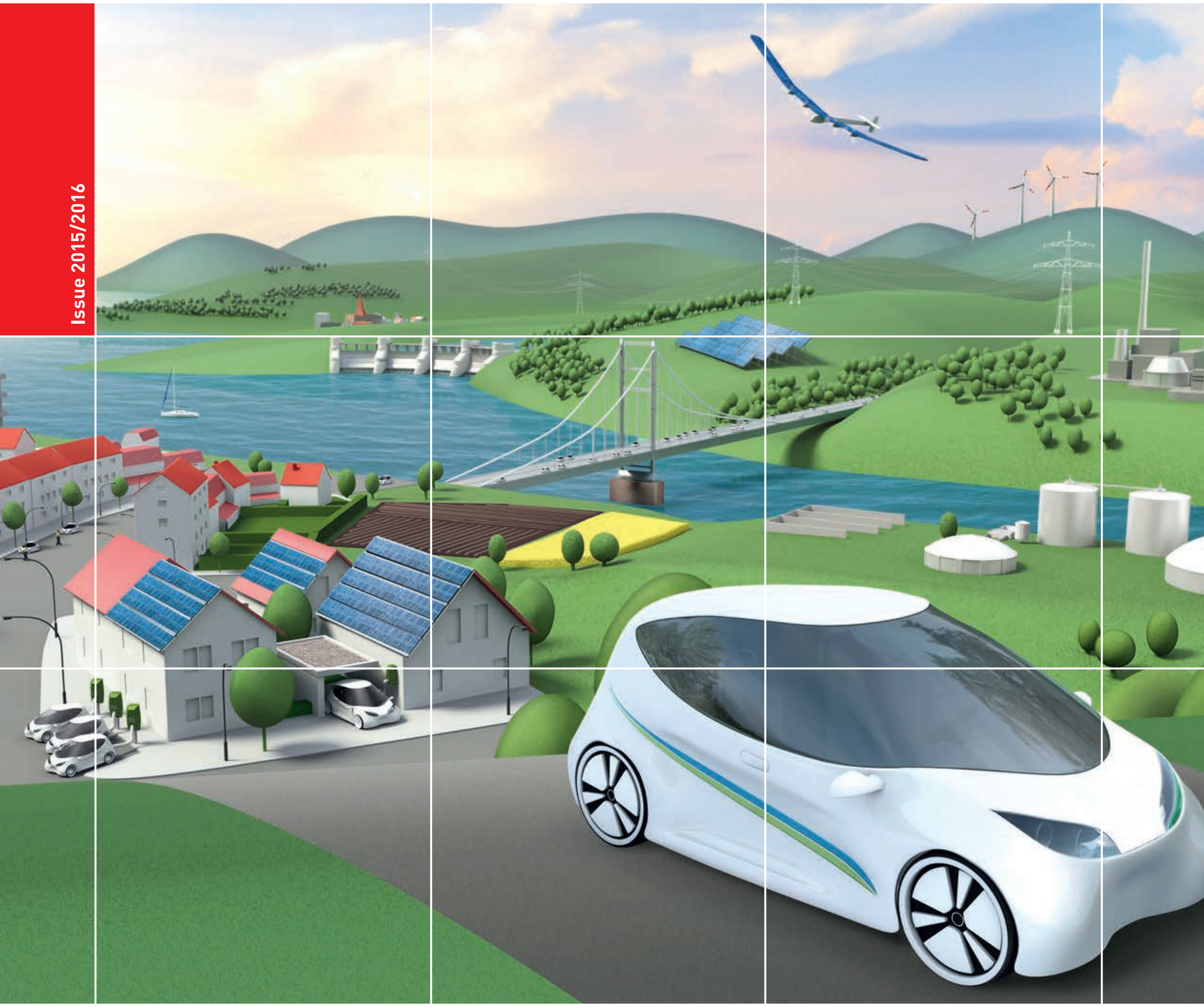
Electromobility in Germany:
Vision 2020 and Beyond

Issue 2015/2016



GERMANY
TRADE & INVEST

ELECTRIC MOBILITY LEAD MARKET AND PROVIDER

Germany has set itself the goal of becoming the lead market and provider for electric mobility by 2020 as part of its long-term zero emission mobility vision. Drive electrification reduces dependence on oil, slashes CO_2 emissions and allows the vehicles of tomorrow to be fully integrated into new multimodal traffic system models.

One million electric vehicles on the road by 2020 – that is the bold aim of Germany's "National Electromobility Development Plan." To date, the German Federal Government has invested in the region of EUR 1.5 billion in electric mobility development. Over the same period, the automotive industry has ploughed EUR 17 billion into electric vehicle development. No other automotive nation can boast a comparable range and diversity of vehicles: Seventeen vehicle series launched by German automotive manufacturers were available by 2014 (including BEV, PHEV and REEV models). A further 12 new model series are already foreseen for 2015, which will allow Germany to further consolidate its lead provider status.

The passing of a new "Electromobility Law" in 2014 advantageous to electric vehicle owners provides further impetus to the country's electric mobility revolution. By putting the appropriate policy measures and R&D funding to implement the necessary changes in place, the German Federal Government is ensuring that the country will play a decisive role in electric mobility. Close networking of the auto, machinery and plant, energy (both conventional and renewable energy sources), electrical, chemical, ICT sectors and their corresponding R&D resources is safeguarded and bundled according to individual competences.

New synergies are created for manufacturers, suppliers and service providers alike along a revitalized value chain (design, R&D, manufacturing, and assembly) – the like of which no other country in Europe can boast. Comprehensive value chain presence ensures that new products, technologies and related services are delivered to the very highest standards. The world's one billion motor vehicles account for almost one fifth of CO_2 emissions. Making the change to alternative fuel represents a significant contribution to climate protection. Smart electric vehicles not only guarantee freedom of mobility for future generations, but also provide a new model of renewable energy-based power supply. Investors who wish to join us on the road to electric mobility are most welcome and enjoy our full and unstinting support. We are committed to establishing Germany as the lead market for electric mobility as part of our environmental and technology leadership vision. You can be a part of it.

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1 million
electric vehicles

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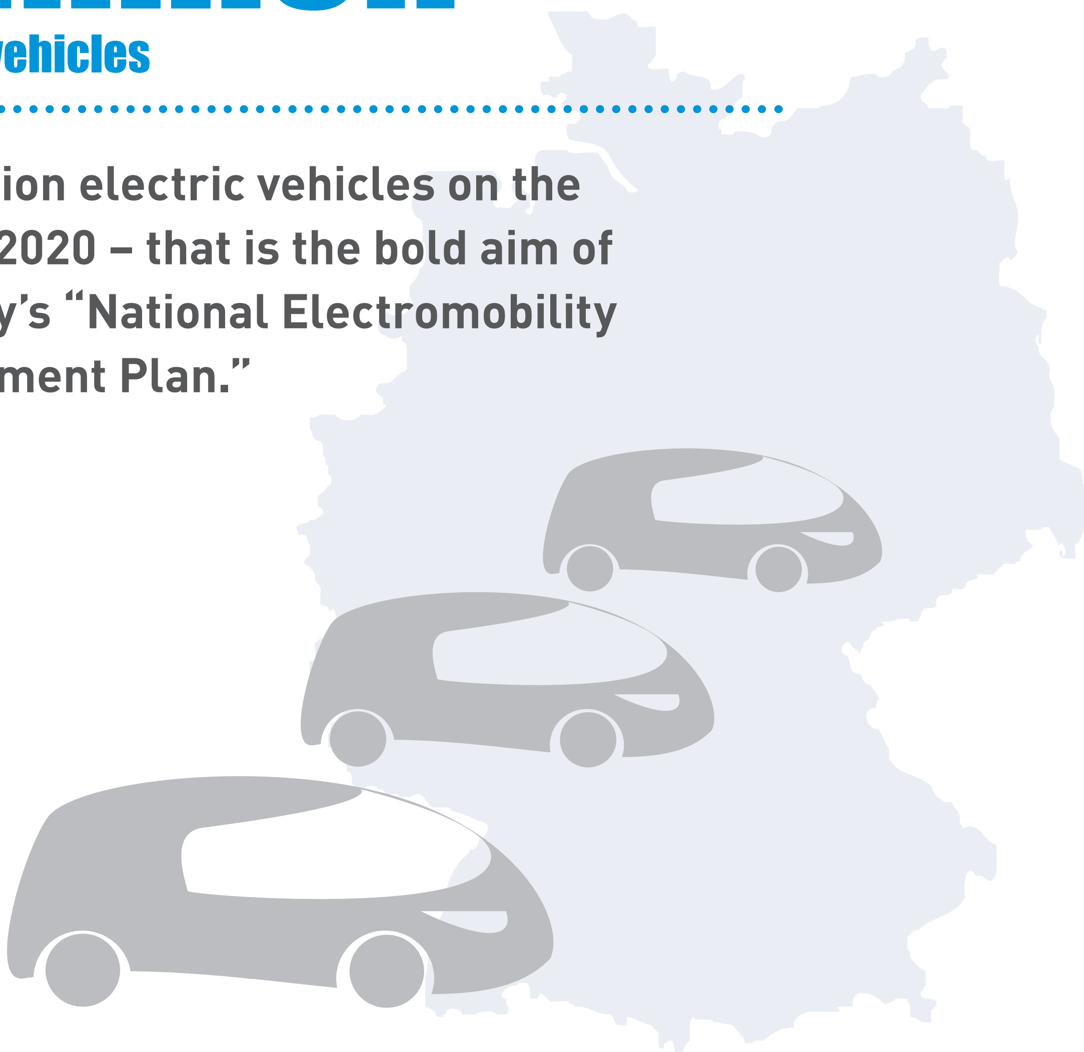


WHAT IS ELECTROMOBILITY?

"ELECTROMOBILITY" – BASIC PRINCIPLES

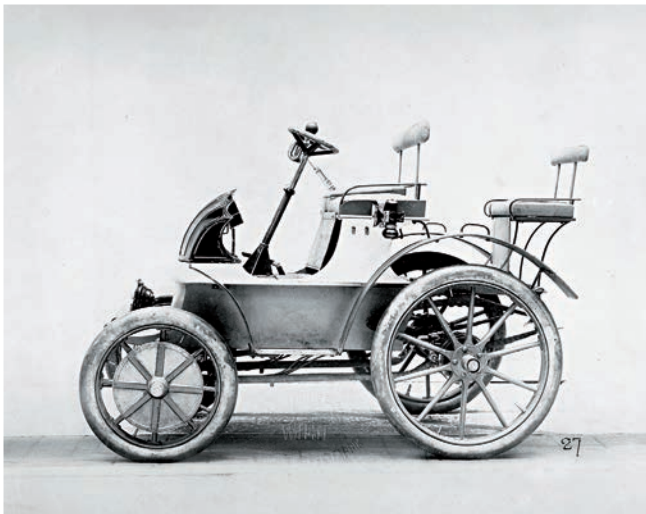
The electric drive train in its most basic form of electric machine and battery is hardly a revolutionary concept. As long ago as the turn of the 19th century, Ferdinand Porsche's "System Lohner-Porsche" carriage car was driven by two battery-powered electric motors. In 1900, Porsche's "La Toujours-Contente" prototype electric power train vehicle won gasps of admiration at the Paris World Exhibition. Less impressive were the physical limitations imposed by the almost two tons of lead acid batteries required to power a vehicle whose weight conspired to make it better suited to downhill driving (the vehicle was fitted with a special switch for battery recharging when running downhill). Moreover, long recharging times proved a hindrance when comparing the unlimited range of fuel powered internal combustion-driven vehicles.

Germany has long been convinced of the importance of electromobility. A large-scale electric vehicle trial to test the viability of electromobility was carried out on the Island of Rügen in the Baltic Sea from 1992 to 1996. Although ultimately ill-fated (due to dependence on a conventional layout converted for electric propulsion and the low efficiency rates of electric energy storage units at the time), the so-called "Rügen Trial" served as a statement of intent to develop electric vehicles fit for purpose.

Much has changed in the intervening years. Drive systems as we understand them today consist of electric motors, power electronics components, high-voltage cabling, transmissions, and a broad array of electric auxiliary units. The battery system is the key component within an electrified drive train: it determines electric vehicle efficiency and represents the single element with the greatest wealth creation share. A battery system is made up of the cells, battery management system (including cell monitoring), electrical and sensor systems, safety elements, cooling periphery, and housing. Battery cell chemistry and cell design are the decisive factors in overall system operation and efficiency.

Today, drive electrification represents the final piece in the sustainable mobility jigsaw (with battery and fuel cell technologies representing supplementary and complementary solutions). As such, electric mobility is now the key technology for the replacement of fossil energy sources in the long term; creating new markets and new technologies, as the old energy order comes to an end and a new one begins.

Drive electrification represents the key to a sustainable mobility future, with battery and fuel cell technologies representing mutually complementary paths to be pursued in tandem. Electromobility "Made in Germany" will transcend traditional industry borders, eliminating historical industry barriers to create new value-added materials, products, services, and business model potential.



Lohner Porsche (1900) – the world's first zero emissions vehicle.

THE BATTERY – THE KEY TO ELECTRIC MOBILITY

The battery represents the key component in an electrified drive train. The battery system (comprising the cells, battery management system including cell monitoring, electrical and sensor systems, safety elements, cooling periphery, and housing) determines vehicle efficiency and counts as the single vehicle element with the greatest wealth creation share (direct share of value added of up to 40 percent). As such, the battery is at the very heart of the electric mobility vision and the key to electric mobility. However, electric mobility requires affordable, safe and efficient battery storage.

Developing affordable, efficient batteries capable of covering greater driving distances is the challenge facing all industrialized nations seeking to make the change to electric mobility. Intensified battery R&D is central to establishing the proper market-competitive cell and battery production conditions for electric mobility to become a reality. Cell and battery production are an extremely important part of an automotive industry value chain in transformation. Third- and fourth-generation batteries must sustain a longer life cycle whilst becoming more efficient, lighter and safer.

Parallel to battery technology developments is the need to ensure that the appropriate battery technology is optimally integrated into the vehicle. Battery integration within the vehicle determines a number of essential vehicle characteristics, allowing for better product differentiation. For that reason, Germany is investing heavily in developing the appropriate R&D conditions and infrastructure for cell and battery production to flourish. The Federal Ministry for Education and Research (BMBF) provides significant targeted funding and facilitates knowledge transfer between science and industry. R&D funding of around EUR 500 million has been made available for battery, whole system energy management, and training and further education activities. As with all aspects of electric mobility, it is important that standards are observed: the market cannot develop without common norms and standards. Battery development and production processes must also satisfy the principle of resource sustainability for the recovery and recycling of materials used.

According to the National Electric Mobility Platform's key performance battery parameters for the reference BEV city vehicle energy and power density levels will improve by 2020, with marked improvements expected in terms of safety and service life. Developments made to date in first and second-generation cells and battery systems have helped create battery energy density levels of around 160 Wh per liter at around EUR 300 per kWh.

LITHIUM-ION BATTERY TECHNOLOGY

At present, the automotive industry almost exclusively uses nickel-metal hydride (NiMH) batteries for high performance applications (hybrid). Lithium-ion batteries however, have an energy density several times higher than NiMH batteries at the system level. As such, lithium-ion battery technology is widely recognized as being the battery technology with the best long-term prospects thanks to its low weight, high-energy density and long durability. For that reason, the industry is committed to evolving lithium-ion technology in order to create a number of electric vehicle mobility strategies (e.g. BEV, REEV) to increase driving distance in all-electric mode. The amount of energy stored requires that electric vehicle cells and batteries satisfy strict safety requirements. There are already a number of cells, batteries and vehicles on the market which make use of lithium-ion technology for hybrid applications.

Tremendous growth prospects exist in the lithium-ion market as battery manufacturers and suppliers strive to provide the cheap, reliable and safe battery solutions with increased energy density which make hybrid and electric vehicles a genuinely feasible consumer option. Nevertheless, intensive R&D activity to evolve lithium-ion technology and develop post-lithium-ion technologies is required. It is imperative that an understanding of the mechanisms along the battery chain and production of materials, cells, and battery components for first and second generation lithium-ion batteries is established in the short to mid-term. Moreover, a significant research effort to evolve lithium-ion technology and identify post-lithium-ion battery technologies is required to establish technology leadership on the road to industrialized production. Battery research in Germany extends across the entire battery production value chain: starting at the identification of new materials to the development of individual components, and cell and battery production.

ELECTRIC VEHICLES – AN OVERVIEW

In the broadest sense, an electric vehicle is any vehicle that has at least one electric motor in the power train driving the vehicle. In its purest form, the vehicle is powered only by the onboard electric motor(s), and, as such, is considered to be an "electric vehicle" (EV). The electricity required to power the motor is typically derived from a battery (hence, the "battery electric vehicle" – BEV); or generated in a fuel cell ("fuel cell electric vehicle" – FCEV). Although a number of alternative fuel cell technologies including hydrocarbon (e.g. methane) and alcohol (e.g. methanol and ethanol) exist, hydrogen is the most commonly used.

BATTERY ELECTRIC VEHICLE (BEV)

A battery electric vehicle (BEV), as the name implies, uses chargeable batteries to power electric motors and motor controllers for propulsion. New battery technology advances (more specifically, lithium-ion batteries) are making BEVs an increasingly attractive proposition as oil prices continue to rise. BEVs are currently best suited to the small car segment and shorter travel time and business models (e.g. car sharing).

RANGE-EXTENDED ELECTRIC VEHICLE (REEV)

The range-extended electric vehicle (REEV) drives in electric mode but makes use of a hybrid internal combustion engine (ICE) to extend vehicle driving range when batteries are low or in the absence of charging infrastructure. As such, REEVs effectively reverse the roles played by the electric motor and combustion engine in currently available hybrid vehicles.

HYBRID ELECTRIC VEHICLE (HEV)

As the name implies, a hybrid electric vehicle (HEV) combines a conventional ICE propulsion system with an electric drive system. The presence of an electric power train increases fuel efficiency and performance levels. HEVs produce fewer emissions than conventional gasoline-run vehicles thanks to a smaller and more fuel-efficient ICE. HEVs come in a range of shapes and guises and can be typically categorized by degree of hybridization and drive train structure.

PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV)

A plug-in hybrid electric vehicle (PHEV) is a hybrid electric vehicle (HEV) which makes use of a rechargeable high-capacity battery bank which can be directly charged from a normal household power current. PHEVs are similar to HEVs inasmuch that they make use of an electric motor and an ICE. Like all-electric vehicles, PHEVs have a plug which can "plug in" to the power grid. PHEVs essentially operate as electric vehicles with an ICE back-up facility.

PHEVs have a greater fuel reduction potential than current HEVs; the key difference being the electromotor that supplements the conventional internal combustion engine, enabling electrical operation for short periods of time. PHEVs enjoy greater fuel reduction potential than existing hybrid vehicles (thanks to periods of electrical only operation enabled by the internal combustion engine-supplementary electromotor).

FUEL CELL HYBRID ELECTRIC VEHICLE (FCHEV)

A fuel cell hybrid electric vehicle (FCHEV) converts chemical energy (e.g. hydrogen) to mechanical energy by burning in an ICE or reacting with oxygen in a fuel cell to power an electric motor. FCHEVs are emission free and climate neutral (producing only water as a by-product).

Hybrid Electric Vehicle Classification by Level of Hybridization

Micro Hybrid

Micro hybrid vehicles are not actually HEVs as such, as they do not use an electric motor to drive the vehicle. Instead, micro hybrids rely on electric "start-stop" (also "stop-start") technology which automatically stops and restarts the ICE engine when not in use (improving fuel economy and reducing emission levels). Electric energy is stored in a battery or ultracapacitator. Micro hybrids also make use of "regenerative braking" systems which recover excess kinetic energy for battery charging.

Mild Hybrid

In contrast to micro hybrid vehicles, so-called "mild hybrids" are genuine HEVs. However, the electric motor in a mild hybrid is only able to support the ICE – it is not powerful enough to drive the vehicle on its own. This provides the advantage of integrating a smaller and more fuel-efficient ICE. Additional electric energy is also typically generated using a regenerative braking system.

Full Hybrid

Full hybrid vehicles can, in part, be powered purely by electric means. Full hybrids house a larger battery and a larger electric motor than mild hybrids for electric launching, acceleration assistance, and electric driving at low speeds. According to the drive train structure, full hybrid vehicles can be powered by the electric motor, the ICE, or a combination of both.

Hybrid Electric Vehicles by Drive Train Structure

Parallel Hybrid

In a parallel hybrid drive train, both the electric motor and the ICE have a mechanical connection to the drive shaft – meaning that the vehicle can be driven by the ICE alone or the ICE assists the electric motor and recharges batteries. A number of "light hybrid" vehicle configurations assign the majority of the propulsion duties to the engine, with the electric motor playing a supporting role. Unlike series hybrids, parallel hybrids can operate like a fully electric car at lower speeds (e.g. 30-50 km/h). In stop-go traffic situations (or accelerating at lower speeds) the vehicle can operate completely electrically.

Series Hybrid

In series (also "serial") hybrids, the electric motor controls all wheel driving duties, with the ICE serving only to recharge batteries. Other than is the case with parallel hybrid drive train configurations, the ICE in a series hybrid set-up is not mechanically connected to the drive shaft. An electric motor is placed "in series" between the engine and the wheels. Some series hybrids have a "start-stop" function which turns the engine off when the vehicle is stationary – restarting the vehicle once the brake pedal has been released. Series hybrids are similar to pure electric vehicles inasmuch that they can, in part, travel without using the ICE.

ELECTRIC VEHICLES – WHY SO MANY?

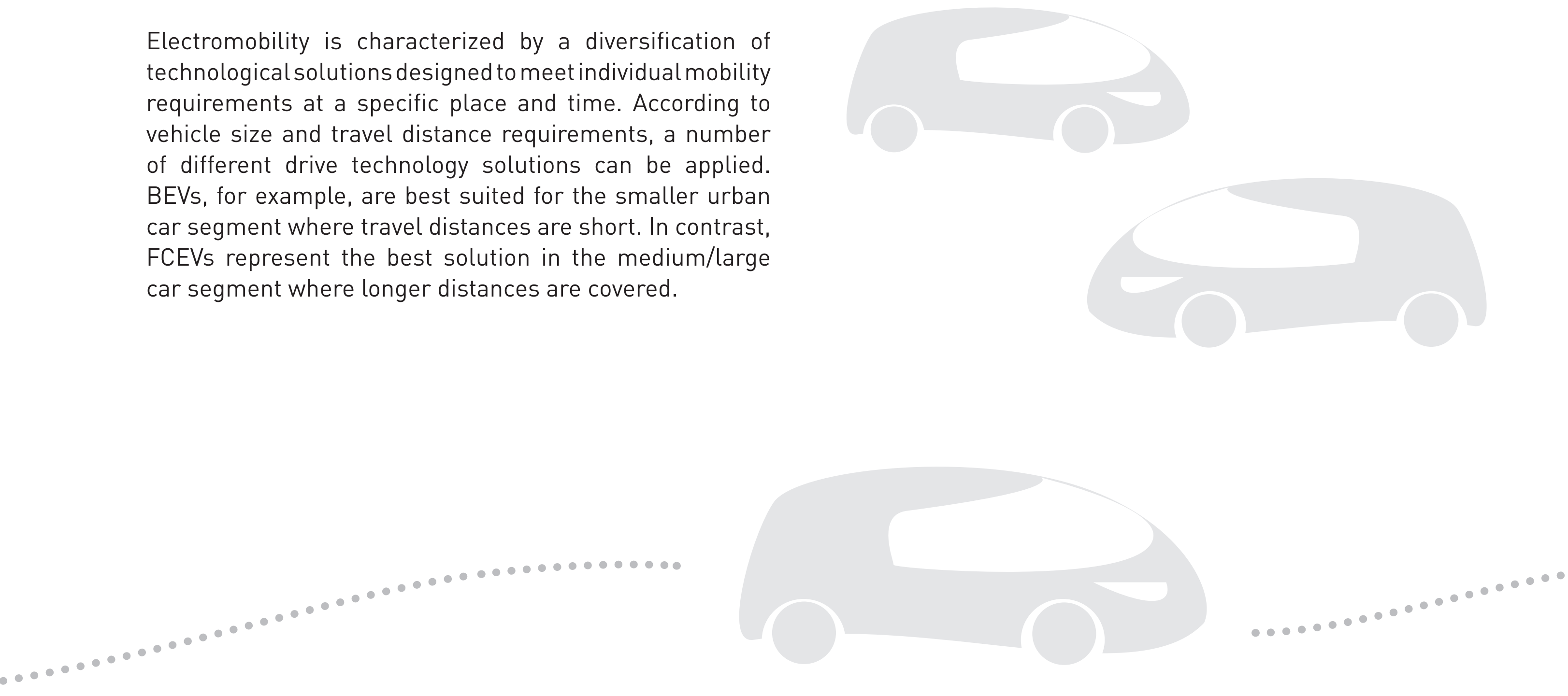
On first glance, it might well seem that the burgeoning electromobility sector is literally awash with different drive train models – so many in fact, that it is difficult to know what is what. It is certainly true that there are more choices than ever before.

There is a very good reason for this. The world is moving away from a dependence on a single power train model (ICE) to a portfolio of power trains designed for every possible driving scenario. No single power train set-up can satisfy all of the different economic, environmental and performance factors at play.

Moreover, a number of different technologies will likewise have to undergo a process of evolution until such time as all vehicles are driven purely by electric means. This means that the conventional ICE still has a bridging role to play - for some time to come - in a number of HEV scenarios. Rising oil prices and CO_2 emission levels similarly increase the demand for more efficient ICEs. And the more individual and longer the driving route, the greater the need to use the hybrid ICE.

Electromobility is characterized by a diversification of technological solutions designed to meet individual mobility requirements at a specific place and time. According to vehicle size and travel distance requirements, a number of different drive technology solutions can be applied. BEVs, for example, are best suited for the smaller urban car segment where travel distances are short. In contrast, FCEVs represent the best solution in the medium/large car segment where longer distances are covered.

As opposed to the existing automotive market state of affairs, electric mobility is much more than a new model for simply selling cars. It is about making new technologies and intermodal fields of application with new business and traffic models visible. It is about successfully integrating the electric vehicle into the energy supply system for better and more efficient energy management. Smart vehicle fleet programs and intermodal linkage with the public transport sector will likewise open up completely new business opportunities.



ELECTRIC VEHICLES – USE SCENARIO AND OUTLOOK

BATTERY ELECTRIC VEHICLE (BEV)

Completely electric-driven vehicles are widely considered as being best used in urban environments. The comparatively limited range (100-200 km) and longer charging times (up to several hours) of BEVs make them the ideal small city car for short journeys. Zero tailpipe emissions mean that BEVs are ideal for built-up urban conurbations. BEVs will also be able to operate virtually CO_2-free subject to the primary source of energy used. New transportation models such as car sharing are currently helping offset the comparatively prohibitive buying price of new BEVs, allowing the driving public to enjoy the benefits of BEV mobility without the major capital outlay required for purchase (all the while owning a conventionally driven or hybrid vehicle for long distance travel purposes). Although initially more expensive than hybrid vehicles, BEVs enjoy lower fuel and maintenance costs.

HYBRID ELECTRIC VEHICLE (HEV)

Hybrid electric cars are the most common form of HEV, supplemented by small commercial vehicles and buses. HEVs are already very much a reality, as they can be fueled using existing gas station infrastructure at significantly lower cost than conventional vehicles. HEVs will soon be seen on the roads in ever larger numbers. However, the fact that they are still fossil-fuel dependent means that, in the long term, they may play a “bridging technology” role on the way to a market defined by BEV and PHEV technologies.

RANGE-EXTENDED ELECTRIC VEHICLE (REEV)

The presence of a “range extending” combustion engine or fuel cell equips REEVs for city driving in full-electric mode and longer journeys in range-extended mode. To that end, and although having the exact same infrastructure requirements as BEVs, REEVs are very much the small family car to the BEV’s city runaround.

PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV)

PHEVs represent a more economical option to BEVs and FCHEVs in the short to medium term (most forecasts expect electric vehicles to be viable alternatives to ICE-based vehicles by 2025). Like BEVs, PHEVs are particularly useful in urban environments where short, low-speed mobility is predominant. PHEVs have a smaller battery capacity than BEVs, providing an electric driving range of 40-60 km. They can also reduce CO_2 emission levels (ICE comparison) considerably.

FUEL CELL HYBRID ELECTRIC VEHICLE (FCHEV)

FCHEVs have a driving range and performance comparable to conventional ICE-driven vehicles. As such, they represent the lowest carbon solution in the medium/ large vehicle and longer range segments. They therefore provide the most effective emissions reduction strategy for a large share of vehicles on the road today. However, the FCHEV market is still beset by a number of research and development and infrastructure challenges which adversely impact on the cost of ownership (infrastructure costs currently represent around five percent of total cost of FCHEV ownership). The absence of hydrogen charging infrastructure in towns and cities currently acts a further short-term block to FCHEV market prospects. This said, FCHEV value in terms of total cost of ownership (TCO) and emission reduction levels is widely forecast to be positive beyond 2030.

MOBILITY – CHANGING MODELS OF USE

Just as the modern vehicle is being transformed, so too are historically dominant modes and patterns of car use. In the past, the type of car owned spoke volumes about its owner and his or her position in the world. Today, cars are no longer the simple indicators of wealth and status that they once were.

Societal trends in western industrialized societies including lifestyle downshifting and increased environmental awareness are being reflected in new car ownership patterns. In the premium segment, "exclusivity" and "high performance" are giving way to sustainable and urban mobility as major selling points.

Today's drivers are just as much interested in a vehicle's impact on the environment as they are in its performance. A growing group of environmentally aware drivers with high purchasing power levels love driving – but aren't prepared to add to global pollutions problems in order to do so. Electromobility allows modern mobility dreams to be fulfilled. Not only is the modern driver more discerning in his or her auto-purchasing behavior, but heightened buyer expectations have created a market in which there is a car for every consumer.

Conventional notions of the role of the traditional original equipment manufacturer (OEM) within the automotive industry value chain are also slowly but surely being consigned to the past. The classic OEM business model – with its dependence on turnover generated from new vehicle sales – is undergoing a major paradigm shift as value creation returns continue to fall.

As a result, OEMs have found themselves in a cycle where ever more and better technological features are required to stay ahead of a congested international market. Moreover, technological advances, historically the sole preserve of the auto manufacturer, are increasingly taking place on the side of the supplier.

An adjunct of the increased sense of environmental responsibility by today's responsible drivers is the development of a broad range of new automotive business and service models. A growing number of drivers want the benefits of mobility without any of the attendant problems of vehicle ownership. For example, carsharing and leasing are increasingly attractive models to both the consumer and industry alike as an effective way of relieving inner city traffic congestion. Moreover, carsharing provides the urban driver with all of the flexibility of mobility with none of the considerations of ownership.

New business models which encompass everything from enhanced services to leasing and mobility service provision are taking root and providing new market opportunities as OEMs and suppliers alike seek to reinvent themselves in a changing mobile market.

2025
280 to 300 Wh/l
battery density volume

Germany has set itself a battery density by volume level of 280 to 300 Wh/l by 2025 as part of the technological development of third and fourth generation batteries.

GERMANY: LEAD MARKET AND PROVIDER FOR ELECTRIC MOBILITY

Germany has set itself the goal of becoming the lead market and provider for electric mobility by 2020 as part of its long-term zero emission mobility vision. "Electromobility made in Germany" means systematic solutions that connect climate and resource conservation measures with technology leadership and new value creation. Three general vehicle categories have been defined to meet this objective:

- All-electric urban vehicle
- Family vehicle
- Light commercial vehicle (with electric range for urban traffic)

Conventional vehicles in these three categories account for 60 percent of all vehicles on the road in Germany today. Although the future portfolio of smart electric vehicles will be significantly wider in scope, these three vehicle categories best represent the e-mobility solutions required in an increasingly urbanized environment. Moreover, they all have in common the very important fact that they can be charged by connecting them directly to the power grid.

The electric vehicles required to realize Germany's 2020 lead market and provider vision can, broadly speaking, be classified in terms of the following categories:

- Battery electric vehicle (BEV)
- Plug-in hybrid vehicle (PHEV)
- Fuel cell electric vehicle (FCEV)
- Internal combustion engine (ICE) including hybridization

In order to meet the objectives of the Integrated Energy and Climate Programme, the National Electromobility Development Plan (see "ELECTROMOBILITY IN GERMANY: PROGRAMS & INITIATIVES – NATIONAL ELECTROMOBILITY DEVELOPMENT PLAN") is primarily concerned with the following vehicle categories:

Mercedes B-Class Electric Drive

- Battery electric vehicle (BEV)
- Plug-in hybrid electric vehicle (PHEV) including range-extended electric vehicle (REEV)

Both vehicle types can be driven solely by electricity and directly charged at the power mains. So-called "plug-in hybrid drives" enjoy greater fuel reduction potential than existing hybrid vehicles (thanks to periods of electrical only operation enabled by the internal combustion engine-supplementary electromotor).

However, establishing Germany as the lead market for electric mobility goes far beyond increasing the number of electric vehicles on the road. It is also about increasing the visibility of technologies and intermodal fields of application, not to mention promoting dynamic new business models. A number of objectives have been identified in order to achieve Germany's goal of becoming the lead market and provider for electromobility. The introduction of an Electric Mobility Act in 2014 advantageous to electric vehicle drivers will further consolidate Germany's lead market status.

GERMANY: LEAD MARKET AND PROVIDER FOR ELECTRIC MOBILITY - OBJECTIVES

ENERGY AND CLIMATE GOALS

- Electromobility will make a significant contribution to meeting climate protection targets.
- Using renewable sources to meet the energy demands of electric vehicles will also contribute to implementing the development targets for renewable energies and improving grid integration of variable producers, thus helping to raise supply security in the long term.
- The use of modern information technologies and the integration of electric vehicles will raise power grid efficiency in Germany.

The additional electrical energy requirements in this sector will be met with electricity from renewable energies. The prime source for electromobility will be current from variable renewable energies that cannot be used elsewhere as part of load management. Additional scope for renewable energies must be harnessed to meet the electricity needs of electromobility in excess of this.

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GERMANY: LEAD MARKET AND PROVIDER FOR ELECTROMOBILITY

- The leading role of the German motor-vehicle manufacturing and parts supply industry will be secured and extended.
- Use will be made of innovative procurement management in the public sector.
- Building production capacities for cell and battery systems in Germany and related recycling facilities will secure the strategic capabilities of German industry.
- Establishing new business models in electromobility will afford opportunities for more growth through new products and services.
- Supporting standardization (e.g. for plugs, power inputs or safety precautions) will enable the internationalization of electromobility and help German industry to position itself.

INNOVATION AND COMPETITIVENESS

- The aim in research is to interlink industry and science as closely as possible. Networking the motor-vehicle manufacturing, energy and information technology sectors along new supply chains will then set an innovatory momentum in motion for electromobility.
- To do this, measures will be taken to step up research in all areas, network and extend research infrastructures and promote mutual exchange between researchers from industry and science.
- Another concern is to ensure long-term excellence and innovative drive in electromobility. An initiative will therefore be launched to train junior technical-scientific personnel.

NEW MOBILITY

- Electromobility is another step in the strategy of lessening dependence on oil.
- Electromobility will help pave the way for a new culture of mobility and modern urban and development planning.
- Measures will be taken to speed up the market introduction of electric vehicles, particularly for short distance traffic: The German Federal Government has set itself the ambitious target of putting one million electric vehicles on the road by 2020, possibly reaching over five million by 2030. By 2050, most urban traffic will be able to do without fossil fuels. This will also entail installing suitable infrastructure for charging the vehicles. The German Federal Government will support this with an appropriate enabling framework.
- Besides private transport, support will also be given to schemes for introducing electromobility for commercial vehicles (e.g. urban delivery vehicles, local public transport) and two-wheeled vehicles.

MARKET ACCEPTANCE

- To implement climate and economic policy goals, the forthcoming changes must gain social approval.
- This is why the German Federal Government aims to ensure transparency and provide information on the implementation of the Development Plan and engage in broad dialogue.
- The opportunities, challenges and goals will be subjected to continual reappraisal in line with developments. The acceptance and market development of electromobility will be supported with a suitable regulatory framework and appropriate systems of incentives.

GERMANY: LEAD MARKET AND PROVIDER FOR ELECTRIC MOBILITY – CHALLENGES

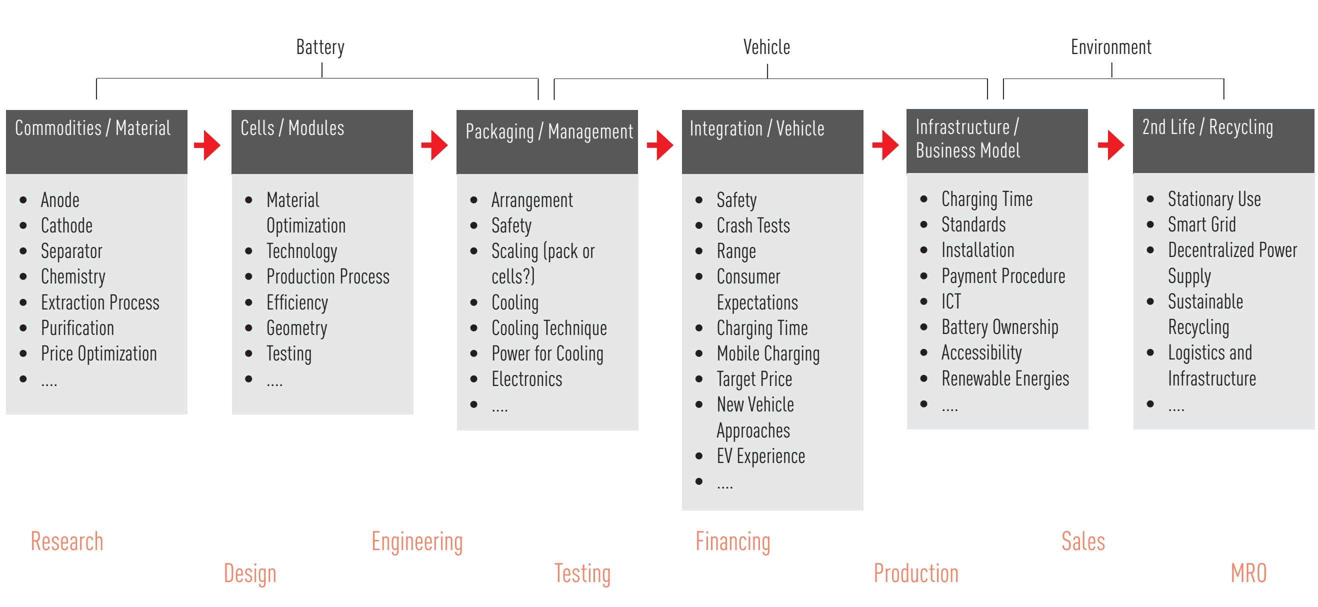
ELECTRIC MOBILITY SUPPLY AND VALUE CHAIN

Electromobility represents a significant new challenge to the established automotive and energy supply order. Germany's stated ambition to become the lead market and provider for electric mobility adds a further dimension to what is already a considerable endeavor.

Electromobility calls upon a cross-sectional industry approach which involves new actors and modes of cooperation. As such, it is imperative to move away from the existing automotive model (which concentrates on single components and subsectors in isolation) towards an inclusive approach which integrates all areas of the supply chain. This encompasses everything from materials and raw materials for lithium-ion batteries and electric motors to innovative new electric drive components and overall energy management. Central to this challenge is the need to create new vehicle concepts and energy supply systems and to build the power supply infrastructure and business models required to make the transition to electric mobility.

Electromobility also represents a major opportunity to manage power supply at source. Electric vehicle charging station infrastructure will allow power generation, grid load and power consumption to be harmonized. Alternative energy sources (i.e. wind and solar power) can help reduce road traffic-generated greenhouse gas emission levels significantly. Electric vehicle batteries can be fed into the power supply for increased medium to long-term grid stability.

Electric Vehicle Value Chain Business Opportunities



Source: Germany Trade & Invest 2015

ENERGY STORAGE

Efficient, safe and affordable batteries are central to electromobility success. Bringing down battery costs is imperative to market introduction and consumer uptake. Germany has set itself a battery density by volume level of 280 to 300 Wh/l by 2025 as part of the technological development of third and fourth generation batteries.

Battery system costs will continue to fall below EUR 200 per kWh (thanks to greater production numbers and economical cell chemistry), promoting increased mass market appeal and acceptance levels.

Just as important as battery cost is battery service life and cycle stability: electric batteries must be able to deal with thousands of charging cycles over a 10 to 15-year service period without any noticeable dropping off in terms of performance. Plug-in and electric vehicles should also have a quick charge capacity for faster charging and increased mobility. Just as performance is a key performance indicator, so too is safety. Similarly, further reductions must be made in terms of weight, volume, charging time, operating temperature dependence, and the use of potentially toxic components. The German energy system is among the most efficient in the world with a particularly high proportion of volatile renewable energy sources. This means that there is significant room for electric mobility synergy maneuvering. Moreover, Germany's renewable energies leadership allows electric vehicles to be integrated into so-called "smart grids" earlier than in other countries. As such, Germany provides a unique global advantage for smart electric vehicle technologies developed on German soil.

VEHICLE TECHNOLOGY

The move to electromobility brings with it the need to develop appropriate vehicle and drive concepts to meet the very different mobility needs of today's environmentally aware driver: be it the city driver, the goods delivery driver or the long distance private or commercial driver. Electrical and mechanical components will need to be further developed, optimized and integrated into vehicles in order to increase cost-effectiveness and market acceptance of PHEVs, REEVs and BEVs.

Similarly, because the electro motor in hybrid vehicle applications operates as both motor and generator, appropriate solutions for the diversity of vehicle types and materials used will need to be identified. ICEs used in hybrid application contexts will also require further optimization in terms of required use, control and vehicle size. Power electronics for motor control and other electronic controllers for drive and stability control systems require further development in tandem with the electrification of (auxiliary) power units. Power electronics and battery cooling in turn creates new onboard technology requirements in terms of installation space, driver and passenger protection, weight, reliability and electromagnetic compatibility.

To that end, Germany has instigated a major R&D funding program in response to the findings of the second report of the National Platform for Electric Mobility (see "GOVERNMENT PROGRAM ELECTROMOBILITY") which sets aside significant funding for electric motors, drives, high performance electronics, control devices and subsidiary electrical units.

TOTAL COST OF OWNERSHIP (TCO)

The initially high additional costs incurred by cost of BEV ownership can only be offset within the context of vehicle service life and operational performance. Nevertheless, in the short to medium term, hybrid and electric vehicles will continue to have a higher total cost of ownership (TCO) than traditional drive system vehicles.

Accordingly, successful market introduction strategies will concentrate on differentiated market and customer segmentation. Initial focus on private and public sector fleets will help accelerate market introduction and acceptance, while creating profitable customer segments.

A raft of tax incentive mechanisms and road traffic management measures have been approved as part of Germany's electromobility program (see "GOVERNMENT PROGRAM ELECTROMOBILITY") to offset consumer TCO reservations in order to achieve the goal of one million electric vehicles on the road by 2020. From 2025 onwards, it is generally forecast that declining depreciation will see BEVs achieve near parity with conventionally driven vehicles.

SMART GRID INTEGRATION

Electric mobility requires new ways of connecting vehicles to the power grid supply. The requisite intelligent grid charging infrastructure needs to be set up to meet the country's ambitious lead market challenge.

Germany is at the international forefront in smart grid development. Intelligent power supply networks or "smart grids" allow fluctuating renewable energy power generation and consumption to be optimally managed by changing the power supply paradigm from one of consumption-oriented power generation to generation-optimized consumption.

Germany is laying down the necessary policy framework for the dynamic networking and management of electricity producers, storage facilities, consumers, grid installations, and infrastructure. Information and communication-based technologies (ICT) will play a decisive role in connecting the different parts of the energy system. By setting fundamental standards, products and services provided by businesses from diverse industry sectors will be able to intelligently communicate with each other, allowing the smart grid system to be incrementally expanded with the addition of new modules and products.

All appliances connected to the power grid are added to the control system in "plug-and-play" application fashion. This allows a completely integrated data and power network to be created. Besides funding and regulatory measures to promote battery technology, Germany is similarly committed to creating the necessary conditions for vehicle grid integration. The German Federal Government's "Energy Concept" promises to transform energy supply. It sets out the establishment of renewable energies as a cornerstone of future energy supply; energy efficiency; the creation of an efficient grid infrastructure for electricity and integration of renewable energy sources; energy upgrades for buildings and energy efficient new buildings; and, of course, the country's mobility challenge.

The first phase of grid integration for electric vehicles will focus on battery charging. Load management grid integration trials will be conducted in the following market start-up phase to 2017; enabled by the development of intelligent integration of electric vehicles into the energy supply system to create smart power grids during the same period.

Advanced charging and energy transmission systems will likewise be developed in phase two on the pathway to electric mobility. Phase three will see the creation of a full coverage charging infrastructure with grid integration and feedback. Economies of scale will be developed in all corners of the burgeoning smart mobility industry to further strengthen Germany's competitive market advantage.

NORMS AND STANDARDS

Early international harmonization of regulations, norms and standards will help position key smart electromobility technologies in global markets. In order to properly integrate electric vehicles into the power grid, the establishment of interface and protocol norms and standards is imperative. The creation of industry standards will ensure that electric mobility is not needlessly handicapped by national boundaries. Germany supports the Combined Charging System (CCS) laid out in European and US guidelines as a globally binding system, and has embarked on talks with China, Japan and other partner countries.

National Electromobility Development Plan

According to the National Electromobility Development Plan, the foremost challenges in electric mobility standardization are as listed below:

- **Energy storage unit.** The energy storage unit is central to the success of electromobility. The creation of energy storage unit standards in terms of minimum safety requirements, capacity and wear resistance will prove pivotal to creating a common international playing field. Energy storage unit information created will help ensure market transparency.
- **Standardized components and interfaces.** The presence of standardized components and interfaces within the vehicle create an open market and reduce dependencies among market players. Standards which allocate specifications and performance features to systems and components facilitate the economic and efficient introduction of new technologies.
- **Material requirements.** Measurement methods and quality and quality assurance efforts need to be assessed. Standards also required for the creation of an appropriate human-machine interface (HMI) in line with new drive technologies.

- **Charging station standardization.** This also includes suitable metering technologies and billing systems currently in development. Public charging points should be available for use of all electricity suppliers and vehicle types in wholly non-discriminatory fashion. Electricity generated by electric vehicles should be delivered in competitive fashion as is the case with domestic household power supply.
- **Vehicle hardware and software architecture integration.** The interface between the charging station and the energy storage unit is decisive to smart load management and grid use/support.
- **Standardized safety requirements.** Crash test behavior; rescue and salvage.
- **Business models.** Appropriate business models should also be subject to norms and standards in order to reduce, for example, subsequent transaction costs in contracts. Agreements must be standardized in order to allocate and invoice services rendered whilst maintaining data protection and customer privacy requirements.

The German Standardization Road Map for Electromobility

The German Standardization Roadmap for Electromobility drawn up by the National Platform for Electric Mobility reflects the mood of consensus among all actors in the electromobility sector (including automobile manufacturers, the electrical industry, energy suppliers/grid operators, technical associations, and public authorities) that a strategic approach to standardization of electromobility is required. The National Platform for Electric Mobility standardization recommendations can be summarized as below:

- **Political engagement.** Political activity at European and international level for optimized research and development networking and regulatory and legislative framework standardization. Standardization measures implemented by individual countries should not adversely impact on harmonization efforts at international level.
- **Timely and international standardization.** Swift implementation and authorization of standards at national level for international standardization transfer. Concerted international efforts to develop unified norms and standards necessary from the outset. This also applies to the development of interfaces between electric vehicles and infrastructure (V2G – "vehicle to grid").
- **Coordination and focus.** Close cooperation between all relevant actors coordinated by the respective standards authority and steering group imperative in order to eliminate duplication of work. Currently existing bodies should be further strengthened rather than creating new entities.
- **Clear and unambiguous standards.** Standards need to be function related and performance based in order to encourage innovation. This said, a number of specific technical solutions cases need to be defined in the realm of interface standards in order to ensure interoperability (e.g. between vehicles and network infrastructure).
- **International charging infrastructure (interoperability).** It is imperative that it is possible to charge electric vehicles "everywhere, at all times." Vehicle interoperability with infrastructure must be guaranteed. Standardization of charging procedures and billing/payment systems must safeguard the development of a charging interface that is user oriented, uniform in nature, and safe and easy to operate: user interest must have priority over those of individual companies.

SAFETY

Electric mobility brings with it a number of vehicle safety challenges. As well as questions of battery safety, smart vehicle electrical components require specific layout attention for the eventuality of an accident. This means that design and layout must ensure that passengers and rescue workers are afforded the maximum amount of protection possible in the event of a road safety accident. The high voltage electric drive, for instance, requires suitable insulation, identification and defeat devices.

Electrical components also have to comply with electromagnetic compatibility requirements: safeguarding against a potential component overload and minimizing potential interference between components in the electric drive (and potential detrimental effect on health and the environment). Sensor-based and vehicle communication active safety systems need to be developed to prepare drivers and pedestrians alike for sound-free electric mobility.

34 million ton

reduction in CO_2 emissions by

2020

Germany has set itself the ambitious target of achieving a 40 percent reduction on 1990 CO_2 emission levels by 2020. There are around 880 vehicle models on the German market today with emission levels of just 130g/km of CO_2 . More than 500 models manage to stay below 120g/km of CO_2.

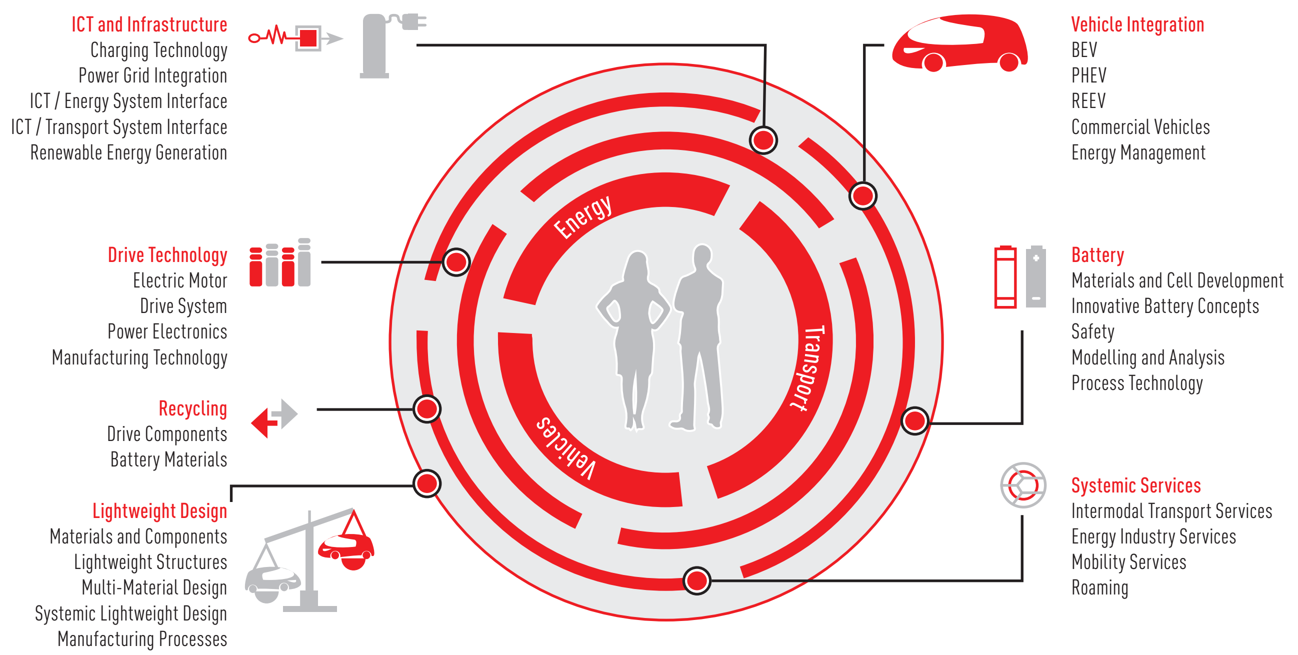
ELECTROMOBILITY IN GERMANY: FRAMEWORK, PROGRAMS & INITIATIVES

ELECTRIC MOBILITY – ADOPTING A SYSTEMIC APPROACH

According to the National Electric Mobility Platform (NPE), Germany's 2020 vision insists on a cross-sectoral industry approach that transcends traditional industry boundaries in order to create the systemic, sustainable electromobility solutions required to meet the country's ambitious targets. Intrinsic to ordinary vehicle drivers buying into electromobility is the presence of a complete, systemic electric mobility solution. By this is meant a holistic approach to electromobility; covering everything from the vehicle itself through to a charging network, traffic management system and smart grid power supply. The implementation of such an approach likewise insists on placing the driver at the center of electromobility activity, surrounded by a number of different subsystems (see "The Electric Mobility System – Putting the User at the Center" below) including the vehicle, energy supply, and transport infrastructure. To do so, it is necessary to adopt an international user-centric approach to individual electric mobility component developments. Mutually compatible standardized solutions are key to creating an environment in which electromobility (and electromobility adoption rates) can and will flourish.

The NPE's R&D flagship or "lighthouse" projects (see "ELECTROMOBILITY FLAGSHIP PROJECTS") provide a solid fundament for the development of the respective electric mobility subsystems. The four showcase electric mobility regions (see "ELECTROMOBILITY SHOWCASE PROJECTS") will also prove decisive in creating real electric mobility scenario data essential to this systemic approach; be it in terms of transport and energy systems, education and training, ICT or climate and environment protection.

The Electric Mobility System – Putting the User at the Center



Source: National Electric Mobility Platform

GERMANY'S ENERGY CONCEPT

The German Federal Government's "Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply" promises to transform energy supply – and provides a road map to a truly genuine "renewable age." In doing so, it will further consolidate Germany's role as a major energy exchange partner in Europe. Officially launched in fall 2010, Germany's "Energy Concept" is a long-term energy strategy for the period up to 2050. The aims of the plan are ambitious in their sweep but simple in their intent: the securing of a reliable, economically viable and environmentally sound energy supply to make Germany one of the most energy-efficient and green economies in the world. The pressing challenge of sustainable energy provision is one born of long-term global trends and harsh energy truths. Transforming this energy vision into a renewable energy age reality is one of the greatest challenges of the 21st century, with global demand for energy expected to lead to a dramatic increase in energy prices in the medium to long term. As a result, dependence on energy imports will also increase significantly. This in turn will lead to increased greenhouse gas emissions – the current energy mix accounting for 80 percent of all emissions at present.

The defining activity areas of the Energy Concept set out the establishment of renewable energies as a cornerstone of future energy supply; energy efficiency; the creation of an efficient grid infrastructure for electricity and integration of renewable energy sources; energy upgrades for buildings and energy efficient new buildings; and the country's mobility challenge (one million electric vehicles on the road by 2020 and six million by 2030). As such, the Energy Concept represents a market-driven, technology-neutral framework which will transform energy supply. In May 2011, Germany announced plans to formally phase out nuclear energy by 2022.

E-ENERGY NETWORK – SMART GRIDS

E-Energy stands for "smart grids made in Germany." Smart grids are the key enabling technology for sustainable economic development and the long-term solution to energy and climate problems. Germany already enjoys an international reputation as a pioneering force in this field thanks to its "E-Energy: ICT-based energy system of the future" project.

The "E-Energy Network" uses predictive systems to forecast power consumption and generation levels according to weather conditions. ICT gateways at domestic and industry points-of-use and energy producer control systems receive pricing information based on these forecasts.

The E-Energy Network allows a revolutionary new ICT-based "energy marketplace" to be created; one where consumers play a more active role as producers of self-generated electricity and electricity is no longer simply traded but instead transferred according to a new usage model (i.e. "allow delayed switch on," "feed into grid in event of demand peaks," and "use only in event of sunshine and/or high winds.").

E-Energy plays a major role in Germany's National Electromobility Development Plan. This is because E-Energy creates a foundation for the intelligent integration of electric vehicles into the smart power supply grids of the future. Within the new E-Energy marketplace, producers and consumers alike are rewarded for their contribution to the securing of a cost-effective and environmentally friendly source of electricity provision.

NATIONAL ELECTROMOBILITY DEVELOPMENT PLAN

The German Federal Government has set an ambitious goal of one million electric cars on German roads by 2020 as part of its "National Electromobility Development Plan" drawn up by all relevant government ministries in accordance with the Integrated Energy and Climate Programme (2007) of the German Government.

The National Electromobility Development Plan represents a concerted effort by actors from science, industry and government. As such, it covers the entire supply chain (from materials, components, cells and batteries to the entire system and its application). It also makes provision for the creation of a plan to integrate electromobility power demand into the power grid in order to link this new demand to renewable energy sources to contribute to grid-load management.

This will position Germany as a lead market and provider for electromobility and enhance the long-term competitiveness of the motor-vehicle manufacturing and parts supply sector as one of the major pillars of German industry. The National Electromobility Development Plan initially set aside more than EUR 500 million in incentives for the development of vehicles, energy storage devices and infrastructure. This figure was subsequently upwardly revised by a further EUR 1 billion to the end of the last legislative period as part of the government's electromobility program. Two key areas of research support are (i) the battery as the heart of future electric vehicles, and (ii) the development of smart energy efficiency, safety and reliability systems for electric vehicles. In addition, research and development in the area of hydrogen and fuel cell technologies will benefit from a total of EUR 500 million funding within the framework of a national innovation program.

Germany has set itself the ambitious target of achieving a 40 percent reduction on 1990 CO_2 emission levels by 2020. At the start of 2012 there were already more than 400 German-produced vehicle models with emissions below the CO_2 target level according to the German Association of the Automobile Industry (VDA).

Major focal points of the development plan include increasing R&D funding and implementing market change strategies to facilitate the future implementation of electric vehicles. The essential technologies required for electric and hybrid drives, energy storage and grid infrastructure have already been developed. Seventeen electric vehicle models produced by German car manufacturers were available in 2014.

JOINT AGENCY FOR ELECTRIC MOBILITY (GGEMO)

In February 2010 the Federal Ministry of Economics and Technology (BMWi) set up a dedicated electromobility coordination office with the Federal Ministry of Transport, Building and Urban Development (BMVBS) in the guise of the Joint Agency for Electric Mobility (GGEMO). The agency has been specially created to bundle and coordinate the Federal Government's electromobility tasks. GGEMO supports both the Federal Government and the National Electric Mobility Platform to implement and further develop the National Electromobility Development Plan.

NATIONAL ELECTRIC MOBILITY PLATFORM

In May 2010, the German Federal Government constituted the National Electric Mobility Platform (NPE), consisting of representatives from politics, industry, science, local authorities, and consumers.

The initiative, which consists of seven working groups of around 20 members, was brought into being in order to direct and shape the road map for the realization of the objectives laid out in the National Development Plan for Electric Mobility.

The different working group areas of activity are as follows:

- Drive technology
- Battery technology
- Charging infrastructure and network integration
- Standardization and certification
- Materials and recycling
- Qualification and training
- Framework conditions

GOVERNMENT PROGRAM ELECTROMOBILITY

In May 2011, the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry of Transport, Building and Urban Development (BMVBS) adopted a government program in response to the findings of the second report of the National Platform for Electric Mobility. Ministry-supported R&D measures will be flagged by regional showcase and technical flagship projects for the creation of increased synergies within the electromobility sector.

ELECTROMOBILITY SHOWCASE PROJECTS

In April 2012 the government appointed so-called electromobility "showcase" projects highlighting application-based R&D as a first step towards market development (following a recommendation of the second NPE report).

The regional showcase projects act as a "shop window" for innovative cross-industry partnerships in the country's different federal states. This means making German technological expertise visible in a small number of large projects in which public and private partners pool their joint competences and resources.

The showcases will allow the general public to literally get to know and experience electromobility. The high profile nature of the successful showcase projects will stimulate international demand for electromobility solutions developed in Germany.

Synergies with existing federal support programs in the energy infrastructure and traffic sectors are evaluated and deployed in the respective showcases accordingly.

The electromobility showcase projects are characterized by the following:

- Systematic approach (energy system electric vehicle, mobility/traffic system and interfaces between these elements);
- Formation of alliances and partnerships that represent the entire mobility value chain; regulatory framework trials;
- Reach critical size in order to draw conclusions as to the mass market viability of the deployed electromobility solutions;
- Integration of a broad public;
- Integration of academic and vocational training and further qualification measures (e.g. visible qualification measures);
- Appropriate level of engagement with the local economy;
- Clear and resilient acknowledgment of the commitment of the participating municipalities and federal states.

A joint statement issued by the Federal Government and German industry, on May 3, 2010, proposed the further development and expansion of the eight model regions for electric mobility to pilot regions. The showcase initiative represents the fulfillment of this shared objective.

Established model regions and projects which do not form part of the showcase initiative will be continued and developed after successful evaluation in limited form. These provide a continuation to innovative impulse and have an important contribution to make in the market start-up phase. Such projects would remain a part of the proven R&D programs of participating government ministries. The focusing of existing resources in showcase projects remains the overarching goal.

ELECTROMOBILITY FLAGSHIP PROJECTS

The Federal Government wants to promote innovation in important electromobility technology sectors and "open" up cross-industry innovation processes ("open innovation") with the setting up of the flagship projects. This will not only intensify the innovation potential within the German research and industry sector, but also accelerate actual use. To that end, a bundling of complementary individual projects (systems, products, and component development) with a clear thematic focus - on the basis of NPE recommendations – is intended. Added value will be created by bringing expertise from different sectors and setting up networked innovation clusters.

Through strong thematic focus and integration of cutting-edge research, the flagship projects will acquire high prestige character for German science and industry. The interdisciplinary nature of the flagship projects means that they will be administered by cross-industry consortia in order to increase technological openness and overall project success. Flagship initiatives in the most diverse electromobility-related sectors are conceivable, with individual flagships being distinct from the showcases in terms of their focus on individual technologies and application areas.

Science and industry resources are bundled together in the flagship projects. As well as having a high strategic value, the flagship projects are applications-based – significantly increasing the likelihood of the technologies developed being successfully implemented. Flagship suitable subject areas have a significant role to play in reducing the cost of electromobility and to technological advances made.

As showpiece projects with a strong media profile, the lighthouse projects have an important part to play in raising the profile of electromobility activities. In accordance with the NPE proposed technology road maps, the Federal Government plans to promote flagship projects in the following areas:

Drive Technology
Complete vehicle
Drive technology
Production technology

Energy Systems and Storage
Materials development
Cell technologies and batteries
Modular production technology
Safety and durability

Loading Infrastructure and Network Integration, Mobility Concepts
Intelligent networks
Energy recovery
Inductive energy transfer and quick-charging systems
Electro-bus systems

Recycling and Resource-Efficiency

Information and Communications Technology

Lightweight Construction

MEASURES AND INCENTIVES

The Government Program Electromobility sets out a range of tax incentive mechanisms and road traffic management measures to promote electric mobility.

A number of these are enshrined in a new Electric Mobility Act approved in September 2014. The legislation is expected to come into effect in early 2015 and is set to expire in June 2030.

Tax Incentive Mechanisms
1. Motor Vehicle Tax Exemption
All completely electric-powered vehicles are exempt from motor vehicle tax. The exemption period has been extended from five to ten years for all vehicles registered by December 31, 2015. Thereafter, completely electric vehicles registered between January 1, 2016 and December 31, 2020 are motor vehicle tax exempt for a period of five years.

2. Company Car Taxation
The Annual Tax Act 2013 rule regulating private use of commercial vehicles has been improved in order to positively counteract the relative price gulf between electric and hybrid electric vehicles and conventionally powered vehicles. The higher cost price of electric vehicles compared to vehicles with conventional combustion engines will be balanced in terms of the measurable benefit attributed to possession of a company car. This will effectively ensure that electric and hybrid electric vehicles are not subject to an income-tax disadvantage as was historically the case.

Road Traffic Measures

1. Special Parking Places for Electric Vehicles
The German Federal Government is comprehensively behind electric vehicles. Special parking privileges for electric vehicles belong to the array of promotional measures drawn up to further promote electromobility. To that end, the government has prepared a traffic guideline statement outlining the uniform sign-posting of parking places (particularly charging stations in public traffic areas) which allows local authorities to implement existing legislation more easily.

2. Suspension of Restricted
Entry Access for Electric Vehicles
Delivery vehicles are ideal for electric drive systems. Restricted entry access will be relaxed or entirely suspended for delivery vehicles. This includes, in particular, time entry restrictions and access restrictions remitted to conventionally driven vehicles for noise limit reasons.

Prioritization of loading and delivery traffic is already possible under law (e.g. in pedestrian zones according to supplementary designation). Special prioritization only for electric-powered vehicles would represent a significant handicapping of normal loading and delivery vehicles. For that reason, an improvement for this reason must be justified by environmental benefits. The federal government will work with the federal states and separate local authorities to further develop the existing environmental law framework conditions.

3. Authorized Use of Bus Lanes for Electric Vehicles
Granting electric vehicles authorized use of bus lanes potentially represents an attractive additional incentive for electric vehicle purchase and use. For this purpose, practical experiences obtained in the flagship and model regions will be assessed to determine the viability of such a scheme and to minimize any possible adverse effect on bus traffic.

4. Special Traffic Lanes for Electric Vehicles
Special traffic lanes and loading lanes could be used to provide an additional medium to long-term incentive to electric vehicle use. The practicability of such an initiative will be evaluated within the framework of the flagship and model regions projects. Based on these experiences the government will complement the relevant parent act where necessary.

Emissions and Environmental Law Measures

Electric vehicles which are linked to renewable energies will benefit from a legal foundation which allows them to be classified as emission-free vehicles. In accordance with the Ordinances to the Federal Immission Control Act, electric vehicles will be issued with a blue sticker which affords special privileges in traffic and public places (e.g. free parking, special lanes privileges, access to special zones etc.). Germany will also actively work at a European level to ensure that all low-emission classified vehicles are entitled to special incentives.

The European Union (EU) has set itself the goal of reducing CO_2 emissions in road traffic by significantly reducing the fleet consumption limit level (fleet average to be achieved by all new EU-registered passenger vehicles is 130g CO_2/km by 2015 rising to 95g CO_2/km by 2020). The definition of Europe-wide CO_2 target levels for new vehicle fleets for cars and light commercial vehicles will prove significant to electric vehicle adoption and receptiveness levels.

By 2015, passenger vehicles with an output of less than 50g CO_2/km and light commercial vehicles (transporters) with a higher factor by 2017 will be included in the fleet consumption calculation and will provide a bonus in terms of CO_2 fleet targets. Germany will continue to work actively at the EU-level to ensure that multiple allowances for these vehicles are a reality by 2020.

Other Measures

Low-interest KfW bank credit
Interchangeable vehicle license plates
Public procurement plan

NATIONAL HYDROGEN AND FUEL CELL TECHNOLOGY INNOVATION PROGRAMME

Hydrogen as an energy and fuel cell source provides an excellent alternative to dwindling natural gas and petroleum resources. Not only are fossil energy sources becoming increasingly scarce and expensive, they also emit CO_2 emissions which are damaging to the climate.

Hydrogen can be stored in liquid and gas form for controlled energy release. And unlike fossil fuels, hydrogen is a "clean energy solution" that does not produce any environmentally harmful pollutants or climate change emissions. Ease of storage makes hydrogen of particular interest in the mobility sector. Hydrogen-powered fuel cell vehicles can make an important long-term contribution to environmentally friendly, sustainable mobility.

The National Hydrogen and Fuel Cell Technology Innovation Programme provides a common framework for a number of hydrogen and fuel cell research projects conducted by academic institutions and industry. The public-private partnership (PPP) is scheduled to run for 10 years.

NATIONAL ORGANIZATION FOR HYDROGEN AND FUEL CELL TECHNOLOGY (NOW)

Germany is Europe's leading nation in the field of hydrogen and fuel cell technology. In 2008, the National Organization for Hydrogen and Fuel Cell Technology (NOW) was set up to promote the development and commercialization of internationally competitive hydrogen and fuel cell technology products. The German Federal Government has set aside a total budget of EUR 1 billion for hydrogen and fuel cell technology research, development and demonstration projects over a ten-year period.

ELECTRIC MOBILITY IN GERMANY – POLICY TIME LINE

Germany's electric mobility ambitions are based in a solid policy framework of legislation, programs and initiatives. The country's electric mobility activities are underpinned by a far-reaching network of framework policy and funding programs, R&D initiatives and external partner support activities. Listed below are just some of the more important policy framework, funding and R&D activities guiding the country's electric mobility vision.

INTEGRATED ENERGY AND CLIMATE PROGRAMME (2007)

In 2007, the German Federal Government declared the promotion of electric vehicles a major building block in its Integrated Energy and Climate Programme to achieve climate protection goals.

LITHIUM-ION BATTERY 2015 – BMBF INNOVATION ALLIANCE (2007)

Germany's High-Tech Strategy to consolidate German innovation leadership aims to combine the forces of science and industry in important fields of the future by using public funding to mobilize private R&D investment. This stakeholder-based approach has led to the creation of the Lithium-Ion Battery 2015-BMBF (Federal Ministry of Education and Research) Innovation Alliance. A consortium of companies including BASF, BOSCH, EVONIK, LiTec, and Volkswagen have made a commitment to invest EUR 360 million in lithium-ion battery research in the coming years, a figure which will be matched by EUR 60 million BMBF funding.

Battery research in Germany extends across the entire battery production value chain: starting at the identification of new materials to the development of individual components, and cell and battery production.

NATIONAL STRATEGY CONFERENCE ELECTRIC MOBILITY (2008)

This was followed by talks with industry, research and policy stakeholders at the National Strategy Conference Electric Mobility in November 2008, which, in turn, paved the way forward for the creation of the National Electromobility Development Plan.

The four government departments responsible at this time (Federal Ministry of Economics and Technology; Federal Ministry of Transport, Building and Urban Development; Federal Ministry of Education and Research; and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) gave their support to a comprehensive package of support measures.

ECONOMIC STIMULUS PACKAGE II (2009)

The *Umweltprämie* ("environmental premium" but more commonly known as the "scrapping bonus") was introduced in January 2009 to help promote demand for new vehicles as part of the *Konjunkturpaket II* ("Economic Stimulus Package II") to counter the global recession.

NATIONAL ELECTROMOBILITY DEVELOPMENT PLAN (2009)

The Economic Stimulus Package II also sets out a number of progress milestones on the route to Germany establishing itself as the lead market for electromobility. These activities will be further developed and implemented within the framework of the National Electromobility Development Plan. As well as this, existing government promotion instruments were adjusted to include electromobility as part of their subsidy and support remit.

JOINT AGENCY FOR ELECTRIC MOBILITY – GGEMO (2010)

The Joint Agency for Electric Mobility (GGEMO) was set up by the Federal Ministry of Economics and Technology (BMWi) in February 2010 to coordinate all federal government electromobility activities. The agency supports both the federal government and the National Electric Mobility Platform to implement and further develop the National Electromobility Development Plan.

NATIONAL ELECTRIC MOBILITY PLATFORM (2010)

In May 2010, the German Federal Government constituted the National Electric Mobility Platform (NPE), consisting of representatives from politics, industry, science, local authorities and consumers. The platform's seven working groups direct and shape the road map for the realization of the objectives laid out in the National Electromobility Development Plan.

GOVERNMENT PROGRAM ELECTROMOBILITY (2011)

In May 2011, the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry of Transport, Building and Urban Development (BMVBS) adopted a far-reaching R&D support program in response to the findings of the second report of the National Platform for Electric Mobility.

Ministry-supported R&D measures will be flagged by regional showcase and technical flagship projects for the creation of increased synergies within the electric mobility sector.

ELECTRIC MOBILITY ACT (2014)

Formally approved by the Federal Cabinet in September 2014, the new act providing preferential treatment to electric vehicles will become effective in 2015 for a period of 15 years (June 2030). According to the new law, vehicles approved in Germany will be identifiable by special number plates entitling them to preferential treatment.

EUR 1.5 billion

public funding in electric mobility development

To date, the German Federal Government has invested in the region of EUR 1.5 billion in electric mobility development. Over the same period, the automotive industry has ploughed EUR 17 billion into development and commercialization activities.

MAKING ELECTROMOBILITY A REALITY: THE STATE OF PLAY IN GERMANY

ELECTRIC MOBILITY IN PILOT REGIONS

To date, the German Federal Government has invested in the region of EUR 1.5 billion in electric mobility development. Over the same period, the automotive industry has ploughed EUR 17 billion into electric vehicle development.

The "Electric Mobility in Pilot Regions" program has allocated a total of EUR 130 million to eight pilot electric mobility projects located across Germany. Eight model regions were selected to test the application of battery-driven mobility within Germany. Thirteen additional locations focused their attentions on smart grid infrastructure as well as information and communications technology for electric mobility. Partners range from carmakers (including BMW, Daimler and Volkswagen) to energy utilities, national and federal state ministries, and renowned research institutes. Pilot projects are already building a charging infrastructure and testing applications. German researchers are addressing a wide range of electric mobility issues, covering such areas as battery capacity and light materials for auto bodies.

Germany's electric mobility strategy will be consistently pursued in line with the joint statement issued by industry and the German government on May 3, 2010. As part of the National Development Plan for Electric Mobility, the government will consistently push for the expansion of electric mobility and create the conditions for rapid market penetration.

Model Regions for Electric Mobility

The R&D measures that have already been successfully launched are unparalleled in Europe in terms of their ambition and scope. The eight model regions for electric mobility are:

- Hamburg
- Bremen/Oldenburg
- Rhine-Ruhr (Aachen and Münster)
- Rhine-Main
- Saxony (Dresden and Leipzig)
- Stuttgart
- Munich
- Berlin-Potsdam

R&D LIGHTHOUSE PROJECTS

Since 2012, the German Federal Government has established 15 R&D lighthouse projects in six thematic application areas. In line with NPE proposals, a number of technology research areas were consolidated into existing projects to create the respective R&D lighthouse projects.

BATTERIES

The batteries R&D lighthouse project was created to help Germany realize its stated aim of being a global leader in cell and battery technology with an integrated domestic manufacturing capability by 2020. Germany has set itself a battery density by volume level of 280 to 300 Wh/l by 2025 as part of the technological development of third and fourth generation batteries. More than 20 consortia have been formed. The consortia are made up of actors from industry and research communities.

The NPE has identified the following important goals within the framework of current battery R&D activity:

- Charge cycle number: At least 1,200 cycles to be ensured.
- Fast Charging Capacity: 80 percent charging achievable in less than 15 minutes.
- Battery materials should allow high-voltage spinels to be deployed in future.
- "Intelligent" cell chemistry: R&D activities to be directed in area of additive electrolytes, ionic solids, and solid electrolytes.
- Cathodes: Development of low-temperature performance materials with higher energy and performancy density levels.
- Maintain safety and reliability of battery systems to high industry standards despite falling prices and rising energy density levels of lithium-ion batteries.
- Exploration, optimization and safeguarding of recycling processes for new cell and battery processes.
- Standardization of cell modules to be pursued as part of activities of Association of the German Automotive Industry.

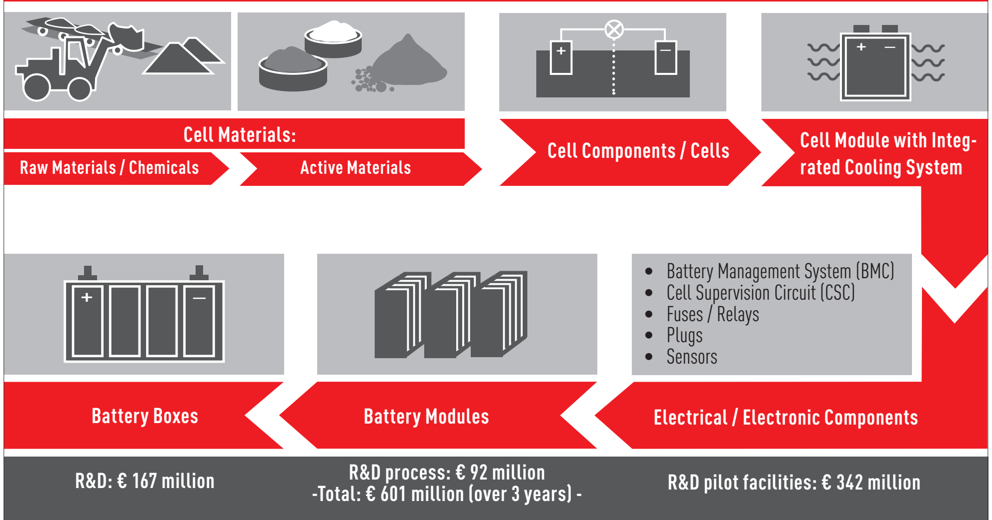
Successful implementation of the battery R&D strategy will allow meaningful progress to be made towards establishing integrated cell and battery system manufacturing capability in Germany.

Batteries Lead Technology Areas (selected examples)

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

Source: National Electric Mobility Platform

Key Components of the Value Chain



Source: National Electric Mobility Platform

DRIVE TECHNOLOGIES AND VEHICLE INTEGRATION

NPE activities during the market start-up phase were largely concerned with industry research and development as well as highly diverse joint funding projects with universities and research institutions. The publication of the third NPE progress report in 2012 saw the beginning of the implementation of detailed technology road maps (high-integration drive technologies, E-machines, and power electronics) within the drive technology lighthouse projects. A number of shared research and development activities funded by the federal government have been called into being on the basis of the road maps – project results will be made public on project conclusion.

The following research focal points have been identified on the basis of the selected projects:

- In the drive system the drive train should be completely optimized in terms of efficiency, cost, weight, and volume as well as for different topologies.
- The fundamental goals of efficient, high performance and cost-optimized vehicle concepts and materials are a focal point of e-machine activity.
- Specific goals of R&D activities in the field of power electronics are significantly increased power density and increased reliability and optimized electromagnetic system compatibility.
- Design of flexible electric motor production processes in electric motor production technology.
- Introduction of a cost-efficient production of plug-in hybrid vehicles on the basis of a scalable, modular system (electric drive, power electronics, operating software) in system integration.

As well as the R&D areas listed, the drive technology lighthouse project area is also concerned with the networking of electric vehicles within the transport and energy systems. This should be achieved by, among other things, the creation of a common vehicle interface.

Historical, current and future activities support the NPE's lead provider target. A number of themes already identified in the road map will be substantiated. New R&D focal points for the technology cluster (Road Map 2.0) and interdisciplinary themes will also be identified in the next phase of activity. Examples include the exploration of alternative materials and winding technologies for e-machine, optimal integration of power electronics, and the ongoing development of charging technology (inductive load) in vehicles. The drive technology targets set for 2020 remain unchanged.

Drive Technologies R&D Lighthouse Technology Road Map

	2010	2012-2016	2017/18		2020
Electric Motors	Permanent Fe-based magnets and Cu/Al coils	• Electric motor designs optimized for automotive applications • Alternative magnet materials and recycling • Alternative electric motors	Alternative designs and materials	Innovative materials and manufacturing processes	Costs reduced by 2/3
Power Electronics	Parts and components from non—automotive applications	• Integrated circuit packaging (1CP) modules and components • Research into modularity and scalability • Increased integration (electronics, mechatronics)	Automotive standards achieved, standardized solutions available	Research into increasing functionality and reducing costs as market expands	5% more efficient
Drive Systems	Low level of integration	• New topologies and highly-integrated approaches • Energy and thermal management • Charging technologies and power grid integration	New system designs	Modular electric powertrain kits optimized for different requirements and suitable for large-scale production	Power density doubled
Production Technology	Low production volumes	• Automated production facilities for inverters and electric motors • Concepts for moving from small to large-scale manufacturing	Automated manufacturing solutions capable of flexible output levels	Development & optimization for large-scale production (process engineering and complete chain)	30% more reliable

Source: National Electric Mobility Platform

Drive Technologies and Vehicle Integration R&D Lighthouse Project Examples

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

Source: National Electric Mobility Platform

LIGHTWEIGHT DESIGN

Resource-efficient lightweight design solutions continue to be of great significance as a major cross-sectoral technology area.

The lightweight design R&D lighthouse project is conducting research into new and modified materials on the way to functionally integrated systemic lightweight design. Activities have been defined in terms of four thematic research areas:

- Development of lightweight materials;
- Optimization and development of components;
- Development of lightweight electric vehicle structures;
- Industrial scale resource-efficient manufacturing processes.

The strategic import of lightweight design within the broader electric vehicle value chain cannot be overestimated. According to the NPE, the potential created by adopting a systemic approach to the fundamental scientific and technical factors of lightweight design unfold in the adoption of a single, coherent approach to the different value process chains.

Lightweight Design R&D Lighthouse Project Overview

Lightweight Design			Projects already awarded funding*	New projects
	1	Development of lightweight materials	6 projects € 30 million	2 projects € 9 million
	2	Optimization and development of components	7 projects € 25 million	1 project € 3 million
	3	Development of lightweight EV structures	7 projects € 70 million	2 projects € 54 million
	4	Industrial-scale resource-efficient manufacturing processes	15 projects € 75 million	3 projects € 34 million
	Total project investment in the lightweight design lead technology area		35 projects € 200 million	8 projects € 100 million

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

Source: National Electric Mobility Platform

RECYCLING

Increased awareness of the need to reduce harmful emissions into the environment is seeing governments worldwide act to regulate permissible vehicle pollution levels. In 2009, the European Union (EU) and G8 member countries agreed to reduce CO_2 emission levels by 80 percent by the year 2050. In order to meet this overall target, road transport must be decarbonized by a striking 95 percent over the same period.

These ambitious goals will only be achieved through creating new vehicle fuel efficiencies by developing sustainable drive train alternatives. Electric vehicles have a major role to play in safeguarding the environment. The NPE concludes that recycling represents a strategic pillar in the development of an environmentally, economically, and socially sustainable electric mobility industry.

The recycling R&D lighthouse project is made up of two thematic areas:

- Battery materials
- Power train component materials

A number of new components and materials are entering the value chain mix as lithium-ion batteries and alternative power trains are further developed. This in turn calls upon the introduction of new or modified recycling processes.

A further overarching theme – besides key materials recycling – is the safeguarding of raw material supply. Germany's raw materials strategy is helping industry to secure raw material sources by establishing partnerships with a number of raw material-supplying countries.

INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) AND INFRASTRUCTURE

The objective of the ICT and infrastructure R&D lighthouse projects is the development of charging and vehicle-to-grid (V2G) technologies as well as related communications processes and transactions.

The second report of the NPE identified four key thematic research areas for the ICT and Infrastructure R&D lighthouse.

These being:

- Charging technologies;
- Power grid integration;
- ICT interfaces – energy systems;
- ICT interfaces – traffic systems.

R&D activities currently being conducted across these four areas take place within a number of broad-based consortia.

Different charging (normal, fast, and inductive) technology progress to date can be tracked according to the NPE's charging infrastructure technology roadmap.

Common interoperable processes and standard solutions are imperative to achieving acceptance within the driving public. Commercially viable fast-charging solutions (including DC and AC-based systems) are being developed by energy utilities, electrical engineering companies, automotive and battery manufactures for introduction within the showcase project regions. Fast chargers with up to 100 kW capacity – which will significantly reduce charging times – are being put through their paces for eventual implementation during the early mass-market phase.

The creation of common charging point and vehicle standards is essential to Germany's 2020 objectives. The NPE endorses the German-American developed Combined Charging System (CCS) universal charging system.

In order to create a charging infrastructure that is fully integrated into the power grid, smart charging (grid-to-vehicle – G2V) and two-way power generation (V2G) models are being researched further, as are dynamic payment tariff models.

ICT-based energy and traffic system interfaces are being created along maximum process simplicity and transparency lines to promote user acceptance and generate appropriate business models. Research findings from the different model regions are being collated for further development in the respective showcase regions.

ELECTROMOBILITY SHOWCASE PROJECTS – THE WINNERS

In April 2012, the federal government identified four electromobility showcase projects for the research and development of alternative drive technologies from a field of over 20 applicants. At the time of publication, 90 projects with 334 individual projects were actively being funded.

Federal funding of up to EUR 180 million has been made available for the three-year showcase program.

The four winning showcase projects are:

- Internationales Schaufenster der Elektromobilität - International Showcase of Electric Mobility (Berlin/Brandenburg)
- Unsere Pferdestärken werden elektrisch - Our Horsepower Turns Electric (Niedersachsen)
- Living Lab BWe mobil (Baden-Württemberg)
- Elektromobilität verbindet - Electromobility Connects (Bavaria/Saxony)

International Showcase of Electric Mobility (Berlin/Brandenburg)

Region

Capital region Berlin-Brandenburg

Project Partners

- 257 partners
- 2 local/regional authorities
- 107 large-scale enterprises
- 90 small and medium-sized enterprises
- 34 higher education and research institutes
- 24 professional bodies, associations, networks and other institutions

Priorities

- Road transport ("zero emission" passenger and commercial transport)
- "Charge and park" (sustainable development of extant public charging infrastructure)
- Storage (electric mobility as part of capital region "smart grid")
- Networking (ICT, education and services/vocational training and CPD, electric mobility districts)
- Public relations (hands-on experience of electric mobility in action, German innovation and technological know-how, electric mobility zones)
- Cooperation (local, national and international)

Our Horsepower Turns Electric (Niedersachsen)

Region

Hanover, Braunschweig, Göttingen and Wolfsburg

Project Partners

- Regional and local authorities (i.e. Braunschweig, Wolfsburg, Hildesheim)
- Large-scale enterprises (e.g., Bombardier, Continental, DB Rent, ÜSTRA, Volkswagen AG)
- Small and medium-sized enterprises (e.g., Rangebike concept, Projektregion Braunschweig, C4C Engineering)
- Higher education and research institutes (e.g., Works Council Electric Mobility Network, Braunschweig Chamber of Trade and Craft Industries, German Red Cross)

Priorities

- Vehicles (electric vehicles "Made in the Metropolitan Region", battery re-use and recycling)
- Energy and infrastructure (smart grid – examples of decentralized energy generation and accessible electric mobility)
- Transport (vehicle fleet conversion, commuter incentives, electric car sharing)

Living Lab BWe mobil (Baden-Württemberg)

Region

Baden-Württemberg (esp. Stuttgart and Karlsruhe regions)

Project Partners

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

Priorities

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

Electromobility Connects (Bavaria/Saxony)

Region

Federal State of Bavaria
Federal State of Saxony

Project Partners

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

Priorities

- Long-distance transport (Munich-Leipzig A9 axis)
- Urban transport (street parking)
- Rural transport (meeting transport needs of rural and sparsely populated communities)
- International visibility and international long-distance transport (e.g. cooperation initiatives with Austria and Quebec)
- Vocational training and CPD (as cornerstone of forward-looking and growing electric mobility system in Bavaria and Saxony)

ELECTROMOBILITY FLAGSHIP PROJECTS – THE WINNERS

Flagship projects are specifically targeted toward advancing the various technologies that are crucial for the development of electric mobility. Limited in number, the flagship projects focus on clear thematic priorities including drive, production, battery, and information and communication technology.

Within the flagships, outstanding projects were selected according to the thematic focal points mentioned. "Flagship" status within the flagships is a seal of approval for important innovations which make a significant contribution to technological development and cost reductions in the field of electromobility.

The following projects were awarded "flagship" project status by the federal government. Currently project evaluation is taking place.

1. INFORMATION AND COMMUNICATION TECHNOLOGY

econnect Germany
(January 2012 to December 2014)
Development of sustainable mobility concepts in municipal environments (public utilities) where the focus is on the intelligent networking of energy and traffic systems using ICT-based solutions.

2. MOBILITY CONCEPTS

a) Demonstration of electromobility in municipal and business traffic: subprojects Metropol-E and Elmo – Electromobile Urban Business Traffic
(September 2011 to end August 2014)
The project highlights the possibilities for new business models with real users from the business traffic sector and municipal applications. Important findings with relevance for the composition of charging infrastructure, charging technologies, and fleet management are expected.

b) Electromobility in heavy commercial vehicles for protection of the environment in urban areas – ENUBA 2
(April 2012 to end April 2014)
The project should lead to the creation of a system for overhead contact wire electric operation of heavy commercial vehicles and buses to be deployed in the public transport space. R&D activities are concentrated in vehicle technology including current collector, overhead contact wire system, and energy supply. Accompanying research work concerns the analysis of all traffic and energy-technology, environmental, economic and legal factors relevant to later deployment in the public space.

3. CHARGING INFRASTRUCTURE AND NETWORK INTEGRATION

Demonstration of contactless static and dynamic loading infrastructure with high performance. Subprojects: Optimization of inductive energy transfer components and system testing – Primove Rail, Primove Road and Primove Braunschweig
(June 2011 to end February 2014)
Contact-free energy transfer by means of resonant induction allows standing (stationary) and moving (dynamic) electric vehicles to be charged in safe and reliable fashion. Systems of this nature tested in day-to-day operations during the course of the project. Major focus is placed upon systems with high transfer performance and efficiency levels in order to be able to efficiently power larger vehicles (e.g. buses and trucks) in contact-free fashion.

4. RECYCLING AND RESOURCE EFFICIENCY

LithoRec II
(July 2012 to end June 2015)
The project examines the complete recycling process chain (from deactivation of batteries and cells to the disassembling of batteries and the reducing and classification of the different component materials. A pilot facility for the recycling of lithium-ion traction batteries will be set up and put into operation in parallel with the project research activities.

5. ENERGY SYSTEMS AND ENERGY STORAGE

a) eProduction – Production research into high voltage storage systems for electromobility
(December 2011 to November 2014)
Research work conducted during the course of the project should lead to safer, more robust and more sustainable production of energy storage systems possible. The specific challenges created by construction, assembly and repair of batteries/battery-driven vehicles (as well as the sustainable use of resources in holistic manner) should already be considered in the battery and battery production system design phases.

b) SafeBatt – Active and passive measures for intrinsically safe lithium-ion batteries
(July 2012 to end June 2015)
The project intends to make models and sensor lithium-ion batteries more reliable through the research, development and introduction of new materials. In parallel, a so-called "digital battery passport" will be created through the continual collation, evaluation and documentation of critical battery parameters.

6. DRIVE TECHNOLOGIES AND LIGHTWEIGHT DESIGN

a) e generation – Key technologies for the next generation of electric vehicles
(January 2012 to end December 2014)
The R&D activities being followed have the stated goal of extending the range of electric vehicles by 40 percent. In order to increase the range, new approaches to vehicle air-condition form a major research focal point alongside a fundamental reduction of energy consumption through a new generation of drive components and control systems. Reductions in overall vehicle weight also contribute to increasing range. To this end, additional lightweight construction factors will also be researched.

b) VisioM – Visionary vehicle concept for urban electromobility
(March 2012 to end August 2014)
New technologies and innovations in vehicle safety, drive technology, energy storage, and operating concept are being tested for readiness for mass production on a miniature electric vehicle. The comprehensive use of lightweight construction materials, particularly in the transmission system, explored as part of the project.

APPENDICES

ELECTROMOBILITY PARTNERSHIPS & ACTORS

Listed below is a selection of electric mobility activities, projects and actors currently active in Germany. The list provides a representative sample of the types of organizations active in the electric mobility sector and is not intended to be exhaustive.

MODEL REGIONS FOR ELECTRIC MOBILITY

- Hamburg
- Bremen/Oldenburg
- Rhine-Ruhr (Aachen and Münster)
- Rhine-Main
- Saxony (Dresden and Leipzig)
- Stuttgart
- Munich
- Berlin-Potsdam

ELECTRIC MOBILITY SHOWCASE PROJECTS

- Internationales Schaufenster der Elektromobilität – International Showcase of Electric Mobility (Berlin/Brandenburg)
- Unsere Pferdestärken werden elektrisch – Our Horsepower Turns Electric (Niedersachsen)
- Living Lab BWe mobil (Baden-Württemberg)
- Elektromobilität verbindet – Electromobility Connects (Bavaria/Saxony)

ELECTRIC MOBILITY FLAGSHIP PROJECTS

1. Information and Communication Technology
econnect Germany (January 2012 to December 2014)

2. Mobility Concepts
a) Demonstration of electromobility in municipal and business traffic: subprojects Metropol-E and Elmo – Electromobile Urban Business Traffic
b) Electromobility in heavy commercial vehicles for protection of the environment in urban areas – ENUBA 2

3. Charging Infrastructure and Network Integration
Demonstration of contactless static and dynamic loading infrastructure with high performance – subprojects: Optimization of inductive energy transfer components and system testing – Primove Rail, Primove Road and Primove Braunschweig

4. Recycling and Resource Efficiency
LithoRec II

5. Energy Systems and Energy Storage
a) eProduction – Production research into high voltage storage systems for electromobility
b) SafeBatt – Active and passive measures for intrinsically safe lithium-ion batteries

6. Drive Technologies and Lightweight Design
a) e generation – Key technologies for the next generation of electric vehicles
b) VisioM – Visionary vehicle concept for urban electromobility

GOVERNMENT MINISTRIES

- Federal Ministry for Economic Affairs and Energy (BMWi)
- Federal Ministry for Education and Research (BMBF)
- Federal Ministry of Transport and Digital Infrastructure (BMVI)
- Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

AGENCIES

- Joint Agency for Electric Mobility (GGEMO)
- National Electric Mobility Platform

RESEARCH INSTITUTES

- The Fraunhofer-Gesellschaft
- Helmholtz Association
- The Max Planck Society
- The Leibniz Association

NATIONAL ELECTRIC MOBILITY PLATFORM

PROGRESS REPORT (2014)

The Progress Report of the National Electric Mobility Platform was published in December 2014. The Progress Report signifies the end of the market preparation phase (2010-2014). At the end of 2014, there were already 17 electric vehicle models produced by German manufacturers on the market, with manufacturers set to extend their product portfolios in the coming years. Twelve new vehicle models are expected to be launched in 2015. The concentration of funding for research and development, standards and standardization as well as training and education is also proven in international comparison. The collaboration between lead industries and science along the electric mobility value chain has also been established. The task is now to realize the potential of the German industry in terms of higher market share in order to attain lead provider status. Electric vehicles have to prove themselves in competition with other drive concepts, particularly in terms of price and range. Pre-competitive research and development at a high level is still required in this respect. The NPE has identified overall research and development project volume of around EUR 2 billion to the end of the market start-up phase in order to drive the innovation process forward. The NPE recommends a cost-neutral extension of the showcase projects by one year to 2016. THE NPE will continue its monitoring duties during the market start-up phase until the end of 2017. The German Federal Government will host a National Electromobility Conference in Berlin in the summer of 2015.

RECOMMENDATIONS

1. Introduction of Special Depreciation Allowance for Commercial Vehicles
Financial incentives are recommended in order to realize the stated objective of 1 million vehicles on German roads by 2020. According to the NPE, particular emphasis should be placed on the introduction of a special depreciation allowance for commercial vehicles, which, according to forecasts, has proven to be a very effective measure. Subject to the number of new vehicle registrations, implementation of a special allowance for commercial vehicles should result in annual tax revenue losses in the EUR 0.2 billion region. In the proposed first year of 2015, the forecast loss in tax revenue would be around EUR 30 million, rising to a maximum of EUR 290 million in 2019.

2. Implementation of Proposed Legislative Package Promoting Electric Mobility
The proposed non-monetary measures are central building blocks for the development of the global lead market and should enter into effect at the start of the market ramp-up phase in early 2015. Alongside the directly funded privileging of the introduction of electric vehicles, the proposed measures help remove existing obstacles in everyday life.

3. Strengthening of Investment Partnerships for Construction of Publicly Available Charging Infrastructure
The NPE is committed to the goal of nationwide expansion of publicly accessible charging infrastructure. This should grow in needs-based fashion according to the acceleration of electric vehicles. According to the current technological level, and based on the goal of one million electric vehicles by 2020, financing in the region of around EUR 550 million is required up to 2020. This amount is expected to decrease as unit numbers increase, thereby reducing production costs from year to year which should be checked regularly.

4. Implement EU Guideline for Alternative Fuels including Deployment of Charging Infrastructure in accordance with the Recommendations of the Standards Road Map Version 3.0
The Combined Charging System (CCS) must establish itself in the future as a globally binding charging system for normal and fast charging. This has been specified by guideline in Europe since 2014, which will also be established in the USA. Negotiations with China, Japan and other partner countries to join CCS are currently taking place at the time of writing. Based on the unity and investment security created, the NPE does not recommend investment in other solutions outwith the CCS Road Map. The infrastructure can quickly be expanded nationally for CCS compatibility.

5. Implement Private and Public Procurement Initiatives
Procurement of electric vehicles to date has only been worthwhile for a few individual user groups – most particularly commercial fleets. These also play an important role for the penetration of the used car market. For that reason, both private and public procurement initiatives should be initiated and implemented. The NPE believes that, for a longer stroke and better visibility, special depreciation allowance rules will support faster market start-up.

6. Continue Research and Development with New Themes and Securement of Federal Government Funding
Research and development provide an important basis for Germany's lead provider status and the creation of a high-quality, international lead market in Germany. The NPE recommends that the federal government promote research and development along the value chain with the provision of funding of at least EUR 360 million until the end of the market start-up phase. This should take place according to the basis of the Systemic Approach and Technology Road Maps as well as the related narrative approaches. Funding should be placed on a secure and calculable basis up to and beyond the market start-up phase.

7. Research and Promotion of Long-term Cell Production in Germany
Substantial overcapacity partially exists for the second generation lithium-ion (Li-ion) cells that currently dominate the market. Further expansion of production of these cells in Germany is, from the current perspective, not economically feasible. Significant expansion of cell production and the materials used is necessary as the number of electric vehicles increases during the market start-up phase. Domestic production of third and fourth generation cells is in Germany's interest as a business location. Research and development efforts in materials, battery cells and systems as well as the optimization of their respective production processes needs to be pushed ahead in order to make this possible. Based on the available research production lines, know-how in Germany should be continually developed in order to establish and make the economically viable, sustainable mass production of cells possible in the future. The NPE recommends the co-financing of further industrialization through a partnership between the private and public sectors. The competences within the complete value chain should be further developed and funded. The NPE will develop a road map for integrated cell and battery production in 2015.

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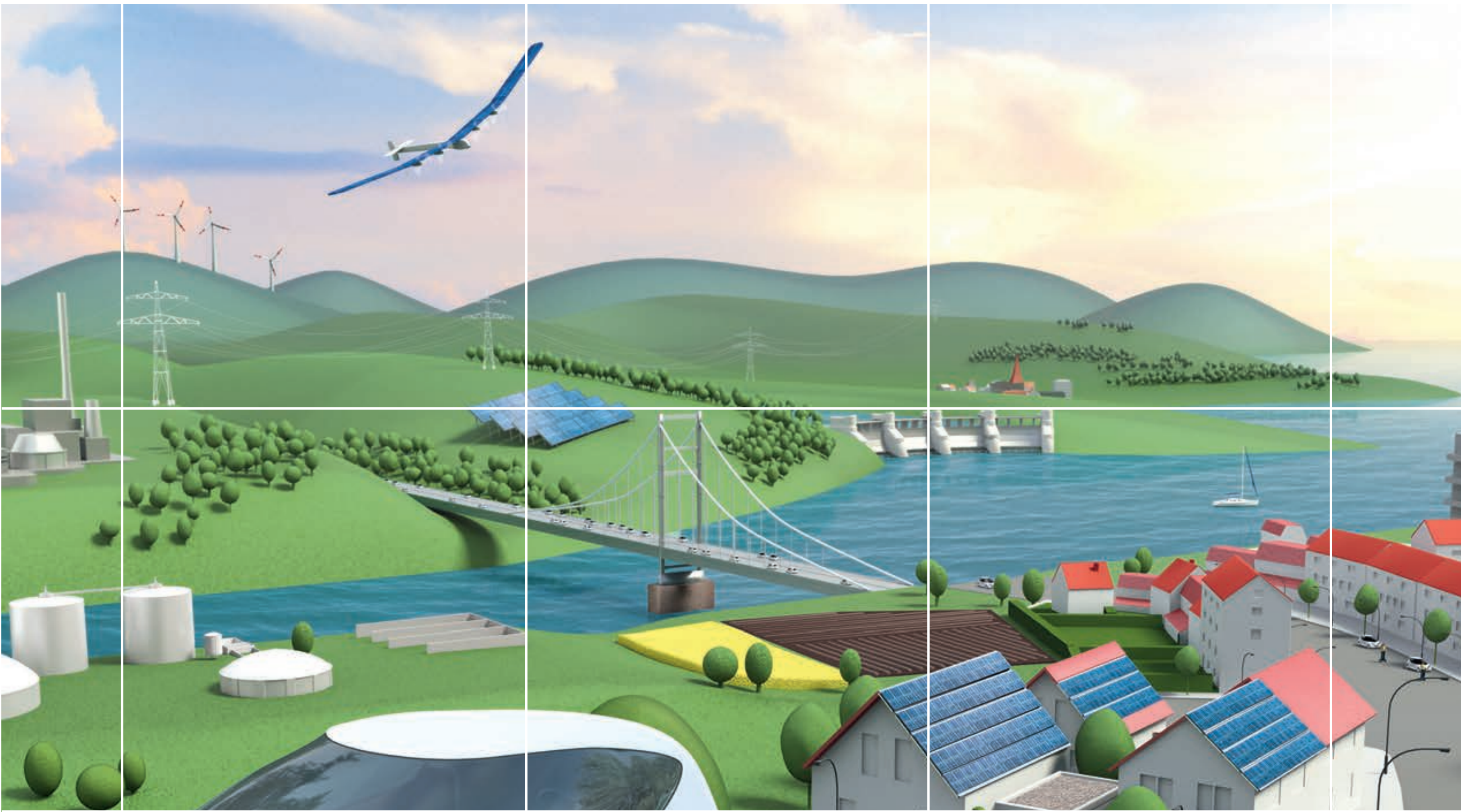

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