the acceptance analysis with further methods that focus for example on the themes of environmental awareness or infrastructure, which from a customer perspective have proved to very significant in previous surveys.

SECTOR ELECTROMOBILITY AND CITIES / LOCAL MUNICIPALITIES

The networking of the agents involved in the topic city / local municipalities, as well as the networking of the local municipalities with each other and their surroundings, is seen to be an important measure that should be continued and further developed. The general transfer of knowledge and the sharing of specific experience all contribute to a more efficient implementation of the theme of electromobility in the cities and the municipalities. The systematic combination of the three industries automobile, information / communication technologies and energy should continue to be promoted and brought in line with user requirements and municipal challenges.

A quantitative survey made to ascertain the status quo as well as the needs of the electromobility sector in differently-sized cities and local municipalities would make an interesting supplement to qualitative surveys. This would make it possible to determine specific starting positions and different requirements and in this way to develop concepts to promote the introduction of an electromobility concept that is tailored to the demands.

>> 04 INNOVATIVE DRIVE BUS

BACKGROUND AND GOALS

The findings of the platform innovative drive bus (bus platform) will be presented in this section. This platform was founded to link the activities focused on the deployment of hybrid buses in the model regions nationwide.

The goal of the platform's work was the documentation and evaluation of the findings of the ongoing analyses of innovative diesel-hybrid buses in German transport companies, sponsored by the Federal Ministry of Transport, Building and Urban Development (BMVBS). The main focus of this analysis, using funding from the economic stimulus package II and the federal state North Rhine-Westphalia, was on "electromobility in the model regions".

From the €130 million funding for the model regions, €26 million was invested in the public transport sector (hybrid buses and purely electric-powered buses). In addition, the transport association resolved to fund the acquisition of 21 diesel-hybrid buses with a total of €10 million in the model region Rhine-Ruhr (VRR) in 2009.

By 2012, approximately €30 million had been provided in the VRR region for the acquisition of additional buses. In this way a total number of 73 hybrid buses was achieved. The findings gained in the context of the bus platforms are based to a large extent on the evaluation of the business operation of these buses. The corresponding accompanying research within the VRR was also funded by the BMVBS with approximately €860,000.

MERCEDES-BENZ HYBRID ARTICULATED BUS IN HAMBURG (MR HAMBURG)

The bus platform began its activities in November 2009. Until September 2011, members of the platform met regularly for all-day events, which covered the following topics:

- Current implementation status of the projects in the model regions
- Evaluation of the technical and operational proficiency level of the hybrid buses in operation
- Identification of scope for optimisation
- Questions concerning the education and further education of technician staff in high voltage technology
- Future requirements of the bus service centres (safety, ergonomics, operational sequences)

The platform consists of representatives from 21 German public transport companies and transport associations in the model regions of Hamburg, Bremen, Rhine-Ruhr, Rhine-Main, Saxony, Stuttgart and Munich. In addition, experts from six bus manufacturing companies as well as two manufacturers of components and systems for hybrid buses have been working together on specific themes. This expert team is supplemented by staff from academic institutions such as the Institut für Kraftfahrzeuge (ika / Institute for Motor Vehicles) at the RWTH Aachen University, the Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), the Technischen Universität Darmstadt (Technical University Darmstadt), TÜV Nord and the individual transportation companies, who support the technical and operational evaluation of the vehicle employment. The BMVBS, representatives of the regional project headquarters in the model regions and the Association of German Transport Companies (VDV) are also involved in the bus platforms. As a result, an expert committee with special competencies was set up, involving of all relevant interest groups.

The National Organisation Hydrogen and Fuel Cell technology – (NOW GmbH) and hySOLUTIONS GmbH were responsible for the specialist and administrative coordination of the activities. PE INTERNATIONAL AG was included in the platform and was responsible for the compilation of data and its subsequent evaluation and analysis. The type and scope of the data collection and evaluation was coordinated between the partners involved, within the context of the bus platform. The partners have drawn up a corresponding cooperation agreement that defines the scope of their collaboration and the subsequent rights and duties.

VEHICLES IN THE MODEL REGION RHINE-RUHR (SOLARIS, MAN, VOLVO, MERCEDES-BENZ, HESS)

The work of the bus platforms focuses on the documentation and evaluation of the tests made of hybrid buses in everyday operations, in transportation companies in the seven model regions. These results are used to assess the scope for technical and operational optimisation. With a test fleet of 59 diesel hybrid buses, evaluations were conducted in what is currently the largest available data pool of this drive technology in Germany. This report represents an initial inventory in what is overall a very dynamic development process. The findings determined and collected as a joint effort in the context of the bus platform, make it possible to systematically evaluate the practical feasibility and the climate protection benefits of hybrid buses for the first time.

METHODOLOGY AND MILESTONES

Today, local public transport is the backbone of climate-friendly mobility. In recent years, the emission of carbon-particulate matter and nitrogen oxides by diesel buses has been reduced by more than 90%. One problem that remains is the carbon dioxide, which harms the climate. This can only be reduced on a broad basis in the bus-based local public transport system by moving to electric and semi-electric drive systems such as hybrid buses. Another advantage of electrification, and subsequently hybrid technology, is the reduction of noise emissions in comparison to conventional buses.

The field tests in the model regions focus above all on urban traffic. Other areas of application such as transport in peripheral regions, is only included in the tests to a limited extent. The bus manufacturers tested serial as well as parallel and power-spilt hybrid drives. The evaluation of all the data therefore provides an optimum foundation for comparing as many combinations of implementation profiles and technically-diverse hybrid systems as possible, with view to their effectiveness.

The main focus of the work of the bus platforms was on the development of an effective information system for a shared technical and operational evaluation of the hybrid buses. This occurred on the basis of regular supplies of data from the regional demonstration projects. The corresponding data was complied and evaluated centrally with the aid of the web-based software tool "SoFi" by PE INTERNATIONAL. In addition, aggregated indicators were compiled for all the partners. The system provided every partner involved with the opportunity to compare their specific findings with the consolidated average values of all the data suppliers involved, in order to gain an idea of the status of development of their own vehicles. The aggregated indicators were presented in the bus platform meetings and discussed intensely by the partners. Conclusions were then drawn regarding potential optimisation.

In addition to this data drawn from the business operations of the vehicles, test runs were incorporated in the evaluation as a further supplement and as a professional backup. These were carried out using specific measurement facilities. These included, for example, analyses of the interior and exterior noise generated by hybrid buses, conducted by the RWTH Aachen, or the exhaust gas emissions calculated by TÜV Nord in the transport association Rhine-Ruhr. In addition, analyses were made regarding the acceptance of hybrid technology on the part of bus drivers, passengers and pedestrians.

INAUGURATION OF 12M MAN-HYBRID BUS IN MUNICH (MR MUNICH)

FIGURE 1: THE THREE PILLARS OF EVALUATION

In some transport companies, comparative test runs were also carried out with conventional diesel buses using identical basic parameters ("twin test runs"). Some findings could be made here with regard to fuel consumption.

Although the bus manufacturers are competitors in the market, the work in the bus platform was characterised by open and constructive communication. With the aid of the results compiled, the specialist exchange of experience between the transportation companies as well as with industry were intensified and discussions were held on how to implement and support the scope for optimisation identified by all parties supported in the next phase of development. In order to protect fair competition, the results of the data evaluations have not been disclosed in detail but presented in an aggregated form.

RESULTS

In the context of the bus platform, data for the determination of operational, technical and ecological reference figures was calculated and evaluated. The data compilation was supplemented by specific technical measurements as well as face-to-face interviews carried out to assess the acceptance of the technology on the part of bus drivers, pedestrians and passengers. The databases comprised a total of 59 diesel hybrid buses (current at September 2011) from six manufacturers[1]. Twelve of the 17 participating transport companies operated hybrid buses by several manufacturers. Two companies operated a mixed fleet comprising of buses with serial, parallel and/or power-split hybrid drives, twelve with only serial drives and three buses with a parallel drive only (see fig. 2).

The evaluation by the partners was based on the joint compilation of binding criteria, e.g. availability, fuel consumption in comparison to diesel reference vehicles. From a present-day perspective, all the central issues that are relevant for the market orientation of urban bus services are covered by these criteria, which were also applied as measurable single values.

1 There is currently no data available for 4 vehicles by 2 manufacturers.

MANUFACTURER	EVOBUS	HESS	MAN	SOLARIS/ ALLISON	SOLARIS/ VOITH	VOLVO	VDL
Type of bus	Articulated bus	Articulated bus	Solo bus	Articulated bus	Articulated bus	Solo bus	Solo bus
Hybrid technology	Serial	Serial	Serial	Power- split	Parallel	Parallel	Serial
Type of energy storage	Li-Ion battery	Supercap	Supercap	Nickel-metal hydride battery	Supercap	Li-Ion battery	Supercap
Number of vehicles	30	17	2	7	3	1	3
Deployment in	Hamburg, Bremen, Munich, Rhine-Ruhr, Saxony, Stuttgart	Rhine-Ruhr, Saxony	Rhine-Ruhr, Munich	Rhine-Ruhr, Munich, Saxony	Rhine-Ruhr	Rhine-Ruhr	Rhine-Main

FIGURE 2: OVERVIEW OF THE VEHICLES *

* A total of 63 hybrid buses are in operation in the model regions. 59 of these buses are actively or passively funded (by the supplementary research). These comprised the basis for the data.

In order to guarantee a largely neutral calculation of the indicators for the evaluation criteria and to enable them to be compared, in the next step standard specifications were defined for putting the vehicles into operation (speed, route structure etc.). By involving PE INTERNATIONAL as an independent institution and establishing appropriate access strategies (clean-room), the data confidentiality could be ensured. In addition, it could be ensured that only those with authorised access were able to review the data. The following data was compiled for evaluation:

- The amount of diesel the vehicle has been fuelled with and the corresponding kilometre readings per bus
- Routes that the buses were deployed on (the corresponding route profile such as the distance between bus stops and average speeds have been recorded in the system)
- Fuel consumption in comparison to conventional buses with comparable operations and the corresponding carbon dioxide emissions
- Mileage and hours of operation
- Status of operation and availability

MERCEDES-BENZ HYBRID ARTICULATED BUS IN BREMEN (MR BREMEN)

In order to achieve results that are as informative as possible, the diesel-hybrid buses and also the reference buses put in operation at the same time were employed as much as possible on clearly defined routes and over longer periods of time (collection of data from September 2010 to September 2011).

The evaluation of the data was made on the basis of different topic areas that were of technical, operational and ecological significance: practical feasibility and operability, efficiency, ecology and climate protection, as well as acceptance (see fig. 3). They allow for a presentation of the current period of reporting as well as the accumulated values for the entire duration of the support programme.

PRACTICAL FEASIBILITY AND OPERABILITY	Mileage, operating hours, availability
EFFICIENCY	Fuel consumption of endurance test consumption measuring
ECOLOGY AND CLIMATE PROTECTION	Exhaust fume emissions (particulate matter / PM, NO_x) noise emission (sound)
ACCEPTANCE LEVELS	Evaluation by drivers acceptance of passengers / passers-by

FIGURE 3: OVERVIEW OF THE REFERENCE VALUES CALCULATED BY ALL PARTIES INVOLVED

The main focus of the results presentation is initially on the relative modifications required when the conventional diesel buses are compared with the hybrid buses.

PRACTICAL FEASIBILITY AND OPERABILITY

In the context of the regional bus trials, which have been collected in the context of the bus platform, total mileage amounted to approx. 1.4 million kilometres with more than 78,400 operating hours[2]. The average daily mileage of the hybrid buses was approx. 210 kilometres. This corresponds with performance that is nearly equivalent to that of conventional buses. The same also applies to the average period daily of use at 14 hours, which is only marginally below the usual value for diesel buses: one can generally assume 16, sometimes 18 hours of operation for diesel buses.

Another positive aspect is the development of the availability of the hybrid buses for longer periods of use than previously (see fig. 4). Although the availability was initially limited, as is typical of such trial projects, these are meanwhile coming increasingly close to the availability factor of 90% that is typical of the conventional buses. Because some of the hybrid buses deployed had only been in service for three months at the time of the report, a further improvement in the average vehicle availability is anticipated.

2 The specification regarding the hours of operation applies to 42 hybrid buses.

AVERAGE MONTHLY AVAILABILITY IN %

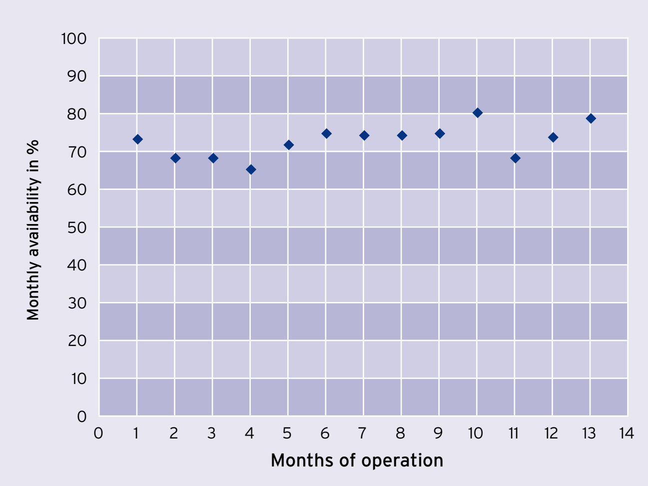


FIGURE 4: AVERAGE MONTHLY AVAILABILITY IN %

AVERAGE USE OF ARTICULATED AND SOLO BUSES

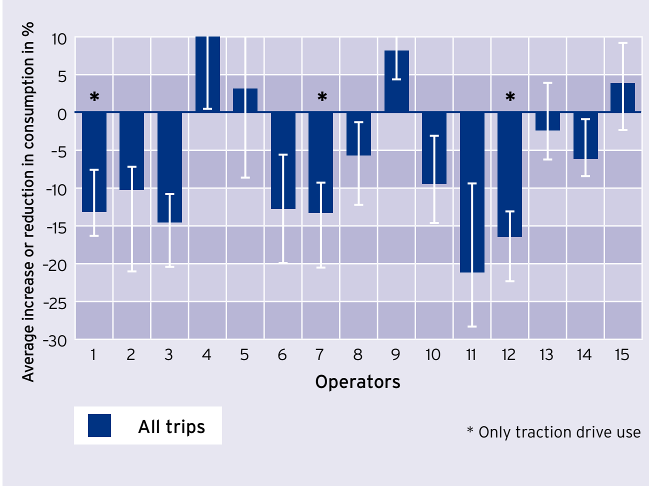


FIGURE 5: AVERAGE CONSUMPTION
(CF. DIESEL HYBRID BUS AND REFERENCE VEHICLES[4])

EFFICIENCY

One significant expectation made of hybrid technology is the reduction of fuel consumption. This is dependent on a large number of factors, including the outside temperature and topography, and above all, the characteristics of the respective routes with different distances between the bus stops, alternating traffic density and not least the driving style of the bus drivers. The analyses show to some extent how the interactions between these aspects differ between conventional diesel buses and hybrid buses and where serial or power-split hybrid drives show greater success. However, further analyses must be made as the results of the fuel consumption in particular still show a mixed picture (see fig. 5).

While in the case of twelve transport companies, fuel consumption savings of between 2 and almost 20% could be made to date, four companies currently have an increase in consumption. According to the status of the analysis, this is the result of different factors, for example, the operation management, the air conditioning, the route characteristics and a limited comparability of the vehicles. Optimisation measures will be particularly affected by these factors.

The savings achieved to date still contain a great deal of scope. However, they also show that further decreases in fuel consumption are possible, in particular in the case of the vehicles that have not yet achieved their full saving potential[3].

3 At this early stage following the initial use of hybrid buses for regular line operation, it is still difficult to calculate a specific quantification of the scope for optimisation.

In order to identify and implement this scope for optimisation, in the accompanying programme implemented in the model region of Saxony, the consumption data was collected section by section and compared to the corresponding speed profiles.

Based on further performance measuring test drives on a test site (see fig. 6) as well as simulations, optimisation proposals for reducing the fuel consumption were prepared. In terms of vehicle specifications, the recommendations referred primarily to the following factors, while taking into account the elevation profile, the location of the bus stop and the speed of the vehicle:

- Traction chain incl. the motor-generator unit
- Controlling the charge status of the energy storage
- Effects of the purely electric vehicle operation
- Controlling of the hybrid-specific ancillary aggregates
- Energy management

In addition, recommendations for the conversion of the vehicles for the purely electric drive with recharging options for the transport companies and respective manufacturers were derived from this.

4 This graph only takes into account data provided by operators with a comparable reference vehicle (Euro V / EEV). Data acquisition: September 2011

FIGURE 6: MEASURING TEST DRIVE ON THE LAUSITZRING (LEFT) AND A FLOW-METER IN OPERATION, MR SAXONY (RIGHT)

ECOLOGY AND CLIMATE PROTECTION

Due to the reduction in fuel consumption achieved for diesel fuel in comparison to the non-hybrid buses, it was possible to save more than 90,000 litres of diesel during the project period in the electromobility model regions. This is equivalent to around 270 tons of the greenhouse gas carbon dioxide (evaluation including path of fuel production).

In addition, the life cycle analyses of three diesel-hybrid buses carried out by PE INTERNATIONAL showed an amortisation after a maximum of two years. In other words, the additional ecological expenditure for the manufacture of the vehicle, including the hybrid drive components, results in effective relief for the environment in comparison to the conventional diesel bus after two years at the latest. With regard to most of the output quantities analysed, e.g. CO_2 emissions, there is an ecological amortisation after just one year.

In the context of the supplementary research of the transport association Rhine-Ruhr, the environmental influences of hybrid buses in comparison to conventional diesel buses was also examined, using methods such as the measurement and analysis of emissions. In addition, eight routes were selected, along which five hybrid buses by five manufacturers were measured by TÜV Nord in two measurement campaigns. In comparison to the articulated buses (hybrid and conventional), it was possible to reduce the particularly significant NO_2 direct emissions in the cities by an average of 75% through the introduction of hybrid buses – and at the same time there was a tendency towards a reduction of the overall NOx emissions. With regard to the CO_2 emissions, average values of about 10% lower compared to conventional vehicles were achieved, depending on the case of operation. In the case of solo buses, a comparison with former measurements made of conventional buses in the city of Hagen shows average NO_2 and CO_2 reductions of approx 54% and 21% respectively.

As an additional field of research, scientific measurements of noise emissions were carried out by the Institut für Kraftfahrzeuge der RWTH Aachen (institute for motor vehicles). These measurements showed that the sound pressure levels of the hybrid buses were mostly below that of the conventional buses, particularly in the purely electric operational mode. The analyses made in the passenger compartment as well as the exterior for the bus stop approach and departure and showed, depending on the specific driving and operating mode the hybrid articulated buses, a reduction in the maximum sound pressure levels of up to 10 dB(A) and a reduction of up to 12 dB(A) in the exterior noise emissions in comparison to the standard diesel buses. The results of the reduction of the exterior noise levels are particularly significant for the acceptance and perception of the technology, above all in the inner cities.

MERCEDES-BENZ HYBRID BUS FLEET IN STUTTGART (MR STUTTGART)

ACCEPTANCE OF HYBRID BUSES

As a supplement to the analyses and evaluations of the vehicle technology and the operating performance, surveys were conducted to assess the acceptance and perception of the hybrid technology. The bus drivers were questioned, as well as the transport associations involved, the passengers and also passers-by. The overall results show that hybrid buses are positively evaluated.

Most of the 250 bus drivers questioned gave very positive reports of their experience. For example, the majority of staff had no difficulties with the adjustment to the new drive technology, which was also due to training being provided (see fig. 7). By training the drivers, further scope for saving could be realised.

SERIAL DIESEL HYBRID BUSES MANUFACTURED BY VDL IN DARMSTADT (MR RHINE-MAIN)

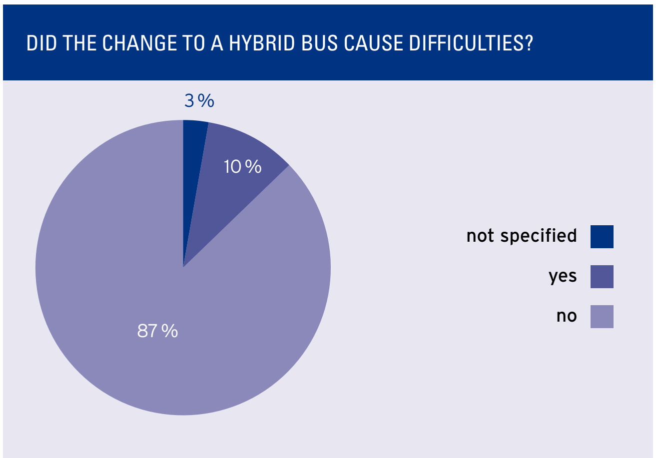


FIGURE 7: DRIVERS' ADJUSTMENT TO HYBRID BUSES

One of the main focuses of the passenger survey was the noise development of the vehicle. The respondents were specifically asked if and how they would recognise that they were in a bus with an innovative drive. About half of the approx. 1,400 passengers questioned perceived lower noise levels as an improvement. 18% of those questioned did not perceive any difference. However, one fifth of the passengers also perceived the hybrid buses to be louder than conventional buses (21%). The reason is probably that after phases of quiet, purely electric driving, the sound of the combustion motor starting up again was perceived more clearly and the passengers were more aware of higher-frequency sounds that are otherwise drowned out by the noise of diesel motors.

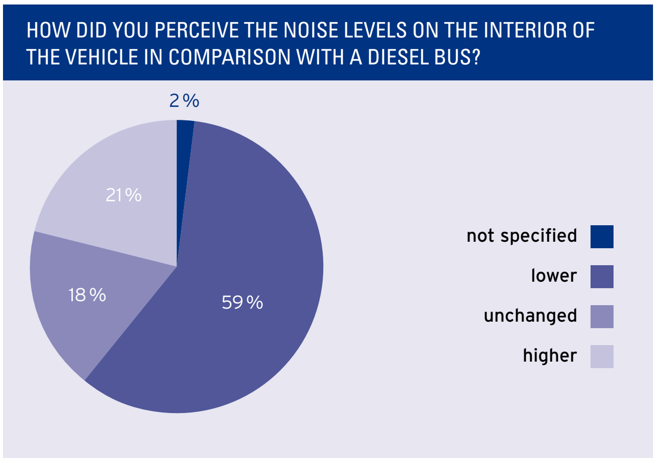


FIGURE 8: PASSENGERS' PERCEPTION OF NOISE LEVELS

INITIAL AND ADVANCED TRAINING OF SPECIALISED STAFF

In addition to developing a high level of awareness in the sectors research and development, the initial and advanced training of drivers and maintenance staff is imperative. Due to the high-voltage technology, the repair and maintenance work on the hybrid buses not only requires the qualification of specialist staff but also an appropriate status of work as well as special safety measures, in order to carry out work on the roof, for example. A large part of the hybrid technology is located on the roof (including the power electronics).

The qualification of the specialist staff is organised in three stages, depending on the work to be carried out. Within these stages, a theoretical and a practical examination qualifies the specialist staff to carry out certain tasks. To this effect, the partners participating in the bus platforms have taken the initiative, together with the VDV, and have produced a VDV publication[5], which contains instructions for the introduction of hybrid buses from a maintenance perspective. Corresponding concepts have already been implemented in the different transport companies.

FIGURE 9: STATUS OF WORK ON HYBRID BUS AT BOGESTRA

5 VDV-communiqué no. 8002: instructions for the introduction of hybrid buses from a maintenance perspective

4. CONCLUSION AND FURTHER RESEARCH AND ANALYSIS NEEDS

The report issued by the platform innovative drive bus provides the first systematically-compiled findings on practical feasibility and operability, fuel consumption, climate-protection impact and the acceptance of hybrid buses. Although the data is generally based on a short utilisation period for the hybrid buses of just three to twelve months, this has created a good basis for an initial evaluation of the hybrid technology. The scope for optimisation that was determined is an excellent staring point for further, targeted phases of development.

In the coming years, the main focus will be on different goals and measures implemented by various manufacturers, for example, the continuous refinement of the fuel consumption levels, the further development of the ancillary aggregates for the utilisation of hybrid buses, analyses of vehicle failure aimed at improving the components (and as a result enhancing the availability) and the improvement of the routine maintenance procedures and the accessibility of the vehicle components.

The hybrid technology makes new demands of the technical support for the vehicles. These include the initial and further advanced training of technical staff from the transport companies. However, an increase in the operation of hybrid buses does not only lead to a growing demand for appropriately trained staff but also means that agreed specifications regarding suitable training content in terms of didactics and subject matter is required for universities, vocational training colleges and further educational institutions.

The testing of the vehicles in the model regions was and is an important step in the development of a market for hybrid buses. The experience documented in the context of the bus platforms illustrates the scope of hybrid technology and sends out a positive signal to political institutions and other potential users.

However, the technical developments have to date not been completed and it is not yet possible to say how the different forms of hybrid drive can be best employed in practice. It is clear that the application profile of a hybrid vehicle has a decisive influence on the corresponding scope for saving. The manufacturers participating in the tests were able to ascertain scope for optimisation during the test phase, which has occasionally already been implemented in the case of vehicles dispatched at a later date. In order to increase the levels of planning and asset protection (for future users as well as for the vehicle industry), further purpose-related funding initiatives will also be needed in the next phase of the market preparation.

From the perspective of the transport companies and bus manufacturers participating in the bus platforms, a continuation of the data acquisition is recommended for the buses in operation. This would result in the generation of even more conclusive information regarding the evaluation criteria. The continued operation of the buses once the programme has been completed will be the responsibility of the transport companies – which is also desired by the funding bodies. Due to the fact that the periods of operation are sometimes short, no conclusive statements can currently be made regarding the economic viability of the operation of hybrid buses. It would therefore be helpful to extend the period of time for the data collection, in order to gain more reliable data regarding operational and maintenance costs – which could also provide important impetus for market development.

The use of hybrid buses in line operation increases the visibility of hybrid technology for passengers and regional decision-makers. It is necessary for the federal government to extend the operational phase and enhance communication with suitable information measures, in order to ensure a broader level of acceptance and establish low-emission buses as the obvious quality standard for bus services. Due to its climate and environmental friendliness, as well as its low noise development, hybrid technology has the potential to win new customers for local public transport and increase the number of climate-friendly vehicles and modes of transport. Corresponding economies of scale based on the level of demand can help achieve more cost-effective prices for hybrid buses.

The response to the demonstration projects, which has so far been positive, as well as the results of the platform's work, document the achievement potential of the local bus industry and the drive system manufacturers, the readiness for innovation on the part of the German transport companies, the importance of the employment of innovative drive systems in public transport for climate protection and the scope for creating added value in Germany.

>> 05 CARS / TRANSPORTERS: SUPPLEMENTARY RESEARCH ENVIRONMENT

BACKGROUND AND GOALS

The goal of the platform supplementary research environment was to assess the environmental impact of the operation of the vehicles in the individual demonstration projects in the model regions, in particular the CO_2 emissions, and to highlight the perspectives with regard to the requirements and scope for the creation of climate-friendly electromobility concepts. The content of this key topic was worked on by the Wuppertal Institute for Climate, Environment and Energy (WI). The institute received support for the data acquisition from PE INTERNATIONAL (PE). The platform that provided the framework for the accompanying research was coordinated by NOW GmbH and EnergieAgentur.NRW. About 40 permanent representatives of the supporting research institutes, the participating automobile manufacturers and companies responsible for the conversion, as well as the energy suppliers working in the context of the main areas of funding, were involved in the work process.

The platform focused on the following environmentally-related tasks:

1. Calculation of loading quantities and energy consumption resulting from the operations of the analysed electric vehicles and their CO_2 emissions, as well as a subsequent comparison with the operation of conventional (fossil fuel-driven) vehicles.
2. Presentation of the future requirements for a climate-friendly electromobility concept with low CO_2 emission levels.
3. Calculation and evaluation of the potential for an increase or reduction of these levels as a result of the implementation of electric vehicles in the environment-relevant areas of noise or sound development, polluting emissions and eco-balance.
4. Estimation of potential changes in mobility structures / mobility behaviour of private persons and (commercial) fleets following the implementation of electric drive systems.

As a result, the supplementary research provides information about the environment-relevant impact currently associated with the operation of electric vehicles in the projects and the impact that can be anticipated in the future. Areas of operation were identified that could reduce the level of damage to the environment caused by the manufacture and operation of electric vehicles. As a result, suggestions for possible follow-up activities were collected. These do not only include indications of how to increase the energy efficiency and incorporate vehicles into a system characterised more strongly by renewable energy. As electromobility is part of a more comprehensive mobility and fuel strategy, a further goal is to position the findings in the overall context of changing mobility structures and to determine synergies for measures set up to avoid or to shift the location of heavy traffic levels.

MILESTONES

The thoughts and ideas on how to design the analysis were presented in the constitutive platform meeting on 30.03.2010. In most of the subsequent platform meetings, discussions were held about which course of action to take with the partners and the interim results were also presented and discussed. Supplementary to this, regional meetings were held with the partners on location (including the model regions Munich, Stuttgart and Rhine-Main). Starting in November 2010, four sub-working groups were formed in order to make decisions regarding individual research aspects. Each of them focused on different contents and human resource issues:

1. Working group: Electricity mix
Topic: Specification of how the electricity used has been generated and how it can be developed in future.
Partners: primarily energy supply companies

2. Working group: Comparison vehicles
Topic: Specification of electric vehicles and vehicles powered by fossil fuel and a comparison between the two based on their environmental impact
Partners: primarily automobile manufacturers and re-fitters

3. Working group: Noise / pollutants
Topic: Evaluation of the influence of electric vehicles on the noise development and air pollutants
Partners: research institutes from the model regions

4. Working group: Eco-balance
Topic: Evaluation of the life-cycle-related environmental impact of electric vehicles and the subsequent effects
Partners: research institutes form the model regions and external parties involved

In these working groups, the active and the external partners in the programme made their relevant findings and expertise available to the platform. The topics dealt with by the working groups have been incorporated into separate results reports, which serve as the basis for the results report of the platform supplementary research environment as well as the corresponding summary. The comprehensive report will be made available following a detailed evaluation of the database.

RESULTS

The main task of the platform was the incorporation of the individual projects in the key areas of funding, with the goal of evaluating the electric vehicles in comparison to conventional vehicles, in terms of their environmental impact. The focus was on fuel consumption and damage to the climate, factors that are currently perceived to be critical. In order to enable a maximum range of participation by the very differently-positioned individual projects, a minimum data set was defined, one that provides sufficient support for the key issue. The exact data specification and the file format were developed and agreed on by all parties in the course of several platform meetings.

In addition to more general tasks (such as vehicle identification, model regions, physical quantity of the reported values), the survey focused on:

- Single trips: including duration, route and amount of energy drawn from the battery
- Charging process: including charging time and amount of energy drawn from the grid

PE INTERNATIONAL was involved in the data acquisition process. The company's data interface SoFi had already been tried and tested in the context of the platform "Innovative drive bus".

EVALUATION OF EXPERIENCE WITH ELECTRIC VEHICLES

Despite initial delays in the data collection from the individual projects, in the end a sufficient number of vehicles, as well as a large number of test drives and charging processes could be included in the analysis and recorded in accordance with the standard data format. One of the reasons for the delays was the step-by-step availability of the electric vehicles for the individual projects, the amount of time needed for the installation of data registration terminals (data loggers) and the challenges posed by the data generation and data transfer. The following raw data could be integrated:

Vehicles included:	more than 350
Test drives included:	approx. 155,000
Mileage included:	approx. 530,000 km
Charging procedures included:	approx. 30,000

MODELS INCLUDED, ACCORDING TO SEGMENTS

Segment	Models
Minis / Microcars	smart ed; THINK City; Mitsubishi I-MiEV; Fiat 500 Electric; CITYSAX; e-WOLF DELTA 1
Small cars	Stromos
Compact category	Mercedes A-Class E-Cell; VW Golf blue-e-motion
Medium class	Renault Fluence Z.E.
Utility vehicles (small)	Renault Kangoo Z.E.; Fiat Fiorino Electric; Ford Transit Connect BEV; Goupil G3
Utility vehicles (large)	Mercedes Vito E-Cell; Ford Transit BEV; Modec

ACCORDING TO THE KBA (FEDERAL MOTOR VEHICLE AUTHORITY) SEGMENT CATEGORIES

The respective completeness and plausibility tests showed a smaller quantitative, evaluable quantity structure. Additional information gained with regard to further vehicles and circumstances was also of assistance to the analysis. In accordance with the vehicle use in the model regions, this made it possible to depict a wide range of vehicle models drawn from different vehicle segments. As is generally the case with the availability of electric vehicles, both the small and very small vehicles (minis and microcars) and the utility vehicles (light-duty commercial vehicles) dominate in the model regions. In the latter case, there are substantial differences in the size and load capacity within the segment. Furthermore, informative data is available for many vehicles in the compact category. However, this is limited to one particular model.

The data evaluation generated the following overall results with regard to the driving distance, duration and charging procedures:

- The average driving distance is approx. 7.3 km, however every second journey is less than 3.6 km and every ninth journey more than 30 km.
- The average journey duration is approx. 17 minutes, while half of the journeys do not last more than 11 minutes and almost 90% of the journeys are not longer than half an hour.

- The charging processes last 2.5 hours on average, however in half of the cases, the vehicle was only charged for 75 minutes, while in 10% of the cases, the charging process lasted 3.5 hours or longer.
- The average quantity of electricity used per charging process is a good 5.5 kWh, in half of the cases 3.5 kW or less, and in 10% of the cases 14.5 kWh or more.

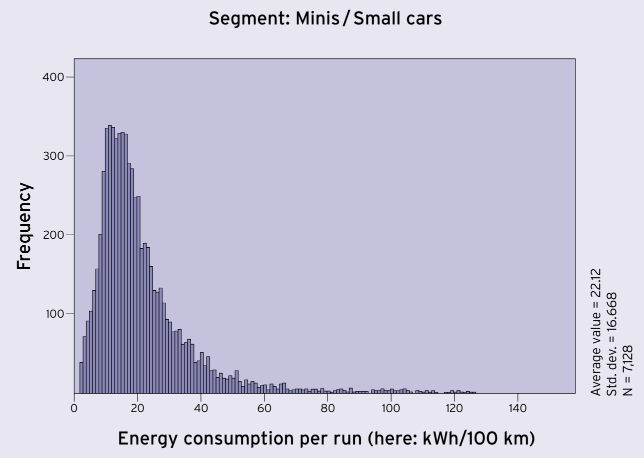
Using this existing database as a starting point, it can be concluded that the distances travelled by the vehicles do not cause any constraints for everyday use. Further findings can be found in the detailed project report.

With regard to the decisive topic of specific energy consumption, the vehicles and the journeys made have been summarised in three more or less homogenous groups:

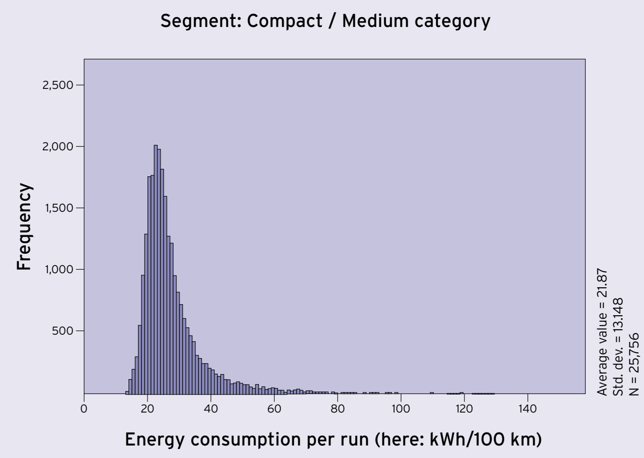
Minis / microcars and small cars (with minis as the dominant group), compact and medium class (with compact cars as the dominant group) and utility vehicles (smaller and larger lightweight utility vehicles). An average consumption value of 18.4 kWh / 100 km for all journeys could be ascertained – depending on the configuration of the vehicles and their utilisation. Hence the differentiation between the market segments is considerable, as expected, in particular between the normal car and the lightweight utility vehicles. In the case of minis / microcars and small cars, an average consumption of 17.2 kWh / 100 km can be ascertained while in the case of the compact and medium class cars the value is 16.9 kWh / 100 km.

The somewhat unexpected higher consumption levels of the minis and small cars in comparison to the compact and medium category vehicles is probably due to the shorter average distance of the mini and small car journeys included in the survey, in comparison to the journeys made by the compact and medium category vehicles. However, this difference is scarcely discernable in view of the available data. In the case of the lightweight utility vehicles, the average consumption is almost twice as high with 30.4 kWh / 100 km. As depicted in the following graphs, the consumption values for the individual journeys are spread plausibly among the respective main areas of focus, which, due to the greater diversity of the models, are somewhat higher in the case of the minis / microcars and small cars and utility vehicles in comparison to the compact and medium category cars characterised by one model. In addition, as anticipated, the median value for all the journeys, which is significantly above average for the total journeys made, confirms that shorter journeys generate higher consumption values.

MINIS AND SMALL CARS
average: 17.2 kwh / 100 km



COMPACT VEHICLE AND MEDIUM CATEGORY
AVERAGE: 16.9 KWH / 100 KM



UTILITY VEHICLES (LIGHTWEIGHT UTILITY VEHICLES)
AVERAGE: 30.4 KWH / 100 KM

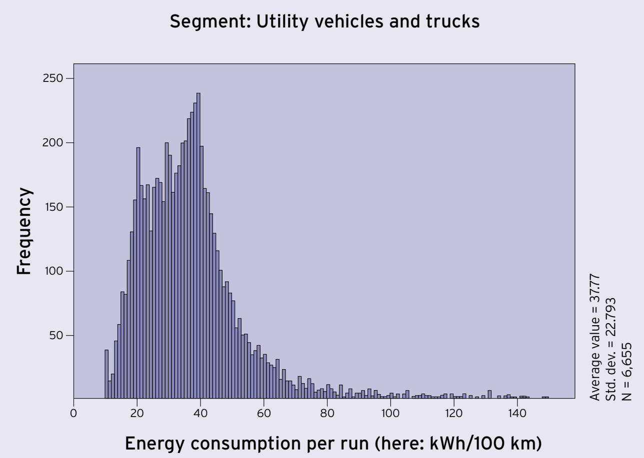


FIG: DISTRIBUTION OF JOURNEYS ACCORDING TO THE SPECIFIC FUEL CONSUMPTION (KWH / 100 KM)

When interpreting these results it should be taken into account that the electric vehicles in operation are pilot series or retro-fitted vehicles. It can be assumed that prior to the market launch, consumption-optimised improvements will be incorporated in the construction. It is not possible to quantify these factors here as they can differ very much depending on the model. For this reason the results can only be evaluated in terms of the current status and perceived as an indicator for the near future.

Furthermore, the available data does not cover the winter operations including the additional costs generated by heating energy, which in comparison to conventional vehicles appears in this analysis in the form of estimated values. The charging losses of the batteries that were not included in the test-run data have also been incorporated in the study in the form of estimated values.

The conventionally-powered vehicles that have been used as a standard of comparison have been divided into segments based on three stages:

- Best of class: the most fuel-efficient serial model according to the Deutsche Automobil Treuhand GmbH- (German Automobile Trust – DAT) list (cf. http://www.dat.de/leitfaden/LeitfadenCO2.pdf)
- Middle market: the sales-oriented average model in the respective category 2010, according to the statistics compiled by the German Federal Motor Transport Authority (KBA)
- Still marketable: the worst market-relevant series of each respective category in terms of fuel consumption / emissions, also according to the statistics compiled by the Federal Motor Transport Authority (KBA).

CONVENTIONAL MODELS USED AS A CRITERIA FOR COMPARISON, DIVIDED INTO SEGMENTS

Segment	Best of Class	Fuel consumption. l / 100 km		CO_2 emissions g / km	
		In the city	comb.	In the city	comb.
Minis / microcars	smart fortwo coupé cdi 40 kW	3.4 DK	3.3 DK	g / km	87
Small cars	VW Polo 1.2 TDI DPF (CR) BM	4.0 DK	3.4 DK	106	87
Compact category	VW Golf 1.6 TDI DPK (CR) BM	4.7 DK	3.8 DK	125	99
Medium-sized category	Toyota Prius (Hybrid) *)	3.9 OK	3.9 OK	92	89
Utility vehicles (small)	Fiat Doblo Cargo 1.3 Multijet Euro 5	5.9 DK	4.8 DK	156	126
Utility vehicles (large)	VW Transporter Kasten 2.0 TDI BMT	8.3 DK	6.7 DK	220	176

SEGMENT LABELLING ACCORDING TO THE FEDERAL MOTOR TRANSPORT AUTHORITY (KBA);
DK = DIESELKRAFTSTOFF / DIESEL FUEL; OK = OTTOKRAFTSTOFF / GASOLINE
*) WITHOUT PLUG-IN ABILITY. DUE TO THE FACT THAT IT IS FUELLED BY A COMBUSTION ENGINE ONLY ON THE PRIMARY SIDE, THIS VEHICLE IS CLASSED AS A CONVENTIONALLY-POWERED CAR.

The first step was used as a measurement value, based on the idea that regarding both conventional and electric-driven vehicles, the aim is to seek alternatives for creating a new vehicle with as low levels of fuel-consumption and environmental impact as possible. In principle, the attempt to establish a suitable basis for comparison is subject to considerable limitations. This goes far beyond the fact that conventional vehicles do not have any mileage constraints, which limits the comparability of electric vehicles used as supplementary vehicles or in special segments. More specifically, these are based on what are currently still differing engine performances, maximum speeds and the subsequent fuel consumption values. These factors can also be extended to include the range of different prices. In terms of price comparison, improvements that reduce the fuel consumption levels for conventional vehicles are also conceivable, as opposed to the potentially time-consuming and technological developments and also economies of scale in the case of electric vehicles.

One limiting factor of the fuel consumption levels included in the calculation is that although the consumption and CO_2 values for the combined driving cycle and for the more representative city drive cycle are available for the benchmark models, when it comes to the sales-oriented segment averages provided by the German Federal Motor Transport Authority (KBA) (and the vehicle series) only the values for the combined cycle are available. The basic limitations on the reliability of a comparison between real data in the case of electric vehicles (primarily in inner city traffic) with cycle data in the case of conventional vehicles should be noted.

A decisive factor that has an impact on the harmful or positive effects on the environment and the comparison with the conventionally-powered vehicles is the CO_2 emission levels, which must be ascribed to the electric vehicles due to the fact that electricity needs to be generated to meet the electricity-consumption requirements of the electric vehicles. An appropriate allocation of CO_2 emission values is however not self-evident or non-contentious but is dependent on the perspective. Here, it is important to differentiate between

- an attribution of CO_2-emissions on the basis of the actual electricity consumption as well as the electricity generation required for this consumption and
- an approach based on financial attributions in the context of a specified overall system (e.g. Germany or the EU) according to the existing regulatory balance values.

The latter observation leads to the conclusion that electric vehicles cannot be attributed their own CO_2 emission values: The total levels of CO_2 emissions resulting from electricity generation are limited by the cap & trade regime of the European Emission Trading Scheme and this limit is considered to be definitive[1]. The amount and type of electricity generation (and current collection) do not change this value, in other words an additional demand for electricity caused, for example, by the operation of electric vehicles would not lead to any changes in the CO_2 emission levels within this system. To what extent the emission permits introduced to ensure adherence to the limited emission target ceiling in the context of the emission trading system can be purchased or sold and who the partners in these trading procedures are, remains insignificant for the overall emission levels attributed to the electricity sector.

In principle, it is worthwhile applying the previously outlined approach in order to evaluate the carbon footprint of electric vehicles from the perspective of a system analysis and against the backdrop of the applicable energy and climate change policy regulations, however the analysis of the attainable net effects requires a broadening of the system boundaries. In particular it is necessary to take into account an allowance – that could be made at the moment – for the electric vehicles in the context of the European fleet fuel consumption limits. In practice this means:

- As long as the fleet fuel consumption limits are adhered to by the inclusion of electric vehicles, these electric vehicles will have no impact on the actual CO_2 emissions generated by the traffic.
- On the other hand, should the fleet fuel consumption limits be achieved without the electric vehicles, these vehicles will generate a reduction in the actual CO_2 emissions caused by the traffic.

With view to the case at hand, if one concentrates, as specified, on the key issue of how the actual journeys made by the electric vehicles have an impact on the CO2 emissions as a result of their electricity consumption, as well as on the creation chain that subsequently no longer applies, no simple answer can be found. In fact, literature and public debate (cf. for example the talks at the 43rd LCA Discussion Forum, Life Cycle Assessment of Electromobility, 6th of April 2011, ETH Zurich) show different perspectives on the allocation issue because an actual, conclusive allocation of a specific means of generating electricity on the one hand to a specific utilisation of electricity on the other hand, is generally difficult. As the different allocation methods lead to results that are too divergent, the subsequent analysis incorporates all the different approaches and makes the differences transparent. In the process, a differentiation is made between

- the complete supply of the electric vehicles with renewable electricity (this is generally aspired to and is to some extent reinforced by the high demands made of the procedure for the certification of the charging electricity in the model regions),
- the supply of electric vehicles with electricity in accordance with the current German energy mix
- the supply of electric vehicles with electricity in accordance with the supplementary generation of electricity for electric vehicles as additional electricity consumers, applied to energy-efficient operations.

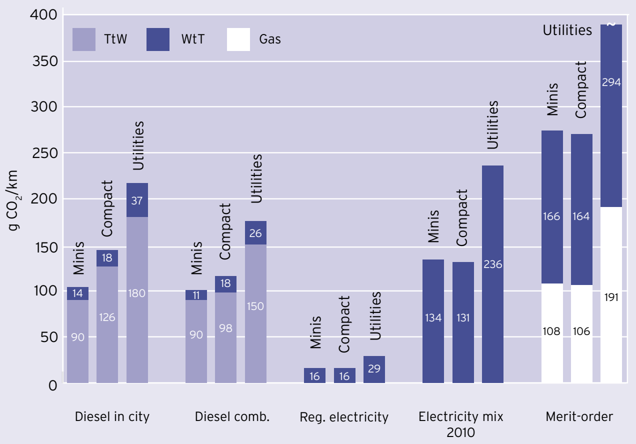
Finally, the different procedures represent evaluations in specific contexts, which each show a high level of traceability depending on the perspective and are differently suited for practical implementation. A comparison of the results of the model calculations allows for a holistic evaluation of the carbon footprint of electric vehicles. The flowchart showing the current status (from 2010) depicts the quantitative results of the comparison of the vehicles in the evaluable vehicle segments. The lower threshold represents the "generation of electricity purely from renewable energy". For the purpose of theoretical comparison, the "evaluation according to the merit-order-method" is applied as the upper threshold and a coal-fired power station as a marginal power station represents the upper margin.

	Conventional drive		Electro-vehicle			
	In city	Comb.	Regen.	Mix 2010	Coal	Gas
Minis / small cars	104	101	16	134	274	108
Compact / medium	144	116	16	131	270	106
Utility vehicles	217	176	29	236	485	191

TABLE: SPECIFIC CO_2 EMISSIONS (G CO_2 / KM) IN A COMPARISON BETWEEN CONVENTIONAL VEHICLES AND ELECTRIC VEHICLES WITH DIFFERENT ELECTRICITY SOURCES

1 According to specifications made by the European Emission Trading Scheme, the greenhouse gas emissions from the energy sector for the period from 2005 to 2020 will be reduced by approx. 21%. According to the directive currently in effect, the EU assumes that there will be a linear, progressive reduction of the caps to the value of 1.74 % pa (cf. Directive 2009/29/ec) for the period after 2020 (that means at the end of the current specified period of commitment).

EVALUATION OF THE CARBON FOOTPRINT OF ELECTRIC VEHICLES



Key: WtT = Well to Tank; TtW = Tank to Wheel; Gas = amounts of gas within merit-order; Minis = Minis / microcars and small cars; Compact = Compact and medium-sized; Utilities = lightweight utility vehicles

FIG: EVALUATION OF THE CARBON FOOTPRINT OF ELECTRIC VEHICLES IN COMPARISON TO CONVENTIONAL VEHICLES BASED ON DIFFERENT PATHS OF ELECTRICITY GENERATION FOR 2010 (DEPICTION ACCORDING TO VEHICLE CATEGORIES AND SEGMENTS: MINIS / MICROCARS AND SMALL CARS (COMBINED), COMPACT AND MEDIUM-SIZED (COMBINED) AND UTILITY VEHICLES (LIGHTWEIGHT UTILITY VEHICLES)

Explanation of figure: the regenerative path is the most effective and in the long term this is the path of electricity generation that should be aspired to. It reduces the CO_2 emissions for example in inner city traffic by a factor of 6–9 (depending on the vehicle category, the real data generated in the model regions can be compared to the cycle data of conventional vehicles). Within the electricity mix path, the CO_2 emission levels are almost as high as those of conventional vehicles. This also applies to the shift in the gas-based capacities within the merit-order curve. As the number of electric vehicles increases and a there is a higher level of integration of renewable energy in the generation system, the impact on the climate will increase considerably (see also the long-term prognoses for the generation of electricity for 2020 and 2030). With the German energy mix, electric vehicles will make a contribution to climate protection in the future too.

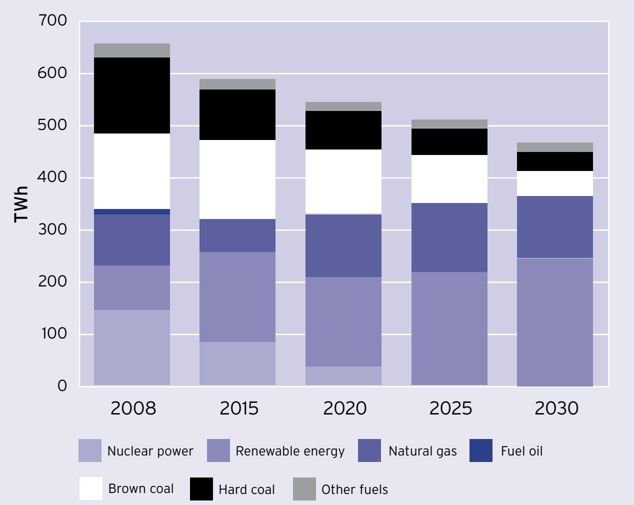
When evaluating the results, it should be taken into account – in addition to their range and quite considerable margin of fluctuation – that at the moment the absolute quantities of the calculated increase or decrease in the environmental stress levels can to a large extent be perceived as meaningless due to the small number of electric vehicles in operation. This also applies on a large scale to 2020, when although according the federal government targets the number of electric vehicles will increase considerably to reach 1 million, they will at the same time only make up about 2%.

With regard to the electric power consumption, the percentage of relevant electric vehicles is even smaller. In 2020 this will probably still be less than half percent of the entire domestic consumption. The evaluation for 2010 is hence a snapshot and should not be equated with the relevance of electric vehicles for the climate in what will potentially be a mass production in the future, in a period of time when the energy mix for the provision of electricity will also change.

OUTLOOK 2020 AND 2030

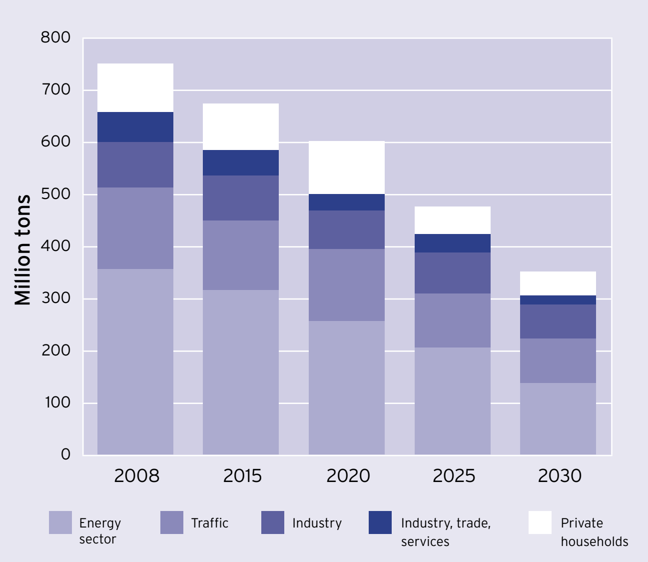
While the specifications for the status quo can be documented using empirical data, for the further outlook, assumptions need to be made, or references to the existing scenarios. The so-called "exit strategy" in the energy scenarios 2011 compiled by Prognos / EWI / GWS could be seen as a benchmark measure here. The predicted development of the electricity generation and the greenhouse gas emissions envisaged here are depicted in the following graphs showing the vehicle population.

GROSS POWER GENERATION BASED ON ENERGY SOURCES IN THE EXIT STRATEGY



DATA: PROGNOS / EWI / GWS 2011

COMBUSTION-RELATED GREENHOUSE GAS EMISSIONS



DATA: PROGNOS / EWI / GWS 2011

As a result of the withdrawal from nuclear power and the increasing ratio of renewable energy, the fuel mix will already have changed considerably by 2020. However, fossil fuel power plants are also responsible for generating a considerable amount of the power.

When predicting the parameters of the evaluation methods examined here, this means the following: in the anticipated mix (with a very high percentage of wind energy), the emission levels of renewable electricity remain low. With regard to the specific emissions of the national fuel mix, by 2020 the "exit scenario" will subsequently result in a reduction of approx. 10% in relation to 2010. The merit-order electricity is clearly shifting towards a gas- electricity based generation of power, depending on the type of deployment of the electric vehicles, and where appropriate it is also shifting to some extent towards the generation of renewable electricity.

Improvements can be anticipated with regard to the energy efficiency of battery-powered vehicles due to the optimisation of the concepts. The scope for energy conversion in the electric engine however, is close to the physical limit and has almost been exhausted. In the case of the conventionally-powered vehicles, in the upstream chain of the fuel supply there is a slight deterioration expected due to an increase in accessing inferior deposits (with higher energy expenditure levels for production), while on the other hand a slight improvement can be anticipated due to the higher ratio of renewable energy sources. With regard to the vehicle, the implementation of the EU target value of 95g CO_2 / km for new vehicles in 2020 will represent a considerable reduction in comparison to 2010 (average for Germany: 151.7g CO2 / km) as it can be anticipated that some of the reduction will be realised as the result of the implementation of electric vehicles themselves.

In 2030 and after, the development could be modified to a considerable extent: regarding the fuel mix, an increasing dominance of renewable energy is anticipated (the German government aims to achieve 55% of the 80% planned for 2050 as an intermediate step, in order to achieve a further step-by-step reduction of CO_2. By then, the maximum current will probably be generated by gas-fired power stations and in the case of charging procedures targets for electric vehicles, subsequently increasingly by renewable electricity.

With regard to the conventional vehicles, after 2030, a significant rise in the levels of CO_2 emissions caused by the upstream fossil fuel supply chain will probably be generated. A more long-term incorporation of renewable fuels (e.g. synthetic methane or other fuel sources from the impact chain wind-power-electrolysis-hydrogen-power synthesis) could however partially or completely compensate this effect. In as much as the generation of renewable electricity will cover a further share of the overall electricity generation after 2020 – in excess of the amount produced by the phased-out nuclear electricity generation, which from today's perspective is to be anticipated and is a clear intention of political programmes – then this ratio will change considerably in favour of the electric vehicles. By 2050, the goal that has to some extent been set foresees that the generation of electricity will be based very much on renewable energy sources (in the federal government energy strategy, a percentage of at least 80% of power requirements for 2050 has been specified) and should this materialise, then the CO_2 value in the power mix will become more similar to that of a power generation based purely on renewable energy.

If one sums up all of the aspects, the following can be ascertained: in the various examples of literature on the subject, different evaluation methods have been used to determine the carbon footprint of electric vehicles, which means there is a great deal of discrepancy in the results that can only be analysed more closely on a mid-term or a long-term basis. If electric vehicles are operated using electricity from renewable energy sources, then their carbon footprint is very much better than that of a fossil fuel-powered car. However, there is some contention over when, to what extent, and based on what preconditions (proof of origin), the traction current can be allocated to electricity production using renewable energy sources. From a pragmatic viewpoint, the fuel mix methods provide a good orientation for the climate-based orientation of electric vehicles. Due to the increase in the ratio of renewable energy in the fuel mix on the timeline, in a period when a significant penetration of the market with electric vehicles is anticipated, this will lead to a considerable improvement in the specific CO_2 emission levels compared to today and as a result more benefits in relation to the fossil fuel-powered vehicles.

If a system-based evaluation of the carbon footprint of electric vehicles is made, taking into account the regulatory parameters (EU Emissions Trading System), then the CO_2 emissions of the electric vehicles can be calculated as zero, at least as long as the EU-specified maximum values for fleet consumption are adhered to without electric vehicles.

FURTHER RELEVANT ASPECTS CONCERNING THE ENVIRONMENT: NOISE AND EMISSIONS

With regard to transport and in particular automobile traffic, the critically-viewed parameters noise, gaseous harmful substances and particles were considered particularly important. The basic benefit of electric vehicles – the low noise levels and the fact that no emissions are generated on a local level – are self-evident here. In the case of noise, however, the concerns that there may be an increase in the number of accidents due to the low noise levels of the electric vehicles should also be taken into account. Currently, the impact is not very significant due to the low number of vehicles in operation. However, a closer analysis leads to the conclusion that despite a considerable increase in the number of vehicles by 2020 and after, only a small impact is to be expected. However, this does not stop significant improvements being made from case to case, or indeed considerable improvements in particular local scenarios in the near future if the changeover to electric vehicles takes place more quickly.

The relativisation of noise levels is a result of the fact that the engine and exhaust pipe noises only represent part of the noise emissions caused by cars and that the acoustic disturbance caused by road traffic is often very much determined by the motorised two-wheelers, heavy traffic or maximum noise levels generated by individual vehicles. Another equally important means for noise reduction can probably be achieved by focusing attention on the delivery vehicles with frequent stop-and-go and start-up procedures. The same applies to the increased electrification of buses, commercial vehicles and two-wheelers. On the other hand, a traffic danger caused by the low noise levels of electric vehicles does not seem relevant in view of the current status.

With regard to gaseous polluting emissions, in the case of carbon monoxide and carbon hydrides, the emissions generated by conventional cars has already dropped to a more or less uncritical level. As a result, if these levels continue to drop for conventional vehicles, then it would not seem relevant to consider the electric vehicle to be completely responsible for reducing the emission loads

As a result of tightening the EU regulations determining nitrogen oxides, a considerable reduction has been achieved in recent years. Hence according to calculations by the Federal Environmental Agency (UBA), the nitrogen oxide levels in the road traffic dropped by approx. 60% between 1990 and 2010. At the same time, the emission scenario in areas with a heavy traffic load remain critical and will probably do so for quite some time; the conceivable contribution made by electric vehicles towards reducing these loads could thus be considerable, however in the case of conventional vehicles it is much smaller in comparison to the anticipated reductions when changing to the emission levels EURO 5 and above all EURO 6 / VI.

In the case of particle emissions, it can also be anticipated that with more cars with low emissions being incorporated into the fleets, one can assume that this trend will continue and that subsequently the substitution of the current vehicles with electric vehicles will become a less relevant issue.

ECOBALANCE-RELEVANT OBSERVATIONS

Regarding the scope for reducing greenhouse gas, which is the main focus of most analyses, the life-cycle analysis has shown that, in particular in comparison to vehicles with a conventional drive, the findings are clearly dependent on the results of the evaluation methods applied to the electricity used. In terms of accumulated energy requirements in the process chain however, the electric vehicles and in particular the provision of batteries for electric vehicles, show negative results in comparison to conventional-drive vehicles. Yet it should be mentioned here that there are considerable uncertainties in both directions, which result from insufficient empirical values regarding the durability of the batteries and the further development potential of the electric vehicles.

In addition, the issue of potential critical resources for electromobility, in particular with view to the components required for the manufacture of batteries and drive motors, is being discussed with regard to their availability and environmental impact. In particular when it comes to nickel and lithium, Germany and the EU are almost completely dependent on imports and this means that although from a geological perspective there are sufficient resources available, there is still a danger of potential supply bottlenecks. In view of the long-term perspective, however, it is necessary to broaden the current limited level of knowledge.

In contrast, in the case of vehicles with conventional drive, the path is more critical and restricted and as a result there is a greater impact on the environment due to the use of accessible energy supplies because the potential CO_2 emissions generated by the energy reserves and resources will exceed the load value considered to have low environmental impact. It can be assumed that in the course of time, the specific CO_2 emissions of the energy supply chain will increase. There could also be supply shortages in the energy supply here too.

Another critical path affecting the environmental compatibility that one could mention here applies to the spatial demands of stationary and moving traffic, in particular in urban areas with very high traffic levels. There will be no changes resulting purely from one particular option of drive system. However electric vehicles can make a contribution in particular towards the creation of more efficient mobility systems. In the model regions, these are frequently analysed in the context of the deployment of integrated mobility concepts. These concepts include car sharing or the linking of electromobility with public transport (e.g. in the sense of a supplementary form of mobility).

FURTHER NEED FOR RESEARCH AND ANALYSIS

PROFESSIONAL RECOMMENDATIONS

From among the several professional recommendations resulting from the supplementary environmental research in the context of the special focus area "electromobility in the model regions", it is possible to highlight central recommendations:

- **Stabilisation of the transition to renewable electricity generation:** As shown by the calculations in the context of the supplementary research, electric vehicles can achieve clear environmental benefits if – as is the goal of political institutions – the generation of electricity in future is characterised to a much greater extent by renewable energy. In the long term, due to the lower levels of CO_2 generated by road traffic, which could be achieved by an increase in the numbers of electric vehicles in the future, a consistent shift in the current electricity generation structures towards renewable energy sources could be of great importance.

- **Use of the noise reduction potential and acoustic identification of electric vehicles:** There is probably scope for noise reduction with regard to delivery vehicles with frequent stop-and-go and approach behaviour. The same applies to the increased electrification of buses, other utility vehicles and two-wheelers.

  On the other hand, it seems that a potential traffic danger caused by the low noise levels of electric vehicles is not particularly significant. As a result of the findings of relevant projects in the context of the main focus of support (AUE-mobility / Angelico-Acoustic-Consult and ColognE-mobil / University of Duisburg), one could make the recommendation that potential risks caused by the low noise levels of electric vehicles should be minimised by a clear, acoustic identification of the vehicles. However, a small increase in the noise level in the lower frequency band and only at low speed levels up to about 30 km/h should be sufficient. This could be important for the electric vehicles in particular during the (early) phase of introduction.

- **Continuation of research and development in the case of electric vehicles:** From an environmental perspective, the continuation of the research and development measures in the area of electromobility also has great benefits. In connection with this, in particular the energy efficiency but also the use of materials and the durability of the batteries are of particular importance. Because it is not anticipated that the electric vehicles will penetrate the market before 2030, or that the electricity will be generated primarily through renewable energy sources before this time, hence contributing very much to the protection of the environment, it is recommended that the conventional drive systems be further developed with view to reducing their energy consumption levels. Large sections of the vehicle fleets in Germany will still comprise of these for several decades.

- **Cost reduction for electric vehicles:** Naturally, the required reduction of costs is also a significant aspect with regard to the suitability of the vehicles for the market, in particular with view to the extensive use of light utility vehicles.

RESEARCH RECOMMENDATIONS

Based on the findings of the platform supplementary research environment, the following tasks can be highlighted as recommended areas for further research:

- **Further efforts to complete the level of knowledge with regard to the operation of the electric vehicles:** Due to the step-by-step access to the vehicles and the data concerning their operation, as well as the existing choice of vehicles, with regard to the winter operations and its special features it is recommended that for the plug-in hybrid vehicles (including range extenders), no empirical findings should be taken as a basis for extensive practical implementation in the research projects. A corresponding broadening of the knowledge base by extending or continuing the recording and analysis of data in real operations is recommended.

- **Deepening the knowledge of the eco-systematic impact of electric vehicles:** The ecobalance observations recorded in the context of the analysis in some cases reveal considerable gaps and uncertainties. Due to the limited experience with electric vehicles and the very rapid technological developments in this area, this cannot be completely avoided. However, in order to achieve a better foundation for the eco-systematic evaluation of the current status of knowledge, this should continue to be developed to a greater extent.

- **Deepening the knowledge of the traffic-systematic impact and its incorporation in the corresponding development goals:** The findings available here have a greater indicative character and this information should be disseminated. In the interests of further development, an optimum linking together of the significant goals for avoiding traffic or moving it to other areas should be explored further. The introduction of more in-depth analyses on the scope and practical requirements regarding the deployment of electric vehicles (including two-wheelers) and car sharing in connection with public transport (multimodality) can be recommended and can provide more in-depth information regarding the design and application conditions of use for electric vehicles.

- **Further open-ended exploration of the scope for incorporating vehicles into an energy sector based on renewable energy in general:** In a greater context, electric vehicles only represent one of the potentially relevant aspects of the transition to a post-fossil fuel-based energy sector and should correspondingly be integrated into a holistic approach. In the context of system-analytical issues that should be examined in relation to this, the system services provided by electric vehicles for the development of fluctuating renewable energy sources through the use of energy storage systems onboard the vehicle are a central issue. Another important issue is the consideration, in the context of an overall strategy for storing fluctuating renewable energy, of whether to use a chemical energy storage method directly (e. g. in the form of hydrogen or synthetic methane) for the vehicle drive system.

>> 06 CARS / TRANSPORTERS: SUPPLEMENTARY RESEARCH SAFETY

BACKGROUND AND GOALS

Ensuring that the electric vehicles in operation in the model regions are safe is a decisive factor governing the success of the support programme. However, the safety aspect of electric vehicles in real operation, in particular the safety of the traction batteries and hence also the high-voltage components, has rarely been analysed in comparison to the safety of conventional vehicles.

As a result, the overall challenge faced by the platform supplementary research safety was the analysis and securement of the safety and functionality of traction batteries in the vehicle system. The goal was to provide evidence of the safety standard of the batteries installed in the vehicles and to identify any potential need for optimisation in the context of the current safety regulations.

There is currently no global standard for the safety of automobile batteries and electric vehicles. However, in view of the approvals for individual and small batch series it is currently possible to authorise an electric vehicle with a corresponding traction battery for use in Europe without having to test the batteries and other electric power transmission components separately and extensively. This supplementary analysis was therefore carried out in the context of the support programme using the documents of the respective vehicles. The corresponding analyses of the documents were made in close cooperation with the project partners and the inspection companies responsible.

With this purpose in mind, an appropriate inspection concept was developed for the electric vehicles. Headed by the battery research centre at the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW – Forschungszentrums Batterie des Zentrums für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg) and the Energy Agency. NRW and in cooperation with the National Organisation Hydrogen and Fuel Cell Technology (NOW), a panel of experts was set up, comprising of companies from the sectors battery safety and procedure testing and the vehicle operators.

This specialist group with approx. 30 participants dealt with the following objectives:

1. **Safety tests:** appraisal of the safety tests carried out in the projects on the basis of documentation and personal interviews with people involved in the individual projects. Using an appropriate checklist to inspect the documents, the status of the projects was identified and summarised in order to determine the scope for improvement.
2. **Monitoring:** recording of malfunctions and failures in the projects (collection of field data, error control). Based on the data collected, it was possible to assess the risks and discover indicators for improving the safety and reliability of the battery system.

The analyses led to application-based recommendations for increasing safety levels. On an international level, these could contribute to the establishment of future standards and help to increase the safety levels of batteries and high-voltage components.

SUPPLEMENTARY RESEARCH MILESTONES
The interdisciplinary theme of safety in the context of the platform environment and safety can be divided into three project phases:
until 31.08.2010 concept phase
from 01.03.2011 data acquisition in the model regions
from 01.06.2011 evaluation of results

CONCEPTION PHASE

The conception phase focused on two parts of the task: on one hand the safety documentation of the vehicles deployed in the model regions and on the other hand the recording of the malfunctions during vehicle operation. In an initial step, an expert working group was set up by NOW GmbH to deal with the topic of vehicle and battery safety. The group consisted of:

- Cetecom ICT Services GmbH,
- SGS Société Générale de Surveillance Holding (Germany) GmbH,
- TÜV Nord Mobilität GmbH & Co KG,
- FUEL CELL and BATTERY CONSULTING – FCBAT Ulm
- EnergieAgentur.NRW.

This panel of experts determined the current status of the vehicle technology and evaluated it with view to the levels of safety. In several workshops (cf. chart) indications for an improved safety concept were compiled using risk analyses.

WORKSHOPS
Dec. 2009 Workshop 1: Expert team (concept phase) vehicle safety
21.2.2010 Workshop 2: Expert team (concept phase) vehicle safety
31.3.2010 Vehicle workshop: environment and safety
9.7.2010 Workshop BMVBS & Federal Road Research Institute (Bundesanstalt für Straßenwesen)
July 2010 presentation of concept: work group 7 – basic parameters of the National Platform of Electromobility
2.2.2011 Platform meeting
10.5.2011 Platform meeting (safety)
31.8.2011 Platform meeting (environment)

In order to determine the current technical status, the documents of relevant components, the energy storage system and the entire vehicle were inspected as part of the safety documentation procedure. This was undertaken by requesting information about the safety measures carried out on the vehicles deployed in the context of the support programme.

First of all, a list of the required testing sequences was compiled for the electric vehicles using a risk analysis procedure. The corresponding areas of testing were:

- Functional safety[1],
- Battery safety,
- EMC (electro-magnetic compatibility),
- Electric safety and
- Vehicle safety (constructive safety)[2]

The expert panel developed the safety analysis procedure (see fig 1). It was then presented to the automobile manufacturers and retrofitters and its feasibility was tested using suitable test runs in the model regions. The appropriate documents for inspection were either provided by the expert panel or were worked through directly by test persons using a checklist. The results of the analysis were passed back directly to the manufacturers and retrofitters and were incorporated in an anonymous form into the results report. This documentation of errors served as a basis for bilateral talks with the vehicle manufacturers and retrofitters for the purpose of identifying scope for improvement and communicating recommendations for action.

SAFETY ANALYSIS PROCEDURE

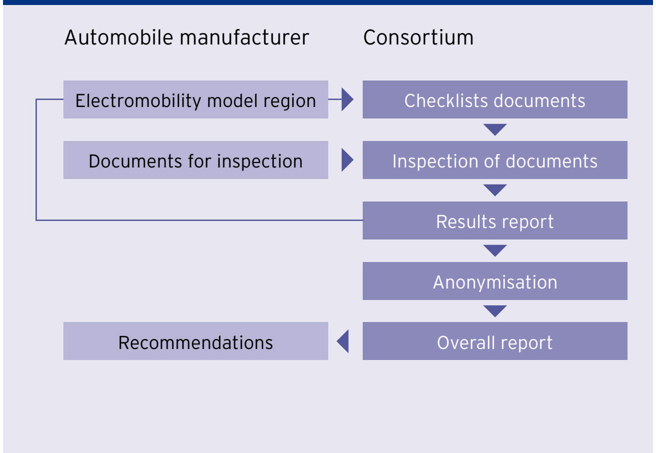


FIGURE 1

In an additional step, the data from the failures and malfunctions of electric vehicles was requested.

1 This testing step was included in the safety analysis as a supplementary aspect. It was not a key aspect of analysis but served to complete the security status.
2 See footnote 1

The goal was to document the current status of safety in the regions and also to minimise the risks and determine scope for improvements.

The malfunctions were recorded and collected as quickly as possible during the field operations. In a similar way to the previously outlined safety documentation, the data was gathered through surveys on location in the form of questionnaires (see fig 2). The results were likewise made anonymous.

In order to accommodate the different effects of the failures and malfunctions, these were categorised according to the severity of the malfunction, as follows:

1. Further operation possible, no service required
2. Further operation possible, service required
3. No further operation possible, no danger
4. Endangerment
5. Rescue operation required

PROCEDURE FOR REPORTING MALFUNCTIONS

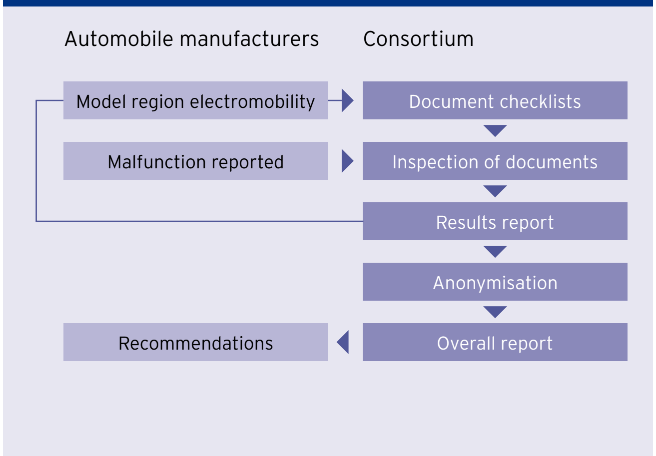


FIGURE 2

In order to incorporate these testing procedures and recommendations in the practical operations and make them available to an expert panel, the following steps were taken:

1. The results of the projects were introduced to the discussions of the Verband der Technischen Überwachungsvereine (Association of Technical Inspection Agencies / VdTÜV) by the technical service providers involved and should be included in the so-called VdTÜV codes of practice. In this way, the findings of the projects can be used as practical recommendations for the technical inspection agencies and services.

2. The findings and the safety concept were included in the National Platform for Electromobility (NPE), AG4 – norms, standardisation and certification (discussion and agreement with the manufacturers in July 2010). The recommendations of the expert panel will be incorporated into the project plan for battery safety compiled by work group 2.

3. Test runs in the model regions using selected individual best practices in cooperation with the respective authorising body.

4. Workshops for users and operators (technical services, manufacturers, retrofitters of electric vehicles, safety and rescue authorities).

5. Internationalisation based on the example of China (collaboration between the model region Rhine-Ruhr and the pilot city Wuhan): in this project existing concepts on the theme of battery safety are being compared.

DATA ACQUISITION

SAFETY DOCUMENTATION:

Safety-relevant data concerning the vehicle, the engine and the drive battery was collected during the data acquisition process.

Using this data, the scope of the safety measures implemented by the manufacturer and those of the vehicle was ascertained. It was assumed that the usual safety measures had already been implemented. The checklist therefore applies to the additional measures. The checklist can be divided into the following areas:

Electrical safety according to ECE-R 100: ECE-R 100 is an international guideline for the inspection and authorisation of battery-driven electric vehicles, which among other things approves statements regarding electrical safety.

Functional safety: in the area of functional safety, the possibility of carrying out a hazard analysis and a risk assessment was examined. The procedure is part of the failure mode and effect analysis (FMEA) and is particularly important for the development process of safety-relevant software or electronic components.

Constructive safety: in the area of constructive safety, crash tests were carried out as well as other possible evaluation and analysis tests.

Battery safety: The tests and analyses of the battery safety were the main focus of this appraisal. Four categories with corresponding sub-categories were requested. The so-called UN transport test is depicted here as an example: lithium batteries must fulfil UN transport requirements. In addition to performance parameters such as capacity, self-discharge and operating life, the environmental requirements (e.g. the European Norm EN 16750), safety and behaviour in the case of an accident or misuse (e.g. US FreedomCAR) were tested.

Electromagnetic compatibility (EMC): Another main area of focus for the documentation check was the inspection of the electromagnetic compatibility (EMC). An examination was made of the extent to which the international standard ECE-R10 (radio interference suppression) has been met. In particular with regard to battery-electric vehicles with high voltage and current levels, the testing of radio interference suppression is of great importance.

Monitoring: As the last key aspect of the safety documentation, the failures and malfunctions in the operation of the electric vehicles in the model regions were recorded using a catalogue of questions (see fig 4).

In order to generate as broad a database as possible, a selection of representative vehicles (manufacturer and retrofitted vehicles) was made in the model regions. In the end 19 manufacturers or operators of vehicles were integrated into the analysis (see fig 3). The selection was based on the aim of integrating vehicles from all the model regions and included ten manufacturers and seven retrofitted vehicles.

The vehicles provided by the manufacturers on the one hand included special test vehicles and on the other hand vehicles for which production will start very soon. Two of the manufacturer vehicles are already available on the market (Think, Smart EV). The selection and the programme sequence were implemented in close co-operation with the manufacturers, retrofitters and vehicle operators.

Based on the status of October 2011, ten manufacturers took part in a safety analysis. Data and documentation is either being awaited from ten further manufacturers or they are not participating in the survey because of the time involved or because they cannot release the data.

EVALUATION OF RESULTS

Safety analysis: In principle, all of the vehicle manufacturers who were included in the survey implemented safety documentation and fulfilled the safety regulations. In addition, some manufacturers carried out more complex testing procedures. Surveys such as crash tests, EMC tests or tests of functional safety are generally standard tests, although some of them are not necessary or mandatory as there are not yet many vehicles in operation. In addition to these tests, the level of security and quality standards has been raised in order to recognise potential sources of danger in good time. The following are extracts of the initial results:

Approval and electrical safety: Of the ten completed documentation checklists, eight manufacturers have checked if they fulfil the requirements of the ECE-R 100, which was confirmed.

Functional safety: Eight of the manufacturers have carried out a hazard analysis and risk evaluation.

Constructive safety: Seven of the ten manufacturers carried out a crash test on the basic vehicle or the battery electric vehicle.

Battery safety: Six of the ten manufacturers carried out a battery safety test. However, in the case of two of the vehicles where the test was not carried out, other battery tests were carried out, which adhere to similar or even stricter regulations and are internationally recognised. Hence there was only one vehicle on which no battery test was carried out and no evidence was provided.

Electromagnetic compatibility (EMC): Nine of the ten manufacturers carried out the EMC testing.

CHOICE OF VEHICLE IN THE MODEL REGIONS

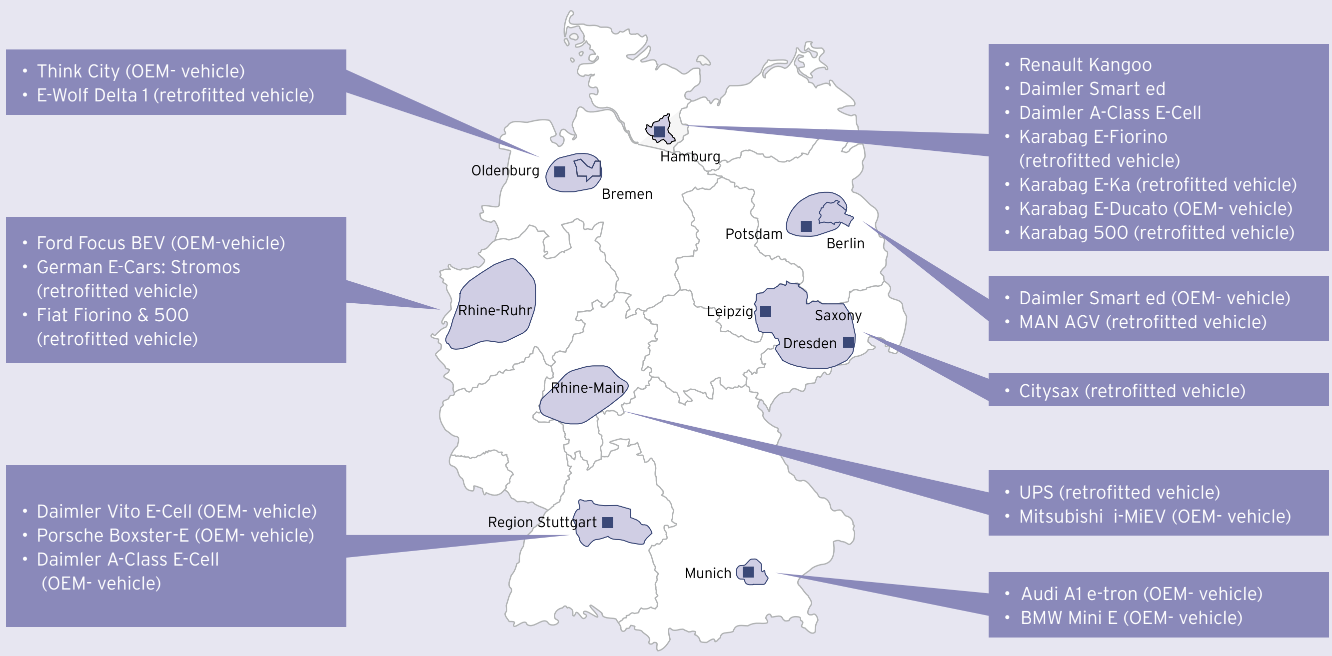


FIGURE 3

RESULTS SAFETY DOCUMENTATION

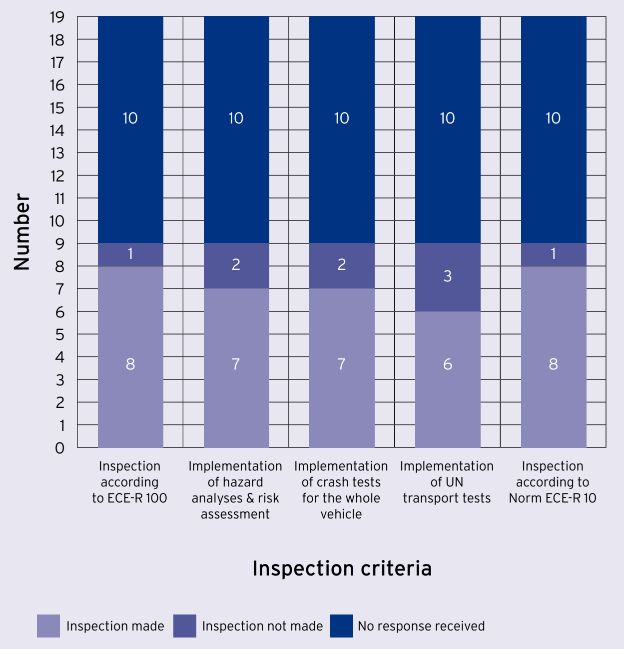


FIGURE 4

Results of monitoring: The results quite quickly showed that there were hardly any defects or failings so serious that vehicle operations had to be discontinued or there was even a potential danger for the user. (see fig 5). In addition, it was evident that many malfunctions were of a purely mechanical-technical nature or were user-related.

Typical errors of application are, for example, mistakes when starting the vehicle that are partly due to the large number of different users and insufficient instructions. These could be problematic for electric vehicles. However, it should be noted that due to the small database, it is not possible to make generalisations regarding the safety of electric vehicles. It is only possible to make statements about the safety of the individual vehicles or vehicle type in their special application as part of an operator-run vehicle fleet. In future programmes, every vehicle should be inspected accordingly.

Results of monitoring in detail: According to the status in October 2011, a total of 352 failures or malfunctions (in ten different vehicle types) were recorded. The following chart shows clearly that there was no case that presented an acute danger to any person. The most serious cases corresponded to a maximum of category 3 (no further operation possible, no danger).

AMOUNT OF MALFUNCTIONS, TOTAL INCIDENTS: 352

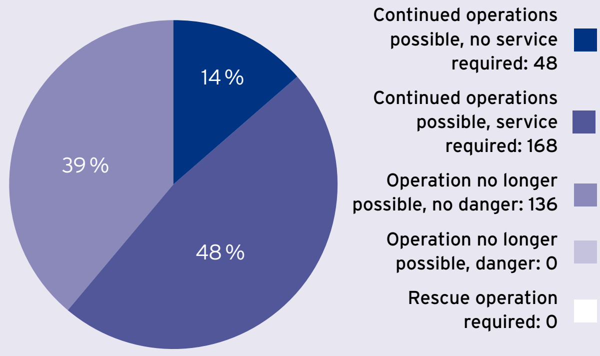


FIGURE 5

Furthermore, the operating status at the time of the malfunction was evaluated. Of the malfunctions that occurred while the vehicle was driving, none of them was so serious that it caused the vehicle to come to an abrupt standstill, which would have made it potentially a source of danger. In all cases, it was at least possible to drive to a lay-by or hard shoulder, or to a parking space or rest stop or similar. More than a third of the malfunctions occurred while charging the vehicle or before beginning the journey. These errors also included application errors such as charging plugs that were not properly connected as well as problems with the technical side of the charging procedure.

MALFUNCTIONS ACCORDING TO OPERATING STATUS,
TOTAL OF INCIDENTS: 352

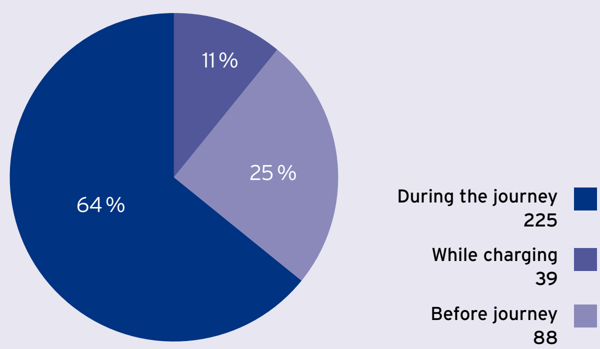


FIGURE 6

The causes of the defects were of a technical nature in 90% of the cases. However, a large number of the malfunctions were defects that are to be expected when new technology is introduced, e.g. a lack of voltage separation or problems with the battery controller. These problems were recognised by the manufacturers concerned and in some cases could be remedied during the project duration.

REASONS FOR MALFUNCTIONING

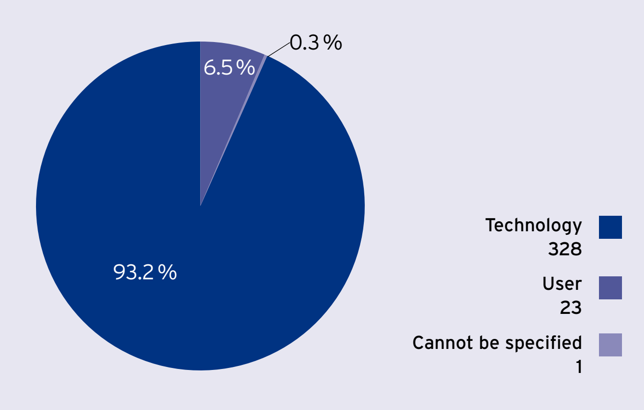


FIGURE 7

Other defects involved software errors, which affected the very complex battery management system (BMS), for example. About 30% – in other words approx. 100 defects or malfunctions – were of a purely technical-mechanical nature and were not specific to electric vehicles.

CONCLUSION AND RECOMMENDATIONS

Safety analysis: During the analyses, no new norms or standards were defined. Instead, the test ranges were incorporated, which are not yet mandatory for the electric vehicles that have been in operation to date, e.g. crash tests, EMC tests and functional safety tests. The manufacturers themselves carried out a large number of these tests. It can be assumed that the correct test ranges have been activated. In a follow-up programme, the details of the inspection catalogue should be discussed with the manufacturers, the retrofitters and the respective technical service providers in order to ensure that everyone involved has the same level of awareness. The testing steps should be standardised and better structured.

Monitoring: To sum up, in this area one can ascertain that the vehicles recorded in the survey and hence the vehicles in operation in the model regions are of a high technical standard. These vehicles did not at any time pose a danger to anyone. A large number of the malfunctions were errors that often occur when new technology is introduced. However, despite the brief duration of the projects, these errors were frequently noticed by the manufacturers and in some cases remedied during the project period. It can be assumed that the malfunctions identified here and the frequency of their occurrence will be reduced over longer periods of observation. An extension of the duration of the survey is therefore recommended.

FURTHER RESEARCH AND ANALYSIS REQUIREMENTS

The federal government has set the target that by 2020 at least one million and in 2030 six million electric vehicles will be on the streets in Germany. In view of these figures and the increase in the range of vehicles available, the already significant theme of safety will become even more important. In future programmes, the safety aspects should therefore be analysed and evaluated as a preventative measure. It is recommended that this approach be extended to include other programmes, also on an international level.

Revision and optimisation: The preventative measures should primarily analyse to what extent the statutory homoglation regulations are being adhered to. The preliminary work in the context of the supplementary research on the subject of safety provides a good starting point for this. The aim should be to carry out the revision and optimisation together with the parties involved. In addition, concepts are required for the identification of weak spots.

Analysis dependent on project duration: In addition, it is recommended that in future safety-relevant components, above all the batteries, be tested in a kind of general inspection that is dependent on the duration of the project. An expert panel should develop specific recommendations and specifications.

Continuation and optimisation of monitoring and further development of the database: With regard to the evaluation, the established procedure for monitoring the failures and malfunctions should in any case be continued and optimised together with all parties involved. It is recommended that the procedure be extended to include other programmes. In this way, proof of the level of security can be provided using real data drawn from the vehicle operations. It is recommended that a detailed evaluation of the currently available and future results is made.

Raising commitment levels among participants: The success of such analyses depends very much on the collaboration of the partners involved. It is recommended that the willingness of the relevant partners to collaborate be increased by special support policy measures.

Detailed analysis of the life-cycle and cross-platform comprehensive exchange: In addition to the utilisation, the phases production, storage, transport and use play a role in the vehicle and battery life-cycle. With regard to the battery it is often the same safety aspects that need to be taken into account in the different phases. It is therefore important that an exchange takes place between the experts of the different life-cycle phases.

Exchange between safety experts, automobile manufacturers and retrofitters: The tests requested by the expert panel should be compiled at short notice by the automobile and retrofitter experts in the form of a catalogue, in order that a common understanding can be reached regarding the theme and the vehicles can be evaluated in the test centres according to a standard procedure.

>> PROJECTS

>> 01 HAMBURG MODEL REGION

Regional project headquarters

hySOLUTIONS GmbH

The regional project headquarters supported the projects in the model regions with coordinating the development of infrastructure and the running of vehicles. This included help with building up the public charging infrastructure, e.g. through discussion with local and district authorities. In its overarching role it was able to ensure the integration of all activities into a top-level strategy aimed at making electromobility a standing item on the region's agenda.

To this end the project headquarters also became involved in developing forward planning for the model region. For instance, it took soundings from the OEMs on the availability of electric vehicles and surveyed potential users on the possibility of their use, both basic requirements for getting the electric vehicle market flourishing as predicted. The focus here was on consistent portrayal of all activities and on ensuring the message was appropriate to the target audience, i.e. decision-makers in politics and business just as much as consumers.

At national level, the Hamburg regional project headquarters assumed control of the nationwide benchmarking of buses and became involved in the other five national platforms. This included contributing its expertise to the development of general parameters in administrative law and to the infrastructure, for example in the discussion around aspects of road traffic legislation. With the model of non-discriminatory access for all electricity distributors to the public charging infrastructure and of obligatory use of green electricity it also provided a fully developed, replicable approach for all regions and local authorities in Germany.

THE REGIONAL PROJECT HEADQUARTERS INITIATE AND COORDINATE THE ACTIVITIES IN THE MODEL REGION.

>> 01 / 01 TRIAL OF FIVE SERIAL DIESEL HYBRID BUSES AT THE HOCHBAHN TRANSPORT COMPANY

Regional project headquarters
Hamburger Hochbahn AG (Public Transport)
Vehicles
5 MB Citaro G BlueTec Hybrid serial diesel hybrid buses (18-metre articulated buses)

The trial of the five serial diesel hybrid buses as part of the Hamburg electromobility model region can be seen as an overall success. The findings gained about the performance of individual vehicle components and their interaction within the complete system can be put to immediate use in the technical enhancement of future vehicles. In fact, this has already happened in the case of several buses that went into operation in 2011, which were fine-tuned in respect of the control system (AC converter etc.) and the integration of the ancillary components into the energy management system. The buses delivered in 2011 were thus able to achieve better average operational performance (currently around 4,000 kilometres more a month) than the first two buses that went into service in 2009. With top levels of up to 90 percent, their availability is also better.

Buses with a serial hybrid drive system were chosen above all because the profile of the Hochbahn bus company's operation is characterised by short distances between stops and much stopping and starting, where such hybrid systems can deploy their advantages better and thus contribute to a reduction in fuel consumption. The expected benefits were indeed achieved in the field test: a survey showed, for example, that the passengers noticed the lower level of noise. However, with the reduction in diesel consumption remaining at 7 to 15 percent this is still lower than expected.

THE HYBRID DRIVE MAKES THE BUS ENVIRONMENTALLY FRIENDLIER AND MORE COMFORTABLE FOR PASSENGERS.

>> 01 / 02 HH=MORE – USE OF ELECTRICALLY POWERED CARS AND SET-UP OF A CHARGING INFRASTRUCTURE IN THE HAMBURG MODEL REGION

Partners

- hySOLUTIONS GmbH (consortium leader)
- Daimler AG
- DB FuhrparkService GmbH
- City of Hamburg
- Hamburg Energie GmbH
- Hamburger Hochbahn AG (Public Transport)
- Hamburger Verkehrsverbund GmbH (Regional Transport Association)
- Vattenfall Europe Innovation GmbH

Vehicles

- 50 Smart Electric Drive
- 18 Daimler A-Class E-Cell

Infrastructure

- 92 charging points on public land
- 8 charging points at P&R car parks
- 78 charging points on company sites

Companies in the Hamburg business community were approached to trial the use of electric vehicles in their fleets. Charging points were installed on the sites of the companies concerned and locations for further charging points along the public road network also identified.

In order to facilitate non-discriminatory access to the charging infrastructure for third-party electricity providers, the consortium created a one-off nationwide legally compliant contractual model for third-party access, which also ensured the use of green electricity. It was defined as a binding criterion in the project that the electricity must be sourced from renewable energy, which was agreed and coordinated with the relevant city authority.

In order to facilitate increased use of green electricity on the power grid side as well and to reduce generation peaks, the consortium ran, as an example, some initial trials of charging vehicles on company sites where the charging process was controlled on the basis of the load on the grid.

Integrating all public and private charging points into one central computer system enabled complete monitoring of the charging infrastructure in respect of any functional deficiencies. It also made it possible to keep a check on consumption levels and charging times in order to explore future development of this innovative charging method and its potential for easing the load on the grid.

50 ELECTRO SMARTS WERE HANDED OVER TO COMPANIES IN HAMBURG IN NOVEMBER 2010.

>> 01 / 03 HAMBURG PURE – PROJECT ON THE UTILISATION OF REGIONAL ELECTROMOBILITY IN HAMBURG

Partner
Renault Deutschland AG (consortium leader)
Vehicles
15 Renault Kangoo Z.E.

In the Hamburg electromobility model region, Renault is deploying 15 battery-powered vehicles from the light commercial vehicle sector. They are being examined in every operation for their technical suitability. In order that the vehicles can be serviced well locally, two Hamburg Renault dealerships have been equipped to carry out maintenance of electric cars. The dealerships' mechanics have also been trained in dealing with high-voltage components. The vehicles were also supplied via the dealerships.

The users were selected based on potential fleet use scenarios. In addition to large companies from the logistics sector (Hermes and HHLA), the consortium was also able to recruit retail and public service organisations (energy, water, airport) as participants in the project. The vehicles proved their technical suitability and the vehicle-to-charging-infrastructure interface also worked perfectly, even if a certain period of familiarisation was required for the users in dealing with the charging terminals and plugs. As all vehicles were deployed in commercial fleets with their own charging infrastructure, it was possible to ensure that the batteries were always adequately charged. The issue of limited range, that is often the subject of public debate, thus represented no problem in this project. Specific range experiments did, however, help to get a more in-depth understanding of battery capacity in real-world conditions, e.g. depending on weather and driving style. The consortium was able to establish the 'User Meeting' initiated in the Hamburg electromobility model region as a forum for the fleet managers involved in the project to share experiences.

KEY HANDOVER: 15 FULLY-ELECTRIC KANGOO Z.E. VEHICLES ARE HANDED OVER TO THEIR USERS.

>> 01 / 04 HH=WISE – THE USE OF BATTERY-POWERED ELECTRIC VEHICLES IN COMMERCE

Partners

- hySOLUTIONS GmbH (consortium leader)
- Karabag GmbH

Vehicles

- 160 Karabag New500E
- 40 Karabag e-Ka
- 20 Karabag Fiorino Electric
- 15 Karabag Ducato Electric

Infrastructure

20 induction chargers

In the largest vehicle project in the Hamburg electromobility model region, 235 battery-powered vehicles of varying sizes were tested for technical suitability in everyday operation.

The vehicles' drive trains were converted to Karabag GmbH specifications, with technical optimisations and experiences from previous deployments being directly incorporated into the production process. It was important here to constantly monitor adherence to quality standards and firmly agreed delivery dates and, where necessary, to make readjustments. The consortium succeeded in achieving large-scale system optimisation in the conversion process (combined with significant cost reduction), which made it possible in the case of many of the vehicles subsidised in the project to supply them at monthly costs of under €300.

The consortium also succeeded in recruiting German industrial and SME businesses as business partners. The electric motors, for instance, will in future be supplied by Linde Material Handling GmbH, the battery management system comes from I+ME ACTIA GmbH of Braunschweig, while locally based suppliers, such as Hamburg-based metal processors Graupe-Thews GmbH, will in future also be involved in the conversion process. A sales strategy, including downstream organisational processes, was also developed and a maintenance infrastructure built up at Karabag GmbH. The vehicles were delivered out to users in several tranches over the period of the project.

VARIOUS VEHICLE SIZES ENSURE DIVERSE AREAS OF APPLICATION IN COMMERCIAL TRANSPORT.

>> 02 BREMEN / OLDENBURG MODEL REGION

Regional project headquarters

- Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung IFAM (Fraunhofer Institute of Production Technology and Applied Material Research – consortium leader)
- Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) GmbH (German Artificial Intelligence Research Centre)

The regional project headquarters took on the coordination of the activities of all regional players who were directly or indirectly involved as partners in the model region's projects. The project headquarters' declared aim is to provide long-term support to players in the field of electromobility. Coordinating the entire project's programme in the model region is done in close consultation with NOW GmbH. This includes the overarching management of all of the region's projects and also coordination with the federal states, districts and local authorities. An advisory council was appointed as the model region's central body, on which representatives from politics, research and business oversee activities.

The project leaders and consortium heads of the model region's projects also came together at regular intervals in the so-called 'Project Leader Group' to discuss top-level issues of coordination, to coordinate platform activities and to establish interfaces between the individual projects.

The overarching management of press and publicity work (trade shows, information materials, events, etc.) is also a role performed by the project headquarters. This ensures a continual flow of information and that all individual projects have a uniform outward image.

Assisting the project partners with the project application – especially during the model region's initial phase – was also a key task of the project headquarters. The project headquarters' staff are also points of contact for other development projects in the field of electromobility.

"ELECTROMOBILITY FOR EVERYONE" IS THE MOTTO OF THE BREMEN/OLDENBURG MODEL REGION. THAT WAS PROVEN AT THE SYMPOSIUM HELD 14/15.9.2011 IN THE PARK HOTEL, BREMEN.

>> 02 / 01 PMC MODULE 1: SET-UP AND OPERATION OF A 'PERSONAL MOBILITY CENTRE' FOR ELECTROMOBILITY

Partners

- Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung IFAM (Fraunhofer Institute of Production Technology and Applied Material Research – consortium leader)
- Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) GmbH (German Artificial Intelligence Research Centre)

Vehicles

- 5 electric cars
- 2 electric vans
- 1 electric scooter
- 5 pedelecs

The aim of the project, among others, was to establish the Personal Mobility Centre for electromobility (PMC) as a permanent facility. This created a central contact point for all electromobility issues in the Bremen/Oldenburg model region. The PMC employees offer advice and support to project partners, businesses, media representatives and the public. The PMC has a small fleet of vehicles available to potential e-vehicle users for test drives. These vehicles are also used for events, trade fair appearances and for training and educational purposes. Since the model region was established, the PMC has organised and run a diverse range of functions and has represented the Bremen / Oldenburg model region at events as the participating partner.

The PMC also acts as support centre for operators of electric vehicles in the model region, for example for the 'e-Car4all' project. In addition to procuring and licensing the vehicles, the PMC also gets them up and running and organises maintenance (vehicle checks, MOTs, winter tyres, etc.) and, if necessary, any repairs. Furthermore, the vehicles are fitted with sensors to ensure continual recording of data on distance travelled (dependent on vehicle type) and individual components of the drive train (battery, motor, inverter). Commissioning of the sensors and of the booking platform for 'e-Car-4all' was done through the PMC.

>> 02 / 02 PMC MODULE 2: INTELLIGENT INTEGRATION OF ELECTROMOBILITY

Partners

- Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) GmbH (German Artificial Intelligence Research Centre – consortium leader)
- Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung IFAM (Fraunhofer Institute of Production Technology and Applied Material Research)
- Der Senator für Umwelt, Bau und Verkehr Bremen (SUBV) (Senator for Environment, Construction and Transport of the City of Bremen)

In the course of the project a comprehensive data capture and processing infrastructure was created as a central element. As such, a platform is now available for numerous evaluations and analyses using modern methods of artificial intelligence. It was also possible to implement basic tools for the pre-processing, preparation and interpretation of data.

Various software packages, so-called logic modules, were linked to the database for working on and evaluating the data. As a first step, an application was developed for decoding the vehicle-specific CAN bus data into individual measurements suitable for further processing. In other modules, the GPS coordinates together with the recorded geo-information are used to depict the route travelled on existing maps. Another logic module separates the vehicles' continually logged data into distances travelled, times spent parked up and charging and changes in the state of charge. The aim is to produce forecasts for usage and charging cycles.

Further specific applications and visualisations can also be found downstream of the database. The function of these tools is to present the data generated in the logic modules. Data can be accessed for this via a web back-end's interface and then displayed on the web front-end. This also makes it possible to use these tools on mobile devices.

>> 02 / 03 PMC MODULE 3: VEHICLE FLEET TRIALS UNDER EVERYDAY CONDITIONS FOR PRIVATE AND COMMERCIAL USE

Partner
Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung IFAM (Fraunhofer Institute of Production Technology and Applied Material Research)
Vehicles
• 20 electric cars • 7 electric vans

In two thematically separate fleet trials the Fraunhofer IFAM undertook examinations of the suitability for everyday use of the electric vehicles currently on the market. On the one hand, it was tested whether the vehicles satisfied the requirements of fleets run on a commercial basis, while on the other, it was examined whether e-vehicles were suitable for private car sharing. The vehicles used for the fleet trial for commercial use were two-seaters, four-seaters (four-door) and a small drop-side van.

The vehicles occasionally served alongside conventionally powered types in addition to existing fleets (e.g. at Bremer Straßenbahn AG), but were also deployed where the e-vehicle was the business' only company vehicle (e.g. at E-Werk Ottersberg). The driving profiles were also different: while some of the vehicles were only used in the city, others were also driven in rural areas. The spectrum of usage thus covered the whole range of short-distance motoring and enabled conclusions to be drawn about the general suitability of electrically powered vehicles.

Private car sharing was also carried out using two- and four-seat vehicles. In addition to the obligatory data logger, some of the vehicles were equipped with an internet-based booking system. Alongside the testing of the vehicles, the Fraunhofer IFAM also examined how well the users managed with the electric cars in their daily life and what their experiences were with the self-organised shared use of vehicles.

DELIVERY OF THE FIRST ELECTRIC VEHICLES.

>> 02 / 04 PMC MODULE 4: DFKI FLEET TRIAL WITH ACADEMIC ACCOMPANIMENT (FOCUSING ON BUSINESS AND PRIVATE USERS)

Partner
Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) GmbH (German Artificial Intelligence Research Centre – consortium leader, individual project)
Vehicles
9 electric vehicles

The vehicles were handed over to various companies in the region and used at locations including the port site in Bremerhaven and the environs of the regional business development and technology park. The companies' reasons for getting involved were largely to gain kudos through the ecologically positive image of electromobility.

The electric vehicles were tested on business journeys such as client visits, customer support journeys and deliveries. The private users were commuters with varying profiles in relation to distance and combined use with other modes of transport.

To equip the company sites and home locations with charging facilities, outside sockets were installed, which posed no significant difficulties.

After initial scepticism, the majority of the users were thrilled. Many of those surveyed can now imagine, after the fleet trial, buying their own electric vehicles, including for private purposes. It is only the currently still very high price and limited availability and variety of models that are responsible for the fact that purchases are not being made in any noteworthy numbers.

Another positive fact that should be mentioned is that the users were able to use their electric vehicles during the winter without any limitations. The range did go down due to the low temperatures, but as the users are permanently informed of the currently available range, they were able to take this fact into account. The conscious planning of journeys with battery-powered electric vehicles proved to be a typical component of electromobility.

ELECTRIC VEHICLES DEPLOYED WITHIN THE FRAMEWORK OF THE FLEET TRIALS BY THE GERMAN ARTIFICIAL INTELLIGENCE RESEARCH CENTRE

>> 02 / 05 EWE ELECTROMOBILITY FLEET TRIAL

Partner	EWE AG
Vehicles	7 electric vehicles
Infrastructure	38 charging points

The fleet trial delivered some important findings in respect to the vehicle batteries' charging/discharging profiles and practical use of the charging infrastructure.

While prior to the start of the trial the vehicles' range was a mystery to most participants. Subsequently, 85% described it as "modest but adequate" or even "convenient and thus fully adequate". A change can be seen here in the perception of their own motoring requirements: the range that the participants thought they would need prior to the trial was on average 100km more than the weekly distance that they actually travelled. Most of them were thus overestimating how far they drove.

In terms of examining the charging pattern, the trial showed that 95% of charging procedures occurred at the place or work or at home. Nevertheless, the public charging infrastructure is a key instrument in relation to improving the participants' confidence in respect to the range issue and is thus essential to any significant roll-out of electromobility. Charging points at car parks where cars tend to be parked for a long time, such as at leisure facilities or shopping centres, would seem sensible in light of the charging times.

Finally, it can be concluded that in the course of the trials the participants developed a considerably more positive attitude to electromobility. It is only the high purchase price, limited variety of models and a high need of public education that is currently holding back greater market penetration of electric vehicles.

>> 02 / 06 PMC MODULE 6: SWB FLEET TRIALS – SET-UP, OPERATION AND FURTHER DEVELOPMENT OF THE CHARGING INFRASTRUCTURE IN BREMEN AND BREMERHAVEN AND THE RUNNING OF FLEET TRIALS

Partner
swb AG (single project)
Vehicles
6 electric vehicles
Infrastructure
25 charging stations

In order to ensure a uniform charging post standard in the model region, the charging post specification in respect to safety, TAB, current meter and RFID standards was defined in tandem with EWE.

The charging stations were set up on the existing car parks of partners that swb was able to recruit during the period of the project. These included, for example, car park management companies, shopping centre operators, businesses that use e-vehicles in their fleet or for car sharing and private car-sharing groups. The power provided at the charging posts was green electricity and it was supplied free of charge.

Compared to its predecessor the P3, the P4 version of the charging post currently being used has been improved in terms of ease of operation and data transfer reliability, and has been upgraded through the addition of a remote maintenance function. Participants generally had no problem using the charging stations. In order to avoid any overloading of the sockets or building circuitry, swb recommends a prior check for suitability by a trained electrician ('Infrastructure check').

The vehicles are equipped with emergency cards that indicate to emergency services personnel where the electrical components of most importance to safety are installed. The vehicles' range is sufficient for the chosen uses and feedback from the users was very positive. During winter use, however, it was noticed that performance and range were highly dependent on the temperature. For reasons of safety and comfort, the vehicles should be fitted with supplementary heaters.

>> 02 / 07 PMC MODULE 7: TRIAL OF TWO ARTICULATED BUSES WITH DIESEL / ELECTRIC DRIVE AND ELECTRICAL STORAGE AND COMPARISON WITH CONVENTIONALLY POWERED BUSES IN SCHEDULED OPERATION

Partner
Bremer Straßenbahn AG BSAG (Bremen Tram Company)
Vehicles
2 Citaro G BlueTec Hybrid buses

To begin, the hybrid buses were procured and integrated into BSAG's existing bus fleet. For this purpose, 400 drivers were educated in their use, workshop personnel (electricians) trained and the vehicles demonstrated to the police and fire service. Since 11 July 2011, they have been in scheduled use. The two hybrid buses and the two reference buses are being used on line 26, a very busy line that runs right through the middle of the Bremen city centre and the low-emission zone. The hybrid and reference buses are deployed in daily rotation on four further selected routes.

As part of the trial, a survey was conducted among the driving staff and the passengers on the hybrid bus and at bus stops on line 26. The results were given to PE International for analysis. Distances travelled, days in use and fuel data were collected on the virtual 'bus platform' and are also being analysed by PE International.

A comprehensive analysis of the data collected has yet to be received. However, some initial findings are already available. These include that the drivers' assessment of the hybrid buses is positive. They contend that they are no different to operate than a diesel bus and that there are also no problems regarding familiarisation with the hybrid bus. They also note that acceleration is smooth and quick and that overall the vehicles produce less noise.

>> 02 / 08 PMC MODULE 8: LIGHT VEHICLES FOR SHORT URBAN MOTORING IN THE FIELDS OF TOURISM AND CIVIC INFRASTRUCTURE

Partner
H2O e-mobile GmbH, Varel
Vehicles
15 converted vehicles
Infrastructure
5 charging stations

The vehicles have proven to be attractive to users, as they have an appealing design and are efficient in use. For vehicles of this class, the payload capacity is unusually large. After initial scepticism, the drivers were quickly able to adjust themselves to the vehicles' particular features and rated the driving experience as very attractive, overall.

The capacity of the AGM lead batteries, which were used due to their low cost and simplicity, was not adequate – especially in cold weather. In urban stop-and-go traffic with frequent stops at which the batteries can regenerate, ranges of up to over 50km were achieved with one charge. However, in cold weather this dropped significantly.

It was only possible to start fitting lithium iron phosphate batteries towards the end of the period and this is still being evaluated. However, the cost-benefit ratio compared to lead batteries is unacceptable, as the additional capacity does not justify the added cost (three times the power for five times the price). Instead of striving for vehicles with an increased range, efforts should therefore be made to achieve a cost structure that is improved all round, with lower base costs for the vehicles.

Through enhanced specifications, new partners and simplified systems, it was possible to greatly reduce the cost of some of the components. The fact that the conversion components could be produced to a very high professional standard locally in Varel had a particularly positive effect.

H2O E-MOBILE ELANO 1.GO ON TOUR AROUND THE VARELER HARBOUR.

>> 02 / 09 PMC MODULE 9: MOVE ABOUT – ELECTROMOBILITY IN PLACE OF VEHICLE OWNERSHIP

Partner
Move About GmbH
Vehicles
4 electric vehicles 6 electric scooters

Besides setting up funding tools and insurance contracts, Move About GmbH developed a functioning workshop infrastructure for the project partners and its own business activity.

For renting out the vehicles, it was necessary to integrate on-board computers and card readers in the vehicle electronics. For the hiring out of scooters, work is being underaken on especially inexpensive solutions that can be used on the move. One challenge is the cost-efficient set-up of a functioning logistics system for spare parts while unit numbers are still low.

The trial of the electric vehicles took place in different scenarios. A THINK City along with two e-scooters were used as car-sharing vehicles at the 'Galileo Residenz' international student hall of residence on the Bremen University campus. The other vehicles were used as customer courtesy cars, for public events and for creating workshop diagnosis systems. In a few cases, private individuals who commute to their place of work used the vehicles exclusively, including over several weeks. In order to service private and business requests for electromobility in the best way possible, a customer relationship management system from the German company SAP was set up and used. On the initiative of the ADAC, Move About compiled information on the THINK City of relevance to safety and included this on an emergency card for the emergency services, a copy of which was put in every vehicle in the model region.

>> 02 / 10 PMC MODULE 10: TRAFFIC CONCEPTS AND BUSINESS MODELS

Partners

- BEI – Bremer Energie Institut
- BIBA – Bremer Institut für Produktion und Logistik GmbH
- Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) GmbH (German Artificial Intelligence Research Centre)
- Fraunhofer Institut für Fertigungstechnik und Angewandte Materialforschung IFAM (Fraunhofer Institute of Production Technology and Applied Material Research)
- Jacobs University gGmbH
- OFFIS e.V.
- Der Senator für Umwelt, Bau und Verkehr Bremen (SUBV) (Senator for Environment, Construction and Transport of the City of Bremen)

A survey was conducted in the Bremen/Oldenburg model region to assess which demographic groups were potential users of electric vehicles and how different groups currently perceived and rated electromobility. In this way it was possible to determine the needs of different potential users, which, looking at the operators and infrastructure, facilitated the development of electromobility business models and traffic concepts.

Within the framework of the everyday driving habits of the people surveyed, most found electric cars perfectly acceptable in terms of their range. The majority of users could also even charge the batteries at home. Due to the short distances, car sharing and Car2Go form a good basis here for establishing electromobility in an urban context. Use in rural areas, for example as a second car, leads to faster amortisation of the purchase price due to the longer distances being travelled here on average – which is nevertheless already within the range of today's electric vehicles. The rural environs in the Bremen/Oldenburg model region generally have a rather thinly spread local public transport network.

As part of the project, a simulation model for planning and management was developed to determine the potential of different infrastructure layouts, especially in relation to the distribution of charging stations.

>> 03 BERLIN / POTSDAM

Regional project headquarters

TSB Innovationsagentur Berlin GmbH

The regional project headquarters answered a multitude of enquiries and provided interested parties with information on the model region and the ongoing project activities. The centre regularly gave presentations, both in the region and on a national and international scale.

A series of discussions with potential project partners, national associations and international delegations led to a closer interlinking with the different players in the electromobility field and also to jointly carrying out measures with the other model regions and NOW. Two 'Berlin-Brandenburg electromobility' seminars were staged in order to provide the regional industry public in-depth information concerning the status of work in the model region and on possible follow-up activities.

The project headquarters also took on a supporting role in the project development process. In consultation with project administrator Jülich (Pt.J), NOW and the Berlin State Administration for Urban Development, the centre was able to accompany multiple projects through to approval, together with its partners.

The formation of the Berlin Agency for Electromobility (eMO) in the second half of 2010 saw a further pooling of strengths in the region, a process in which the project headquarters was also involved.

The 'Electromobility – Berlin 2020' programme of actions produced in collaboration with the centre, which was presented in March 2011, sketches out the path that Berlin will be taking to achieve its objectives in the field of electromobility and defines various areas of action. Over the course of the year, the programme was translated in partnership with the State of Brandenburg into a concrete action plan.

>> 03 / 01 BERLIN ELEKTROMOBIL (FOR SHORT: BEMOBILITY)

Partners

- Deutsche Bahn (consortium leader)
- InnoZ
- Bosch
- HaCon
- RWE
- Vattenfall
- DAI-Labor
- Solon
- Contipark

According to the research made, electric vehicle users generally match the following profile: mainly male, approx. 40 years old, high level of education, working with an above average income, smartphone access, diverse forms of mobility. Initial analyses indicate high general interest in using the service, but a lack of willingness to pay significantly more than for traditional car sharing. The buyers of the mobility card are also of this user type. The improvements primarily desired include more charging stations and a reduction in the number of cards.

The locations chosen for the stations proved successful. The vehicles' range is viewed as adequate in everyday use, as a whole. Due to a lack of standardisation of the charging infrastructure, to date, there are no charging stations for pedelecs in public areas. In the case of the first generation electric conversion vehicles, there were also some technical weaknesses that impaired reliability in car-sharing use. Furthermore, gaps in data interfaces between the suppliers require these to be bridged in both technical and organisational terms. On the regulative level, the approvals procedures for setting up the parking spaces also proved to be time consuming. On the organisational level, the collaboration between different companies proved key.

Preparations have been made through international contacts to transfer the concept for use in similar environments abroad. Due to the differing conditions, however, this will represent a challenge.

>> 03 / 02 AUE-MOBILITY – ACOUSTIC CHARACTERISTICS OF ELECTROMOBILITY

Partner

Angelo D' Angelico

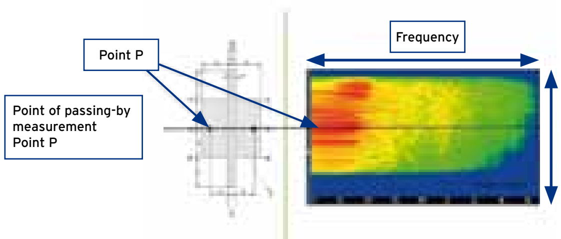
The project uncovered structural errors in the standard measurement method for acoustic comparisons of electric vehicles with those using internal combustion engines. The project undertook the demanding task of designing its own measuring system. The measurements taken using this new method revealed considerable differences in the acoustic pattern of approaching electric and conventional vehicles.

A universally valid acoustic structure was identified in the case of vehicles with internal combustion engines. Based on this structure, an artificial driving noise was developed that electric vehicles can emit using an audio generator. It was evident that road users noticed the modified vehicles much better than standard electric vehicles, even if the audio volume was low and the modification only switched on when approaching: clearly the type of sound plays a more decisive role than its volume.

The research was unable to find any documented accidents that are directly attributable to electric vehicles' lack of noise. In an online survey, experienced users were asked for their assessment of the risks of electric vehicles. This enabled, among other aspects, descriptions of critical situations to be recorded, which are being incorporated into the examination of measures to increase safety.

The communication between partners from different model regions should be improved for future projects, as it was apparent that cross-project synergies were not being sufficiently realised until late in the project.

VEHICLE PASSING-BY MEASUREMENT ACCORDING TO DIN ISO 362 MEASUREMENTS AUE-MOBILITY



The actual value is calculated by offsetting the maximum levels of various passes.

The results in one absolute value. The size of the value is significantly determined from the measurement at point P.

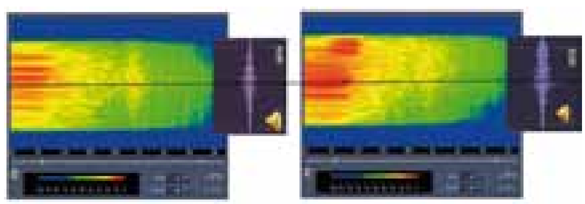
A time span is looked at.

Every point in time is allocated a frequency-dependent relative level.

No absolute value. For every point in time, the level of the frequency is depicted.

ACOUSTIC COMPARISON: COURIER VEHICLE PASSING BY AT 30 KM/H

Electric vehicle | Vehicle with combustion engine



>> 03 / 03 E-CITY LOGISTICS

Partners

- Deutsche Post DHL
- Meyer & Meyer
- Fraunhofer Institut IPK
- Verkehrsinformationszentrale Berlin (VMZ – Berlin Traffic Information HQ)
- Logistics Network Consultants (LNC)
- Deutsches Zentrum für Luft- und Raumfahrt (DLR – German Aerospace Centre)
- City of Berlin Development Office (SenStadt)

The Meyer & Meyer and DHL sub-projects pursued the objective to review the feasibility of operating their respective logistics processes using fully electric vehicles.

Meyer & Meyer:

- A commercial vehicle converted to electric power fulfilled the requirements of regular goods distribution motoring
- The use of electric power did not require any change in route planning
- The battery technology is susceptible to faults, expensive and curtailed vehicle availability during the test
- The battery charging infrastructure is not able to cope with the capacity or time-related needs of a large commercial vehicle in operational use
- A cost-efficient level of usage of the very expensive electric commercial vehicle can only be achieved through multi-shift operation, for which a replaceable battery system is required

DHL:

- The operational requirements for delivering parcels are fulfilled in the same way as with conventionally powered vehicles
- Public charging stations are of little importance from the drivers' point of view, as the time spent in charging bays is generally under 10 minutes
- In contrast to textile logistics, courier and parcel delivery services offer only minor potential for rescheduling
- Although courier and parcel delivery vehicles are perceived to have a high presence on public roads, the distance that they actually travel tends not to be that great. This explains the fairly modest overall ecological effect of electrifying such vehicles, although when looking at a fleet, the effect remains significant.

HANDOVER OF LOGISITICS VEHICLES AT THE BMVBS WITH DR. PETER RAMSAUER, MINISTER FOR TRANSPORT, BUILDING AND URBAN DEVELOPMENT.

>> 03 / 04 EXAMINATION OF THE POTENTIAL FOR REDUCING THE STRAIN ON THE ENVIRONMENT THROUGH INCREASED USE OF SMALL BATTERY-POWERED ELECTRIC VEHICLES AS PART OF THE 'E-MOBILITY' PROJECT

Partner

Öko-Institut e. V.

Analysis of current patterns of private car usage shows that everyday journeys can generally be handled without any problem by a purely electric vehicle. Less frequent long journeys, on the other hand, represent the greatest problem. In the relevant 'mini' to 'compact' segments, long distances were only possible in up to 13% of cases using a battery-powered electric car without alternative mobility options. The potential in commercial vehicle fleets is between 53% and 81% depending on the segment. The theoretical total potential for battery-powered electric cars in Germany is around 4 million vehicles.

Over 30 fleet operators were surveyed on the suitability and acceptability of electric vehicles. The results show that the most important procurement criteria are purchase and operating costs. Companies that attribute a high level of importance to the environmental characteristics of their fleet and a 'green' company image would accept a cost premium of 10-20%.

The electricity demand was portrayed on a precise hourly basis for various scenarios based on typical private and commercial car usage patterns. The results show that the total electricity demand through to 2030 is relatively low. However, without any system of charge management new load peaks could occur sooner. Furthermore, while simulations show that electric vehicles may in future become so-called 'flexible consumers' of temporary excess renewable energy, their power demand, however, will not be sufficiently or completely covered in this manner.

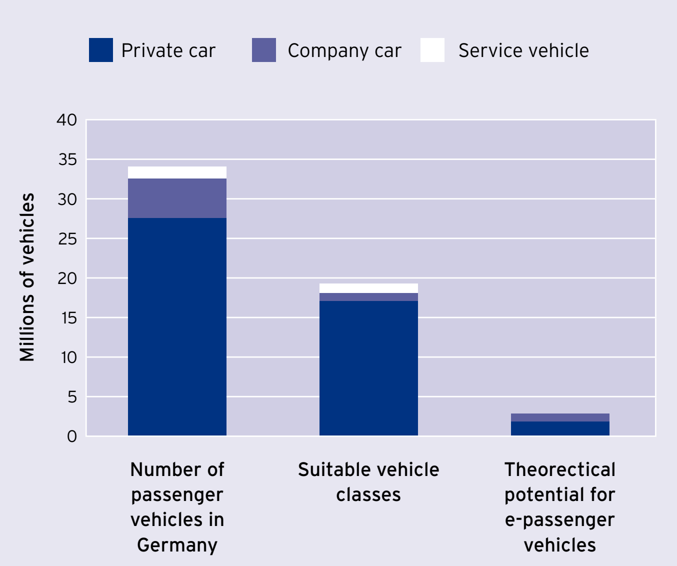


FIG 1: DERIVATION OF THE THEORTICAL POTENTIAL OF BATTERY ELECTRIC PASSENGER VEHICLES IN THE YEAR 2030 WITHOUT TAKING ACCEPTANCE INTO ACCOUNT. SOURE: ÖKO-INSTITUT E.V. 2011

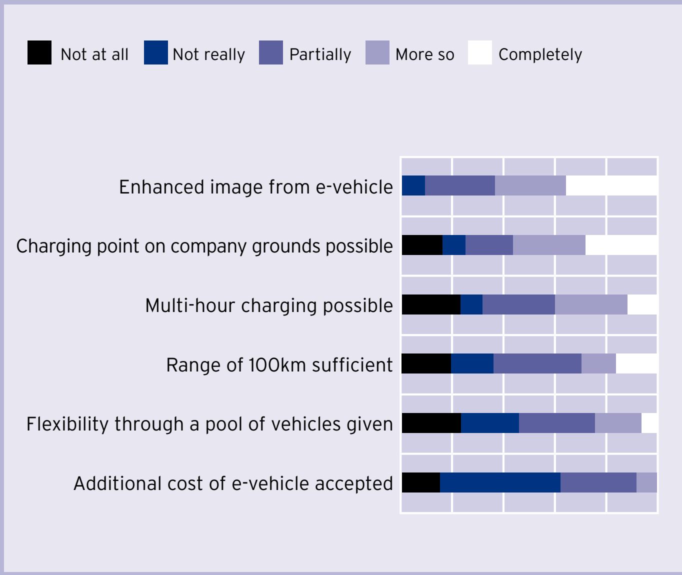


FIG 2: COMMENTS ON THE INTEGRATION OF E-VEHICLES IN COMMERCIAL FLEETS. SOURE: CORPORATE SURVEY ÖKO-INSTITUT E.V. 2011

>> 04 RHINE-RUHR MODEL REGION

Regional project headquarters
EnergieAgentur.NRW

With its projects, the Rhine-Ruhr model region focused on three areas:

1. The use of electric vehicles (cars, commercial vehicles and two-wheelers), refuse collection vehicles with hybrid drive systems and hybrid buses in local public transport, in order to test the vehicles in everyday operation, to ascertain the current state of electromobility technology and to deduce areas of potential for technical optimisation and development.

2. Setting up and testing a charging infrastructure tailored to the respective use, including appropriate billing systems, and developing suitable business models for different areas of use.

3. Providing academic support to the projects (including examination of user behaviour, vehicle acceptance, technical issues, required training for emergency services and technical support staff, etc.) in relation to conceiving and evaluating more far-reaching development programmes both at national and federal state level.

Due to the general conditions that exist in the Rhine-Ruhr model region (i.e. industrial conurbation conditions), the focus of the projects was primarily on the use of vehicles at commercial and fleet customers:

- Pool and fleet traffic in the local authority field
- Cross-mode commercial traffic in conurbations (civic utilities, energy suppliers, local authorities and local authority services, etc.)
- Inner-city distribution traffic
- Modern drive system and traffic concepts for local public transport

In total, 50 partners used and tested around 200 electric vehicles and 500 charging points. The distance travelled by the vehicles used was well over a million kilometres. The 23 hybrid buses alone travelled more than 690,000 km.

>> 04 / 01 COLOGNE-MOBIL

Partners
• Ford-Werke GmbH (consortium leader) • RheinEnergie AG • City of Cologne, Duisburg-Essen University
Vehicles
• 10 Transit BEV trial vehicles • 10 Transit Connect pre-production vehicles • 5 Focus Electric
Infrastructure
16 charging stations with 32 charging points

After a project term of 24 months, over 70,000 kilometres travelled and around 1,800 charging events, one of the key findings from the cologneE-mobil project is that electric vehicles can already be integrated into commercial vehicle fleets without any problems.

The results of the fleet trials and the accompanying research showed that the limited range of electric vehicles compared to conventionally powered types leads to no restrictions of any kind in everyday operation. In the case of 50% of the urban trips, the daily power consumption was in fact only 4kWh, meaning that with a battery capacity of 20kWh there is not even any need to charge the battery every day. These results coincide with the wishes of potential customers, who would ideally like to charge their vehicle at home or at their place of work.

Extensive surveys of potential customers have shown that, in principle, they have a positive attitude towards electric cars. Key reasons for considering a purchase are environmental friendliness and independence from oil. In the area of urban delivery, analyses have shown that battery-powered electric vehicles are already an economically attractive alternative.

With the help of measurements and experiments on noise perception it was also possible to obtain empirical data to confirm the suspicion that electric vehicles are subjectively noticed less quickly. It was apparent, however, through a direct comparison with modern petrol vehicles with a similarly low level of noise, that innovative solutions will be necessary in this area in the future for more than just electric vehicles alone.

COLOGNE-MOBIL PRESS CONFERENCE: WITH PROF. FERDINAND DUDENHÖFFER (UNI DUISBURG-ESSEN), JÜRGEN ROTERS (LORD MAYOR, COLOGNE), BERNHARD MATTHES (FORD-WERKE GMBH), DR. DIETER STEINKAMP (RHEINENERGIE AG)

>> 04 / 02 ELECTROMOBILITY IN COMMUTER TRAFFIC

Partners

- RWE Effizienz GmbH (consortium leader)
- Renault Deutschland AG
- Forschungsgesellschaft Kraftfahrwesen Aachen (Aachen Institute of Automotive Research)
- Institut für Hochspannungstechnik der RWTH Aachen (RWTH Aachen Institute of High-Voltage Technology)

Vehicles

- 30 Renault pre-production vehicles (25 x Kangoo Z.E., 5 x Fluence Z.E.)
- 42 converted Fiat vehicles

Infrastructure

306 charging points

As part of the large-scale fleet trial, the consortium could test the functionality of the charging infrastructure, especially in respect to the robustness of the technology applied and the ease of use in everyday operation. Based on the findings obtained, the technical interfaces between e-vehicle and charging infrastructure were improved.

During this process, challenges arose both in legal and technical terms: delays sometimes occurred in developing the charging infrastructure due to the absence of any standard approvals procedure and belated approval of power grid connections from the respective distribution grid operators.

Looking at the users of electric vehicles, it was apparent that they use the private, semi-public and publicly accessible charging infrastructure for charging and would like to see these facilities universally available. Due to the different user requirements and areas of use, it will also be necessary to add to the range of products provided by the charging infrastructure, e.g. by adding easily integrated home charging systems or also ultra-fast charging systems at selected locations. It was further established that the early adopters are predominantly fleet customers at relatively small companies and also within larger groups.

LEFT TO RIGHT: BÉATRICE DEGAND (PROJECT LEADER ELECTRIC VEHICLE RENAULT DEUTSCHLAND) MICHAEL SOMMER (RWE), HANNA RIEKE (MANAGING DIRECTOR DETEFLEETSERVICES), STEFAN SCHÄFER (DIRECTOR OF FLEETS RENAULT DEUTSCHLAND AG)

FROM LEFT TO RIGHT: JAKOB HOUBEN (DEUTSCHE POST BONN), STEFAN SCHÄFER (DIRECTOR OF FLEETS RENAULT DEUTSCHLAND AG), RAINER BACHMANN (RWE E-MOBILITY), MICHAEL TAUE R (VEHICLE FLEET DEUTSCHE POST)

>> 04 / 03 E-AIX – 'ELECTROMOBILITY REGIONAL CENTRE AND RURAL REGIONS' FEASIBILITY STUDY

Partners

- Stadtwerke Aachen Aktiengesellschaft (STAWAG, Aachen Public Utilities, consortium leader)
- Innovationszentrum für Mobilität und gesellschaftlichen Wandel GmbH (InnoZ, Centre for Innovation in Mobility and Social Change)
- DB Rent Group GmbH
- MOTOO – Hans Hess Autoteile GmbH
- HOPPECKE Batterien GmbH & Co. KG
- City of Aachen
- Rheinisch-Westfälische Technische Hochschule Aachen (RWTH University)

Vehicles

- 6 electric vehicles
- 6 electric scooters
- 20 pedelecs

Infrastructure

- 3 pedelec stations
- 3 battery change stations
- 14 charging stations
- 1 DC charger

An aim of the project was to take a complete look at electromobility, paying special attention to urban infrastructure models, in order to subsequently be able to support the conception of different traffic models based on structural data.

The first step was a network analysis, in which estimates were made for the topological network requirements over the next four decades. Building on this data and incorporating various different scenarios in relation to the spread of electrically powered vehicles, an estimate was made of the need for the necessary expansion of the charging infrastructure in the Aachen urban area. Various manufacturers' different electricity charging posts were then examined and evaluated in respect to their suitability for optimised operation in terms of energy supply.

In a further step, an ecological assessment was carried out based on the findings obtained. This enabled the consortium to assess the increase in quality of life achieved through a higher proportion of electric vehicles.

A model of mobility appropriate to the requirements of urban traffic was conceived and implemented as part of the 'Two-wheel' sub-project, which was dedicated to the integration of electrically powered two-wheel vehicles. To establish a suitable infrastructure, three pedelec rental systems and three electric scooter battery change stations were set up in Aachen.

REPRESENTATIVES FROM CITY PUBLIC UTILITIES AND MINISTRIES, INCLUDING DR. STEINLE, PERSONALLY EXPERIENCE THE ELECTRIC VEHICLES.

>> 04 / 04 USE OF HYBRID BUSES IN THE VRR – RESEARCH SUPPORT FOR THE USE OF HYBRID BUSES ON THE RHINE-RUHR PUBLIC TRANSPORT NETWORK

Partners
• Institut für Kraftfahrzeuge der RWTH Aachen (University of Aachen Automotive Institute, consortium leader) • TÜV Nord Mobilität GmbH & Co. KG • Verkehrsverbund Rhein-Ruhr (Rhine-Ruhr Public Transport)
Vehicles
21 hybrid buses

In this articulated bus comparison (hybrid vs. conventional), the direct emission of NO_2, which is of particular importance to the emission situation within cities, was reduced through the use of hybrid buses by 74.9%, on average. At the same time, there also tended to be a reduction in total NO_x emissions. Depending on use, the CO_2 emissions are also up to 10.3% lower than for conventional vehicles. For solo buses it is only possible to make a comparison with earlier measurements on a conventional bus in Hagen. Average reductions of NO_2 can be seen here at 53.9% and of CO_2 at 21%, with a slight increase in NO_x at 6.2%.

As part of the tests, the consortium characterised the pattern of noise vibration harshness (NVH) in the passenger area of standard diesel buses and hybrid buses and also analysed the external noise emissions for pulling up at and away from bus stops. Depending on the specific driving and operating conditions, it is possible to show for hybrid buses compared to standard diesel buses a reduction of peak acoustic pressure levels in the passenger space of up to 10 dB(A) and in terms of external noise emissions of up to 12 dB(A).

It can consequently be stated that the potential for a reduction in emission levels and an increased level of acceptance is proven. However, more far-reaching development optimisation is still needed in order to be able to permanently utilise this potential in the future for the entire spectrum of driving and operational situations in scheduled bus service use.

>> 04 / 05 DEMONSTRATION USE OF FOUR REFUSE COLLECTION TRUCKS WITH HYBRID DRIVE IN KREFELD

Partners
• Gesellschaft für Stadtreinigung und Abfallwirtschaft Krefeld mbH & Co. KG (GSAK, Krefeld City Cleaning and Waste Management, consortium leader) • SWK MOBIL (100 % subsidiary of SWK STADTWERKE KREFELD AG, Krefeld Public Utilities Company)
Vehicles
4 hybrid refuse collection trucks with Rotopress system

During the demo use of the hybrid refuse collection trucks, a significant reduction in noise emission was recorded. The noise pollution for the surrounding area, the driver and the operator of the lifting and tipping device was considerably reduced compared to a conventional vehicle. It was perceived as having been halved (a reduction of more than 10 dB(A)) and consequently the reactions from workers and residents were always very positive.

The results so far also permit expectation of reasonable potential for reducing fuel consumption and thus also CO_2 emissions.

>> 04 / 06 ACQUISITION OF TWO ARTICULATED BUSES WITH PARALLEL HYBRID DRIVE IN THE COURSE OF THE 'SOLARIS / VOITH' PROJECT FIELD TRIAL

Partner
Bochum-Gelsenkirchener Straßenbahnen AG (BOGESTRA – Bochum & Gelsenkirchen Tram Co.)
Vehicles
2 hybrid buses

Due to the short tender invitation period, an application had to be made for a project extension, which was approved. During daily refuelling of the vehicles an automatic fuel data capture system is being used. These figures, along with statistics on locations, breakdowns and periods of use, are relayed to PE International, where they are evaluated.

The manufacturers are currently fine-tuning the operational concept in order to further improve the vehicles' performance. The collaboration with the manufacturers is running very satisfactorily. Further workshop personnel are continually being trained. Involvement in the cross-region 'Buses' forum is enabling experiences to be exchanged with manufacturers, financial backers and colleagues.

>> 04 / 07 ELECTROMOBILITY'S SUITABILITY FOR EVERYDAY USE – BUILDING BLOCKS FOR A TECHNOLOGY ROADMAP: INFRASTRUCTURE, VEHICLES AND RELIABILITY

Partners

- Ruhr University Bochum (consortium leader)
- Delphi Deutschland GmbH

Vehicles

6 electric vehicles

Infrastructure

6 charging posts (3 from own funds)

Using six vehicles, over 50 test drivers of all ages travelled more than 45,000km within a short period. They were very enthusiastic about the electric vehicles. Using survey questions, the consortium was able to record increases in their acceptance levels and in their trust in the cars' range and technology as a result of their personal experience with the vehicles.

The test drivers for the field trial were deliberately selected from a very wide spectrum of working environments and had varying usage profiles and socio-economic backgrounds. In combination with the chosen technology matrix, which featured consideration of normal and fast charging and of varying vehicle concepts (including converted vehicles with manual transmission, limited edition models and mass-produced vehicles), the necessary breadth was achieved for representative results and findings.

Analyses show that the range of the vehicles currently available is totally adequate for a large number of the users, as distances of less than 30km at a time are largely those being covered in most instances. In order to also enable people who drive very often or commute long distances to switch to electromobility, efforts should be made to push on with the expansion of the fast-charging infrastructure and improved integration of electromobility into the local public transport system. On the technical side, clear potential for improvement can be seen in relation to energy recovery when braking (recuperation) and in the selection and control of auxiliary power trains.

WORKSHOP AT THE RUHR UNIVERSITY: NORTH RHINE WESTPHALIA MINISTER FOR ECONOMICS H. VOIGTSBERGER, PROF. C. SOURKOUNIS AND C. SCHÄFER (FROM LEFT TO RIGHT).

>> 04 / 08 E-MOBILE NRW

Partners

- Stadtwerke Düsseldorf
  (SWD, Dusseldorf Public Utilities, consortium leader)
- Drive CarSharing
- Lufthansa Technik AG
- Wuppertal Institute
- State Capital City of Düsseldorf
- Stadtwerke Brühl (Brühl Public Utilities)
- Stadtwerke Hilden (Hilden Public Utilities)
- Stadtwerke Fröndenberg (Fröndenberg Public Utilities)
- Stadtwerke Schwerte (Schwerte Public Utilities)
- Stadtwerke Emmerich (Emmerich Public Utilities)
- Energieversorgung Oelde (Oelde Energy Supply)
- Monheimer Elektrizitäts- und Gasversorgung
  (Monheim Electricity and Gas Supply)

Vehicles

55 electric vehicles

Infrastructure

58 charging posts

The great majority of private participants in the pilot trial show the typical attributes of pioneering users: they are predominantly men of an 'active' age with above average formal education and above average income. They are generally interested in technology, have a pragmatic affinity with cars and are moderately environmentally aware. In the case of the car users, their positive expectations were sometimes even exceeded by their experiences with the electric vehicles. Their willingness to use an electric car or scooter in their everyday lives in future is high, despite the attendant restricted flexibility. However, for the period through to 2015, the respondents could more likely imagine using a plug-in hybrid or a vehicle with a range extender and then for the period thereafter probably use a battery-powered electric vehicle.

In the case of business uses of electric cars and light commercial vehicles, differing fields of use and areas of potential substitution are emerging that are of significant scale and if fully exploited allow us to expect corresponding ecological effects. In the pilot calculations, the levels of potential in the fleets examined as examples run at between 15 and 40% of the current conventional vehicle fleet, depending on assumptions. Lufthansa Technik (Lufthansa Engineering) represents an exception, where due to very special and uniform requirements applicable to the vehicle fleet, the potential for substitution is almost 100%.

>> 05 MODEL REGION OF SAXONY

Regional project headquarters

Sächsische Energieagentur – SAENA GmbH
(Saxony Energy Agency)

The project partners in the State of Saxony are working together to promote local public transport through the use of innovative and environmentally friendly technology and developing it into a competitive alternative to individual motoring. The 'SaxHybrid' project was deliberately designed with a long-term strategy beyond the period of the report in order to prompt the development path from the previous state of technology with diesel/electric hybrid systems through to predominantly electrically recharged hybrid buses.

Through the joint project on fleet operation with electric vehicles, the basis was created for the establishment of individual electric motoring (primarily in company fleets), including the associated infrastructure. The results form the foundation for a follow-up project (provisionally due to commence in October 2012), in which the aim is to create the link between individual motoring and local public transport, including through the use of uniform billing and car-sharing systems.

An essential aspect of the successful implementation of electric drive systems on our roads is the constant enhancement of battery technology. This is taken account of within the model region by the project on the development of process and production technologies for energy storage systems, which is also being supported by the project headquarters. In addition to this, the centre was also able to recruit new project partners for more far-reaching research and development projects.

SAENA STAND AT THE 2011 "DAY OF THE SAXONS" IN KAMENZ.

LIVELY DEBATE AT THE "FUTURE-ORIENTED PUBLIC TRANSPORT – THE PATH TO THE E-BUS" CONFERENCE IN 2011.

>> 05 / 01 DEVELOPMENT OF PROCESS AND PRODUCTION TECHNOLOGIES FOR ENERGY STORAGE SYSTEMS IN INDUSTRIAL APPLICATIONS IN THE FIELD OF ELECTROMOBILITY

Partner
HOPPECKE Advanced Battery Technology GmbH
Vehicles
2 hybrid buses

Through the project entitled 'Development of process and production technologies for energy storage systems in industrial applications' run as part of the electromobility model region activities, Hoppecke developed expertise in the field of lithium-ion technology. The following results were achieved:

- Establishment of an innovative, universal test infrastructure for electrochemical storage systems and peripheral components for electrochemical and chemical characterisation and analysis.
- Based on the electrochemical cells tested for application-specific requirements and validated for use, a new kind of modular energy storage concept was developed and created that can be used for practically all voltage ranges and can be interconnected.
- Compared to individual, application-specific developments, an economic advantage is in particular achieved when interconnecting modules up to 400V.
- Unique integration of the specifically developed peripheral components, such as the battery management system (BMS), the various cooling concepts and the modular communication system.
- A new form of development of a modular concept for the highly varied levels of electrification in the field of electromobility: the 'high-power' version for hybrid drive systems and the 'high-energy' version for fully electric types.
- Through the development of innovative processes it was possible to demonstrate that the module could be economically produced for new niche markets with small unit numbers.

>> 05 / 02 SAXHYBRID – SERIAL HYBRID BUSES WITH PARTIALLY PURE ELECTRIC DRIVE OPERATION

Partners

- Dresdner Verkehrsbetriebe AG (DVB, Dresden Public Transport, consortium leader)
- Leipziger Verkehrsbetriebe GmbH (LVB, Leipzig Public Transport)
- Fraunhofer Institute for Transportation and Infrastructure Systems (IVI)

Vehicles

20 hybrid buses

The use of the vehicles showed that the optimisation of drive systems is only possible in actual scheduled service operation. Using measurement results it was possible to give recommendations for optimising the systems that could be practically implemented and to improve fuel efficiency, within the scope of the project. The standardised operating cycles for hybrid buses and the adaptation of the vehicle models are intended to serve as a recommendation for evaluating such drive concepts. The project laid the foundations for a subsequently envisaged field trial using buses capable of quick charging:

- Gaining of experience from fleet use of serial hybrid buses on different lines with varying terrain and differing operating conditions
- Objective and independent accompanying analysis of the scheduled service deployment, focusing on fuel consumption
- Generation of standardised operating cycles for hybrid buses, which take comprehensive account of their characteristics
- Creation of vehicle simulation models for deriving deployment recommendations for other lines
- Utilisation of the vehicle simulation models for optimisation of the vehicles to be used
- Working up of principles for an 'auto-learning' energy management system
- Deriving specifications for the later conversion of vehicles for recharging operation, including storage system sizing
- Planning the technology and infrastructure to be used for electricity supply points as preliminary work for the subsequently planned field trial

VEHICLE HANDOVER BY FEDERAL TRANSPORT MINISTER DR. RAMSAUER ON 25.6.2011 IN LEIPZIG.

>> 05 / 03 SAXMOBILITY – FLEET OPERATION USING ELECTRIC VEHICLES AND FLEET MANAGEMENT GEARED TO ELECTROMOBILITY IN THE SAXONY MODEL REGION

Partner

- KEMA IEV GmbH (consortium leader)
- Stadtwerke Leipzig GmbH (Leipzig Public Utilities)
- DREWAG Stadtwerke Dresden GmbH (Dresden Public Utilities)
- ENSO Netz Gmb
- Telekom AG - Hochschule für Telekommunikation Leipzig (Leipzig Telecommunications College)
- Hochschule für Technik und Wirtschaft Dresden (Dresden College of Technology and Business)

Vehicles

- 30 electric cars
- 8 electric scooters
- 3 pedelecs

Infrastructure

- 60 charging stations
- 155 charging points

- The production vehicles' suitability for everyday use in the areas of reliability, user satisfaction and environmental compatibility was proven.
- With the conversion of individual vehicles to lithium-ion batteries and the enhancement of the battery management system, increases were achieved in performance and range.
- Regulatory decision makers in the model region's local authorities were made more aware of the issue of electromobility and it was possible to channel the set-up of the public charging infrastructure into one process.
- The power grid measurements (energy balance, stand-by losses) and studies show that with a low percentage of electric vehicles no supply bottlenecks or performance limitations need be foreseen in the electricity supply networks.
- As part of the accompanying research, surveys were carried out with potential market partners, customers and users. The results show that the press and publicity work done succeeded in raising perception and acceptance of electromobility. As business users, fleet operators want an electric vehicle with a range of approx. 200km and the certainty of being able to recharge at any time within a reasonable radius; plus they are prepared to pay a maximum of 10% more than for comparable conventional vehicles and are interested in leasing models. Based on the results, a market strategy was developed.

>> 06 RHINE-MAIN MODEL REGION

Regional project headquarters

Stadtwerke Offenbach Holding GmbH
(Offenbach Municipal Utilities Ltd)

Experience from the projects so far shows that the greatest obstacle to widespread introduction of electromobility is the comparatively high purchase price of vehicles and the charging infrastructure. In order to enable the use of a high number of electric vehicles, it is thus essential to look at electromobility in an integrated way within innovative systems of mobility and smart grids.

At the current stage, a prerequisite for the sustainable introduction of electric vehicles is the creation of an opportunity to 'try them out' and thereby generate visibility and confidence in the 'new' technology. Broad acceptance needs to be achieved among the public and the technology must be brought into line with user needs through trials in everyday situations. It is further shown by initial socio-scientific studies that the residents of Hesse could cover 90% of their need for mobility through the use of electric vehicles and to a large degree have the ability to charge such a vehicle at home or at work.

A requirement of the city of the future and of the organisations based within it is therefore not just to create the regulatory framework for electromobility, but in particular to provide services with easy access. This relates both to fleet solutions at businesses and to mobility solutions connecting to local public transport and leads to a new business model, enabling electromobility to be presented as an economically efficient long-term option. However, it is precisely this aspect that is proving to be a current challenge, as many players from extremely varied fields need to work intensively together. Research areas – such as our model region – are important platforms in this regard for bringing the participants together and enabling synergies to be utilised.

EXHIBITION AREA OF THE "SUSTAINABLE ELECTROMOBILITY IN THE RHINE-MAIN MODEL REGION" EVENT ON 1.10.2010.

MEETING OF PROJECT PARTNERS ON 7.7.2011.

>> 06 / 01 FLEET TRIAL OF ELECTRICALLY POWERED COMMERCIAL VEHICLES – USE OF ELECTRICALLY POWERED PARCEL DELIVERY VEHICLES IN URBAN DELIVERY SERVICES WITH AN EMPHASIS ON CENTRAL AREAS IN ELECTROMOBILITY MODEL REGIONS

Partner
United Parcel Service Deutschland Inc. & Co. OHG
Vehicles
6 delivery vehicles
Infrastructure
6 external charging stations

Despite some initial reservations about the new technology, acceptance among the drivers and operations managers was good overall. The customers, too, reacted very positively to the electric mobile delivery service from the outset. In terms of the general public, there was also great interest, especially at the start of the project period.

There was also no evidence that low operating noise has any negative effects: during the course of the project there were no reports of any dangerous situations nor did any accidents occur. Conventional vehicles can be completely replaced by electric types if certain basic conditions exist, such as in respect to delivery volume and density of delivery addresses in the destination area. Integration of electrical vehicles into typical courier industry processes and the vehicle's technical features also require corresponding adaptation to operational workflows and equipment.

Looking at life cycle costs shows that even with optimistic assumptions the vans originally designed as electric vehicles cannot be expected to be economically competitive this decade.

In addition to technical faults, the maintenance complexity observed is also significant in evaluating their use, especially from a technical design perspective. Some parts of the accompanying research work had to battle with compatibility problems and a lack of availability of suitable analysis data.

ELECTRIC VEHICLE ENTERING RECHARGING BAY.

ELECTRIC VEHICLE WITH DELIVERER.

>> 06 / 02 FIELD TESTS INTO DEVELOPING AND SUPPORTING THE STANDARDISED USE OF ELECTRIC CARS, SCOOTERS AND PEDELECS, PLUS CHARGING STATIONS AND BILLING SYSTEMS

Partner
ABGnova GmbH
Vehicles
• 2 Citroen C1 • 1 Tesla • 25 Mitsubishi i-MiEV • 50 pedelecs of various makes
Infrastructure
40 public charging stations

Working in collaboration with ABG Frankfurt Holding, Mainova AG developed a charging infrastructure for public use in parking bays and multi-storey car parks that is unique in Germany. All users of electric cars can use the charging stations – without pre-registration or any base fees.

Mainova AG also proposed converting one of Lufthansa Engineering's electric vehicles to inductive charging and subsequently carried out the conversion. By operating the infrastructure the energy supply company hopes to gain insights into efficiency, user acceptance and characteristic radiation values. The components for inductive charging were developed by Bruchsal-based firm SEW-Eurodrive GmbH. Far-reaching visions also see the charging inductors integrated into the road carriageways.

Pedelec stations for automatically securing and charging pedelecs:

Within the scope of the group proposal, a customer-friendly, open electricity charging infrastructure was successfully developed, built and tested. The 'Frankfurt Model' is of particular interest to local authorities. They are able to build on an existing distributed infrastructure for billing and on multi-storey car parks and parking ticket machines in central urban areas. The need for identification is done away with, due to the traditional parking ticket. Pedelecs can supplement an ecological system of mobility on residential estates, combined with local public transport and car sharing. As part of the project, pedelec stations for securely parking and charging pedelecs were selected, built and tested.

PEDELEC STATION FOR AUTOMATIC SECURITY AND CHARGING OF PEDELECS.

"FRANKFURTER MODEL": OPEN ELECTRICITY CHARGING INFRASTRUCTURE WITHOUT ACCESS DIFFICULTIES IN COMBINATION WITH PARKING SYSTEMS.

>> 06 / 03 GREEN MOVE – HYBRID BUSES IN DARMSTADT

Partners
• HEAG mobilo (consortium leader) • VDL Bus & Coach, Vossloh Kiepe, Darmstadt Technical University
Vehicles
3 VDL Citea SLF-120 / hybrid

Within the scope of the Green Move project, the consortium succeeded in integrating hybrid technology into a standard bus for use in scheduled urban service. As a prerequisite for use in scheduled service, homologation for obtaining type certification was achieved within a very short time. The consortium also created a modern drive concept that uses an electric portal axle with hub motors. For this they adapted the hardware and software in the power electronics and in the diesel engine's management system as required. In enhancing the drive controls and energy management, regulating the EEV-format diesel engine represented a particular challenge. There is still potential here for further development, as the consortium was not able to achieve a satisfactory outcome within the research period. They did succeed, however, in improving the operation of electric auxiliary consumers such as fans, pumps (cooling system) and power steering pump in respect to noise generation and energy consumption. They also compared different energy management systems, e.g. trajectory operation, output tracking and best point operation. By stipulating an energy management system inclusive of stop / start function that is location dependent and delivers optimum energy efficiency, the hybrid technology became something that passengers could really experience. The simulation calculations carried out in parallel, in which the reference bus' results were compared with the hybrid drive system's theoretical results, produced fuel consumption savings in every driving cycle performed.

>> 06 / 04 PUBLIC UTILITY VEHICLES WITH HYBRID DRIVE TO REDUCE HARMFUL EMISSIONS - THE HYBRID REFUSE COLLECTION VEHICLE

Partners
• ESO Offenbacher Dienstleistungsgesellschaft mbH (consortium leader) • Fraunhofer IWES, Kassel • Frankfurt am Main Technical College
Vehicles
4 hybrid refuse collection trucks with Rotopress system

The consortium sees the use of hybrid technology as a groundbreaking technological enhancement in the area of drive systems for domestic refuse collection vehicles. In this project, the pre-production VarioPress DualPower vehicle from Faun Umwelttechnik GmbH & Co. KG is being used for the first time on a long-term basis within the normal operations of a refuse collection organisation.

Two power trains are combined in this model: for the journey to the refuse collection area the power train used is a standard diesel truck engine with automatic transmission and an output of 213 KW. Within the collection area itself an electric motor is then used that is powered via a diesel generator and a high-capacity energy store, known as the 'Super Caps'.

As due to the nature of its work a refuse collection vehicle regularly spends over three quarters of its time collecting rubbish, the effect of this diesel/electric drive system has a clear impact. It is also expected that due to the energy recovery through electrical braking, wear on the brakes will be much less than on comparable vehicles. Electrical braking also avoids the energy-intensive consumption of compressed air.

Compared to conventional vehicles, the following results can be recorded:

- Approx. 30% fuel saving in refuse collection mode
- Approx. 20% less payload
- Significantly less generation of noise
- Vehicle regarded very positively by crew and public

>> 06 / 05 PILOT: PEDELEC IDSTEINER LAND ON TOUR

Partners
• Süwag Energie AG (consortium leader) • Storck Bicycle GmbH
Vehicles
Approx. 150 pedelecs
Infrastructure
4 solar charging stations and 8 grid-connected charging stations

The rechargeable batteries used in the project have a capacity of 10 Ah and are boosted by so-called recuperation mechanisms (power recovery) in order to increase their range. On the drive system prototype, the fitted controller circuit boards became damaged by the flow of energy produced at excessive speed. The circuit boards were adapted to the loads and the drive housing optimised to take the spokes better. Manufacture of the motors was also moved from China to Europe.

As a result, two types of charging post were developed: the solar charging post is independent of the electricity supply grid. It can therefore be set up, for example, in tourist areas away from any development. The charging process is performed on the pedelec itself via direct current. The grid-connected charging locker, on the other hand, facilitates safe charging via an earthed socket. In both cases the charging points are enabled using RFID chips.

The accompanying socio-scientific research showed that the batteries' range is adequate for the current user group. Greatest demand came from the '50 plus' clientele. The major criterion in deciding to use a pedelec is actually trying one out, as it is the positive experience from doing so that first conveys the bike's benefits. The price, by contrast, seems to play a subordinate role. Widening the use of pedelecs in the business environment as a substitute for commuter car journeys requires an extensive promotional campaign and is achieved less well by targeting car drivers in their private environment.

>> 06 / 06 ELECTRIC CHARGING OUTSIDE OF COMPANY HQ

Partners
Stadtwerke Offenbach Holding GmbH (Public Utilities)
Vehicles
• 2 electric vehicles • 2 pedelecs
Infrastructure
4 solar charging stations and 8 grid-connected charging stations

The range of the batteries being used is currently one of the most critically discussed aspects of electric vehicles. Although one battery charge is sufficient for over 80% of the daily trips driven, situations do arise where a greater range must be reliably guaranteed. Stadtwerke Offenbach Holding GmbH is therefore running a trial of two fast-charging technologies in order to be able to drive purely on electric power even in the event of longer journeys arising. The group's delivery vehicles generally need an average daily range of 50-70km and in any case not more than 170km. Not all journeys, therefore, can be made on a purely electric basis using the electric car models currently on the market – especially if auxiliary consumers such as heating and lights are switched on or the outside temperature is low and battery capacity thus drops.

Against this backdrop the group installed two different fast-charging technologies in the trial. Using the DC fast-charging method the user is able to charge the vehicle battery back up to 80% within 25 minutes. This is being tried out in the project with the Mitsubishi I-MiEV, which in addition to this connector has another for gentle charging of the battery overnight from a domestic electricity socket. For comparison purposes, AC charging, the method primarily favoured in Germany, was tried out with the Stromos vehicle. The electric car charges through an intelligent control system between vehicle and charging infrastructure at up to 32A and 400V. The charging process takes up to 3 hours. The plug used is an IEC type II, which is currently going through the standardisation process.

>> 06 / 07 BIKE + BUSINESS 2.0 – PEDELECS AS A COMPONENT OF BUSINESS MOBILITY MANAGEMENT

Partners
Regionalverband Frankfurt/Rhein-Main (Regional Association)
Vehicles
151 pedelecs

Feedback from the project participants has so far been overwhelmingly positive. This suggests that over the next few years pedelecs will play a much more significant role in company fleets and on the journey to work. Concrete results will be available when the socio-scientific and technical research projects have been completed. Being undertaken by the Fachhochschule Frankfurt / Goethe-Universität Frankfurt and the Fraunhofer-Institut IWES respectively, these are currently still ongoing.

Collecting data via questionnaires, diaries and interviews, the socio-scientific research is focusing on the employees' patterns of use of the pedelecs and on the factors that influence this. Using equipment such as GPS-compatible computers and energy loggers, the technical research project ensured regular capture of data.

The collaboration between the FrankfurtRheinMain Regional Association, acting as project leader, and project partner riese und müller worked very well. The same also applies to the collaboration with the participating institutions, local authorities, businesses and research institutes.

>> 06 / 08 USE OF THE HYBRID DRIVE SYSTEM ON MUNICIPAL VEHICLES TO REDUCE HARMFUL EMISSIONS

Partners
• City of Darmstadt Municipal Services (EAD, consortium leader) • Technical University of Darmstadt Institute of Internal Combustion Engineering (VKM)
Vehicles
• 1 hybrid refuse collection vehicle • 1 self-propelled road sweeper

Use of the hybrid refuse collection vehicle under real conditions showed that, in part, the technology is not yet fully developed and that some is even still at the development stage. Operation of the drive system's complex add-on unit required the user to have a thorough understanding of the technology. The reduction in payload compared to conventional refuse collection vehicles (at 26 tons permitted total weight, down by around 1 ton) is one of the main areas of criticism. However, the reduction in fuel consumption and the lower noise level do open up the possibility of using such vehicles at marginal times, which would bring with it several advantages.

To analyse the stock of vehicles it proved sensible to divide the existing municipal fleet into vehicle groups based on permitted total weight. Using reference vehicles it was thereby possible to establish which vehicles showed potential for savings. From here, specific options for handling the management of the fleet could be derived.

To this end, a self-propelled road sweeper (Bucher Schörling City Cat 5000, weight category 7.5–12 tons) was fitted out in a complex procedure with a total of 16 sensors in order to record all hazardous substances produced during real driving operations – auxiliary equipment simultaneously switched – which had previously never been done in this form.

>> 06 / 09 'NEMO' (NORTH HESSE ELECTROMOBILITY) – IMPLEMENTATION OF A JOINT CONCEPT FOR DEVELOPING AND BUILDING UP A UNIFORM INFRASTRUCTURE ACROSS NORTH HESSE FOR CHARGING ELECTRIC VEHICLES

Partners

- Bad Sooden-Allendorf Public Services
- Eschwege Wolfhagen Public Services
- EWF Energie Waldeck-Frankenberg GmbH
- Homberg Power Purchasing Cooperative
- Witzenhausen Public Services (joined end of 2010)
- Städtische Werke AG Kassel (Kassel Municipal Services Ltd, consortium leader)

Vehicles

- 9 electric vehicles
- 3 electric scooters
- 25 pedelecs

Infrastructure

61 charging points

In March 2011, the first of 23 Mennekes charging posts so far supplied went into operation. The same charging technology is now being used in seven different power grid areas. The EBG, Langmatz and emco charging equipment is still included in the test, as is the Tesla charging box.

The RFID charging cards are now being managed by the newly formed Union of North Hesse Public Services (SUN), to which the NEMo partners belong.

The pilot system on Karlsplatz in Kassel has four charging spaces. Two of these are reserved for e-mobiles and two are charged-for parking spaces. In the period from June 2010 to August 2011, 2,516 kWh of electricity was discharged in 837 charging processes. The amount of power issued per charging point will probably go down as a result of other charging places coming on stream.

The power consumed by Kassel Municipal Services' two vehicles through to August 2011 was 3,340 kWh.

The total distance travelled was 13,850 kilometres. On cross-country trips both Stromos vehicles were also charged at other charging posts. It can be assumed that the Kassel Municipal Services' vehicles consume on average approx. 18 kWh per 100 kilometres.

>> 06 / 10 MOREMA – INTEGRATION OF ELECTRIC VEHICLES INTO THE JUWI FLEET

Partners

- Frankfurt University of Applied Sciences
- Goethe University of Frankfurt and e-hoch-3 GbR (accompanying socio-scientific research)
- Fraunhofer IWES (accompanying technical research)

Vehicles

- 16 pedelecs
- 9 electric scooters
- 10 electric vehicles
- 4 electric sports cars
- 1 electric van

In the course of the MOREMA project the partners examined how electric vehicles can be integrated into the everyday lives of their employees and into their fleets. Based on surveys, diaries and electronic driving profiles, they were able to determine what opportunities electromobility offers for juwi's fleet. The aforementioned project participants' results are being provided by them in separate reports.

juwi's main task was to provide the vehicles and the test participants for the field trials. Way back in October 2000, juwi was already integrating Germany's first non-pool company car into its fleet. Since January 2011, a total of ten employees have been driving a Mitsubishi I-MiEV as their company car. Contrary to the general assumption, difficulties were created in the beginning not just by the vehicle's limited range and long charging times, but also by tax disadvantages compared to conventional cars. On this score juwi contacted the relevant offices right at the start of the project with some initial suggestions and took the tax burden off their company car drivers through the so-called 'juwi Package' (tax compensation and mobility guarantee).

During the period of the trial two fuel-saving studies were also conducted. They showed that through simply changing driving style it was possible to considerably reduce CO_2 emissions with conventional cars as well (average reduction over 20,000km: 282.14 kg CO_2).

>> 06 / 11 LINE 103 – ELECTROMOBILITY IN RHINE-MAIN

Partners

- Offenbacher Verkehrs-Betriebe GmbH (Offenbach Transport Company, consortium leader)
- Rhein-Main-Verkehrsverbund (Rhine-Main Transport Association)

Vehicles

- 1 electric bus
- 2 electric cars
- 15 pedelecs

The trial of electric means of transport – both e-buses and electric vehicles for public hire – is helping to create broader public acceptance of the concept and is aiding with the technical advancement of electromobility so that a greater expansion of such systems also becomes economically sustainable. Acceptance and curiosity on the part of the users certainly exist: after just one month of opening, the 'eMobil Station' already had over 100 registered customers and each month around 20 more signed up.

The second module of 'Line 103', the trial of Germany's first solely electrically powered bus in test operation, began just after the end of the funding period (mid-October 2011). The public presentation of the electric bus took place on 27 October 2011. The main aim of this whole project is the integration of electrically powered mobility into the public transport system. This makes it possible to take climate-neutral journeys using interconnected modes of travel and enables a significant contribution to be made to reducing noise and emissions in city centre areas. In combining both modules of 'Line 103', Offenbach is achieving an ideal electrically based travel chain: the 'eMobil Station' is located right next to the central 'Marktplatz' bus and metro hub. Anyone who has already travelled thus far without internal combustion engine, i.e. by electrically powered metro or bus, can continue their climate-friendly journey by electric car or pedelecs. A perfect combination is thus achieved of public and individually configurable mobility.

>> 06 / 12 ACCOMPANYING SOCIO-SCIENTIFIC RESEARCH INTO ELECTROMOBILITY IN THE RHINE-MAIN MODEL REGION

Partners

- Goethe University of Frankfurt
- e-hoch-3 GbR Darmstadt

Vehicles

- 9 electric vehicles
- 3 electric scooters
- 25 pedelecs

Electric cars can be used for daily mobility, especially for the journey to work. An average electric car has a range of 100km, even in unfavourable weather, while only 2% of the users surveyed travelled longer distances on their way to work. Accordingly, 98% of the users can use an electric car without any problem for their journey to work.

Although most of those surveyed drive less than 100km a day, nearly two fifths of them indicate that electric vehicles would require a range of over 200 kilometres in order to be something that they would consider. It seems that a change in mobility behaviour is required, which ought to be conveyed to the potential users of the future.

For short distances, pedelecs are an alternative to the car, as 36% of those surveyed travel a distance of 5km or less to work. The data analysis shows that for their daily journey to work nearly half of all respondents could use a pedelec.

The users of the Rhine-Main model region were very enthusiastic about the project and return rates were therefore practically 100%. Using standardised questionnaires, a total of 399 users were surveyed. Taking initial, interim and final surveys together, 648 completed questionnaires were returned.

The users' positive expectations were largely fulfilled during the test period.

However, only a few users are prepared to accept the high additional cost currently charged for an electric vehicle. Consequently many otherwise enthusiastic users would not make the switch. For example, of 146 people surveyed only around one sixth are prepared to bear additional costs of 20% or more than the price of a car with an internal combustion engine.

>> 06 / 13 'ZUKUNFTERFAHREN' – RESEARCH AND DEMONSTRATION PROJECT TO ASSESS AND INCREASE ACCEPTANCE AND MARKET POTENTIAL OF ADAPTED LIGHT ELECTRIC VEHICLES

Partner

Verein für Ökologie, Gesundheit und Bildung e.V., Kaufungen
(Society for the Promotion of Ecology, Health and Education)

Vehicles

- Pilot fleet with a wide spectrum of various new kinds of vehicles from the market segment between bicycle and car: pedelecs and special bikes with electric assistance (12 German and 1 British), hybrid velomobiles and electric scooters (3 German, 1 Danish)
- Electric buggies and small cars, from single-seater to 2+2 (2 German, 1 Italian and 1 Indian) and electric vans (1 German and 1 French)

Infrastructure

One public 'park & charge' space per vehicle

The electric bicycles and light electric vehicles were in principle well accepted. The total distance travelled was approx. 70,000 kilometres, with around 60% of journeys replacing those by conventional car. The easy availability of the multifaceted array of vehicles made it simple to use one suited to the requirements of the trip. Technical and logistical solutions are being considered in respect to a precise forecast of (remaining) range, increased charging efficiency and extended battery life. Trials of these are to follow. During the period of the project it is, for example, possible through switching the vehicles from lead to lithium battery technology to demonstrate improved usability through increased range and payload and shorter charging times.

In general it can be said that adapted light electric vehicles represent a serious alternative to conventional types and are recognised by the public as such. They happily accept these vehicles, which require no great getting used to. An improvement in the road / cycle path and charging infrastructure would promote wider use.

>> 06 / 14 ELECTROMOBILITY MAINTENANCE DIAGNOSES ON THE FLY

Partners

- Fraunhofer LBF (consortium leader)
- ALL4IP Technologies GmbH & Co. KG

Vehicles

2 pedelecs

When a new category of vehicle is launched, both user behaviour and the likely stresses placed on it in everyday use are unknown. In the case of pedelecs these factors differ significantly from those for traditional bicycles. For this project the stresses on the bike when in use are important, which is why they were examined in a series of trials. To this end, a pedelec was fitted with sensors in order to record the levels of stress on frame, yoke, handlebars and seat tube caused through use. A typical city course of 10.5 kilometres in length was chosen for the test journeys. At 20–22 km/h, the average speed of the journeys was around 40% above the average speed of standard cyclists.

The second component in the project is the development of an embedded system for pedelecs that captures, automatically processes and relays relevant data via GSM / GPRS to the central maintenance diagnosis server. The system that was duly developed is compact and can be integrated into the swing arm of the rear wheel. The database on the maintenance diagnosis server enables a display to be provided online or on mobile devices. What is shown is dependent on the viewer. While users see the nearest pedelec available for use, maintenance personnel are able to identify which bikes need their attention. The internet front-end is an interactive map, on which the position and status of the pedelecs is shown.

>> 07 STUTTGART REGION MODEL REGION

Regional project headquarters
PMC: Wirtschaftsförderung Region Stuttgart GmbH (WRS – Stuttgart Regional Development Agency)
Vehicles
• 600 electric bikes and scooters • 100 rental pedelecs • 59 electric buses • 46 electric cars • Segways, e-boards etc.
Infrastructure
• 130 charging stations • 40 charging stations

Around 500 people tested the vehicles made available by Energie Baden-Württemberg AG. In addition, around another 100 e-bikes for municipal fleets in the region were tested. It is worthy of note that there were no accidents attributable to the vehicles' silent movement. Two-wheelers are predominantly being used during the week for the journey to work as a substitute for the car.

The projects with an urban development character in Ludwigsburg and on the airfield in Sindelfingen / Böblingen are aimed at working up sustainable traffic concepts and preparing for the market launch of electric vehicles. Central elements here include developing the infrastructure and researching user behaviour and pre-competitive business models.

50 battery-powered Vito E-CELL vans are in everyday use all around Stuttgart. Tests are being done on their efficiency in respect to consumption and range and on their suitability for urban delivery work. Development of the Vito E-CELL and one other model was only possible thanks to model region funding. The Stuttgarter Straßenbahnen AG (Stuttgart Tram Company) also has five articulated buses with hybrid drive systems in scheduled service. Initial results show that the buses use 20–30% less fuel than is currently used by the most economical diesel buses.

Stuttgart is upgrading its 'Call a Bike' bicycle hire system to 'eCall a Bike Stuttgart' with the addition of 100 DB rental pedelecs. The bikes can be hired out from 45 specially designed terminals. In addition, three fully electric Porsche Boxsters built for research purposes are also being tested in the region.

One special feature of project work in the region is EleNa, a project being run by automotive suppliers, who have jointly developed an electric drive retrofit kit, with which conventional vans can be fairly easily converted to (parallel) hybrid vehicles.

>> 07 / 01 500 ELMOTOS FOR THE STUTTGART REGION

Partner
ID Bike GmbH
Vehicles
• 500 ELMOTOS • 100 electric scooters
Infrastructure
• 45 Stuttgart charging posts + 30 charging posts from the Karlsruher project MeRegioMobil • Online electromobility portal for the 'electronauts' and visitors

Over the two years, the electronauts travelled a total of around one million kilometres – practically without any accidents – and published over 4,000 entries on the "Electronauts' Blog". During the project there were 13 public earthed plug-in charging points provided for two-wheelers spread around the city centre. 3,000 public charging processes were carried out. The total charge volume was 2,000 kWh and the total charging time 6,400 hours.

35% of the electronauts lived within the Stuttgart city area, but not centrally: 25% in suburbs, 22% centrally within a town and 18% in rural regions.

43% of those questioned used the e-bike daily and 45% one to three times a week. Also, 83% rode it exclusively for personal use and of these 40% used it as their primary means of transport. Following the fleet trial, only 10% of the users would replace a traditional vehicle with an electric one, although 40% would continue to use one. The factors seen as negatives were above all the high cost of purchase and the inability to carry passengers. Factors seen as positive included safety, ease of charging and low running costs. The fun of riding the e-bike and the attention attracted from other road users were also perceived as very positive.

The greatest challenge existed at the start in getting the vehicles finished in time. Furthermore, all needed to be fitted with data loggers to enable the up-to-date data to be put online on the electronauts' portal.

>> 07 / 02 S-HYBUS – DIESEL HYBRID BUSES FOR STUTTGART

Partners

- Stuttgarter Straßenbahnen AG (Stuttgart Tram Company, consortium leader)
- TÜV Nord
- PE International

Vehicles

5 Citaro BlueTec Hybrid articulated buses

Careful preparation and management of the rollout proved to be the key factor to success, along with close collaboration with the manufacturer.

Compared to a vehicle of the very newest design with full air conditioning and particle filter, fuel consumption fell by approx. 18%. Compared to a Euro 2 bus and older technology, it was down by as much as 30% or more.

Measurements in real operation have shown that the emission values are appreciably lower than the saving in fuel. This is attributed above all to the smaller engine and its new operating concept.

The level of noise developed when approaching, especially at bus stops, is viewed very positively. In order to deploy hybrid buses in a really energy-saving way, it is necessary to have precise knowledge of the route characteristics and vehicle attributes and to schedule the vehicle deployment accordingly.

During the term of the project, the vehicles proved to be far more reliable than the Stuttgart Tram Company had assumed. The hybrid buses are very well accepted by the drivers and preferred to diesel ones. This can be attributed above all to the handling qualities and reduced noise.

Maintenance of the hybrid buses is carried out within the workshop's normal workflow. The existing personnel were trained accordingly. In future, all Stuttgart Chamber of Trade and Industry vehicle mechanic trainees will obtain the basic qualification as part of their training.

>> 07 / 03 ELENA – ELECTRIC DRIVE RETROFIT KIT FOR DIESEL VANS

Partners

- ARADEX AG
- J. Eberspächer GmbH & Co. KG
- Stuttgart Institute of Automotive and Vehicle Engine Research
- Fraunhofer Institute of Production Technology and Automation (IPA) (consortium leader)
- Heldele GmbH Elektro-Kommunikations-Technik
- Esslingen University
- Huber Automotive AG
- Kompetenznetzwerk Mechatronik BW e.V.
- Lauer & Weiss GmbH
- Telemotive AG
- TÜV SÜD Automotive GmbH
- WSEngineering GmbH & Co. KG

Vehicles

Development of a prototype electric drive retrofit kit for vans with internal combustion engines

In the project twelve partners developed an electric drive retrofit kit for conventional diesel engine vans and equipped a demonstration vehicle with it. The prototype can be operated purely by internal combustion engine, purely electrically or in hybrid mode. The driver selects the mode via an HMI touchscreen, which can display all key information on battery status, energy recovery and boost availability. The big advantage of this hybrid concept is the possibility of being able to operate the vehicle in the conventional way without any limitations on the motorway by using its internal combustion engine. With its electromotive energy recovery brake (recuperation) system, the vehicle also provides the possibility of charging the battery while on the move.

A battery charging station was also set up and checks made to ensure that the charging post communicated properly with the vehicle. Methods and training documents were also drawn up, with which vehicle workshops can be trained in respect of quality, efficiency and workplace safety related to the electrification of vehicles.

In order to ensure the safety of the newly developed retrofit kit, the project was constantly run taking into account the latest standards and norms. This included producing an integral safety concept. It incorporated a comprehensive dangers and risks analysis for all three available driving modes, a system analysis based on the specification sheets and ensuring the retrofit kit's functional and electrical safety. In all three driving modes all safety systems present in the original vehicle are fully available and thus also ensure a high level of safety after the conversion.

RETROFITTED SPRINTER WITH NEWLY-DEVELOPED BATTERY CHARGING STATION.

>> 07 / 04 ELECTROMOBILITY CONNECTS FOR THE LONG TERM

Partners

- City of Ludwigsburg (consortium leader)
- Stadtwerke Ludwigsburg-Kornwestheim GmbH (Ludwigsburg-Kornwestheim Public Utilities)
- Stuttgart University Institute of Industrial Science and Technology Management
- Fraunhofer Institute of Production Technology and Automation Cargo-Logix GmbH

Vehicles

- 6 electric cars
- 5 electric scooters
- 7 pedelecs
- 4 e-bikeboards
- 2 Segways

Infrastructure

- 39 normal charging stations
- 1 fast charging station

The acceptance of the public infrastructure by users is still low. Possible reasons for this are the modest spread of electric cars and the lack of the ability to do a quick charge at public charging stations.

A list of requirements for an automated parking / charging system for pedelecs was produced and possible approaches examined, including alternative methods for grasping and positioning.

For better utilisation of the vehicles in the municipal fleet increased centralisation in larger vehicle pools is advisable. The vehicles were generally well accepted by the employees. The cars used each travelled on average 990km per month, scooters 165km, pedelecs 70km and Segways 93km. Range appears to hardly present any problem in Ludwigsburg, as proved by residual charge levels of sometimes well over 60%. There are differences in the quality of the vehicles and in servicing. Although the project tended to use high-priced vehicles, nearly all scooters needed some attention or repairs in the course of the project.

The attempt at integrating a relatively large number of charging stations into a multi-storey car park showed that the installation costs of individual charging stations increase appreciably if the connection work for numerous stations has to be done locally. On average, installation costs emerge of up to €4,000 per normal charging station and €10,000 per fast charging station.

SEGWAY CITY TOURS IN FRONT OF THE BAROQUE ROYAL PALACE IN LUDWIGSBURG.

>> 07 / 05 IKON E – INTEGRATED CONCEPT FOR SUSTAINABLE ELECTROMOBILITY

Partners
• Daimler (consortium leader) • EnBW, Fraunhofer Institute of Labour Management and Organisation, Stuttgart (IAO) • TÜV Süd Automotive
Vehicles
Approx. 170 Mercedes-Benz Vito E-CELL panel vans
Infrastructure
• Infrastructure built up in actual customer depots and garages, charging stations as wall boxes, mode 3, 400 V/16 A, 3-phase, electricity charging over night, max. charging duration of 5 hours (0–100 %) • Construction of 4 prototype minibuses for evaluating commercial transportation of passengers

As far as customer acceptance goes, it was noticeable in the course of the driving sessions that the initial reticence turned into confidence in the new drive technology and the customers expressed increasing enthusiasm for the concept. The driving trials' initial analysis results prove high product reliability and quality. Charging times here were relatively short and the average distances travelled were not more than 35 kilometres.

The high quality and good driving performance are confirmed by numerous awards. These include the 'Postal Technology International Award 2010' in the category 'Transport / Logistics Innovation of the Year', the title 'KEPTransporter des Jahres 2011' (Courier Van of the Year) in the category 'Innovationspreis' (Innovation Prize) and the 'International Design Award 2011' at the 'Michelin Challenge Bibendum 2011'.

THE VITO E-CELL.

>> 07 / 06 BOXSTER E – ELECTROMOBILITY IN A SPORTS CAR

Partner
Porsche Engineering Group GmbH
Vehicles
3 Porsche Boxster E with electric drive in fleet operation

The development phase delivered some important findings for integration of the electric components into the vehicle, which could be housed within the existing constructed space without impairing the car's everyday capabilities. That applies both to the integration of the electric motors and power electronics, as well as to the battery. The latter, developed in house at Porsche and based on lithium iron phosphate cells, is fixed to the chassis structure in the same place as the internal combustion engine on the conventional Boxster S. This solution not only provides excellent protection for the battery in the event of an accident, but also offers the best conditions for preserving the base vehicle's good handling qualities. In addition, the vehicles were equipped with acoustic generators in order to test the possibilities and acceptance of generating driving sounds.

Using comprehensive measuring equipment in the vehicles, all relevant parameters are being recorded and evaluated in the field test. This enables energy flows, energy consumption, efficiency and user behaviour to be analysed.

Based on over 23,000 kilometres driven in the field test, results and verdicts from approx. 200 drivers are available so far. The project goals in the areas of performance, range and energy consumption have been confirmed and the vehicles were in total judged very positively. In addition, over the course of comprehensive driving trials, valuable findings in relation to energy recovery, operating and display concepts, noise generation, charging and usage profiles were also gained.

>> 07 / 07 E-MOBILE CITY – INTEGRATION OF E-MOBILE CONCEPTS INTO CITY PLANNING

Partner

- Zweckverband Flugfeld Böblingen/Sindelfingen, Stadtmarketing Böblingen e.V. (Böblingen/Sindelfingen Airfield Association, Böblingen City Marketing Society, consortium leader)
- Wirtschaftsförderung Sindelfingen GmbH (Sindelfingen Development Agency)
- Langmatz GmbH
- Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO, Fraunhofer Institute of Labour Management and Organisation)
- Stuttgart University Institute of Industrial Science and Technology Management (IAT)
- Stuttgart University Institute of Town Planning
- Sindelfingen and Böblingen Public Utilities' Fernwärme Transportgesellschaft mbH (FTG, Community Heating Transport Company)

Vehicles

10 electric cars

Infrastructure

14 charging stations with 21 charging points

The vehicles supplied in the project were all in all very well accepted by the users and used for numerous journeys. Analysis of the distances travelled, charging patterns and user acceptance is not yet complete.

In stop-go traffic in the city the regenerative braking (recuperation) system could play a major role for electric vehicles. A simulator has been developed, programmed and assembled for future trials in respect of the effectiveness of different energy recovery methods.

Considerable delays had to be accepted at times in the vehicle procurement process. Various technical points of failure have been identified and partially remedied already. Despite newly agreed VDE application rules for the introduction of charging equipment, when it came to building up the charging infrastructure incompatibilities emerged between the different manufacturer's plug and communications concepts. As a strategy to resolve this issue, a system for communication between vehicle and charging infrastructure was conceived and installed in several prototypes. Locking mechanisms were also developed that take account of the different earthed plug-in systems. An evaluation of the user trials is not yet available.

In the course of the project, the partners, including city administration departments, building firms and users, succeeded in establishing a cross-municipality network.

>> 07 / 08 PEDELECS – E-CALL A BIKE STUTTGART

Partners

- State Capital City of Stuttgart (consortium leader)
- DB Rent GmbH
- EnBW GmbH

Vehicles

100 rental pedelecs

Infrastructure

45 stations with combined terminals for hiring via touchscreen and with integrated charging function for electric bicycles at five satellites, plus two further charging points for electric vehicles

The project partners are pursuing the joint aim of encouraging even more residents, commuters and visitors than before to use the hire bikes and of making the system an integral part of local public transport. They want the Stuttgart system to become even more modern and customer friendly. The City of Stuttgart is coordinating the civil engineering works for the station system. EnBW is installing and operating the terminals for the 45 stations. DB Rent is upgrading the existing 'Call a Bike' system and adding a total of 100 pedelecs. As the operator of 'Call a Bike', DB Rent GmbH is able to call on many years of experience, especially in relation to users' everyday experiences, integration into the booking system and station selection. EnBW is able to build on experience from developing the charging infrastructure and operating the largest two-wheel fleets in Germany as part of the national government's KoPa II economic stimulus package.

For the first time ever, an automated public rental system for bicycles and pedelecs with terminals for the registration, hiring and bike return process, plus charging spaces for further (private) electric cycles is being developed, constructed and tested by customers in everyday operation. Within this process, the technical aspects of every component are being redeveloped (pedelecs, terminals, charging posts and communications components).

>> 08 MUNICH MODEL REGION

Regional project headquarters
Stadtwerke München GmbH (Munich Public Utilities)

The aim in the Munich model region was to trial electromobility (vehicles and charging stations) in everyday operation and to prepare for a successful introduction of the concept into the market based on the findings. The three projects related to vehicles and charging stations made a major contribution in this regard. The project on a 'Sustainable Municipal Electromobility Concept' provides information on how electromobility can develop between now and 2030 and what supporting measures can be taken by a city in this area. With the findings from the four projects pooled together, Munich is well equipped for the future of electromobility.
The key points that the project headquarters was able to contribute to the overall results are summarised here:

- Central support of the individual projects in the model region
- Organisation & running of regular project manager meetings
- Ongoing coordination of the individual projects
- Holding regular advisory council meetings
- Ongoing advice and information on the subject of electromobility, including promoting the further development of electromobility outside of the scope of the model region concept
- Acquisition of projects (with and without grants), which are being tackled after the end of the KoPA II economic stimulus package

>> 08 / 01 PRACTICAL TRIAL OF A HYBRID BUS WITH DIESEL ENGINE AND SERIAL DRIVE AND COMPARISON OF THREE HYBRID BUS CONCEPTS

Partner
Stadtwerke München (Munich Public Utilities)
Vehicles and infrastructure
Three hybrid buses from three different companies (Solaris, MAN, Mercedes-Benz) are being used for the hybrid comparison test. They differ in type of drive system and capabilities for storing electric energy.

Fuel efficiency

The expected results in terms of fuel savings of 10 to 30 percent were only partially achieved by the hybrid buses. In the case of the MAN bus, fuel savings of around 20 percent compared to a conventional diesel bus can be achieved. A clear statement on fuel savings in the case of the Mercedes-Benz hybrid bus cannot yet be made, as it has so far only been in use for six months, which is too short a period.

Technical stability

The technical condition of the Solaris bus is stable, although the brake system requires improvement: the operating brake pressure needs to be increased for calculating the minimum braking ratio. In the case of the MAN bus, there are frequent malfunctions to report. Frequent problems are also noticed with the Mercedes-Benz vehicle, which are largely caused by not yet fully developed software.

The system comparison of the different hybrid technologies in respect to environmental aspects and economic efficiency and the analysis of fuel savings commenced on 13 April 2011, when the third bus went into operation. Here too, the period to date is too short in order to make any reliable statements.

>> 08 / 02 DEVELOPMENT OF A SUSTAINABLE MUNICIPAL ELECTRO-MOBILITY CONCEPT WITHIN THE FRAMEWORK OF THE MUNICH MODEL REGION, INCLUDING CONSTRUCTION OF AN APPROPRIATE CHARGING INFRASTRUCTURE

Partners
• Stadtwerke München GmbH (SWM, Munich Public Utilities) • State Capital City of Munich (LHM)
Vehicles
40 MINI E
Infrastructure
32 public charging stations and 36 home charging stations

The future potential for electric vehicles was examined using three different scenarios including any possible impact on the environment as well as infrastructure. By looking at the results, it can be concluded that there is major potential in Munich for electric vehicles if certain general requirements are fulfilled.

In the best-case scenario, electric vehicles could replace around 80% of Munich's cars by 2030. Key in determining the potential was the assessment of the significance of the individual influencing factors and the strength of their respective effects. It emerged here as sensible to divide these into changeable and given factors. While, for instance, the movement in the price of oil is determined by global parameters, other influential factors can be changed in a targeted way by public policy.

The relevant influencing factors for electric vehicle potential are:

- The range of electric vehicles available on the German car market
- Suitability for everyday use
- Cost efficiency

Taking into account the foreseeable available charging systems, the characteristics of the sites available for setting up the charging infrastructure and the vehicle users' mobility requirements, it can be assumed that home charging stations will form the basic framework for the gradual development of the charging infrastructure. These can be implemented quickly and easily and for the majority of typical journeys solve the problem of range and charging times.

1 Arcisstraße 68-74 / Zufahrt über Nordendstraße 21-23
2 Blumenstraße 19 (1)
3 Blumenstraße 19 (2)
4 Landshuter Allee 54
5 Seidlstraße 20
6 SWM Zentrale / MTZ / Agnes-Pockels-Bogen
7 P+R Parkhaus Fröttmaning Werner-Heisenberg-Allee 21 (1)
8 P+R Parkhaus Fröttmaning Werner-Heisenberg-Allee 21 (2)
9 P+R Parkhaus Fröttmaning Werner-Heisenberg-Allee 21 (3)
10 P+R Parkhaus Messestadt Ost Willy-Brandt-Allee 11 (1)
11 P+R Parkhaus Messestadt Ost Willy-Brandt-Allee 11 (2)
12 Siemens-Forum Oskar-von-Miller-Ring (1)
13 Siemens-Forum Oskar-von-Miller-Ring (2)
14 Siemens-Forum Otto-Hahn-Ring 6 (1)
15 Siemens-Forum Otto-Hahn-Ring 6 (2)
16 BMW Pavillion / Lenbachplatz 7 Zufahrt über Maxburgstraße
17 BMW Welt / Am Olympiapark 1 (1)
18 BMW Welt / Am Olympiapark 1 (2)
19 BMW FIZ / BMW Allee
20 BMW Hochhaus / Dostlerstraße 5
21 BMW Niederlassung Frankfurter Ring 35
22 SWM / MVG Fahrzeugcenter Heßstraße 121 (1)
23 SWM / MVG Fahrzeugcenter Heßstraße 121 (2)
24 SWM / MVG Truderinger Straße 2 (1)
25 SWM / MVG Hans-Thonauer-Straße 5 (1)
26 Innung für Elektro- und Informationstechnik / Schillerstraße 38

>> 08 / 03 DRIVE E-CHARGED

Partner
• BMW Group, Siemens (consortium leader) • Stadtwerke München (SWM, Munich Public Utilities)
Vehicles
• 40 MINI E • 1 DC test vehicle
Infrastructure
32 public and 36 home charging stations

Surveys

- For 96% of private users the range of the MINI E is sufficient for daily use
- 82% of the Bavarian Red Cross outpatient care service's daily journeys could be made using the MINI E
- For 88% of private users, charging at a charging point is a more pleasant experience than going to a filling station
- 84% of private users would like to charge their vehicles exclusively with electricity from renewable energy sources
- There are calls for a clear reduction in charging times at public charging posts

Charging system

A DC-based fast-charging system was developed and trialled: only one charging socket is required on the vehicle for AC or DC charging. This approach was presented to international standards bodies (IEC) in order to create corresponding areas of market potential through standardisation.

With consistent use of the current standardisation, no negative effects on power grid quality need be expected due to electromobility. The additional load on the grid from the demand and the required amount of power is transferable in the medium term (until 2025) within the scope of the usual development and rehabilitation measures.

Legal aspects

Providing suitable sites for public charging posts proved, in part, to be problematic. As at the time of the planning stage the general legal conditions did not permit the exclusive utilisation of car parks as charging points (non-discrimination), charging posts were set up in semi-public places. Sometimes significant costs were associated with this for space management.

HANDOVER EVENT (MUNICH, ODEONPLATZ)

PODIUM DISCUSSION ABOUT THE RESULTS FROM THE FIELD TRIALS.

>> 08 / 04 A1 E-TRON FLEET MUNICH

Partners
• Audi AG (consortium leader) • Stadtwerke München (Munich Public Utilities), • Munich Technical University • E.ON
Vehicles
20 A1 e-tron Period in use: w/c 29/09/11 to w/c 24/12/12
Infrastructure
The charging post infrastructure is being provided by E.ON and Munich Public Utilities.

Using market research, data logging and a vehicle application for the iPhone (OCU), the required data on usage patterns is currently being gathered. As the collection of data will continue until the end of 2012, no results are yet available. Within the project team, the user data is being collected in collaboration between Munich Technical University, E.ON and Munich Public Utilities.

>> CROSS-REGIONAL PROJECTS

>> 09 / 01 E-MOBILITY BERLIN / HAMBURG: CONSTRUCTION AND DEMONSTRATION OF BATTERY-POWERED ELECTRIC VEHICLES

Partner
Daimler (consortium leader)
Vehicles
• Berlin: 100 smart fortwo electric drive • Hamburg: 50 smart fortwo electric drive
Infrastructure
• Berlin: 500 charging points • Hamburg: 100 charging points

The objective was to examine customer behaviour and acceptance levels in respect of the issue of electromobility. To this end, the use of electric vehicles and a charging infrastructure was tested in customer and everyday operation. The vehicles and infrastructure were monitored throughout the trial.

Daimler put more than 200 electric cars on the roads in Berlin and Hamburg. At the Daimler factory in Hambach, in addition to the conventional vehicles, the electrically powered version of the smart fortwo was built, while in the Rastatt factory the A-Class E-CELL was produced.

Based on focus groups, interviews, technical data and observations, it was possible to draw conclusions about customers and vehicles. In order to ensure that the data was saved and processed, it was relayed wirelessly to a database. An ongoing analysis of the data in respect to the load being put on components and customers' patterns of use, was then instigated.

Various scenarios representing the potential 'electromobility worlds' of 2030 in Berlin and Hamburg were developed and described in expert workshops.

In the after sales area, the probable failure rates of vehicle and drive system components forecast in advance for both models were verified. The amount of work involved in the event of repairs was also assessed.

THE MERCEDES-BENZ A-CLASS E-CELL

>> 09 / 02 ELMOS – ELECTROMOBILITY IN BUSES: DEVELOPMENT, TESTING AND PREPARATION OF THE TRIAL DEPLOYMENT OF AN INITIAL SMALL FLEET OF DIESEL HYBRID BUSES WITH ELECTRIC DRIVE CAPABILITY

Partners
• Daimler Buses • EvoBus GmbH
Vehicles
16 Citaro BlueTec Hybrid buses at various client firms
Infrastructure
Workshops of the respective bus operators equipped for hybrid vehicles

By the end of 2010, a total of 16 buses had gone into operation in various client fleets across Europe. Production and servicing personnel received continual training in working efficiently and safely with the new technology.

During the reporting period, the vehicle concept, which had previously only been portrayed in prototype form, was further developed. As part of the hybridisation process, design adjustments were made to the drive system components, e.g. the axles. In order to reduce fuel consumption, hybrid-specific adaptations were made in relation to the control and optimisation of auxiliary unit management. Optimisation of the heating and cooling circuits, adaptation of the HV system in terms of cable runs and distributor system and also battery development were further project outcomes during the reporting period.

The serial hybrid bus vehicle concept proved its suitability in daily use for the project clients. For public use of the vehicles at Hamburger Hochbahn, specific approval needed to be obtained pursuant to clause 21 of the German Road Traffic Licensing Regulations (StVZO). An application for European type approval was also prepared.

Further significant outcomes of the project include the measured data on emissions and consumption, diverse test results, technical drawings and parts lists and corresponding documentation.

HANDOVER OF THE CITARO BLUETEC HYBRID BUS IN MARCH 2010.

>> 09 / 03 ELMOS FLEET TEST

Partners
• Daimler Buses • EvoBus GmbH
Vehicles
30 Citaro BlueTec Hybrid buses (CBTH)
Infrastructure
Workshops equipped for hybrid vehicles

Insights gained into vehicle functionality and suitability for everyday operation were utilised to further develop the components and software and to enhance ease of maintenance.

The following work was carried out:

- Reworking of the bonnet concept for better access to components, reduction of the total height when opened and optimisation of the locking mechanism
- Integration of a plate heat exchanger into the heating circuit in order to utilise engine heat for interior heating
- Optimisation of the cable widths and runs
- Optimisation of the diesel engine in terms of resistance to wear in order to meet the demands of hybrid use
- Further development of the wheel hub axle, e.g. noise reduction and easier maintenance through integration of shut-off valves in the cold water supply
- Improvement of vehicle diagnosis capability through a software update
- Enhancement of the operating strategy in order to stabilise the entire control system, optimise consumption savings and validate different usage profiles
- Design and trial of an indicator concept for optimised-consumption driving
- Development of an automatic cold water refill mechanism and oil level measurement for improved ease of maintenance

European type approval and the Blue Environmental Angel award were also obtained for the Citaro BlueTec Hybrid.

The customer support concepts were improved in respect to personal and on-site contact with customers, technical information and fault feedback processes.

HANDOVER OF 8 VEHICLE TO THE MODEL REGION SAXONY IN DRESDEN, JUNE 2011.

>> 09 / 04 HYMEP – HYBRIDISATION OF MERCEDES-BENZ TRUCKS IN DEVELOPMENT AND PRODUCTION

Partners
• Daimler AG • Mercedes-Benz Leasing GmbH
Vehicles
68 Atego BlueTec Hybrid 1222
Infrastructure
Workshops of the respective bus operators equipped for hybrid vehicles

The project used a customer survey to ask drivers, fleet managers and general managers from the participating companies their opinion on hybrid technology and its cost-efficiency and reliability. While their responses in relation to expectations and fears prior to delivery of the Atego BlueTec Hybrid vehicles were – although overall positive – very varied, the surveys conducted after they had been using them for a certain period produced a generally high level of satisfaction. They praised, for instance, the vehicles' economic and environmental qualities and their handling.

The vehicles drove on average to eight loading stations a day, so were predominantly used in distribution operations. At the start, a few customers had problems with the hybrid truck's different new functions. However, once they had become familiar with these, the problems were quickly resolved. The drivers indicated that they were consciously utilising the fuel-saving options and said that the energy flow indicator on the hybrid display helped greatly with this.

Some haulage companies stated that for financial reasons they would not be in a position to buy a vehicle with an alternative drive system without a subsidy. Due to the high level of satisfaction it can therefore be assumed that more customers would buy trucks with hybrid drive systems if the purchase costs were not so high.

AN ATEGO BLUETEC HYBRID IN ACTION.

>> 09 / 05 DIWA HYBRID PARALLEL DIESEL HYBRID BUSES

Partners

- Voith Turbo GmbH & Co. KG (consortium leader)
- Solaris Bus & Coach S.A.
- Bochum-Gelsenkirchener Straßenbahnen AG (BOGESTRA – Bochum & Gelsenkirchen Tram Co.)

This project gave the drive systems producer Voith and bus manufacturer Solaris the opportunity to optimise bus hybrid systems in conditions other than just on a test bench: the pre-production vehicle was optimised and tested in real operation on site in the presence of future operator BOGESTRA. The participating companies were able to acquire important expertise in developing and using the pre-production vehicle. The insights gained have already been successfully implemented at Voith and Solaris in the course of full production of 18 further buses of the same type. All of the participants now have the necessary experience in the areas of repairs, servicing and especially in respect to working with high-voltage equipment. During the long-term use of the bus in scheduled operation, BOGESTRA, as the operator of the pre-production vehicle, was able to test out the handling of such vehicles, to satisfy itself about their possible uses and to examine the potential for fuel savings, as well as to train safety personnel.

>> 09 / 06 CROME – CROSS BORDER MOBILITY FOR EVS*

Partners

- Daimler
- Électricité de France (EDF)
- EnBW (consortium leader)
- Bosch
- Karlsruhe Institute of Technology (KIT)
- Porsche
- PSA Peugeot Citroën
- Renault
- Schneider Electric
- Siemens

Planned vehicles

- Daimler: 25 smart ed
- 15 A-Class E-Cell in Germany
- 30 smart ed in France (Moselle)
- Porsche: 3 Boxster E, 2 Panamera Plug-in
- PSA Peugeot Citroën: 25 to 30 iOn / C-ZERO
- 10 Partner / Berlingo
- Renault: 10 Kangoo Z.E.

Planned infrastructure

- 50 public charging stations
- Prototype for 4 fast-charging stations
- Private / business charging stations
- Overarching service platform

* Associated project

A joint CROME concept for mode 3 charging stations (3.5 to 22kW) was agreed between EDF and EnBW and appropriate specifications drafted for the 'dual type socket' charging stations. Additional specifications were defined for charging in mode 3 in France and tested for compatibility with vehicles and charging stations in Germany. On the German side the CROME charging stations are being delivered and installed. On the French side the public institutions are currently inviting tenders for the charging stations and installation can be expected at the end of the first quarter of 2012. It was agreed that an RFID-based method would be used for identifying users in the first stage of the project.

The basic services to be implemented in interoperable form by June 2012 were defined: site selection, charging, emergency solutions (lost cards, etc.), personal usage data, issuing and cancelling of ID cards, examination of user behaviour and the individual stations' charging processes. Other services to be implemented by December 2012 are preconditioning, booking, direct payment and fleet management.

>> 09 / 07 BMW FOLDING PEDELECS AS PART OF AN OVERALL MOBILITY CONCEPT

Partners
BMW AG
Vehicles
2 maxi scooters

The prototype industrialisation process was implemented on schedule in the first half of 2011. A number of initial bicycles have been built and are currently in use. Thanks to the extension of the funding period it was possible to run the planned fleet trial through to the end of September. Based on this trial, the decision was taken to manufacture the pedelec on a full production basis. It can already be seen that in terms of quality, the model will mark the start of a totally new class of folding bicycles. Worthy of particular emphasis are the great frame rigidity and the style of ride that has previously been experienced only on bicycles with large wheels, which is why this pedelec will offer a much higher degree of road safety. In terms of ease of use and reliability, the new folding mechanism is also unique. This development has greatly surpassed all expectations and the research project is a complete success.

>> 09 / 08 DEVELOPMENT OF A BATTERY-POWERED ELECTRIC DRIVE UNIT FOR INTEGRATION INTO A COMPLETE SINGLE-TRACK BEV

Partners
BMW AG
Vehicles
53 folding pedelecs

Using the two prototypes it was possible to show that the chosen vehicle concept – an electrically powered maxi scooter – is indeed ideally suited as a vehicle for commuters who drive to work daily in urban conurbations or surrounding areas. The vehicle is on the one hand small enough to cope with parking and traffic problems in big cities and on the other powerful enough not to hold up traffic on main rural roads or motorways.

The trial confirmed the calculations on required battery capacity. Over the course of the trial the range of at least 100km in practical use proved correct. This capacity gives users the freedom to charge in general at home or at places convenient to them without having to constantly be thinking about where the nearest charging station is located.

Summing up, these concept prototypes therefore fulfil the requirements that a potential customer could have of such a vehicle. However, in the course of developing and building the prototypes certain technical challenges were identified that would need to be comprehensively tackled before any implementation as a possible full-production project (in the case of the concept vehicles through appropriate measures such as vehicle training sessions and use on non-public test circuits only).

>> 09 / 09 NILS – MICRO-MOBILITY PROJECT

Partners
Volkswagen AG – Group Research

The project's emphasis was on carrying out research into an innovative concept of micro-mobility using electric traction, looking at cost-efficiency and new technologies for electric vehicles. The Nils was thus created from deliberations about an innovative car with an electric motor that fits into the space between velomobiles and both light electric and small conventionally powered vehicles. It opens up a market that covers 75% of road-using commuters, who could make their journey to work with an innovative vehicle of this kind.

A summary of the vehicle concept's technological themes:

- Lightweight construction and new body structures
- System-level battery technologies
- Electric motors and drive system design
- Power electronics and control systems
- Energy management for low energy consumption concepts
- Safety concepts for very small vehicles
- Operating concepts for small electric vehicles

The new form of body structure in a lightweight design assures an extension of the vehicle's range through weight savings. Also contributing to this is the selected design of traction battery with a capacity of 5.3kWh and the light electric motor, which weighs just 19kg. Features such as the city emergency stop function and driver assistance systems also provide the necessary level of safety to achieve the safety-related objectives with this micro-vehicle. The digital instruments too were designed specifically to address the need to effectively control the electronic consumers in electric vehicles.

The project has answered a few important questions and objectives relating to small, innovative vehicle concepts, such as in respect to active and passive safety and methods of lightweight construction. However, some areas of potential for technical development still exist, which need to be researched, developed and differentiated further until such a vehicle concept is ready to go into full production. These include, for example, questions about the long-term durability of the traction battery and the vehicle's functional, client-specific electronic equipment.

>> 09 / 10 'E-GOLF ELECTRIC MOBILITY' FLEET TRIAL

Partners
Project responsibility: VW Kraftwerk GmbH in close collaboration with Volkswagen AG

For selected users to personally 'experience' electric vehicles, is an essentially new quality – in the literal sense of the word. All experiences by customers are thus not just assumptions and assessments, but represent the real customer experience. In the field of electromobility that is indispensable as a valid basis for customer surveys.

Numerous experiences were made in this way, in the area of wall box installation. The situations that the installers find on site differ in very varied ways. For example, it is a challenge to install a wall box for a business customer who only has a rented parking space in a multi-storey car park, as the agreement of the building's owner is also always needed. Surveying the customers also produced numerous valuable points for the ongoing full-production trial, which have also been passed on as a return flow of know-how to the developers of the current production projects.

Customers are very enthusiastic about driving these vehicles. Even though the final survey has yet to come as the vehicles are still in use, we can already report that the customers are wholly satisfied. So far, the Golf Blue-e-Motion has fully proved itself in everyday urban use – and even for four adults is a fully-fledged vehicle that through its qualities delivers substantial motoring joy and satisfaction.

>> 09 / 11 RESEARCH PROJECT: NON-CONTACT POWER TRANSMISSION FOR TRAMS – AUGSBURG PILOT PROJECT

Partners

- Bombardier Transportation GmbH (consortium leader)
- Stadtwerke Augsburg Verkehrs GmbH (City of Augsburg Transport Company)

Experiences:
The test results to date prove the functionality of the system in a long-term test. The measurements to demonstrate environmental compatibility are positive. Various components of the inductive power transfer system are currently being optimised in relation to acceptance tests pursuant to the German Regulations on the Construction and Operation of Light Rail Systems (BOStrab).

Programming and technical challenges:
One particular challenge is that the existing standards for equipment approval for local public transport cannot always be applied to this innovative power transfer system. Solutions need to found here in consultation with the licensing authorities and expert inspectors.

>> 09 / 12 DEMONSTRATION OF A HYBRID RAILWAY VEHICLE AND EVIDENCE OF SUITABILITY FOR EVERYDAY USE

Partners

- MTU Friedrichshafen GmbH (consortium leader),
- DB RegioNetz Verkehrs GmbH

In order to be able to correctly estimate the consumption potential, MTU Friedrichshafen developed a simulation model of the complete railway system specifically for the purpose. Built in modular form, the model made it possible to dynamically calculate key operational values taking into account the relevant line details (journey times, line resistance, speed restrictions). In order to check the computer model's accuracy, a series of test runs were conducted by a VT642 with a conventional diesel/mechanical drive system.

Test bench results

Material findings from the system simulation were confirmed on the system development test bench. In addition to power and consumption measurements, measurements were also examined in relation to vibration characteristics and the drive system's acoustics, while the software's different functions were also tested.

Electromagnetic compatibility compliancy with the relevant norms in the rail sector was also proven.

Vehicle integration

After detailed technical calculations and trials, extensive conversion and adaptation work was necessary in order to integrate the hybrid concept and the other innovative technical developments into the existing vehicle.

One focus in terms of implementing the new hybrid components into the vehicle structure is the optimum distribution of mass and adherence to the kinematic vehicle gauge.

The existing R 134a climate control system is also being replaced using compatible interfaces by the new environmentally friendly CO_2 climate control system. In order to achieve economic hybridisation of the existing vehicles, the top-level control system on the software side should be left as untouched as possible.

Material areas of emphasis of the preliminary investigations and subsequent simulations also included adherence to the permitted axle loads and evaluation of the vehicle's functional safety. At the same time the clearance profile and the handling characteristics of the vehicle were key factors in the subsequent decision to comprehensively change the structure of the vehicle's roof construction.

MINISTER FOR TRANSPORT DR. PETER RAMSAUER HANDING OVER THE FUNDING APPROVAL OF THE TRANSPORT MINISTRY FOR THE TESTING OF THE HYBRID POWERPACK TO TOGNUM ENGINES DIRECTOR RAINER BREIDENBACH AND DB CHAIRMAN OF THE MANAGEMENT BOARD RÜDIGER GRUBE AT THE INNOTRANS 2010 RAIL TRANSPORT FAIR.

HANDOVER OF THE INNOVATION PRIZE TO MTU ANBD WESTFRANKENBAHN IN JUNE 2011 IN FRIEDRICHSHAFEN. PICTURED: DR. VEIT STEINLE (BMVBS), CLAUS WERNER (DB REGIONETZ VERKEHRSGESELLSCHAFT), INGO LEHMANN (MTU FRIEDRICHSHAFEN), MARTIN RECHE (PRIVATBAHN MAGAZINE), DR. INGO WINTRUFF (MTU FRIEDRICHSHAFEN).

>> 09 / 13 ZSW LABORATORY FOR BATTERY TECHNOLOGY (ELAB) AND BATTERY TESTING AND SAFETY CENTRE

Partner

Zentrum für Sonnenenergie und Wasserstoff-Forschung Baden-Württemberg - ZSW (Centre of Solar Power and Hydrogen Research)

Construction of the test centre was planned with the architects and specialist planners in accordance with the list of technical requirements that had been produced. What test and inspection facilities were needed was ascertained in collaboration with potential users and from analysing a variety of presentations. The building project was realised via a general contractor. Construction work, specification and correction were carried out by ZSW in close collaboration with the general contractor and largely completed after just ten month's of construction.

Any special appliances not matching the usual standards were developed in collaboration with the respective manufacturers. Procurement of equipment and appliances as well as their installation and commissioning should be finished by the end of the project in December 2011.

CONSTRUCTION WAS COMPLETED IN JUNE 2011 OF THE ELAB WITH 6,600 SQUARE METRES OF FLOOR SPACE FOR RESEARCH.

>> 09 / 14 BATTERY TEST CENTRE P 10

Partners

SGS Germany GmbH

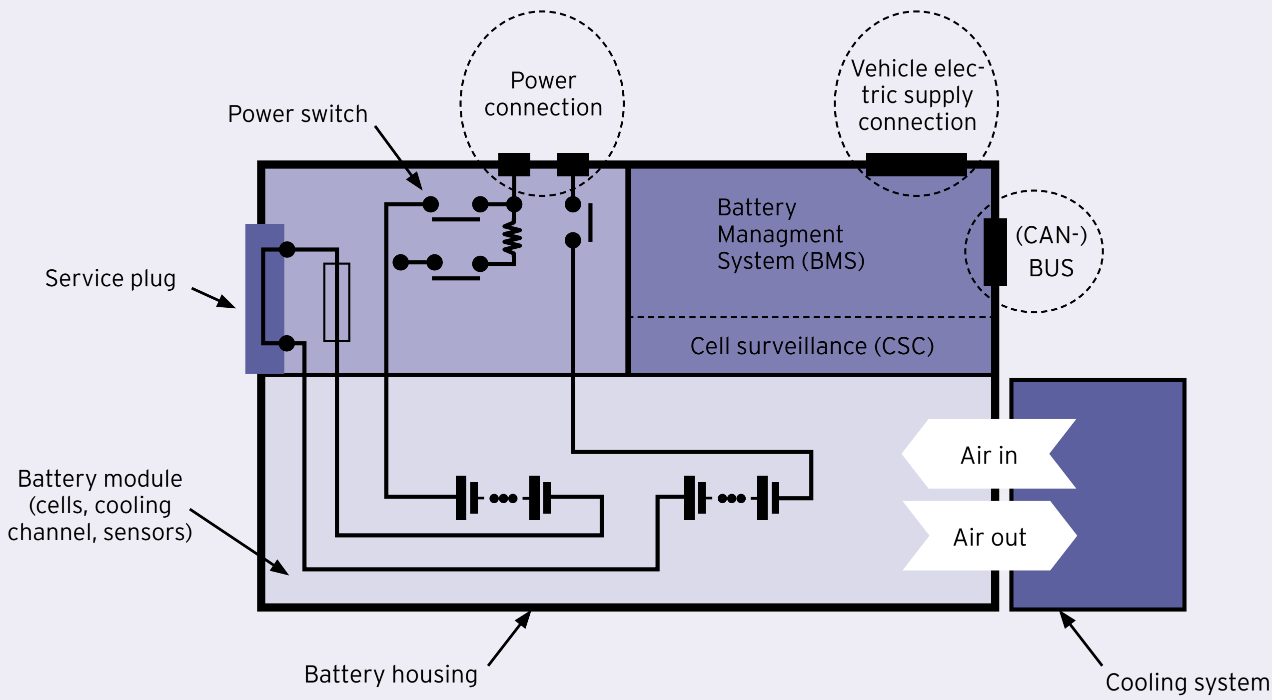
In working up efficient test methods for traction batteries and their components the project team looked very closely at the specific aspects of safety at work and implemented concrete technical and structural measures in collaboration with fire safety experts.

A cyclical endurance test on a hybrid battery served as a pilot experiment for gaining experience with temperature control, current feed and time-critical monitoring of batteries with feedback to the charging generator. A thermo/vibration test bench with associated safety infrastructure and control elements was designed and the requirements for test equipment and safety infrastructure defined and planned.
An existing EMC test site was upgraded to the new high-voltage requirements and test object specifications of large traction batteries.

In order to record the test object characteristics in a clear, comprehensive and reproducible manner, existing methodological descriptions in standards are often inadequate. Here, the project team devised new approaches for improvements and tapped into areas of potential to increase effectiveness. Based on preliminary experiments and in dialogue with vehicle and battery manufacturers, the necessary processes, actions and requirement specifications of test sites and safety systems were defined. Based on an accompanying hazards and risks analysis, the project team defined key tests, which were run on cells or modules and on safety systems. Indicative tests can thus be run at early stages of the product creation process and the scope of elaborate tests on the complete battery reduced. Special event rooms inclusive of the necessary infrastructure for controlling any fires or explosions that may occur were also planned and built.

The existing methods for evaluating battery safety concepts were enhanced in a manner aligned to real-world operation using approaches from machine safety and taking into account ISO 26262. The battery testing centre created in Munich will continue to expand after the end of this development project in order to then largely cover vehicle and battery manufacturers' testing needs.

BASIC CONSTRUCTION



SKETCH OF A BATTERY SYSTEM WITH INTERFACES AND COMPONENTS YET TO BE TESTED.

>> 09 / 15 BATTERY SAFETY LABORATORY FOR LITHIUM-ION BATTERIES FOR ELECTROMOBILITY

Partner
CETECOM ICT Services GmbH

The aim in this project was to create test facilities and to validate the processes produced for checking batteries' safety against typical long-term loads and loads arising from 'misuse'. After being set up, these facilities are particularly suited to enhancing the technology of batteries in respect of their structure such that loads do not lead to an uncontrolled disaster in real use on the open road.

A core issue here was constantly evaluating the attendant risk whenever tests are being run on a charged battery. These tests can therefore only be performed by controllable methods in fireproof rooms with increased monitoring sophistication and suitable extinguisher systems at the ready.

The test facilities set up are suitable for simulating the scenarios that could currently and in the foreseeable future be expected to endanger a battery. The facilities have already been available to industry for several months for running qualification tests, both for products at cell and module level and for complete systems.

One special area in the qualification of battery systems is without doubt the certification of drive system batteries. With a view to a simplification in the process of licensing electric vehicles, the safety of a drive system battery gets assessed here in respect to electrical and functional safety and electromagnetic compatibility in a neutral certification procedure. This assessment ultimately leads to a battery safety specification sheet, which summarises the important data for the battery's further use.

>> 09 / 16 ELECTROMOBILITY AND INFRASTRUCTURE: ECONOMIC ANALYSIS OF ORGANISATIONAL AND OPERATOR MODELS, OF DEVELOPMENT AND FUNDING STRATEGIES AND OF REGULATORY ISSUES (EM-INFRA)

Partner

- Technical University of Berlin, Workgroup for Infrastructure Policy (WIP), Infrastructure Economics and Management Section (consortium leader)
- Becker Büttner Legal Chambers

Allocative significance of coverage effects frequently gets neglected in the debate on public charging infrastructure (CI)

- A 'guarantee' for electric vehicle users of available public CI has the potential to considerably reduce transaction costs
- Public CI can reduce costs of electric vehicles
- Public CI can consequently have an effect analogous to monetary incentives

Semi-public CI can be an effective partial substitute for public CI

- Efficient development without state incentives / requirements questionable
- Semi-public CI can significantly reduce transaction costs
- Requirements relating to the development of semi-public CI will, from a systems perspective, also be accompanied by inefficiencies

Central funding instruments can/ought to be worthwhile and should be linked to requirements relating to (marketing and other) standards

- Against the backdrop of public CI's option benefit, centrally established development incentives for local authorities / operators working in their areas ought to make sense
- With a view to limiting transaction costs (especially in sales), linking with requirements in relation to marketing and other standards should be considered

During the R&D stage, the public authorities should keep structural options open and generate knowledge

- Due to still high levels of uncertainty / more advantageous technologies and concepts, lock-in effects should be avoided
- The process of reaching decisions on establishing standardisation/regulation rules and subsidy / incentive rules in a few years time should be prepared now

>> 09 / 17 ETRUST – MODELS AND FUTURE CONCEPTS OF ELECTROMOBILITY

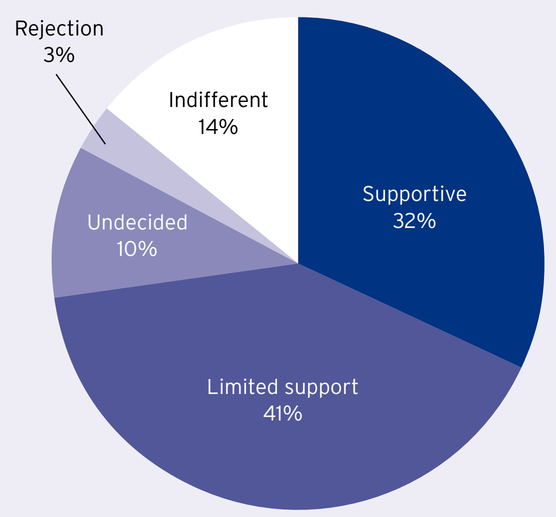
Partners

- Unabhängiges Institut für Umweltfragen e.V. (Independent Institute for Environmental Issues, consortium leader)
- Institute of Transportation Design, Braunschweig University of Visual Arts
- Spilett New Technologies GmbH

In the results of the study entitled 'eTrust – Models and future concepts of electromobility', which was conducted on behalf of NOW GmbH, the essentially positive image of electromobility in society is apparent. Electromobility is associated, above all, with being environmentally friendly, free of emissions and low in noise. However, these positive attributes of electromobility scarcely generate any enthusiasm to buy among consumers. Personal benefits are missing both on a pragmatic and emotional level. Instead, potential users perceive the drawbacks of electric cars in a very clear, concrete way. Evidently the perceived satisfaction of needs by privately used conventional cars continues to form the frame of reference for judging electromobility. With the technology at its current state of development, the electric vehicle can't compete when compared this way. If electric cars are to gain approval in society, it is important to infuse them with emotional qualities that appeal to many user groups. It appears necessary to offer consumers much more than, as has been the case to date, merely opportunities to experimentally 'experience' electric cars under everyday conditions.

The analysis clearly shows the discrepancy that currently exists between the possibilities in relation to a social change in mobility based on electric vehicles and the perceptions and requirements in terms of mobility shaped by conventional motoring.

POSITIONING OF GERMAN PRINT MEDIA IN 2010 IN REGARDS TO ELECTROMOBILITY



327 RESPONSES WERE EVALUATED.

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