Electromobility in Germany

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Finpro Germany
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Germany is the leading automotive country in Europe. The role of the automotive industry is very crucial for the society. Almost 20% of German GDP comes from automobile sector. There are 723,000 employees direct and over 5 mio people who are working indirect for the sector. About 1,500 SME companies are dependent from the German car manufacturing companies and their suppliers.

Germany is car friendly country with 44,632 Mio. Cars (VDA 2010), which is more than 500 per each 1000 citizen.

Only about 1,500 electric cars in Germany in June 2010.

The predictions about the market size are also in Germany very contradictory; whereas German Government has set the goal to have 1 Mio electric cars on the Germany roads by 2020, energy provider RWE estimates 2,4 Mio electric cars at the same time.

The experts agree that Germany will remain mobility friendly country with lot of combustion motors for many years. Though, Germany wants and aims to be amongst leading industry nations within electromobility as they are in conventional car industry.

No incentives for buyers until now, but experts estimate the government to launch one when Germany OEM’s have their own EV’s on the market. Today the incentives would much more support the foreign manufacturers.
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To enable electric vehicle industry succeed, new kind of cooperations are needed. Not just the traditional partnerships between OEM and supplier, but also with the players outside the conservative automobile industry, as Utilities, Charging station manufacturers etc. Also much bigger role of the government as earlier is needed.

In Germany, the big utility companies has taken a big role in electromobility. There are lot of cooperations between utilities and OEM’s, and these partnerships are a kind of drivers on the field, also pushing and controlling the most pilot projects.
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Governmental role

- The government’s goal is to make Germany a leading market for electro-mobility in the long term, and by 2020 to get one million electric vehicles onto German roads.

- With its National Electromobility Development Plan, The German government and German industry intend to work together to make Germany the leading international market for electro-mobility. The "National Platform for Electro-Mobility" will bring together the activities of the various branches and the research community.

- Under the terms of the German government’s second rescue package, for instance, 500 million euros are to be used to promote electro-mobility. Players from the fields of research, industry and the local authorities involved are working together within the framework of these model projects to establish an infrastructure and to anchor electro-mobility in the public consciousness. A system for the future is needed – financial incentives to encourage consumers to buy electric vehicles are not to be part of the package though.

Source: National Electromobility Development Plan
In May 2010 the German government and industry established the National Platform Electric Mobility. Industry announced annual investments in RTD of 20 billion € of which a high share will be dedicated to efficient drive technologies and electric vehicles as well as other energy saving measures. Seven working groups will be established to elaborate detailed roadmaps to reach the targets of the National Development Plan for Electric Mobility. The government announced to exlarge funding of research and innovation for batteries (mainly preparation of industrial production), electric engines and electronics, grid integration, storage management and charging systems, recycling, but further development of (existing) pilot regions as well.

SWOT analysis of German electromobility on the right hand side (source: National Electromobility Development Plan)
Market development up to 2020 is to take place in three phases:

- Phase 1: market preparation up to 2011
- Phase 2: market development up to 2016
- Phase 3: high-volume market from 2017

One of the schemes of the National Electromobility Development Plan is called "Electric Mobility in Pilot Regions". This is a funding priority of the Federal Ministry of Transport, Building and Urban Development, and provides a total of 130 million euros to 8 pilot projects. Players from academia, industry and the local authorities involved are cooperating closely in these pilot projects in order to progress the development of an infrastructure and to ensure that electric mobility is firmly embedded in the public realm.

8 model / pilot regions and their targets, background, key aspects:
## Governmental role – Pilot regions

- **8 pilot regions and their partners**

<table>
<thead>
<tr>
<th>Model regions</th>
<th>Actors / partners</th>
<th>Number of charging spots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamburg</td>
<td>Hamburg Energie, Vattenfall Europe, DB AG, Stadt Hamburg (Behörde für Stadtentwicklung und Umwelt sowie Landesbetrieb Straßen, Brücken und Gewässer)</td>
<td>100 public, 150 semi-public</td>
</tr>
<tr>
<td>Nord West (Bremen/Oldenburg)</td>
<td>BREPARK GmbH, die Städtische Parkgesellschaft Bremerhaven mbH, EWE, Airport Bremen und die Bremer Straßenbahn Aktiengesellschaft</td>
<td>10 public, 40 private</td>
</tr>
<tr>
<td>Berlin/Potsdam</td>
<td>RWE, APCOA, Siemens, Vattenfall, ADAC, IHK Berlin, Elektroinnung Berlin, REWE, Contipark, IAV, Total, Messe Berlin und Gravis, Deutschen Bahn AG</td>
<td>600 total, 500 public and semi-public (76 in operation)</td>
</tr>
<tr>
<td>Rhein-Ruhr</td>
<td>RheinEnergie, Stadtwerke Düsseldorf, Stadtwerke Aachen-STAWAG und RWE Effizienz GmbH</td>
<td>500 public, semi-public and private</td>
</tr>
<tr>
<td>Rhein-Main</td>
<td>u.a. Stadtwerke Offenbach, Mainova AG, UPS, Offenbacher Verkehrsverband, RheinMain Verkehrsverband, Energieversorgung Offenbach, Städtische Werke AG</td>
<td>115 public, semi-public and private</td>
</tr>
<tr>
<td>Sachsen</td>
<td>ENSO Netz GmbH, DREWAG Stadtwerke Dresden GmbH, und die Stadtwerke Leipzig, KEMA-IEV Ingenieurunternehmen für Energieversorgung GmbH und die Hochschule für Telekommunikation Leipzig</td>
<td>8 public, 25 semi-public, 32 private (65 total)</td>
</tr>
<tr>
<td>Stuttgart</td>
<td>EnBW AG (Rollout &amp; Betrieb der Ladesäulen in Stuttgart), die Robert Bosch GmbH (Entwicklung der Ladestationen für den öffentl. sowie gewerblichen/privaten Raum), das EIFER Institut (Analyse Ladestationsorte in Stuttgart), die Stadtwerke Ludwigshburg, die Landeshauptstadt Stuttgart, DB Logistics und sonstige Eigentümer der Standorte wie Handwerkskammer, Landkreise und weitere</td>
<td>630 (60 public, 500 semi-public, 50 private)</td>
</tr>
<tr>
<td>München</td>
<td>AUDI AG, BMW AG, SIEMENS AG, E.ON Energie AG, Stadtwerke München GmbH, Forschungsstelle für Energiewirtschaft mbH, Technische Universität München, fortiss GmbH, Münchner Verkehrsgesellschaft mbH</td>
<td>260 (16 in operation)</td>
</tr>
</tbody>
</table>

Source: Modellregionen Elektromobilität
Governmental role – Pilot regions

Example: Model Region Rhein-Ruhr

Model Region – Overview (1/2)

- Inter-City Transport (Dortmund, Mülheim, Essen, ...)
- Scientific Evaluation of Diesel Hybrid buses (VRR, several cities)
- Integrated E-Mobility (Düsseldorf, several other cities)
- E-Aix (3 parts) (Aachen)
- ColognE-mobil (Cologne)

Facts
- Five Starter projects
- Funding ~22.3 Mio. Euro by total costs of approx. 40 Mio. Euro
- Projected operation of approx. 400 vehicles including:
  - 190 Cars
  - 150 E-Scooter and Bikes
  - 23 Utility Vehicles
  - 25 Hybrid Buses
- Projected infrastructure: Installation of approx. 480 charging stations
- In total more than 25 locations

Model Region – Overview (2/2)

Passenger Vehicle Field Trials

- Trial of about 160 cars (several types and manufactures)
- Infrastructure (charge points, roaming, grid connection, ...)
- Education of users, repair shops, authorities, fire brigades, ...
- Studies on acceptance, technology, environment, ...

Objectives:
- Definition of current technical status of passenger EV
- Evaluation of perspectives for EV within private transport and commercial fleet operations (e.g. car sharing, ...)
- Design appropriate further R&D topics and programs
- Investigate the role of EM from an energy perspective
- If appropriate, design or concepts for incentive programs

Logistics / Utility Cars

- Development and testing of technical solutions for
  - Drive trains concepts for commercial vehicles (e.g. zero emission last mile logistics)
  - Electric auxiliary components (e.g. waste collection)
  - Special infrastructure solutions (if required)

Objectives:
- Preparation of appropriate R&D programs (e.g. components)
- Integration of public / commercial fleets into advances mobility concepts (what is EM able to offer for these applications?)
- Analysis of additional market opportunities for suppliers for electric auxiliary components or costumer designed solutions

Public Transport Field Trials

- Comprehensive field trials with different drive train concepts for public transport buses (focus serial hybrids)
- Evaluation of current technology by measurement of e.g. efficiency, noise, emissions in comparison with most advanced “conventional” vehicles
- Benchmark of vehicles and suppliers
- Identification of further needs for improvement and optimisation

Objectives:
- Benchmark of “new” and “current” technology
- Analysis and forecast of economics
- Definition of further steps toward market introduction
- Preparation of public support for investment programs

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ICT will become more and more important to automotive industry

"ICT for Electric Mobility“ (www.ikt-em.de) is a support program operated by the Federal Ministry of Economics and Technology.

A total of 47 companies and scientific research institutes are involved in the projects. The projects focus chiefly on ICT-based charging, control, vehicle navigation and billing infrastructures for various vehicle types and effective business models, services and potential standards that can be developed to fit these infrastructures.

This will provide solutions that make electricity production, grids, storage and consumption more intelligent, advance the integration of renewable energies and enable communication across all the links in the supply chain.

Total investment amounting to roughly 100 million euros will be allocated to these projects, which will develop prototypes and economically viable solutions to be assessed for the very first time in comprehensive field tests. Thus the “ICT for Electric Mobility” program forms a key pillar of the German government’s National Development Plan for electric mobility.

The seven model projects of the ICT for Electric Mobility program are:

- eE-Tour Allgäu - Efficient electric mobility and tourism
- e-mobility - ICT-based integration of electric mobility into the networks of the future
- Future Fleet - Integrating electric vehicles into company car fleets
- GridSurfer - Integrating electric vehicles into rural energy systems - battery change included
- Harz.EE-Mobility - Linking the use of electric mobility with the RegModHarz renewable energy project in the Harz region
- MeRegioMobil - Minimum-emission regions with electric mobility
- Smart Wheels - Smart electric mobility in the model region of Aachen

Governmental role – ICT for Electromobility

"ICT for Electric Mobility" - 7 model regions in detail:

**e-Tour Allgäu**
Blazing trails with electric power
ICT and electric mobility for environmental protection and tourism in the Allgäu region

Environmental protection and tourism promotion are not necessarily mutually exclusive priorities. The Allgäu region in southwestern Germany wants to prove that the two can go together. In Germany’s largest contiguous tourist area, it is important for both locals and guests to be able to get wherever they need to at any time. The result: today the environment bears the burden of increasing traffic, and this detracts from both the attractiveness of tourist destinations as well as the recreational value of the countryside.

The e-Tour Allgäu project aims to use electric mobility to help solve the region’s needs for full mobility as well as the highest possible level of environmental protection. This will be done by creating a fleet of electric vehicles that can be rented by both locals and tourists. The e-Tour project places a central priority on putting together a diverse fleet of vehicles and establishing a charging infrastructure that incorporates communication technology. The electricity for charging stations is derived entirely from renewable energy sources. The project is developing a new ICT-based concept for these charging stations, which will communicate with in-vehicle computers so that drivers can travel safely, silently and emission-free through the Allgäu.

**Future Fleet**
Green energy for company cars
Integrating electric vehicles into company car fleets

For the first time ever in Germany, two major companies – the software giant SAP AG and the energy group MVV Energie AG – plan to convert a portion of their company car fleets into electric vehicles. Within the framework of the Future Fleet project, about 100 electric cars will be charged exclusively with renewable electricity and used by both companies. To enhance the efficiency of vehicle deployment, the project will test a software prototype for the smart management of company car fleets. This software will make it possible to analyze the interrelationships between mobility needs, technical possibilities, and new requirements resulting from the use of electric vehicles. This analysis will take a wide variety of driving and vehicle parameters into account, including the distance and duration of planned drives as well as vehicle range.

The Future Fleet project also aims to gather new findings on key issues such as user acceptance, changes in transport habits, as well as barriers to and opportunities for the use of electric vehicles by companies. These issues will be studied on the basis of comprehensive field tests and statistical analyses carried out by the research partners involved in the project.

**Consortium leader:** Allgäuer Oberlandwerk GmbH  
**Contact person:** Stefan Mayer (info@e-tour.de)  
**Consortium partners:** Allgäuer Oberlandwerk GmbH, Kempten University of Applied Sciences, SolaPlan GmbH, Move About GmbH, University of Tübingen, Technical University of Munich, John Deere Werke Mannheim, Energy4U GmbH  
[www.ee-tour.de](http://www.eee-tour.de)

**Consortium leader:** SAP AG (SAP Research)  
**Contact person:** Joachim Marx (j.marx@sap.com)  
**Consortium partners:** SAP AG (SAP Research), MVV Energie AG, the Öko-Institut, the Institute for Social-Ecological Research (ISEO), Mannheim University of Applied Sciences  
[www.futurefleet.de](http://www.futurefleet.de)
Governmental role – ICT for Electromobility

"ICT for Electric Mobility" - 7 model regions in detail:

GridSurfer
Taking electric mobility into the countryside
Integrating electric vehicles in rural energy systems – battery change included

Electronic mobility makes sense – and not just in metropolitan areas. The GridSurfer project analyses the use of electric mobility in the largely rural region between the Erms, Weser and Elbe rivers. This region poses specific challenges to electric mobility while also offering great opportunities for the use of electric vehicles thanks to the high availability of renewable, fluctuating sources of energy.

GridSurfer will develop and field-test key components of electric mobility systems and their interfaces, including storage and charging stations; metering and control systems; ICT-based storage management, billing, and marketing processes; as well as low-emission and business models. The project will also place a particular emphasis on the development of information and communication systems for electric vehicles. For this purpose, six vehicles will be built and outfitted while undergoing continuous development and fine-tuning.

Additional priority will be placed on developing and testing a system for changing batteries in order to solve the problem of vehicle range. While quickly restoring mobility to drivers, this system will also make it possible to integrate high levels of storage capacity into the power grid.

Harz.EE-mobility
Harnessing the wind and the sun to make people mobile
Electric cars as rolling energy storage units

In Germany’s mountainous Harz region, alternative energy sources already account for half of the area’s power generation. The Harz.EE-mobility project aims to harness as much of this renewable energy as possible to enhance passenger mobility. By doing so, the project also aims to ensure the stability of energy networks, to boost economic performance, and to foster energy security and climate protection. An intelligent ICT-based system is used to calibrate the energy supply in accordance with the existing power grid and individual mobility needs. Harz.EE-mobility demonstrates how drivers of electric cars can fuel up on carbon-neutral electricity without regard to network area or power provider. The ICT-based system will help drivers to plan their driving routes in accordance with the state of charge of their vehicle batteries and to make optimal use of the charging stations available along the way.

This project is also committed to using open and internationally standardised interfaces that allow the newly developed technologies to be quickly and efficiently disseminated beyond the test region.

CONSORTIUM LEADER:
Otto von Guericke University of Magdeburg
Contact person: Prof. Dr.-Ing. Zbiagiewi A. Szymskis (info@bartze-mobility.de)

MeRegioMobil
When washing machines talk to cars
Electric vehicles as mobile energy storage units in smart home energy management systems

If you want to sell electricity, drive a car. The electric cars of tomorrow will not only be emission-free but will also be capable of being integrated into existing energy networks, and this will enable them to function beautifully as mobile energy storage units.

Within the framework of the MeRegioMobil project, excess energy generated by electric vehicles will be stored in batteries. When these batteries are hooked up to home energy supply systems, the excess energy drawn from electric vehicles can be used to power household appliances or can even be fed into the power grid.

Another key priority of the project is to develop an electric vehicle charging infrastructure for the federal state of Baden-Württemberg and to field-test this infrastructure by the end of 2011. The charging infrastructure will aim to provide uniform billing procedures with different energy providers and to establish a smart charging communication system that can function effectively across borders and across different charging technologies.

CONSORTIUM LEADER:
EnBW AG
Contact person: Lars Walch (l.walch@enbw.com)
CONSORTIUM PARTNERS: EnBW AG, the Karlsruhe Institute of Technology (KIT), Fraunhofer Institute for Systems and Innovation Research (ISI), Adam Opel GmbH, Daimler AG, Robert Bosch GmbH, SAP AG, Stadtwerke Karlsruhe GmbH (www.smartswhw.de)

Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Examples of other government supported projects:

- **Goal**: Improve the efficiency of the electrical vehicle using advanced semiconductor components in the areas of:
  - Power Conversion
  - Power Management
  - Power Distribution Network
  - Smart Dynamic Monitoring

- **Audi as a driver in the future oriented ePerformance project.**
- **Goal**: Improve the efficiency of the electrical vehicle using advanced semiconductor components in the areas of:
  - Power Conversion
  - Power Management
  - Power Distribution Network
  - Smart Dynamic Monitoring


**Design and construction of a battery-electric vehicle**

**Aim**: Research on the interaction of new components for an electric vehicle in high-end

**Partner**: 5 with 7 subcontractors
- Audi AG (TU Dresden, TU München, TU Ilmenau, Fortiss)
- Audi Electronics Venture (FHG-IESE, FHG-ISB, Uni Hannover)
- RWTH Aachen University
- Robert Bosch GmbH
- Bosch Engineering

**Budget**: 36 M€, 22.2 M€ BMBF funding

**Website**: [www.audi.de/eperf/brand/de.html](http://www.audi.de/eperf/brand/de.html)


**Nanoelectronics for an Energy Efficient Electrical CAR**

**Aim**: New concepts for energy transformation, power and battery management

**Partner**: 6 in Germany, 31 overall in 10 European countries
- OEM: EBIll, THINK, Fiat, Audi
- Tier 1: Siemens, Bosch, Valeo
- Tier 2: Infineon, Atmel, AMS, Onsemi, ST, CISC

**Budget**: 9.5 M€ for German partner, 3.35 M€ BMBF funding, 42.8 M€ overall

**Biggest project on e-mobility in Europe!**

**Top target for energy savings by**:
- Converter efficiency (9% potential)
- Mileage of battery set (11% potential)
- Weight by integration (10% potential)
- Power distribution net (10% potential)
- Overall target: 35% energy savings

**Website**: [www.e3car.eu](http://www.e3car.eu)

Source: BMBF
Case study – Bundesland Baden-Württemberg

- About 5% of world’s value creation in automobile sector comes from Germany’s federal state Baden-Württemberg.
- 200,000 employees in 357 companies direct in the sector, about 60,000 of them are dealing with traditional combustion technology => need to make decisions regarding electromobility
- Many of the German big players are located there, such as Daimler, Porsche, Bosch.
Case study – Bundesland Baden-Württemberg

- Lot of players in different fields in Baden-Württemberg
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The most important assets of German car manufacturers are based on old technology: factories, patents and subcontracting industry, not to even mention know-how of the employees. Considering this, it is no surprise that the established automobile manufacturers take a sluggish if not rejecting approach to electric vehicles. A rapid changeover to electric automobiles is not possible. The current approach is to keep the weakening cash cow alive as long as possible.

The situation is quite different for the automobile industry in the Far East. Not having the burdens of established business, companies like BYD and TATA can build up a dominant position in the new electric car market. Instead of dealing with the strict regulations and partly shrinking market in the developed countries, they can offset the growing demand on mobility in their own emerging markets with simple basic products. They can thus gain extensive experience and build assets, for the Brilliance crash test disaster taught the Chinese car industry branch an important lesson: they can only have success here with advanced and competitive products after having grown up to the demanding developed markets.

It seems that after its cooperation with Daimler in China, BYD is now ready to hit the European market in return. As revealed on June 7th 2010, the Chinese battery and vehicle manufacturer is planning to open its Europe headquarters in Germany this year. Hybrid and electric vehicles ought to be sold in Germany from 2011 on i.e. significantly earlier than the arrival of electric vehicles from German serial production, in a very different price-quality ratio, though. Market shares lost by the German industry are not going to be easy to gain back in the future automobile market. Examples from other branches show that this is not an ungrounded worst-case-scenario, but a hard fact. Who would have thought a few years ago that well-established traditional German products such as mobile phones of Siemens, entertainment electronics of Telefunken and Dual or Computers of Nixdorf and Peakock would disappear from the market and be replaced by products from the Far East? The reprieve is over.
Besides putting lot of efforts to electromobility, the OEM’s are now very keen to lower the CO² emissions of the traditional combustion engine.

“The challenge is to reduce the CO² emissions from 120 gr to 95 gr until 2020, and that is possible with combustion engine”, says Peter Gutzmer, responsible foe engine systems at Continental.

Some examples of reducing CO² emissions in traditional cars with combustion engine:
Germany is a country of big and well known OEM’s. There are many manufacturers of premium segment, such as Mercedes, BMW, Audi and Porsche.

Also the segment below premium is known of the good German quality. Manufacturers in this segment are Opel, VW, Ford.

Some electric vehicles by the traditional OEM’s:
Some German OEM’s are active in fuel cell technology. Above all Daimler, who believes fuel cell is the technology that wins against normal electric vehicles in the long run. Also the technologies with hydrogen differ from each other: Daimler converts hydrogen with fuel cells in electricity, whereas BMW burns the hydrogen in conventional combustion engine.

As the country of big traditional OEM’s, in Germany there are not many electric car specialists. Though, some player outside the field have had pilot projects to develop their own e-car. Examples of this are e.g. energy provider EWE, which together with Karmann developed as first utility company a e-car. Also University of Munich has developed own e-car called MUTE. Following some e-car specialists or pilot projects:

- MUTE developed by University Munich (www.mute-automobile.de)
- Stromos by German e-cars (www.german-e-cars.de/Der-neue-Stromos.98.0.html)
- 4U green by supplier Luis (http://4u.luis.de/)
- CitySax (http://citysax.com/citysax/html/preise.html)
- LuisFree (www.luis.de/elektro-auto/elektroauto-luis-free/)
- Reva (www.smiles-world.de/konzept-reva)
- City El (3 wheel, www.smiles-world.de/konzept-cityel)
- Twike (3 wheel, www.bavariabike.de/twike.htm)

In the following pages the big OEM’s are listed and their electromobility plans are described shortly.
Hybrid/electric and FuelCell Plans:

- S 400 hybrid in 2009 (the first European hybrid car produced in a large series and the world’s first car produced in a large series with a lithium-ion battery)
- Mercedes puts lot of efforts to fuel cell technology. B-Class F-CELL, Mercedes-Benz is the world’s first manufacturer to put a fuel-cell car on the road that was produced under series conditions
- A-class E-cell since 2010 as a complete rent service for customers in Germany, France and Netherlands. Range 200 km, electric engine 70 kW.
- Also electric sports car Mercedes SLS AMG E-Cell
- Daimler daughter company Fuso presented 2010 a concept of electric truck with 120 km range
Many cooperations, e.g.:

- Cooperation with Nissan/Renault with focus on technology sharing on upcoming fully electric versions of the Renault Twingo (very popular in Europe) and the Smart ForTwo as well as diesel engine sharing for both models. Smart EV coming 2013.
- Joint-venture with BYD, aiming to start the EV production in 2013. New brand formation by BYD and Daimler together. Technology partnership for Chinese-market-oriented new electric vehicle.
- Daimler plans cooperation with Toyota in fuel cell technology
- In January 2009, Daimler teamed up with US electric carmaker Tesla Motors to develop its Smart microcar, for which Tesla will be producing a battery pack and charger.
- Battery technology: Li-Tec, a joint Venture of Daimler and Evonik, own production planned 2012. “The energy storage is at the very heart of vehicle electrification and thus the key component for sustainable mobility,” explains Dieter Zetsche, CEO of Daimler. Today Daimler buys the batteries for Elektro-smart and A-class E-cell from Tesla.
- Very active in pilot region Baden-Württemberg, cooperation e.g. with energy provider ENBW to put 200 e-cars and 700 charging stations on place
Pilot project in Berlin:
- Daimler is going to Berlin together with RWE with over 100 electric Smarts. RWE is taking charge of the development, construction and running of the charging infrastructure with some 500 electricity charging points, supplying electricity and the central system operation. The electricity can be paid via a data exchange between a special communication system in the vehicle and an intelligent charging point. The chargers are located at the customer’s home, at work and in the public. In addition, business-to-business partners like shopping centres, parking houses and fleet customers are integrated to the infrastructure.
Fuel Cell:
- Daimler is maybe THE forerunner in fuel cell technology and puts lot of efforts towards this technology.
- Daimler plans cooperation with Toyota in fuel cell technology
- Daimler, Linde, Shell, OMV, ENBW and Vattenfall to build hydrogen stations German wide
- Hamburg as the pilot city for Daimler’s fuel cell technology
Hybrid and electric plans:

- Plans to build a full electric city car “Megacity Vehicle” in Germany 2013 (until October 2009 the plan was to start production 2015, this shows the big changes in the segment). Wants to use carbon fiber reinforced plastic in the car body. Lithium-Ion battery should come from Joint venture of Bosch and Samsung
- BMW Mini Cooper electric plug-in since 2009 with many pilot projects e.g. in Berlin and London
- BMW X6 hybrid since 2010
- Wants to start building Lithium-Ion batteries also
- BMW has calmed down their efforts in fuel cell technology.
- Different cooperations, e.g.: with PSA Peugeot Citroen in components to hybrid vehicles

### Mini-E project

**Important features**

<table>
<thead>
<tr>
<th>Fahrzeug</th>
<th>2-Sitzer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elektromotor</td>
<td>Leistung</td>
</tr>
<tr>
<td></td>
<td>Drehmoment</td>
</tr>
<tr>
<td></td>
<td>Höchstgeschwindigkeit</td>
</tr>
<tr>
<td>Energiespeicher</td>
<td>Lithium-Ionen-Speicher</td>
</tr>
<tr>
<td></td>
<td>Spannung</td>
</tr>
<tr>
<td></td>
<td>Anzahl Batteriezellen</td>
</tr>
<tr>
<td>Kühlung</td>
<td>Luftgekühlt, abhängig von der Zellentemperatur</td>
</tr>
<tr>
<td>Ladezeiten (230 V)</td>
<td>2,4 Stunden bei 50 A</td>
</tr>
<tr>
<td></td>
<td>3,8 Stunden bei 32 A</td>
</tr>
<tr>
<td></td>
<td>10,1 Stunden bei 12 A</td>
</tr>
<tr>
<td>Gewicht</td>
<td>260 kg</td>
</tr>
<tr>
<td>Reichweite</td>
<td>Real bis zu 180 km; gemäss FTP72: 240 km</td>
</tr>
</tbody>
</table>
Lot of pilot projects with E-Mini around the world

- To test the technology in normal use and with normal end clients BMW has lot of pilot projects around the world.
- The driver behavior is analyzed very carefully, e.g. when and how is the car charged, how the distances driven by e-car differ from them driven by normal car etc.

Example of the pilot project in Berlin

<table>
<thead>
<tr>
<th>Politische Unterstützung</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wissenschaftliche &amp; Technische Partner</td>
<td></td>
</tr>
<tr>
<td>Feldforschung</td>
<td></td>
</tr>
<tr>
<td>Infrastruktur &amp; Energie-Partner</td>
<td></td>
</tr>
</tbody>
</table>
Hybrid and electric plans:

**Volkswagen:**
- The brand's first electric car, launching in 2013, is the Up blue-e-motion (a new city specialist). Following in the same year are the Golf blue-e-motion (85 kW, 140 km/h, up to 150 kilometre range) and the technically closely-related Jetta blue-e-motion. In the same timeframe, the Lavida blue-e-motion will also launch in China. With these four models – offered worldwide – Volkswagen will build a solid bridge to the era of electric mobility.
- In parallel with the electric vehicle offensive, Volkswagen AG is accelerating its introduction of new hybrid models. The new Touareg Hybrid and the Porsche Cayenne Hybrid are already on the market; in late 2010 the Audi Q5 Hybrid will launch, followed by the Audi A8 Hybrid; a hybrid version of the Jetta debuts in 2012, then in 2013 more new hybrids will be introduced, including the Golf Hybrid and Passat Hybrid.
- E-Golf should come 2013 at latest on the market
- Touareg hybrid 2010 in series production
- Hybrids of Passat, Golf and Jetta 2012
- VW wants to bring on Chinese market an e-car 2013, produced in China as well

**Audi:**
- As soon as late 2012, the company will launch a small production run of the high-performance Audi e-tron sports car (150 kW, 5.9 s for 0-100 km/h, up to 250 kilometre range). And anyone who has seen the compact Audi A1 e-tron at the Geneva International Motor Show knows that this will just be the beginning.
- E-Tron should come 2010 on the market
- Audi A2 to full electric, launch set for 2012
  - New Audi A2 electric car sets long-distance record 600km 10/2010 ([www.dw-world.de/dw/article/0,,6150836,00.html](http://www.dw-world.de/dw/article/0,,6150836,00.html))

**Porsche**
- The 918 Spyder (with lithium-ion battery, electric motors and V8 petrol engine) has already written automotive history as the sportiest plug-in hybrid; the 320 km/h concept car completed the North Loop of the Nürburgring with a lap time of 7 minutes 30 seconds, minutes faster than the legendary Porsche GT. It is a sensation considering its rated fuel consumption of 3.0 l/100 km and 70 g/km CO2. By the way, in E-Drive mode, the Porsche 918 Spyder moves with zero emissions.
Hybrid and electric plans:

- Opel Ampera Electric concept car, should come 2012 on the market, it promises 500km reach. For trips up to 60 km, the five-door, four-seat hatchback runs on electricity stored in the 16 kWh, lithium-ion battery, and emits zero CO2. Middle of 2010, there were discussions, that Opel might bring Ampera yet only as hybrid.
- Launching an extended-range electric vehicle in addition to the Ampera
- Introducing pure battery-electric vehicles in smaller-size segments
- Expanding LPG and CNG applications, start/stop technology and right-sizing of engines.
Hybrid and electric plans:

- C-Max as full hybrid and Plug-in Hybrid 2013
- Ford Transit Connect Electric 2011
- Work is also underway on four new electrified vehicles, including the Transit Connect plug-in hybrid electric vehicle and a next-generation hybrid.
Participating the German Electro-Mobility Pilot Regions

The colognE-mobil project is targeted at piloting electro-mobility in the Rhein-Ruhr area in NRW as one of the 8 “Pilot Regions Electro-Mobility” in Germany. Project Lifetime: 01/10/2009 – 30/06/2011

High-Level Project Goals: promote consistent and long-term strategy of the Rhein-Ruhr area towards a market introduction of battery electric vehicles (BEVs) development of an integrated approach for electro-mobility in a metropolitan area

Technical specifications:

- **Transit BEV**
  - Technical Specifications:
    - Range: 160 km (100 mi)
    - Motor Power: 90 kW
    - Charging Time: 8 - 10 hours
    - Energy Storage: Li-Ion Battery (40 kWh)

- **Transit Connect BEV**
  - Technical Specifications:
    - Range: 130 km (80 mi)
    - Motor Power: 100 kW
    - Charging Time: 6 - 8 hours
    - Energy Storage: Li-Ion Battery (28 kWh)

- **Focus BEV Prototype**
  - Technical Specifications:
    - Range: 120 km (75 mi)
    - Motor Power: 100 kW
    - Charging Time: 6 - 8 hours
    - Energy Storage: Li-Ion Battery (23 kWh)
Lot of efforts towards Hydrogen / fuel cell technology in Germany
- Daimler maybe THE forerunner worldwide
- Daimler converts hydrogen with fuel cells in electricity, whereas BMW burns the hydrogen in conventional combustion engine
- German fuel cell system developers are technological leaders in Europe, strong suppliers of key technologies
OEM’s – Fuel cell development
snap shot

- Total very active in fuel cell infrastructure:
- **Case study** - new international airport in Berlin:

![Diagram of Berlin Airport: Hydrogen production, storage and station](image_url)

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**The concept at the capital airport BBI**

- Possible Refueling of 9 BVG hydrogen busses for several public transport lines
- Refueling Refueling of the hydrogen vehicles with 350 bar und 700 bar belonging to the CEP
- Possibility to fuel hydrogen for other applications by using 700 bar cartridges:
  - Fork lift trucks, compact, mini-busses for the crew etc.
- The options to fuel a BZ-Trainof the German Rail (DB) over the rail access of the fuel depot
- Integrated supply of the future TOTAL hydrogen refueling station at Berlin main Station (Berlin Heidestraße) using trucks
- Usage of the heat of the block heat and power plant and of the electrolyser for the car wash and the shop
- The service station uses green electricity coming from the wind park built by ENERTRAG
- Preparation and testing of the possibility to add of hydrogen to CNG
- Integration of 4 to 6 electro-charging units on the site as well as at the TOTAL service station at Berlin main Station Heidestraße

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**The concept at the capital airport BBI**

- Integration of hydrogen as a fuel at the future TOTAL service station on the TOTAL site of the airport, where we have our fuel depots
- The hydrogen service station will be supplied with green hydrogen directly on-site by ENERTRAG within the concept of a centralized wind-hydrogen production unit. This unit has a capacity between 0.5 and 1 tonnes per day, while the capacity of the unit is modularly extendable up to 3 tonnes/day.
- The facility is supposed to integrate 2 loading sites for trucks in order to have the possibility to provide green hydrogen also to other service stations (Berlin Heidestraße) or to other customers. In the direct vicinity of the airport, ENERTRAG will build a wind park in order to provide green electricity.
- In cooperation with the Land Brandenburg and the Technical University BTU Cottbus a showroom has been designed in order to accommodate seminars for a professional audience as well as for delegations of the Bund and the Federal Länder.
- The aim is to present a measuring station of the same style as the hybrid power plant at the BBI. In addition, one can simulate via an online tool and special software the integration of renewable energy pathways in the electricity mix as of today and in the future.
Case study – H2 Mobility:

H2-Mobility

On September 10, 2009 TOTAL together with Daimler, EnBW, Linde, OMV, Shell, Total, Vattenfall and the National Organisation for Hydrogen and fuel Cell Technology (NOW GmbH) signed a Memorandum of Understanding (MoU) in Berlin with the participation of the German Minister of Transport, Wolfgang Tiefensee.

The agreement intends the setup of a hydrogen infrastructure in Germany so as to promote serial production of electric vehicles with fuel-cell. This marks a major step towards the commercialization of such locally emission-free vehicles.

Beforehand, Daimler, Ford, GM, Hyundai, Kia, Nissan/Renault and Toyota signed a LoU for the development and launch of fuel cell vehicles. They assume several hundred thousands in-use fuel cell vehicles by 2015 worldwide.

The MoU comprises two phases:

- Phase One includes the evaluation of options for an area-wide roll-out of hydrogen fuelling stations in Germany and the definition of a joint business plan agreement including an analysis of possible public support measures.

- In Phase One partners intend to leverage plans to install new hydrogen fuelling stations by 2011. This will take place within the framework of the German economic stimulus package (Konjunkturpaket II) and other national and state programs to jointly address standardization and cost reduction issues.
OEM’s – Fuel cell development
snap shot

Clean Energy Partnership Berlin (CEP)

- Unites 14 companies from France, Germany, Norway, Sweden, United Kingdom and the US
- International Public-Private Partnership
- Supported by the German Federal Government through the National Innovation Programme of Hydrogen and Fuel Cell Technology (NIP)

Clean Energy Partnership Berlin (CEP)

- Aim: Market preparation of hydrogen activities
- Continuation of CEP from 2008 – 2016
  - Phase II: 2008-2010
  - Phase III: 2011-2016
- Larger quantities of H2 vehicles
  - Phase II: up to 40 cars
  - Phase III: several hundred cars, up to 30 busses (Hamburg+Berlin)
- Increased H2 production
  - Target end 2010: 20% from renewable sources
  - Target end 2016: 50% from renewable sources
- New hydrogen stations in Berlin
  - Improvement of the existing TOTAL station Heerstraße
  - New TOTAL station (GH2 in cooperation with StatoilHydro)
  - New joint TOTAL/ BVG station after 2010
- Integration of Hamburg and Berlin

Case study – Enertrag:

Study with Enertrag - Hydrogen production

- Enertrag is operating more than 400 wind mills in Germany, France and the UK (Investment volume of more than 850 Mio Euro)
- Enertrag builds the first German Hybrid Power Plant:
  - Production of hydrogen from Wind-Power through electrolysis
  - Production of Biogas
  - feedstock for production of electricity and heat or feed into the natural gas grid
  - Use of Hydrogen for Transport Applications
- Demostration project start in 2010 (electrolyzer with 120 Nm³/h, Biogas unit of 625 kW el, production capacity of 350 kW el with 30% from Biogases and 70% from H2).

Result of the Enertrag and TOTAL joint study:
- Production of > 3 tonnes H₂ per day in the Berlin area
Outcome: Price H₂ @ 8€/ kg with current technology
1. Introduction
2. Ecosystem
3. Governmental role
4. OEM’s
5. Suppliers
6. Infrastructure
7. Conclusions
8. Sources
Meeting of the car crisis, general economical downturn and the start of the electrification at the same time brought very hard times for the traditional suppliers 2008-2009.

The economical downturn had big influences on the automotive suppliers. According to the survey of D&B Deutschland almost 20% of the companies were somehow at risk to go bankruptcy.

Though, the recovery has been much faster than expected, and many companies are showing very good figures in 2010.

The experts have different opinions on when exactly will the electromobility replace traditional combustion engine as a whole. Though they all agree, that system change will completely disorder the old and traditional automotive branch. New technologies, systems and modules need to be developed and then produced in mass production. It is not just about the direct powertrain (engine, gear box, tanks, brakes etc.), but it effects much more all the components.
At present about 50 per cent of the value in German power train production is created directly by the car manufacturers and the remaining 49 per cent by German subcontractors such as Bosch for electronic equipment, ZF for transmission or Mahle for pistons. According to the current prospect, 100 per cent of the value in electric power train industry will come from suppliers, most of them from subcontractors in Far East. Superior combustion engines and transmission have so far been the core of German car industry, a technology that is no longer needed for electric cars.

“The electric car means revolution and threat at the same time for all automotive suppliers”, says Willi Dietz from Institut für Automobilwirtschaft in Geislingen. According to him the change will not be so fast that expected, he believes that 2030 still 90% of all the cars will have a combustion engine.

Mahle and Ebersbächer are good examples of traditional suppliers for the combustion engine. Both have about 5.000 employee and the core business is components for combustion engine. This kind of companies are now forced to rethink their business model and strategy. Even if the transfer to electromobility would not be so fast than expected companies have to invest for R&D in in this sector. All the suppliers have to think about electromobility already today.“The companies have to have a clear conception where and what they want to be in 20-30 years”, says automotive expert Matthies from Bain & Company.

Kolbenschidt Pierburg has about 10.300 employees world wide. 80% of companys turnover comes from combustion engine technology. “From our point of view the electromobility brings opportunities and challenges”, says Hans-Joachim Esch, head of R&D. Above all in field of hybrids they see big chances.
Due to the demand for system solutions and specialization for modules instead of separate parts, the car makers want to deal with fewer Tier1 suppliers in the future, says Christian Kleinhans from Oliver Wyman in Munich. These Tier1 companies have then on the other hand big network of different component suppliers as Tier2 underneath them.

According to the study of HWWI and Berenberg Bank the traditional suppliers have the problem to be financial double loaded as they are investing in new technologies, but have to put efforts still long time in traditional technologies like combustion engine as well. Here the experts see the big change for the newcomers. First of all, they do not have the big and slowly changing processes and structures. Secondly, they can focus only on the new technologies, whereas the old ones need to put efforts on both ones.

Many experts predict German automotive industry to lose market share in new technologies also at the supplier level. Asian companies have been more active towards new technologies and many of them are more flexible than the German ones, as they do not have the old structures and history. Anyhow many see the Germans still in the front. “It is one thing to develop and produce new components and systems, but it is much more difficult to make a functioning unit out of these separate components. The Germans are very good in system integration”, says Jose Avila, head of power train at Continental.

As far as automobiles are concerned, Germany remains one of the leaders in electric motors and vehicle electronic systems. However, the situation is different with regard to battery technology. Here, most new developments are taking place in China and Korea; only around 1% of all lithium-ion batteries are manufactured in Germany. Still, Germany has produced some new developments, like LiTec as a joint venture of Daimler and Evonik.
According to the Oliver Wyman Study “E-Mobility 2025” in view of the immense investments that all participants will have to make in the coming years, the focus now is establishing new partnerships and cooperations. An automaker’s vertical partnerships with key strategic suppliers and research institutions should be supplemented with horizontal cooperations between manufacturers or suppliers in order to create an extensive network for electric mobility. Through expanded or new business models, suppliers and engineering service providers can leverage opportunities and develop new profit areas with electric drive. In the process, company mergers or acquisitions will play a key role. Players that do not stem from the traditional automotive supplier group, such as consumer electronics companies, are important for securing production expertise for the large lot quantities involved in manufacturing batteries. Established players in the traditional combustion drive area also have the challenge of effectively balancing the major step of electrifying the drive train while also making further investments to achieve competitive advantage with the combustion engine today in order to maintain this edge for as long as possible.

Examples of announced cooperations where suppliers are part of the partnership:

- Bosch and Samsung (SB LiMotive) - batteries
- Daimler and Evonik (LiTec GmbH) - batteries
- Continental and Deutsche Telekom
- Johnson-Controls and Ford
- Toshiba and Volkswagen
- ZF, Conti and Ads-tec
Suppliers – case study

Sportive hybrid SUV

- Important suppliers of Porsche Cayenne hybrid.

Motor und Aggregate
Denso (Kompressor), EuWe (Abdeckung Wasserkasten inklusive Wartungs-klappen), GPM (Wasserpumpe Motorkühlung), Magneti Marelli (Injektoren), Breu (Zündspulen), hws (Steuerkettene, Spanner), Mann + Hummel (Luftrohre), Vibroacoustic (Motorlager), Borschied + Wenig (Motorabdeckung), Federal-Mogul (Geteilte, Buchsen, Anlaufschäden), Mahle (Lufthansa-abela-module, -filter), Kolben, Kolbenringe, Ventile), INA (Ventiltriebenelemente, Komponenten Kerzen-/Riemenscheib, Wasserpumpe-Klarger, FAG (Wälzlager), HP Pelzer (Dämpfung), Kolbenschmidt Pierburg (Zylinderkurbelgehäuse, elektrisches Umschalthebel), Polytec (Abschirmung vorn), ElringKlinger (Zylinderkopf-, Spezialdichtungen), ThyssenKrupp (Nockenwellen), Bosch (elektrische Maschine, Hybrid-Leistungselektrotronik, Starter, Zusatzwasserpumpe, Kühleinheit), FTE (Leitungen Kolbenkühlungssystem)

Getriebe und Antrieb
GKN Driveline (Seitenwellen, Differenzialsperrre), Rollax (Spindellager), ContiTech (obere Drehmomentstütze), Castrol (Differenzialöl), LäuF (Zweimassenschwingrad, Kupplungsscheiben, Leitungen Ausrücksystem, hydraulische Zentralaus-riecher). HP Pelzer (Dämpfung Schaltgehäuse), Schleimer (Kabelschutzsystem), IFA Rotorion (Längswellen), Bose (Aktuatoren)

Elektrik/Elektronik
Denso (Batterielüfter), ZF (Wankstabilisierung, Komponenten), Borschied + Wenig (Batteriekühler), Eberspächer (Wander Bordnetzstabilisierung Start/Stop), HellermannTyton (Kabelnabeleungs- und Befestigungselemente), Hella (Fahrpedale, Sonnensensor), Bosch (Radiatorsensor), Johnson Controls (Garagentöröffner), NXP (elektronische Vernetzung)

Heizung und Kühlen
HP Pelzer (Dämpfung Klima), Bose (Heiz-, Kühlgebläse)

Lenkung
Agap (Steuergeräte elektrisch verstellbare Lenksäule), Leopold Kostal (Lenksäulenmodul, -verstellteiler), Kaco (Radialwellendichtringe Hydro- lenkung), TRW (Schaltersausstattung Lenkrad), ZF (Servotronic)

Fahrwerk
SNR (Radicaster Vorder- und Hinterachse), ContiTech (Stoffdämpferbälge), Castrol (Achsöl), ZF (Achsgestänge, elektronisches Dämpfersystem, Komponenten), Benteler (Schwenklager Vorderachse), ThyssenKrupp (Achsmontierung, Federbeine vorn und hinten)

Beleuchtung
Valéo (Nebelscheinwerfer, LED-Tagfahrlicht,- Rückleuchten), Hella (Bi-Xenon, AFS-Scheinwerfer, Zusatzleuchte, Innenleuchten, Scheinwerfer-Reinigungsanlage)

Bremssystem
TRW (Aktuatoren, Bremsefänger verstärker), TMD Friction (Bremsebeläge vorn und hinten), Bremsbo (Bremssättel)

Räder und Reifen
Borbet, Ronal, BBS (Leichtmetallräder), Beru (Reifendruckkontrollsystem), Michelin (Reifen)

Türen
Rehau (Griffleisten, Abdeckteil/Zierleiste Heckklappe), Stabilus (Gasfedern Heckklappe), Peguform (Türseitenverkleidung), HP Pelzer (Vlies Heckklappe, Dämpfung Türverkleidung), Scherer & Trier (Türabdeckung), Edscha (Türscharniere, -fester), Magna (Außen- und Innenteile)

Quecke: Herstellerangaben (ausgewählte Bauteile) © Automobilwoche
Important suppliers of Opel Ampera electric with range extender

- Karosserie
  - Veritas (Heckanschlagpuffer), HellermannTyton (Kabelbündelungs- und Befestigungselemente)

- Scheibenwischer
  - Bosch (Frontwischersystem)

- Rückhalte- und Sicherheitssysteme
  - Takata-Petri (Fahrraumrucksack)

- Scheiben und Spiegel
  - Gentex (automatisch abblendender Innen- und Außenspiegel)

- Beleuchtung
  - Magneti Marelli (Bi-Xenon-Scheinwerfer, LED-Rückleuchten)

- Abgasanlage
  - Victor Reinz (Abgasanlage-Komponenten), Freudenberg (Aussparungs- und Schutzverkleidung), Eberspächer (Abgasanlage inklusive Krümmer)

- Schließsystem
  - VAST Alliance (Heckklappenschloss, Fahrzeugschlüssel), NXP (Wegefahrsperrere, Funkschlüssel inklusive Transponder)

- Sitze
  - VAST Alliance (Rücklehne), Brose (Sitzverstellungen)

- Reifen
  - Michelin

- Fahrwerk
  - ZF (Fahrwerkkomponenten)

- Motor und Aggregat
  - Hutchinson (Keilrippenriemen), Iwis (Steuerkette), Bühler Motor (Zusatzwasserpumpe), Federal-Mogul (Zündkerzen, Ventilsitze, Ventilführungen), Kolbenschmidt Pierburg (Kolben, Kurbelwellenlager, Pleuellager), Freudenberg (Ventschaffungsdichtungen, Simmerringe, Kurbelwellendichtung, O-Ringdichtung, Injektor dichtung), Witzenmann (Schlauchleitung Abgasanlage Range-Extender), Bosch (Kraftstoff-Rail, Injektoren, Drosselklappe)

- Elektrik/Elektronik
  - TRW (Pedalweg-Sensor), Hella (Fahrpedalgeber), TRW (Leitungshalter), Eberspächer (Hochvolt-Wasserheizgeräte), Eberspächer Controls (Elektronik Hochvolt-Wasserheizgeräte), Freudenberg (Batterie- und Antriebs system), Bosch (Parkpilot), Johnson Controls (Batterie)

- Getriebe und Antrieb
  - TRW (Schlupfreglerung), GKN Driveline (Seitigwellen), Freudenberg (Dichtungen Getriebeausgang und Schaltaktuatorik, O-Ringe Getriebeausgang, Kupplung und Akkumulator)

- Heizung und Klima
  - Behr (Kühlmodul, Chiller)

- Lenkung
  - Takata-Petri (Lenkrad), ZF Lenksysteme (elektromechanische Servolenkung)

- Bremsystem
  - TRW (Bremsen, Antrieb Bremszylinder), Brose (Antrieb elektrische Parkbremse)

Quelle: Herstellerangaben (ausgewählte Bauteile) © Automobilwoche
In the endeavour to reduce weight in order to improve fuel efficiency in normal cars and range in electric vehicles, the automotive sector has come up with a number of material changes over the last few years. Manufacturers are experimenting with aluminium and carbon fibre to replace steel, the real deal however seems to lie in a new generation of polymers, composites and fabrics that will help build the light-weight, ultra-performant, climate friendly car of the future.

Will the next car be without metal?

The chemical industry is working on nylon products designed to provide increased stability for items that are exposed to high temperatures such as hot oil or coolants, steadily improving conventional engineering resins and developing speciality polymers. Important characteristics of these materials are their low moisture absorption rate and the high-temperature performance.

The trend clearly goes to non-metal materials. The Think City, for example, is made of thermoplastic body panels. However, it will not come down to just replacing a piece of metal with a piece of plastic or nylon. The change will be multifaceted which means a wide range of solution will be employed in order to replace one specific metal part. And new propulsion systems are likely to urge manufacturers to move faster in this direction.

A bundle of new solutions

An example for a combination of new solutions is the Hyundai i-flow. The Korean car manufacturer has worked closely together with the chemical giant BASF to develop new approaches with new materials. The seats of the i-flow are formed of BASF’s Steron, which are supposed to reduce unnecessary mass areas that had been revealed in the seat area through advanced stress analysis. But more importantly, BASF and Hyundai developed together a thermal engine encapsulation that helps to significantly reduce emissions. During the i-flow's development, the engineers realised a combined fuel and emissions saving of 5% in the summer months and 9% during winter evaluations. Further benefits derive from a jointly developed thermoelectric waster recovery and from BASF’s new Liquid Metal coating for the car's exterior.

Another approach is pursued by Hugo Spowers, founder of Riversimple and developer of alternative-powered technologies. He is working on a car based on two main pillars, which maximises recyclability and greatly reduces weight. The concept has not reached prototype stage yet, but Spowers is also bending towards the use of composite materials instead of steel. However, this is not as simple as it may sound as some problems persist: Riversimple aims for complete recycling of the structural material used in their cars and that is not yet possible with composites.

But composites is not all there is. The car will also include sandwich materials such as foams or honeycombs. Aramid fibres will be employed for their separability characteristics and the company is looking for further biologically based materials. To the Electric & Hybrid Vehicle Technology Magazine, Spowers confided that the company was talking with the EPEA in Hamburg, Germany, about two different nutrient cycles - one being biological (biodegradable) and the other being technical, using completely synthetic materials.
Market implications

If electric cars are broadly adopted, no matter which kind of new material they use, they will cause a shift in the relative demand growth rate for certain basic materials of conventional cars. Stock market analysts see following developments:

- Demand for aluminium, for example, is likely to increase.
- Copper demand may increase as well due to the high copper content of electric motors used to power the wheels of electric cars.
- Corn relative demand may decrease due to the reduced use of liquid fuels, of which ethanol is a component, and for which corn is an important feedstock.
- Coal and natural gas relative demand may increase due to increased demand for electric power plant output for plug-in electric vehicles (gas being a major energy source of electricity generation).
- Demand for lead may increase due to possible increased use of lead-based batteries in some electric vehicles, but may be relatively flat if other metals are the battery base of choice.
- Lithium relative demand may increase due to the use of lithium in some percentage of electric car battery systems.
- Nickel relative demand may increase due to the use of nickel-based batteries in some percentage of electric car battery systems, but may be relatively flat due to possible preference for other battery materials.
- Oil relative demand may decrease due to lower demand for gasoline for which electricity would be the substitute.
- Platinum relative demand may decrease due to smaller catalytic converters, or due to a lower rate of replacement, as a result of lower average gasoline consumption per driven mile per vehicle.
- Uranium relative demand may increase due to the increased demand for electric power plant output for plug-in electric vehicles (uranium being a significant energy source for electricity generation, particularly in some countries).
- Zinc relative demand may increase due to the use of zinc-based batteries in some percentage of electric car battery systems, but may be relatively flat due to possible preference for other battery materials.
- Whether your future car is full electric, a plug-in hybrid or an improved ICE, it is bound to be made of a viariety of materials that have not much left in common with steel.

Source: cars21.com
Bosch is world’s second biggest supplier with 275,000 associates generated sales of 38.2 billion euros in fiscal 2009.

Bosch is investing yearly about 400 Mio € for the R&D in electromobility.

Bosch has already established a complete product range for hybrid and electric powertrains. It includes core components such as the power electronics which control the energy flows in hybrid and electric vehicles, as well as high-torque electric motors. Work is underway to prepare series production of power electronics components in Reutlingen and of electric motors in Hildesheim.

Bosch started 2004 a “project house” Hybrid technology with 100 employees. Today, some 800 Bosch associates worldwide develop technologies for hybrid and electric vehicles. Development takes place on three levels:

- First, Bosch is gaining experience with the hybrid drive, which we see as an interim technology en route to the electric car. The technology was taken into series operation at the start of 2010.
- Second, a dedicated product unit with over 500 associates is working on vehicle electrification.
- Third, the joint venture with Samsung SDI (SB LiMotive) is dedicated to developing the heart of the future electric drive – the lithium-ion battery – which is scheduled for market launch in 2011. E.g. BMW will buy the batteries for its Megacity Vehicle 2013.
To explore and create the environment needed for electromobility, Bosch is working together with other companies in three government-funded projects that cover the major areas of electromobility development: “e-performance” deals with the electric vehicles themselves, “MeRegioMobil” covers the integration of the electric vehicle into a future (battery-charging) infrastructure and with new mobility services, while “BeMobility” addresses these mobility services themselves. Within these projects, Bosch expertise contributes a great deal toward exploring, evaluating, and further developing technology, infrastructure, and mobility concepts. In the end, this will pave the way for a gradual roll-out of electric vehicles.

Bosch full hybrid with parallel technology in series production. There are already 2 cars with Bosch parallel hybrid technology on the market: Porsche Cayenne S and VW Touareg. In addition, PSA Peugeot Citroen and Bosch have formed an engineering alliance to develop a diesel hybrids with an electric 4-wheel drive, which will go into series production 2011.

Bosch produces also charging stations.

**Bosch’s “eMobility Solution”:**

**Multi-functional, ecologically and economically sustainable city transportation system for Singapore**

- October 2010, Bosch appointed Infrastructure Service Provider for Electric Vehicle Test Bed in Singapore by the Singapore Government
- Bosch provides charging stations and software to manage mobility in megacities and support the proliferation of electric vehicles in Singapore
Continental Provides a Broad Range of Electric Drives for Electric Vehicles

- Different motor concepts for use in hybrid and electric vehicles.
- Complete portfolio with battery, power electronics and e-machines for electrification of the powertrain.
- The industrialization of the new drive technology has already become reality at Continental, which has successfully completed the step from the development labs and test applications to industrial-scale production. “Continental has pushed forward with the development of core components for electromobility already since the 1990s. We have repeatedly received production orders in this field, and we are more than willing to contribute our knowledge and experience to the ‘National Platform for Electric Mobility’ which has now been called to life,” says Continental Executive Board chairman Dr. Elmar Degenhart.

![Diagram showing different types of vehicles and energy sources]

**EVs to Come**

1. Improve efficiency of conventional powertrain (short and mid-term)
2. Back-up combustion engine by electric motor (mid-term)
3. Emission free electric vehicles (EV) (long-term)

**Vehicle Production**

- Combustion Vehicle (Internal Combustion Engine)
- Hybrid Vehicle (Internal Combustion Engine + Electric Motor)
- EV (Electric Motor)

**Energy Sources**

- Renewable Fuels (Ethanol, Bio-Methane, BiL)
- Fossil Fuels (gasoline, diesel, CNG, CIL)
- Electricity from Power Grid (solar, nuclear, geothermal, wind, ...)

© Finpro
As the first supplier worldwide, Continental has produced lithium ion batteries since 2008 for a standard production model – the Mercedes S 400 HYBRID. These particularly high-performance batteries are used as the energy accumulator for the electric motor, which helps the combustion engine save fuel in the mild hybrid version of the S Class, turning the car into a highly efficient luxury sedan.

Starting in 2011, Continental will produce the first complete electric powertrain for a European carmaker’s standard production vehicle. “For this, we have invested €12 million in our plant in Gifhorn, Lower Saxony. The annual production capacity is designed initially for up to 60,000 electric motors. With this step, Continental is putting the third key component for electro-mobility into production, in addition to the battery and power electronics,” said José Avila, head of Continental’s Powertrain division.
Cooperation: ZF Friedrichshafen AG, the automotive supplier, and Continental have concluded an agreement on the cooperation in the fields of the development and production of commercial vehicle hybrid drives. To this end, ZF, as the systems supplier, is in charge of the system integration for the hybrid system; the latter is made up by a parallel hybrid transmission by ZF, a lithium-ion battery accumulator, and system electronics by Continental.

Conti is searching also in battery sector for new cooperations. Some developments with Johnson Controls and Litec has been initiated. In the beginning Conti wanted to be part of the alliance Litec, but did not have the money to enter that. Today, Litec is a Joint Venture of Daimler and Evonik.
Li-Tec Battery GmbH – a Joint Venture of Evonik Industries AG (50.1%) and Daimler AG (49.9%) – develops, produces and markets large-scale lithium ion battery cells for automotive applications and battery systems for industrial and stationary applications.

Advanced battery technology: The CERIO® technology – unique in the world – is based on the special combination of ceramic materials and high-molecular ion conductors. This grants the Li-Tec cells all-time superior properties. CERIO® technology which has been developed for Formula One is based on the ceramic SEPARION® separator and sets standards for cycle stability, rated power and safety. Moreover, the compact design of the Li-Tec cells allows for high energy density at low weight.

Cell portfolio for EV, Plug-in and HEV

- 40 Ah High Energy cell
  - EV & Plug-In
- 10 Ah High Energy cell
  - LEV
- 5.7 Ah High Power cell
  - HEV
- 3 Ah Super High Power cell
  - Special HEV
- Full Battery Packs Solution
  - Stationary and industrial
- Specific custom designed products

Li-Tec CERIO® battery system

<table>
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<th>Anode</th>
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<th>Cathode</th>
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<td>Organic Carbonates Salt: LiPF₆</td>
<td>Active Material: LiNiMnCoO₂</td>
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<tr>
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<td>Separator: ceramic (SEPARION®)</td>
<td>Collector: Al (LITARION®)</td>
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Technology for infrastructure/system and grid integration

- In grid infrastructure, the use of electric vehicles in the introductory phase will place demands on charging and billing procedures. The application of modern communication technologies is a key element here.
- Key Elements in the Electricity Industry: storage, grids, integration. Providing testing facilities, but also testing advanced network components will lay the technical foundation for the speedy development of an efficient grid infrastructure.
- Suitable infrastructure and equipment need to be developed for the grid-vehicle interface. These include charging and grid stations, controllers, meters and measuring devices. Coordinated production, distribution and storage also require the development and testing of innovative communications facilities (smart metering). Grid restrictions must be brought into line with the state of charge of traction batteries and the individual operating parameters of a variety of vehicles. Load-dependent rates, billing modes and data protection provisions also need to be developed and tested with a view to cost effectiveness and the competition framework.
- At the international level, aid priorities should account for trans-systemic interactions between electric vehicles and power grids in smart grid management.

Different charging options:
- Slow Charging
- Fast Charging
- Battery Swapping
- Others

![Diagram showing different charging options](image-url)
In Germany the big utility or energy providing companies are very active in electromobility. E.g. EWE has launched as a first utility company in the world their own developed (in cooperation with Karmann) e-car E3. Practically in all pilot projects or infrastructure developments on or many of the big utilities are involved. The biggest energy companies with activities in electromobility in Germany are.

- RWE
- ENBW
- EON
- Vattenfall

It is essential for utilities to work closely with automakers, as extensive R&D investment will be required—particularly in the fields of energy storage, vehicle engineering, and power-grid integration.

In fact, such alliances are already in place. For instance, BMW, Daimler and Volkswagen are working with major German power suppliers such as RWE or Vattenfall. Daimler, for example, is looking to establish an alliance with energy provider RWE that would standardize battery charging stations. Similarly, BMW and Volkswagen are working with energy companies—among other things in order to determine which types of infrastructure are necessary for different mobility requirements.
The electric car does not only share the market anew to the advantage of new automobile manufacturers. There will also be entirely new players on the field to share the market. These are mostly utilities such as big electricity suppliers and public utilities, but also telecommunications suppliers, that are not only interested in offering battery chargers but entirely new mobility packages.

Almost all big electricity suppliers are now working on contract deals for electric cars such as leasing or monthly fees. For example EWE (German energy supplier and a multi-service company) has with its own concept study, the electric car E3, made it clear that it will not wait until the German automobile industry delivers its vehicles. RWE is taking a step even further and offering a commercial, mobility model that combines car electricity with Mitsubishi i-MiEV.

The significance of combined offers will grow in future as all the suppliers offer energy and mobility solutions in one package. The combined services will not initially be offered only to consumers, but above all to fleet managers. Long-term extensive contracts enable cross subsidies that can help to reduce the so far very high prices in battery leasing. Utilities could therefore be able to offer electric mobility for a competitive price that car manufacturers and leasing companies can not afford.

Meanwhile, the results of representative studies of eg. Technomar are problematic. They show that 80% of the Germans want to charge their cars by themselves at home. The same signal is gained from extensive field experiments, for example in Berlin, in which 50 Mini Es are on the streets daily and public charging stations are hardly being used.
E.ON and TÜV SÜD are working closely together to further develop electro-mobility to market readiness. The focus of this strategic partnership is on a broad spectrum of charging systems for electro-vehicles. Developing user friendly electricity fuel stations with the highest safety standards will be an important contribution to building up the infrastructure necessary for the wide use of electro-cars in the future.

15 MINI E cars have been roaming the streets of Munich and neighboring rural districts with E.ON power until July 2010. E.ON’s part in the demonstration project with BMW involved building a network of public charging stations, while ensuring that the test participants were able to recharge their cars both at home and close to work.

E.ON and SWM are installing the necessary charging infrastructure

The project partners Audi, E.ON, Stadtwerke München (SWM) and Technische Universität Munich (TUM) fired the starting shot for a fleet test with electric cars in the Munich model region today. By the middle of next year 20 Audi e-trons will come onto the roads successively and 200 new charging stations will be set up. The project is running as part of the “Munich Model Region Electro-mobility” under the name “eflott” (efast) supported by the German federal Ministry of Transport. Among others it will look at data transmission between the driver, car and electricity fuel station all the way up to the electricity grid. For this purpose the use of smartphones as a central interface for the driver will be tested, for example.

E.ON joined forces with Volkswagen, the German Environmental Ministry and other partners in June 2008 to work on the "Electric Mobility Fleet Test." Our objective is to explore the commercial opportunities offered by charging large numbers of electric cars using the existing power grid by 2010. The trial is designed to make use of vehicle batteries as power reservoirs within the electric grid in the near future.

Inductive charging: E.ON promotes research in the field and is already subjecting inductive charging to daily tests on a daily delivery van equipped with an electric drive.

E.ON starts a pilot project with Audi A1 e-tron in Munich

The project partners Audi, E.ON, Stadtwerke München (SWM) and Technische Universität Munich (TUM) fired the starting shot for a fleet test with electric cars in the Munich model region today. By the middle of next year 20 Audi e-trons will come onto the roads successively and 200 new charging stations will be set up. The project is running as part of the “Munich Model Region Electro-mobility” under the name “eflott” (efast) supported by the German federal Ministry of Transport. Among others it will look at data transmission between the driver, car and electricity fuel station all the way up to the electricity grid. For this purpose the use of smartphones as a central interface for the driver will be tested, for example.
The automotive industry, scientists and the energy industry are working at full stretch on this future form of mobility. RWE is developing innovative e-mobility solutions. To enable everyone to drive an electric vehicle, the necessary infrastructure has to be built in Germany. RWE has already started setting up customer-friendly charging points in several major German cities. And this is only the beginning – our aim is to establish a network of charging stations in Germany. RWE is testing customer acceptance and the systems used for billing and network control in pilot projects carried out in conjunction with Daimler and Renault in Berlin and NRW.

In Berlin, automobile manufacturer Daimler and energy supplier RWE are developing the components necessary for efficient use of vehicles driven by electric batteries – from drive engineering to an infrastructure convenient for customers. RWE plans to set up a total of 500 charging stations in Berlin by 2012, take responsibility for billing infrastructure, and operate the system.

Example BeMobility: RWE, Deutsche Bahn and other partners are developing a car-sharing project with e-autos as a part of the public transport in Berlin.
Utilities – RWE

RWE positioning in e-mobility

- Technological leadership role
- Focused business approach
- Dedicated roll-out plans
- Announced pilot “e-mobility Berlin” together with Daimler

Daimler and Renault on board as OEM partners

AUTOMOTIVE PARTNERS RWE

- DAIMLER
- RENAULT

- World’s largest integrated project with implementation of vehicles, charging infrastructure, electricity supply
- Test of technology and customer behaviour
- 500 charging points 2009/2010
- 100 near-series electric vehicles by mid-2010
- More vehicle manufacturers in 2010
- Cooperation for standardisation and technology

- As from the end of 2010, joint pilot trial
  - Approx. 100 Renault cars
  - RWE charging infrastructure
- Joint product in mid-2011
  - Electric vehicle
  - RWE car power, RWE charging box, access to public charging posts
- Cooperation for standardisation, technology and new services

STRATEGIC GUIDELINES

- Marketing partnerships with OEMs
  - Secure initially scarce electric vehicles
  - Market RWE car power directly when vehicles are purchased
- Marketing of e-mobility to private and fleet customers

- Separate smart charging infrastructure
- Standardisation driven by electric car/charging station interface
- Competitive edge through comfortable charging infrastructure system

- Winning over TOP partners for charging stations at the most attractive locations
- Participation of the partners in infrastructure costs
- Joint marketing / co-branding

- Comprehensive information on e-mobility
- Concrete product offerings for end customers
- Targeted media and advertising work
- Marketing jointly with OEM and other partners

Market preparation with focus on metropolitan areas and fleet customers by 2012

MARKET PHASES AND RWE COMMITMENT

- Market expectation electric vehicles Germany (# vehicles in the market)

- Year
  - 2009
  - 2010
  - 2011
  - 2012
  - 2013
  - 2014
  - 2015
  - 2016
  - 2020

- Targets of RWE electro mobility
  - Positioning as first mover
  - Test of technology and infrastructure
  - Presence in relevant metropolitan areas
  - Attraction of fleet customers with OEMs
  - Expanded area-wide coverage
  - Attraction of more private customers with OEMs
  - Secure market shares
  - Expand separate business
  - Rollout charging infrastructure and offers

© Finpro
Source: RWE
• Energy, IT and telecommunications: EWE AG is one of the largest multi-service companies in Germany

• Developed own electric car E3 with Karmann within the space of a year. As a fully featured compact car, it has a range of approximately 170 kilometres and a top speed of 140 km/h.

• The EWE E3 is a world premiere as it is the first electric car to be built on behalf of an energy service provider. Its primary purpose is to enable the company to research the integration of electric cars into the electricity network.

• For this reason, the vehicle forms an important part of the company's overall strategy, which is dedicated to energy conservation, energy efficiency and extending use of renewable energies.

• EWE's aim is to research how electric cars can be integrated into smart grids. To achieve this, the company is involved in various research projects on electric mobility. It is also looking into smart grids by running a pilot project in Cuxhaven. The EWE Research Centre for Energy Technology in Oldenburg, NEXT ENERGY, is also conducting research in the field of battery technology.
Mini E Berlin powered by Vattenfall

Vattenfall Europe and BMW have started the first field test of electric cars in Berlin. The joint project “Mini E Berlin powered by Vattenfall” started in November 2008 in order to launch emission-free driving in Germany’s capital, and to develop the infrastructure necessary to make the project a success.

One of the first real life tests of plug-in hybrids together with Volvo Cars in Sweden. Vattenfall’s role is to develop and test electricity infrastructure and various charging alternatives and analysing customer experiences.

The Vattenfall Activities will be Embedded in an Multi-Modal eMobility Platform in Berlin and Hamburg [2009 – 2011]

- The Economic Stimulus Package focusses on Integration of eMobility in Public and Private Fleets and in Public Transport
- The Partner Network will expand.
- Vattenfall will incorporate the Requirements of a larger set of Stakeholders into the Development of Charging Concept V2.0 [Hardware, Software]
- Important Learnings expected for Business Development of Green eMobility powered by Vattenfall
Active in many pilot regions, also active in fuel cell development

  - From 2015 commercialization and start of serial production of fuel cell vehicles.

- Memorandum of Understanding (MoU) signed on 10. Sep. 2009 between Daimler and the infrastructure partners Shell, TOTAL, EnBW, Linde, ÖMV and Vattenfall Europe
  - Ramp up of a hydrogen infrastructure in Germany (up to 1000 filling stations) as initial market in Europe

Hamburg and Vattenfall very active in fuel cell development

- Production and delivery of hydrogen to busses and vehicles
- On site production of hydrogen with electrolysis (50%)
  - From 2010 520 kg hydrogen per day
  - From 2013 720 kg hydrogen per day
- From 2011
  - Hamburger Hochbahn will extend the fuel cell bus fleet (20 busses until 2013)
  - Daimler will deliver up to 500 fuel cell vehicles until 2015
EnBW active in model region MeRegio

EnBW roadmap to smart grid (step 1)
Siemens AG is a German engineering conglomerate that is the largest in Europe. Company has three main business sectors: Industry, Energy, and Healthcare.

Siemens is conducting extensive and intensive work on electromobility. It is more or less only company worldwide that covers the entire electromobility process chain – ranging from intelligent energy and IT infrastructure solutions via charging technologies to research into the requisite drive technologies.

“We are already on the optimal course in the Smart Grids business and will be running at top speed in the future. A new age for power supplies is dawning with Smart Grids,” said Wolfgang Dehen, CEO of the Siemens Energy Sector.

Lot of pilot projects in Europe, e.g.:
- Harz.EE-Mobility with 15 other partners in Germany
- Edison project in Denmark

[Image of the vision of the future]

The vision of the future
More control, less wastage, greater efficiency

- CO₂ emissions are constantly on display
- large centralized power plants still supply the majority of power demand
- micro generation (PV) as part of smart buildings
- large and very small generation plants need to be managed in parallel
- wireless sensors and smart metering coupled to load management and market driven energy supply software
- storage plants buffer fluctuating generation
- car-parking for plug-in vehicles, buy or sell electricity shaving peak loads

[Website link: www.edison-net.dk]
Siemens, in association with the high-performance carmaker Ruf Automobile GmbH, has demonstrated how attractive electric vehicle can be with the eRuf sports car built on the basis of a Porsche 911. Researchers at Siemens Corporate Technology have developed an integrated system of engine/generator, power electronics, and an interface with battery application for the eRuf sports car prototype from Ruf Automobile GmbH. Siemens’ central research unit is conducting an exhaustive investigation into electric mobility, including the requirements for the electric car with the electric drive and recovery of energy, as well as the configuration of the infrastructure.
Sitraffic Epos charging system - The smart electric vehicle charging solution (source: Siemens)

- The Sitraffic Epos electric charging station from Siemens Mobility is more than just a charging plug for electric cars, it is a complete unit with an info-terminal and payment system.

- The smart charging station from Siemens is markedly different from those previously tested and used in pilot applications. Sitraffic Epos is a modular system which can be configured as a sole charging point or as a station with up to ten satellite connections. It can be installed anywhere where multiple electric cars need to be charged, i.e. in public places, where it can be combined with car park ticket machines, for example, or on company property. The occupancy of a charging station can be wirelessly reported to a back office system, which therefore continually monitors the utilization and availability of the charging stations. The integrated user identification of Epos which is achieved by means of a contactless card allows optimum access control and gathers information about actual usage and invoicing. High standards of safety are also ensured: the Epos charging satellites are only powered when a car is connected and the terminal has actually been released. The charging station is fitted with a color display which guides each user very simply through its operation. The connection to a data center means that additional information can also be shown on the display, such as city information, tourist destinations or nearby hotels and restaurants. It is planned to transmit the locations of the electric charging stations directly to the route planners in automobiles. This way, the driver will always know where to find the nearest available charging point. Since the electric charging points have the same design as the Sitraffic pay & display machines from Siemens, they blend into the cityscape.
eCar and infrastructure: Siemens TIEM approach
- Total Integrated eMobility

eCars and their infrastructure have to be considered as an integrated system:
- eCars need an infrastructure for charging
- Growing share of renewable power challenges grid stabilization
- The eCars could stabilize the grid as movable batteries
- Information and communication technologies will enable the interaction between eCars, buildings and power grid
Some of German charging station manufacturers listed below:

- Rittal (www.rittal.de)
- Mennekes (www.mennekes.de)
- Rohde & Schwarz Teisnach (www.teisnach.rohde-schwarz.com/de/Branchen_Referenzen/Projekte/Ladestation/)
- ERO Edelstahl Rohrtechnik (www.edelstahltechnik.com)
- Bosch (www.bosch.de)
- Siemens (www.siemens.com)
- Bals Elektrotechnik (www.bals.com)
- Schletter GmbH (www.schletter.de/131-0-P-Charge.html?80,84)
- Langmatz GmbH (www.lic-langmatz.de)
- Fröschl Systems (www.froeschl-systems.de)
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Conclusions

- Electromobility will require new collaborations and joint ventures between suppliers and OEM’s to control costs. Lot of these kind of partnerships have already taken place with German companies.

- Utility companies are very active in Germany, together in cooperation with OEM’s they are building and developing sustainable business models.

- From product to service – electromobility may require a change in the traditional purchase model, offering an opportunity for a longer term OEM/customer relationship.

- Customers buy vehicles – not powertrains: Electric vehicles have to compete on costs, utility, image and lifestyle requirements as well as safety. Though, electric vehicles will require subsidies at the beginning to encourage consumer demand.

- Fuel cell: Daimler very active, believes in fuel cell technology to be the final solution

- Germany has a strongest automotive ecosystem and players, thus often difficult market to enter for foreign companies above all without strong automotive references and background. An interdisciplinary approach may often mean long term industry ecosystem commitment starting within the definition/standardization phase and may require a very structured, process-oriented, and documented approach and a special focus on reliability and security.
Following industry studies/publications were used in this study additional to information from seminars/conferences, newspapers, internet and interviews:

- E-Mobility by Oliver Wyman Management Consulting (spring 2010)
- Elektromobilität by PriceWaterhouseCoopers and Fraunhofer (June 2010)
- Challenges for a European Market for Electric Vehicles by EU Industry, Research and Energy (summer 2010)
- Zum Elektroauto gibt es keine Alternative by Bain & Company (summer 2010)
- E-mobility study by CAR Center Automotive Research of University Duisburg-Essen (summer 2010)
- Wegweiser Elektromobilität by B.A.U.M. Consult GmbH (June 2010)
- Alternativ angetriebene Fahrzeuge in Europa by EurotaxSchwacke and Prgnoseinstitut BDW (July 2010)
- E-Mobility study by Bain & Company (July 2010)
- Elektromobilität in Megastädten by McKinsey (June 2010)
- Mobilität – Strategie 2030 by Berenberg/HWWI (summer 2010)
- Elektromobilität by BITKOM (spring 2010)
- Comeback of the Electric Car by Boston Consulting (January 2009)
- Electric Vehicle Index by McKinsey (updated continuously)
- Challenges for a European market for electric vehicles by European Parliament (2010)