E-Mobility & Beyond

How to Master the Future of Mobility

FLICK & PARTNER

Management consulting

E-Mobility & Beyond

The electric car has arrived in the automotive world. However, is it also here to stay? The current situation cannot be considered as a breakthrough on the mass market, yet. The registration figures of electric vehicles are still in the low single-digit percentage range in all relevant markets. The existing exceptions, like for example the Norwegian and Dutch market, are nothing more but a direct consequence of massive public subsidies.

In Germany, the federal government proclaimed a goal of 1 million electric vehicles (EVs) on Germany's roads by 2020. In recent years, numerous studies have been published discussing the development of electric mobility (e-mobility), many predicting a broad market penetration in the near future. However, current registration numbers in Germany as well as worldwide disprove these predictions.

The goal of 1 million electric vehicles in Germany is thus considered to be highly unlikely or even unrealistic by many industry experts and the public opinion alike.

The future of mobility in general and electric mobility in particular are discussed as an important contribution to the "Energiewende" (exit from nuclear and fossil-fuel energy). The related issues are heavily debated in the mass media, by experts, politicians, and increasingly among potential car buyers. The search for indications and signals for a rapid increase of the market penetration for EVs has thus reached its full inertia and is a burning issue.

This publication describes in detail how Flick&Partner views the development of the EV market for the next years. Furthermore, a precise outline on which criteria have a major influence on the time and speed of the breakthrough of e-mobility is given. For this purpose, the following three main areas are covered below and analyses as well as findings are presented for each case.

» Indicators and Levers for the Breakthrough of E-Mobility

The calculations of Flick&Partner project that the 1 million electric car goal of the German government will not be met. However, the deviation will be less considerable than expected by many. It is shown how the sales figures of EVs will develop in the next years. Describing the key topic of price development for automotive battery cells, it is also outlined why Tesla's strategy with its Gigafactory is a chance and a risk at the same time. Additionally, a cost comparison between the necessary charging infrastructure for battery electric vehicles (BEVs) and a fueling infrastructure for hydrogen vehicles is presented for Germany. Moreover, the key role of the Chinese car market is discussed.

» These Customer Needs Will be Decisive for Electric Vehicles

Besides purely technological issues and uncertainties regarding the right development focus, the question of how to deal with complex and volatile customer needs is increasingly arising. Specifically the customer needs concerning range and charging speed are still not fulfilled by today's EVs. Additionally, a holistic view on e-mobility has to be taken and the integration into the respective infrastructure needs to be considered. The electrification of the powertrain fundamentally changes the value chain, which presents substantial challenges for car manufacturers and their suppliers.

» Potentials for Differentiation and Future Key Competences

E-Mobility will further complicate differentiation of the product range for automotive original equipment manufacturers (OEMs). Yet, e-mobility also offers the chance for OEMs to differentiate through the development and implementation of novel unique features. Fast and comprehensively available charging technology, alternative billing models for the charged energy, driver assistance systems and the integration of the vehicles into digital ecosystems are some examples.

From the presented analyses and problem areas, it can be derived which expertise and strategic decisions are crucial in order to maintain a competitive advantage on the future car market.

Indicators and Levers for the Breakthrough of E-Mobility

E-Mobility causes large challenges for the automotive industry. Hardly any other topic has engaged the industry in a similar way and no other has been discussed as controversial over the last few years.

At the moment, particularly the question regarding the optimal technological characteristics for e-mobility is being disputed. It is debated whether or not the hybrid powertrains of plug-in hybrid electric vehicles (PHEVs) are only a transitory technology until pure battery electric vehicles (BEVs) offer the necessary range. Moreover, the chance of fuel cell electric vehicles (FCEV) becoming the dominant form of electric vehicles in the future is evaluated.

Every one of the aforementioned electrified powertrain concepts can additionally be sub-classified further, yielding vehicles with totally different powertrain specifications.

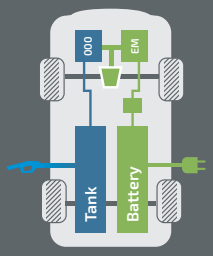
This technological variety already hints at the economic challenges of a parallel research and development of the various concepts. However, as long as none of them definitely prevails in the market, many automotive companies see no real alternative to following different approaches at the same time.

Politics and Businesses Seeking the Right E-Mobility Strategy

From a governmental perspective, the significance and sustainability of political influence and support is questioned. At the same time, merely waiting for a definite market breakthrough and subsequently reacting to consolidated technological facts does not seem to be a wise move in the long run, due to numerous economical, research-related and eco-political aspects. Valid forecasts of the future market development are thus essential for an optimal strategic orientation.

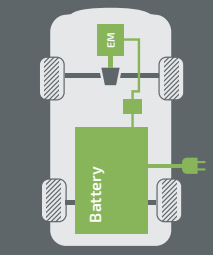
Various forms of propulsion concepts*

PHEV | Plugin-Hybrid-Electric Vehicle



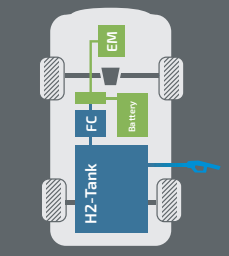
- Combination of combustion engine and electric motor (depending on battery size and driving profile a pure electric propulsion is possible)
- Variable degree of electrification: from using a combustion engine as main propulsion to range extending auxiliary propulsion (Range Extender -REX)
- Differentiation from HEV by external battery charging capability on the normal power grid and typically higher battery capacity

BEV | Battery Electric Vehicle



- Pure electric propulsion with recuperation potential
- No combustion engine, no fuel tank
- Relatively large batterypacks which can be charged via the standard power grid
- Relies on external charging stations

FCEV | Fuel Cell Electric Vehicle



- Fuel cell vehicle
- Pure electric propulsion
- Energy source hydrogen, fuel cell functions as energy converter to power the electric motor
- Additional small battery to enable boost and recuperation
- Refueling hydrogen at specific fueling stations

*per definition: pure hybrid vehicles (HEV) without external charching capability are not considered as electric vehicles

» Market Forecast for Electric Vehicles in Germany

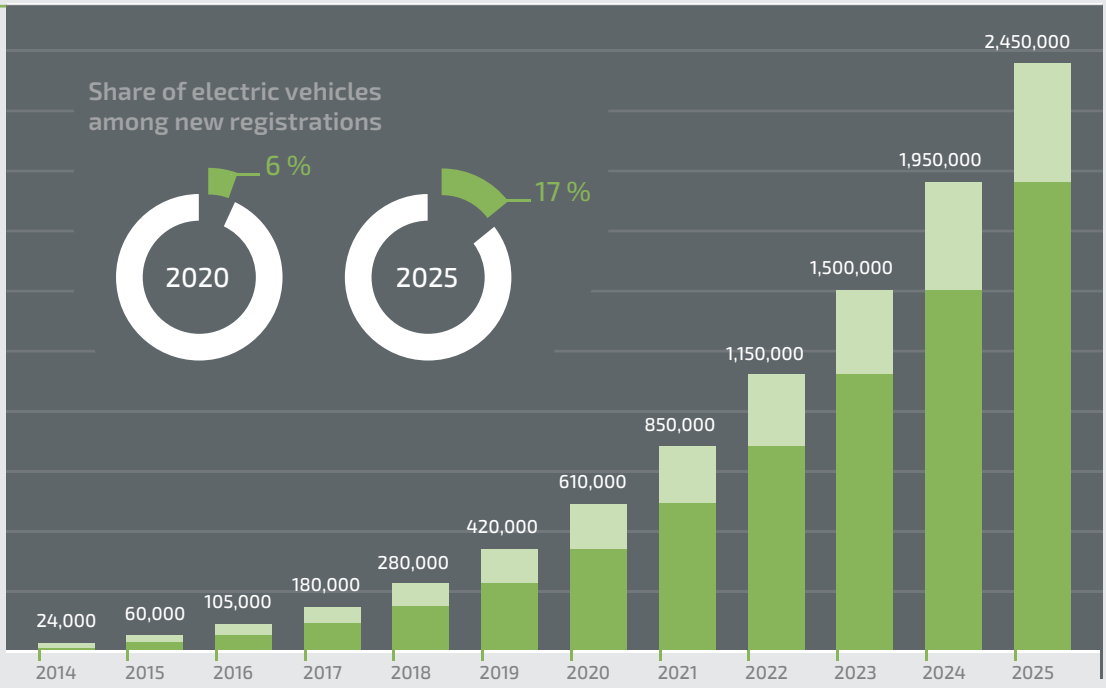
This Flick&Partner analysis is based on a combined evaluation of a variety of references and influencing parameters. Current registration figures were comparatively interpreted and a number of studies and research publications were combined to a meta-analysis.

Key indicators such as the development of automotive battery prices, cost degression of vehicle components and planned vehicle launches were continuously monitored. The projections were complemented and validated by expert interviews. The forecasts rely on the assumption that the support for e-mobility, as currently planned by the German federal government, is going to be implemented, and that the consistent expansion of a public fast-charging infrastructure is promoted sustainably.

The Goal of 1 Million Will Be Missed, but More Marginally Than Expected by Many

The proclaimed goal of the German federal government to have 1 million EVs on Germany's roads by 2020 will be missed. However, surprisingly for many, to a lesser extent than expected. According to the assessment of Flick&Partner, the threshold of 1 million EVs in Germany will already be exceeded in 2022. The ambitious aim of the federal government will thus only be missed by approximately 18 months.

Total amount of electric vehicles in Germany



Electromobility Picks up Momentum Internationally

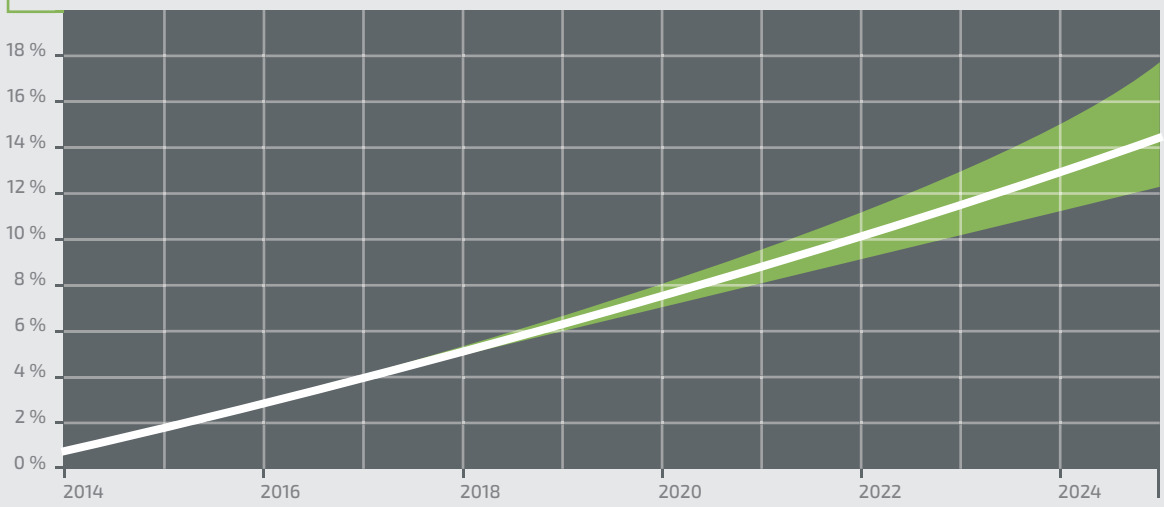
Until 2020, around 600,000 EVs will be driving on German roads. Nearly 200,000 new electric cars are going to be registered in 2020, which corresponds to market share of ca. 6 % for new registrations. In subsequent years, an even stronger trend towards e-mobility is foreseeable, so that in 2025 one out of six newly registered cars (17 %) will be electrified.

With expected constant yearly sales figures of approximately three million cars in Germany, this corresponds to 500,000 new EVs being sold in 2025 alone.

The numbers for the worldwide automotive market, as forecasted by Flick&Partner, show that the trend towards e-mobility gains speed faster initially, yielding a market share of 7 % for new EVs in 2020. Until 2025 this market share will rise to about 13 %.

This shows that the relatively upscale German market, which is dominated by technologically advanced new vehicles, has a higher potential for a strong market penetration of EVs. Many global markets will still be dominated by low priced, conventionally powered vehicles, so that the averaged worldwide market share of EVs will increase more linearly than in the German market.

Worldwide market share of electrified vehicles



The global market share of electric vehicles rises unexpectedly linearly. This is caused by different rates of market penetrations in different sales regions.

E-Mobility in Germany is Lagging Behind on an International Comparison

The currently lower German market shares of EVs as compared to other major vehicle markets, such as the US, are primarily caused by weak governmental incentives for EV buyers and the unsatisfactory availability of a charging infrastructure in Germany. It is likely that catching up will only be possible after 2022.

Moreover, the portfolio of EVs is still limited and many offerings are not sold comprehensively by OEMs, due to a challenging sales environment. The slow development of the EV market also shows the oftentimes hesitant attitude of German customers towards technological innovation.

In the opinion of Flick&Partner, the subsequently described levers and recommended courses of action can influence the development of e-mobility on a worldwide scale – and particularly in Germany – and can significantly increase the speed at which it is established.

Due to the uncertainty of implementation for the respective measures and the overall market dynamics, reliable forecasts beyond 2025 are difficult. However, the accelerating increase of EV market share hints at rapidly growing sales figures beyond 2025.

Three Key Factors Determine the Future Market Development

Especially from 2020, the sales volumes are significantly increasing in Germany. For the first time, more than 3 million EVs will be sold globally from this year on. According to Flick&Partner, three main factors are decisive for this breakthrough:

- The battery cell price
- The availability of charging infrastructure
- The continuous development and promotion of e-mobility in China

Other factors, such as the price of oil, political decisions regarding environmental or energy-related aspects as well as future CO_2 and pollution regulations will play a subordinate role.

» The Prices for Battery Cells Will Continuously Decline in the Next Years

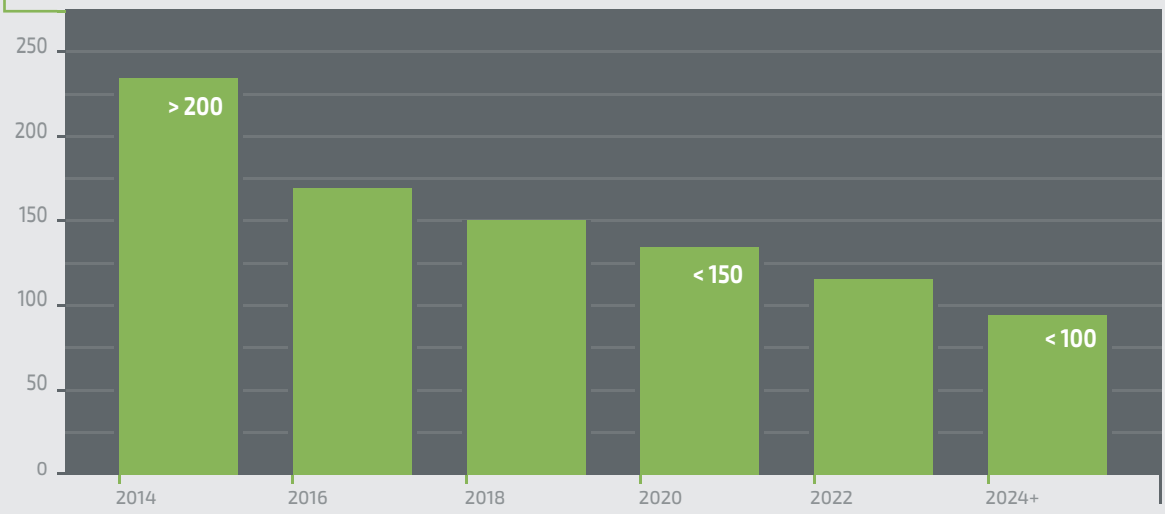
The specific prices for lithium-ion battery cells will considerably decline further until 2025. This implies that the price per kilowatt-hour of battery capacity – and correspondingly per kilometer of vehicle range – will be significantly lower.

Already today, the cost of lithium-based battery cells is substantially lower than predicted by many industry experts and studies in the last years.

Amongst others, the main reasons for this development are:

- The consequent expansion and low degree of utilization of cell manufacturing capacities
- Increased purchase quantities by automotive OEMs
- More long-term contracts between OEMs and cell manufacturers.

Specific cell prices of typical automotive cells in €/kWh



The figure of the forecasted specific prices for typical automotive battery cells shows that, already today, purchasing prices below 250 EUR per kilowatt-hour are possible for automotive manufacturers. Until 2020, cell prices below 150 EUR will be achieved. On a time horizon of ten years, prices will fall below 100 EUR per kilowatt-hour.

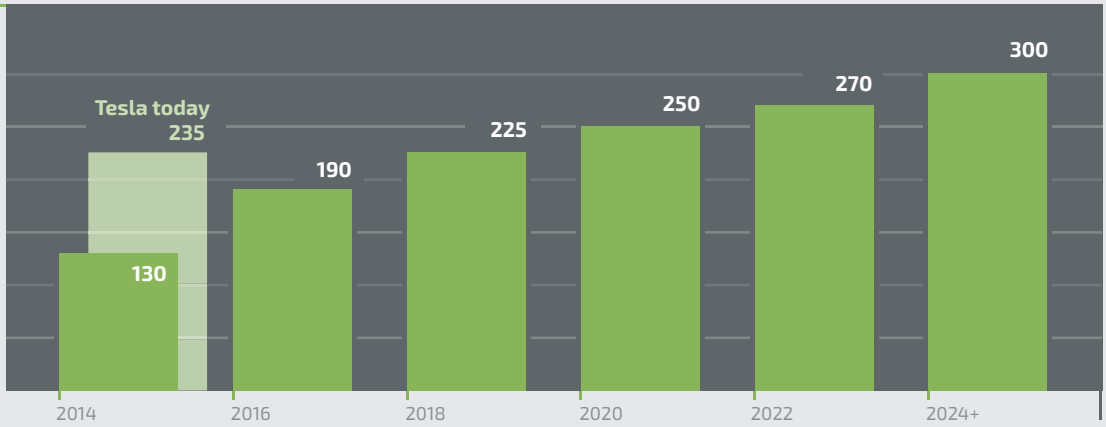
By 2019, EVs Will Have Twice of Today's Range With the Same Amount of Battery Cells

The expected cost reduction of automotive battery systems is mainly caused by the increased performance of new battery cells. For example, Samsung SDI – one of the largest cell manufacturers for automotive purposes – recently presented a roadmap for the next years. The expected cost reduction of automotive battery systems is mainly caused by the increased performance of new battery cells. In practice, this implies that an EV will achieve almost twice of today's range with the same number of Samsung battery cells in 2019. It is expected that the increases in energy density as described by Samsung will similarly be achieved by competing cell manufacturers. Therefore, the cost of an EV battery offering the same range will almost be cut in half within the next five years just by means of the increased capacity on the cell level.

Of course, the cost-neutral implementation of the announced increase in energy density presents a challenge to cell manufacturers.

Obviously, the significant challenge for battery manufacturers is to implement the promised increases in energy density without a significant impact on manufacturing costs. If the goal for 2019 is reached, batteries can economically be introduced to the majority of the globally available vehicle portfolio.

Gravimetric energy density of typical automotive cells in Wh/kg



The figure shows the expected advances in gravimetric energy density of automotive battery cells. Although the increase in energy density has to be considered with cost, durability and safety in mind, significant advances can be expected within the next years.

Major technological leaps – such as post lithium cells or the use of solid electrolyte materials – are consciously not taken into account due to the lack of reliable information on the suitability for series production.

Description of Battery Parameters

Battery and accumulator

The terms can only be diffusely separated from one another and are often used synonymously - be it for a single battery cell or a large interconnection of several cells. Thus the term battery cell can be used to clarify the reference of a single cell.

Capacity

A quantity for the maximum electric charge that a battery can store. For EVs, the capacity is usually specified in watt-hours (Wh) for single battery cells, and in kilowatt-hours (kWh) for larger battery packs. It should be noted that there may be a difference between the nominal capacity and the net capacity that can be extracted from the battery; i.e. if an energy buffer is kept in the battery to increase the life span of its cells.

Gravimetric Energy Density

A specific quantity for the amount of energy that can be contained in a battery cell per unit of weight. It is typically specified in watt-hours per kilogram (Wh/kg).

Volumetric Energy Density

A specific quantity for the amount of energy that is contained in a battery cell per unit of volume. It is typically specified in watt-hours per liter (Wh/l).

» Why Tesla Motors is Breaking New Ground in Battery Sourcing

Tesla Motors, a newcomer in the automotive industry, has closely linked its strategy and success to the market development and profitability of BEVs. After the successful launch of its premium sedan Model S, Tesla has announced to introduce more purely electric vehicles to the market within the next years.

Tesla Motors Plans to Scale up Production Capacity

At first glance, the plan to offer a long-range BEV for the mass market by 2017 already seems highly ambitious and evokes skepticism. Tesla wants to sell several hundred thousands of cars by 2020, which constitutes an enormous increase compared to the ca. 30,000 Tesla Model S that can currently be produced per year. While the Model S uses battery cells manufactured by Panasonic, Tesla is planning to implement its own cell manufacturing in cooperation with Panasonic in the future. For this purpose, Tesla is currently building a battery manufacturing plant, referred to as Gigafactory, in the US. It is announced to be equipped with an immense yearly production capacity of 50 GWh. It is expected that the Gigafactory will decrease the cost for battery cell production significantly.

This also hints at why Tesla has announced to launch a mass-market long-range EV in 2017. A thorough consideration of the aforementioned development of energy densities and expected cost reductions in comparison to Tesla's current cells shows that such a vehicle will be feasible even if the Gigafactory cannot achieve the announced cost-reduction potentials.

Tesla Has a Cost Advantage Today

The Panasonic battery cells, currently used by Tesla, have a gravimetric energy density of more than 230 Wh/kg already. Additionally, Tesla benefits from the use of the small standardized round cell format 18650 through scaling effects. Therefore, Tesla can profit from lower specific battery prices in comparison to the competition, already today. However, this also limits the potential for further cost degression with the employed cell technology. Thus, it will be difficult to achieve the significant cost reductions as announced for the Gigafactory on the cell level only. The factory's main objective will more likely be to profit from economies of scale through a strategic integration of cell production and battery pack assembly. It also provides Tesla with a subsidized possibility to enlarge its production area, which is anyways necessary should Tesla be able to reach its declared goal of multiplying the production volume. In the long run, Tesla's integrated manufacturing process chain also secures reactivity and bargaining power on the global battery market.

The Chance to Establish a New Cell Format

A strategically attractive option which the Gigafactory offers, is the possibility to develop a purpose optimized cell format. The round cell format 18650, as currently used by Tesla, has not originally been developed for automotive usage. For instance, a large number of single cells is required for the battery pack of each vehicle. Primarily, larger cells allow for a better volume utilization and a reduction of material costs for cell liners and cell housings, respectively.

The Gigafactory is announced to have such a large production capacity, that sufficient economies of scale can be expected even if a completely new cell format was to be produced. Contrarily, Tesla's decision to use small round cells, unlike most established automotive OEMs, has offered some advantageous design options. For example, the battery pack of the Model S is relatively flat and can thus take up a large area under the vehicle without remarkably compromising the overall height of the vehicle. In addition, Tesla has significantly invested in the development of various systems inside the battery pack, such as the cell contacting, cooling system and safety concept.

These developments are, however, mostly optimized for a specific cell format. A complete chance of the cell

The so called Gigafactory that Tesla Motors builds in Nevada, USA is supposed to double the global production capacity of lithium based battery systems.

format in the Gigafactory would thus cause Tesla having to redo many of the aforementioned developments. Therefore, it seems most probable that Tesla will develop a new cell format which combines the advantages of bigger cells with the developed know-how of round cell integration and small total height. A concrete solution would be to create a revised larger round cell format.

An evolutionary advancement of the 18650 format would not only, due to the sheer production capacity of the Gigafactory, set a new de-facto cell format standard, but also allows for a continued use of such cells outside of automotive applications. This would, at least partially, decouple the capacity utilization of the Gigafactory from the market success of Tesla's vehicles.

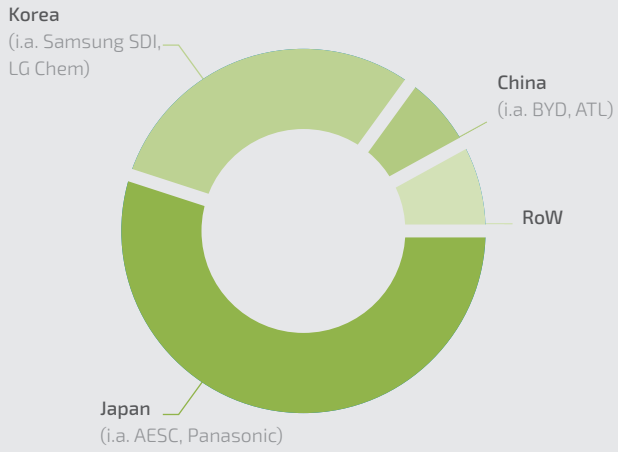
The Risks of an Aggressive Expansion of Tesla and Necessary Future Investments

Considering the current cost advantage of Tesla Motors, the announced aggressive and fast expansion strategy becomes more easily understandable. The cost advantages will successively decline over the next years. As competing OEMs will establish similar research programs. Besides the high cost to gain market share, Tesla is forced to significantly invest in the research of future cell chemistries. The planned fast expansion strategy and the earliest possible entrance into the mass market, combined with cost leadership for battery cells, can help Tesla to succeed in increasing its revenues and market shares. This, in turn, can justify the respective investments in battery research and the high spending for battery production capabilities.

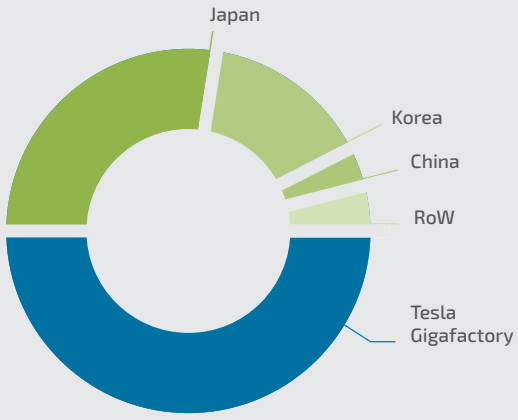
» Asia is Leading in Cell Development and Production

Governmental stakeholders should be equally aware of the importance that battery technology has for the success of e-mobility. The Asian manufacturers of lithium-based battery cells are highly dominant on the global market and are the technology leaders. Attempts, such as the Li-Tec GmbH - a joint-venture of Daumler and Evonik - have been made to build up know-how and production capacity in Europe. However, given the exit of Evonik, they have to be rated a failure, at least in regard to large-scale cell production. Governments and the automotive industry need to decide in coherence with each other, if and to what degree Europe can or should recover from this shortfall. The European Union perceives itself as one of the high-tech centers of the world. Therefore, every effort should be made in order to catch up to the market leaders in such a key technology. Facing the competitive advantage of Asian manufacturers, many industry experts doubt that efforts of increasing development and production capacities in Europe can be effective. Europe (and in a lesser form also the United States) face the threat of a development similar to the one of the solar industry, which is meanwhile dominated by Asian manufacturers. Therefore, political actors and the automotive industry have to reflect on how to generate a significant share of value creation in Europe and how to strengthen the European negotiating position with Asian suppliers.

Distribution of global production capacity for lithium-ion battery cells



Today



Planned capacity of Telsa's Gigafactory compared to today's production

» The Crucial Role of Charging Infrastructure

According to Flick&Partner, besides the prices for battery cells, the availability of a public charging infrastructure is the second main factor to influence the time and rate of a significant breakthrough of e-mobility.

Correlation between Charging Infrastructure and Sales Figures of Electric Vehicles

Already today, the sales figures of electric vehicles are higher in countries, where governmental support fostered the installation of charging infrastructure and which consequently already have a high number of publicly accessible charging stations. Yet, this is not a sufficient indicator that a comprehensive installation of charging infrastructure can actually boost e-mobility on its own, as most of these countries also offer direct incentives to EV buyers.

Nonetheless, surveys among EV customers in these countries show, that EVs are particularly interesting for people who perceive the availability of charging infrastructure in their environment as sufficient. This perception eliminates the necessity for charging as an obstacle for e-mobility, regardless of the actual utilization of public charging infrastructure.

The Importance of Fast-Charging

As shown by the example of Tesla's Supercharger and its usage to market their cars, a fast-charging infrastructure on interstate highways can debilitate arguments regarding the incapability of BEVs for long-range travel.

Thus, the focus should be placed on the comprehensive installation of a fast-charging infrastructure; first along interstate highways and subsequently in urban areas. Moreover, semi-public areas, such as company or supermarket parking lots, are suitable for the installation of collectively accessible charging infrastructure.

Cross-Selling as a Chance for Semi-Public Charging Infrastructure

Semi-public charging infrastructure, in combination with other attractive offerings, offers the potential for cross-selling and sustainable increase of customer loyalty. Already today, many companies, like PUMA and Ikea, install charging stations at its store locations. In most of the cases, customers can charge their EV for free while shopping at the respective stores. In proximity to interstate highways, (fast-) charging infrastructure can even generate a new kind of walk-in customers.

In the future, governments and car manufacturers should be more supportive towards such models and initiatives. An interesting example for such an initiative is the collaboration of BMW's car sharing program Drive Now with the German retail corporation REWE Group. A rented BMW car-sharing vehicle can be parked for free or at a reduced fee, while the customer is shopping at a REWE store. These offerings can be extended to include charging or serve as an example for new collaboration programs. With these features, the additional time expenditure for charging, as perceived by the customer, can be eliminated.

Intelligent Integration of Charging Infrastructure Minimizes Efforts for Charging

Supermarkets and stores gain an innovative additional marketing instrument and create an additional reason for visiting the respective shop. Moreover, this will also reduce the charging management of EV fleets and car-sharing providers can reduce the effort that they have to put into this issue. However, until now, only few companies show an interest in such offerings and are hesitant with collaborations and business models related to charging infrastructure.

Visitors of the PUMA Store at the headquarter of PUMA in Germany can charge their electric vehicles for free. The energy comes from the photovoltaic power plant installed on the roof.

» Comparison of Installation Costs for the Required Infrastructure for BEVs and FCEVs in Germany

The uncertainty about technological characteristics of future EVs, among other factors, is often used as a reason for the reluctant attitude towards infrastructure development in Germany. Besides BEVs, more and more FCEVs might exist in the future. The latter do not require a charging infrastructure, but have to be filled up at special H2-fuelling stations. Thus, the question arises about which type of infrastructure will be required in the future and what investments are necessary. Various economic scenarios, partially of significant difference, have been developed, and even the German national platform for e-mobility does not commit to a specific differentiation of the required infrastructure.

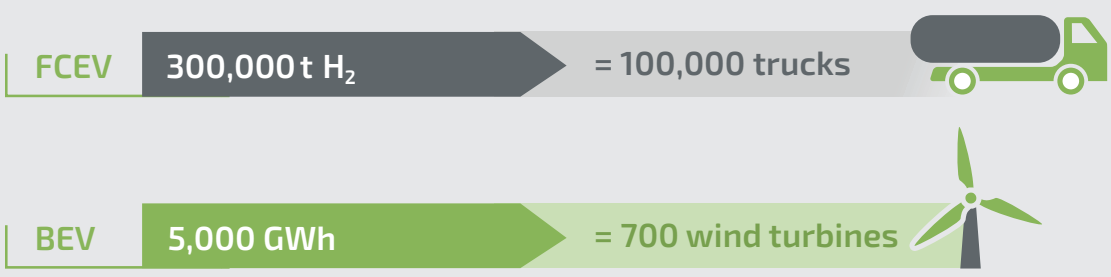
Infrastructural Requirements for 2.4 Million EVs in 2025

As an example, the theoretical minimum infrastructure requirement is analyzed for the 2.4 million EVs in Germany by 2025, as predicted by Flick&Partner. The required infrastructure is exemplarily calculated for a pure BEV fleet and for a FCEV fleet, entirely fueled by hydrogen.

Under the assumption that the demand for individual mobility of currently ca. 11,500 km per year and car in Germany will not change until 2025, this annual kilometrage also applies to EVs. The predicted 2.4 million EVs together will then travel around 28 billion kilometers in 2025.

Assuming an energy demand of 18 kWh/100 km for BEVs, about 5,000 GWh of electrical energy are required for all vehicles per year. This corresponds to the annual energy production of around 700 wind turbines. Alternatively, assuming an average hydrogen consumption of 1.2 kg/100 km, 330,000 tons of H_2 would be necessary per year for the FCEV fleet, which corresponds to nearly 100,000 truckloads.

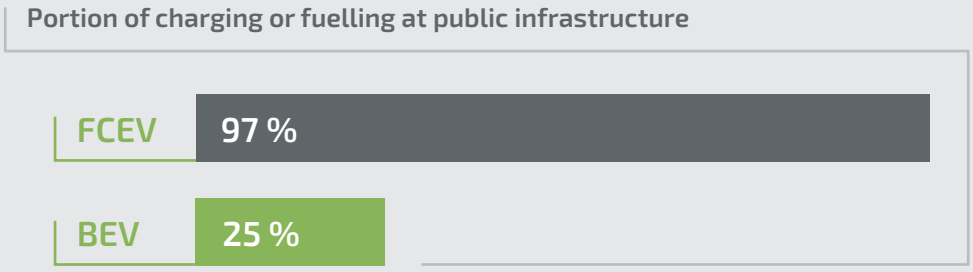
Annual energy demand for 2.4 million electric vehicles in 2025

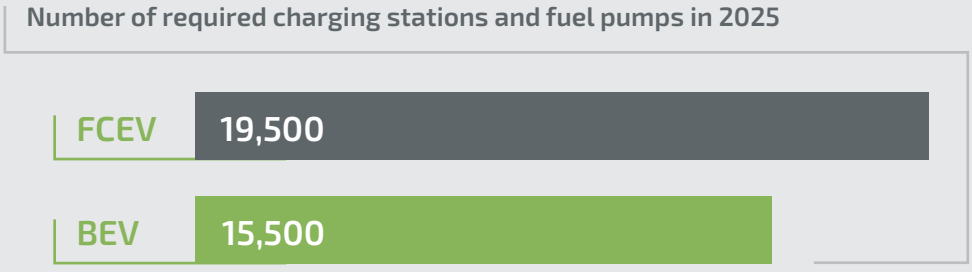


Private Charging Will Cover the Majority of the Energy Demand for BEVs

Another important criterion for evaluating the required infrastructure is the capacity utilization of each charging station or hydrogen fueling station. A relatively low average degree of capacity utilization of 9 % is assumed for the calculations outlined below. This means, that each public charging station or hydrogen fueling station would only be in use for about two hours per day. An identical use of the electric and hydrogen infrastructure is assumed here. Consequently, a hydrogen fueling station can provide the daily energy for a significantly higher range, due to the shorter fueling time. This effect is increased or decreased, depending on the maximum charging power available from a fast-charging station.

In contrast to the majority of hydrogen vehicles, it can be expected that a considerable part of the kilometers travelled with BEVs will be supplied by energy from private charging at home or at the workplace. FCEVs, in turn, almost always require a public refueling station. It is assumed that 75 % of the required energy for BEVs is supplied by private charging stations. Contrarily, only 3 % of the energy for FCEVs can be supplied privately, e.g. by fleet operators. This yields an overall number of 15,500 charging stations and 19,500 hydrogen fueling stations, which will be necessary in 2025. Based on the assumed costs of 25,000 EUR for an electric charging station and 100,000 EUR for a hydrogen fueling station, the overall cost comparison yields a significant difference. It becomes clear that an electric infrastructure would be substantially cheaper than a hydrogen infrastructure.





An Investment of 400 Million EUR for an Electric Fast-Charging Infrastructure Is Necessary Until 2025

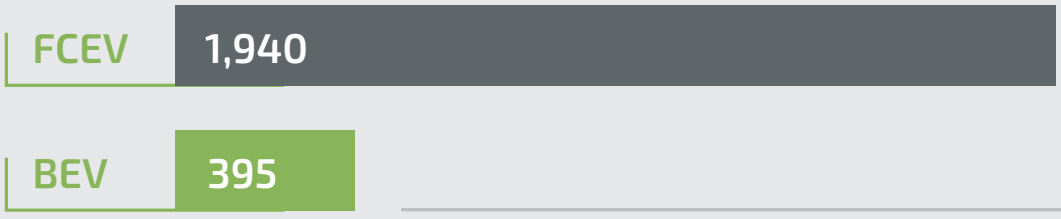
The calculations for Germany as an example show that the installation of the required fast-charging infrastructure for the 2.4 million EVs expected in 2025 is financially feasible. The overall cost amounts to 400 million EUR, which, considering the aforementioned assumptions such as a constant cost for charging stations, is a conservative estimate. This corresponds to a necessary investment of merely 170 EUR per vehicle. Even splitting the infrastructure cost in 2025 to only 1 million EVs, as demanded by the German federal government in 2020, would result in a cost of just 400 EUR per vehicle. In 2009, the German government granted 2,500 EUR as a car-scrapping bonus ("Abwrackprämie") for old vehicles. The total cost for 1.8 million cars amounted to almost 5 billion EUR, which is more than ten times of the forecasted cost for installing a fast-charging infrastructure.

An Equivalent Hydrogen Fuelling Network Would Cost Nearly Two Billion Euros

The installation of a comparable hydrogen fueling station network amounts to nearly 2 billion EUR and is therefore much more cost-intensive.

Another aspect that has not yet been considered in more detail is the head start of BEVs compared to FCEVs. Therefore, the installed charging infrastructure would be used more frequently in the initial stage, which would support the refinancing of further investments in infrastructure development. Contrarily, a limited portfolio of FCEVs is expected for the next years, which causes the necessity to plan a hydrogen infrastructure much more long term.

Cost of necessary infrastructure in 2025 in million EUR



Flick&Partner assessment for the costs of ca. 19,500 H_2 gas stations (100,000 EUR each) or ca. 15,500 electric fast charging stations (25,000 EUR each). These investments would cover the installation costs of the minimum required infrastructure for 2.4 million electric vehicles expected in 2025 in Germany.

The High Investments Necessary for Either Infrastructure Are Hard to Refinance

One of the most important underlying reasons for lower cost of an electric charging infrastructure is the possibility to recharge BEVs in a private environment, as previously mentioned. This means that BEV customers, with their private investments, help to lower the cost for a publicly required charging infrastructure, which has to be paid for by the state of private economy. Contrarily, a hydrogen fueling infrastructure does not offer this chance.

From an economic viewpoint, the operation of hydrogen fuelling stations is more similar to the traditional business model of gas station operators, as, in essence, only the type of fuel is different. Additionally, the high percentage of home-charging for BEVs has a negative impact on the achievable sales of charging station operators. Despite active discussions about new business models and providers, the problem of high investment cost remains. All the more, automotive manufactures and political entities have to promote the development of a fueling and charging infrastructure as the decisive impulse for e-mobility.

Toyota Is on a Seperate Path

Given the expected economic challenges of an installation of a H_2 infrastructure, the communicated strategy of the largest global car manufacturer Toyota seems surprising.

Toyota publicly doubts the performance lifespan and feasibility of lithium-ion batteries for pure BEVs. Instead, Toyota already introduced a fuel cell electric vehicle, the Toyota Mirai, into market and plans to increase production quickly. Such that in a few years FCEVs will be available in larger numbers. Based on Toyota's leading position in fuel cell vehicle development, the strengthening of fuel cell R&D seems logical and purposeful from Toyota, even if the economic conditions for a hydrogen infrastructure installation currently look unfavorable. The hesitant and observant position towards battery electric vehicles on the other hand might be a risk even for an industry heavyweight like Toyota, it could in the medium-term prove to be one-sided. The public testimony towards hydrogen is however in slight contrast to some of Toyota's activities, which hint at BEVs as a possible other future option. For example, Toyota owns a small minority stake in Tesla Motors and also invests further in battery technologies which might succeed lithium-ion batteries.

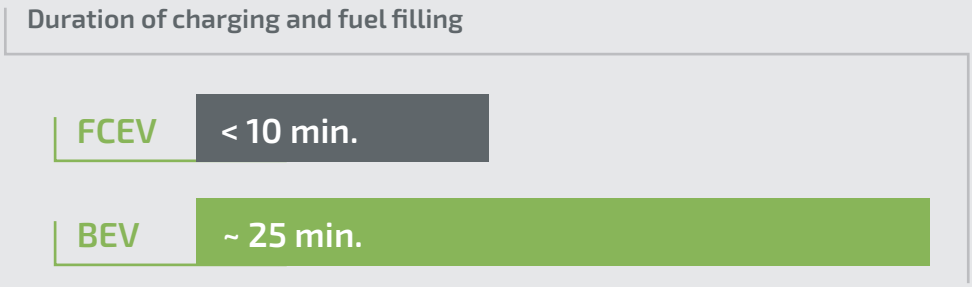
The problem of infrastructure costs involved with FCEV is obviously also known by Toyota. It can be assumed that Toyota will choose countries for its FCEV market entry where a hydrogen fuelling infrastructure is particularly supported by government grants like for example Japan. This approach resembles thereby other automotive OEMs when they introduced either their FCEVs or externally charged vehicles.

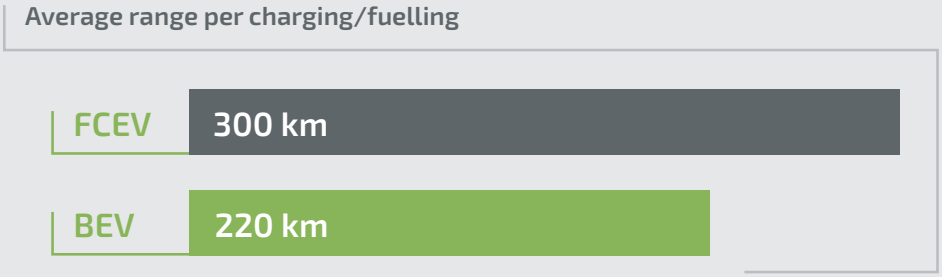
» How Targeted Governmental Subsidies Can Promote E-Mobility

Another decisive criterion which influences the comparison between a hydrogen- and an electric infrastructure is the maximum possible charging or fuelling speed, respectively. The duration of a refueling process at a hydrogen fuel station is comparable to a conventional fueling process today, and hence, does not require major discussion. In contrast, the number of required charging stations and the overall cost for the infrastructure are highly dependent on the maximum possible charging speed.

Fast-Charging Standards Have to Be Forward-Looking

Almost all of today's fast-charging systems are capable of a power of 50 kW at maximum, which translates to a charging time of around 50 minutes for 200 km of additional range. However, the presented analysis of Flick&Partner uses a deviating essential assumption of an available fast-charging technology with similar performance to a Tesla Supercharger (about 120 kW maximum charging power, or about 20 minutes for 200 km of range). This assumption was made with the full awareness that such charging stations are not available on the free market, yet, and neither standardization nor compatible vehicles of other manufacturers exist for such charging power levels at the time. The analysis consciously depicts a technologically ambitious, yet feasible, scenario, in order to outline economic possibilities and technological challenges.





The willingness to finance such a development of infrastructure can certainly exhibit options to influence decision processes and the duration of the latter. Regardless of the existing Combined Charging System (CCS) standard with the combo-plug, every funding of public charging infrastructure should demand the quick and consistent advancement of standardization towards higher charging power levels. The same applies for the respective compatibility of future EVs. Moreover, a faster charging infrastructure would be more cost-effective, as it requires fewer stations. Additionally, faster charging stations, like for example the Tesla Supercharger, are most likely to meet customer expectations.

Public Financing of a Fast-Charging Infrastructure Is Sustainable and Effective

Governmental investments in the installation of charging infrastructure can have a steering influence on the market entrance and, consequently, the portfolio of EV models. Publicly funded charging infrastructure is experienced first-hand by EV customers and paves the way towards a widespread adoption of electric cars. Concurrently, it is a sustainable and long-term oriented instrument of support for e-mobility. Contrarily, other forms of subsidies are only short-term effective or do not decisively influence potential EV buyers. Direct grants for EV customers are particularly cost-intensive, and, therefore, mostly short-term focused.

Direct Purchase Subsidies Display Quick Results, but Usually Offer Only Short-Term Effects

These incentives mostly achieve a quickly measurable success, however, they cannot be considered a sustainable model. Nevertheless, they can enhance the acceptance of EVs in general and create indirect dynamics regarding the installation of infrastructure. If instead of a direct premium for EV sales, the equivalent financial means were used to build a charging station, the money would be invested considerably more long-term oriented and beneficial to society. Still, this approach must take the upgradability and progressiveness of the installed infrastructure into account. One reason, why the installation of charging infrastructure has not been subsidized more intensely yet, may be the small short-term effect. It cannot be expected that the sales of EVs would surge as sudden as it would happen with direct buyer incentives.

Public Support Should Not End at the Highway Exit

Functional public support of charging infrastructure should not only be limited to a public fast-charging network. It should also include legal guidelines for mandatory charging points at new building or garage sites. Private investments in publicly accessible charging station are worth being promoted. Moreover, dedicated public EV parking spots should be established.

In this context, the government should evaluate possible solutions to the, yet unsolved, problem of street parking and the unavailability of charging stations.

Creative approaches and support for new ideas are necessary. Some individual countries, like the Netherlands, outline some interesting solutions already. These include, for instance, local surveys among residents, local EV owners and potential EV buyers, which specifically ask for the best possible locations for new charging stations.

Subsequently, the recommendations and survey results are interactively discussed online, before the installation of a new charging station is decided. Furthermore, there are considerations to limit the access to certain charging points to residents only, depending on the time of day. This model is similar to the limitation of overnight parking to direct residents on certain local streets in Germany.

To Date, the Proposed Support Mechanisms for EVs in Germany Are Rarely Effective

In the opinion of Flick&Partner, other government programs, such as the exemption from toll or vehicle taxes, bus lane access and free parking, as already in effect in other countries and proposed in Germany, are not effective instruments to decisively influence the buying behavior of customers.

Their economic signaling effect is limited and the public percipience is minor. Therefore, it cannot be expected that a sustainable impulse for the demand of EVs will be generated by these instruments.

» China as a Key Factor

In the long run, China will also become a key market for e-mobility. The significance of the Asian region for global automotive sales has continuously been increasing for years and has been acknowledged and strategically eval-uated for conventionally powered vehicles long ago. For electric mobility, this development will proceed equivalently.

Industrial Policy Will Determine the Advancement of E-Mobility in China

Due to the strong influence of the central government in Beijing, political targets have a crucial impact on the success und the speed of the adoption of e-mobility in China. Previous public statements of politicians and some already established government programs prove that Beijing does have serious plans and targets concerning e-mobility. Unlike in most western countries, ecological or energy political aspects do not play major roles in those plans, but specific industrial policy dictates the direction. The plan is to strengthen the local Chinese car industry, and, at best, it is supposed to make up the technological leeway still present in comparison to the Western competition. However, in the field of modern internal combustion engine technology, the Western lead is so considerable, that it is hard to catch up in the short term. Hence, the Chinese automotive OEMs currently compete mainly in the low-margin market for cheap vehicles. Nevertheless, as key expertise for e-mobility, such as battery technology, is not at all the home turf of established Western automotive companies either, the Chinese do necessarily have chances to quickly build up know-how in these new technologies and compete on par. Of course, this opportunity is also recognized by the political leadership in China.

Additionally, the Chinese government can benefit from the secondary advantages that result from the support of e-mobility. On the one hand there is a theoretical chance of reducing the dependency on imported oil, while on the other hand the Chinese public lately experienced and addressed the consequences of extreme air pollution in their megacities. Thus, a governmental support for e-mobility could be promoted as a highly visible positive signal of reaction.

Experts controversially discuss about what the support for e-mobility in China will look like in the next years. Some scenarios forecast that Western OEMS will face particular difficult times. It is considered possible, that, for the protection and promotion of the local Chinese car industry, the support and incentives could be limited to vehicles which were locally developed or produced. Moreover, high import duties could be forced on foreign vehicles. However, based on the example of the German car industry, it can be shown that such scenarios exaggerate the situation and are not likely to occur. The German automotive industry has a long standing presence in the Chinese market and is well established through multiple joint ventures. This significantly reduces the risk to suffer from arbitrary market constrains. Nevertheless, it is still important to stay in close contact with Chinese decision makers in regard to e-mobility, to prevent future unilateral technological specifications. Examples for the latter are the special Chinese charging standard and plugs currently in effect.

Chinese Customers Are Ready for E-Mobility

Generally, Chinese customers have a positive attitude towards e-mobility. However, they usually remain in a hesitant position and oftentimes only official impulses can have a transforming effect on the masses. A good example for this is the big success of cheap electric scooters in China, which have only been widely and rapidly established as soon as the government regulated their use in the cities by law.

A large number of potential Chinese customers has not bought any type of automobile before. These new customers oftentimes have no or limited experience regarding the range of conventional vehicles with a combustion engine. Therefore, they are less likely to consider the limited range of EVs as a constraint.

Insufficient Charging Infrastructure Restricts E-Mobility in China

The still insufficient charging infrastructure and the partially barely capable power grid is a significant problem for electric mobility, also on the Chinese market. Yet, it can be assumed, that the Chinese leadership will find solutions as soon as the industrial policy favors stronger support for local EV companies. Any decision in Beijing on these issues can have broad consequences and generate significant results rapidly. Thus, any advances of the Chinese charging infrastructure development should be closely monitored. Manufacturers of charging equipment should evaluate if a collaboration with Chinese companies, in order to produce with local content – similar to the approaches in the automotive industry – can be an interesting strategic option.

Which Customer Requirements Will Be Decisive for Electric Vehicles?

Looking at the current sales figures of EVs, recent studies and EV-related coverage in the media, it becomes obvious that many potential EV buyers and even EV owners are not satisfied in all aspects by the currently available electric vehicle offers.

Besides the frequently mentioned range-anxiety and the insufficient availability of charging infrastructure, the manufacturers' sales channels as well as the service sector are not yet optimized for the new challenges imposed by EVs.

Are PHEVs the Solution to Range-Anxiety or Rather a Fleeting Star?

The most frequently cited and discussed problem of EVs is the still limited range of most available pure BEVs. Numerous studies show that the average travel distances of an automobile per day is far less than the range of nearly all BEVs currently available. Therefore, seen purely from a scientific perspective, even today the range rarely seems to be a genuine problem. The lion share of daily trips is less than 100 km in distance. The battery capacity of most available BEVs can cover more than this distance without a recharge. Additionally, many households already own a second car, which could be used for the few remaining longer trips. Though, the decisive points are the perception and the emotions of the (potential) customers. From their point of view, the flexibility or loss thereof and the long-range capability are some of the decisive factors for or against the purchase of an EV, as well. In addition, the range quoted by the manufacturers is perceived with a certain mistrust and the range-shortening influence of heating, air-conditioning, and other electric loads is consciously dreaded by many customers.

In combination with the sparse availability of the charging infrastructure, the scenario of stranding with an empty battery seems to be a real threat to many customers. This risk perception is in fact more psychological than rational and differs quite substantially from the actual risk.

Nevertheless, the automotive OEMs must acknowledge that this perception will persist, even with larger battery capacities. Due to the aforementioned advances in battery technology, however, the offered range of most future EVs will not be a problem for most drivers any more. Thus, it will become more of a strategic challenge in regard to communication rather than technical capabilities to offer certain range options in the future.

PHEVs are Perceived as an Innovation as Long as They Are Driven With Electric Support

With the increasing range of BEVs the already ambiguous desirability of PHEVs is decreasing. PHEVs offer very attractive performance and capabilities when looking at the respective sales brochures, but customers experience them as futuristic and advanced mainly in the electrically supported drive mode. Contrarily, their limited performance when driven fully electric is less promising in regard to their success. In consideration of the currently quite limited electric range, the added value of recharging the car is oftentimes unclear to customers. Manufacturers struggle to get out of the economical dilemma caused by fitting two powertrains in the car. PHEVs are thus often considered a necessary addition to the powertrain portfolio of car companies in order to reach fleet emission limits, rather than advanced and lucrative future offerings.

The Increasing Range of BEVs Promotes the Demand for Purely Electric Vehicles

Flick&Partner is convinced that with increasing available electric range the market will shift towards BEVs. Hence, PHEVs will only establish themselves on the market for a short transition period. In the long run, PHEVs look promising only in special niche markets, such as sports cars. The marketing of current or coming generations of PHEVs as 'real' electric vehicles might turn out to be risky long-term and could even hurt the perception of the manufacturer as innovative and forward-looking. Especially Opel with its PHEV Ampera and Audi with its PHEV A3 e-tron, as their only electrified offerings, are yet lacking an innovative BEV. Similarly, the strategy of some other OEMs, to offer their BEV model as barely distinguishable powertrain option of existing models, can hardly be perceived as innovative.

Additionally, many customers do not understand the conscious decision of many manufactures to limit their BEV offerings to small city cars. A large number of customers, who travel mostly short distances, still do not want to renounce the spaciousness or driving characteristics of a bigger car. This is also proven by the unbroken trend towards sports utility vehicles and dynamic or sportive powertrain options. From a customer point of view, the poor efficiency of such models is less important than many other factors. Thus, car manufacturers should intentionally electrify less efficient vehicle classes as well.

» Charging Speed – How Fast is Fast Enough?

A crucial feature, which still lacks proper fulfillment of customer requirements, is the charging speed of an EV. The desired increase in battery capacity and the simultaneous decrease of charging duration represent conflict of technical objectives.

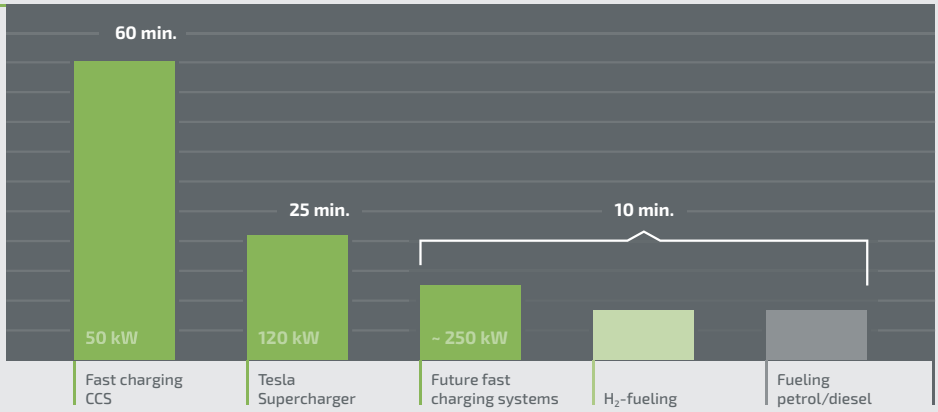
Tesla's Supercharger is Faster than the Competition

Until today, automotive battery research focused mainly on increasing the range of an EV rather than improving charging speed. Currently, Tesla represents an exception to some extent, as the Superchargers are capable of delivering unchallenged short charging times. Yet, even the Tesla Superchargers are not powerful enough to fulfill the expectations of the most critical customers towards a genuinely advanced recharging technology.

The high expectation of some customers, that charging times comparable to the duration of today's gas refueling can be reached, is hard to satisfy. In order to recharge the energy for a range of 250-300 km within about 10-15 minutes, fast-charging systems with a power level of more than 200 kW would be necessary.

Even this might seem technically unfeasible today, it must not be used as an excuse to refrain from moving ahead with R&D in this direction.

Approximate charging and fueling times of different systems for a range of ca. 250 km



The figure about the approximate charging and fueling times of different systems shows that even the fastest charging systems today would have to double their power in order to achieve standing times comparable to those of refueling.

Dissatisfying Coexistence of Different Fast-Charging Standards

Mainly, a standardization has to be achieved that is resilient to future developments and sufficiently visionary. Today's coexistence of different fast-charging standards, which are not even fast enough in the opinion of most customers, is a pathetic sign of incapability of the automotive industry and the politics.

China's proprietary fast-charging standard, of type CN, left aside, globally three different standardized systems for fast-charging currently exist in parallel:

- Fast three-phase AC charging up to 44 kW
- DC charging according to the CHAdeMO standard up to 62.5 kW
- DC charging according to the CCS standard up to 86 kW

None of the standardized systems is globally supported by all manufacturers. However, they mostly agree that fast-charging should be implemented with DC in the future. Only this technology offers the technological option of placing the heavy and expensive charging hardware inside the charging station rather than the vehicle. In practice, the two existing DC fast-charging standards are currently still competing for a clear predominance. It is evident, that this is very deterrent for potential customers, who fear to bid their money on the wrong standard.

In light of this unresolved issue, the proprietary development of Tesla as a newcomer in the sector becomes more understandable and is of great strategic interest.

Inductive Charging will not Become a Mainstream Solution

The clearly articulated customer demand for fast charging puts the often forecasted success of inductive charging into question. Flick&Partner is convinced, that inductive charging will remain more of a niche product and a cost-intensive optional equipment for the luxury car segment. Despite the requirement for expensive hardware inside the car and at the parking spot or in the garage, the actual additional benefit for the customer is small; similar to the inductive charging of mobile phones. The process of plugging in a conventional charging cable only takes a few seconds and the procedure is clean, except for potential dirt on the cable. Therefore, it is questionable, if customers are actually willing to spend a substantial price premium for the small comfort gain offered by inductive charging, particularly if they have to sacrifice charging speed for it. Comparably, the job of a filling station attendant has virtually become extinct over the years (as has the willingness to pay extra for this service). The customer experience at the gas station has been more and more tailored towards cost savings.

» Sales and Distribution Channels for EVs

Aside from the high customer expectations regarding the vehicle itself, today's car buyers expect the highest level of comfort, customer-orientation and interaction opportunities based on modern technology in the entire sales and service environment as well. The automotive OEMs mainly face the challenge of forming future sales channels.

Sales and Service Did Not yet Sufficiently Adapt to the Change Caused by EVs

Until now, it appears that numerous dealers still have to broaden their knowledge in regard to EVs. With the exception of the employees in Tesla's showrooms, many sales employees in the car dealerships are still poorly informed about the offerings and specifications of the EVs in the portfolio of their brand.

If dealers seem uninterested, uninformed and, in some cases, do not even have a real interest in selling electric cars, only few customers will decide to buy an EV from a dealership. The car companies have to take action, and train their sales people even more intensely.

At the same time, the selling EVs must not be an economic disadvantage for the dealers, if there is serious interest in the further promotion of the technology. At the same time, the automotive industry needs to evaluate alternative marketing and sales channels, which is, for example, shown by Tesla and its successful direct sales over the internet. Especially the informational search of potential customers through channels like internet videos, interactive sales apps and alike has to be thoroughly analyzed.

Additional, specifically tailored, trainings are also necessary, because the sales process for an EV is currently significantly more complicated than for a conventional vehicle: most potential customers have little knowledge about EVs and are lacking basic experiences with the respective drive components. Dealers have to attentively explain the usage of an EV to their customers from the start. In order to overcome their customers' inhibitions and debilitate, often unfounded, prejudice, a positive experience needs to be created.

For a broader acceptance of e-mobility, it is decisive that as many potential customers as possible get the chance to test an EV in their everyday life and get to experience advantages first hand.

In Addition, it is the collective responsibility of the automotive manufacturers and the dealers to build trust in the durability and service of EVs.

Potentials for Differentiation and Future Key Competences

Already today, car manufacturers invest considerable resources in communicating how individual vehicles differentiate from the offerings of their competitiors.

This is mainly a consequence of the tendency that modern vehicles in the same segment resemble each other more and more, share similar technical features, and generally offer a very high level of production quality and appealing driving characteristics.

Electric mobility makes it even more difficult for the customers to differentiate between the different offerings. For example, the powertrain dynamics and driving characteristics are much less distinguishable for an EV. The quiet nature of an electric powertrain makes it hard to create a differentiable sound experience. The expertise in developing and manufacturing of internal combustion engines, which is emphasized as a core competency by various car manufacturers, will lose its relevance and advertising power with e-mobility.

Electromobility as a Chance for Differentiation

However, automotive OEMs have the chance to avoid the aforementioned issues in regard to lacking differentiation by developing and communicating novel distinguishing features. Besides the customer requirements as previously discussed, the following factors will become decisive for customers to buy one EV over another in the future:

- Charging speed, availability and compatibility
- Innovative energy billing models
- Connected cars and advanced future technologies
- Sharing economy

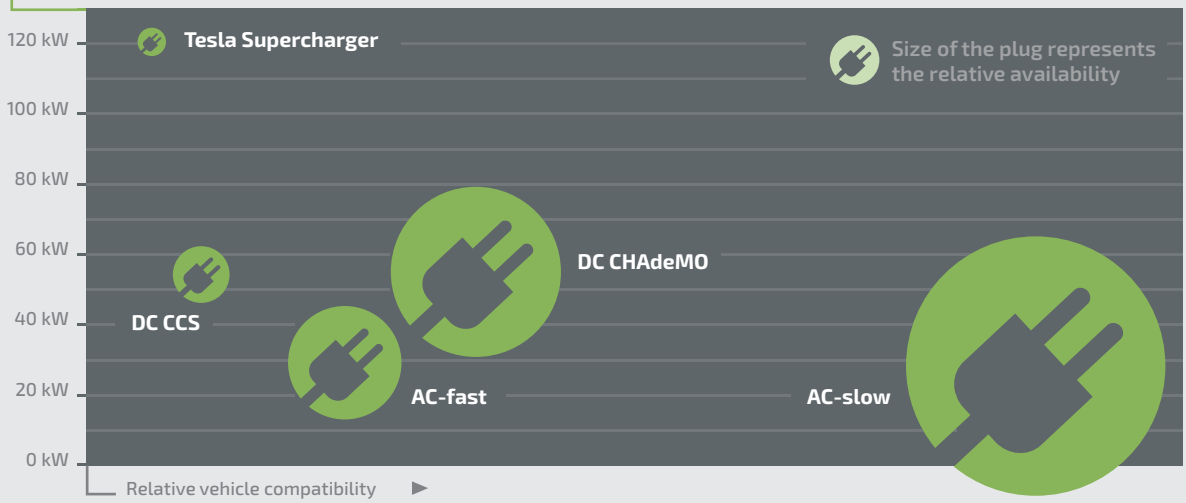
» Charging Speed, Availability and Compatibility

The capability of an EV for fast charging and the availability of corresponding infrastructure are important selling arguments, as they are directly related to the long-range driving capability of the vehicle. An initial differentiating feature is the compatibility of a vehicle with diverse types of existing charging stations. Most of today's EVs do not fulfill this requirement, yet. However, this compatibility will ultimately be taken for granted by customers and will therefore not serve as a differentiating feature in the long term. It is self-evident, that customers will not show any understanding towards competing automotive OEMs, preventing the aforementioned compatibility.

Sparse Availability of Fast-Charging Systems Today

As shown by the diagram on the distribution of different charging systems, the currently existing fast-charging solutions have neither a broad compatibility, nor a large availability, yet. Solely slow AC charging stations are commonly available and compatible to almost all EVs.

Compatibility and availability of charging systems in relation to the power



Up to now, fast-charging systems are particularly sparse. A further problem is the restricted compatibility of EVs, due to the coexistence of competing standards.

» Innovative Energy Billing Models

Besides the availability and compatibility of charging infrastructure, another decisive factor will be the underlying billing of the charged energy. Preference will be given to the manufacturers with the most practical and convenient solutions. Some OEMs already show today how customer retention could be improved though innovative energy billing models.

All-Inclusive Energy Offerings are an Interesting Alternative

These offerings provide the customers to charge their EV "for free", as the energy cost is already included in the price of the vehicle or charging station, respectively. Further developments of such models could include the charging at the customers' home without the occurrence of a directly billable cost in the classical sense. If combined with renewable energy offerings, these business models are well suited for a communication strategy emphasizing the ecological and economical sustainability of the electric driving experience. In a similar fashion, a package containing service plans or warranty contracts could influence the buying behavior of potential customers.

Current inclusive charging offerings of individual OEMs

» BMW

BMW has just announced to offer a fast-charging station called „i DC Fast Charging Unit" in the US, which will enable buyers of the BMW i3 to charge for free until the end of 2015.

» Renault-Nissan

The French-Japanese company cooperates with various charging station operators to provide Nissan Leaf customers in the US with two years of free public charging, within the scope of its "No Charge To Charge" program.

» Tesla Motors

Public and semi-public fast-charging infrastructure is independently installed by Tesla in the US, Europe and Asia. The so-called Superchargers offer unlimited free charging of Tesla's top-of-the-line Model S.

» Connected Cars and Advanced Future Technologies

In the minds of many customers, e-mobility as an innovation is closely linked to modern technologies from other sectors. For automotive companies, this means that even more resources have to be assigned to the integration of their vehicles into the various existing digital ecosystems. Compatibility with smart personal devices, cloud services and digital offerings from different providers is seen as a matter of course by customers and expected already today.

The Trend Towards Connected Cars

Therefore, the collaboration with telecommunication, IT and technology companies has to be extended and intensified, such that the internet will become a natural part of the driving experience; unlike today, where access is mostly limited to the luxury segment. Aside from compatibility, the ease of use of the vehicles' user interface will be a major differentiation potential. One large part of advanced future technologies are modern automotive electronic systems, such as safety and driver assistance systems. Customers of EVs, who are by trend a more up-to-date, progressive and of younger age group of buyers, compared to luxury car customers, are especially interested in these technologies. Therefore, it is beneficial for OEMs to use EVs as first target vehicles when releasing new high-tech related features to the market.

German Car Manufacturers Have to Leverage Their Head Start in Driver Assistance Systems

The German car industry is a leader in the areas of safety and driving assistance systems. This lead must be fostered and communicated more clearly with regard to e-mobility. The technological advantage should also be used to counteract newcomers like Tesla in a customer-effective way by first-to-market introduction of innovations. The driver assistance features Tesla is currently offering are, for example, lagging behind those of other premium OEMs and can hardly compete with the advanced configurations of German OEMs. Even though Tesla has announced to bring autonomous driving to market by 2020, its current vehicles are lacking automatized features like assistance for parking, lane keeping, road work, congestion or highway driving. Only very recently, Tesla presented some of these modern technologies, which are presently available from competitors, in its new Model D, the all-wheel-drive version of the Model S.

» Sharing Economy

In more and more areas of life, smartphones and location services facilitate the collective usage of goods and sharing of belongings. This trend towards a so-called "sharing economy" has already been recognized by automotive companies like Daimler and BMW; their respective car sharing services experience steady growth.

Car Sharing and its Direct Link to Electromobility

In the cases where EVs are already part of car sharing fleets, they are well reived by customers, as shown by their positive feedback. Car sharing services are mainly offered in urban areas, which are well suited field of application for EVs, given that adequate charging infrastructure exists. However, cust-omer requirements for car sharing vehicles differ from those for a private car, such that, with rising popularity these services, the special requirements should already be taken into account in the development process of new cars. This can pave the way for cost-effective sharing versions of certain models, which in reverse boost attractiveness and thus collaterally increases the profitability of such services for the providers.

In the Future, the Sharing Economy will Include the Entire EV Environment

In the future, it is likely that access to charging infrastructure will be shared and made available to the public as well. The automotive industry has to be aware of this trend and needs to develop sharing concepts and collectively usable charging hardware accordingly.

From a Car Manufacturer to a Mobility Provider

Some automotive OEMs have already recognized the aforementioned developments and are consequently extending their competencies towards becoming holistic mobility service providers. Examples, apart from car sharing services, are the investments in mobility platforms, such as Moovel. At the same time, it is presently still a major challenge to implement profitable business models in these areas. Therefore, the necessary investments are controversially discussed in many companies. However, the positive resonance, the indisputable value added for customers, as well as the high visibility to the media and the public show how important these new long-term oriented activities are, in addition to the core business.

Executive Summary

E-mobility is on the verge of an international breakthrough with only few things standing in its way. The problem regarding the range of BEVs is, already today, more founded in the risk perception than in the probability to actually being immobilized due to an empty battery. Advances in battery cells development will facilitate continuously increasing ranges at lower cost. Nevertheless, the existing concerns of many potential customers have to be taken seriously and the communication strategies of the OEMs have to be tailored accordingly.

Manufacturers and suppliers of the automotive industry have to act now in order to secure their long-term competitive advantages. For achieving this objective, significant efforts in key areas are indispensable.

Master the Customer Experience of Fast-Charging Technology

From a technological perspective, it is crucial to meet the customers' need for short charging duration. It has to be critically reviewed to what extent the present CCS-standard fulfills customer requirements and technological alternatives have to be evaluated strategically.

Advancement of Sales & Services for Electric Vehicles

On a short-term basis it is of foremost importance to better prepare commerce and sales channels for e-mobility. Especially in the early stage of e-mobility, the marketing and communication strategy is crucial for OEMs in order to not lose ground in the long term.

Strengthening the Symbiosis of Automotive and Information Technology

The inextricable ties of e-mobility and advanced technologies, as perceived by customers, have to be accentuated even more by automotive manufacturers. The corresponding collaborations with technology companies have to be intensified. New business models and fields of application, such as the sharing economy, represent major challenges.

Critical Strategic Evaluation of a Limited Focus on PHEVs

There is considerable evidence that customers tend to perceive PHEVs as an interim technology rather than associating them with the same technological pioneering spirit as BEVs. Accordingly, the roll-out of BEVs across all vehicle segments has to be evaluated strategically and a limited focus on PHEVs has to be revised.

Monitoring the Development of FCEV Technology and Evaluate Strategic Capabilities

The juxtaposition of Flick&Partner shows that a sufficient infrastructure for H_2 vehicles is significantly more expensive than comparable electric charging infrastructure. Furthermore, the increasing range of battery electric vehicles and the expected cost reductions of the battery cells make a broad breakthrough of fuel cell technology seem unlikely on the passenger car market. Nevertheless, advances in the field of hydrogen fuel cell vehicles must be pursued and monitored.

Extension of Battery Development by Including Fast-Charging Requirements

In battery development, the focus needs to increasingly be placed on fast-charging capabilities. Future charging technologies must not be limited by technological limitations of the available batteries. Developments in cell technology have to be closely monitored by the automotive OEMs and collaborations in this field have to be intensified.

Assessment and Development of New Sales Potentials

Alternative distribution and information channels have to be evaluated and implemented accordingly. Amongst others, this includes differentiation possibilities, such as new pricing models and “free” charging of EVs.

Assessment of the Market Potential for Inductive Charging Technology

In view of the demand for increased charging speed, a wide market penetration of inductive charging technology is unlikely. The customer benefit is just too small compared to the high costs.

From a governmental perspective, the support for e-mobility has to be expedited in a more targeted manner. Especially automotive precursors like Germany and the US should have a strong interest in advancing e-mobility and take a leading position in the international competition. According to the forecast of Flick&Partner, the goal of 1 million electric vehicles on Germany's roads in 2020, as set by the German federal government, will be missed. However, it is not as unattainable as outlined by many critics.

» Setup of Public Fast-Charging Infrastructure

The main focus of public funding has to be placed first and foremost on the sustainable installation of a comprehensive public charging infrastructure. This should include joint efforts and initiatives in collaboration with the automotive industry. It should also be of major public concern to mediate the controversial debate about which fast-charging technology is the most promising. The government has to propose solutions that are in line with the common interest.

» Support of Non-Public Investments in Charging Infrastructure

Beyond the support of fast-charging infrastructure, governments have to tackle administrative barriers and bureaucratic hurdles. They have to pave the way for semi-public and private investments in order to expedite the development of a comprehensive charging infrastructure.

» Intensify and Expand Public Support for Competence Centres on Key Topics of Electromobility

Systematical and targeted investments in research and development are necessary to guarantee the competitiveness of the automotive industry. Governmental support and the ramp up of competence centers are especially crucial in key topics like the battery cell production.

The automotive industry can only master these manifold challenges, if the appropriate interdisciplinary competencies can be developed internally or are selectively brought in from the outside. Fresh and innovative thinking has to be combined with proven automotive technology expertise. The industry needs to be aware that its changing conditions result in a new competitive landscape. Automotive companies now have to compete against new opponents in the war for talent, such as popular high-tech software and hardware giants along with aspiring start-up firms. Consequently, clever and versatile positioning is essential.

List of Abbreviations

AC	Alternating Current
BEV	Battery Electric Vehicle
CCS	Combined Charging System
DC	Direct Current
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
OEM	Original Equipment Manufacturer
PHEV	Plugin-Hybrid-Electric Vehicle
SUV	Sports Utility Vehicle

Sources and Methodology

Flick&Partner publications use a broad variety of sources and information. The work of our industry analysts is based on primary research through interviews with experienced industry leaders including executives, engineers and marketing professionals as well as on in-depth analysis of secondary sources and our own research results. The primary and secondary research sources are expanded by the broad expertise of our industry specialists.

The combination of this information yields the quantitative and qualitative results as presented in the Flick&Partner publications. Special attention is paid to provide comprehensively fact-based analyses as far as possible. In cases where insufficient data is available and assumptions are made, Flick&Partner analysts are prepared to explain their assumptions and methodology in detail, be it in publications or in the direct discussion with our clients.

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As a dynamic and independent consulting company, Flick&Partner is best placed to provide innovative, unbiased and promising solution approaches as an intellectual sparring partner unaffected by entrenched structures and customary patterns of thought.

Through continious market observation and in-depth analysis, Flick&Partner constantly provides up-to-date know-how and expertise to our customers. We would gladly discuss these topics in further detail with you in a direct dialogue. Please contact our authors directly.

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