

# **An Analysis of the German Electric Mobility Market from an International Perspective**

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## **Summary**

There is growing awareness that preventing climate change can only be achieved by making societal changes. Policy makers have introduced regulations for carbon emissions in the automobile industry with the aim of promoting a new market for low-emission vehicles. The market for electric mobility holds great potential and larger industrial countries are at the fore front of establishing a market with innovative technologies. In this paper we present an analysis of the German market for electric mobility from an international perspective based on stakeholder interviews [1]. Our goal is to review the current German market situation from an outside perspective.

*Keywords: Germany, incentive, infrastructure, market, state government*

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## **1 Introduction**

Stricter legislation on carbon emissions for passenger cars has triggered changes in the automotive industry. As an example, in order to meet the EU requirements of 95 g of CO<sub>2</sub> per kilometre by 2020 [2] car manufacturers have to come up with a range of solutions. Besides improving the conventional drive train technologies the automotive industry has bet on more radical technologies such as low- and zero emission vehicles. After a number of failed attempts, fully electric or plug-in hybrid vehicles are now a popular option and are available on the market.

The success of the transition from traditional combustion engines towards electric mobility, however, will not solely depend upon car manufacturers. Cooperation among a broad range of stakeholders is needed in order to produce affordable electric vehicles as well as to develop an early market and the necessary charging infrastructure [3]. These stakeholders are paving the way for the large-scale introduction of electric vehicles and include car manufactures, national and local governments, the electric power and IT industries as well as innovative start-ups.

In 2011 the federal government of Germany made a decision to introduce measures to support electric mobility and set the goal of becoming the leading market for electric mobility [4]. Therefore it has implemented a funding program called “Electric Mobility Showcase” through which it supports the cooperation between industry, science, and the central government in order to test innovative elements of electric mobility. This Showcase Programme provides a very broad range of positive results. In terms of the leading provider, Germany has been on the right track so far. Based on McKinsey's Electric Vehicle Index [5], it ranked third among the producers of electric vehicles in January of 2016, only surpassed by China and Japan, and according to Roland Berger's Electric Mobility Index the market conditions have continuously been improving over the past years [6].

Compared to countries such as Norway or the Netherlands, Germany is still lagging behind in certain respects. Thus, in order to continue the success of the Showcase Programme and to reach its goals for the

future, Germany has to set the right framework in order to promote electric mobility. To do so, interviews with numerous stakeholders were conducted in order to find out about their perspective on the German market and other key international markets for electric mobility. In this article the results of these interviews are presented, which provide an extensive overview of the German market for electric vehicles and possible measures are discussed for improving the market roll-out for electric vehicles in Germany.

## 2 Method

In order to receive an overview of the current electric mobility market in Germany we conducted around 45 qualitative interviews with representatives of various stakeholders from eight different countries: automotive manufacturers (11), automotive suppliers (6), electric power companies (5), research institutions (6), electric vehicle associations (5) and others (2). The interviews took place in 2015. Interviews held in person were conducted during international conventions such as the International Motor Show in Frankfurt (IAA) or the eCarTec in Munich. In order to involve the whole range of relevant experts, additional telephone interviews were carried out.

The interviews were semi-structured, meaning that a guideline was used in order to ensure that the interviewees covered the relevant topics. The interviewees were granted anonymity in order to stimulate openness and honesty during the interviews. Therefore, and for privacy reasons, company names and the names of the individual respondents are withheld in this paper. For each interview, a report was written from which the most relevant information was distilled, as for example the stakeholders' interests, strategies and views on the German or national market for electric vehicles. Interview results and the summary findings and experience of the Electric Mobility Showcase were joined together in order to formulate the conclusions of this survey.

## 3 Results and Discussion

In this section we present the results of our stakeholder interviews and describe the current situation of the German electric mobility market as well as the stakeholder opinions on different areas of the market for electric vehicles. We have structured our results into the following topics: market potential, product portfolio, automotive industry and suppliers, battery production, public charging infrastructure, regulatory framework and the role of politics.

### 3.1 Market Potential

**Electric mobility is a disruptive technology. Electric vehicles will conquer the market. The technologies for electrification are in place and its development is a target of climate change policy. The electric drivetrain is more efficient and powerful than the traditional combustion engine. Energy storage, the only area where a good solution is still missing, is expected to develop in a positive way.**

**Is it only a matter of time before electric vehicles will conquer the market?**

Most of the interviewees, regardless of their country of origin, supported the assumption that electric mobility will assert itself in the long run. The disruptive potential of electric mobility is confirmed without exception even though uncertainties concerning the development of different types of alternative drive technologies continue to exist. This finding, in combination with McKinsey's future scenarios regarding CO<sub>2</sub> regulation [7], further strengthens the assumption that some types of electrified drive systems will eventually supplant and almost completely replace the traditional internal combustion engine. Therefore, it can be concluded that electromobility has huge potential in every market in the world. The push and pull factors that influence the pace of this development in either a positive or a negative way include economic, technological, political, ecological and social factors (see Fig. 1).

### **3.1.1 Economic factors**

An important factor for the introduction of electric mobility is whether a country has an automotive and supplier industry of its own and its role for the overall economy. This is because the disruptive potential of electromobility triggers the need for transformation of the old business models of the affected companies. Jobs need to be preserved. The common goal of policy-makers and economic leaders is to safeguard employment. Moreover, the production of electric vehicles requires changing the value creation structures in the industry since the battery takes up an above average proportion of the process. Therefore, it is important from an economic point of view whether a country has got the necessary competencies for battery production.

### **3.1.2 Technological factors**

To what extent are car manufacturers able to offer a portfolio of electric vehicles across the entire model range that meets customer requirements in terms of range, convenience, and price? The variety of models offered is an extremely beneficial factor. Another relevant issue is whether there is already a charging infrastructure available for users of electric vehicles. In addition, technical interfaces between the relevant charging infrastructure providers must be seamless, convenient, and easy to use (e-roaming, ad-hoc access).

### **3.1.3 Political factors**

Politics can tackle the current non-competitiveness of electric vehicles caused by their high purchase cost, low range, and still insufficient charging infrastructure with an array of measures aimed at actively accompanying and promoting the market launch and ramp-up. These include, among other things, incentive mechanisms. In this context, the interaction between business and politics is important as well. The overlapping challenges of electric mobility in research, development, and market implementation can only be successfully overcome with close cooperation between these two sectors.

### **3.1.4 Ecological factors**

Ecological aspects can further drive electromobility. The current scandal at Volkswagen has shifted the media focus to hazardous vehicle emissions. Recently this is an opportunity to position electric mobility as an superior alternative to traditional drive technologies. The interviewees agreed that transport policies must contribute to reducing CO<sub>2</sub> and other pollutants. Fostering electromobility is an appropriate way to achieve this.

### **3.1.5 Social factors**

The cultural shift in countries and markets has resulted in previously unseen customer demands. At the same time, attitudes towards new technologies and sustainability are changing. Societies that are open-minded in principle towards new technologies and towards testing them without reservations will tend to be less sceptical about using electric vehicles than more conservative societies.

|                       |                                           |
|-----------------------|-------------------------------------------|
| Economic factors      | Model range on offer                      |
|                       | Domestic automotive industry              |
| Technological factors | Domestic battery production               |
|                       | Charging infrastructure                   |
| Political factors     | Incentive mechanisms                      |
|                       | Political enforceability                  |
|                       | Interaction between business and politics |
| Ecological factors    | Goals of climate protection               |
|                       | Energy turnaround                         |
| Social factors        | Cultural shift                            |
|                       | Attitude towards new technologies         |
|                       | Attitude towards sustainability           |

Figure 1: Factors that hinder or drive electric mobility

### 3.2 Product Portfolio

**The product range made available by the automotive industry for both private and commercial use has a large impact on the point of time when electric mobility will assert itself. Products have to meet the needs of customers. Otherwise the industry will fail to take advantage of a huge sales opportunity. In particular, the range of electric vehicles and light vehicles for commercial use is currently by no means sufficient.**

The product portfolio offered by OEMs has a large impact on the success of electric mobility. This becomes clear when looking at Norway. Despite considerable incentives, sales of electric vehicles in Norway increased only marginally between 1990 and 2010. Only after a certain breadth of the product range had been reached did sales figures skyrocket [8].

An appropriate number of different models is necessary to target each and every potential group of electric vehicle users. There are, for example, still target groups for which no suitable electric cars are available, such as families with comfort and space requirements. Potential demand that is currently not met by manufacturers is also seen for light commercial vehicles, especially in European markets like France and the Netherlands. Therefore, car manufacturers should continue to extend their range of electric vehicles if they take electromobility seriously.

The huge potential of commercially used electric vehicles is yet another important area, as all surveyed experts agree. Some experts would even regard the commercial use of electric vehicles as a lever to boost sales volume and thus to promote electromobility. Electric vehicles can provide substantial benefits for commercial operators such as access to restricted inner city zones and lower operating costs. When operated with the appropriate driving pattern, these vehicles do not need recharging during the day. The French postal service, for example, already operates 7,000 Renault Kangoo electric vehicles. German pilot projects for electromobility come to the same conclusion: Replacing the entire fleet of courier, express and parcel service providers with electric vehicles would be feasible. Manufacturers thus need to offer more models suitable for commercial use to take advantage of this market.

Some experts think that the strategy of German car makers to offer hybrids and fully-electric vehicles in parallel is not particularly reasonable. In the long run, hybrid cars will remain more expensive than fully-electric vehicles since they need two engines and their maintenance requires much more effort. Mild hybrid cars (48 volt technology) are not considered superior either, since they will only slightly improve the combustion technology, which cannot make up for the general inferiority of internal combustion engines. Hybrids can only serve as a bridge technology which cannot compete with fully electric vehicles in the long run. Some interviewees, however, expressed understanding for the German manufacturer's strategy.

### 3.3 The Role of the Automotive and Supplier Industries

**The industry is changing. Many businesses, particularly German manufacturers, are sticking too closely to the combustion engine. It is difficult for developers and decision-makers to turn away from this sophisticated technology. Growing ecological, political, and social pressure is causing the international automotive and supplier industries to tackle the issue of electric mobility. Technological progress is becoming evident whereas the lack of customer acceptance is still a problem. This also applies to most of the other markets investigated.**

The manufacturers with a large share in markets in Europe are affected by the goals of climate protection and the limits on fleet emissions defined by EU agencies [2]. A similar development can be seen in the US, especially in individual states like California [9]. In this context, the manipulations of exhaust emissions and fuel consumption measurements with diesel and petrol engines at Volkswagen are seen as even more scandalous. It is a high-profile issue not only in Germany and the US but also in the rest of the world. Air pollution in megacities in Asia is increasing the pressure to introduce new zero-emission drive systems. It is therefore not only political pressure that prompts the car industry to act, but also trends in society. Car makers are faced with the challenge of lowering their fleet emission levels while maintaining their competitiveness. The scale of this challenge becomes clear when looking at EU emission limits. Based on current rules, the big OEMs will have to reduce the overall CO<sub>2</sub> emissions of their fleets by 28 percent on average [10].

The persons surveyed see challenges for the automotive and supplier industries particularly in battery technology, body weight reduction, and the intelligent integration of the car into the energy and transport infrastructure (smart car, smart grid, smart traffic). They also have to keep up with shorter development cycles. When looking at the value chain, it becomes clear that suppliers and OEMs are developing electric mobility in a symbiotic relationship. Here, the suppliers are the driving forces that lead the OEMs towards new technologies. "The suppliers have a lot of visionary ideas!", one interviewee said. During market ramp-up, manufacturers generally focus their sales efforts on the countries that offer subsidies. In general, several interviewees held the opinion that OEMs had to commit themselves more to offering electric vehicles at competitive purchase prices.

Few of them assumed that any other new players besides Tesla will enter the market. The opinion prevailed that Tesla had taken advantage of a window of opportunity which then closed because large manufacturers recognised the potential of electromobility and mustered the necessary resources to block market entry of other firms. Only technology companies from other areas, such as Apple and Google, were considered to have sufficient financial and personnel resources to overcome these barriers and possibly position themselves on the market in the future.

### 3.4 Battery Production

**The battery has a very high share of the value of the overall vehicle. The dependency on this component will become critical for the success of the OEMs. Due to the importance of the German automotive industry for the economy as a whole, it is imperative that competencies for battery technology and research are established in Germany.**

The traction battery is an important core component for electric vehicles. It has a decisive effect on both range and price of electric vehicles. Generally, intense research is needed to improve battery technology which is why setting up a battery research and production site is an important investment. However, it is not that important whether the actual knowledge is located in Asia or in Europe. What is paramount is that the owner structure ensures access to know-how and resources.

Another important factor is battery price. The price must fall substantially to increase both user acceptance and competitiveness of electric vehicles. The battery price is the key element that determines the total cost of ownership (TCO) of an electric car [11]. Lowering battery prices would therefore bring down the TCO of electric vehicles and boost their competitiveness compared to internal combustion engines. Current forecasts [e.g. 12] give reason to expect that battery prices will fall faster than assumed in previous cost assessments by the industry and many interviews have confirmed this forecast. Most interviewed stakeholders expect rapidly falling battery prices with increased competitive pressure and demand as well as with steadily improving battery and production technology.

### 3.5 Public Charging Infrastructure

**Electric vehicles in everyday life are only viable with a charging infrastructure that is available everywhere and permits rapid charging. The charging infrastructure is considered a critical factor for a successful market ramp-up. A financial cooperation between state agencies and automobile manufacturers such as in Japan can speed up its installation.**

All interviewees, regardless of their country of origin, regarded a public charging infrastructure as a key success factor not only to cover the actual need but also psychologically to prove the existence of a charging network. They pointed out that a sufficient number of charging stations were necessary to allow electric vehicles to cover long distances.

Still, the charging infrastructure is only a necessary, but not a sufficient condition for a successful market ramp-up. Portugal or Ireland, for example, have quite a good charging infrastructure but not that many electric vehicles drive on their roads. The Netherlands and Norway are pioneers for setting up charging columns. The best conditions for expanding the charging infrastructure today are found in Norway. The infrastructure for power supply in this country has always been very capable since the time when it was installed for independent electric vehicle heaters.

Today, none of the markets analysed offers a profitable financing and operating model for regular charging. There are, however, functional business models for fast-charging columns provided they are operated under sufficient load. Currently, electric vehicle owners usually need several charging cards for the charging stations operated by different providers. This is not convenient. Unified access and billing procedures (e-roaming and ad-hoc charging) are pressing issues in all of the analysed markets. For cross-border traffic, things get even more complicated. There are often no roaming contracts between providers from different countries. Therefore, initiatives for setting up a single European standard are warmly welcomed. Among other things, this would make user-friendly payment schemes possible.

### 3.6 Regulatory Framework

**In many countries, individual transport is being increasingly restricted in order to reach climate targets. In addition, many countries are promoting electromobility, in particular by granting regulatory privileges or by providing special funding. Incentive mechanisms designed to promote electric mobility are complex since they have to be tailored to the actual situation of any given country as well as to the needs of the users. If government manages to provide a suitable package it will speed up the expansion of electric mobility.**

Offering benefits is an important measure for the promotion of electromobility. In California, for example, the multi-driver lane, which is usually restricted to car pools, was opened for all types of low-emission

vehicles [13]. Another example is the metropolitan region of Oslo where the permission to use bus lanes is a major incentive since it cuts commuting time from suburbs by up to 40 minutes [14]. This allows users of electric vehicles to reach their workplace much faster. This shows that it makes sense to foster electromobility by means of a regulatory framework. Such a framework, however, largely depends on the actual political and social situation. Therefore, it is recommended to adapt the incentives to the requirements in the respective countries.

There is a wide variety of monetary and non-monetary incentives with a great leverage potential (Tab.1). In China, measures such as assigning licence plates without lottery and exemptions from access restrictions in cities with heavy traffic have proven very effective [15]. Examples of monetary incentives can be found in many countries. Countries that do not have a strong automotive industry can more easily introduce tax breaks for electric vehicles. Table 1 shows an overview of different incentives in the markets investigated.

Table 1: Overview of relevant incentive mechanisms and their application by country

| Countries   | Incentive Mechanisms                                                                                           |                                        |                    |                 |                                        |                                 |                            |
|-------------|----------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------|-----------------|----------------------------------------|---------------------------------|----------------------------|
|             | Monetary                                                                                                       |                                        |                    |                 | Non-monetary                           |                                 |                            |
|             | car tax exemption or reduction related to CO <sub>2</sub> emissions                                            | reduced taxation of company fleet cars | exemption from VAT | buyer's premium | access privileges for EVs <sup>1</sup> | privileged parking <sup>2</sup> | access to privileged lanes |
| Netherlands | •                                                                                                              | •                                      |                    |                 | •                                      |                                 |                            |
| Norway      | •                                                                                                              | •                                      | •                  |                 | •                                      | •                               | •                          |
| France      | •                                                                                                              | •                                      |                    | •               | •                                      |                                 |                            |
| China       | •                                                                                                              |                                        | •                  | •<br>(regional) | •                                      | •                               |                            |
| South Korea |                                                                                                                |                                        |                    | •               |                                        |                                 | •                          |
| Japan       | •                                                                                                              |                                        | •                  | •               |                                        |                                 |                            |
| USA         | •                                                                                                              |                                        |                    | •               |                                        | •                               | •                          |
|             | 1. environmental zone, extended delivery times, toll cuts etc.<br>2. free of charge, EV exclusive parking etc. |                                        |                    |                 |                                        |                                 |                            |

Experience shows, however, that non-monetary incentives such as access to bus lanes or free parking in cities become ineffective more rapidly than monetary ones. After all, electric vehicles need space as well. Therefore, incentive systems cannot be maintained forever. They should be seen as temporary measures during market ramp-up that are to be abolished at the appropriate time. Incentives should be evaluated before they end and extended, if necessary.

### 3.7 The Role of Politics

**In the case of disruptive innovations such as electric mobility, which trigger a transformation process across industries and within society, the interaction between the various stakeholders in business, science and politics is extremely important. In democratic countries, the greatest challenge in the transformation process towards electric mobility is the integration of disparate interests in a way that makes it possible to take decisions jointly and to set the course for the target. A broad social consensus helps master this challenge. A strong domestic car industry hampers the consensus-finding process.**

Cooperation between the different industries and the stakeholders from business, science and politics is a key factor for the successful implementation of electromobility. The interviews showed that political structures in the different countries have a large impact on the process of implementing electromobility. It also became clear that the regulatory framework varies significantly by culture. The US, for instance, is focused far more on the business success of the companies involved than on their interaction with politics. South Korea, on the other hand, is characterised by a close interleaving between major companies and politics and by industrial policies clearly tailored to the needs of big business. According to the interviewees, a similarly close intertwining between the car industry and politics exists in Japan.

How fast electric mobility evolves in a country also depends on whether there is a social consensus about it. In Norway and in the Netherlands, for instance, the laws for promoting electric mobility were adopted in a consensus that spanned several parties. On this basis, laws can be passed with much greater ease. It is safe to assume that the fact that neither country has a significant automotive industry with jobs in need of protection played an important role in this context. On the other hand, countries with a strong automotive industry such as Sweden and Germany focus more on research funding and are reluctant to offer purchase incentives.

A communication platform for stakeholders in politics, business, science and society is considered very important. As one interviewee put it: "Business needs an interface to feed back its assessments to politics". Some of the foreign experts surveyed knew about the German National Platform for Electric Mobility (Nationale Plattform Elektromobilität, NPE) and praised it as a model for cross-sector cooperation. In the Netherlands, the Formula E Team has a similar function to the German NPE. It includes representatives from politics, business and science and advises the government in its electric mobility strategy. In 2008, the Norwegian Ministry of Transport set up an expert commission on the electrification of the transport sector. In fact, many of the measures it proposed have already been adopted and implemented.

A collaboration on European level is also desired. In order to promote electric mobility, communication is necessary especially in general matters such as financing options and technical cooperation. This was stressed by many interviewees.

### 3.8 Summary

We conclude that stakeholders agree in general on the high potential of electric vehicles and on the view that electric mobility will play a large role in the near future. However, many are disappointed in the slow progress of some electric mobility markets. This could be due to a lack of governmental support, incentives or missing charging infrastructure. These constraints prevent the overall acceptance of electric mobility in the general public and among policy makers.

It has also become evident that some preconditions for electric mobility are similar in the markets analysed. However, significant differences were identified for other factors. (Tab. 2)

Table 2: Country comparison by factor

| Countries | Factors        |             |                                                                                                           |                                                                                          |                                                                                      |                                                                                     |                                                                                 |
|-----------|----------------|-------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|           |                |             | Economic                                                                                                  | Technological                                                                            | Political                                                                            | Ecological                                                                          | Social                                                                          |
|           | demand country | Netherlands | + innovative supplier industry                                                                            | + good charging infrastructure                                                           | + numerous incentive mechanisms                                                      |                                                                                     | + high acceptance in society in terms of sustainability                         |
|           |                | Norway      | + no automotive industry                                                                                  | + good charging infrastructure<br>+ infrastructure already partially in place            | + consensus across different groups of society<br>+ numerous incentive mechanisms    | + ambitious sustainability targets<br>+ almost completely ecological energy concept | + high acceptance in society in terms of sustainability                         |
|           | supply country | France      | -risk of losing prosperity                                                                                | + know how of e-drive through cross-industry cooperation                                 | + numerous incentive mechanisms                                                      |                                                                                     |                                                                                 |
|           |                | China       | + great market potential<br>+ potential for automotive industry to catch up with established players      | + good charging infrastructure planned                                                   | + numerous incentive mechanisms<br>+ close cooperation between business and politics | + great pressure from air pollution                                                 |                                                                                 |
|           |                | South Korea | + battery know how                                                                                        | + in-depth competence of electric mobility                                               | + close cooperation between business and politics                                    |                                                                                     | + openness of people towards new technologies                                   |
|           |                | Japan       | + battery know how                                                                                        | + good charging infrastructure<br>+ long-standing experience with electric drive systems |                                                                                      |                                                                                     | + openness of people towards new technologies                                   |
|           |                | USA         | + battery know how<br>+ willingness to cooperate and interact between established companies and start-ups | + good infrastructure (in certain regions)                                               |                                                                                      | + ambitious sustainability targets (in certain regions)                             | + environment very open for innovations<br>+ promotional effect of testimonials |

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