NATIONALE PLATTFORM ELEKTROMOBILITÄT

Progress Report of the German National Platform for Electric Mobility (Third Report)

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Executive Summary

1 Executive Summary

Electric mobility is key to achieving climate-friendly and sustainable transformation of our transport systems. For Germany, it represents an opportunity and a challenge to secure and develop its leadership position in the realms of industry, science and technology. The German National Platform for Electric Mobility (Nationale Plattform Elektromobilität – NPE) was established by the federal government and brings together representatives of industry, the research and political communities, the trade unions and civil society in Germany. Its members have agreed on a systemic, market-driven approach characterised by a readiness to deploy a variety of different technologies in order to achieve the goal of making Germany the world's **leading supplier and market** for electric mobility by 2020. In this report, the NPE monitors the progress made towards implementation of its recommendations since the publication of the Second Report in May 2011. The three-phase market development model and interim goals described in the NPE's Second Report continue to apply today (Fig. 01).

Fig. 01
Phases of the Market Development Model

At the moment, Germany is in the pre-market phase which is set to run until the end of 2014. Progress is currently on track.
During the past twelve months, a huge amount of work has been carried out on implementation of the NPE's proposals.
The verdict of the experts is unequivocal: the NPE's key forecasts have largely proven to be correct, as have the focus on research and development (R&D) and the establishment of a limited number of large-scale electric mobility showcases during the pre-market phase. The showcases are now being used alongside the results of the projects in the R&D lighthouse projects (known as *Leuchttürme* in German) as an instrument for verifying the models and forecasts prior to the second phase and adjusting and refining the recommendations.

German industry is investing across the entire electric mobility value chain, from batteries to drive systems, lightweight design, energy management and vehicle design right up to smart charging technologies and the integration of renewable energy. As a result, German automotive manufacturers will be in a position to start marketing over **15 new electric vehicle models** during the pre-market phase. It is industry that is providing the bulk of the huge investment sums. In the pre-market phase alone, up to 17 billion euros will be invested in research and development related to electric mobility.

In its **programme for electric mobility** announced in May 2011, the German government adopted many of the NPE's key recommendations and it is now working towards their implementation.

Between 2009 and 2011, the federal government made 500 million euros available for research and development through its Second Economic Stimulus Package. It is now set to redouble its efforts by providing up to a billion euros of additional funding by the end of the current parliament. Moreover, the announcement of the *Elektromobilität Südwest* and *M.A.I. Carbon* cluster initiatives in January 2012 and the four showcase electric mobility regions (Baden-Württemberg, Bavaria/Saxony, Berlin/Brandenburg and Lower Saxony) in April 2012 marked the launch of two measures that will play a key role in achieving the German government's overall goal. The four showcase regions are set to receive 180 million euros of central government funding which will generate a substantial leverage effect in terms of private sector investment and co-financing from regional government. The showcase regions will offer potential users and the general public in Germany the opportunity to gain first-hand experience of the system electric mobility. It is also expected that a lot of new information will be obtained, for example in the fields of transport and energy systems, training and qualifications, information and communication technology (ICT) and climate and environmental protection.

"There is no doubt that getting a million electric vehicles on the road in Germany is going to be a marathon journey. Nevertheless, I am very confident that we can achieve this goal.
Why am I so sure? More than anything, it's because electric mobility is a truly thrilling ride! Everyone who has driven an electric car has been really enthusiastic about it."

Prof. Dr. Henning Kagermann | President of acatech – National Academy of Science and Engineering | NPE Chairman

The NPE's experts firmly believe that a systemic approach is key to successfully delivering the common targets. In the field of electric mobility, it is important to establish more closely knit networks between the traditionally separate silos of vehicles, transport and energy, e.g. to facilitate electric vehicle charging.

During the reporting period, various **R&D projects** have been established and funding applications submitted for all six of the R&D lighthouse projects described in the NPE's Second Report:

- Batteries: 21 consortia; total project budget of 601 million euros
- Drive technologies: 28 projects; total project budget of 230 million euros
- Vehicle integration: six projects; total project budget of 113 million euros
- Lightweight design: eight projects; total project budget of 100 million euros
- Recycling: two projects
- ICT & infrastructure: 17 projects; total project budget of 125 million euros

These joint projects address the urgent need for strategic R&D and will help to make electric mobility competitive. The projects involve cross-sectoral, pre-competitive collaboration between several research institutions and small and medium-sized enterprises, some of which are NPE members and some of which are not.

The key foundations have been laid to enable Germany to become the world's leading supplier for electric mobility by 2020. To ensure that we stay on the right track, the NPE recommends the following measures:

- The funding for the proposed R&D projects needs to be delivered and the measures need to be consolidated
- Academic and vocational training, CPD and certification of the necessary specialised and management personnel, in accordance with the finalised competence roadmap
- Move forward on the issues described in the revised version 2.0 of the standardisation roadmap and use the progress already achieved as the basis for national and international cooperation with regard to common standards and regulations

Failure to implement the recommended **measures to promote** market growth or any delay in their implementation could lead directly to a reduction in the sales volumes that can be achieved in Germany. Other barriers to growing the electric mobility market, such as excessively narrow assessment criteria, will curb the number of vehicles on the road still further. The NPE is therefore of the opinion that the monetary and non-monetary incentives should continue to be implemented consistently.

In addition, the demand for innovative transport solutions should be reflected in public procurement programmes. Monitoring should be carried out to follow market trends and assess the effectiveness of the monetary incentives that have been implemented, adapting them where necessary. The initial results from the showcase projects will enable the potential of these incentive measures to be evaluated. The pre-market phase will also prepare the ground for the ramp-up in the number of vehicles on the road and the construction of the relevant infrastructure. The NPE recommends using the showcases and other pilot studies to undertake a more detailed study of issues relating to customer acceptance and demands.
Initial field trial results indicate that the deployment of electric vehicles in car sharing schemes and other vehicle fleets is a promising strategy in terms of its marketability. The showcase regions will develop new business models and place particular emphasis on providing comprehensive communication in support of their activities.
The showcase regions will also support the continued development of an appropriately-sized charging infrastructure and smart energy system. Today, Germany already has more than **2,200 publicly accessible charging points for the 4,500+ electric vehicles** on the road.[1] A constructive **continuation of the successful, cross-sectoral cooperation within the NPE** will be key to Germany becoming the world's leading supplier and market for electric mobility. Consequently, the NPE's work in terms of consultancy and providing a platform for experts should be extended to include an ongoing monitoring role.

2
Background

2 Background

The race is on across the world to develop the best ideas for achieving the goal of sustainable transport, and electric mobility is well-equipped to take its place among the frontrunners. Germany acted swiftly to lay the foundations for the long-term success of electric mobility by establishing the NPE in May 2010. The NPE is a body that brings together experts from industry, the research community, government, the trade unions and civil society. Its stated common goal is to make transport even more sustainable in the future: to build a transport system that is more climate- and environmentally-friendly, uses fewer natural resources and is consequently also more competitive.

Germany has laid the foundations to become the leading supplier and leading market for electric mobility

The strategy for promoting electric mobility in Germany is based on a **systemic, market-driven** approach and a **readiness to deploy a variety of different technologies**. The NPE's focus is on three types of electric transport applications that also serve as reference vehicles[2]: BEVs, REEVs and/or PHEVs as well as lightweight commercial vehicles featuring electric operation for driving in towns and cities. One feature common to all these drive technologies is that they can be charged directly from the mains (Fig. 02).

The NPE is continuing to implement its market-driven approach characterised by an openness to different technologies and systems

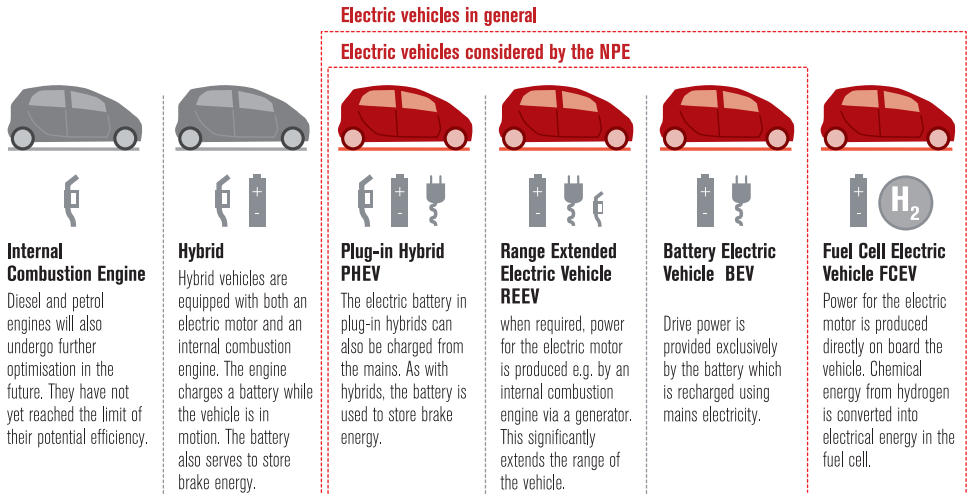


Fig. 02
Overview of Drive Technologies

This restricted focus reflects a consensus among the partners that the selected drive types offer significant opportunities and have great potential for achieving sustainable transport. At the same time, however, they will need to be more heavily promoted if they are to achieve lasting market success, since there are a number of major challenges that will need to be addressed in order to grow the market.[3]

The NPE's forecasts (2011) of the economic implications of electric mobility remain valid today and highlight the potential to create value and jobs in Germany

In its Second Report, published in 2011, the NPE modelled the potential economic implications of electric mobility, enabling it to establish the associated value creation opportunities, calculate the possible fiscal effects and identify the potential for up to 30,000 new jobs in Germany by 2020.

These calculations remain valid today and form the basis of the current report.

"Electric mobility represents a huge challenge for German industry. It offers us the opportunity to use the outstanding know-how of Germany's workforce to make industrial production compatible with good environmental sense. For this to happen, we need to keep working to ensure that all the links of the value chain are fully integrated into this innovation process. I'm excited about this development, and very optimistic."

Berthold Huber | President of Germany's IG Metall trade union | Coordinator of German Business for Electric Mobility and member of the NPE Steering Group

Against this background, this Progress Report marks the first step in the NPE's implementation of a comprehensive and regular monitoring process of the common forecasts, goals and recommendations. Following an examination of the systemic aspects of electric mobility (Chapter 3), Chapter 4 will describe the progress made with the systemic, pre-competitive joint projects in the six R&D lighthouse projects. Chapter 5 will present a market analysis focused on the core aspects of user acceptance, market stimulation measures and charging infrastructure. Finally, in Chapter 6, the findings will be compared to developments elsewhere on the international market.

German industry is currently implementing its plans to invest 17 billion euros by the end of the pre-market phase

It is a common goal of all the NPE's stakeholders to use this new technology to create as much value and as many jobs as possible for German industry. German businesses have been quick to commence research and development activities and build pre-production models. German industry is investing up to 17 billion euros in electric mobility during the pre-market phase. The German automotive sector alone is investing between 10 and 12 billion euros in the development of alternative drive systems, 80 percent of which is focused on electric mobility. This substantial commitment is being complemented by investment from other industries such as mechanical and plant engineering, electrical engineering and electronics, chemicals, metalworking and metal processing, information and communication technology, textiles and the energy and transport sectors.

Over fifteen electric vehicle production models have been announced so far

These investments are currently being delivered as planned.[4] More than **15 new electric vehicle models** built by German manufacturers will go on sale during the pre-market phase. Each one of them is the product of several hundred million euros of investment in the automotive sector as a whole.

The overall range of different activities is wider still. Investment plans and/or new jobs have been announced by every branch of industry, from SMEs right up to large-scale undertakings.

3
The systemic approach

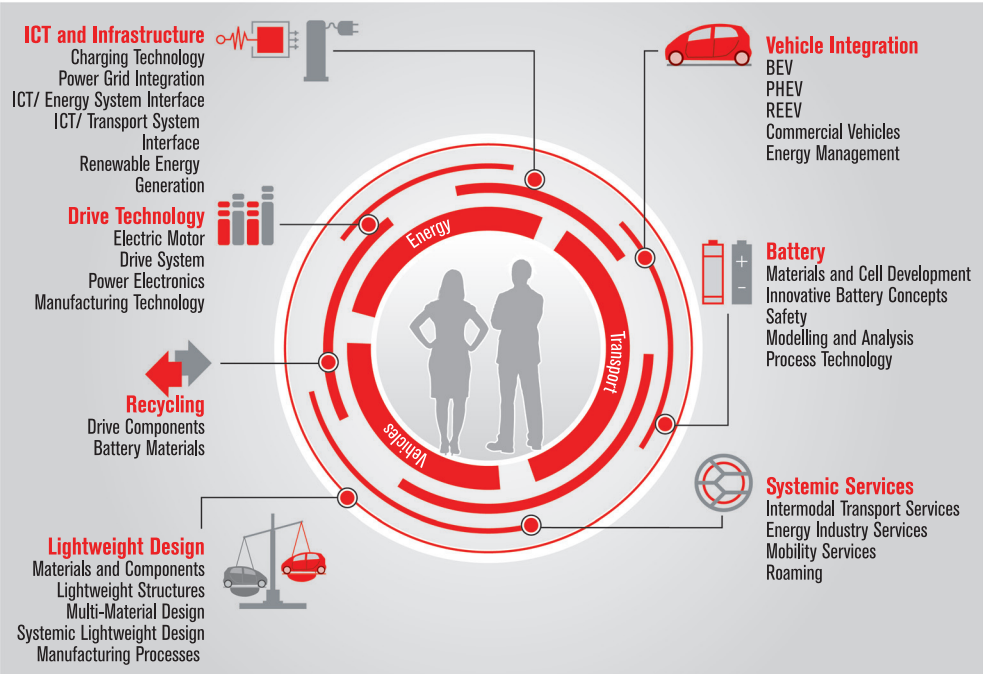
3 The systemic approach

Vision 2020: *"Electric mobility made in Germany" stands for systemic and sustainable solutions that cross the boundaries of traditional industries.**

Only a properly functioning total system will achieve customer acceptance of electric mobility and ensure that full advantage is taken of the opportunities it offers with regard to transport and the environment

Customers will only buy into electric mobility if it is a properly functioning, complete system. Users are not interested in the individual elements of electric mobility, what matters to them is the overall service, including everything from renewable electricity, fast charging and integrated transport design to resource-efficient vehicles with alternative drive systems. In the type of system we are talking about, electric vehicles are connected to smart traffic systems using information and communication technology, forming an integral part of a smart grid energy system.[5] **The user is at the centre of this overall system**, with the individual subsystems (vehicles, energy supply, transport infrastructure) surrounding him, allowing interactions between the different subsystems and between user and subsystem (Fig. 03).

Fig. 03
The Electric-Mobility System – Putting the User at the Centre



In order to deliver the overall electric mobility system, it will be necessary to take a user-centric approach to the development of individual components

In order to deliver this overall electric mobility system, it will be necessary to take a global, user-centric approach to the development of the individual components. In the case of smart charging, for example, this would involve using standard charging interfaces, ensuring that battery life is not significantly impaired by two-way charging and making sure that all the relevant interfaces are mutually compatible and user-friendly. Particularly in major urban centres, this approach is also key to integrating electric mobility into a sustainable transport planning system that prioritises ecomobility, since even with electric vehicles the problems associated with noise pollution, traffic accidents and land use for both moving and parked vehicles continue to exist.

* *The visions for 2020 are based on the NPE's Second Report published in 2011.*

"The NPE's work is key to the successful implementation of electric mobility in Germany. It has facilitated exemplary cooperation between industry and the research community whilst also engaging with representatives of government and German society. It is helping to strengthen our competitiveness in the field of sustainable transport across all modes of transport. This will enable us to secure Germany's ability to innovate and create value for all the different drive technologies. The network on the theme of transport that has been created with the Forschungsunion Wissenschaft-Wirtschaft will also contribute to achieving overall success in this area."

Prof. Dr. Thomas Weber | Member of the Board of Management, Daimler AG, Group Research & Mercedes-Benz Cars Development | Spokesperson for the MOBILITY Promoters Group of the Forschungsunion Wissenschaft-Wirtschaft and member of the NPE Steering Group

The NPE's R&D lighthouse projects (Chapter 4) provide an excellent basis for the individual subsystems. The showcase regions electric mobility recommended by the NPE in 2011 are the logical next step for obtaining empirical data that can be used to further develop the systemic approach.

The broad-based remits of its working groups and the overarching cooperation between them mean that the NPE is well-equipped to take a systemic approach to electric mobility. The cross-sectoral cooperation within the NPE has already enabled it to identify some of the challenges in implementing a total electric mobility system:

- Creating the conditions to allow smart (managed and networked) vehicle charging in order to contribute to the transition to sustainable energy use
- Enabling cooperation between local and regional authorities and the relevant industries
- Finalising standardisation of data formats and requirements for the various types of information exchange involved in telematics solutions by 2013
- Developing better regulations for the transport of Li-Ion batteries and achieving international harmonisation of the relevant regulations

In accordance with the systemic approach, electric mobility has also been adopted as a key component of the work being carried out by the *Forschungsunion Wissenschaft-Wirtschaft*[6]. This body's Mobility Promoters Group has drafted a package of additional measures that takes on board the work undertaken by the NPE. The Promoters Group's recommendations were brought together under the project "Sustainable Transport for the Future"[7] and incorporated almost wholesale into the German government's High-Tech Strategy Action Plan[8] in April 2012.

Against this background, the NPE will produce a **Systemic Approach to Electric Mobility Roadmap** during the market ramp-up phase and initiate cooperation activities geared towards its implementation, for example with regard to the integration of road and rail electric mobility into local public transport systems.

The NPE will produce a general roadmap for its systemic approach

4
The road to becoming the world's leading supplier

4 The road to becoming the world's leading supplier

Vision 2020: *Outstanding scientists and specialists are the foundation of Germany's sustained competitive advantage in the field of electric mobility. There are common international standards for electric mobility. Germany is the leading supplier and market for electric mobility and a world leader in the relevant key technologies.*

The NPE's readiness to deploy a variety of different technologies has proven to be the right approach in Germany's journey towards becoming the world's leading electric mobility supplier. Following a critical assessment of the current situation in the 2010 Interim Report, goals were established, technology roadmaps were developed, R&D requirements were identified and implementation recommendations were formulated for all the relevant aspects. In addition to the roadmaps for the key electric mobility technologies, the NPE has also produced comprehensive roadmaps for regulation and standardisation (2011) and training and qualifications (May 2012) which are being updated on an ongoing basis. The content and priorities for the R&D lighthouse projects and showcase regions were developed on the basis of these roadmaps and were, for the most part, endorsed by the **German government's 2011 programme for electric mobility**. These measures[9] are currently being implemented, having been proposed as part of the pre-market phase (running to 2014) in the Second Report published in 2011. Electric mobility projects have been launched in some existing funded programmes and there have also been a number of new calls for tenders. Implementation is progressing with the formation of several consortia and cross-sectoral partnerships. The NPE is working to promote cooperation in this regard. The projects have been particularly beneficial for small and medium-sized enterprises (SMEs) and research institutions, whilst there are several partners who are not NPE members but are nonetheless involved and engaged at every level.

The German government's Programme for Electric Mobility took on board the NPE's recommendation to create an coordination office for electric mobility at the Federal "Research and Innovation" Funding Advisory Service (*Förderberatung des Bundes „Forschung und Innovation"*) (www.foerderinfo.bund.de). The coordination office is intended to make the funding process transparent and customer-friendly for interested businesses and research institutions as well as establishing where applicants' proposed research topics fit in within the overall electric mobility picture. The coordination office cooperates closely with the German Federal Government Joint Unit for Electric Mobility (*Gemeinsame Geschäftsstelle Elektromobilität – GGEMO*) and is fully included in the processes of both central government and the NPE.
The progress in research, development and networking in six R&D lighthouse projects is described in detail under section 4.1. Section 4.2 looks at additional measures geared towards training, continuing professional development (CPD) and qualifications for specialised and management personnel, while Section 4.3 addresses the strategic orientation with regard to regulation and standardisation.
The goal of becoming the world's leading electric mobility supplier by 2020 is ambitious, however it can be jointly achieved through cross-sectoral cooperation to ensure prompt implementation of the R&D lighthouse projects and roadmaps.

4.1 Research and development lighthouse projects

Vision 2020: *The research and development undertaken by German research institutions and industry sets the benchmark for electric mobility innovation worldwide.*

Compared to other countries, Germany is well equipped to carry out research into electric mobility. In order to deliver the target of becoming the world's leading electric mobility supplier, the NPE established **six R&D lighthouse projects** that are already operating successfully. The NPE's working groups identified research requirements for all the relevant technology areas, consolidated these with existing projects that are already receiving funding and ensured that all the different individual projects were geared towards the overarching goal of "becoming the leading supplier for electric mobility".

"Electric vehicles are an important component of transport strategies in the context of future energy systems. Their introduction will be an acid test of whether of not we are truly willing to employ new technologies to enable more responsible energy use. Whilst much theoretical and applied research still needs to be carried out into the relevant battery technologies, recent success stories mean that we are now ready to roll out the first serious applications."

Prof. Dr. Robert Schlögl | Director of the Fritz Haber Institute at the Max Planck Society

The German government's programme for electric mobility took on board the NPE's proposal to create R&D lighthouse projects to promote lead technology areas. The government developed a special implementation concept to ensure that the lighthouse projects generate new impulses and incentives, develop existing strengths and improve the visibility of these strengths to the general public. The electric mobility R&D lighthouse projects will account for an extremely high proportion of all R&D measures funded by the German government. In individual cases, lighthouse projects selected by the German government may be assigned to the NPE's R&D lighthouse projects.[10]

All the R&D lighthouse projects have initiated projects geared towards implementing the NPE's goals

This chapter will describe the first implementation steps taken in individual R&D lighthouse projects, as well as the progress achieved to date. Overall, implementation has been progressing very well. It is already evident that the NPE's work in the **batteries** R&D lighthouse project has allowed synergies and potential savings to be identified, resulting in a 40% reduction in the level of investment that had originally been planned. Nevertheless, continued prompt and consistent implementation of the various projects will be essential. Furthermore, it is becoming clear that the rapid pace at which the relevant technologies are developing means that it is important to keep identifying new mission-critical R&D projects and bringing new project partners on board. Last but not least, the systemic approach highlights the importance of cooperation between the different R&D lighthouse projects, and this is something that will need to be developed in the future.

4.1.1 Batteries

Vision 2020: *Germany is the global leader in cell and battery technology and has an integrated domestic manufacturing capability.*

The **batteries** R&D lighthouse project is geared towards promoting the establishment of an integrated cell and battery systems manufacturing capability in Germany. The NPE identified the research priorities for achieving this goal and established five thematic areas in close consultation with experts from industry and the research community and with input from the relevant federal ministries. A total of 21 consortia[11] were formed, comprising stakeholders from the research community and industry (small and medium-sized enterprises and large-scale undertakings) (Fig. 04).

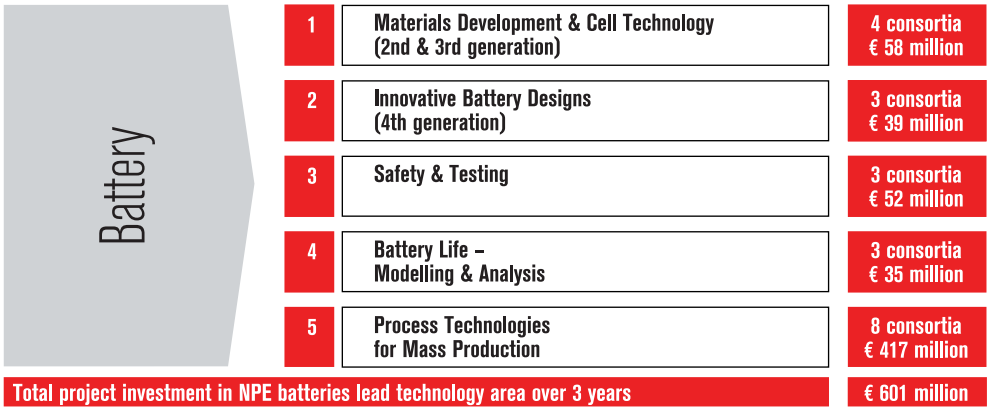


Fig. 04
Progress in the Batteries Lead Technology Area (Project Overview)

All the thematic areas have been derived from the technology roadmap presented in the NPE's First Report (11/2010). The lighthouse project's first thematic area is focused on optimising cell components (high-energy materials). The second thematic area is geared towards the development of cost-effective and optimally efficient post Li-Ion technologies while, under the heading of "safety and testing", thematic area three is focused on building testing equipment and defining test procedures for carrying out safety and risk assessments. In order to increase the lifespan of battery systems, thematic area four is studying ageing mechanisms and smart control designs with a view to increasing efficiency. In the fifth thematic area, process technologies for mass production are being tested and investigated through pilot applications to establish which production technology should be employed and which demands need to be met for large-scale production.

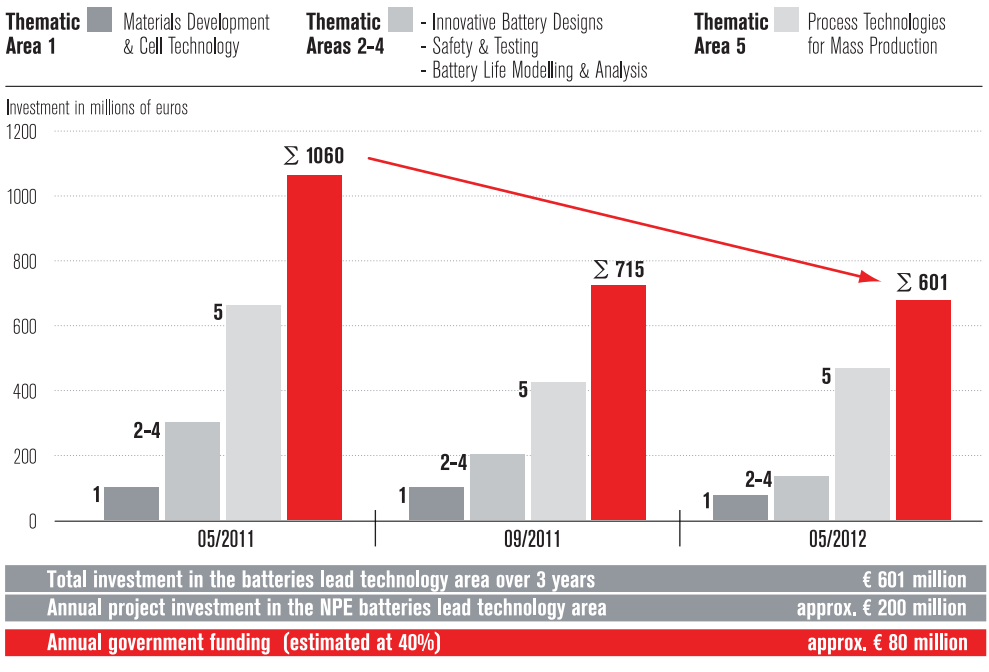
In its **Programme for Electric Mobility** launched on 16 May 2011, the German government endorsed the NPE's thematic priorities:
"[…] analyses and indeed the NPE's Second Report make it clear that cell and battery manufacture forms an extremely important part of the new value chain. The Federal Government therefore regards this area as a particularly important funding priority. Establishing our own competitive cell and battery manufacturing capability is a key enabler for developing electric mobility in Germany. Manufacturing process priorities include materials procurement, the development of new manufacturing processes

including post-lithium-ion technologies, innovative battery concepts and the integration of batteries into the vehicle's overall energy and thermal management systems. The appropriate competitive manufacturing and production technologies will need to be developed rapidly if we are to succeed in establishing a battery cell manufacturing capability in Germany […]."[12]
In accordance with the guideline recommendations, the consultation process in the NPE's battery technology and battery materials working groups has been continued and intensified, in order to maximise the synergies between the individual thematic areas and identify potential savings. During the consortium-building process in 2010 and 2011, it was possible to consolidate the research topics that had initially been identified. Pre-competitive R&D themes had originally been established for projects requiring an estimated initial investment totalling approximately one billion euros.

However, following a consolidation process in which all the stakeholders were closely involved, it proved possible to remove duplications, identify priorities and sharpen the focus to topics exclusively related to batteries. This was achieved both horizontally (within each thematic area) and vertically (across all the thematic areas).

As a result, it proved possible to reduce the 2011 projection of a one billion euro investment in the batteries lead technology area to just 601 million euros (over a three-year period). Within the consortia, research institutions are receiving up to 100% public funding (compared with a figure of 40% for private companies). As such, the funding is being concentrated on those research topics that are highly relevant to the current pre-market phase (Fig. 05). Furthermore, targeted support is being provided for the practical implementation of the research topics through the establishment of pilot facilities for cell and battery production.

Fig. 05
Creating Synergies in the Batteries Lead Technology Area



These projects are geared towards defining the specific requirements for Germany to develop an integrated cell and battery systems manufacturing capability. It is the NPE's belief that implementation of the proposed projects will help Germany make the qualitative leap needed for it to steal a march on its international competitors and become the global leader in battery technologies.

The research themes have been addressed through the **creation of a total of 21 consortia** comprising members from industry, SMEs and the research community (Fig. 06), with the bulk of the funding being targeted at research institutions and SMEs. Examples include the *E-Drive Battery 2015*[13] und *SafeBatt*[14] consortia.

Thematic Area	Project	Content
Materials Development & Cell Technology	ALPHA-Lion Lithium Metall E-Lab KoMBat	Development of **3rd and 4th generation cells** using high energy materials **Test facility** for the preparation of coated lithium metal powders designed for optimum processability **Electrolyte laboratory**, high-throughput synthesis (automatic electrolyte analyser) **Carbon materials** for next-generation Li batteries. Lab-scale materials
Innovative Battery Designs	FutureBatt Lithium/Luft-Bat. KPPP	Research into **next-generation battery systems** (standard pouch cells) Development and production of a **commercially viable lithium-air battery** **Cost-effective** product, process and production development of lithium energy storage devices
Safety & Testing	SafeBatt BALSAC K-LIB	Passive/active measures for creating **safe long-life battery systems** Battery laboratories with **test facilities** for the development and production of energy storage devices Research into **test procedures and standards** for safety assessment
Battery Life Modelling & Analysis	Balanse E-DriveBattery Lastkollektive	**Ageing mechanisms** in lithium-ion batteries Smart **control and connection designs** for modular EV battery systems Creation of an **industry specifications document** on the battery life of electric vehicles
Process Technologies for Mass Production	Competence E PEB SSLBa π-Lion K-LIB NP-LIB CHaR-Li iFaaB	Integrated **"Research Factory"** for future electrical energy storage devices and drive systems **Development centre for battery production technologies** Core process development for **cell production** Processes and facilities for the **production** of thermodynamically stable **thin film solid-state batteries** **High-performance manufacturing** of Li-ion cells Facility for **research** into and optimisation of lithium-ion cell manufacturing Test facility for **high-performance battery materials** Integrated **manufacturing concept for Advanced Automotive Batteries**

Fig. 06
Project Content in the Batteries Lead Technology Area (Selected examples)

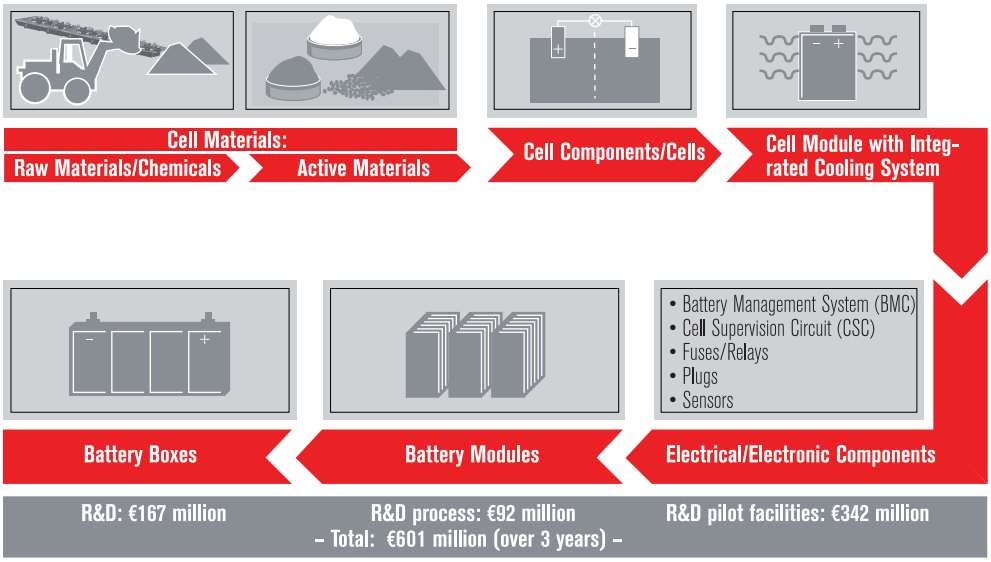
This consortium composition ensures that the research will have a practical focus, generating synergies and enabling optimal allocation of resources.
In order to address the goal of becoming the **leading supplier**, all the projects were assessed in terms of their place in the value chain (Fig. 07). Assigning projects to one or other of the different value chain categories ensures transparent allocation of resources to the different stages of the manufacturing process. The projects cover all the necessary aspects of the value chain and set a new quality standard across the entire system.

Practical research in the consortia enables optimal allocation of resources

In accordance with the NPE principle of being prepared to deploy a variety of different technologies, **a two-pronged strategy** has been adopted by the **batteries** lighthouse project. The first component is **Li-Ion technology**, which is currently the best option for maximising the range of BEV, REEV and PHEV vehicles. The **second** component focuses on strategic research into **post-lithium-ion technologies** for the period post-2025, such as lithium-sulphur, zinc-air and lithium-air systems.

The batteries lighthouse project is contributing to the establishment of an integrated cell and battery systems manufacturing capability in Germany

Fig. 07
Key Components of the Value Chain



The batteries R&D lighthouse project is contributing to the establishment of an integrated cell and battery systems manufacturing capability in Germany

The NPE experts recommend prompt and consistent implementation of the projects in order to deliver an integrated cell and battery systems manufacturing capability in Germany.
The proposed projects are the result of an approach whereby the relevant tasks were shared between research institutions and industry in consultation with the relevant federal ministries. The businesses and research organisations involved have demonstrated their commitment by providing concrete plans regarding the level of personnel and resources that they are prepared to devote to the projects. Their implementation will enable significant progress to be made towards the establishment of an integrated cell and battery systems manufacturing capability in Germany.

CASE STUDY: Hoppecke Advanced Battery Technology GmbH

In the short time since it was established, the cross-sectoral cooperation and R&D funding facilitated by the NPE have already resulted in a tangible boost to investment and jobs in Germany, especially in small and medium-sized enterprises. Hoppecke Advanced Battery Technology GmbH is an impressive example of this trend. This young technology company opened its new innovative energy storage device facility in Zwickau on 9 March 2012. Coming hot on the heels of a modern R&D centre that opened in April 2011, the new facility now allows the company to manufacture batteries and assemble complex energy storage systems.
The 1,500 square metre premises of the modern R&D building provide Hoppecke's developers with all the space and equipment they need to develop mechanical and electronic components, software and management systems and to integrate all these elements into energy storage systems.

4.1.2 Drive technologies and vehicle integration R&D lighthouse projects

Vision 2020: *One million electric vehicles with innovative drive systems on the road thanks to the deployment of holistic, integrated solutions combining advances and discoveries in battery and drive technologies, lightweight design, information and communication technology (ICT) & infrastructure and recycling.*

The NPE's Second Report (2011) presented detailed technology roadmaps for the **drive technologies and vehicle integration** R&D lighthouse projects in the thematic areas of highly-integrated drive systems (including on-board charging technology), electric motors and power electronics/inverters. These support the vision of producing innovative drive technologies and holistic, integrated solutions. The associated projects will be required to focus on cutting costs and increasing production volumes, improving power density and power-to-weight ratios and enhancing efficiency, quality and reliability (Fig. 08).

The NPE's work builds on internal R&D activities from within German industry and various joint projects that have been funded in the past (Fig. 09). Additional joint research and development projects were launched during the most recent reporting period. 34 new proposals were consolidated into concrete projects which are now starting to be implemented. The total level of investment in these projects currently stands at approximately 340 million euros. If we add this figure to existing projects that are already being funded (approx. 530 million euros), the total level of investment for all

Key themes in the fields of drive technologies and vehicle integration are being addressed through research projects worth 870 million euros. Some 340 million euros of this total is being invested in 34 completely new projects

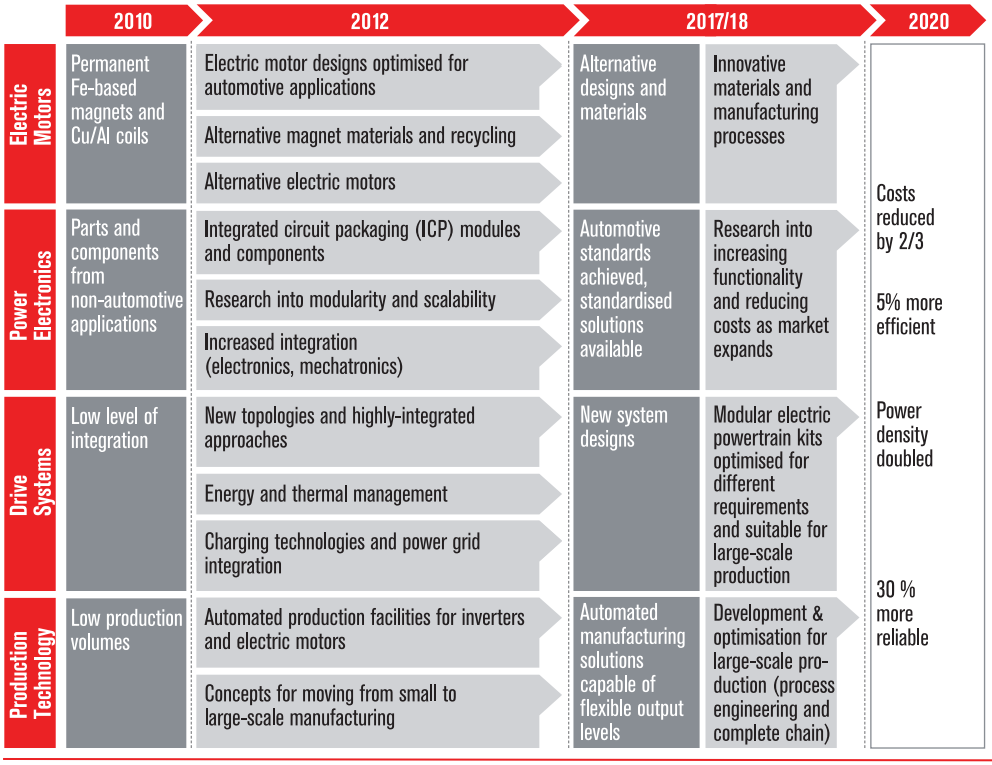
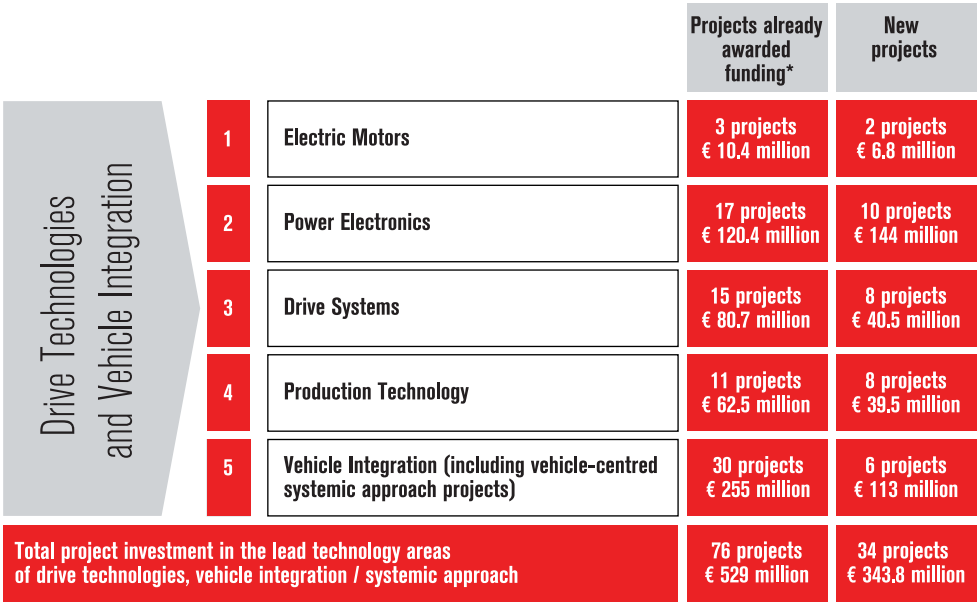


Fig. 08
Technology Roadmap for the Drive Technologies R&D lighthouse project

Fig. 09
Progress in the Drive Technologies and Vehicle Integration R&D lighthouse projects (Project overview)



*) NPE estimate of total project investment assuming a government funding percentage of 40 %
based on information provided by the relevant federal ministries regarding current funded projects in February 2012.

projects comes to around 870 million euros. The joint projects involve partnerships between research institutions, SMEs and large-scale undertakings including some that are not members of the NPE. This composition ensures that the research will have a practical focus, generating synergies and combining resources.
Some of the joint projects and the lead technology area that they come under are described below:

The projects in the field of electric motors are focused on two main areas: efficient, high-performance and cost-effective motor designs and materials. The *E-Limo* project is geared towards improving the entire drive system through alternative electric motor designs. It is hoped to achieve weight savings of up to 30 percent by developing lightweight motors and new approaches to integrating them (*SpHin(x)*) with other vehicle parts.
In addition to lowering the weight of motors, it is also important to develop ways of reducing both costs and their footprint within the vehicle.
Joint projects are also planned to identify and evaluate designs for increasing power density, alternative electric motor technologies and standardisation of specifications and test procedures.

A successful start has been made on implementation of the comprehensive technology roadmaps

The goal of the **power electronics** projects is to deliver a significant reduction in the system costs for the large-scale production of electric motors and the associated power electronics. Important contributions to achieving this goal will be made through mechatronic integration of subsystems (*E-Mile*), reduction of interfaces and manufacturing steps, the development of a standard inverter (*STIEV*) and the investigation of integrated and scalable solutions.

CASE STUDY: TE Connectivity

In a world full of hybrid and electric vehicles, it will be necessary to rethink and redesign many major aspects of how we supply energy, both on board vehicles and in terms of infrastructure. DC voltages of up to 1,000 volts and currents of over 100 amps will require significantly greater cable cross-sections. New plug and switch types and safety devices will also be needed to protect users against electric shocks and arcs.

TE Connectivity is a world leader in this field. With a portfolio that includes high-voltage connectors and cabling, connection systems and safety solutions for battery cells and charging interfaces and power transmission technology for smart grids, TE's products offer solutions right across the value chain. Germany is a key location for TE Connectivity. The company already employs 40 people in Bensheim and Berlin to develop and market electric mobility components.

As far as integrated circuit packaging technology is concerned, a new project to develop high-temperature components and their packaging has been expanded (*SPICE*). Furthermore, a project has been approved to develop more robust power modules and improve the integration of logic and power components. A number of major projects have been launched to develop cost-effective and robust high-temperature printed circuit board (PCB) systems and to promote the integration of heat sink and high-current PCBs using metal-ceramic composites. Efforts to develop reliable and safe electronics systems for electric vehicles are focused on project proposals geared towards optimising (passive) components and power semiconductors/power modules by reducing power dissipation and improving durability whilst simultaneously cutting costs (*ZuSiEL*). In the **area of drive systems**, work is underway to investigate and implement end-to-end optimisation of the efficiency, cost, weight, volume and reliability of different powertrain topologies (*Elektrofonie*). New ideas are under development with regard to highly-integrated approaches to a comprehensive thermal management, energy management using innovative recovery strategies and specific electronic stability control technologies (as well as vehicle integration).

As far as **the area of manufacturing technologies and testing techniques for power electronics** is concerned, research projects have been initiated with regard to quality assurance of innovative bonding processes such as silver sintering for use in large-scale production (*SinTest*). There are a number of general projects focused on process monitoring of entire units in the value chain, e.g. to enable early fault detection in the manufacturing process (*SerTest*). Since flexible production systems are especially important for the market ramp-up phase, a further development priority involves the design of flexible production processes capable of manufacturing variable quantities (*HeP-E*). The NPE has identified several research projects (Fig. 10) to address important aspects of vehicle integration in the reference vehicles. These range from lightweight structural components to flexible, modular electric drive designs for private cars. The projects focus on both family cars (*BEREIT*) and larger electric commercial vehicles. In addition to powertrain components and lightweight design, non-powertrain components that consume large amounts of energy such as heating and air-conditioning systems are also key aspects of efficient electric vehicle design.

Fig. 10
Project Content in the Drive Technologies and Vehicle Integration R&D lighthouse projects (selected examples)

Thematic area	Project	Content
Electric Motors	E-Limo SpHin(x)	Alternative electric motor designs Highly-integrated, scalable EV drive systems
Power Electronics	EMiLE STIEV SPICE ZuSiEL	Integration of electronics with/in electric motors Standard inverters for electric vehicles and plug-in hybrid vehicles Automated testing of silver sintering processes in mass production Safe and reliable electronics systems for electric vehicles
Drive Systems	Elektrofonie	Integrated drive modules for electric vehicles
Production Technology	HeP-E SerTest SinTest	Highly flexible production systems for enhanced-efficiency electric traction drive systems Production technology and testing techniques for power electronics production processes Automated testing of silver sintering processes in mass production
Vehicle Integration/ Systemic Approach	BEREIT INEES EMELY	Family vehicle with range extender and/or plug-in hybrid Energy industry system services Framework regulations on electromagnetic compatibility for electric and hybrid vehicles

Integrated energy management is key to reducing energy consumption

These ancillary components can lead to an increase in total power consumption during winter, for example, causing a substantial contraction in the vehicle's range. Consequently, **integrated energy management** is indispensable in electric vehicles. The key to product innovation in this area is the development of materials capable of influencing the heat exchange between the vehicle and the surrounding environment. The R&D efforts in this field therefore include projects to develop heat-reflective or heat-absorbent materials for automotive paints, windows or vehicle interiors together with the use of high-performance insulators to achieve efficient cab insulation. These solutions can be supported by the deployment of special materials to enable targeted insulation and storage measures in batteries and fan units. However, in view of the current level of technological development in this field, these materials still pose a major challenge. It is therefore essential to design and fund targeted research projects.

In addition to the R&D topics described above, the R&D lighthouse project is also working on developing links with the transport and energy subsystems. Electric vehicles are just a part of the overall system electric mobility (see Chapter 3). In order to put this systemic approach into practice, the **drive technologies and vehicle integration** R&D lighthouse projects also need to address the design of the interfaces between the vehicle and the power grid and transport system. As a result, R&D projects on "networked" cars have been launched (*INEES*) and plans are also afoot to implement charging technology projects in the showcase regions.

More than 15 electric vehicle production runs have been announced for the next two to three years

We are starting to witness concrete results from the technology transfer through the R&D lighthouse projects, as first results of these projects are already been taken into account in development activities of production vehicles. **More than 15 electric vehicle production runs** have been announced by the German automotive industry (OEMs and suppliers) for the next two to three years (see Chapter 2). Getting to this stage has involved a huge amount of development activity and investment.

As described above, the activities and projects carried out under the banner of the **drive technologies and vehicle integration** R&D lighthouse projects support the achievement of the NPE's goal of making Germany the world's leading supplier. The roadmap is the product of a consensus-based approach where the various tasks were distributed among the different stakeholders. However, some of the topics that have been identified need to be made more specific so that they can be incorporated into future projects as efficiently as possible. Consequently, it will be important to ensure that the concerted efforts currently being made are continuously going forward.

4.1.3 Lightweight design R&D lighthouse project

Vision 2020: *In conjunction with the advances in battery and drive technology, lightweight design developments give German industry a competitive advantage.*

This R&D lighthouse project is promoting the first successful steps on the road towards functionally integrated systemic lightweight design

Following on from the second NPE report (2011), lightweight, multi-material design was identified as a key future technology for electric mobility and a separate **lightweight design** lead technology area was created.

Industry and the research community worked together to identify the key actions and research priorities that need to be addressed and these were subsequently grouped into four thematic areas. The total investment figure required for projects in the **lightweight design** R&D lighthouse project comes to approximately 328 million euros, meaning that the figure remains unchanged from 2011.

German **industry** has been active in meeting the demand for new and modified materials and processes throughout the value chain.
For example, research is being conducted into new metal alloys, fibre-reinforced materials, optimisation of vehicles' structural geometry and efficient manufacturing processes. In addition, broad-based conceptual approaches to implementing multi-material designs are also being investigated (see the example in Fig. 11).

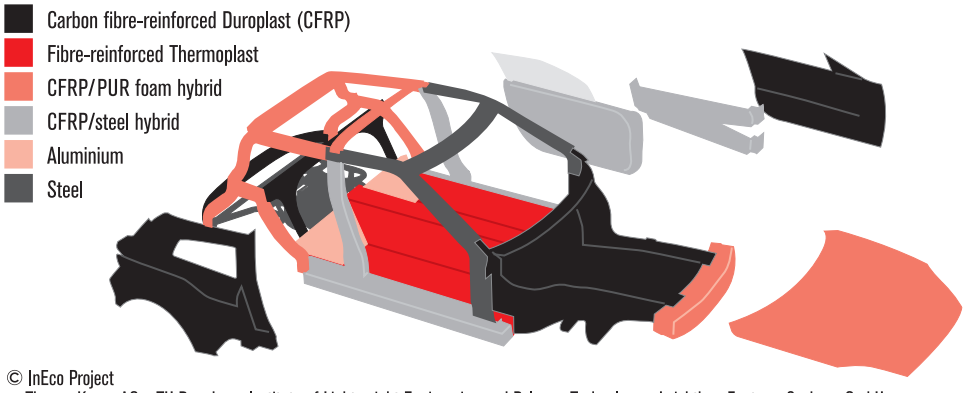


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Fig. 11
Examples of Lightweight Components in Vehicle Construction

In addition to applied research, the level of basic research also needs to be stepped up

Industry is turning to joint ventures to address the development and investment risks implicit in a technological landscape that is currently undergoing seismic changes. This will enable progress to be made with regard to industrial-scale production and processing of fibre-reinforced composites and the development of novel thermoplastics. Furthermore, industry is working much more closely with research institutions in order to support crucial basic research and participate in the training of urgently needed specialised personnel.

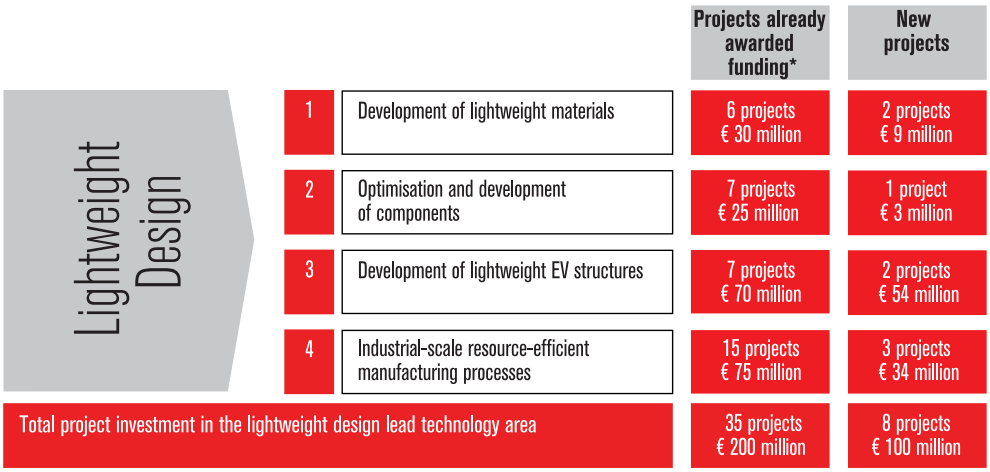
Significant levels of investment have gone into supporting these research activities.[15] German industry is taking an array of measures to expand its manufacturing capability. Particularly in view of the fierce competitive pressure from elsewhere, it is important that these measures should be complemented by prompt implementation of the recommended government funding.

Projects in four thematic areas are being funded to the tune of 200 million euros

Materials manufacturers are making an active contribution to achieving the vision of Germany becoming the world's **leading supplier**, for example by developing new lightweight material systems and technologies, simulation tools and components and opening new testing centres.

The German **government's programme for electric mobility** did not explicitly include **lightweight design** as a lead technology area. Nevertheless, there was a consensus between the relevant ministries and the NPE that, in view of the importance of lightweight design as a key cross-cutting technology, it should be an ongoing priority in the ministries' funding programmes. Research and development projects worth approximately 200 million euros are currently being funded in the **lightweight design** lighthouse project (Fig. 12):

Fig. 12
Progress in the Lightweight Design Lead Technology Area (Project overview)



*) NPE estimate of total project investment assuming a government funding percentage of 40 %
based on information provided by the relevant federal ministries regarding current funded projects in February 2012.

CASE STUDY: An integrated approach to electric mobility – the smart forvision concept vehicle

German industry is already implementing cross-sectoral initiatives to promote electric mobility. One example is the cooperation between Daimler AG and BASF SE which resulted in the unveiling of the smart forvision concept vehicle at the 2011 International Motor Show in Frankfurt, Germany. This demonstrated how the partnership is already delivering important solutions to tomorrows challenges.
The smart forvision vehicle combines futuristic design with innovative technologies in the fields of lightweight design, heat management and energy efficiency. Researchers and Designers at the two companies have managed to incorporate five worldwide technological firsts into the smart forvision. Transparent organic solar cells and LEDs, all-plastic wheels, novel lightweight components, infrared-reflective films and high-performance insulating materials and paints all reduce energy consumption, extend the vehicles range and make for a more comfortable driving experience. This is an excellent example of the automotive and chemical industries working in concert to make a major contribution towards affordable, environmentally-friendly, attractive and safe electric vehicles.

Alongside these projects, on the initiative of Carbon Composites e.V. (CCeV), a regional leading-edge technology cluster known as *M.A.I. Carbon* is being funded to the tune of 40 million euros over a five-year period to focus on one very specific aspect of the lightweight design R&D lighthouse project, namely the design of lightweight materials using carbon fibres.

The main aim of the cluster and its partners from industry and the research community is to develop the Munich, Augsburg and Ingolstadt area into a European competence hub for CFRP[16]-based lightweight design covering the entire CFRP technology value chain.
The importance of topics connected with lightweight design and the consistently high level of interest shown by the business community in this area were demonstrated in the context of manufacturing research funding when the design contest was held for the 29th call for proposals for "energy-efficient lightweight design" projects.
Ultimately, only 15 or so of the 92 project outlines submitted – involving over 600 project partners – were granted funding[17]. In addition to these, the NPE is aware of at least a further 100 million euros worth of additional lightweight design development projects that came about through the NPE in the summer of 2011 and are currently being studied by the relevant ministries. The innovation potential offered by a systemic approach to the basic scientific and technical aspects of lightweight design resides in particular in the adoption of a single, consistent approach to the various process chains, irrespective of material type.
The NPE's group of experts recommends that the measures planned by the German government and proposed by the NPE with a view to strengthening the field of lightweight design technology should continue to be implemented in accordance with the NPE roadmap. A further recommendation geared towards enabling the necessary coordination of the different themes under the systemic approach to lightweight design is the establishment of a central systemic lightweight design research and demonstration centre. This would allow basic research to be carried out both at the material interfaces and across the entire value chain.

4.1.4 Recycling R&D lighthouse project

Vision 2020: *Recycling plays a key role in ensuring the sustainability of the raw materials used for electric mobility. In conjunction with an active raw materials policy, commercially viable recycling solutions make an important contribution to ensuring the long-term availability of key raw materials for Germany.*

By using renewable energy, electric cars can contribute to environmental protection. A number of costly recent life cycle assessments[18] indicate that, compared to the use of primary raw materials, recycling materials from vehicles, and particularly batteries, can offer environmental benefits in a variety of impact categories, including greenhouse gas potential, resource consumption and acidification potential. Consequently, an integrated recycling strategy must form part of the overall system electric mobility.

Recycling is an aspect of raw materials management and is therefore a strategic pillar in the development of an environmentally, economically and socially sustainable electric mobility industry in Germany. As a result, the NPE's Second Report, published in May 2011, recommended that the themes of recycling strategies and securing Germany's raw materials supply should be promoted through the recycling lead technology area. The R&D lighthouse project comprises two thematic areas focused on the materials used for batteries and powertrain components. Projects worth a total of approximately 90 million euros have been identified for the **recycling** lead technology area.

More work needs to be done to promote developments geared towards making Germany the leading supplier in the field of recycling

The use of lithium-ion batteries and electric motors means that a lot of new components and materials are involved in the manufacture of electric vehicles. This trend is being accentuated by the intensive development efforts geared towards improving existing systems. As a result, either completely new or modified recycling processes are often required, although these do also provide new opportunities to create value. The development of these processes should focus on their effectiveness and efficiency in order to secure the supply of important raw materials and ensure that recycling costs do not hinder the progress of electric mobility. Given the low number of vehicles on the road, it is not easy to carry out concrete research during the pre-market phase. Nonetheless, it is essential that the importance of recycling should be factored in from an early stage.

Sustainable raw materials management is key to securing Germany's competitiveness

The content of the projects developed by industry and the research community indicates that they are committed to fostering the developments needed to make Germany the leading supplier in the field of commercial recycling. The next step is to ensure that these projects are implemented promptly.

In addition to key materials recycling, the overarching theme of securing the nation's raw materials supply is of fundamental importance to German industry. As part of its new raw materials strategy, the federal government is helping German industry to diversify and secure its sources of raw materials, for example by establishing raw materials partnerships with a number of other countries. Twelve German businesses are providing the financial backing for the launch of the Raw Materials Alliance which is being set up with the aim of achieving a sustainable improvement in Germany's raw materials security. This will be achieved through direct involvement particularly in the early (prospecting) stages of raw materials projects.

4.1.5 Information and communication technology and infrastructure R&D lighthouse project

Vision 2020: *One million electric vehicles are linked to smart traffic systems using information and communication technology (ICT). Charging and feeding electricity back into the grid – as well as the associated communication processes and transactions – are simple, safe and attractive.*

In its Second Report, the NPE identified four key thematic areas for this lead technology area: charging technologies, power grid integration, ICT interfaces with energy systems and ICT interfaces with traffic systems. The R&D activities currently being funded in these four thematic areas are being carried out by 15 broad-based consortia with total project investment standing at over 175 million euros. A number of additional project proposals are currently being studied by the relevant ministries (17 projects with a total budget of 125 million euros).

Research activities to the tune of 175 million euros are currently being funded in the ICT and Infrastructure R&D lighthouse project

In all three types of charging technology – normal charging, fast charging and inductive charging – progress can be measured against the charging infrastructure technology roadmap (the roadmap is contained in an appendix to the Second Report published in 2011). In order to achieve the customer acceptance that is so crucial to the ICT thematic areas, it is necessary to establish common interoperable processes and technical solutions. Greater coordination is needed with existing ICT projects in order to reflect ICT's central role in electric mobility (e.g. in enabling smart fleet management solutions).

As far as **charging technologies** are concerned, energy companies, electrical engineering companies, automotive manufacturers and battery manufacturers are working together to develop commercially viable fast charging systems (including both DC- and AC-based systems) in time for them to be introduced in the showcase regions.

For this to be feasible, it is necessary to ensure simple and safe operation despite the higher power requirements placed upon the cables and plugs. As production volumes rise, it will be possible to deliver further cost savings. Fast chargers with charging capacities of up to 100 kW are being investigated with a view to implementation during the early mass-market phase in the run-up to 2020. In conjunction with suitably specified – e.g. 20 kWh – batteries, this will make it possible to achieve charging times of under 15 minutes.

The goal for a European electric mobility market is to achieve a common standard for plugs and communication between charging point and vehicle. The German-American developed Combined Charging System (CCS), sometimes also known as the Combo-System, is a universal charging system based on a single on-board interface that enables customers to charge their vehicle using any of the available charging methods. This futureproof charging system is endorsed by the NPE and by leading automotive manufacturers around the world.

The goal for the European market is to achieve common standards for communication between vehicle and charging point

In addition, designs for cable-free, inductive charging are also being investigated. One of the benefits of this approach is that it increases the availability of the batteries to the power grid. Efficiency figures of around 90 percent can be achieved in experimental set-ups. It is hoped that the showcases will successfully demonstrate higher user acceptance of this technology and the interoperability of products made by different vehicle and infrastructure manufacturers.

The goal of the developments being undertaken in the thematic area of power grid integration is to create a charging infrastructure that is integrated with the power grid, enabling both smart charging and potentially also allowing electricity to be fed back into the grid. To this end, research is being carried out not only into managed battery charging (Grid-to-Vehicle – G2V), but also into the possibility of two-way energy exchange (Vehicle-to-Grid – V2G). This also includes offering dynamic tariffs as an incentive to customers. As regards projects in the area of power grid or energy supplier-controlled management, research is being carried out into the legal access rights of power grid operators and energy service providers wishing to manage the charging of individual vehicles in order to maintain overall power supply quality. In addition, the technical requirements for assessing grid status and making real-time interventions to regulate supply are being tested and developed using existing grids.

The rapid deployment of smart technologies will be key to integrating electric vehicles into energy and transport systems

The developments with regard to **ICT interfaces** with the **energy and traffic systems** (see Chapter 3) are geared towards maximising process simplicity and transparency in order to increase user acceptance and facilitate successful business models. Since large amounts of personal data will be being handled, it will be necessary to design in data protection measures by adopting a "privacy by design"[19] approach. Practical research findings are currently being gathered in the model regions and should be developed further in the showcase regions. Over the course of the past few months, it has become apparent that the principle of customer-friendly accessibility called for in the Second Report is going to be an increasingly important issue.

Fig. 13 illustrates the accessible charging, authentication and payment options provided during the pre-market phase. As a rule, individual operators provide one of the combined options. Also in connection with accessibility, it will be important to develop mobile phone roaming-style systems and structures designed to provide users with as smooth and comfortable a charging experience as possible at the highest possible number of charging points.

90 percent of public charging stations will provide full accessibility by 2014

The energy industry is keen to provide customer-friendly access to the public charging infrastructure, since this is essential if electric mobility is to gain acceptance. The industry is targeting a figure of 90 percent of public charging stations to be technically capable of providing fully accessible charging for all customers by 2014.

The goal of the research projects in the field of ICT and infrastructure is to further develop charging and vehicle-to-grid technologies and the associated communication processes and transactions in order to ensure that they are as safe, simple and attractive as possible. The NPE's work during the last reporting period has facilitated the

CASE STUDY: Providing easier access to the public charging infrastructure

hubject GmbH

In order to provide comfortable and safe access to Germany's charging infrastructure, the BMW Group, Bosch, Daimler, EnBW, RWE and Siemens have launched a joint venture called "hubject GmbH". Its goal is to develop and operate a data platform to enable the creation of a network of transport providers and vehicle suppliers in the field of charging infrastructure. Its next step will be to develop a logo for compatible charging points. The logo will be a byword for safe charging and payment procedures and will guarantee users comfort and peace of mind. This will be delivered through background roaming and clearing services running on a software platform operated by hubject GmbH. By making pre-payments to just one of the individual partners, electric car drivers will be entitled to use charging stations run by different operators.

Ladenetz.de

The Ladenetz.de initiative uses a common IT solution to provide customers in 17 different municipalities with access to over 150 charging points in Germany alone. Furthermore, the first cross-border roaming agreements have now been signed with the Netherlands and Austria.

ongoing development of customer-oriented charging solutions and payment methods. Promising ideas should be tested and, where possible, standardised in the showcase regions.

Despite this, the low numbers and diverse nature of current users mean that it has hitherto not been possible to deliver statistically meaningful results. It is therefore important that the technologies and products should continue to be developed in a high-profile manner in the showcase regions.

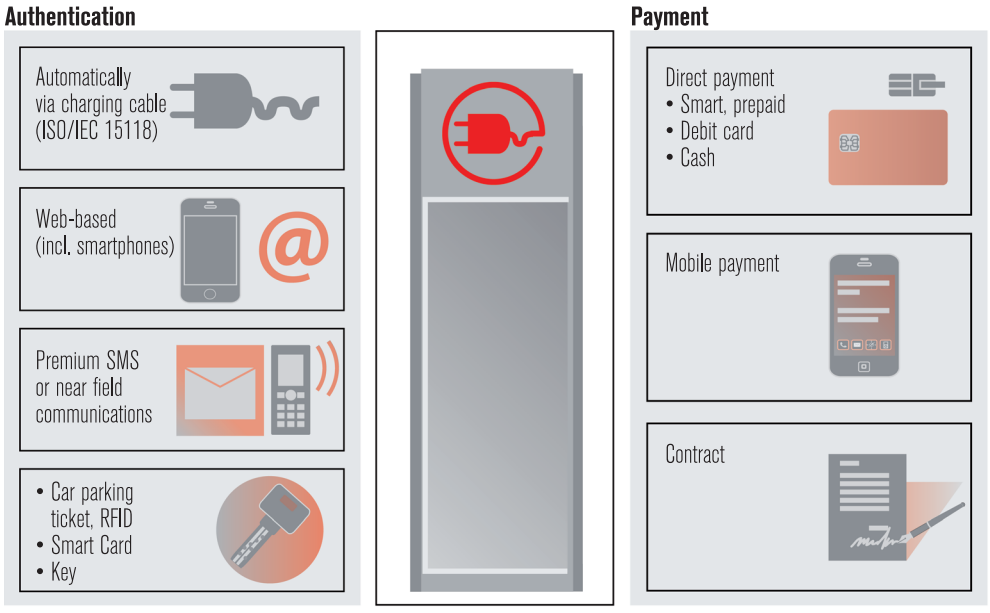


Fig. 13
Accessible Charging Options Overview

One challenge for low charging voltage technologies is the difference in the voltages used by different EU countries for electrical sockets and domestic mains electricity points. In addition to efforts to regulate and standardise voltages, it will be especially important to provide the relevant information to customer groups such as cross-border commuters and hire car users.

Close coordination is ongoing among all the stakeholders regarding the handling and disclosure of data obtained from metering and payment procedures. This is important as far as both data protection (an individual's charging behaviour) and data security (battery charging status) are concerned. Data protection profiles and individual data release mechanisms continue to be tested with a view to rolling them out in both the private and public charging infrastructures.

4.2 Academic and vocational training

Vision 2020: *German training and qualifications concepts cover the entire electric mobility system and are implemented right across the value chain. They are also sought after internationally. Outstanding scientists, engineers and specialists are the foundation of Germany's sustained competitive advantage in the field of electric mobility.*

Germany's higher education system is responding energetically to the challenges of electric mobility

The **German education system** is currently responding energetically to the challenges posed by electric mobility. Virtually all the relevant higher education institutions have extended or made the necessary modifications to their curricula. Projects such as the Mute (Technische Universität Munich) and StreetScooter (RWTH Aachen) vehicle concepts attracted a lot of attention at the 2011 International Motor Show and are a testament to the excellent performance of German higher education institutions. Support from industry and central and local government has facilitated the appointment of new professors and the establishment of competence centres and other initiatives.

The first "National Education Conference for Electric Mobility", held in Ulm in June 2011, marked the first step in the NPE's implementation of its competence roadmap:

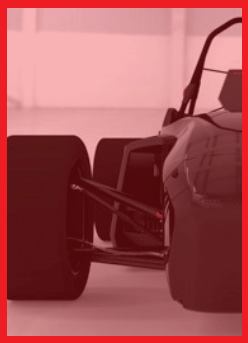
- The conference brought together 450 education experts from the trade and craft industries, manufacturing industry, professional associations, trade unions, universities, other higher education institutions and local and regional authorities to create the first comprehensive nationwide network for training and qualifications in the field of electric mobility
- During the interactive workshops, several experts expressed their willingness to participate actively in the development of much-needed learning and teaching materials for electric mobility in their respective fields

The NPE has produced a competence roadmap for education

The recommended actions that were adopted at the conference are described in detail in the current competence roadmap.[20]

CASE STUDY: Student initiative "Formula Student Electric"

How can the thrills and spills of motor racing be combined with a vision of sustainable transport? This is the challenge that, since 2010, has been inspiring more than 2,000 budding engineers a year from 27 countries to build their own electric race cars as part of the Formula Student Electric Germany initiative. In the time-honoured motor racing tradition, different teams compete against each other to build the fastest, most reliable and safest car which must also be easy to maintain and cost-effective.
Thanks to the generous sponsorship of industry and the research community, 49 teams of students from German universities and other higher education institutions also participate in the international student constructor's championship for single-seater electric race cars. The idea is to develop technical solutions under the extreme conditions of motor racing that might potentially be used for road traffic applications in the future.



With regard to vocational training and qualifications, recent years have seen the development and implementation of modern, forward-looking training provision in the metal-working and electronics, electrical engineering, IT and automotive industries. This has made it possible to meet the qualifications requirements of the fast-moving electric mobility sector. Building on these steps, the following additional joint actions have been defined for the electric mobility industry:

Important steps have been taken in the field of vocational training and qualifications

- Annual meetings on implementation of the National Education Conference for Electric Mobility recommendations *(eMob in progress)*
- Marketing activities to ensure a steady flow of new recruits to the industry and for professional development of specialised personnel
- Development of handouts and practical aids regarding vocational training and further education qualifications
- Development of handouts and practical aids regarding in-service retraining (quality-assured continuing professional development standards, modular training blocks, learning platforms, expert networks, etc)

A key question as far as the NPE is concerned is how to coordinate and ensure transparency of these changes within higher education institutions and with vocational training and in-service training providers, and potentially also how to manage them. It is essential to use the existing and future projects resulting from the various calls for tenders in different areas of electric mobility to make a lasting contribution to the direction of both academic and vocational education. This should also occur in the electric mobility showcase regions electric mobility.

Benchmarking academic and vocational education internationally

As far as **academic education** is concerned, a survey of various experts enabled examples to be gathered of the situation at higher education institutions in other countries[21] that are very active in the electric mobility arena. The unanimous consensus of these foreign experts was that higher education institutions elsewhere are undergoing the same transformation that we are witnessing in Germany. Throughout the world, the most successful higher education institutions are those that cooperate closely with industry.

This benchmarking exercise did not provide any evidence to suggest that German higher education may be losing ground vis-à-vis its international competitors. Nevertheless, there is a possibility that existing and recently announced government funding packages might enable foreign higher education institutions to develop their competences in the near future. This applies in particular to the plans of all the surveyed countries to modernise the laboratory equipment in their higher education institutions and to appoint new professors.

An indirect answer to the question of whether Germany's **vocational training system** is competitive compared to similarly-sized economies elsewhere is provided by the competitiveness of German industry on the global market. Smart and efficient manufacturing is key to being competitive internationally and this is a great strength of the German economy. A key requirement in this regard is a qualified and highly-skilled workforce. Germany has a longstanding track record of adapting its workforce's skills to new challenges, and this is also true of the occupations related to electric mobility in the trade and craft industries, manufacturing industry and automotive sector (see above). Current training provision is thus able to meet the requirements of the different areas involved in electric mobility. This means that high-quality content can be developed for electric mobility qualifications.

This NPE Progress Report also includes the electric mobility competence roadmap which is designed to ensure that academic and vocational qualification requirements are properly taken into account as electric mobility continues to be developed in Germany. Consideration should also be given to producing an updated version of the competence roadmap post-2015.

4.3 Standardisation

Vision 2020: *There are common international standards for electric mobility. The regulations pertaining to electric mobility are internationally harmonised.*

International regulations and standards for electric mobility are indispensable in order to provide a sound basis for planning and investment. It is therefore crucial that they should be developed for all the relevant industries. They are a *sine qua non* for commercial success and will be key to Germany becoming the world's leading provider as soon as possible.

The NPE has published an updated version of its standardisation roadmap

The NPE has developed overarching documents covering all the relevant sectors on the topic of "regulation, standardisation and certification" describing the approach and tools needed for standardisation both nationally and at a European and global level. The basis of all standardisation activities is the NPE's "electric mobility standardisation roadmap version 1.0" which, since its publication in 2010, has been actively fed into all the relevant European and international bodies. The progress made to date with regard to the various themes is described in version 2.0 which was published in February 2012.[22] In order to ensure that Germany's standardisation bodies are kept constantly up to date with the NPE's activities, the NPE Working Group 4 Steering Group[23] was established in 2011. Its office is at the German Institute for Standardisation (DIN). The steering group's main task is to take appropriate measures to support critical issues that cannot be adequately resolved through ordinary committee work. An example of this would be the need for a standard charging infrastructure across Europe as identified in the NPE's Second Report. The steering group is currently working on the following, predominantly international, issues.

The NPE Working Group 4 Steering Group is promoting implementation of the standardisation roadmap both nationally and internationally

In **Europe**, the NPE's activities since the start of 2011 have focused on ensuring the cross-border interoperability of electric vehicles within Europe, since the establishment of a standard charging infrastructure, especially of publicly accessible charging points, will be key to achieving commercial success. The NPE has a clear target for all the relevant sectors in this regard: Type 2 plugs for AC charging and the "Combined Charging System" for DC charging. Hitherto, even the European Commission's CEN/CENELEC Focus Group has been unable to devise a single recommended standard for the whole of Europe. Whilst most countries have already come out in favour of Type 2 plugs, France and Italy are still not on board. In conjunction with the German government, the NPE has been holding intensive discussions, particularly with France, for several months now. This has involved bilateral talks both with French businesses and with the responsible French standardisation body, AFNOR. The aim is to find a mutually acceptable compromise in order to avoid the need for a transition period where different solutions would be running in parallel, with all the implications that this would have in terms of wasted investment.

The issue has been taken up by DG Enterprise and Industry under the leadership of the Vice-President of the European Commission. The NPE will submit the available information on the legal situation (in a legal opinion) and the content of a technical opinion both to the DG and to all other relevant bodies and will continue to call for and promote the introduction of Type 2 plugs and the Combined Charging System (CCS) throughout Europe.

The NPE is promoting the adoption of Type 2 plugs and the Combined Charging System (CCS) as international charging standards

The first successes in terms of introducing and implementing the **global CCS charging standard** came about in the **United States** towards the end of 2011. American and German OEMs issued a joint press release in support of CCS, reinforcing the message of the European ACEA's position paper. Since 2011, DIN has been chairing intensive discussions in the US with the Society of Automotive Engineers (SAE) and the International Organisation for Standardisation (ISO) with a view to brokering an agreement on the problems concerning intellectual property rights and the harmonisation of emerging international standards as described in the last report. The relevant ISO and SAE committees are currently consulting on the next steps. DIN will continue to participate in this process in order to protect the interests of German industry. The stated goal is to ensure that all standards are established as consistent ISO/IEC standards.

In addition, the NPE has been participating actively in the Transatlantic Economic Council (TEC) through the TransAtlantic Business Dialog (TABD), which established electric mobility as one of its key projects in 2010. The joint Work Plan adopted at the end of 2011 incorporated much of the content of Germany's standardisation roadmap. The same is true of the American standardisation roadmap adopted in April of this year, which was developed by the Electric Vehicles Standards Panel (EVSP) reporting to the American National Standards Institute (ANSI). Borrowing from the example of the NPE in Germany, an industry-wide "European-American Round Table" with representatives from government and the business community is planned for later this year.

The relevant German authorities are being supported by the NPE in their efforts to make progress in various international bodies on the issues that are key to achieving market success

Another increasingly urgent key issue that has already been incorporated into the TEC's Work Plan is the **need for action on the transport of hazardous materials**, a topic that was already raised in the last NPE report. In this case, rather than being a question of standardisation, it is more an issue of harmonising international rules and regulations as described in the first NPE report on "Regulations in the Fields of Automotive Engineering and Transport of Hazardous Materials", published in 2010. However, despite the best efforts of the relevant German authorities, it has proved difficult to make much headway on the key issues (removal of the 35 kg air cargo limit, source document recognition for return and onward transport). Since the transport of hazardous materials is a rather sensitive issue for vehicle and battery manufacturers around the world, this issue will be one of the TEC's main priorities in order to ensure that national and international commercial success is not jeopardised by logistical problems.

In June 2011, during the German-Chinese Government Consultations, the "Standardisation Working Group" was relaunched as the "Committee for Cooperation on Standardisation" of the German-Chinese Joint Economic Committee. The aim is to further facilitate bilateral trade between the two nations, promote bilateral economic and technical

CASE STUDY: "Ecosystem Electric Mobility" at the 64th International Motor Show for Passenger Cars in 2011

The world's largest motor show in 2011 offered visitors the first opportunity to fully familiarise themselves with the "ecosystem electric mobility" concept. A dedicated electric mobility hall at the 64th International Motor Show for Passenger Cars in Frankfurt allowed businesses from all the participating industries and higher education and research institutions to present a comprehensive, cross-sectoral overview of the key areas of activity in the realm of electric mobility. The products and ideas on display ranged from individual components and batteries right up to complete vehicles and transport concepts. This was complemented by a display featuring the entire energy chain, from energy conversion through energy transport right up to the integration of the end user.

A Congress "Ecosystem Electric Mobility" was held in conjunction with the motor show on 21 September 2011 supported by several major industrial federations. The congress offered the opportunity to present the entire value chain and associated products and services to over 500 delegates from around the world.

cooperation, strengthen the dialogue between the two nations on standardisation and coordinate their activities in international standardisation organisations. The Committee established an electric mobility sub-group at the International Motor Show in September 2011. The sub-group will operate as a platform for experts from both countries in order to facilitate ongoing technical exchanges. The group's members agreed on its goals and working methods and established an operating structure based on four expert groups (charging systems; charging station/vehicle communication; electric vehicle safety issues; and charging station safety issues/data exchange between charging stations and smart grids). The exchanges and coordination between the experts are proving to be very successful. Nevertheless, there is room for improvement in terms of how their work is translated into the relevant national standards and regulations. At a political level, the process is benefiting from the support of the Standardisation Committee. At the Hanover Trade Fair, the close cooperation between the two countries – not just with regard to standardisation but across the entire field of electric mobility – was further endorsed by the signing of a Memorandum of Understanding (MoU) with the Chinese Ministry of Industry and Information Technology (MIIT). The MoU will lead to regular meetings between government representatives with a view to ongoing representation of the Committee's activities vis-à-vis China's decision makers. As such, cooperation between Germany and China can now be said to have been placed on a sound political footing.

The German-Chinese Electric Mobility Sub-Group is facilitating ongoing cooperation between German and Chinese experts on international standardisation bodies

Following on from this, a number of activities relating to "certification" are being planned. The NPE has established this as its next priority once work on the theme of achieving a "standard charging infrastructure in Europe" has been concluded.

5
The road to becoming the world's leading market

5 The road to becoming the world's leading market

Vision 2020: *As the world's leading market, Germany has now put electric mobility's innovative technologies into practice. Private motor vehicles are increasingly environmentally-friendly and innovative business models and intermodal solutions are making a significant contribution to solving the growing challenges of urban transport.*

The key to Germany becoming the leading market for electric mobility is to create a self-sustaining market where suppliers and customers in all the different branches of electric mobility are prepared to invest because it is in their own interests to do so. The road to achieving this goal might be likened to a marathon – it is extremely challenging, but can also be extremely rewarding.

"First and foremost, it will be consumers who will decide if and when electric cars make the breakthrough. Consumers will only accept battery-powered vehicles as a viable alternative to the conventional internal combustion engine if they are not significantly more expensive and offer comparable levels of safety and suitability for everyday use. So all the relevant industries are going have their work cut out, but they also have a great chance of succeeding. This is because German industry today is already a technological leader in many areas, and it is determined to achieve a similar leadership position in the field of electric mobility through new cooperation arrangements and substantial levels of investment."

Matthias Wissmann | President of the German Association of the Automotive Industry (VDA) | Coordinator of German Industry for Electric Mobility and member of the NPE Steering Group

Electric cars are being introduced into a mature automotive market and are in direct competition with vehicles using conventional petrol engines whose total cost of ownership will continue to be significantly lower over the medium-term. Even if charging facilities are now much more readily available, several issues pertaining to standards and business models currently remain unresolved. Furthermore, in many areas the existing charging infrastructure is incapable of competing with the established petrol station network for conventionally powered vehicles. Once the NPE had identified these challenges, its Second Report recommended a number of concrete measures to address them. The NPE continues to believe that implementation of these recommendations will enable the target of a million electric vehicles by 2020 to be met.

The development of the market has been broken down into three separate phases with different priorities. The pre-market phase, which will run to 2014, is focused on answering the remaining questions and raising the profile of electric mobility through the showcase regions. The market ramp-up phase, which will run from 2014 to 2017, is key to ensuring rapid growth of the electric mobility market. The aim is to significantly reduce the total cost of ownership differential between electric and conventional cars whilst at the same time ramping up the supply of vehicles in different market segments. Targeted use of market incentives during this phase should lead to a significant acceleration in the market penetration of electric vehicles. By the time the mass-market phase begins in 2017, it should have been possible to establish an increasingly self-sustaining market.

5.1 User acceptance as the key to market leadership

Acceptance of electric vehicles increases significantly once users have some initial experience of driving them

Together with an attractive portfolio of products and services, user acceptance is the main driver of a self-sustaining electric mobility market. Academic research has shown that acceptance of electric mobility increases significantly once consumers have some initial experience of using electric vehicles. If electric vehicles can be positioned as an attractive alternative to purchasing a conventional vehicle whilst also enhancing the unique selling points of this mode of transport, higher market penetration should follow.

Although the early adopters[24] are already very positive about electric mobility[25], a number of challenges still need to be addressed before mass-market success can be delivered. The numerous user surveys and academic studies that have been carried out have enabled the following **four key areas for achieving user acceptance of electric vehicles** to be identified:

Getting across the fact that electric vehicles are suitable for everyday use:
Acceptance increases once users have concrete experience of electric vehicles. One finding to come out of all the pilot projects is that participants had much more critical attitudes towards electric mobility before they started using electric vehicles than by the end of the project. Consequently, communication and education to convey the actual features and potential of electric vehicles for everyday use will be an important catalyst for achieving higher user acceptance of electric mobility.
People's main preconception about electric vehicles is that their range may not be sufficient to adequately meet their normal transport needs. However, an analysis of transport data in Germany shows that 80 percent of Germans drive no more than 39 kilometres a day[26] in their cars. Since even the current crop of electric vehicles have an average range of 160 kilometres, they actually already satisfy most people's transport requirements. For users who do need a greater range, other types of electric vehicle are available (REEVs and PHEVs) that can achieve a significantly higher radius of action by using an efficient internal combustion engine in tandem with their electric motor. Longer journeys can also be made using intermodal transport or a variety of short-term vehicle use services. Initial research findings indicate that the introduction of electric vehicles into car fleets or car sharing models has been very well received by users, especially in cities.[27]
Consumer organisations can also contribute to increasing user acceptance by conducting objective tests and publishing reports on what electric vehicles are like to use in practice.
In addition to the range issue, it is also necessary to ensure that electric vehicles can run normally even in very cold weather. The performance of current battery technologies does suffer when battery temperature falls beneath five degrees centigrade and the majority of consumers are not prepared to accept large variations in the range and charging times of electric vehicles depending on the weather. Work is ongoing to find technological solutions to this issue (see section 4.1.1).

"We don't have a car ourselves, but we're still glad to see electric vehicles coming onto the market. We have particularly enjoyed riding pedelecs and the ability to charge up the electric car without having to use cables: you just park the car, there's no need to plug a cable into it, you don't have to give it a second thought, and the next morning your car is charged up and ready to go."

The *Welke/Wiechers* family who participated in testing in the Effizienzhaus Plus electric vehicle house

Guaranteeing the vehicles' environmental credentials: Many of the people interviewed wanted to be sure that using electric vehicles would result in clear benefits in terms of the environment and climate change. While people welcome the fact that electric vehicles produce zero emissions locally, they also explicitly call for them to be powered by renewable energy. Consequently, as electric vehicles are introduced onto the market, it will be necessary to develop sustainable concepts for supplying them with renewable electricity and integrating them into the power grid. In keeping with their promise in the NPE's Second Report, Germany's energy suppliers remain committed to making additional renewable energy sources available to supply the energy requirements of electric vehicles. The NPE will support the development of the pending implementation recommendations of the relevant actors in this regard. The most straightforward practical opportunity for linking electric vehicles with additional renewable electricity would be through the domestic electricity used by consumers to charge their vehicles. This could receive support depending on local circumstances, but is not something that can be implemented for all potential customers. Consequently, developing ideas for promoting green electricity usage will be another important factor in increasing user acceptance of electric mobility.

The clear environmental and climate benefits of electric vehicles are a key aspect for many customers

Reducing ownership costs: Over the next few years, electric cars will continue to have a substantially higher total cost of ownership than comparable vehicles powered by the internal combustion engine. The main reason is the higher cost of purchasing an electric vehicle, which is mainly due to the cost of the batteries. Variable costs, on the other hand, are currently significantly lower than for conventional vehicles. Among the people who were interviewed, even those who were considering buying an electric vehicle expected to pay the same or at least not substantially more than for a conventional car. Unless the appropriate measures are taken, the higher price of electric vehicles could significantly restrict the potential customer base.

Customers expect the total cost of owning an electric car to be similar to or at least only slightly higher than a conventional car

Optimising the charging process: Many people interested in electric vehicles view the long charging times and currently still rather underdeveloped public charging infrastructure as important constraints[28]. However, model projects have demonstrated that most charging requirements can be easily met either at home or in the workplace. Pilot users were very positive about this charging method[29]. Nonetheless, the availability of a user-friendly public charging infrastructure continues to be a key user demand.

The rapid deployment of smart technologies will be key to integrating electric vehicles into the power grid

One further major challenge is the need to expand the energy infrastructure and adapt vehicles to the requirements of the power grid. In order to support power grid integration of electric vehicles, smart technologies need to be introduced as soon as possible on both the power grid and vehicle sides. An appropriate framework also needs to be established to support this process. Furthermore, regular monitoring of the implementation of measures designed to increase user acceptance should be carried out with the active involvement of consumer organisations. This will support the relevant communication measures and help to increase consumer confidence.

5.2 Model regions and projects promoted by the German government

Some 2.500 electric vehicles have been successfully deployed in the eight government-funded model regions

Between 2009 and 2011, the German government used funding available through its Second Economic Stimulus Package (*Konjunkturpaket II*) to set up model regions and projects with a view to obtaining insights to help establish an appropriate framework for promoting electric mobility. Whilst part of the programme deals with regulatory issues, it also addresses the incorporation of electric mobility into the existing traffic and energy systems. Information and communication technology plays a key role in this regard. Field tests conducted under everyday conditions for both private and commercial transport enabled important information to be obtained concerning vehicles' actual energy consumption and environmental impact (e.g. the CO_2 emissions of plug-in hybrids).

It is already possible to run electric commercial vehicles profitably

In order to raise the public profile of electric mobility, incorporate it into the overall traffic system and drive the installation of the necessary infrastructure, funding was provided for **8 model regions** (Hamburg, Bremen/Oldenburg, Rhine-Ruhr, Rhine-Main, Saxony, Stuttgart, Munich, Berlin-Potsdam). Approximately 2,500 electric vehicles were deployed in the model regions, including some 1,300 two-wheeled electric vehicles. User acceptance of these vehicles was high. The projects demonstrated that electric vehicles can serve as a basis for novel transport concepts. Hybrid and electric buses were particularly well-received owing to their lower noise emissions and energy consumption. Environmental considerations were also a factor for commercial vehicles. At least in some cases, access restrictions and night-time noise abatement regulations in sensitive areas such as town centres and low-emission zones are not applicable to electrically-powered delivery vehicles. As a result, it is already possible to run electric commercial vehicles profitably, even today.

As regards the integration of electric mobility into the energy system, a number of model projects developed and tested new technologies and processes for managed charging and feeding electricity back into the grid. It was possible to demonstrate that, up to a certain point, electric vehicles do not place any additional burden on the power grid and furthermore that they can even contribute to better integration of fluctuating renewable energy supplies into the overall energy system. The key to achieving this, however, is for the vehicles to be connected to the electricity grid as frequently as possible. Cable-free charging has a central role to play in this regard, since it requires significantly less effort for users to connect their vehicles up to the grid. Several programmes in the model projects and regions were able to demonstrate the effectiveness of cable-free inductive charging (see section 4.1.5).

Tests in the model regions found that electric vehicles do not place any additional burden on the electricity grid where controlled charging is in place

CASE STUDY: Electric mobility as a pillar of a carbon-efficient supply chain

Green technologies are key to achieving a carbon-efficient supply chain. Battery electric vehicles can contribute to cutting greenhouse gas emissions, particularly in a "last mile" delivery environment characterised by short journeys with a lot of stopping and starting. Deutsche Post DHL is working with several automotive manufacturers to test electric vehicles in its day-to-day operating environment. This is allowing information to be gathered that will be used to develop production model electric commercial vehicles.

In 2011, Deutsche Post DHL tested more than 130 electric vehicles belonging to a variety of commercial vehicle categories, from compact utility vans to 12 tonne lorries. The electric vehicles were a hit in terms of reliability, range and user acceptance. However a number of challenges still need to be addressed with regard to management and control of the high local energy demands of large fleets, the design of charging infrastructure to facilitate commercial use, lower vehicle payloads and the cost-effectiveness of electric vehicles.

The operators of smaller fleets such as home delivery services and hospitals are also starting to go electric. For example, Joey's pizza delivery service is trialling one electric car and six electric scooters at one of its branches. If the trial is a success, they plan to gradually convert their entire fleet of 400 cars and 1,000 scooters over to electric vehicles.

5.3 Showcase regions electric mobility

In April 2012, the German government selected four electric mobility showcases to receive funding

Based on the results obtained from the German government's established model regions and projects, the NPE recommended the development of a small number of large-scale showcase regions electric mobility with showcase projects to be awarded by transparent competitive tender. The German government adopted the NPE's recommendation and promptly included the development of large, relevant showcases in Germany into its May 2011 programme electric mobility. As a result, a novel and innovative instrument has been created that brings together key actors, knowledge and experience in the areas of energy, vehicles and transport in a systemic fashion, providing a focus for activities relating to electric mobility.[30] An independent expert panel comprising representatives of the research community, local authorities, the German automobile club ADAC, the WWF, the Federation of German Industry (BDI) and the coordinators of German Businesses for Electric Mobility judged the 23 entries submitted before the deadline for showcase applications in March 2012 and picked out four particularly innovative concepts that were deemed to be especially deserving of funding which were subsequently recommended for selection to the German government.

- Following the judging panel's recommendations, in April 2012 the German government selected the following four showcase projects to receive funding:
- Living Lab BW Electric Mobility (Baden Württemberg)
- International Showcase Electric Mobility (Internationales Schaufenster der Elektromobilität) (Berlin/Brandenburg)

"International Electric Mobility Showcase Region of Berlin-Brandenburg"
(Details from the project outline)

General framework
- High profile as Germany's capital region means it offers various channels for increasing electric mobility's visibility internationally (political centre, tourist magnet, national and international media hub, conference city)
- Pioneer in intermodal transport provision (Germany's largest real-life experiment in integrated transport provision and innovative drive systems)
- Excellent local conditions for everyday large-scale use of electric vehicles
- Local cooperation between manufacturers
- Model for sustainable energy generation and supply
- Highly acclaimed interdisciplinary research location

Themes and Priorities
- Road transport (zero-emissions passenger and commercial transport)
- Charge & Park (sustainable expansion of the public charging infrastructure)
- Storage (Electric mobility as part of a Berlin-Brandenburg smart grid)
- Networking (information and communication technology, qualifications & services/vocational training and CPD, electric mobility districts)
- Public relations (provide hands-on experience of electric mobility in action, publicise German innovation and technological know-how, electric mMobility zones)
- Cooperation (local, national and international cooperation with political, business and research communities)

Region
- Capital region Berlin-Brandenburg

Project partners
- A total of 257 partners from the political, business and research communities as well as automotive manufacturers and suppliers and members of the energy supply and technology, infrastructure, logistics, transport and information and communication technology sectors:
- 2 local/regional authorities
- 107 large-scale enterprises
- 90 small and medium-sized enterprises
- 34 higher education and research institutions
- 24 professional bodies, associations, networks and other institutions

Implementation
- Provision of an extensive and diverse range of vehicles, charging methods and projects (novel types of transport provision through multimodal passenger transport design, trialling and further development of different business models with different user requirements)
- Hands-on experience of electric mobility for user groups, providing a flexible, simple and user-friendly experience
- Connectivity of transport solutions with the power grid and innovative ICT-based business models
- International visibility through coordinated public relations activities (communication aimed at specific target groups, showcase of showcases)

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"We're switching to electric horsepower – electric mobility in Lower Saxony"
(Details from the project outline)

General framework
- The region combines numerous towns and cities with a diverse mix of rural areas, providing a representative model of Germany and many other parts of the world
- Excellent relations between towns and surrounding areas
- Highly acclaimed research location
- Leading role in renewable energy generation
- Metropolitan region of Hanover, Braunschweig, Göttingen and Wolfsburg committed to supplying all its energy needs from renewable sources by the middle of the century
- Hanover's trade fair provides a technology showcase, facilitating access to the world's leading markets

Themes and Priorities
- Vehicles (electric vehicles "made in the Metropolitan Region", battery re-use and recycling)
- Energy and infrastructure (smart grid – relevant examples of decentralised energy generation in action, accessible electric mobility)
- Transport (conversion of vehicle fleets, commuter incentives, electric car sharing)

Region
- Hanover – Braunschweig – Göttingen – Wolfsburg

Project partners
- Regional and local authorities (e.g. Braunschweig, Wolfsburg, Hildesheim)
- Large-scale enterprises (e.g. Bombardier, Continental, DB Rent, ÜSTRA, Volkswagen AG)
- Small and medium-sized enterprises (e.g. Rangebike concept, Projekt Region Braunschweig, C4C Engineering)
- Higher education and research institutions (e.g. Ostfalia University, Technical University of Lower Saxony, German Aerospace Center [DLR])
- Associations, professional bodies etc. (e.g. Works Councils Electric Mobility Network [Betriebsräte Netzwerk Elektromobilität], Braunschweig Chamber of Trade and Craft Industries, German Red Cross)

Implementation
- On the ground: Hundreds of companies employ more than 150,000 people in the field of electric mobility and renewable energy in the Metropolitan Region
- Research and Development: Investing in funding for electric mobility projects. Researchers are improving the performance of electric vehicles
- Education, vocational training and CPD: Developing an integrated strategy to embed electric mobility across all areas of training and education
- Political commitment: State and local authorities promoting a broad range of measures to support electric mobility
- Communication: Consistent communication strategy to transform public awareness of electric mobility

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"LivingLab BWe mobil"
in Baden-Württemberg
(Details from the project outline)

General framework
- Most important region in Europe for the automotive industry
- Established partnerships between global market leaders in automotive technology and energy supply
- Geographical challenges for transport solutions
- High population density and commuter numbers
- Link between urban population centres and rural areas
- International connections and outreach vis-à-vis France, Switzerland and Austria
- Major political commitment at federal state, regional and local authority level (major federal state initiatives: electric mobility I and II)
- Large number of educational institutions active in field of electric mobility
- Far-reaching social impact through a variety of initiatives aimed at engaging the public
- Reliable experience from previous projects in model regions

Themes and Priorities
- Intermodality
  - Fleet operation
  - Car sharing
  - Commercial transport
  - Transport planning
  - Public relations
  - Vocational training and CPD

Region
- Baden-Württemberg, in particular the Stuttgart and Karlsruhe regions

Project partners
- Local and regional authorities (e.g. Baden-Württemberg state government, Stuttgart region, Karlsruhe, city of Stuttgart)
- Large-scale enterprises (e.g. Audi AG, Daimler AG, Porsche AG, IBM GmbH, TÜV Süd, Renault AG)
- Small and medium-sized enterprises (e.g. Yellow Map AG, e-Wolf GmbH, Huber Automotive GmbH)
- Higher education and research institutions (e.g. University of Stuttgart)
- Associations, professional bodies etc. (e.g. IG Metall trade union, chambers of commerce)

Implementation
- Public participation: engaging the public by providing hands-on experience of electric and intermodal transport systems and incorporating the topic of electric mobility into educational curricula
- Technological integration: trialling of vehicles and infrastructure under everyday conditions by leading technological partners
- Economic integration: validation of new business models aimed at specific target groups to make electric mobility a commercially attractive and economically viable proposition
- Future plans: integration into the Stuttgart regional transport plan and ongoing development of the "Baden-Württemberg Sustainable Transport Roadmap"

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"Electric mobility connects"
in Bavaria and Saxony
(Details from the project outline)

General framework
- Represents a large part of Germany (20 - 25%) in terms of GDP, geographical size, population and vehicle numbers
- Participation of world-leading companies from right across the electric mobility spectrum
- Includes large metropolitan centres and rural areas
- Involvement of educational institutions specialising in electric mobility R&D
- High percentage of renewables generated using all the available methods
- Varied geographical and climatic conditions
- High levels of financial investment from the two federal states involved, in addition to central government funding

Themes and Priorities
- Long-distance transport (Munich-Leipzig axis along the A9)
- Urban transport (street parking)
- Rural transport (meeting transport needs in rural and sparsely-populated areas)
- International visibility and international long-distance transport (e.g. cooperation initiatives with Austria and Quebec)
- Vocational training and CPD (cornerstone of a forward-looking and growing Electric Mobility system in Bavaria and Saxony)

Region
- Federal State of Bavaria
- Federal State of Saxony

Project partners
- Regional and local authorities (e.g. federal states, districts and towns and cities such as Dresden, Ingolstadt, Leipzig, Munich, Nuremberg)
- Large-scale enterprises (e.g. Audi, BMW, E.ON, MAN, N-ERGIE, Porsche, Siemens, municipal utility companies in Dresden, Leipzig, Ingolstadt and Munich)
- Wide variety of small and medium-sized enterprises in Bavaria and Saxony
- Numerous universities and other higher education and research institutions (e.g. Augsburg, Deggendorf, Dresden, Landshut, Mittweida, Munich)
- Associations and professional bodies (e.g. chambers of trade and craft industries, chambers of commerce and trade associations in Bavaria and Saxony)

Implementation
- Territorial approach geared towards increasing acceptance across a broad spectrum of user groups
- Inclusion of diverse customer groups from large metropolitan centres and rural areas with very different transport requirements
- Increased use of electric vehicles in local public transport in order to reduce noise pollution and emissions in city centres
- Switch to electric vehicles for commuter transport between rural and urban areas
- Two-stage market development across the entire region:

1. Identify joint learnings and resolve remaining issues,
2. Increase vehicle numbers, commence large-scale production

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- We're Switching to Electric Horsepower (Unsere Pferdestärken werden elektrisch) (Lower Saxony)
- Electric Mobility Connects (Elektromobilität verbindet) (Bavaria/Saxony)

The key issues in the field of electric mobility are being investigated systemically in the showcase regions

The federal government's decision was followed by a process for checking and approving the individual projects grouped together under each of the four successful showcases. Following discussion within the NPE, the showcases were required to investigate the following issues and themes:

- Broad-based communication activities to raise the profile of electric mobility in the individual showcase projects and across all the showcases
- The effectiveness of the non-monetary incentives recommended by the NPE in its Second Report in terms of the potential they offer to help close the total cost of ownership gap between electric and conventional vehicles
- Demand for and distribution of a user-friendly charging infrastructure, together with appropriate operator and funding models
- The correlation between the number of charging point visits and the (growing) number of vehicles in order to establish public charging infrastructure requirements post-2020
- Business models for incorporating electric vehicles into attractive, multimodal transport service solutions
- Power grid integration models and concepts for managed, user-friendly charging (e.g. I.D.E.E.)[31]
- Ideas for using additional renewable energy to supply electric vehicles and how this correlates with customer acceptance
- Insights contributing to a sustainable orientation for academic education and vocational training and assessment of the required training and continuing professional development measures
- User acceptance of electric vehicles' charging and driving experience, including assessment of how environmentally-friendly they are and whether they are fun to drive
- Involvement of trade and craft industries, SMEs and start-up companies in the showcase activities.

Furthermore, it was required that detailed exchanges and tight networks should be established between the participants in the individual showcases and in particular also between the different showcases.

5.4 Status of market stimulation measures

Vision 2020: *A targeted, customer-oriented package of measures ensures a rapid market ramp-up of BEVs, REEVs and PHEVs on the German market in pursuit of the goal of a one million-strong electric vehicle fleet by 2020. The development of the market is broken down into three phases, with the aim of creating a self-sustaining market as soon as possible, with as high as possible a proportion of the value creation taking place within Germany.*

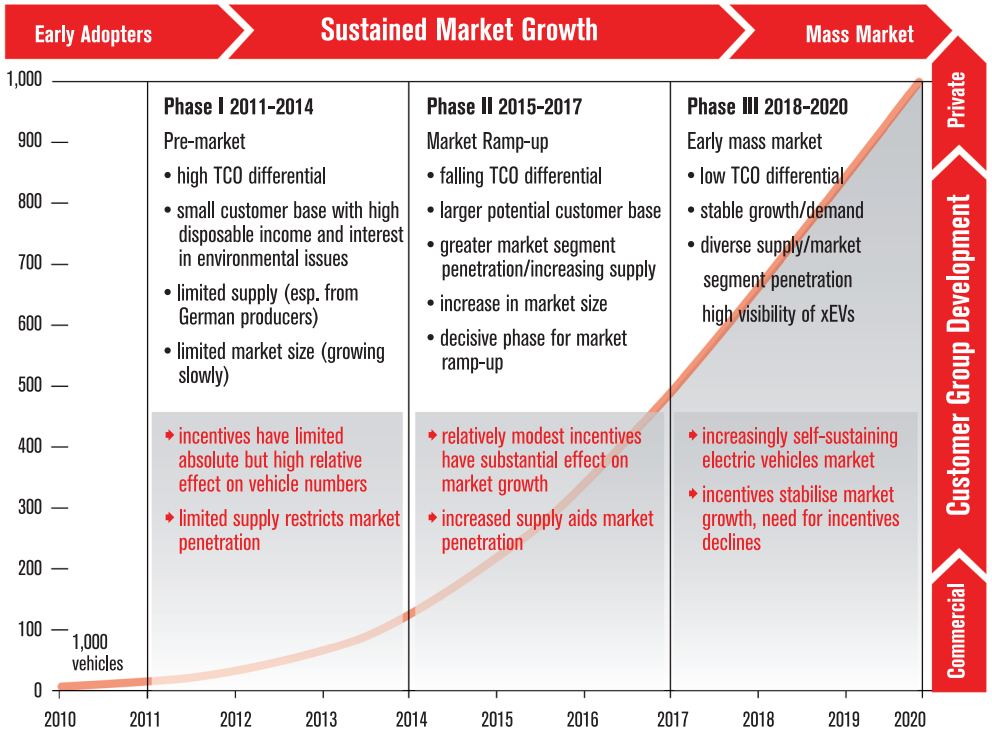
The package of measures recommended by the NPE in 2011 remains a valid proposal for stimulating market growth

In its Second Report, published in 2011, the NPE presented a consensus-based action programme comprising both monetary and non-monetary incentives. The NPE believes that this programme is capable of delivering the ambitious goal of one million electric vehicles by 2020 and making Germany the world's leading market for electric mobility. The key points of the package are as follows:

- Special arrangements regarding depreciation of electric vehicles
  A special depreciation allowance amounting to 50% of the purchase price in the first year of use for electric vehicles used for commercial purposes, in view of the rapid pace of innovation in this area
- Measures to compensate for disadvantages in company car taxation
  A lump sum deduction from the taxable amount in order to compensate for the tax disadvantages of electric vehicles compared to conventional vehicles. A deduction of 500 euros/kWh (capped at 20 kWh) to be applied based on the installed battery capacity
- Low-interest loans from the Kreditanstalt für Wiederaufbau (KfW)
  Special KfW loans of up to 30,000 euros with an effective annual interest rate of approx. 2.5 percent
- Road tax incentive
  Tax incentives (100 euros per kWh for commercial customers and 150 euros per kWh for private customers up to a maximum of 20 kWh), including exemption from road tax
- Evaluation of a public procurement programme for electric vehicles
  In order to support the development of the market, a number of further, non-monetary incentives were recommended, such as priority parking for electric vehicles and a feasibility study of priority bus lane use. Further incentives should also be assessed, such as the introduction of transferable number plates or incentive payments for connecting electric vehicles to the power grid.

The recommended action programme is based on the electric mobility market development phases in Germany and provides targeted solutions for the different customer groups – private users, commercial users and customers who buy their vehicles for commercial use but also use them privately (Fig. 14).

Fig. 14
Target Curve for Market Growth 2010-2020



A public procurement programme for electric vehicles has begun

The German government's 2011 **Programme for Electric Mobility** expands the existing, market-based promotion of electric vehicles. The current five-year road tax exemption for private cars is to be increased to ten years and extended to commercial vehicles. In addition, a public procurement programme for electric vehicles was promised and is now being implemented. Moreover, the programme has taken on board the NPE's recommendation for measures to counteract the current tax disadvantages with regard to private use of electric company cars (BEVs, REEVs, PHEVs). It is hoped that removing the tax disadvantages may lead to increased use of electric vehicles as company cars.

A further NPE recommendation adopted by the German government is the introduction of transferable number plates. However, the NPE's proposal of a lower road tax rate for registered second vehicles has not yet been implemented and the same applies to other NPE proposals such as special depreciation allowances, KfW loans and tax incentives. The measures announced in the government programme are currently being transposed into concrete legal regulations by the relevant government departments.

According to our current calculations, failure to implement all the incentive measures proposed by the NPE would lead directly to a reduction in the sales figures that can realistically be achieved. Other barriers to growing the electric mobility market, such as narrower assessment criteria, will only serve to reduce these figures still further.
As a result of the above, the NPE calculates that the monetary incentives announced in the government's programme will only deliver an increase of between 10 and 20 percent over the figure of under 500,000 electric vehicles by 2020 that was forecast in

the NPE's Second Report. In order to achieve the common goal of a million electric vehicles by 2020, the appropriate adjustments and changes to the framework will need to be made wherever necessary.

The NPE recommends continuous monitoring of market development to facilitate decisions about any additional incentive measures

The NPE recommends that the monitoring process should follow the evolution of the market and assess the effectiveness of the monetary incentives that have been implemented. The showcases have a key role in this respect. For example, it soon became clear during the planning stage of the showcase projects that non-monetary incentives such as the use of special lanes for electric vehicles or the introduction of priority parking spaces at a local level would involve significant challenges. This makes the trialling and evaluation of such measures based on trial clauses in the different showcase regions seem even more essential. It is important to test how much potential these measures really have for reducing the total cost of ownership differential between electric and conventional vehicles.

The decision as to whether additional incentives need to be introduced will depend on the actual supply figures for electric vehicles on the market, the actual evolution of their total cost of ownership (TCO) and actual sales of electric vehicles. The NPE's three-phase model suggests that during the pre-market phase (up to 2014) monetary incentives will have only limited effectiveness, owing to the extremely high TCO differential and the very limited supply of electric vehicles in individual market segments. In the market ramp-up phase (2014–2017), the TCO differential is expected to become significantly smaller and the supply of electric vehicles to increase. Consequently, it will be important to undertake a further critical review of the market incentive measures before this phase begins. Once the mass-market phase has started (2017–2020), the increasingly self-sustaining nature of the market should allow major incentive measures to be phased out.

The debate on **incentives for commercial vehicles** needs to take into account the specific characteristics of the commercial vehicles market. For example, different applications and weight classes mean that it would be impractical to introduce a single common assessment basis. Furthermore, the pressure to keep costs down in the commercial environment means that the TCO comparison becomes an even more sensitive issue for potential customers than in the case of private cars. A variety of electrically-powered commercial vehicle designs are currently being piloted with the aim of developing innovative technologies at price points that are acceptable to the target customers, thereby enabling attractive but also commercially viable solutions to be delivered for both the supply and the demand sides. We recommend that the pilot projects and development programmes should be continued during the current phase in order to analyse the vehicles' technical feasibility with particular emphasis on their cost-effectiveness in real-life deployment scenarios.

5.5 Infrastructure initiatives

Vision 2020: *Private and commercial charging points make up the largest part of the charging infrastructure by 2020. Fast charging stations increasingly enable travel between cities and major population centres. Public and semi-public charging stations encourage electric vehicle use in towns and cities.*

The installation of a number of fast charging stations is considered necessary in order to combat range anxiety

The goal of a million electric vehicles by 2020 will be supported by the provision of a charging infrastructure that meets users' needs. Charging infrastructure construction must keep pace with the ramp-up in electric vehicle numbers and the economic costs must be kept to a minimum. In order to tackle the issue of range anxiety (see section 5.1), it will be essential to build a certain number of fast charging stations, even though there will be proportionately fewer of these than normal charging points. This will be key to addressing potential customers' concerns about range limitations and 24/7 availability of charging facilities. Furthermore, in order to achieve the electric vehicle ramp-up targets, it will be important to ensure that charging facilities are also available on demand to users who do not have their own private parking space. Finally, a publicly accessible charging infrastructure[32] will be a key enabler for transport strategies featuring electric vehicle car sharing schemes.

There are three main charging infrastructure types:

1) **Private normal charging**[33] **points:** these include both domestic charging points and those sited on commercial premises (power points with fuses and power cables, wall box chargers on company premises and in publicly accessible areas).

2) **Public normal charging points:** these are charging points situated in places that are fully accessible to the public (roadside charging stations in towns and cities).

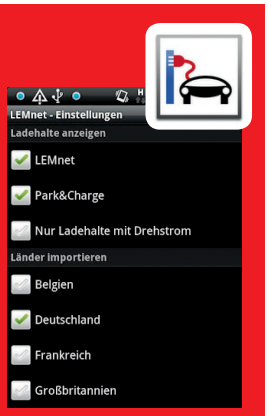
3) **Fast charging points**[34]**:** these comprise fast charging stations situated in busy public locations.

During this reporting period, the NPE has focused on development of the public charging infrastructure

In order to forecast what the specific demand for fully public charging infrastructure would be by 2020, the NPE **focused** predominantly on type (2), i.e. "public normal charging points". The current report pays particular attention to this charging infrastructure type, since it is not self-financing and its construction will require concerted and regulated action by all the relevant stakeholders. Investments in public infrastructure with a mix of public and private funding require a systemic approach (see Chapter 3) involving local authorities, planning authorities, investors and the charging infrastructure operators. In the case of car sharing schemes, for example, the problem of how to achieve optimal capacity utilisation of the public charging infrastructure needs to be solved. This includes issues such as the length of time spent at the charging point by vehicles that have already been charged up, as well as how to deal with people who "illegally" park conventional vehicles at charging stations. If they decide to charge a rental fee or levy a special user charge, councils and local authorities will need to ensure

CASE STUDY: LEMnet – the international electric charging station directory

You're planning a weekend trip in your electric vehicle – but where are you going to charge it up while you're on the road? IT and directory services need to be developed to help customers locate the right charging points. LEMnet is a successful example of an impartial database that is run independently from manufacturers and providers. The database already contains information about more than 3,600 public and private electric vehicle charging stations. Locations, technical details and other information can be viewed free of charge at www.lemnet.org, or via smartphone apps and GPS devices. LEMnet Europe e. V. was established this year to operate the platform more professionally and there are now plans to expand it to the rest of Europe. Businesses, higher education institutions and a variety of associations are all involved in the development of this initiative.



that doing so does not further jeopardise the charging points' economic viability. Particular thought also needs to be given to the commitment to short waiting times.

To date, Germany's energy providers have built more than 2,200 publicly accessible (public and semi-public) charging points (see report by Working Group 3, Chapter 10), more than a thousand of which are in places that are fully accessible to the public. Fast charging is currently available at twelve stations situated on motorways and in towns and cities. Furthermore, experience with private vehicles in the model regions indicates that virtually all electric vehicles have access either to a private charging point in the owner's home or workplace.
According to the needs analysis in the NPE's Second Report, the three categories described above should be providing a total of just under 950,000 charging points by 2020, assuming that the ramp-up to one million vehicles is achieved (Fig. 15).

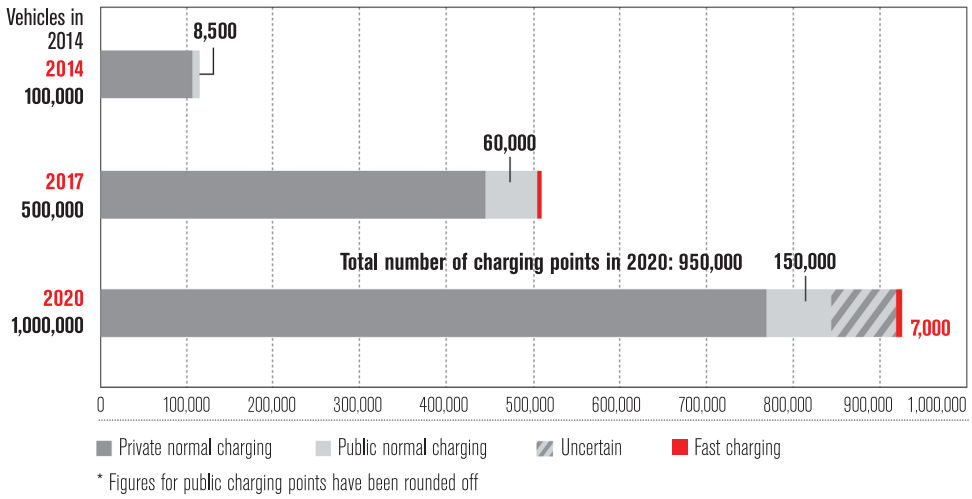
The NPE will draw on the results from the showcase regions to revise its projection of the number of charging points that will be required by 2020

Consequently, a total of **approximately 800,000 of these 950,000 charging points will be built by private investors**. This figure includes some 7,000 fast charging points by 2020 – different business models could be developed in this regard, depending on how the market evolves.

As things currently stand, the figure of 150,000 public charging points by 2020 will only be achievable if the right framework conditions and appropriate funding models are provided. This rather cautious estimate is regarded as an upper limit and is being tested and adjusted based on the results of the showcase projects. Consequently, the upper portion of the forecast in Fig. 15 is described as "uncertain".

In addition, it is possible that the estimated cost per public charging point published in the Second Report of between 4,700 and 9,000 euros could fall still further either as a result of the targeted deployment of simpler basic solutions, overall cost reductions and/or lower demand for general charging points. This type of initiative should continue to be developed in the showcase projects.

Fig. 15
Charging point numbers projected by NPE Model



In some countries, the charging infrastructure is being co-financed during the market ramp-up phase

Based on the estimates in the Second Report, a figure of 150,000 public charging points would require a total investment of between 0.7 and 1.35 billion euros. In view of the low sales volume per charging point together with the high depreciation and operating and maintenance costs, each charging point would be expected to make an annual loss of between 500 and 2,000 euros. This would amount to a deficit of up to 300 million euros a year. As with other infrastructure projects, e.g. broadband expansion, there would be nothing unusual about co-financing of public charging infrastructure during the market ramp-up phase. It is still too early to expect the construction and operation of the public charging infrastructure to be carried out solely by the private sector. Since supplementary commercial activities such as using the charging stations as advertising space are still not sufficient to enable profitable operation or are in some cases restricted by local regulations, the data that are currently available indicate that a limited level of start-up funding and support from the planning authorities would be required.

There are a number of **funding models from abroad** that address the problem of capacity underutilisation and have already achieved substantial success with regard to the construction of **public charging infrastructure** (see Chapter 6). The work is often **publicly funded e.g. through taxation** or other revenue such as investment fund solutions (UK, France) or investment grants (the Netherlands). Furthermore, the funds can be allocated to a variety of bidders by tender and through impartially awarded project grants. Other funding models have hitherto only been used sporadically. For example, **pay-as-you-go financing** is not used at all in other countries, while only two countries (Italy and Ireland) have adopted **grid charging** as a financing mechanism. The decision on the most suitable financing mechanisms for Germany should be left until more information has been obtained from the showcase projects.

"Electric drive systems have systemic advantages. They are very quiet and robust, do not produce any exhaust fumes and achieve maximum torque from a standing start. In a rally, an electric car would be far quicker off the grid than its petrol-engine counterparts. The challenge for electric cars is getting them charged up with electricity – if it wasn't for this they would have become established years ago. This makes it very important to invest in research and development into the relevant battery technologies and power grid infrastructure, focusing on renewable electricity sources such as wind power, solar and hydroelectric."

Jutta Kleinschmidt, Engineer | Professional Marathon Rally Driver and Instructor

In order to estimate the likely need for long-term funding as opposed to just start-up funding, the NPE has discussed the funding requirements of the additional public charging infrastructure that would need to be built between 2020 and 2030. If the ratio of public charging points to electric vehicles were to remain the same in the longer term, public charging infrastructure would require a significant level of ongoing subsidisation that would in fact be expected to rise over time. However, the NPE has concluded that there is absolutely no reason why the number of fully public charging points should continue to rise at the same rate as the number of electric vehicles in the long term.

Indeed, if we draw an **analogy** with two other infrastructure markets – petrol stations and telecommunications – we might predict that the charging infrastructure market will eventually become saturated. During the market ramp-up phase, the relevant infrastructure (petrol stations or telephone boxes) increases in proportion with the number of private cars or telephone usage figures. The market then eventually becomes saturated during the mass-market phase, when more efficient or disruptive technologies come to the fore. An example would be the use of mobile phones instead of telephone boxes. Once the product has fully penetrated the market, demand falls back to a lower level.

If we apply the analogy to charging infrastructure, it points to two phenomena that can be expected to check demand:

1) Improved charging point capacity utilisation, thanks to higher market penetration (more charges per charging point) and more efficient batteries with longer ranges (longer charging times per charging point).

2) The gradual spread of fast charging units acting as a disruptive technology, since a fast charging point can serve several times more customers a day than a normal charging point.

In the long term, the number of fully public charging stations will not continue to rise in proportion to the number of electric vehicles

Once fast charging facilities are available on motorways and in city centres, drivers will have a relatively straightforward means of charging their vehicles – irrespective of where they live or work – and will be less reliant on public roadside charging stations. Consequently, caution should be exercised with regard to the extent of public charging infrastructure construction over the next few years. At the same time, it is also important to ensure that future charging facilities are still able to function when new developments in vehicle and battery technology come online.

Post-2020, it is highly likely that extensive subsidisation of (especially public) charging infrastructure will no longer be necessary and that electric vehicles will increasingly be able to rely on the construction of privately financed public charging points. Since in the long term the electrical power used by each publicly accessible charging point will rise, as new infrastructure is built it will also be necessary to investigate the extent to which it is necessary to expand the power grid to keep pace with demand. Looking ahead to 2025, work will have to be undertaken to expand the power grid. This work should be planned well in advance and be appropriately regulated, i.e. it should be reflected in the relevant power grid charges.

The creation of the showcase regions (see section 5.1) provides public and private actors with an excellent opportunity to work together to test and evaluate different infrastructure solutions and the customer benefits that each one entails as well as the relevant business models. This will include funding models such as mixed financing. In view of the above, the provision of start-up funding for both publicly accessible normal charging and fast charging would appear to make sense during the transition from the pre-market to the market ramp-up phase. Between now and 2014, the NPE will use the results of the showcase projects to test the accuracy of its forecasts and establish the exact charging infrastructure requirements for the market ramp-up phase. The results in terms of the necessary charging infrastructure will be published in the next NPE report.

6
Benchmarking electric mobility internationally

6 Benchmarking electric mobility internationally

Vision 2020: *Germany is the leading supplier and market for electric mobility and a world leader in the relevant key technologies. Germany's technological and conceptual competitive advantage over its international competitors results in a higher than average export demand for German-produced electric mobility goods and services.*

The extent to which the NPE actually achieves its goal of making Germany the world's **leading supplier** and **leading market** needs to be benchmarked internationally. It will only be possible to undertake a full analysis at the end of the pre-market phase in 2014. By this time, different suppliers will have rolled out new electric vehicles in their respective markets across the world, the necessary infrastructure will have been built and new, innovative business models will have been developed. Furthermore, it will only be at this point in time that we will be able to see the first pointers as to how the market has developed under the frameworks established by different governments. It is nevertheless worth taking a brief look at the market development and support measures in different countries.

There has been a noticeable surge in the electric vehicles market since 2010. However, the total number of electric vehicles on the road remains low all over the world

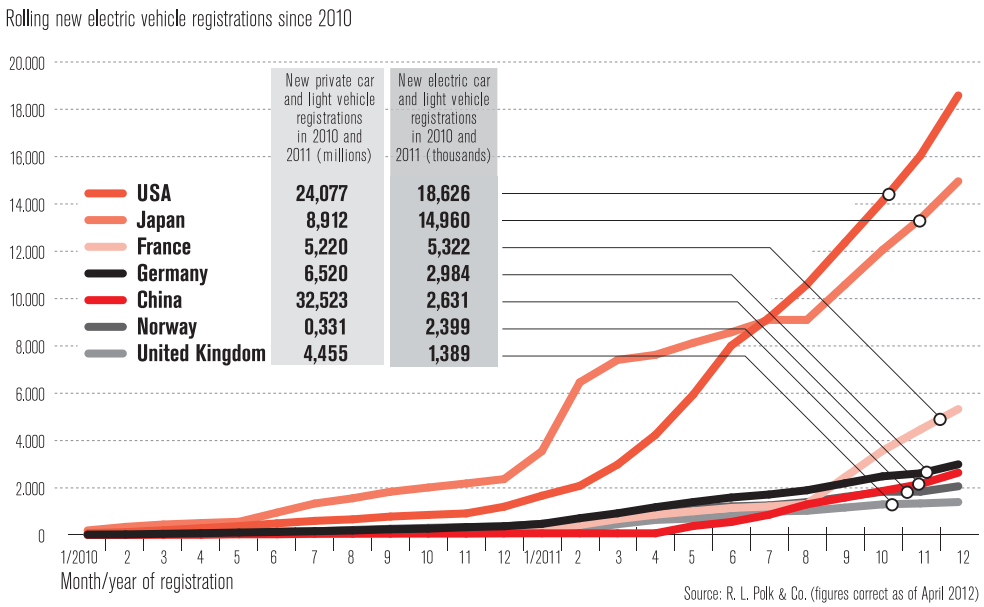
"This is my vision for 2020: Electric mobility "made in Germany" is a world leader – innovative, climate-friendly and affordable. We can make this happen. German industry, with its systemic competences and leadership in many of the relevant technologies, is extremely well-equipped to meet this industry-wide challenge. What we need now is a concerted effort by government and the business community to promote research and development into any technology that can contribute to this goal."

Prof. Dr. Hans-Peter Keitel | President of the Federation of German Industry (BDI) | Member of the NPE Steering Group

Outlook for international electric vehicles market development

Last year was the first time that the international market for electric vehicles experienced tangible growth, however the absolute numbers of new electric vehicle registrations remain extremely low across all markets. One ongoing limitation common to all markets is the limited supply of electric vehicles for sale. A comparison of market data taking into account the different framework conditions that are in place indicates that the only countries to have experienced significant market growth are those where the government has offered high one-off payments to people purchasing electric vehicles. The United States tops the table for new electric vehicle registrations since 2010 with a total of 18,000 new registrations, followed by Japan (15,000) and France (5,300). Approximately 3,000 electric vehicles were registered in Germany over the same period (Fig. 16). If this figure is added to the number that were already registered before January 2010, we can conclude that a total of more than 4,500 electric vehicles are already on the road in Germany.

Fig. 16
International EV market trends since 2010



The market leadership currently enjoyed by the US and Japan is attributable to a wider range of vehicles and a significant level of financial support to the tune of between 5,000 and 9,500 euros per vehicle. A comparison of current market trends points to major local differences (Fig. 16). The US, China, France and the Netherlands achieved more than a tenfold increase in registrations between 2010 and 2011. If we extrapolate the growth figures for the Chinese electric vehicles market, we can expect China to overtake Germany at some point in the near future. Consequently, Germany needs to introduce additional measures to strengthen its current good position.

A further important enabler of electric mobility market growth is the establishment of the necessary charging infrastructure (see section 4.1.5). For example, Germany currently has twelve fast charging stations[35] and over 20 more are planned as part of the four showcase projects. A comparison with selected European countries reveals that the provision of start-up funding (predominantly in the shape of government grants; see also the section on charging infrastructure), particularly during the roll-out phase, can be an effective means of promoting the construction of (fast charging) infrastructure. For example, more than 40 fast charging stations have already been installed in the UK and a further 60 are planned, while Ireland currently has 27, with 45 more in the pipeline. Portugal and the Netherlands have 20 and 23 fast charging stations respectively, whereas Norway, France and Spain all have 16 or 17. The one thing common to all these countries is that the stations were built with government funding.

Funding programme outlook for selected countries

Other countries and regions have already set themselves ambitious targets for pre-market activities in the electric mobility sector. Fig. 17 provides an overview comparing selected countries with Germany based on the available data. This should enable a comparison of planned funding programmes and initiatives across the globe (see also VDE 2010)[36]. It is the NPE's view that it will only be possible to make a meaningful assessment of the extent to which the various plans have actually been implemented at the end of the pre-market phase in 2014.

The **Chinese car market** is already the world's largest single market and can be expected to remain the fastest-growing market for the foreseeable future. As a result, China will become one of the world's most important markets for car manufacturers and will also offer enormous potential in the field of electric mobility.

The Chinese government has launched a funding programme for alternative drive designs and electric mobility called "New Energy Vehicles: 12th 5-year plan for EV (2011–2015)", thereby following the lead of other countries in providing a government stimulus during the pre-market phase.

The **French government** set out its intentions and goals with regard to the development of electric mobility in the "Pacte Automobile" (2009). The government is lending extensive support to the efforts of the French automotive sector to become a leading supplier in electric mobility technology.

The **Japanese market**[37] for electric vehicles (BEVs and HEVs) is currently one of the most highly developed markets in the world. Japan has vehicle manufacturers, infrastructure and battery manufacturers and more registered electric vehicles than any other country in Asia. The construction of charging infrastructure has also been accelerated, and by the end of 2011 there were more than 800 fast charging stations. The Japanese government has launched a series of initiatives aimed at delivering its target of 80% of all vehicle sales being environmentally friendly vehicles by 2013 (Fig. 17). Furthermore, all of Japan's automotive manufacturers and other relevant Japanese businesses are very actively involved in the fields of smart grids, smart cities and smart homes, where Japanese industry is building a clear competitive advantage.

"Electric mobility has a key role to play in delivering climate protection targets and transforming energy systems. By adopting the National Development Plan and establishing the German National Platform for Electric Mobility, Germany has taken an important step towards closing the gap on its international competitors. Innovative German electric mobility products have a great chance of becoming world leaders."

Prof. Dr. Dietmar Harhoff | Director of the INNO-tec Institute at the Ludwig Maximilians University (LMU), Munich | Chairman of the Expert Committee on Research and Innovation (EFI) and member of the NPE Steering Group

The position of market leader is still up for grabs – incentive measures need to be adjusted in a targeted, flexible and dynamic fashion

All the current initiatives and funding programmes in the **United States** are coordinated under the US Department of Energy. The American Recovery and Reinvestment Act (ARRA) has made $2.4 billion available to support the development of electric vehicles, of which $1.5 billion has been earmarked for battery research and development. The funding is geared towards achieving the following key deliverables for batteries over a five-year period: a twofold increase in energy density, a threefold increase in battery life and a 30 percent cost reduction. The whole programme is aimed at getting one million plug-in hybrid and electric vehicles on the road in the US by 2015.

It is clear that these examples can only be regarded as an initial interim overview. It is nevertheless evident that the above countries have, like Germany, set themselves ambitious targets for implementing electric mobility.
However, there are significant differences in some of the measures and conditions for delivering these targets which are largely attributable to each country's different transport requirements and the technological capabilities of their respective industries. The NPE believes that Germany is starting from a good position in the forthcoming race to be the leader of the future electric mobility market. Its activities in the educational arena in particular mean that Germany is extremely well-equipped compared to other countries as far as training and continuing professional education are concerned (see section 4.2).

The NPE will be undertaking regular critical reviews of the extent to which the measures currently planned for Germany are sufficient to meet its targets, or whether they need to be adjusted.

Fig. 17
International Comparison of Funding Plans and Initiatives

China

Buyer incentives:	Incentives of between €6,000 and €7,200 per vehicle depending on drive system and battery sizeKfz-Steuerbefreiung für 42 BEV- und 7 FCEV-Modelle
Tax incentives:	Road tax exemption for 42 BEV and 7 FCEV models
Charging infrastructure:	Installation of more than 2,500 charging points, 100 charging stations and 20 battery exchange stations; subsidies of up to 30% depending on model region
Model regions:	Progressive establishment of several model regions; 100,000 vehicles per model region by the end of 2015
Production:	Creation of an annual capacity of 2 million electric motors, 200,000 batteries and 2 million supercapacitors

Germany

Initiatives:	National Development Plan for Electric Mobility (2009); NPE (5/2010); Second NPE Report (5/2011); German Government Programme for Electric Mobility (5/2011)
R&D funding:	Government economic stimulus package KoPa II 2009-2011: €500 million; government programme 5/2011: €1 billion up to the end of 2013; €40 million each over 5 years for the two leading-edge technology clusters "Elektromobilität Süd-West" and "MAI-Carbon" (2/2011); additional funding from the federal states
Compensatory measures:	1. BEVs exempt from road tax for 10 years; 2. Company car tax breaks for BEVs/REEVs/PHEVs – both measures are currently being implemented
Model projects:	€255 million invested in 17 model projects up to 2011; from 2012, creation of 4 showcase regions in Baden-Württemberg, Berlin/Brandenburg, Lower Saxony and Bavaria/Saxony
Public procurement:	Public procurement programme for electric vehicles now underway

France

Buyer incentives:	€5,000 per vehicle with CO2 emissions of <50g per km
R&D funding:	€1.5 billion funding as part of a total investment of €4.75 billion up to 2020 in the development of alternative drive designs
Charging infrastructure:	Target of charging infrastructure comprising 10% public and 90% private or workplace charging points; funding by government tender
Production:	Government-funded construction of a battery factory
Procurement:	Target of 100,000 electric vehicles to be procured and operated by public sector and businesses by 2015

Japan

Initiatives:	Energy Conservation Law 2015; Eco Car & Next Generation Vehicle (NGV) funding packages for the reduction of CO2 emissions
Buyer incentives:	Under the NGV initiative, approx. €10,000 for e.g. Nissan Leaf; under the Eco Car scheme (where the funding is available for limited periods only) approx. €1,000 from 04/2009 to 09/2010 and from Q2/2012 to Q4/2012
R&D:	Roadmap for batteries aimed at achieving 150% improvement in performance of Li-ion batteries for 17 cost drivers compared to current values; development of post Li-ion technology
Tax incentives:	Under the Eco Car and NGV schemes, (staggered) exemption from VAT and car weight tax (for 3 years) from 04/2009 – 04/2015
Charging infrastructure:	Subsidisation of up to 50% of purchase price depending on charging speed
Model regions:	Creation of 11 model towns with a total of 34,000 BEVs/PHEVs; additional regions planned

USA

Buyer incentives:	Tax incentives of approx. US $7,500; increase to US $10,000 currently under discussion; tax breaks of 50% of purchase cost for corporate fleets
R&D funding:	US $226 million for research into drive systems, power grid infrastructure, power electronics, batteries and vehicles; a further US $650 million over the next 3-5 years for research into lightweight materials, multi-material design, battery research, drive systems and charging technologies
Model regions:	US $1 billion funding for 10-15 model regions; set-up, infrastructure and achieving a critical mass of vehicles

7
Take-home messages and recommendations

7 Take-home messages and recommendations

This Progress Report is based on the forecasting models that were used for the Second Report. The input values have been checked during the period to which the Progress Report relates. The NPE used a volume/market model (TCO model) to calculate the market ramp-up rate and total costs. The model's forecasts proved to be accurate for the first year of the pre-market phase (2011) both with regard to total cost of ownership and market growth.

In order to ensure that broader social interests are taken into account, the updating of the model is to be outsourced to an independent academic institution. A key criterion in the tender process will be the ability to provide a transparent explanation of how the model operates. The selection procedure will begin in 2012.

The NPE has developed another model to calculate electric mobility's economic potential. A further development of this model is currently under investigation.

The accuracy of the forecasting models means that the Second Report's recommendations remain valid today. The following take-home messages and recommendations are designed to expand upon the Second Report's recommendations and make them more explicit. They are aimed at experts from industry, the research community, government, the trade unions and civil society.

TAKE-HOME MESSAGE: SYSTEMIC APPROACH

Electric mobility should be approached from the user's perspective and in order to achieve customer acceptance it should therefore be understood and developed as a holistic system.

The NPE recommends:

- Strengthening cooperation between all the actors in the separate vehicles, transport and energy subsystems that make up the overall electric mobility system and testing this cross-sectoral cooperation in the showcase regions
- Prioritising the development and implementation of international regulations and standards for all the different subsystem interfaces during the current pre-market phase
- Continuous cross-technology cooperation in the R&D lighthouse projects
- The production of a "Systemic Approach to Electric Mobility" roadmap in order to complement the activities being carried out in the R&D lighthouse projects and showcase regions

TAKE-HOME MESSAGE: LEADING SUPPLIER

The goal of becoming the world's leading supplier by 2020 is achievable, however it will require prompt implementation of the NPE's technology roadmaps, Germany's electric mobility standardisation roadmap and the competence roadmap for education.

The NPE recommends:

- Ongoing implementation of the NPE's technology roadmaps right across the electric mobility value chain in order to develop and secure German industry's technological leadership
- Ongoing development and implementation of the NPE's standardisation roadmap, with particular emphasis on strengthening international networks (initially in Europe, the US and Asia)
- The development, introduction and harmonisation of practical international regulations for the transport of lithium-ion traction batteries
- The implementation and continuous updating of the NPE's competence roadmap for education, with the establishment of an electric mobility vocational training and CPD coordination office that should, however, not duplicate existing structures. Furthermore, the development of funding guidelines for R&D projects in the field of vocational training and CPD
- Identify and unlock synergies through collaboration with other institutions for the promotion of electric mobility
- The development and communication of a medium-term plan setting out the German government's funding priorities for electric mobility in order to enable better planning of R&D measures on behalf of applicants and to facilitate access to funding programmes, especially for the research community, SMEs and start-up companies

TAKE-HOME MESSAGE: R & D LIGHTHOUSE PROJECTS

The NPE's readiness to deploy a variety of different technologies has proven to be the correct approach – the project proposals in the different R & D lighthouse projects now need to be implemented promptly and consistently.

The NPE recommends:

- Identification of additional mission-critical R&D projects in the relevant technology areas to be launched as joint projects
- Strengthening systemic, cross-sectoral cooperation within and between the individual technology areas
- Consistent implementation of projects on the themes of cell chemistry, systems integration and battery management together with consistent testing of efficient mass production facilities
- Establishment of a research and demonstration centre for systemic lightweight design
- With a view to achieving the goal of electric vehicle technology leadership, the proposed projects in the R&D lead technology areas of drive technologies and vehicle integration and the associated thematic areas should be implemented promptly and consistently
- The technologies should be tested in the showcase regions with regard to user acceptance and functionality, especially those relating to the ICT and charging infrastructure R&D lighthouse projects
- Closer cooperation with the business, political and research communities within the ICT lead technology area, in particular on the themes of data security and data protection
- Further support from the recycling lead technology area for the activities of the Raw Materials Alliance, especially through targeted complementary projects

TAKE-HOME MESSAGE: LEADING MARKET

User acceptance is key to the success of electric mobility and to achieving the goal of making Germany the world's leading market for years to come. The key factors for gaining user acceptance are suitability for everyday use, running costs, charging performance and convincing consumers of the environmental benefits.

The NPE recommends:

- Removal of barriers to growing the electric mobility market
- Continuous monitoring of the development of the electric vehicles market and the effectiveness of the monetary incentives that have been deployed
- If the desired market growth is not achieved, implementation of the market incentive package recommended by the NPE
- Construction of a public charging infrastructure for electric vehicles in Germany at an appropriate pace that takes into account actual growth in e-vehicle numbers and the demand figures obtained, for example, from the showcase regions
- Strengthening research into potential new charging solutions in the vehicle and battery domains in order to enable continuous implementation of technical innovations
- The development of concepts and concrete action proposals for supplying electric vehicles with additionally generated renewable energy and to ensure that their integration with the power grid keeps pace with their integration into the market
- Ongoing efforts to identify barriers to market and customer acceptance and solutions to overcome them

TAKE-HOME MESSAGE: SHOWCASES

The four showcase regions electric mobility are key to the knowledge transfer needed for the market ramp-up phase beginning in 2014.

The NPE therefore recommends that the **following issues and themes** should be investigated in the four showcases with a view to promoting knowledge transfer and verifying the NPE's forecasts and models:

- Broad-based communication activities to raise the profile of electric mobility in the individual showcase projects and across all the showcases
- The effectiveness of the non-monetary incentives recommended by the NPE in its Second Report in terms of the potential they offer to help close the total cost of ownership gap between electric and conventional vehicles
- Demand for and distribution of a user-friendly charging infrastructure, together with appropriate operator and funding models
- The correlation between the number of charging point visits and the (growing) number of vehicles in order to determine public charging infrastructure requirements post-2020
- Business models for incorporating electric vehicles into attractive, multimodal transport service solutions
- Power grid integration models and managed, user-friendly charging methods (e.g. I.D.E.E.)
- Ideas for using additional renewable energy to supply electric vehicles and how this correlates with customer acceptance
- Insights contributing to a sustainable orientation for academic education and vocational training and assessment of the required vocational training and continuing professional development measures
- User acceptance of the charging and driving experience provided by electric vehicles, including perception of how environmentally-friendly they are and whether they are fun to drive
- Participation of trade and craft sectors, SMEs and start-up companies in the showcase activities

TAKE-HOME MESSAGE
LEADING SUPPLIER AND LEADING MARKET

A self-sustaining electric mobility market will create jobs and added value.

The NPE recommends:

- Contracting an independent academic institution to update the TCO model in view of its key role in monitoring market development
- Using international benchmarking to evaluate progress towards the target of becoming the world's leading market, through a sound, fact-based analysis to be carried out at the end of the pre-market phase in 2014
- Development of the model on value creation and employment

8
Outlook

8 Outlook

Germany's intention to become the world's leading supplier and market for electric mobility by 2020 is undoubtedly achievable. A key requirement is for the general public and potential customers to understand and accept the "electric mobility system". In this regard, the showcases will be key to providing an immediate and comprehensive demonstration of the innovative qualities of the electric mobility system by showcasing how it works in practice, bringing it closer to the user and stimulating demand. The target of "one million electric cars by 2020" remains extremely ambitious and might be likened to a marathon, in
that it will require the ongoing engagement of all the actors for the entire duration of the pre-market, market ramp-up and mass-market phases. At the same time, it will be important for communication strategies to manage expectations appropriately.

Over the coming years, the NPE will carry out international benchmarking and monitor market trends and the implementation of its recommendations in a variety of different ways. This will include regular reviews and modification of its medium-term goals, milestones, recommendations, measures and roadmaps. The German government and the NPE are planning an international conference on electric mobility for 2013 in order to allow the general public to see and experience the progress that has been made and broaden the debate. The next progress report is scheduled for the conclusion of the pre-market phase in 2014.

Incorporating electric mobility as a central plank of future transport policy will make a major contribution to cutting local emission levels, curbing primary energy consumption and fostering climate protection by incorporating additional renewable energy into our energy supply. It is the NPE's aim to make this vision a reality. We believe that it can be achieved if all the relevant actors continue to engage consistently in its implementation.

9
Glossary and footnotes

Glossary

AC
Alternating Current; →DC
ACEA
Association des Constructeurs
Européens d'Automobiles
(European Automobile Manufacturers' Association)
AFNOR
Association Francaise de Normalisation
(French national standardisation organisation)
ARPA-E
Advanced Research Projects Agency – Energy
ARRA
American Recovery and Reinvestment Act
BEV
Battery Electric Vehicle
BMC
Baseboard Management Controller
CARS 21
Competitive Automotive Regulatory System
for the 21st century
(European Commission strategy)
CCeV
Carbon Composites e.V. (fibre-reinforced composites technology competence network)
CCS
Combined Charging System
CEN
Comité Européen de Normalisation
(European Committee for Standardisation)
CENELEC
Comité Européen de Normalisation Électrotechnique
(European Committee for Electrotechnical Standardisation)
CFRP
Carbon-fibre reinforced plastic
CPD
Continuing Professional Development
CSC
Cell Supervision Circuit
DC
Direct Current; →AC
DoE
United States Department of Energy
DIN
Deutsche Institut für Normung e.V.
(German Institute for Standardisation)
FCEV
Fuel Cell Electric Vehicle
G2V
Grid to Vehicle; →V2G
HEV
Hybrid electric vehicle
ICP
Integrated Circuit Packaging
ICT
Information and Communication Technology
IEC
International Electrotechnical Commission
IEKP
Integriertes Energie- und Klimaschutzprogramm
(German government's Integrated Energy and Climate Programme)
ISO
International Organization for Standardization
Li-Ion technology
Lithium-Ion technology, also Lithium-Ion battery or Lithium-Ion secondary battery
KfW
Kreditanstalt für Wiederaufbau (German government-owned development bank)
METI
(Japanese) Ministry of Economy, Trade and Industry
MIIT
(Chinese) Ministry of Industry and Information Technology
MoU
Memorandum of Understanding
NIP
Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (National Hydrogen and Fuel Cell Technology Innovation Programme established by the German Federal Ministry of Transport, Building and Urban Development)
OEM
Original Equipment Manufacturer

PCB
printed circuit board
PHEV
Plug-in Hybrid Electric Vehicle
R&D lighthouse projects
Research & development lead technology areas / germ. Leuchttürme, engl. Lighthouses
REEV
Range Extended Electric Vehicle
RFID
Radio Frequency Identification
SAE
Society of Automotive Engineers
SoC
State of Charge
TCO
Total Cost of Ownership
TEC
Transatlantic Economic Council
V2G
Vehicle to Grid
VDE
Verband der Elektrotechnik Elektronik Informationstechnik e.V. (Association for Electrical, Electronic & Information Technologies)
xEV
Collective term for electric vehicles, including →BEV, →FCEV, →PHEV and →REEV
ZEW
Zentrum für Europäische Wirtschaftsforschung (Centre for European Economic Research)

1 Figures for charging points provided by the German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft).
Figures for electric vehicles from the Federal Motor Transport Authority (Kraftfahrtbundesamt).

2 The NPE's reference vehicles also represent three types of electric vehicle application: city runarounds, family cars and commercial vehicles.

3 The development and demonstration of fuel cell electric vehicles and hydrogen-based solutions are already covered by separate central government funding programmes, e.g. the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP), and are therefore not being addressed in depth by the NPE. Nonetheless, fuel cell electric vehicles also form part of the electric mobility system.

4 Competition law prohibits publication of the exact amount invested by individual companies. The list was compiled from published company reports and press releases (e. g. relating to factory openings) and does not claim to be exhaustive.

5 Second Report of the National Platform for Electric Mobility, p. 12.

6 Homepage of the Forschungsunion: www.forschungsunion.de.

7 Compare also the recommendations of the Transport Promoters Group of the Forschungsunion Wirtschaft-Wissenschaft. The report is available at: http://www.forschungsunion.de/veroeffentlichungen/index.html.

8 The HTS Action Plan can be found at: http://www.bmbf.de/pub/HTS-Aktionsplan.pdf

9 Second Report of the National Platform for Electric Mobility, 2011, p. 10.

10 In its Programme for Electric Mobility (May 2011), the German government announced the future establishment of lighthouse projects "[. . .] to support innovation in the key electric mobility technologies and open up innovation processes to a much wider community (Open Innovation)." (p. 29). These R&D lighthouse projects will be based on the technology roadmaps put forward by the NPE.

11 "Project" and "consortium" are used synonymously in the context of the R&D lighthouse projects.

12 German government's Programme for Electric Mobility, May 2011, p. 20

13 Members: Infineon Technologies, individual automotive manufacturers, Dt. ACCU, Sensortechnik Wiedemann, Technical University of Munich, RWTH Aachen, TWT and BVB INNOVATE.

14 Members: Infineon Technologies, individual representatives of the automotive industry, BASF, Wacker Chemie, Li-Tec, Evonik, Dt. ACCU, University of Münster, Fraunhofer Institute for Chemical Technology, SGS Germany GmbH, Technical University of Munich, Technical University of Braunschweig and ElringKlinger.

15 The ZEW indicator report on innovation trends in German industry indicates an above-average level of investment in innovation in the mechanical engineering, vehicle technology and plastics processing industries in 2011. A survey at the Composites Europe Trade Fair found that 20 percent of the companies present were planning to invest more than 500,000 euros each in 2011/12. What is more, half of these companies were planning to invest a figure in excess of 3 million euros.

16 CFRP stands for "carbon-fibre reinforced plastic".

17 http://www.produktionsforschung.de/national/archiv/UCM01_000847

18 cf. http://www.pt-elektromobilitaet.de/projekte/batterierecycling/abschlussberichte-recycling/lca-analyse-lithorec.pdf and http://www.pt-elektromobilitaet.de/projekte/batterierecycling/abschlussberichte-recycling/lca-analyse-libri.pdf

19 "Privacy by design" means that relevant data protection requirements need to be checked and solutions that comply with data protection legislation need to be developed right from the design stage of processes and technical systems.

20 See link in Chapter 10, "NPE publications".

21 Surveys were carried out in Italy (Politecnico di Torino/Politecnico di Milano), Japan (Chiba University) and the US (Ohio State University).

22 See Chapter 10, "NPE publications".

23 The steering group is composed of the chair and members of NPE Working Group 4, plus one representative each from DIN, NA Auto and DKE. Depending on the topic being discussed, government representatives and experts from different industries are brought in as required.

24 A very tech-savvy user group that is happy to pay for innovations.

25 See, for example: Vilimek, R., Keinath, A. & Schwalm, M. (in press). The MINI E field study – Similarities and differences in international everyday EV driving. In: Proceedings of the 4th International Conference on Applied Human Factors and Ergonomics 2012. London: Taylor & Francis.

26 If all types of transport are taken into account, Germans travel an average of 39 kilometres a day, although the figure for car use alone is even lower. In any case, electric vehicles' range is enough to cover even the total transport requirements. The most recent study on this issue is "Mobilität in Deutschland" 2008; see also: http://www.mobilitaet-in-deutschland.de/02_MiD2008/publikationen.htm Even people in full-time employment only travel 58 kilometres a day.

27 cf. BerlinelektroMobil, www.bemobility.de; Hoffmann, Christian, et al., Bewertung integrierter Mobilitätsdienste mit Elektrofahrzeugen aus Nutzerperspektiven, Berlin 2012: InnoZ Baustein Nr. 11; and Knie, Andreas et al., E-Carsharing als Bestandteil multimodaler Angebote, in: Internationales Verkehrswesen (64), 2012, pp.42–45

28 ADAC 2011: representative members survey.

29 For example: Vilimek, R., Keinath, A. & Schwalm, M. (in press). The MINI E field study – Similarities and differences in international everyday EV driving. In: Proceedings of the 4th International Conference on Applied Human Factors and Ergonomics 2012. London: Taylor & Francis.

30 The showcase projects were awarded through a transparent competitive tender process which the German government initiated on 13 October 2011 with its "Announcement on Research and Development Funding Guidelines for Showcases Electric Mobility".

31 I.D.E.E. stands for Innovationsförderung in Deutschland für Erneuerbare Elektromobilität (Innovation Funding in Germany for Renewable Electric mobility) and is a concept for funding electric mobility which forms part of the systemic approach and which was put forward by certain NPE members as a means of helping to achieve the target of 1 million vehicles. For more details on I.D.E.E., see the appendix of the Second Report.

32 Charging point denotes the smallest unit in a charging station or charging facility, in other words the individual power point or charging cable. A charging station – in a similar way to a petrol pump – can therefore have several charging points. Charging infrastructure refers to all charging points collectively.

33 Normal charging denotes charging capacities of up to 44 kW.

34 Charging capacities of up to 100 kW are being investigated. See section 4.1.5 ICT.

35 Source: http://www.goingelectric.de

36 Becks, Thomas et al.: "Wegweiser Elektromobilität", VDE Verlag, Berlin, Offenbach, 2010

37 cf. METI: "Views and Policies on Japan's Automobile Industry", presented by Shin Hosaka at "Making Green Cars Reality: Policies and Initiatives in the EU and Japan", 25.2.2010
cf. http://www.elmost-conference.de/page/downloads/12.30–12.50_Kenji_Miura_JP.pdf
cf. Becks, Thomas et al.: "Wegweiser Elektromobilität", VDE Verlag, Berlin, Offenbach, 2010

38 The Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie - BMWi), the Federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung – BMVBS), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit – BMU) and the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung – BMBF).
Electric mobility pages on Federal Ministry websites: http://www.bmbf.de/de/14706.php and http://www.bmu.de/verkehr/elektromobilitaet/doc/42735.php
http://www.bmwi.de/BMWi/Navigation/Wirtschaft/industrie,did=329150.html,
http://www.bmvbs.de/DE/VerkehrUndMobilitaet/Zukunftstechnologien/Elektromobilitaet/elektromobilitaet_node.html;)

10
NPE publications

NPE publications

All NPE reports can be accessed via the electric mobility pages of the four Federal Ministries (BMWi, BMVBS, BMU, BMBF).

Interim Report of the National Platform for Electric Mobility (2010)
(Zwischenbericht der Nationalen Plattform Elektromobilität [2010])

Second Report of the National Platform for Electric Mobility (2011)
(Zweiter Bericht der Nationalen Plattform Elektromobilität [2011])

Progress Report of the German National Platform for Electric Mobility (Third Report) (2012)
(Fortschrittsbericht der Nationalen Plattform Elektromobilität [Dritter Bericht, 2012])

The German Electric mobility Standardisation Roadmap – Version 2 (2011)
(Die Deutsche Normungs-Roadmap Elektromobilität – Version 2 [2011])

Available via the Office for Electric mobility (Geschäftsstelle Elektromobilität) pages of the German Institute for Standardisation (DIN) www.elektromobilitaet.din.de

Competence Roadmap for Education (2012)
(Kompetenz-Roadmap Bildung)

Available via the homepage of the University of Ulm: www.uni-ulm.de

Report by Working Group 3 Charging Infrastructure and Power Grid Integration:
“Smart Power Grid Integration of Electric Vehicles”
(Elektrofahrzeuge intelligent ans Netz bringen)

Available via the E.ON homepage: www.eon.de

11
NPE information page

NPE information page

Background

The transformation of global energy and transport systems represents both a challenge and an opportunity for Germany, since it is a leading supplier in many of the technologies that are relevant to this transformation as well as having an established automotive sector. In the long term, the introduction of electric drive technologies could help to reduce fossil fuel consumption and traffic emissions as well as contributing to the development of more efficient transport systems. As long ago as 2007, the German government's Integrated Energy and Climate Programme (IEKP) announced a commitment to make funding for electric mobility a key component of its strategy for delivering its climate protection targets. The programme's implementation report calls for the creation of a National Development Plan for Electric Mobility. In November 2008, the federal government organised a "National Strategic Conference on Electric mobility" where the key content of a national development plan was discussed by representatives of industry, the research community and government. Following the conference, the "German Government's National Development Plan for Electric Mobility" was announced in August 2009 with the goal of getting one million electric vehicles on the road in Germany by 2020.

In order to achieve this goal, the federal government and representatives of German industry issued a joint declaration on 3 May 2010 in which they announced the establishment of the German National Platform for Electric Mobility (NPE). The role of the NPE would be to generate momentum and act as a consultant and think tank for electric mobility. They also committed to the common goal of making Germany the world's leading supplier and leading market for electric mobility. Since that date, over 150 high-level representatives from industry, the research community, government, the trade unions and civil society have been participating in this novel cross-sectoral dialogue. Seven Working Groups focus on priority themes as part of a holistic "systemic approach" geared towards unlocking the economic potential of electric mobility and developing recommendations designed to secure Germany's competitiveness going forward.

The NPE's priorities are as follows:

- Identification of relevant, mission-critical R&D themes that are key to becoming the world's leading supplier
- Coordination of the overall requirements for establishing the world's leading market
- (infrastructure, products, standardisation, training)
- Monitoring and evaluation of activities elsewhere in the world and monitoring of the showcase projects
- Providing stable and continuous support (including moral support) for electric mobility

The Working Groups meet year-round and regularly discuss shared issues among each other. Their recommendations form the basis of the NPE's reports and continuous monitoring activities. The NPE is supported by the German government through its Joint Unit for Electric Mobility (GGEMO) to which representatives of four federal ministries are attached.[38]

NPE Working Groups:

- WG 1 - **Drive technologies**
- WG 2 - **Battery technology**
- WG 3 - **Charging infrastructure and power grid integration**
- WG 4 - **Regulation, standardisation and certification**
- WG 5 - **Materials and recycling**
- WG 6 - **Training and qualifications**
- WG 7 - **General framework**

Chairmen and Members of the Steering Committee

Industry chairman: **Prof. Dr. Henning Kagermann** (acatech)
Federal government chairmen: **Rainer Bomba**
(State Secretary at the Federal Ministry of Transport, Building and Urban Development)
Dr. Bernhard Heitzer
(State Secretary at the Federal Ministry for Economics and Technology)

Members:

- **Jürgen Becker** (State Secretary at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
- **Dr. Roland Busch** (Siemens AG)
- **Michael Dick** (Audi AG)
- **Dr. Klaus Draeger** (BMW AG)
- **Prof. Dr. Karl Joachim Ebeling** (University of Ulm)
- **Dr. Ulrich Eichhorn** (Coordination Office of the Electric Mobility Industry Committee [Koordinierungsstelle Industriekreis Elektromobilität])
- **Dr. Klaus Engel** (Evonik Industries AG)
- **Prof. Dr. Burkhard Göschel** (Magna International Inc.)
- **Prof. Dr. Dietmar Harhoff** (Ludwig-Maximilians-University LMU Munich)
- **Berthold Huber** (IG Metall trade union)
- **Prof. Dr. Hans-Peter Keitel** (Electric Mobility Industry Committee [Industriekreis Elektromobilität])
- **Dr. Rudolf Krebs** (Volkswagen AG)
- **Dr. Andreas Kreimeyer** (BASF SE)
- **Dr. Karsten Kroos** (ThyssenKrupp AG)
- **Prof. Dr. Klaus-Dieter Maubach** (E.ON AG)
- **Ingrid Ott** (German Federal Government Joint Unit for Electric Mobility *[Gemeinsame Geschäftsstelle Elektromobilität der Bundesregierung]*)
- **Dr. Peter Sallandt** (German Federal Government Joint Unit for Electric Mobility *[Gemeinsame Geschäftsstelle Elektromobilität der Bundesregierung]*)
- **Dr. Georg Schütte** (State Secretary at the Federal Ministry of Education and Research)
- **Prof. Dr. Thomas Weber** (Daimler AG)
- **Matthias Wissmann** (Electric mobility Industry Committee *[Industriekreis Elektromobilität]*)

NPE Interim Report (First Report, 2010)

The NPE unveiled the results of its year-long analysis phase in the interim report that it submitted to the federal government on 30 November 2010 and in the individual working group reports. These reports defined the Platform's fundamental goals and made initial recommendations, based on the results of the working groups, for the immediate steps to be taken in individual technology fields (Batteries, Training and Qualifications, Materials and Raw Materials, and Vehicle Integration). These were subsequently presented to the German government. The reports also outlined additional tasks and themes.

Second NPE Report (2011)

In its Second Interim Report published on 16 May 2011, the NPE proposed an extensive catalogue of measures that was used by the federal government as an input for its own initiatives in the field of electric mobility. The technology roadmaps were used as the basis for establishing overarching lead technology areas, with each of them focusing on a number of specific thematic areas. Measures geared towards growing the market and raising the profile of electric mobility were also devised. The NPE also committed to conduct a regular review of its work, timetables and the goals established in its recommendations and to adjust them wherever necessary.

NPE Progress Report (Third Report, 2012)

The current First Progress Report (2012) is the first report to present details of the NPE's monitoring activities.

Fig. 18
NPE timeline

As well as the NPE reports, two of the working groups have published roadmaps which have also been incorporated into the monitoring process:

- The German Electric mobility Standardisation Roadmap (*Deutsche Normungs-Roadmap Elektromobilität*) | WG 4 "Regulation, Standardisation and Certification"
- Competence roadmap (*Kompetenz-Roadmap*) | WG 6 "Training and Qualifications"

Outlook

Over the next few years, the NPE will continue to perform its monitoring role in a variety of different ways. The German government and the NPE are planning an international conference on electric mobility for 2013 in order to allow the general public to see and experience the progress that has been made, broaden the debate and facilitate an international exchange of knowledge and experience. The next progress report is scheduled for the beginning of the market ramp-up phase in 2014.

Author
German National Platform for Electric Mobility (NPE)
Berlin, May 2012

Publisher
German Federal Government Joint Unit for Electric Mobility (GGEMO)
Scharnhorststraße 34–37
10115 Berlin

Editorial Support
acatech – National Academy of Science and Engineering
Ariane Hellinger, Michael Püschner
www.acatech.de

Translation
Dr. Helen Galloway, Joaquin Blasco

Typesetting and Layout
heilmeyerundsernau.com

Infographics
isotype.com

Printed by
Federal Ministry of Transport, Building and Urban Development
Bonn