# A 6 ELECTROMOBILITY: SOME ACHIEVEMENTS, AND A LOT MORE TO DO

The development of the transport sector towards climate and environmentally friendly electromobility is considered central to the sustainability of future energy systems.[94]

For Germany as an "automotive country", this development presents a key challenge. Considerable efforts will be required to transfer technological leadership in conventionally powered vehicles to the new markets for electrically powered vehicles. The traditional automotive industry currently generates around 16 percent of Germany's industrial value added.[95] This sector employs ca. 740,000 people, and if one includes the supply industry, this figure rises to almost two million.[96]

Since 2009, politics and industry have considerably strengthened their efforts to promote electromobility with the goal of establishing Germany as the leading market and supplier in this sector. To this end, the Federal Government concluded the National Electromobility Development Plan in August 2009, financing it to the tune of 500 million EUR in the period to 2011. Industry representatives also committed themselves to wide-ranging investments.[97] Furthermore, approximately one billion EUR in additional public funding has been earmarked for the period up to 2014. As a result, a number of research centres for high-performance batteries have been established or expanded, and numerous joint research projects have been initiated.

In 2010, the National Platform for Electromobility (NEP) was established, composed of top representatives from industry, science, associations and politics, with the aim of coordinating and implementing the National Development Plan.[98] Individual federal states have also initiated programmes for the promotion of research activities and the market entry of electric vehicles.[99]

The National Electromobility Development Plan has set itself the goal of placing one million electric vehicles on Germany's streets by 2020. The one million target is to be reached in three phases. The market preparation phase, running through to 2014, is characterised by a number of support programmes. In eight model regions, different approaches to the development of infrastructure and the integration of electromobility in the public sphere are being supported.[100] In four major demonstration and pilot projects – so-called showcase projects – electromobility technologies and concepts are being examined for their practicality, user acceptance and environmental impact.[101] R&D funding is organised in a range of categories, which are referred to as lighthouses. These include battery, propulsion technology and vehicle integration, lightweight construction, recycling, and ICT.[102] A market launch phase is planned for the period before 2017. By 2020 a mass market for electromobility is to be established. Industry has committed up to 17 billion EUR in electromobility-related research and development for the market preparation phase.[103]

In its 2010 and 2011 Reports, the Expert Commission explicitly welcomed the concerted efforts of politics and industry – in particular the announcement of massive investment in research and development. At the same time it pointed to deficits in scientific and technological developments. This especially applies to research in the areas of high-performance electronics and high-performance batteries. These represent key electromobility technologies and make up a large part of industrial value added.

**Current developments in Germany**

The total number of electric vehicles in Germany is currently very low. At the start of 2013, there were only ca. 16,000 electric vehicles (electrically powered cars, plug-in hybrids, motorcycles, vans and buses) in use.[104]

The recommendations of the Expert Commission[105] to provide tax incentives for the purchase of company cars with electric or hybrid motors were incorporated into the 2013 German Annual Tax Act. With respect to the taxation of the monetary advantage from the private use of company cars, the cost for the batteries – the most expensive single component –

was deducted from the list price. The high number of model regions, criticised by the Expert Commission[106] because of the risk of fragmentation, was reduced from seventeen to eight.

**Can one million electric vehicles be put on the streets by 2020?**

A study by the Fraunhofer Institute for Systems and Innovation Research (ISI), commissioned by the Federal Ministry of Economics and Technology (BMWi), has examined the diffusion of electric vehicles under different framework conditions. In addition to fuel, electricity and battery prices, factors such as the choice of models, willingness to pay more and the battery charging infrastructure were also included.[107] According to the study, under favourable conditions the goal of one million electric vehicles can be reached without additional measures. Under unfavourable conditions the authors of the study still predict between 150,000 and 200,000 vehicles. The authors see significant potential for the deployment of electric vehicles in commercial fleets, which make up around 30 percent of the new car market. This area displays favourable operational profiles for the use of electric vehicles, with high annual mileage composed of predictable short and medium length journeys. In this context, the provision of public and semi-public battery charging infrastructure plays a less important role. Furthermore, existing depreciation options and a lower purchase price due to exemption from VAT increase the attractiveness of electric vehicles.

**Status of research on high-performance electronics and high-performance batteries**

The Expert Commission's 2010 Report investigated the number of patent applications and publications in internationally renowned journals in order to assess the performance of the German research system in the two key technologies of high-performance electronics and high-performance batteries, drawing an international comparison for the period up to 2007. Germany only achieved a middle position in research into high-performance electronics and was far down the ranking for battery research. The updated analysis of patent applications (up to 2011)[108] and publication activities (up to 2012) shows mixed results. Across the globe, both technology fields are undergoing a very dynamic development. While Germany is not keeping pace with developments in high-performance electronics, it is gaining significant ground internationally with its battery research.

Patent applications as well as publications in the area of high-performance electronics display a positive trend worldwide (Figures 5 and 6). However, Germany's share of patent applications, averaged over three years, has declined slightly since 2007. The analysis of publication activity also fails to show any marked improvement since 2009. Consequently, the measures initiated since 2009 to promote electromobility have not yet resulted in increased publication activity in the field of high-performance electronics. However, it is too early to undertake a final assessment of the Federal Government's support measures.

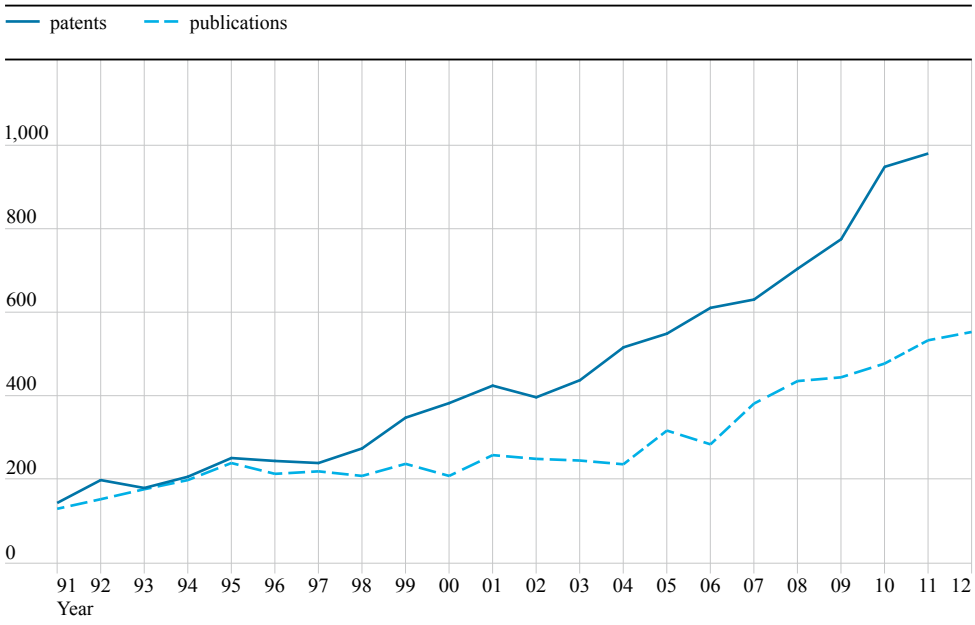
The updated analysis for the field of high-performance batteries indicates above-average activity for German patent applications between 2007 and 2011. With strong global growth – the number of patent applications worldwide almost tripled between 2007 and 2011 – Germany's average share of applications, calculated over three years, shows a positive trend for this period. The analysis of publication activity points in the same direction. This has also displayed a clear upward trend since 2007. The development of German research in the area of high-performance batteries is thus to be assessed as positive. However, on the basis of this data it is again not possible to provide a conclusive assessment of the contribution of public research support measures since 2009.

**The fuel cell – another propulsion technology option for electric vehicles**

In addition to high-performance batteries, the fuel cell could also become established as an electromobility propulsion technology in the medium to long term. Studies which explicitly consider electric vehicles powered by fuel cells have predicted significant, long-term market advantages for this propulsion technology.[109] The main competitive advantage of the fuel cell over high-performance batteries is the greater range and the shorter fuelling time compared to battery charging times. A number of car manufacturers, e.g. Daimler, Ford, Toyota and Honda, are currently pushing ahead with the development of fuel-cell powered electric vehicles.[110]

FIG 05 **Number of worldwide transnational patent applications and internationally renowned publication in the field of high-performance electronics**
(updated figures up until 2011 (patents) and 2012 (publications))

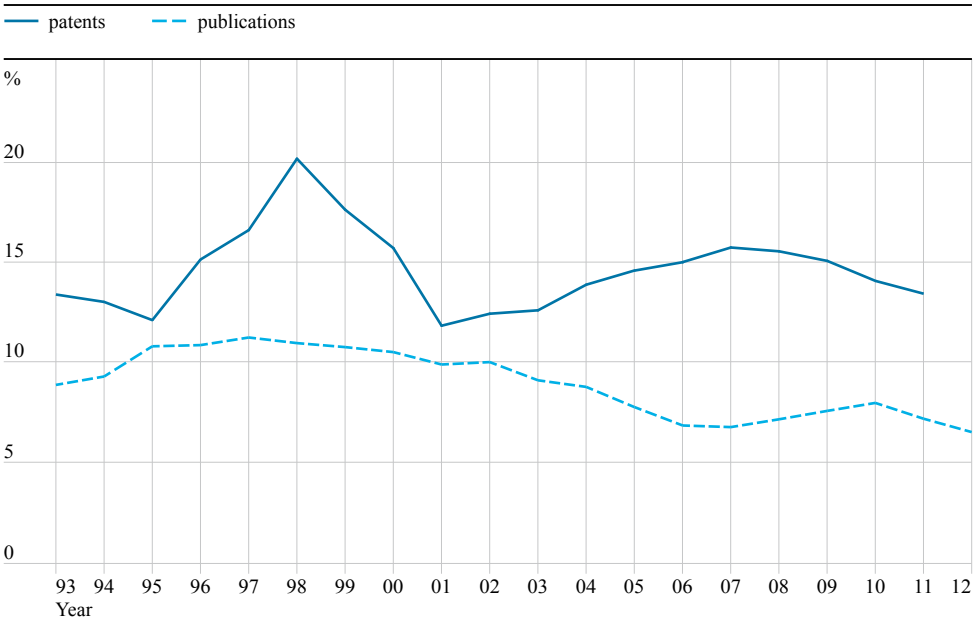
DATA DOWNLOAD




Source: Patents: own depiction based on WPINDEX (STN), own surveys and calculations.
Publications: own depiction based on SCISEARCH (STN), own surveys and calculations.

FIG 06 **Germany's percentage share in transnational patent applications and internationally renowned publications in the field of high-performance electronics**
(updated figures up until 2011 (patents) and 2012 (publications); Germany's share averaged over three years due to high variance)

DATA DOWNLOAD

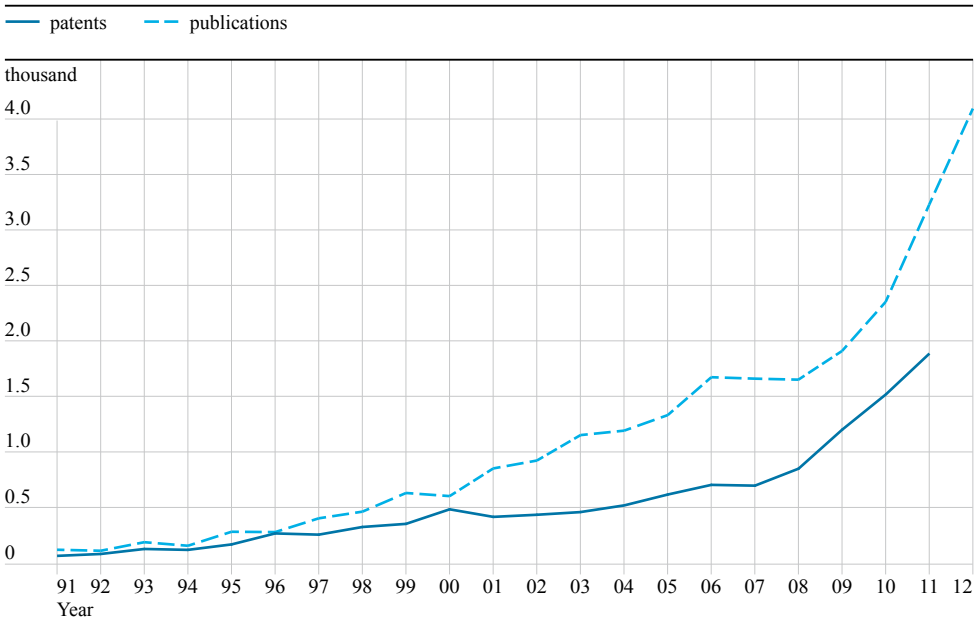



Source: Patents: own depiction based on WPINDEX (STN), own surveys and calculations.
Publications: own depiction based on SCISEARCH (STN), own surveys and calculations.

**Number of worldwide transnational patent applications and internationally renowned publications in the field of high-performance batteries**
(updated figures up until 2011 (patents) and 2012 (publications))

FIG 07

DATA DOWNLOAD

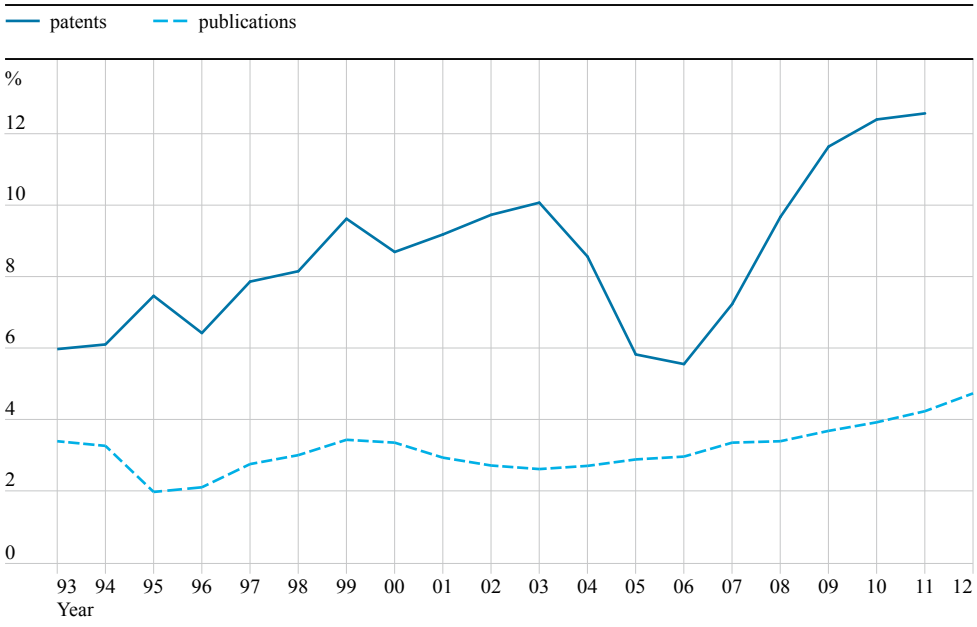



Source: Patents: own depiction based on WPINDEX (STN), own surveys and calculations.
Publications: own depiction based on SCISEARCH (STN), own surveys and calculations.

**Germany's percentage share in transnational patent applications and internationally renowned publications in the field of high-performance batteries**
(updated figures up until 2011 (patents) and 2012 (publications); Germany's share averaged over three years due to high variance).

FIG 08

DATA DOWNLOAD




Source: Patents: own depiction based on WPINDEX (STN), own surveys and calculations.
Publications: own depiction based on SCISEARCH (STN), own surveys and calculations.

However, this technology requires a comprehensive network of hydrogen filling stations.[111]

Developments in the electromobility market are closely intertwined with the future design of the electricity supply system. Consequently, the type of technology – high-performance batteries or fuel cells – which becomes established in the mobility sector, and the depth of market penetration, are of great relevance for the electricity supply from renewable energies. A mass market for battery-powered vehicles could contribute to the stabilisation of the distribution networks by deploying the vehicles' electricity storage capacity to buffer the fluctuating electricity supply form renewable energies. At the same time, this poses the challenge of avoiding peaks in electricity demand which could result from users loading their batteries at the same time – for example in the evenings after work. That said, a mass market for fuel cell vehicles would interact positively with an infrastructure for the hydrogen supply, which in the electricity sector could arise from the large-scale deployment of power-to-gas technologies.[112]

German fuel cell research is publicly funded, amongst other sources, by the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP), initiated in 2006.[113] The projects funded by the programme are bundled and coordinated by the National Organisation Hydrogen and Fuel Cell Technology (NOW) platform, founded in 2008.[114] The total budget of the ten year NIP programme (2006–2016) is EUR 1.4 billion, of which just under 60 percent is allocated to the "Transport and Infrastructure" programme area. Half of the budget is provided by the Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Federal Ministry of Economics and Technology (BMWi), the other half by industry. The NIP supports both R&D and demonstration projects.[115]

If one assesses German innovation activity in the area of fuel cells according to the same criteria as those applied to high-performance electronics and batteries, the picture is sobering.[116] During the highly dynamic global growth in transnational patent applications in the 1990s, Germany's share of applications, averaged over three years, rose to nearly 30 percent in 1997. Between 2000 and 2011, worldwide applications exhibited a downward trend and the German share has generally fluctuated between 10 and 15 percent – with a current downward trend. The analysis of the publication data shows a steady increase in publications worldwide over the last 20 years. However, in contrast, the German share has fallen continually since the start of the millennium. A possible reason for this is that Germany's R&D strategy in this sector has a strong focus on close-to-market projects, often with a high demonstration character, while more innovation-oriented research plays a less prominent role.[117]

**Recommendations**

In recent years, Germany has launched major electromobility research programmes in the fields of high-performance electronics, high-performance batteries and fuel cells. The development of research activities in the area of high-performance batteries – measured in terms of patent applications and publications – is positive. As regards high-performance electronics and fuel cells, it is not possible to observe any improvement in patent applications and publications as indicators for innovation activity, which might be due to the strong product orientation of current R&D activities. However, it is too early to provide a conclusive assessment of the effectiveness of research support programmes as patent applications and publications often require a considerable lead time.

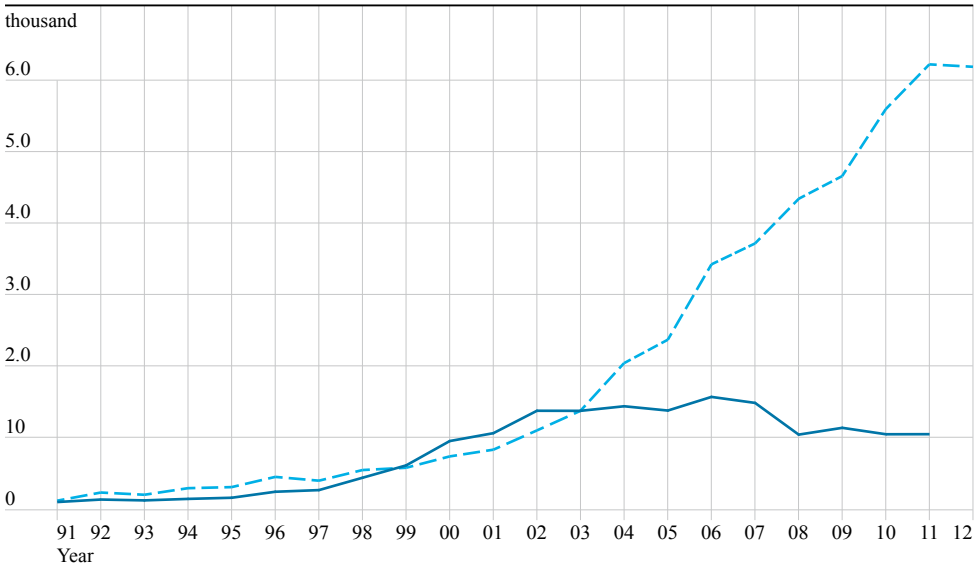
In recent years, efforts to introduce electromobility have been focussed on battery-powered vehicles.[118] In the long term, research funding policy should be technology open, i.e. it should not discriminate between research in the fields of high-performance batteries and fuel cells. The Expert Commission welcomes the fact that this is also anchored in the coalition agreement.[119] Funding of the "National Hydrogen and Fuel Cell Technology Innovation Programme" expires in 2016. Following a review of the measures' effectiveness and an assessment of future potential, a continuation of funding would be expedient in order to preserve the know-how developed in Germany and successfully support market launch.

The interface between electromobility (whether on the basis of batteries or fuel cells) and electricity networks is of central importance. Mutual dependencies exist between grid management and energy storage technologies, respectively, and propulsion technologies for electric vehicles. The research and

**Number of worldwide transnational patent applications and internationally renowned publications in the field of fuel cell technology**
(updated figures up until 2011 (patents) and 2012 (publications)

FIG 09

DATA DOWNLOAD

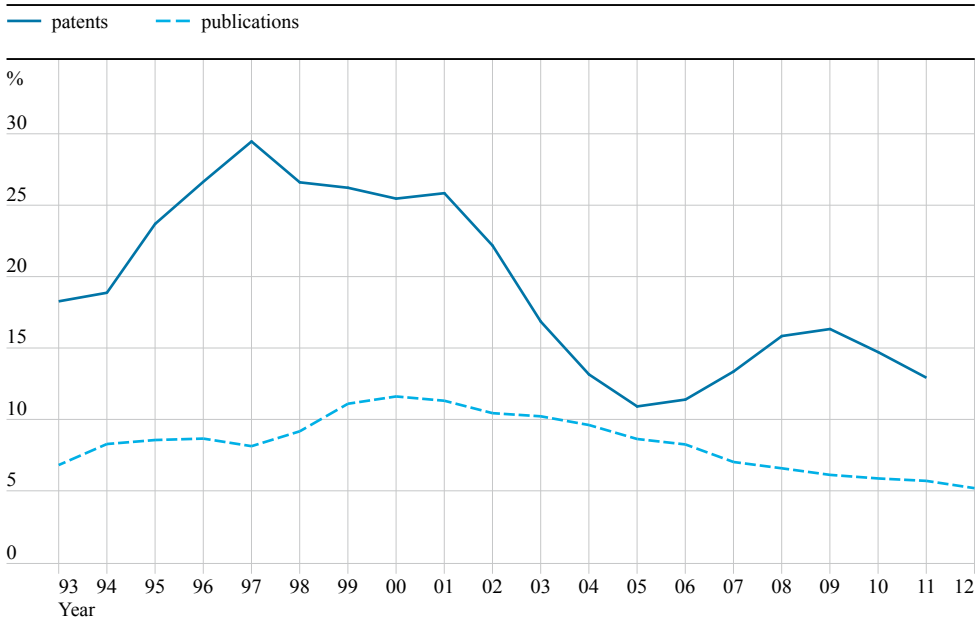



Source: Patents: own depiction based on WPINDEX (STN), own surveys and calculations.
Publications: own depiction based on SCISEARCH (STN), own surveys and calculations.

**Germany's percentage share in transnational patent applications and internationally renowned publications in the field of fuel cell technology**
(updated figures up until 2011 (patents) and 2012 (publications);
Germany's share averaged over three years due to high variance).

FIG 10

DATA DOWNLOAD




Source: Patents: own depiction based on WPINDEX (STN), own surveys and calculations.
Publications: own depiction based on SCISEARCH (STN), own surveys and calculations.

development of integrated technology concepts should be driven forward. This represents an important starting point for public coordination and public funding of research cooperation between car manufacturers, electricity supply companies as well as tertiary education institutions and non-university research institutions.

The Expert Commission welcomes the fact that the coalition agreement has distanced itself from buyer's premiums for electric vehicles and calls for the continuation of public R&D support programmes.[120]

Electromobility represents an important field of application for ICT. A close integration of research programmes on electromobility and ICT should be conducted as part of the Federal Government's Digital Agenda.