NATIONALE
PLATTFORM
ELEKTROMOBILITÄT

Interim Report of the National Platform for Electric Mobility

Contents

1 Executive Summary 5

2 Preamble 8

3 Global challenges in mobility as an opportunity to enhance German competitiveness in the global economy 9

4 The National Platform for Electric Mobility – objectives and interim conclusions 12

5 The German approach to becoming a lead provider and lead market 15

6 Findings of the working groups of the National Platform for Electric Mobility 19

7 Initial recommendations 37

8 Recommendations on shaping the future activities of the National Platform for Electric Mobility 45

9 Mandates and need for further clarification 46

The contents of this report are based on the activities of the seven working groups of the National Platform for Electric Mobility. The documentation of these activities is a component of the interim report. The working groups are responsible for the contents. The documents can be downloaded from the websites of the following federal ministries: Economics and Technology; Transport, Building and Urban Development; Environment, Nature Conservation and Nuclear Safety; and Education and Research.

1 Executive Summary

The global transformation of energy and mobility systems is both a challenge and an opportunity. Electric mobility technologies offer solutions for environmental protection and resource conservation. At the same time, there is potential for growth and employment inherent in the new technologies. In the long run, electric mobility can become the key technology for the replacement of fossil energy sources in road transport. Until we reach that stage, all technological options, including more efficient internal combustion engines, have to continue to be pursued.

The international competitive pressure in the development of electric mobility is enormous – existing positions on the global market are being challenged. The German industry must join forces with government, academia and society to act rapidly and proactively in a spirit of close solidarity.

Against this background, representatives from industry, academia, government, trade unions and society in Germany, following an invitation from the Federal Government, have come together in the National Platform for Electric Mobility (NPE). The members of the NPE have agreed to pursue a systemic, market-focused and technologically neutral approach with the aim of developing the German industry, together with SMEs and the crafts sector, into a lead provider and Germany into a lead market for electric mobility by 2020. They started to prepare this interim report in May 2010. A second report will be published in the spring of 2011.

The initial findings of the NPE are:

- The German industry is a lead provider in many of the fields of technology that are relevant to electric mobility. Its efforts must be stepped up so that it can also become a world leader in products and solutions for electric mobility. In this way, it may be possible to safeguard, and even enhance, wealth creation and employment in Germany.
- The establishment of an electric mobility lead market in Germany is designed to encourage action to tackle climate change and conserve resources. In addition, it is of crucial importance for the success of products and solutions. Skills in the establishment of intermodal transport services and new business models will be developed in a targeted manner in the lead market.
- The findings available so far focus on research and development in the field of cutting-edge technologies and integrated solutions. Cross-sectoral technology roadmaps set out the development paths. The industry and academia are already cooperating closely to implement them. Further research projects worth around 4 billion euros over the period to 2013 have been defined and prioritized.
- The battery is a key component of the electric vehicle. Here, there is great scope for optimization. Intensive research and development activities to evolve lithium-ion technology and develop new battery technologies (post-lithium-ion technology) are urgently required. Germany needs integrated cell and battery system production. Development should be progressed in this field.

- In the field of electric drivetrains, a coordinated and focused approach is necessary, with the aim of cutting costs, increasing power density and power-to-weight ratio, enhancing efficiency and improving quality and reliability. To achieve this, it will be necessary to implement packages of measures in research and development, production technologies and manufacturing for electric motors, power electronics and drivetrains.
- Resources and materials are at the beginning of the value added chain. Innovative materials are the foundation for competitive finished products. New recycling technologies can reduce geopolitical dependence by providing better access to secondary raw materials. It is imperative that necessary raw materials be strategically safeguarded.
- The German energy system is among the most efficient in the world. Compared with other countries, it has an especially high proportion of volatile renewable energy sources. This means that there is great scope for synergy with electric mobility. Electric vehicles can thus be taken into account in smart grid controls earlier than in other countries. In this way, a genuine unique selling proposition can be created for German technologies on the global market.
- Account has been taken of the strategic importance of standardization in consultation with representatives from all relevant branches of industry. A German standardization roadmap has been adopted and has to be systematically implemented and updated.
- Concrete steps to safeguard Germany's competitive position by improving the skills base and providing vocational and academic training have been defined and are being implemented.
- A cross-system approach to technology development is designed to deploy the strengths of the German industry in a targeted manner on the global market. Development schemes are to be consolidated to form lighthouse projects. Approaches are being developed for this purpose.
- The existing pilot regions and projects are being evaluated. A small number of large showcases are being designed and quickly established in order to make products and solutions visible and to give people first-hand experience of electric mobility.
- The general framework will play a major role in achieving the lead market objective, especially in the initial phase of market growth. The NPE is developing a catalogue of measures to support a successful transition to mass marketing. This catalogue comprises a wide range of different instruments, including financial and fiscal options, adaptation of traffic law or the creation of infrastructure conditions. An assessment of the measures also has to take into account an international comparison with the general framework in other European and non-European countries. Every effort must be made to create a common competitive environment in Europe in which the objective of a German lead market of one million electric vehicles by 2020 is achievable.

Publication of the interim report marks the conclusion of the analysis phase. The definition of the technology roadmap, which is necessary for the “lead provider” issue, will permit a rapid start in the cross-sectoral process of innovation.

The parties involved consider the activities in the NPE beyond the concrete findings to be a success. With the NPE, there exists for the first time an institutionalized platform for a cross-sectoral dialogue. It has already sent a clear message to the industry and society and is providing an additional boost to the establishment of electric mobility.

2 Preamble

Electric mobility is driving changes throughout the world. New markets are being created, new technologies are being developed and established positions on the global market are being challenged. In Germany, as in other countries, industry, government, academia and society face the challenge of shaping these new markets and defending the outstanding position of German businesses on the world market.

The experts gathered in the National Platform for Electric Mobility (NPE), following an invitation by the Federal Government, are convinced that electric mobility represents a great opportunity for German competitiveness in the global economy. With the skills available here in Germany, our economy can respond to the global challenges of environmental protection and resource conservation and can itself set priorities in the establishment of a worldwide market for electric mobility.

The members of the NPE are united in their conviction that the German industries will join forces to develop products and solutions with which electric mobility "made in Germany" becomes a leading internationally recognized trademark as a component of future mobility systems.

The parties involved are aware that success is the outcome of a long-term process and requires a cross-sectoral consolidation of competencies. Rapid and joint action has to be taken if Germany is to achieve a leading position and not to fall further behind developments in economies such as China, Japan, France or the USA.

Against this background, the NPE presents its first interim report.

3 Global challenges in mobility as an opportunity to enhance German competitiveness in the global economy

The increased focus on environmental protection and resource conservation is resulting in changed mobility requirements throughout the world. The electrification of drivetrain technology involves opportunities to reduce the transport sector's dependence on oil, to significantly reduce emissions from transport and to evolve efficient transport systems. Tomorrow's mobility will be characterized by a diversification of technological solutions. To reduce the climate change impact of mobility, all solutions are necessary – even more efficient internal combustion engines and electric mobility.

The challenges involved in managing massive growth in volumes of traffic – in the growth regions of the emerging markets in Asia and Latin America and in the traditional industrialized nations – are becoming greater. New transport strategies are necessary that also form the basis for close intermodal interaction between the modes of transport in order to combine traditional mobility needs with new requirements of urban target groups with as little climate change impact as possible. Here, too, electric mobility provides the basis for new markets and business opportunities. It will create further sales potential for German products and services on the global market.

Electric mobility's contribution

The accelerated development of electric mobility will augment the vehicle product portfolio. The introduction of all-battery electric vehicles and (plug-in) hybrids will usher in a new technological era. The main changes will be in the automotive and component supply industries. The German industry must be proactive in shaping this change. This is the only way it will be able to assert and evolve its hitherto successful competitive position.

Electric mobility, as a technology linking sectors and as a basis of innovative services, will open up growth opportunities for Germany as a competitive business site. Growth in cutting-edge fields can help to safeguard wealth creation and employment in the long term and even to expand them. Interaction between flagship industries, in which Germany already plays a leading role internationally, is the key to a leading role on the international electric mobility market.

Technologically superior and sustainable strategies are to be developed along the entire electric mobility value added chain. These developments have to be progressed quickly and vigorously in order to prevent Germany from falling behind in global competition.

In vehicles, new technological questions have to be answered, such as the use of efficient and safe batteries, the realization of cost-efficient lightweight design or the integration of electric systems into new vehicle architectures. The electrification of the drivetrain will, in the long term, result in a reshaping of the automotive value-added chains and lead to the creation of new partnerships and attractive markets.

Challenges faced and contribution made by German businesses
In this field, in particular, German businesses are under pressure to succeed – the dynamic developments, especially in Japan and China but also in the USA and France, pose a challenge for the German industry.

The worldwide change in the energy system is a major determinant. The increasing amount of energy generated from renewable sources and the increasing changeover of final energy consumption from fossil energy sources to electricity call for a rearrangement of the interplay between energy generation, transport, storage and consumption. The progressive electrification of drivetrain technology can play an important role here. Combined with the establishment of an intelligent energy system (smart grid), it will make possible the optimum incorporation of flexible loads, for instance by charging electric car batteries at flexible times, preferably with electricity generated from renewable sources. As developments in battery technology progress, the batteries will be able to act as a control element to help stabilize the grid. As a result, it will be possible to ensure the integration of renewable energy while simultaneously improving the stability of the grid. Thus, electric mobility provides scope for efficient interaction between mobility and energy systems. It is also the basis for the development of new technologies and business models. This is where the German industry has especially good opportunities.

The need for specialists and skilled labour, especially in engineering and scientific disciplines and in the industrial/technical sector, will continue to rise. The availability of appropriately trained graduates and skilled workers when they are needed will be crucial to the successful establishment of the aforementioned skills.

Industries throughout the world realize that these opportunities exist and are endeavouring to exploit them. A race is underway to become the world leader in innovation and technology. Here, industrialization goes hand in glove with market development. Countries such as the USA, Japan, China or France have already launched programmes worth billions of euros to create totally new markets and provider structures within a short period of time. Existing competitive disadvantages are to be overcome by rapidly and successfully shaping the technological change associated with electric mobility (leapfrogging).

The German industry must interact with all groups of society and take rapid action to preserve and to be able to further expand its existing positions on the global market. A structural rupture in the value-added chain, leading to the loss of jobs, has to be avoided at all costs. Policy decisions have to support this. Targeted industrial, innovation and transport policies are important complementary measures to enable the automotive industry to make a smooth transition to the era of electric mobility.

SMEs and craft enterprises will play a major role in quickly establishing a lead market in Germany. They rapidly disseminate innovations to rural areas and, through their involvement in numerous collaborative applied R&D projects with academia, help to accelerate creative technological development steps. It is imperative that greater use be made in the field of electric mobility of this competitive advantage – which is not to be underestimated in the international race – enjoyed by our decentralized economic structure, which is dominated by SMEs.

The trade unions represented in companies play a major role as a link between the employees, employers and government policy. Trade unions will help to ensure that the system change in drivetrain technology that electric mobility involves is perceived not as a threat to existing jobs but as an opportunity for innovation and growth.

In addition, industry, academia, the Federal Government and the federal states must join forces with customers and users to formulate a strategy for developing the Federal Republic of Germany into a lead market for electric mobility. A framework has to be created in which innovative, customer- and environment-friendly and sustainable (i.e. resource-conserving) solutions can be made internationally competitive.

4 The National Platform for Electric Mobility – objectives and interim conclusions

Building on the 2009 National Development Plan for Electric Mobility, the National Platform for Electric Mobility (NPE) was established on 3 May 2010 at a meeting hosted by the Federal Chancellor. A joint declaration issued by government and industry confirmed the objective of developing Germany into a lead provider and lead market for electric mobility by 2020.

The National Platform for Electric Mobility aims to develop strategies with which the German industry can reach the top of the newly emerging global market for electric mobility. In addition, it is to identify ways in which electric mobility can also make a breakthrough in Germany, with initially one million electric vehicles by 2020.

The NPE brings together all the relevant stakeholders from industry, government, academia and society in Germany. They have agreed on a systemic and technologically neutral approach in order to achieve the described objectives in a market-focused manner. The NPE will take concerted action to concretize the necessary measures. It will send a signal, going beyond the measures, for a lasting integration of industry, government, academia and society.

These joint objectives of the NPE have assumed concrete form in the following points:

- Focus expertise and the necessary funding to develop a competitive advantage through research and development in the key sectors of electric mobility.
- Develop attractive and internationally competitive electric mobility products and solutions.
- Establish a substantial domestic market for the implementation of innovative technologies and services.
- Safeguard and expand high-value wealth creation and employment in Germany.
- Standardization at international level.
- Ensure the excellence of academic teaching and research and of initial and continuing vocational training to meet the requirements of electric mobility.
- Make an active contribution to environmental protection and climate change mitigation by means of clean and quieter mobility and further integration of renewable energy.

The NPE’s guiding principle is to leave the establishment of electric mobility to the market as far as possible and only to regulate it where this is necessary.

The interim conclusions are clear-cut. The National Platform for Electric Mobility has proved a success as a new form of intersectoral and interdisciplinary dialogue:

1. The analysis of the competitive position clearly illustrated that countries such as China, Japan, Korea, the USA or France launched ambitious programmes at an early stage in order to assume a leading role in international competition. If the Federal Republic of Germany is to achieve its own objectives, it has to take rapid, concerted and targeted action.
2. The NPE provides a forum for newly arising partnerships and fosters dialogue across industrial boundaries and occupational profiles. The different experiences, perspectives and objectives unlock potential for innovation and business in a newly emerging economic field.
3. Coordination between the industries on strategic issues, such as standardization, is facilitated and deepened by the NPE.
4. The interlinking of industries and sectors and branches of the economy has to be accelerated and placed on a permanent basis, because the lead provider and lead market functions for the complex system of electric mobility make interaction between all the relevant stakeholders necessary.
5. A list of issues with focus projects in the categories of research, development and skills development has been sent to the relevant Federal Government departments. In this document, industry and academia propose activities with project funding totalling around 4 billion euros over the period to 2013. The industry will make a significant contribution. The appropriate Federal Government departments are currently considering the level to which the proposed projects will be funded by the public sector.
6. The analyses and recommendations on skills development and training have been concluded. A full appraisal and plan of action have already been presented. Implementation will commence in the first half of 2011.
7. A definition of reference vehicles provides guidance to all working groups and acts as a common benchmark for their development activities. This definition can also support the cost-benefit assessment.
8. Concrete technical projects in the fields of drivetrain technology, batteries, materials, recycling and charging technology have been consolidated in research and technology roadmaps. They form the basis for the successful attainment of the objectives of the National Development Plan for Electric Mobility.
9. The availability of international standards is a key prerequisite for achieving the German objectives of becoming a lead provider and a lead market. Concrete measures and recommendations on this can be found in the standardization roadmap that has been published.
10. Initial recommendations for direct action, for instance in the fields of battery production, training and skills development, materials and resources or integration of electric vehicles into the power grid have been developed and submitted to the Federal Government.
11. There is a consensus that the technological excellence that distinguishes Germany has to be focused on systemic approaches, i.e. the integration of different industries, disciplines and market players. On this assumption, research and development is to be supported beyond the existing programmes.

The NPE is to provide answers to unresolved issues via a broad-based consensus among the social stakeholders. Given the complex challenges it faces, this approach would appear to be appropriate. The NPE participants are in agreement that they wish to jointly and successfully continue along the path upon which they have embarked and find answers to the issues raised in this report..

5 The German approach to becoming a lead provider and lead market

The NPE's stated objectives are that Germany is to become a lead provider and lead market. A clear definition and delimitation of these terms involves the determination of strategic objectives for industry, government, academia and society. This delimitation took place in the first phase of the NPE.

5.1 German industry as a lead provider of electric mobility

The conditions for successful attainment of these objectives are good. The German automotive industry is already a lead provider in the field of internal combustion engine drivetrain technologies. The German economy can also build on established competitive advantages in other key industries for electric mobility. Examples include expertise in sectors such as electronics and electrical engineering, heavy engineering, chemicals, steel and steel processing, metalworking, textiles, information and communications technologies and aviation.

The German transport and energy systems are among the most advanced in the world – they form the framework for optimizing the technologies and solutions for electric mobility. In the development of solutions to meet the global challenges in the transport and energy systems, in particular, this framework provides German industry with a head start in terms of experience that can rapidly be translated to the development of products and solutions.

With a turnover of more than 260 billion euros, the German automotive industry is one of the most important sectors of the economy in Germany and accounts for just over 20 % of the total turnover of German industry. At the same time, it is representative of the exporting strength of German industry. Three out of four cars built in Germany are sold abroad. The entire value-added chain provides over 5 million jobs, because a wide range of other sectors of industry are involved alongside the vehicle manufacturers and component suppliers.

If there are one million electric vehicles on the roads in 2020, and assuming a high share of local wealth creation, this could create new jobs in the German automotive industry and the various component supply industries. Stepping up the development and manufacture of batteries in Germany will unlock further potential in the electrical and chemical industries. Changes in production processes will open up additional prospects for wealth creation for the German heavy and plant engineering sectors. In particular, this will involve the development of necessary production technologies.

Existing wealth creation can only be safeguarded by means of international competitive strength. All potential is directly linked to the success of German products and solutions on the global market. The foundations for this success have to be laid quickly and resolutely:

- Building on its cutting-edge position as an innovation and quality leader, the German industry must develop new, and evolve existing, key technologies for electric vehicles, from batteries through vehicles to charging infrastructure and grid technologies. The new applications and services created as a result will be the foundation for the further optimization of industrial products.
- Integrated battery production for electric vehicles in Germany is possible, appropriate and imperative. In the case of lithium-ion cells for electric vehicles, there is an open competitive situation in the technology. The production technology has some catching up to do. For the first and second generations of lithium-ion technology (up to 2017), an understanding of the mechanisms along the entire interdependent chain of the battery and the automated, industrialized production of the materials, cells and battery components has to be established in the short and medium term. In parallel with this, there is the need to promote research activities for the evolution of lithium-ion technology and for research into post-lithium-ion technologies in order to secure technological leadership
- In the field of electric motors and power electronics, the German industry has an edge mainly in products that are developed, manufactured and used in smaller quantities and not necessarily for mobile operation. These technologies have to be upgraded for use in the automotive sector. The focus must be placed on cost optimization by means of better manufacturing processes and production.
- One of the strengths of the German industry is its system competence, which has to be widened in a targeted manner to cover electric mobility. To this end, it is necessary to optimize the interaction between technologies from the fields of drivetrain, battery, lightweight vehicle design, power generation and distribution and to incorporate information and communications technologies to a greater extent.
- The German tradition of an efficient and broad-based research and skills base in industry, SMEs and the crafts sector has to be realigned and optimized for electric mobility rapidly and in a targeted manner.
- International standardization is absolutely essential if technologies and solutions are to be commercialized and establish themselves internationally. The Federal Government is providing support to this aspiration at European and international level.
- The introduction of electric mobility will not make a significant contribution towards tackling climate change unless it is ensured that the energy requirements of the electric vehicles are met using renewable energy.

5.2 The Federal Republic of Germany as a lead market for electric mobility

The aim of establishing a lead market is to deploy innovative and competitive technologies and solutions and make them visible to everyone. The positive effects of electric mobility in terms of resource conservation, emissions reduction, integration of renewable energy and new approaches to mobility are to fully deploy their potential in Germany as well. Electric mobility is thus not only a technological but also a social and political challenge in the sense that it marks a transition to sustainable mobility.

The most important objective in establishing the lead market is to have one million electric vehicles operating on German roads by 2020. To provide guidance and describe a common benchmark, three vehicle categories have been defined:

- all-electric urban vehicle;
- family vehicle;
- light commercial vehicles with an electric range for urban traffic.

The lead market goes beyond just the number of electric vehicles. It is also about making technologies and intermodal fields of application with new business models visible.

The successful application of new technologies, solutions and services for the efficient incorporation of the electric car into the energy system via various stages of charge control and the use of vehicle batteries can be an important unique selling proposition on the global market and have a positive influence on the competitive situation of German technologies. The creation of the infrastructure conditions must be part of the lead market strategy.

Intelligent vehicle fleet programmes and the intermodal link-up with public transport systems will open up new business areas. Germany has a network of railways and buses that is one of the best developed in the world, and this network must be deployed strategically in the development of the lead market.

Electric mobility performs a cross-cutting function in the development, trialling and marketing of innovative transport and energy services. In both sectors, the problem-solving skills acquired in Germany for the optimum coordination of the technologies of the system can prove to be a major advantage in global competition.

Germany has a diverse economy. Between and behind the major industrial corporations there are a large number of small and medium-sized enterprises and craft-based companies. Compared with other countries, they offer a high level of broad-ranging expertise. With their skilled workforce, SMEs and craft-based companies provide many of the innovations and individual services that will be necessary to make Germany a lead provider and lead market. It is imperative that greater use be made of this competitive advantage – which is not to be underestimated in the international race – in the electric mobility sector as well. This is even more important in view of the fact that direct customer access by service providers and craft-based companies can make a significant contribution towards enhancing the uptake of new technologies.

In an initial phase of the market development, therefore, a small number of large and focused “showcases” are to be built as quickly as possible, based on the findings in the existing pilot regions and projects. They will perform an extremely important function in the establishment of a German electric mobility market. New technologies and solutions will be deployed. In these showcases, electric mobility will for the first time be made visible and accessible to the population at large. Exposure to the new technology is the basis for uptake and growing interest. Above all, these showcases have to actively encourage the public’s receptiveness to new technologies.

Industry and government are to consolidate skills and funds to make these showcases efficient. Use is to be made of the lessons learned from previous financial assistance programmes.

Going beyond the showcases, the course has to be set at an early stage for greater market penetration by electric vehicles, in support of the vision of becoming a lead market. Potential barriers to the development of a significant demand for electric mobility are to be identified and neutralized.

In the market launch phase, and especially in the pre-competitive funding of research and development, it will be crucial that government establish the right regulatory framework

The National Platform for Electric Mobility is thus developing proposals for an appropriate framework for the sustainable development of the lead market. The paramount objective is to ensure a sound basis for planning, so that both the supply and the demand sides have confidence regarding investment in electric mobility.

6 Findings of the working groups of the National Platform for Electric Mobility

Seven working groups were established to address the different fields of action. These working groups have published their own reports documenting their findings. The full reports can be downloaded from the websites of the following federal ministries: Economics and Technology; Transport, Building and Urban Development; Environment, Nature Conservation and Nuclear Safety; and Education and Research. Alternatively, copies can be obtained from the chairs of the working groups. The following synopses have been prepared by the working groups and refer to the current status of work and recommendations. In addition, the working groups have identified those issues that require clarification before the next report.

6.1 Drivetrain technology

The “Drivetrain Technology and Vehicle Integration” Working Group studies electric and electrified drivetrain systems for use in passenger cars and light commercial vehicles in terms of the objectives of the NPE. Transferring the findings to heavy commercial vehicles is also to be considered.

In this context, drivetrain systems comprise electric motors, power electronics components, high-voltage cabling, transmissions and diverse electric auxiliary units. The technological capabilities of the German industry that exist today in the field of electric motors and power electronics are based on products that are developed, manufactured and used in smaller quantities and predominantly not for mobile operation. Prerequisites for ensuring market entry by reducing costs are a speedy and significant increase in quantities and the establishment of automotive production technologies in learning cycles that follow one another as closely as possible. The benchmarks for electric traction in Germany are the production levels in other parts of the world, both those of today and those planned for the near future. The Chinese electric mobility programmes and the large number of hybrids being produced, especially by Japanese manufacturers and component suppliers, represent a genuine threat to, or genuine competition for, the German ambitions.

To provide guidance and describe a common benchmark, reference vehicles have been defined. This reference cannot and is not intended to be a full description of all the vehicles included in the future portfolio. The selection comprises a typical small urban vehicle, a family car and a light commercial vehicle, because these match initial deliberations on electric vehicles in urban areas. Today, the aforementioned vehicle segments account for around 60 % of the total fleet on German roads. The degrees of electrification of the drivetrain systems can vary widely. Vehicles with an all-electric drivetrain are conceivable, as are plug-in hybrids with an internal combustion engine and an electric drivetrain or range extender variants. What all the variants considered here have in common is that they can be charged by connecting them to the external power grid.

Achieving the objectives regarding lead provider and lead market for electric mobility calls for a coordinated and focused approach heading in the following direction in the field of electric drivetrain systems (values for 2010 versus 2020):

- The costs of the overall system have to be reduced by two thirds.
- The power density (kW/l) and power-to-weight ratio (kW/kg) have to be doubled.
- The average efficiency in operation has to be increased by more than 5 percentage points.
- Reliability and quality have to be improved.

To this end, comprehensive packages of measures in the fields of research, development and production technologies have been identified and consolidated to form a technology road map.

In the next **product generation**, power electronics will be based on electronic components, power modules, plugs, housings and cables that are already in use in the industrial environment. In electric machines, magnetic circuits made of iron and permanent magnetic materials will be linked to copper or aluminium windings. The manufacturing methods and quality assurance procedures are adapted to the quantities that are currently customary in industrial drivetrains and have proved themselves over decades.

In the **product generation** entering the market in the period **to around 2017,** the harmonization and standardization of plugs, housings and cables will permit economies of scale. The electronic components will have less power dissipation and improved cooling systems, so that less effort is required to cool them. In this period, in the field of system integration, new, holistic system architectures (including for thermal management) are to be developed at the whole vehicle level and the strategies for highly integrated drivetrain systems are to be evaluated. At the component level, progress must be made with the in-vehicle charging technology, the range extender variants and the starter generator.

The **2020 product generation** will achieve cost improvements by means of improved electronics with less power dissipation and even greater integration (power electronics and motor). New materials (see also Working Group 5) will be used in the drivetrain system and vehicle. Improvements to the ferromagnetic materials for the magnetic circuits of the motors and to the permanent magnetic materials are possible. New semiconductor materials will make it possible to further reduce power dissipation, which will permit an increase in power density and thus also new integration and cooling strategies. In all strategies, the aspects of recycling and production of secondary raw materials are to be taken into account. The increasing degree of functional integration will make the components more complex and will result in more stringent quality requirements to be met by production technologies that are suitable for mass production, robust and scalable. The action required can be described as follows:

- development of winding, cutting and packaging technologies that are suitable for mass production and automated implementation (electric machine);
- automated assembly of complete mechatronic systems;

- adapted production processes for new vehicle structures (e.g. lightweight design);
- improving the efficiency of the manufacturing steps and new assembly and connection technologies for power electronics (provision, assembly, connection to plugs and housings, testing, system integration) for automotive production.

The development of simulation and calculation tools for manufacturing processes, for durability and reliability forecasts, for functional descriptions and for the optimization of the electric drivetrain systems, plus the development of appropriate testing procedures, is a major prerequisite for the successful development of drivetrains and vehicle integration, and must be pursued proactively.

Consolidation, acceleration and promotion of these activities, ranging from research to product- and production-related development in centres of excellence and lighthouse projects for drivetrain technology and vehicle integration, is recommended. The following topics are especially suitable for lighthouse projects:

- development, demonstration and trialling of the suitability for everyday use of vehicles with different degrees of electrification and of the drivetrain systems and components (including lightweight design);
- development of a modular architecture and trialling it by demonstrating various technological solutions;
- standardization and optimization of components and the external and internal interfaces of the electric drivetrain system;
- holistic energy and thermal management at whole vehicle level;
- scalable production in a virtual model factory.

Existing instruments of cooperative industrial research should also be used for this purpose.

6.2 Battery technology

Current situation and general framework
The battery system for powering vehicles is the key component in an electrified drivetrain. The battery is instrumental in defining the efficiency of electric vehicles and is the element which has by far the greatest share of wealth creation. A battery comprises the cells, the battery management system including cell monitoring, the electrical and sensor systems, the safety elements, the cooling periphery and the housing, and has to be regarded as a system. 60 to 80 percent of the entire wealth creation in a battery is determined by the cells. The cell chemistry and cell design are crucial factors determining the operation of the overall system.

Depending on the application, different types of battery and cell are used. Because of their degree of maturity and the available manufacturing capacity, the automotive industry currently uses almost exclusively nickel-metal hydride (NiMH) technology for high-performance battery applications (hybrid applications). Compared with NiMH batteries, lithium-ion batteries have an energy density that is several times higher at the system level. To rapidly implement electric mobility strategies on the basis of all-electric plug-in or range-extender vehicles with the aim of being able to drive as far as possible in all-electric mode, the industry is therefore committed to evolving lithium-ion technology. .

The application for drivetrains in plug-in or range-extender vehicles and in all-electric vehicles calls for large batteries as energy storage devices with a specific chemistry. The basic elements are large cells compared with consumer and hybrid applications. The requirements to be met by large lithium-ion cells are significantly different to those to be met by consumer cells and cells for hybrid applications. They have to offer an energy density that is several times higher, they should be able to withstand at least 2,500 full charging cycles and exhibit a service life that is appropriate to the car. Because of the amount of stored energy, the cells and batteries to be used in electric vehicles have to satisfy much more stringent safety requirements. In the case of lithium-ion technology for hybrid application, there are already ranges of cells, batteries and vehicles on the market, whereas the race to develop and deploy high-energy cells for traction batteries (battery powered vehicles) is still fully open. Here, German companies can seize the opportunity to compete among the world leaders and establish a stable supply chain from material production to the manufacture of cells and batteries,

At present, countries such as China, Japan, Korea and the USA are providing massive financial assistance to support their domestic battery industry (for instance the USA: the Department of Energy is providing funding totalling $ 5.4 billion for the period from 2010 to 2011, thereby clearly focusing on the industrialization of cells and batteries).

Requirements to be met by battery systems

In the development of lithium-ion batteries for the automotive industry, eight criteria have to be met in equal measure in order to establish the battery technology in the corresponding electric vehicles on the market in the long term (see Figure 4.2.1). This spectrum of requirements makes the batteries for mobile applications considerably different to the cell packs in the consumer sector. Thus, understanding the battery as an overall system and knowledge of the options for integrating it in the vehicle represent key expertise. This knowledge makes possible the targeted development of cell materials and cell mechanics and exists in abundance in Germany.

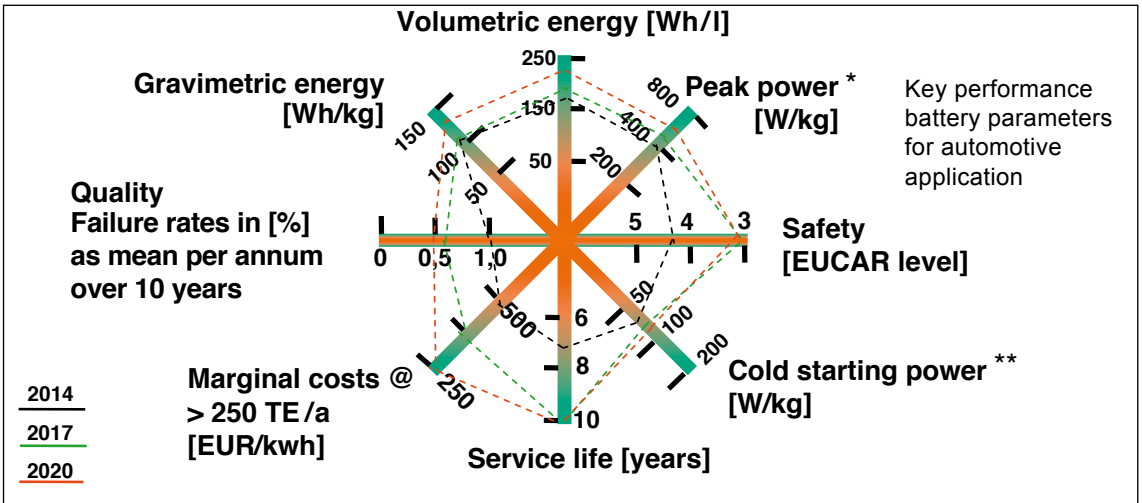


Figure 4.2.1: Key performance parameters, battery systems for reference vehicle 1, 2014–2020, for a battery electric urban vehicle (cf. Working Group 1, Drivetrain Technology).

A development cycle for lithium-ion batteries, starting with the materials and progressing through cell design, the cell, the battery to the mass produced vehicle, lasts around 10 years. Up to and including the vehicle generation that will be on sale after 2020, market entry and market penetration will have to be achieved with this continuously improved technology.

The diagram shows that energy and power density, in particular, will only improve slightly by 2020 compared with today. Significant improvements are likely in the fields of safety and service life. Moreover, battery prices will fall significantly by 2020 as a result of an increase in quantities and improvements in production technology, and will then range from 250 to 300 euros per kWh.

The necessary research into post-lithium-ion technologies must start as soon as possible so that, if it is successful, they could be used in electric vehicles after 2025.

Conclusions and recommendations for the establishment of battery technology in Germany

Integrated battery production for electric vehicles in Germany is possible, appropriate and necessary. In the case of lithium-ion cells for electric vehicles, there is an open competitive situation in the technology.

The fundamental strengths in Germany include not only a strong automotive industry with a high level of skills for the car as an overall system, but also, and above all, an innovative chemicals industry for electro-chemical applications and good research infrastructure, both public and private. There is a need for action in the development of chairs in battery technology and electrochemistry, the strengthening of production technology and plant engineering for cells and batteries and the development and production of materials in Germany.

If the aforementioned objectives of the NPE are to be achieved, it is necessary that a skills base be established in two fields of battery technology.

First, a profound understanding of the mechanisms along the entire process chain of the battery has to be developed, especially regarding the safety and service life parameters.

Second, priority must be given to the industrialization of cell and battery technologies, especially in terms of reducing costs.

As a major step towards addressing these areas of action and verifying the findings in practical applications, Working Group 2 strongly recommends the establishment of pilot plants along the entire value added chain of the battery system. The components involved here comprise:

- resources/materials;
- active materials;
- cell components/cell;
- cell modules with cooling;
- electrical/electronics systems;
- battery modules;
- battery housings.

If academia, industry and the Federal Government adopt an appropriate agenda that is interdisciplinary, based on a division of labour and financially complementary, it will be possible to establish Germany as a integrated location for the production of battery systems.

6.3 Charging infrastructure and grid integration

The establishment of a mass market for electric mobility requires an efficient, economical charging infrastructure. It must be possible for consumers to charge their electric vehicles safely and conveniently. In the energy system, the prime consideration will be to make full use of the possibilities for electric vehicles to make a contribution towards optimizing the integration of renewable energy. Capacity constraints in the power grids are not likely until there has been sizeable market penetration or until there is a local accumulation of charging processes. In the medium term, it will be necessary to exploit the potential provided to the energy supply industry from vehicle-to-grid and grid-to-vehicle applications.

As a basis for quantitatively validated recommendations regarding the installation of charging infrastructure and necessary measures to ensure grid integration and the exploitation of potential, the Working Group presents initial observations on the following thematic areas:

Charging point technology roadmap

The technology of the charging point as a basis of the installation of infrastructure will make considerable advances in development over the next ten years. The variety of charging options will increase and the performance parameters will greatly improve. There will be significant improvements in all requirement areas: speed and convenience of charging, safety and, above all, in the communications technologies that are used for grid integration. Fast charging and fast top-up charging will, depending on the capabilities of the batteries, be feasible by 2020 and will make charging times of around 10 minutes possible. For a significant increase in charging speeds with charging currents of more than 150A, solutions will, in the long term (post-2020), have to be sought in a post-lithium-ion technology.

	Home Charging			Public AC charging points				Inductive charging				DC charging		Fast charging
Charging power	3,7 kW	11 kW	22 kW	3,7 kW	11 kW	22 kW	44 kW	3,7 kW	11 kW	22 kW	60 kW	< 20 kW	< 50 kW	60 kW
Voltage	230 V	400 V	400 V	230 V	400 V	400 V	400 V	230 V	400 V	400 V		450 V dc	< 450 V dc	400 V dc
Current	16 A	16 A	32 A	16 A	16 A	32 A	63 A	16 A	16 A	32 A		32 A	< 100 A	150 A
From SOC min	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %	30 %
To SOC max	100 %	100 %	100 %	100 %	100 %	100 %	80 %	100 %	100 %	100 %	80 %	100 %	80 %	80 %
Duration of charge (20 kWh battery)	3,8 h 230 min	1,3 h 80 min	0,6 h 40 min	3,8 h 230 min	1,3 h 80 min	0,6 h 40 min	0,3 h 20 min	3,8 h 230 min	1,3 h 80 min	0,6 h 40 min		0,6 h 40 min	0,3 h 20 min	0,2 h 12 min
Chronological availability 2010–2020														
2010–2013	+	+	+	+	+	+		It is hoped that data will be available in time for the second report, following consultation with vehicle manufacturers				+		
2014–2017							+						+	+
2018–2020														

Chronological availability of charging technologies

In terms of costs, there is scope for economies of scale, but these can only be described as a function of quantities. A deepening of the dialogue with the OEMs regarding technological preferences has to be sought, and standardization requirements have to continue to be identified and pursued. Applied research and development is to be intensified.

Electric mobility and the conflicting interests of the grid and renewable generation
Ambitious programmes for the expansion of renewable energy confront the major economies with radical changes in the energy conversion chain, from generation through transport to consumption. In this respect, Germany is ahead of much of the world. The aforementioned change is taking place in Germany and is speeding up. The development of a smart grid is a major prerequisite for guaranteeing the further expansion of renewable energy with the customary security of supply.

On the consumer side, the electric car can become a major system component. During the market launch phase, a comparatively simple charging infrastructure can form the basis for the spread of these vehicles. However, this infrastructure should also offer the option of a simple technological upgrade in order to facilitate smart integration into the grid in the medium term. As market penetration grows, the energy supply potential will increase. The development, trialling and successful application of technologies, solutions and services in the development of the smart grid and the efficient integration of the electric car into the grid via various stages of the vehicle-to-grid approach will be an important German unique selling proposition on the global market.

Potential inherent in the integration of electric mobility into the smart grid
If the energy supply industry is to benefit from electric vehicles in the smart grid, it is necessary not only that these vehicles have adequate market penetration, but also that there be an appropriate density of information in a grid area and smart grid control. The increasing benefit of smart systems is usually offset by increasing costs. When assessing the options, therefore, the benefit for customers and/or grid operation and/or service providers has to be viewed in relation to the costs.

Stipulations on infrastructure requirements based on mass marketing scenarios will be made before the second report. On the basis of these stipulations, the impact on grid capacity will be calculated and the potential for the energy supply industry of the future integration of electric vehicles into the grid infrastructure will be identified. Information and communications technologies have an important role to play – both in the development of a smart energy system and in the supply of energy to and the integration of electric vehicles. ICT aspects will be described and assessed in the second report. The findings of this analysis will then result in the recommendations for the policy framework.

6.4 Standardization and certification

Standardization in the field of electric mobility is characterized by some aspects that distinguish it from standardization in the past. The special challenge is to coordinate and integrate the multiplicity of activities of different sectors and branches of industry in a manner that meets requirements and is properly targeted.

Electric mobility is a quantum leap innovation that calls for new, holistic systems thinking. In the past, standards have been regarded separately for the domains of electrical engineering/energy engineering and automotive engineering. There is as yet no holistic approach and clear thematic classification for merging these domains and for the resultant new points of contact and interfaces.

The first task of Working Group 4 is to develop a standardization roadmap that covers and coordinates all the relevant standardization activities in the field of electric mobility and from which recommended courses of action, including time-related prioritization, are derived. Appropriate measures are to be initiated on this basis. Its second task is to address the licensing and regulatory issues involved in electric mobility. Separate working papers on these issues will be adopted by the Working Group, clearly documenting the boundaries.

The roadmap that has been developed contains the common perception of all the players involved in electric mobility – ranging from vehicle manufacturers through the electrical industry and energy suppliers to academia, trade associations and government – concerning the strategic course of action with regard to the standardization of electric mobility. To summarize, the focus is on the following recommendations – supported wholeheartedly by all the stakeholders – for encouraging the spread of electric mobility:

- Political support at the European and international levels is necessary.
- Standardization must be rapid and international.
- Coordination and focusing are imperative.
- Standardization must be clear and unambiguous.
- The implementation of a uniform charging infrastructure throughout the world is necessary.
- Existing standards must be used and evolved without delay.
- It is essential that the industry be involved in European and international standardization.

In addition to this standardization roadmap, Working Group 4 has presented a report on automotive engineering provisions and dangerous goods provisions. This report identifies the ongoing adaptation activities with a view to boosting the rollout of electric vehicles. For the approval and licensing of motor vehicles in Germany, the provisions of European regulations and directives, in particular, are mandatory. In the future, this legislation will increasingly draw on ECE regulations or global technical regulations. These are developed at the international level by the “World Forum for Harmonization of Vehicle Regulations” (WP.29) at the United Nations Economic Commission for Europe (UNECE).

6.5 Materials and recycling

Innovative materials are the basis for technologically superior and sustainable strategies for competitive electric vehicles. Because the choice of material is at the beginning of the value added chain, it has a major impact on the downstream processes. Although it has some catching up to do (in some cases a considerable amount), the German industry has enormous potential in the field of innovative materials for helping to achieve the objectives of the National Platform for Electric Mobility. Unlocking this potential is a great challenge, with the aim of making electric mobility affordable. This includes the industrialization of the necessary technologies in processes that are suitable for mass production.

The major requirement areas include:

Battery materials
The development and manufacture of high-capacity and low-cost batteries is the key to the success of electric mobility. The capacity of the batteries is determined to a large extent by the active materials used for the chemical cell components (cathode, anode, electrolyte, separator, additives) and their interaction.

The energy densities achievable in first and second generation lithium-ion batteries with the materials currently available, and the associated limitation of range, represent a great obstacle to the commercialization of electric vehicles in large numbers. Moreover, a large-scale rollout requires scope for optimization in the performance parameters of service life, safety and costs. New high-voltage cathode materials based on lithium-ion technology in the 5 V range (third generation) represent a first step towards the production of higher energy densities. Cathode and anode materials have to be developed for this, as do stable electrolytes and separators. The aim is to provide these by 2015.

However, significantly higher energy densities are not likely until fourth generation batteries based on post-lithium ion-technology are available. The metal-chalcogen systems belonging to this generation (such as lithium-air, lithium-sulphur, zinc-air) have been established as primary cells for a long time but – with the exception of initial lithium-sulphur prototypes – have not yet been realised in multi-rechargeable secondary systems. The aim is to make the first prototypes of these new battery systems available for mobile applications as of 2020. This will require substantial research efforts and the creation of cross-sectoral industrial and research consortia in order to resolve basic material and systems issues concerning cyclability, stability and safety.

In addition to the intensification of research activities, the industrial establishment of the battery process chain is to be progressed. The investment required for this, which is substantial and involves a high level of entrepreneurial risk, will not be feasible without the help of structural policy incentives by the government and the commitment of all the sectors involved.

Structural and lightweight construction materials

The energy requirements and dynamics of an electric vehicle are determined to a large extent by the vehicle mass. Despite the likely increase in the capacity of energy storage devices, it is therefore imperative that a considerable battery-related increase in mass be compensated for if the requirements regarding range, speed and vehicle handling are to be met. This requires a shift from thinking purely in terms of materials towards functionally inclusive lightweight systems. This means taking a holistic approach to the mass, costs and reliability of the technical system, focusing not on the individual components but rather on their interaction in the overall system. To this end, it is necessary to integrate materials yet to be developed and existing materials in a multi-material approach.

This involves both the systemic development of lightweight and composite materials adapted to the application and the development of specific lightweight structures for electric vehicles. Within the framework of Working Group 5's lightweight design roadmap, various strategies have been outlined, ranging from conversion design to purpose design. The aim is to make multi-material strategies for mass produced vehicle structures competitive by 2020. Likewise, material systems that can be specifically adjusted and fail-safe materials are to be made available for mass production.

The requirements derived from the objectives of the roadmap to be met by the materials and material pairs optimized for these applications identify the areas of action in the research and development of the material manufacturers and the processing industry. The selection of the various materials is governed by the following principle: cost-benefit aspects and a balanced economic and ecological performance of the materials used must be major decision-making criteria. Existing and new value added chains that are required for material manufacture and processing have to be shaped on the premise that existing jobs have to be safeguarded and new jobs created in this country.

Resource security and recycling

The demand for resources for electric mobility (e.g. cobalt, rare earths, et al.) will rise sharply in the future. The availability of adequate numbers of these resources and materials will have a direct influence on the success of the electrification of mobility and the competitiveness of the industries concerned, because Germany will continue to be a country with few natural resources. The secure supply of primary resources is directly linked to the geopolitical situation at any given time and must therefore also be addressed politically. In addition to implementing the Federal Government's raw materials strategy, the enforcement checks for the EU export of economically strategic metal components, in particular, are to be improved, so that the recycling industry has easier access to resources under competitive conditions.

Even though they will not have an impact for a long time, because of the life cycle duration of electric vehicles, cost-effective recycling technologies should be developed today in order to reduce dependence on strategic primary resources. Germany should seek technological leadership in the tapping and recycling of these secondary resources. This involves the design of recyclable products, the establishment of the entire process and logistics chain as well as effective incentives for the final consumer.

Materials for other key components
Through the development of new materials for specific assembly sections that are critical to the success of electric mobility, such as electric drivetrains and bodies, the energy consumption of the main and auxiliary units can be further reduced, resulting in a greater range and improved driving comfort of electric vehicles.

These materials include, in particular:

- soft and hard magnetic materials for use in highly efficient drive motors;
- materials for range extenders, such as high performance fuel cells or internal combustion engines optimized to a single operating point with low-temperature catalytic converters;
- materials for efficient solar and thermal management, such as high performance insulating materials or innovative IR-active pigments for windows and paints;
- materials for the evolution of capacitors, resistors and inductors (passive components);
- materials for power electronics and integrated circuit packaging.

In the aforementioned fields addressed by Working Group 5, numerous projects are already being implemented today. However, because of the existing pressure to act, these projects have to be intensified further. This will not be possible unless concerted action is taken by industry, the research community and government within the framework of the National Platform.

6.6 Training and skills

In the first phase of the NPE, Working Group 6 – Training and Skills – has explored what has to be done in order to successfully gear initial and continuing academic and vocational training to the objective of developing Germany into a lead provider and lead market for electric mobility by 2020. An analysis was conducted to compare the range of academic and vocational training courses (initial training and continuing and advanced vocational training) with the skills required in electric mobility, thereby identifying strengths and weaknesses and deriving, prioritizing and quantifying the need for action.

Academic training

Electric mobility requires a large number of newly trained specialist workers and the timely establishment of the necessary skills base. For the academic disciplines to be included, this development poses a challenge in that many sub-disciplines have to work together and find a common interlinked academic basis. For businesses, it is of great importance that they can recruit suitably trained graduates as soon as they need them.

As a rule, such a development takes place over a longer period. However, the NPE's objectives now involve ensuring, in the short term, that the engineering courses relevant to electric mobility are system-focused and interdisciplinary in keeping with the requirements. The Federal Government's National Development Plan for Electric Mobility addresses the entire value added chain. In all parts of this chain, there is a need for training and for the establishment of a skills base. This is especially true of the three core issues of electric mobility: electrochemistry/battery research, power electronics and lightweight design. Moreover, an approach that views electric mobility as an overall system necessitates the integration of specialist disciplines that have not so far been involved. The following have been identified: sociology, economics, social sciences and humanities, in order to appropriately address the subjects of marketing, business management aspects, future business models and advanced services, as well as, in particular, the rooting of electric mobility in society.

A random analysis of competition with foreign institutions of higher education in Italy (Politecnico di Torino/Politecnico di Milano), Japan (Chiba University) and the USA (Ohio State University) does not show that training at German higher education institutions is already lagging behind as a result of special efforts in other countries. Nevertheless, there is a danger that, as a result of ongoing or announced government funding measures, the foreign institutions of higher education will expand their skills base in the short term. This is especially true in view of the fact that a drive is planned in all countries to provide laboratories at these institutions with more equipment and that new chairs are to be established.

Vocational training
In the metalworking and electrical industries, the electrical and information technology trades and the automotive industry, modern, forward-looking occupational profiles have been developed and implemented in recent years which meet the skills requirements of this dynamic sector. A prominent feature of the new regulated professions is that they have broad-based skills profiles. They are based on a holistic occupation perception that is guided by business processes and focuses on customer relations. These process-based occupational profiles offer great advantages wherever dynamic change, a multiplicity of innovations or complex questions – and these are characteristic of the fields of activity of electric mobility – pose challenges in day-to-day working life. The existing vocational training courses are open to the integration of new skills derived from the fields of activity and associated business processes of electric mobility. New occupational profiles are not necessary in either vocational training or advanced training. What is necessary, however, is the development and integration of skills specific to electric mobility. For the field of continuing vocational training, this would ideally take place within the framework of skills development based on work processes.

The objective of becoming a “lead provider” involves cross-sectoral cooperation with new value added chains, new business processes and workflows and processes of technological transformation. It will not be possible to manage these changes unless the sectors have staff who support and shape this change. Businesses must therefore ask themselves whether the right experts are on board at the right time and are contributing the necessary expertise. But this is the crux of the problem, because while the sectors’ need for skilled labour and skills requirements are rising, their workforces are becoming older and new recruits scarcer. In this way, demographic scenarios that have so far been abstract are becoming pressing challenges for companies.

If the environment changes and the sectors keep reinventing themselves, initial and continuing vocational training, and thus human resources development, in businesses will need new strategies to secure competitiveness in the future. Businesses will not be able to meet the shortage of skilled labour unless they succeed in unlocking new potential for the industrial/technical occupations and the engineering courses. To this end, the image of these occupations needs be improved and repositioned in the context of electric mobility.

6.7 General framework

In the General Framework Working Group (WG 7), experts from industry, academia, society and government formulate recommendations on the general framework for the sustained and successful development of the market for electric mobility in Germany.

The Working Group will present a self-consistent, phased programme of measures for the second report of the NPE. The findings of the NPE available at the time of the interim report (including reference vehicles, costs, market development phases) will form the basis for this programme proposal.

In order to structure the work process, four subgroups have been formed.

1. The “Customer” subgroup consolidates and evaluates information on the expectations and willingness to act of future users and analyzes the national and international findings available so far on the use of electric vehicles.
2. The “Vehicle” subgroup is developing an appraisal of the current technological and commercial potential inherent in electric mobility and – derived from this – the possible incentive tools.
3. The “Infrastructure and Energy” subgroup assesses possible models for an electric mobility charging infrastructure and derives recommendations for regulatory measures for the installation of an appropriate charging infrastructure.
4. The “Employment and Competitiveness” subgroup is developing evidence relating to the value added chains of electric mobility and possible measures to secure employment in Germany and to enhance the international competitiveness of Germany as an industrial location.

The findings of the working group available for the interim report show that, because of the high costs of manufacture, electrified vehicle strategies will, in the medium term, have a significant drawback in the total cost of ownership (TCO), i.e. the costs of acquisition and operation, compared with conventional vehicles. Moreover, analyses of potential buyers’ willingness to pay show that users are highly reluctant to pay a significantly higher total cost of ownership for electric vehicles than for vehicles with an internal combustion engine. Combined with the fact that segment penetration on the supply side will continue to be low over the next few years, this means that intelligent funding will be required if the objective of one million electric vehicles by 2020 is to be achieved.

Infrastructure, transport policy and financial measures can make a contribution to this. To support a successful transition to the mass market, the NPE has produced a catalogue of measures that will be published in the NPE’s next report. The aim is an intelligent combination of suitable instruments, geared to the specific need for action among various user groups in any given phase of market development.

User groups and phases of market development
From a **short term** perspective, the user group most relevant to the development of the market for electric mobility is the average commercial customer with a special focus on sustainability and technology – irrespective of the size of the fleet they operate. Commercial use covers a wide spectrum of applications ranging, for instance, from small and medium-sized enterprises to commercially operated fleets used by companies for distribution operations, by technical and social services or by mobility providers offering car sharing services.

Compared with private users, there are numerous advantages in the use of electric vehicles by commercial users:

- The fact that the vehicles are kept for a shorter period means that there will be quicker market penetration of electric mobility because more vehicles will be available on the second-hand market after their initial use by commercial operators.
- Fleet operators focus on a TCO approach, which makes it possible to exploit the advantages of the lower running costs of electric vehicles. Fleet operators respond to calculable incentives (taxation, depreciation, etc.) much more quickly than private operators.
- Fleet operators can use different funding models to those used by private customers.
- More and more companies are explicitly including sustainability criteria in their choice of vehicles and fleet management, which will support an early and demonstrative deployment of electric vehicles.
- In many cases, the area of operation is identical to the optimum usage profile of electric vehicles. Thus, vehicles engaged in urban and regional distribution operations have a usage profile with a clearly defined mileage per day and frequent start/stop operation. The vehicles can be recharged at the depot overnight and in the operating environment during the day. This will reduce the pressure on the installation of public charging infrastructure.
- If there is sufficient concentration, fleet operations provide the possibility of testing integrated systems in combination with intelligent fleets in intermodal services (combination with public transport operators, intelligent communications and accounting processes, smart home and smart grid approaches, grid-to-vehicle). This will also make it possible to develop and deploy schemes for the integration of renewable energy.

The main conditions encouraging the purchase of electric vehicles by commercial buyers are fiscal instruments and investment incentives, such as special loans provided by the state-owned development bank, the Kreditanstalt für Wiederaufbau (KfW).

From a medium term perspective, the private market for electric mobility will become increasingly interesting, with the so-called “early adopters” performing a pioneering function for mass marketing

On the basis of the evidence available at present, this target group will probably have the following features:

- lives in conurbations;
- uses own garage/parking space;
- has a relatively high net household income;
- can probably use an official car with above-average frequency;
- has a second or third car but does not drive more than 100 km a day in any of the vehicles or has no need for a long-range vehicle;
- is “technology-savvy” (20 to 30 % in this group) rather than “green”.

The group of early adopters will then charge their electric vehicles (second car) either in their garage at home or at their place of work and use the vehicle for short journeys or as a commuter for precisely defined routes.

In order to encourage uptake for investment in the installation and operation of charging points at companies’ premises (for use by staff on the company’s car park, in the vehicle fleet, etc.) and commercial sites (customer car parks at shopping centres, restaurants, railway stations or airports), appropriate instruments such as accelerated depreciation are being studied. On similar lines, investment by residential property owners in the installation of charging infrastructure, for instance in underground car parks, should be encouraged by tax incentives and KfW funding and accompanied by adjustments to building law.

From the initial findings from the pilot regions and projects, the conclusion can be drawn that public charging infrastructure providing blanket coverage in the next few years will not be crucial to the market success of electric mobility. The minimum coverage for the psychological uptake of electric mobility is to be ascertained on the basis of the progress on the market and expressed as the necessary number of publicly accessible charging points. Further incentives should be considered if there is a backlog. The extent to which fast charging stations influence the various user groups’ decision to buy and usage profile and thus encourage market penetration is being studied and will depend on the market phase at any given time. The main conditions here are those that will facilitate the installation of charging infrastructure in the public, semi-public and private sectors and encourage its penetration.

The regulatory and competition models required for the development of sustainable infrastructure are still being coordinated. Essentially, two model approaches are currently being discussed: “commercial installation and operation of public charging infrastructure” and “installation and operation of public charging infrastructure by a partially regulated operator”. The spectrum of variations in the model approaches will be studied in depth and assessed before the second report.

The General Framework Working Group is engaged in a close exchange of ideas and experience with the assembled experts of the NPE to perform preliminary work to develop various business cases and an overall macroeconomic approach. The findings published in the interim report represent the key input variables for this. The models, currently being developed, to calculate the microeconomic total cost of operation (TCO), including the assumptions on price-volume sensitivity and on the rollout of public charging infrastructure and the value added chains of electric mobility, will form the basis for calculating appropriate business cases and deriving recommendations for action by the date of the next report.

The clear objective is to present a consistent, phased programme of measures, taking explicit account of the various phases of technology development, customer groups and business models, while avoiding any hasty commitments. The individual measures must satisfy the following, jointly defined criteria for successful economic, energy, climate change and transport policies:

- **Effectiveness –** Is the measure likely to generate higher demand?
- **Efficiency –** What is the relation between the costs of the measure and its concrete effect?
- **Avoidance of deadweight effects –** Would the outcome have been achieved in a similar form without the measure?
- **Sustainability of the measures –** Will the measure result in sustainable resource conservation?
- **Avoidance of distortions of competition –** Will the measures support a level playing field and prevent barriers to market entry?
- **Impact on wealth creation in Germany –** Will the instrument have a positive impact on safeguarding and/or expanding wealth creation in Germany?

7 Initial recommendations

7.1 Becoming a lead provider and shaping a lead market for electric mobility

One of the major factors contributing to the strength of German industry is its success on export markets. Extending the “Made in Germany” seal of quality to electric mobility is essential if a strong position on the new market is to be achieved and key German industries are not to forfeit the competitive advantages they currently enjoy.

Establishing a skills base and capturing key positions on the world market are priorities. The efforts made within the industry and the funds to be committed in the future should, in the medium term, be concentrated on securing Germany’s role as a lead provider. The focus is on research and development in all sectors and the establishment of an integrated value added chain. The ambition of becoming a lead provider in electric mobility is closely connected to technological leadership in the field of batteries. In this context, industrialization and manufacturing skills are a major success factor.

The lead market is closely linked with the ambition of the German industry to become a lead provider. It must demonstrate the contribution made by electric mobility to sustainable mobility and send strong signals on the global market by successfully applying cutting-edge technologies and solutions in Germany.

The general framework will play a major role in achieving the lead market objective, especially in the initial phase of mass marketing. The NPE is developing a catalogue of measures to support a successful transition to mass marketing. This catalogue comprises a wide range of different instruments, including financial and fiscal options, adaptation of traffic law or the creation of infrastructure conditions. An assessment of the measures also has to take into account an international comparison with the general framework in other European and non-European countries. Every effort must be made to create a common competitive environment in Europe in order to achieve, in particular, the objective of a German lead market of one million electric vehicles by 2020.

Future activities will involve investigating how elements of this catalogue can be appropriately consolidated to form an effective package. To ensure the necessary planning certainty for both the installation of the infrastructure and forthcoming investment decisions, clarity will be established in the near future regarding the measures to be applied in the individual phases. The recommendations to policymakers on shaping and implementing a package of measures for a successful transition to mass marketing will be presented before the NPE’s second report.

7.2 Research and development as the key to success

Private sector involvement and public sector funding should continue to focus on laying the foundations for achieving the desired innovative advantage.

Pre-competitive funding instruments with a broad impact have to be expanded. This should involve rethinking some of the funding mechanisms and further optimizing them across departmental boundaries within the Federal Government. It must reflect the approach of a cross-system development of products and solutions.

The funding and implementation of stand-alone projects is only one step. What is more important is that a major effort be made to better dovetail industrial research and development with university and non-university research and teaching.

7.2.1 Implementing defined research, development and skills projects

In the years ahead, the Federal Government should continue to support research, development and skills projects by providing additional funding in order to promote the development of electric mobility beyond existing programmes (Second Economic Stimulus Package, etc.). Government, industry and SMEs are collaborating closely.

Technology roadmaps, combined with the research and development requirements derived from them, have been drawn up in the working groups of the National Platform for Electric Mobility and submitted to the Federal Government along with the reports of the working groups.

The working groups have prioritized the projects involved in terms of time.

The projects are to be reviewed in this order under current state aid rules to determine whether they are suitable for funding. Subsequently, the funding rate to be applied in each case is to be calculated using the existing rules for funded projects.

7.2.2 Optimizing the value added chain of knowledge

Germany has a very intricate and highly specialized research and development landscape. Nevertheless, the productive cooperation between university and non-university institutes and between academic research and industry could be intensified even further. The guiding principle of intersectoral cooperation is that the funding landscape should focus on issues and problems. This involves academic institutes, industrial corporations and centres of excellence of the craft professions cooperating at the pre-competitive stage.

A more precise definition will be provided, and recommendations on viable research funding strategies will be developed, by the spring of 2011. The result will be a feasibility analysis and, if the appraisal is positive, a strategy for development, funding and integration into the higher-level problem-focused research projects will be presented.

7.3 Boosting technological development in lighthouse projects

The aim should be to comprehensively consolidate as many different stand-alone projects in product and component development as possible to form a small number of lighthouse projects. In addition to the more efficient use of available funds, the consolidation of the skills of the German industry is to produce a crucial advantage in international competition.

In a technological lighthouse, stand-alone development projects from the NPE roadmaps will be consolidated to form a technological project transcending the boundaries of the working groups.

Lighthouses have the character of large-scale projects and are distinguished by the achievement of milestones and targets within a fixed timeframe and with a defined budget. The subject matter should be cross-sectoral, interdisciplinary issues relating to the convergence of various technologies (battery, body, chassis and drivetrain, transport and energy infrastructures, ICT, mechatronics) plus associated innovative business models, uptake, standardization processes and legal issues.

To promote technological neutrality and competition, competitive consortia under the auspices of a large-scale project are explicitly desired. Proposals for the technology lighthouse strategies and/or design will be developed in the second phase of the NPE and placed in the context of the technology roadmaps.

7.4 Creation of showcases as the first step in market development

Showcases focused on a limited number of locations or regions are intended to satisfy the need for knowledge, for instance on user behaviour and on the interplay between different technologies in day-to-day use, while at the same time demonstrating the technology, service and interaction skills of the German industry in the context of interaction in a delimited system.

Showcases have a great appeal to the general public going way beyond the current pilot regions and projects. They must be designed such that they achieve a critical size in order to draw conclusions about the suitability for mass production of the electric mobility solutions applied. The systemic approach must be ensured in the showcases.

In addition, the aspects of initial and continuing academic and vocational training are to be added to the objectives of the showcases. Visible measures for the development of a skills base will underscore the “showcase character”.

A major aspect of the showcases must be the inclusion of the public at large. The objectives must be to encourage uptake, arouse interest and generate readiness for the market.

7.5 Evaluation of the existing pilot projects and follow-on schemes

The programme to promote electric mobility, which was launched as part of the Federal Government's Second Economic Stimulus Package, will come to an end in October 2011. All the parties involved realize that it is absolutely essential that work commence today, going beyond the existing programmes, to design showcases.

To this end, a comprehensive and critical impact assessment and a detailed analysis of the findings from the various stand-alone projects are to be carried out, both during the lifetime of the pilot regions and projects and after their conclusion. From this, conclusions will be drawn on how the processes can be optimized in the future. Follow-on schemes are to be discussed under which further use can be made of the infrastructures, installations, products and knowledge networks created as part of the projects.

From a present-day perspective, it would appear advisable to define consolidated follow-on programmes at an early stage that can provide answers to any subsequent questions or issues still unresolved from the previous projects and – building on this – to conclude the necessary preparations for establishing the key showcase projects to support a broad-based market launch of electric mobility. Before this happens, however, the existing programmes should be evaluated.

7.6 Recommendations for training and skills development

On the basis of the work relating to training and skills development, a skills roadmap of the initial and continuing academic and vocational training in the field of electric mobility has been identified, which is to be implemented in the near future. The successful implementation of the recommendations made therein will be the basis for all further activities.

National conference on initial and continuing academic and vocational training

This conference will give the starting signal for all further measures and will be held in the first half of 2011. It will be attended by the Federal Ministry of Education and Research, the Federal Ministry of Economics and Technology and all stakeholders from the field of initial and continuing vocational and academic training – lecturers, professors, trainers, vocational school teachers, centres of excellence, education providers, occupational accident insurance funds.

The conference is expected to produce the following results:

- Raise awareness that training and skills development in the field of electric mobility have to be regarded and shaped in a manner that is system-oriented and cross-sectoral
- Flesh out the skills roadmap with measures that are planned in terms of subject matter, time and funding
- View training in the field of electric mobility as a unit at all levels

- Create sustainability – establish the structures to implement the measures
- Agreements on monitoring implementation

If an adequate skills base for the electric mobility markets is to be available within the foreseeable future, investment must be made now in training the necessary academic specialists. At such an early stage, this can only be done in close cooperation with the research community. The new knowledge must be quickly incorporated into the curricula. Building on this, cooperative industrial research and other institutions (e.g. the German Research Foundation), as tried-and-tested instruments with an existing and robust network between industry and academia, are recommended for implementation of the research.

In both academic and vocational training, there is a considerable need for advanced in-service training of today's workforce. To this end, centres of electric mobility excellence have to be established and provided with trainers and equipment as quickly as possible.

Further recommendations

Academic training

- New chairs (primarily in electrochemistry/battery research, lightweight design), development/implementation of courses of study, provision of equipment for higher education institutions
- Advanced postgraduate training: development of training courses, establishment of and provision of equipment for advanced training centres, training the trainers
- Industry-academia linkage by expanding project funding of pre-competitive cooperative industrial research in parallel with the expansion of collaborative research supporting electric mobility (see other working groups' reports).

Vocational training

- Marketing electric mobility to ensure recruitment and the development of a skills base
- Toolkits/guides for electric mobility skills development in initial and advanced vocational training, skills modules, teaching and learning media, training the trainers, pool of expertise, provision of technical equipment for training establishments
- Toolkits/guides for in-service electric mobility refresher training, quality-assured continuing training standards, skills modules, eMedia, learning platform, certification, networks of experts, provision of technical equipment for centres of electric mobility excellence

A joint project entitled "academic training/vocational training"

- Portfolio of skills for the global electric mobility market

7.7 Recommendations for a German standardization roadmap

Political support at the European and international levels is necessary
It is necessary to closely dovetail research and development, regulation and the statutory framework with standardization. National standardization and regulation by individual states must not hamper international standardization. Standardization should also be an important issue in existing fora such as the Transatlantic Economic Council.

Standardization must be rapid and international
National and international approaches to standardization currently compete with one another. However, given the international nature of the markets for motor vehicles, international standards must be sought from the outset. The same applies to the vehicle-infrastructure interface. Exclusively German or European standardization for electric mobility is deemed inadequate. For this reason, the rapid development of national proposals and the short-term implementation of the results achieved in Germany in international standardization are essential.

Coordination and focusing are imperative
Electric mobility is characterized by a large number of players and fields. For this reason, cross-body cooperation and coordination by the existing EMOBILITY steering committee (DKE/NA-Automobil) and the Electric Mobility Unit in the German Institute for Standardization are important to avoid a duplication of work. No new bodies are to be created. Instead, the existing bodies in the German Institute for Standardization and German Commission for Electric, Electronic and Information Technologies are to be strengthened.

Standardization must be clear and unambiguous
To encourage innovations, standardization is to be performance based rather then descriptive. However, to ensure interoperability in the case of interface standards (e.g. between vehicle and grid infrastructure), technological solutions must be specified.

Charging infrastructure that is uniform throughout the world is necessary (interoperability)
It must be possible to charge electric vehicles at all times and in all places. The interoperability between vehicles of different manufacturers and infrastructure of different operators must be ensured. Standardization of the charging technology and accounting must ensure that the user is provided with a uniform, easy-to-use and safe charging interface. The interests of the users must take precedence over the interests of individual companies.

Existing standards must be used and evolved without delay
A large number of required standards already exist in the established domains of “automotive engineering” and “electrical engineering”. These standards must be appropriately used and publicized. Information on these standardization activities and their status are a component of this standardization road map. In addition, the focus of the required activities is less on the launch of new standardization projects and more on the widening of existing standards and their adaptation to the requirements of electric mobility. In the case of the interface issues, in particular, there must be cross-domain cooperation at international level.

Involvement in European and international standardization is essential
Greater involvement at national and international level is necessary in order to exert active influence and implement the objectives. German companies must therefore play a greater part in German, European and international standardization activities.

Cooperation between the ISO and IEC standards organizations must be ensured
To reach an international consensus between the ISO and IEC, greater use should be made of joint working groups (JWGs) operating under mode 5. Regarding the issue of “electric vehicle charging” (IEC series 61851), the most urgent need for action is between IEC/TC 69 and ISO/TC 22/SC 21. It should be observed whether the Memorandum of Understanding (cf. 3.5) between the ISO and IEC, which is currently in the process of being adopted, has been implemented in the shape required.

Consortia must be involved in the activities of the ISO and IEC
Standardization is to be performed in the established international organizations – the ISO and IEC. Consortia, in particular the SAE, must be invited to participate in the standardization activities of the ISO and IEC, rather than developing additional specifications of their own. It is assumed that the SAE standards are mandatory for many states of the USA. Adoption of the contents of SAE standards by international consensus-based standards (ISO, IEC) is difficult because of copyright (e.g. SAE J 2929). However, the objective must be to harmonize the contents of the SAE standards with the contents of the ISO and IEC standards. This is the only way to reduce the additional licensing effort of the automotive industry in the USA. For the transitional period, it is recommended that representatives of the European industry participate in the SAE bodies in order to avoid divergent rules. In addition, there are numerous other organizations which, because of their activities, exert an influence on the requirements to be met by electric vehicles or electric mobility in general and thus directly or indirectly influence standards. It should be considered whether, and if so in what form, coordination of the activities is necessary and, above all, to what extent activities of other organizations have to be transferred to the ISO and IEC.

The EMOBILITY steering committee and the Electric Mobility Unit at the German Institute for Standardization should coordinate a suitable course of action for liaison with other organizations. Other organizations are to be identified in a timely manner, and the establishment of conflicting requirements to be met by electric mobility is to be avoided by establishing contact with and involving these organizations at an early stage. Involvement in standards organizations other than the ISO and IEC must only be a temporary option.

Cooperation with China must be stepped up and the country's participation in the ISO and IEC progressed

It is not likely at present that national Chinese standards for electric vehicles will become international standards. However, it is likely that compliance with these standards will be a prerequisite for access to the Chinese market. Translations and interpretations of Chinese standards are frequently problematic. Through standardization and the Sino-German Economic Commission, the German side should be proactive in involving China in international standardization to a greater extent.

The standardization roadmap has now been published. Working Group 4 believes that the renowned national and international standardization bodies, with the support of industry and government, should now immediately submit it to the necessary bodies, where it should be supported by all parties.

8 Recommendations on shaping the future activities of the National Platform for Electric Mobility

To meet the NPE's objective of rapidly laying the foundations for Germany to become a lead provider, issues on which decisions have been taken, such as the R&D roadmap, are implemented with the publication of this interim report.

A second report is to be published as soon as possible. To this end, work on unresolved issues will be continued directly. A decision on the date of publication will be taken in early 2011.

For the period until the second report, it is recommended that the National Platform for Electric Mobility be preserved in its present structure. Unresolved issues have been clearly identified in this report. They will – if this is feasible in terms of their subject matter – be addressed within one working group in order to make optimum use of the established processes and coordination channels.

A number of issues have been identified that transcend the boundaries of the working groups. These issues are to be addressed and resolved in NPE expert groups (subgroups transcending working group boundaries). They will operate under the organizational lead responsibility of the General Framework Working Group but will be augmented by members of other working groups.

The frequency of meetings of the working groups and steering committee will be determined by the coordinated project plans.

All the parties involved consider the National Platform for Electric Mobility to be a success. The aim is to continue its existence beyond the agreed timeframe to summer 2011. In addition to monitoring the measures adopted, its tasks are to include the continuation of a cross-industry dialogue, involving all sectors of society, to ensure a general consensus. As a monitoring and advisory body, the National Platform for Electric Mobility can ensure a concerted course of action to safeguard Germany's international competitive position. The steering committee will be retained as a decision-making body. The Joint Unit for Electric Mobility will continue the successful organization of the NPE's activities.

Within the framework of the institutionalization of the planning, assessment, guidance and implementation of electric mobility projects, the core tasks of the National Platform for Electric Mobility are to include:

- identification of relevant R&D issues;
- monitoring and analysis of international activities;
- provision of stable and continuous (also conceptual) support to electric mobility.

A detailed proposal on the organizational structure and modus operandi will be presented in the second report.

9 Mandates and need for further clarification

With the publication of this interim report, the National Platform for Electric Mobility is entering a second phase. This phase will address the following delimited issues, which are to be resolved before a second report to be presented as soon as possible:

9.1 Development of showcase programmes

Within the framework of the National Platform for Electric Mobility, a proposal should be developed – making use of the assembled expertise and answering the following questions – for an appropriate showcase programme. The strategy is to be developed by the time of the next report and will comprise the following aspects:

- number and size;
- components;
- funding;
- management and assessment.

The pilot regions and pilot projects established as part of the “Second Economic Stimulus Package” should be subjected to an overall evaluation to determine whether components of the projects can be transferred to the showcase projects to be developed.

Here, the focus should be on examining the suitability of existing projects in the context of the system character and fitness for everyday use of electric mobility and the objective of becoming a lead provider and lead market. Decisions on the criteria and details of the work flow for the evaluation process will be taken by the federal government departments; the process should be launched immediately. The NPE will develop recommendations on this.

9.2 Consolidation of the mass marketing scenarios

Within the NPE, a common understanding of a self-consistent and probable mass marketing scenario is to be established that is based on likely user profiles and market segments to be exploited over time. This common qualitative understanding will then form the basis for fleshing out the work packages entitled ”incentive measures”, “framework for the lead provider objective” and “infrastructure installation”.

9.3 Policy framework and measures for mass marketing

The continuing activities of the NPE will involve finalizing the catalogue of measures to support a successful transition to mass marketing and an expansion of technological skills. Before a recommendation is made to the Federal Government, ways of consolidating this catalogue in an appropriate and effective manner will be explored.

9.4 Infrastructure installation and implications for the energy supply industry

On the basis of the findings produced to date on infrastructure technologies and basic requirements to be met by the establishment of a lead market in Germany, a concrete implementation plan for infrastructure requirements over the period to 2020 will be developed, based on the mass marketing scenarios. This plan combines two perspectives: the concrete requirements for charging infrastructure to support the lead market objective and conditions that have to be met to ensure charging and grid stability while supporting the Federal Government's energy policy objectives. The potential that vehicle-to-grid applications offer to the energy supply industry will be further verified on the basis of concrete assumptions.

9.5 Criteria for the funding of research and development

The working groups have identified a large number of research fields that are key to electric mobility. In the next phase of the NPE, a working group transcending the boundaries of the other working groups should be set up to define whether these research fields, in the way they are addressed, meet competitive or pre-competitive criteria. Early coordination and classification will accelerate project development and the possible allocation of public funds and the related instruments.

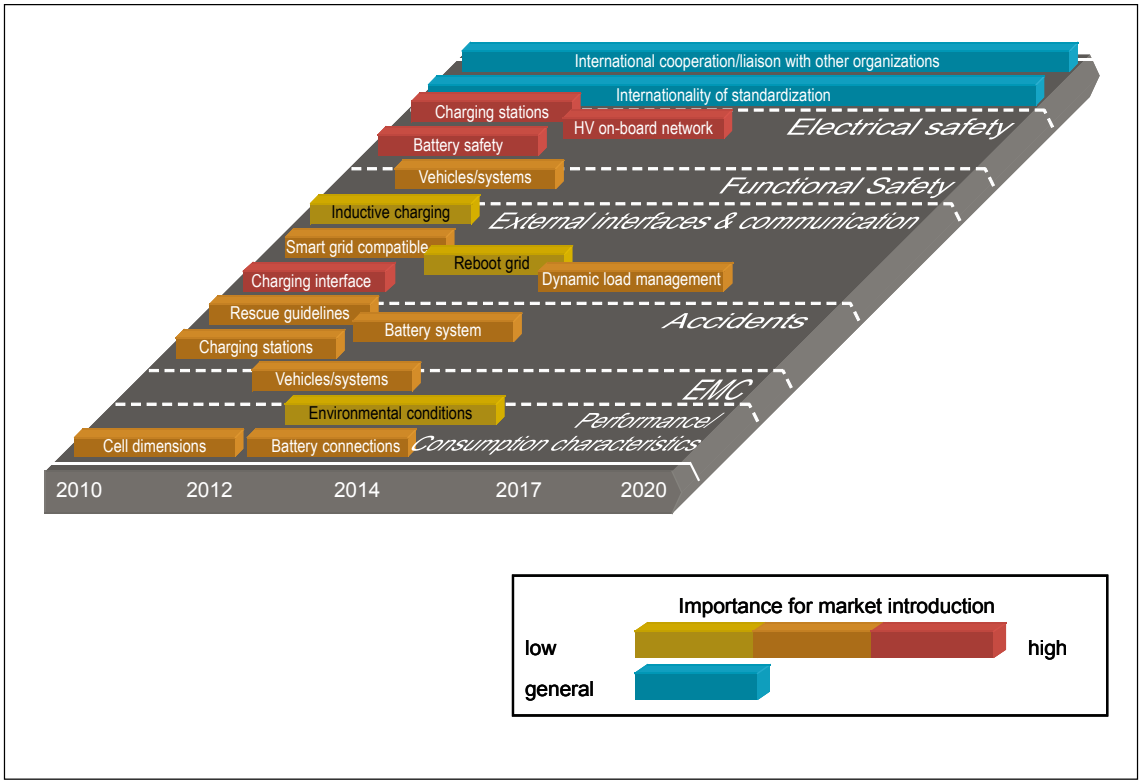
9.6 Finalization of the standardization roadmap

The timetable for implementation of the standardization road map results from the identified and estimated

- priorities
- effort required to clarify the scope of standardization (establishment of an ad hoc working party)
- research requirements.

The outcome of this analysis is that there is a significant need for standardization in the years ahead, which is detailed in version 1.0 of the "German Standardization Roadmap for Electric Mobility". Figure 1 shows an overview of the major fields of action for the market launch of electric mobility.

Version 1.0 of the standardization roadmap provides a snapshot and is to be reviewed at regular intervals to check that it is being implemented and is up to date. An appropriate strategy is being developed and will be published in the next report.



Issues in the standardization roadmap

9.7 Communication

If electric mobility is to achieve the desired success, it must enjoy broad support in society. The objective of public communication must be to develop uptake for new technologies and new approaches to mobility. It is only on this basis that a market can be created and that the public will understand and support policy decisions setting the future course. The NPE is therefore to develop a broad-based communication and marketing strategy by the next report.

9.8 Future organization of the NPE

A strategy for the continuation of the NPE is being developed. It will describe tasks, composition and responsibilities and develop a proposal for an organizational structure. The objective is to be to institutionalize the cross-industry dialogue involving all sectors of society and to establish a monitoring body to assess and evolve the measures adopted. The steering committee and the Joint Unit for Electric Mobility will be a key component of this new structure.

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