

Charging Infrastructure for Electric Vehicles in Germany

Progress Report and Recommendations 2015

**Working Group 3 – Charging Infrastructure
and Power Grid Integration**





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1 Executive Summary

In this 2015 progress report, working group 3 of the German National Platform for Electric Mobility (NPE) reports on the current status of Germany's publicly accessible charging infrastructure. It provides an outlook for planned and necessary investment in the ongoing expansion of the charging infrastructure up to 2017 and 2020 and estimates the scope for lowering costs up to 2020. It also sets out the most important political measures that the NPE will need to pursue in order to kick off further expansion in the charging infrastructure. Consequently, this publication aims to address all NPE members and investors in charging infrastructure as well as additional players at national, state (regional) and local level who are responsible for the charging infrastructure.

To achieve a successful market ramp-up in Germany, politicians, vehicle manufacturers and potential operators of, and investors in, charging infrastructure must make it a priority to boost the appeal of electric mobility. The existing approaches for charging infrastructure are heterogeneous by nature and the number of charging points no longer adequate for an accelerated ramp-up in vehicle numbers. More also has to be done to make charging infrastructure easier to use, simplify payment and improve accessibility for the general public.

From the customer's point of view, it is less important whether an electric vehicle uses an AC or DC charging station. How long it takes to charge and how easy it is to charge are more important than the type of technology used. There are various usage scenarios – long and short charging periods at home, at work or at the journey's destination and fast charging while undertaking longer journeys. It is important that vehicle manufacturers provide customers and charging infrastructure operators with accurate and detailed information on how the vehicles in question and future vehicles can be charged.

The status of fast charging

The fast charging infrastructure is being expanded primarily under the auspices of **funding programmes** at EU, national and state levels. The planned expansion comes under the **NPE planning corridor** ("Pro" scenario). This will help to significantly mitigate the perceived undersupply and anxieties about range. In the period from **2017 to 2020**, approximately **5,700 additional fast charging points will be needed** and both the industry and the public sector will have to **initiate** new projects in good time.

The establishment of approx. 1,400 DC fast charging points is planned up to 2017.

The NPE recommends a staggered approach to developing a nationwide fast charging network that takes into account "German Standardisation Roadmap Electric Mobility – Version 3.0".

Stage 1 (approximately 1,400 charging points projected) – up to 2017:

- Preparing the grid supply capacity to several times ≥ 150 kW at central intersection points and important transport links
- Building some 1,000 charging points with a charging capacity of 50 kW on main traffic arteries
- Plus, building some 400 charging points, mostly with a 50 kW charging capacity, in major cities

Stage 2 – from 2017:

- Increasing the number of DC charging points towards the 7,100 DC fast charging points that are required by 2020
- Simultaneously increasing the output of individual charging points at traffic intersection points and important transport links to ≥ 150 kW
- Installing 150 kW charging stations at several hundred locations on motorway arteries and a correspondingly high grid supply capacity for simultaneous fast charging at several charging points, each with a 150 kW charging capacity.
- Increasing the density of the fast charging network at important transport links and in major cities with 150 kW and 50 kW charging points in preparation for Stage 3 (also beyond 2020).

Stage 3 – from 2020:

- By 2025, it is anticipated there will have been a significant improvement in battery performance and thus in the range that electric vehicles can cover. This will require higher charging capacity.
- Depending on the availability of vehicles with the corresponding battery technologies, individual charging points on main traffic arteries will prospectively be configured with a charging capacity of up to 350 kW – with a corresponding improvement in grid connection/expansion.
- In terms of power generated from renewables, legislation stipulates an increase to a share of 40 to 45 percent by 2025.

The status of normal charging

There are currently some 5,600 publicly accessible normal charging points in Germany – usually Type 2 AC units. Expansion has largely stagnated since 2014.

User groups including commuters and owners of two vehicles have options for setting up charging points at home and/or at work. With regard to workplace-based charging solutions, it is essential to resolve legal uncertainties due to differing user groups and payment rules, which are inhibiting further growth. Furthermore, a considerable proportion of today's electric vehicles belong to company fleets that are almost exclusively charged on company premises, which means these vehicles do not usually suffer from a shortage of potential charging points. However, in areas where there is considerable pressure on parking (this user group includes “free-floating” carsharing fleets and on-street parkers), there is at present only a small number of instances where the normal charging infrastructure is adequate, meaning that a further increase in vehicle numbers would create pressure for action.

The three biggest cities in Germany – Berlin, Hamburg and Munich – have recognised this and are setting aside a good 14 million euros to continue expanding the publicly accessible charging infrastructure. The state of Baden-Württemberg is safeguarding the existing public infrastructure with funding up to mid-2018.

Action plan with recommendations for expanding the customer-friendly charging infrastructure in line with demand:**1. Demand-based direct funding for normal charging (including through a “10,000 charging station programme”)**

- Operating publicly accessible charging stations is usually a loss-making affair.

- The aim is to stabilise the expansion of the public AC charging infrastructure, primarily for drivers who do not have a permanent parking place of their own and for carsharing fleets in inner cities.
- To keep the need for financing as low as possible, it would be prudent to increase the number of charging stations by an additional 10,000 AC stations.

2. Building regulations and tenancy law

- Change residential property law for the installation of private charging points so that the supply of EV (electric vehicle) power counts towards the safeguarding of power supplies and the assumption of costs is regulated.
- Amend the parking place provisions in regional planning regulations to include obligations for setting up charging infrastructure or cabling in new-build and renovation projects.
- Check the legal framework for the obligatory construction of charging infrastructure in car parks and parking garages that are owned by the federal state. These include car parks for public buildings, motorway service stations, railway stations, airports and housing complexes.
- Make it a requirement for private car park operators to install charging points in a minimum number of their publicly accessible car parks. In this case, the needs-based construction of publicly accessible charging infrastructure could, for example, be financed by linking up with parking management.
- Modify the Land Use Act and trade law regulations so that the operation of charging points and the supply of electricity are, to a certain degree, exceptions not defined as commercial activities, e.g. by using minimal thresholds or exemptions.
- Give tenants opportunities under tenancy law vis-a-vis their landlords to carry out structural alterations such as installing private charging points.

3. Tax law

- Modify income tax law so that the cost of electricity for charging company cars at home can be calculated and reimbursed on a lump sum basis.
- Modify income tax law so that when employers make available charging infrastructure for a company car it is classed as tax-free income and not a non-cash benefit.

4. Energy law and calibration regulations

- Insert a legal definition for charging points into energy law, which clarifies that a charging point is not part of the power grid and that the operator of a charging point is not obligated to transmit electricity on a non-discriminatory basis.
- Modify the regulations governing measurement and calibration to the effect that the associated requirements for alternating current and direct current charging points are unambiguous.

5. Central roll-out planning for the DC fast charging infrastructure in Germany

- Coordinated, needs-based expansion of the public DC fast charging infrastructure should be implemented on a national and regional level by 2020. The needs-based expansion of the public DC fast charging infrastructure is to be managed and actively supported with appropriate measures under the auspices of the EU directive on the deployment of alternative fuels infrastructure (AFI Directive).

2

What is the
current status?

Current status of
Germany's charging
infrastructure

The majority of vehicle users have so far been charging their vehicle at home or at their company premises. This is because it is convenient to charge your vehicle in your garage or parking space overnight or at the workplace during working hours and because the vehicle can stay connected there for several hours when not in use. Additionally, however, there are some user groups that require a publicly accessible charging infrastructure.

In mid-2015, the approximately 37,600 electric vehicles that are relevant to the charging infrastructure were being served by a total of just under 5,600 charging points at 2,500 publicly accessible charging stations and more than 100 publicly accessible fast charging stations with Combo 2 connectors. The growth rate for vehicles has outstripped that for the charging points. If the number of vehicles increases to more than 50,000 by the end of 2015, without further expansion, there will be a ratio of one publicly accessible charging point for every ten electric vehicles.

Ongoing expansion in the publicly accessible normal charging infrastructure has been slowing since 2012 due to poor cost-efficiency caused by low utilisation levels. The establishment of the DC fast charging infrastructure is currently much more dynamic (see Section 3). The vehicle ramp-up is altogether much stronger than the continued development of the publicly accessible charging infrastructure, which is stagnating at present.

Number in units

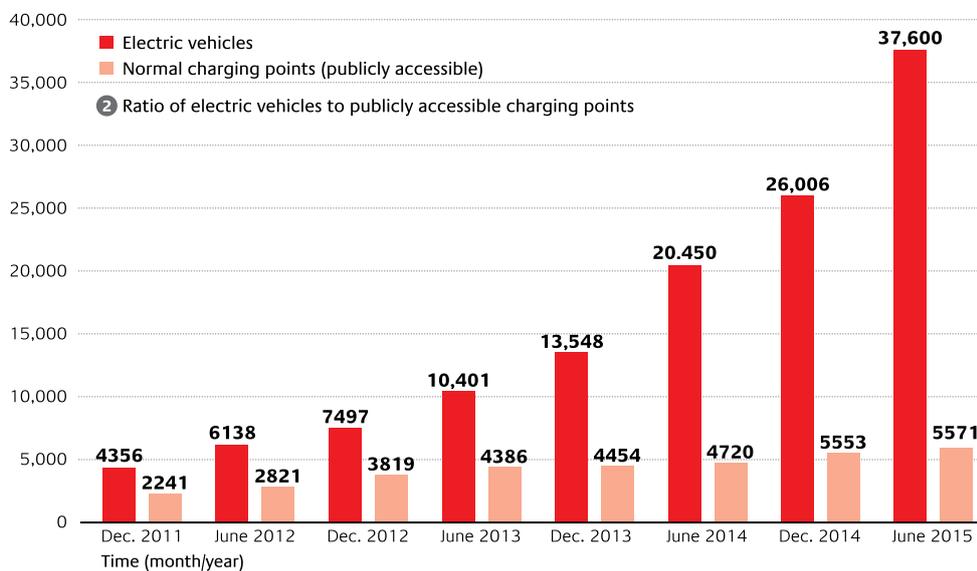


Figure 1: Comparison of the market ramp-up of vehicles and the publicly accessible normal charging infrastructure

The ratio of electric vehicles to publicly accessible charging points continues to rise



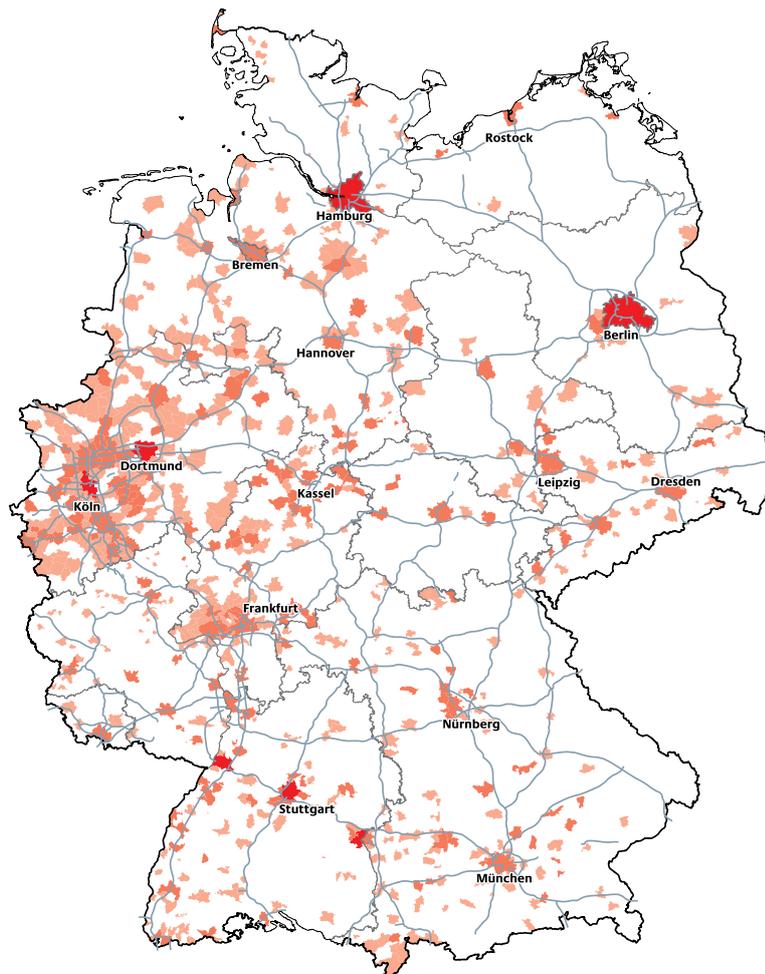
Source: German Federal Motor Transport Authority (KBA) / VDA for registration data, BDEW for charging points

In a comparison of the various states in Germany, the 1,321 publicly accessible charging points in North Rhine-Westphalia put that state in first place, ahead of Baden-Württemberg (1,115). Amongst Germany's cities, Stuttgart (384), Berlin (247) and Hamburg (236) have the most publicly accessible charging points.

The most dense concentration per square kilometre can be found in the city states of Berlin, Hamburg and Bremen. Stuttgart boasts the most dense concentration per inhabitant. Working group 3 is continuing to monitor the needs-based distribution of charging points across the country.

The following illustration shows the density and geographical distribution of charging points. Charging infrastructure is present primarily in urban areas and regions benefiting from subsidies on electric mobility.

Figure 2:
Distribution of
the publicly
accessible
charging
infrastructure
in Germany



Source: BDEW (June 2015)

On the one hand, there is a need for reliable **statistics** about charging points in Germany, on the other hand, customers want real-time data in their vehicles about where they can charge their vehicles and need very detailed location data. That includes information about attractions and accommodation options close to the charging point and about its status and availability.

- Every six months, the German Association of Energy and Water Industries (BDEW) surveys and publishes the growth and the size of the publicly accessible charging infrastructure in Germany. All aspects of customer-friendly charging are queried (location data, opening times, methods of authentication and payment, charging capacities and connector types).
- The surveyed charging infrastructure is used as a basis for evaluating the publicly funded hardware in the current funding projects that are part of the “showcase” (Schaufenster) and “model region” (Modellregion) programmes. This evaluation is carried out by the Central Data Monitoring unit (ZDM) on behalf of the Federal Government.
- An element of the charging station act involves creating a registration office that the NPE believes should be organised so that it is as cost-efficient and unbureaucratic as possible.
- Through their portals and portfolios, charging infrastructure operators and electric mobility service providers also offer reliable information regarding accessibility, opening times, charging connections and the availability and/or status of charging stations. These can often be accessed on a cross-supplier and user-friendly basis via (mobile) websites, apps and customer cards, including through underlying roaming platforms. What’s more, roaming platforms also provide this information on a cross-supplier basis.

Suppliers are also working to improve their customer focus, e.g. by adopting a standardised approach to transmitting information about the relevant charging points. Besides apps from vehicle manufacturers, charging station operators and mobility suppliers such as service station card operators and mobility start-ups, there is also a wide range of private websites and smartphone apps that show the fastest route to the nearest charging point. Most of these websites also offer an overview of the access options, opening times and charging connectors of the relevant charging point. Here is a selection:

www.lemnet.org/de

www.plugsurfing.com

www.goingelectric.de/stromtankstellen/routenplaner

www.plugfinder.de

Reliable information about locations and availability within the charging infrastructure

3

What are the costs
of current charging
solutions?

Cost analysis and
financing

The NPE has set itself the task of also monitoring the costs of the publicly accessible charging infrastructure as the technology continues to develop. This will provide a sound basis for debate surrounding planning for further expansion.

The required leap in development can only be achieved if users appreciate that electricity from the charging stations is more expensive than their domestic electricity supply. Fast charging in particular is a higher-end service than simply selling electricity, as it is tied up with additional infrastructure costs. Customers expect their car to charge as quickly as possible, so the battery is charged with a high charging capacity to meet this customer requirement. Charging takes place regardless of the battery's charge level and whether or not the price of electricity is low. As a result, fast charging is a premium service geared toward customer benefits. The pricing for fast charging is not just based on the energy, it also has to factor in the high initial investment required for charging stations, installation costs and grid transmission capacity increasing.

Cost analysis for fast charging

As the projects for establishing the publicly accessible fast charging infrastructure up to 2017 have a limited timescale, it is conceivable there will be a gap in development from 2017 to 2020. Some 1,400 DC fast charging stations can be assumed for 2017 and the NPE estimates that 7,100 DC fast charging points will be required in 2020. Early efforts should be made to establish the extent to which a publicly accessible fast charging infrastructure can be established without public subsidies.

What will this additional expansion cost?

In an optimistic scenario developed by the NPE (the "Pro" scenario), approximately 5,700 additional publicly accessible DC fast charging stations will be required between 2017 and 2020 with an investment volume of around 140 million euros (based on 24,000 euros per station, see Table 1 for hardware costs).

Refinancing fast charging

Operating a fast charging station in 2020 will be a viable business model based on the following assumptions:

- Economies of scale regarding hardware for charging stations and running costs (see Table 1).
- An average of 10 charging processes per day, per charging station.
- Willingness on the part of users to pay a surcharge of around 1.5–2 euros for each charge on top of the simple power costs and/or to accept a time-based and charging technology-dependent pricing model.
- This would make it possible to get a full charge (to 80 percent) for less than 8 euros (at a charge of 20 kWh).

Complementary business in terms of retail and parking services are not taken into account here, but these business models are being analysed further in WG 3.

Table 1: Estimate of the net costs associated with the publicly accessible charging infrastructure for 2020

Charging technology	Smart charging box		Charging station		Charging station	
Voltage type	AC		AC		DC	
Smart meter and energy management	Included		Included		Included	
Charging point	1		2		1	
Charging capacity (kW)	> 3.7		11 or 22		50	
	2015	Forecast 2020	2015	Forecast 2020	2015	Forecast 2020
Complete hardware, incl. communication and smart meter	€1,200 ¹	€700	€5,000	€2,500	€25,000	€15,000
Grid connection costs	€0–2,000	€0–2,000	€2,000	€2,000	€5,000 ²	€5,000
Authorisation/planning/location search	€500	€500	€1,000	€1,000	€1,500	€1,500
Installation/building costs/signage	€500	€500	€2,000	€2,000	€3,500	€3,500
Total investment (CAPEX)	€2,200	€1,700	€10,000	€7,500	€35,000³	€24,000
Special usage	Example – call for bids in Berlin: €180					
Hotline, maintenance, disposal costs	Standard market maintenance contracts/experience from charging station operation					
Communication costs	Standard market mobile telephony contracts/experience from charging station operation					
Contract management/billing	Assumption: ½ to 1 member of staff					
IT system	Based on internal outlay and/or market tender					
Running costs (€/a) OPEX	€1,000	€500	€1,500	€750	€3,000	€1,500

¹ Not including communication/energy management/billing option starting from approx. €500

² Initial cost estimates for grid connection for 3 x 150 kW and accordingly 630 kVA including investment in a transformer station amount to €150,000

³ Current funding projects have shown that the set-up costs for DC charging stations are between €20,000 and €30,000, depending on the location. However, in individual cases, the set-up costs can also be significantly higher.

The perspective for fast charging

In the case of future charging processes, particularly with higher ranges of the vehicles, customers will want to be able to charge their cars faster. According to the publication “German Standardisation Roadmap Electric Mobility – Version 3.0” this is possible with charging capacities of 150 kW and over. This brings added convenience and higher investment costs. Funding will also be necessary for a transition phase in this regard, as only very few electric vehicles will be compatible with fast charging connectors at the start of the investment process and it will therefore not be possible to achieve an economically viable level of capacity utilisation.

Refinancing normal charging

In 2020, running a publicly accessible AC charging station with 2 charging points will be a viable business model based on the following assumptions:

- Investment and operating costs (not including the costs for vehicle power consumption at the station) can be reduced by 50–75 percent compared to today's level of around 8–15 euros per day.
- An average of at least 4 charging processes per day, per charging station (at most charging stations in Berlin and Hamburg there are currently fewer than 0.5 charging processes per day, per charging point).
- Users are prepared to pay at least one euro per use on top of the power costs incurred by charging the battery.

As in the case of fast charging, complementary business in terms of retail and parking services are not taken into account here, but are being analysed further in WG 3. Overall, it will be possible to push forward sustainable development in the publicly accessible normal charging infrastructure for the ongoing market ramp-up if there are further developments in terms of supply (costs), demand (locations, business models) and financing. Simple, low-maintenance and reliable solutions will also be required in order to reduce operating costs.

It should be noted that there are concepts that could considerably reduce the costs for establishing and running charging points compared to conventional charging stations: These include concepts that involve fitting an intelligent charging point to a streetlight or integrating a mobile energy meter with authorisation technology into an intelligent charging cable, so that a simple system socket integrated into a wall or streetlight can be used as a charging point. However, in the latter case – as in the case of all charging stations – the downstream implementation costs for the grid operator must be taken into consideration. When considering new concepts such as these, it is also important to examine in greater detail the factors of interoperability and barrier-free/non-discriminatory access, so as to meet the requirements for customer-friendly charging (at charging stations) as published by the NPE.

Creating an intelligent link between electric vehicles and the power grid will also tap into the additional commercial and social potential offered by nationwide expansion in the charging infrastructure. The opportunities for controlled/bidirectional charging are already anchored in the current charging standard as per the EU Directive, and functionality is being validated in funding projects. As a result, the basic technical prerequisites are in place for actual implementation in vehicles and the charging infrastructure. The effects and the achievable benefits from flexible integration into the power grid are still to be evaluated. The NPE is formulating recommendations for creating appropriate conditions for activating the as-yet untapped potential offered by an intelligent charging infrastructure and the power grid integration of electric vehicles.

**Potential
commercial
opportunities
from connecting
to a smart grid**

4

What are the
requirements for
charging?

Customer wishes and
the industry's view

The aim is put in place adequate, reliable and convenient charging facilities that electric vehicles can use on an everyday basis as appropriate to their mileage and travel radius. Consequently, the further development of the charging infrastructure should be needs-based, along the lines of the following illustration.

Distribution of charging processes	Private location 85%			Publicly accessible location 15%		
Typical locations for charging infrastructure	 Single/double garage or parking place at home	 Parking spaces or parking garage for residential sites, multiple occupancy dwellings, apartment buildings	 Company car parks/fleet car parks on premises	 Motorway service stations	 Shopping centres, multi-story car parks, customer parking spaces	 Kerbside/public parking spaces

Figure 3: Overview of location types of charging infrastructure

The following is based on customer experience from the “electric mobility showcase” (Schaufenster Elektromobilität) and “electric mobility model regions” (Modellregionen Elektromobilität) programmes:

I. Regular charging/overnight charging (private and publicly accessible charging)

Electric vehicles are predominantly charged at locations where vehicles can be left for long periods, such as parking spaces at home or at work. While installing charging points on private property does not present any obstacles – other than in terms of residential property law – it can be more difficult to provide charging points for e-carsharing fleets and electric vehicle users who do not have a parking space of their own and need to park their car in public areas. What’s more, users are unable to charge their vehicles in multiple occupancy dwellings or at the workplace unless a solution is in place for billing.

II. Fast charging (publicly accessible charging):

Thanks to the fast charging infrastructure, e-vehicles can cover distances outside their current range (150–200 km) without losing a lot of time. On the one hand, fast charging acts as a basic network for all journeys above the daily routine (i.e. commuting to and from work). Indeed, the need for mobility goes beyond everyday journeys to include “optional mobility benefits” (e.g. the option of heading out on a spontaneous family trip at the weekend). On the other hand, fast charging also acts as an emergency charging network, in case drivers suddenly and unexpectedly find they need to charge their vehicle.

Fast charging will also support long-distance electric mobility in the future. As electric vehicles with long ranges (>250 km) become more prevalent from around 2018 and high-performance charging stations are established, the use of the fast charging infrastructure will become more relevant for medium and long-distance journeys.

III. Interim charging (publicly accessible charging):

In addition to parking times at home and at work, the driving profiles of users also

include charging-relevant stopping times at temporary locations, such as when shopping, visiting public institutions or undertaking leisure activities. Interim charging complements a widespread fast charging network based at central locations.

Field studies from the showcase and model regions also show that the range of series electric cars is entirely adequate for nine out of ten planned journeys.

Potential locations for normal charging stations

- Single-family homes can be fitted with charging points very easily. However, around two thirds of the population in Germany lives in multiple occupancy dwellings. Some residents have their own parking spaces, some residents rent specific spaces in the locality and others have to use on-street parking.
- In theory, there is huge potential for charging in multi-storey car parks and publicly accessible parking spaces. Besides commercially run parking in multi-storey car parks and open-air car parks there is an even higher number of parking spaces on public streets and traffic routes and on private property. Some of these parking spaces can be converted to permanent spaces for on-street parkers, while others could be offered to customers for charging. In addition, particularly in inner cities, there is a large number of freely available parking spaces or parking spaces for resident permit holders that could also be electrified.
- Installing charging stations in customer parking spaces is a highly promising option for businesses. According to studies, consumers are very willing to organise their shopping or similar activities according to whether they can charge their electric vehicles for free.
- In order to support new mobile offerings, it will be particularly important to have charging stations at intermodal transition points. For example, charging options at locations such as airports, train stations, bus terminals and P&R car parks are appealing to customers.

eRoaming

Since the publication of the 2014 progress report, the topic of eRoaming has become extremely dynamic. eRoaming platforms enable users to charge their vehicles at charging points run by different operators – similar to the way third-party network operators are used in telecommunications. For example, it offers electric vehicle users cross-operators billing processes, whether via a smartphone app, by card, or potentially through vehicle-based identification (see IEC /ISO15118). In Germany and Europe, there are various suppliers of roaming platforms such as these that are in competition with each other. Interoperable platforms make barrier-free electric mobility possible. Electric vehicle users could easily charge and pay at any charging station anywhere in Europe. The first step in achieving this is the pan-European eRoaming initiative, which was launched in March 2015 by various roaming platforms such as e-clearing.net, GIREVE, MOBI.E, Enel and Hubject. Start-ups and app services are also contributing to this development.

Due to the large number of market participants in the relevant roaming platforms, this “interroaming” is being implemented in several stages. The market partners are in unanimous agreement about the long-term goal. The first stage will be to introduce the sharing of point-of-interest data, then another important step will be authentication, which is already being prepared. Drivers of electric vehicles will find that the process of charging will become increasingly straightforward and more standardised and long-distance mobility will become an increasingly achievable reality.

Simple access to and use of the charging infrastructure

All publicly accessible charging points should be available for ad-hoc use by customers. Thanks to the interoperability of charging points as a result of eRoaming services, it should easily be possible to offer customers reliable, convenient and inter-regional charging with market solutions that are already available.

The following NPE recommendations are designed to ensure easy access and ease of use of the publicly accessible charging infrastructure:

- From 2016, all new publicly accessible charging points (and or mobile charging points) should be fitted with remote capabilities. Among other things, this is essential so that the charging infrastructure can be easily located and for the transmission of status reports from charging stations.
- From 2016, operators should support access (authentication) to publicly accessible charging points (and/or mobile charging points) using smartphone apps and/or RFID cards. When it comes to RFID solutions in particular, it would be constructive to harmonise cross-supplier usage within Germany as quickly as possible.
- The recommendations for “remote capability” and “authentication” should be factored into all national and regional (funding) programmes with immediate effect.

To implement the EU directive on the deployment of alternative fuels infrastructure, all (newly built) publicly accessible charging points (and/or mobile charging points) must be configured to allow ad-hoc use (i.e. charging without an electric vehicle power contract) by no later than the end of 2016.

In specific terms, the NPE recommends the following course of action:

- Only digital payment methods (e.g. mobile payment, SMS, credit card) should be used for widespread ad-hoc access,
- Mobile telephony-based solutions in particular should be used for normal AC charging (e.g. mobile websites, smartphone apps),
- Both mobile telephony-based solutions (e.g. mobile websites, smartphone apps) and card-reading devices should be used for DC fast charging.

It is possible – on a voluntary basis without being forced to change supplier by the charging station operator – to meet the demand from some customers to have a free choice of power supply company at a charging station. These charging stations can be marked out accordingly.

5

What will we
achieve by 2017
during the market
ramp-up?
Expansion plans

While the NPE's 2014 progress report primarily presents scenarios for 2020, the charging infrastructure action plan complements these scenarios with information about the market ramp-up up to 2017 by analysing target figures from the publicly funded projects. These target figures provide a picture of the growth in the number of publicly accessible charging points.

Fast charging – ramp-up thanks to multi-tiered funding

The fast charging infrastructure is currently being built up through multi-tiered funding programmes at EU, federal and state levels because it is assumed that the majority of BEVs will be compatible with fast-charging systems. Due to the anticipated longer range, a nationwide fast charging infrastructure could be interesting for PHEVs with an electric range of more than 50 km. This effect can currently be observed in the peer market of Japan due to the well-established CHAdeMO charging infrastructure there.

The current stage of planning for the construction of fast charging stations coincides with NPE forecasts ("Pro" scenario). If the present public and private projects are implemented consistently, electric vehicle users will have access to a fast charging network of 1,400 charging stations in 2017. The NPE scenario anticipated 1,000 charging stations. The Pro scenario assumes there will be 7,100 charging stations in 2020. The 1,400 charging stations are being built to the stipulations of the EU directive for alternative fuels and are fitted with the Combo 2 connector as a minimum (Alternative Fuels Infrastructure Directive, 2014/94/EU). The installation of additional connectors has therefore not been ruled out. The perceived undersupply of charging stations is being further mitigated and long-distance mobility is being made possible. However, these two targets cannot be met on a broader scale simply by establishing a larger number of fast charging stations. These stations should also be developed into a network that covers the widest possible area and is geared to the needs of the licensed electric vehicles in terms of charging capacities (> 150 kW). The charging stations should account for the main traffic arteries and the number of registered vehicles in major cities. The desire to travel long distances as well as shorter ones should be met by implementing fast charging facilities on motorways.

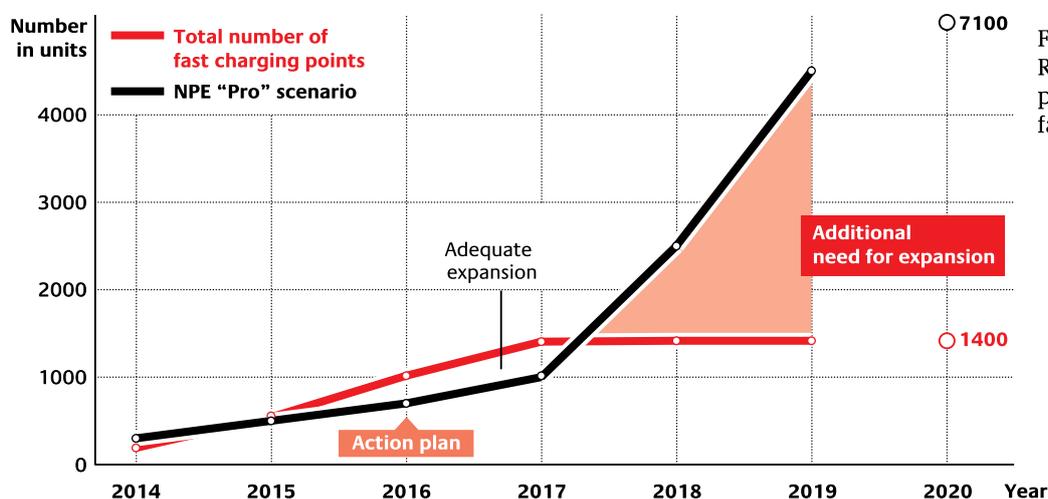


Figure 4: Ramp-up planning for fast charging

The above graph (Figure 4) compares the number of fast charging stations currently planned for the next few years with the required figures calculated by the NPE (in this case, in the “Pro” scenario).

It is important that the actual growth of the Combo 2 charging infrastructure in Europe over the coming years continues to be closely checked against the NPE scenario. The NPE scenario itself must also be reviewed, and the regular BDEW survey on the status of the publicly accessible charging infrastructure in Germany offers a particularly ideal basis for this. Furthermore, new measures for developing fast charging stations, including in the context of higher charging capacities, should be initiated in good time for the period from 2017 to 2020. Indeed, it cannot yet be safely assumed that the operation of fast charging stations will be an exclusively viable business model even by 2017, as it is unlikely that the number of charging processes will be sufficient then.

As in the past, instead of adopting a standardised concept for charging strategies, vehicle manufacturers have a dynamically evolving approach to the subject. In the case of fast charging, a trend towards 150 kW and more is emerging for battery electric vehicles (BEVs) designed for long-distance mobility. As a result, the fast charging infrastructure being established today and over the next few years should be adapted or planned so as to allow upgrading to higher performance classes in the medium term, in order to avoid stranded investments.

Throughout this decade, vehicle manufacturers will continue to launch long-distance BEVs based on the Combo 2 connector. If fast charging with outputs of 150 kW and over is made available that will require more major investment in terms of hardware and grid connection – ultimately, new transformers and medium-voltage connections will be needed in some instances. The share of costs carried by investors (connection costs and contributions to building costs) will not pay for itself if only a small number of electric vehicles are using these services at first.

Consequently, the NPE recommends a staggered approach to developing a nationwide fast charging network that takes into account “German Standardisation Roadmap Electric Mobility – Version 3.0”.

Stage 1 (approximately 1,400 charging points projected) – up to 2017:

- Preparing the grid supply capacity to several times ≥ 150 kW at central intersection points and important transport links
- Building some 1,000 charging points with a charging capacity of 50 kW on main traffic arteries
- Plus, building some 400 charging points, mostly with a 50 kW charging capacity, in major cities

Stage 2 – from 2017:

- Increasing the number of DC charging points towards the 7,100 fast DC charging points that are required by 2020.
- Simultaneously increasing the output of individual charging points at traffic intersection points and important transport links to ≥ 150 kW.
- Installing 150 kW charging stations at several hundred locations on motorway arteries and a correspondingly high grid supply capacity for simultaneous fast charging at several charging points, each with a 150 kW charging capacity.
- Increasing the density of the fast charging network at important transport links and in major cities with 150 kW and 50 kW charging points in preparation for Stage 3 (also beyond 2020).

Stage 3 – from 2020:

- By 2025, it is anticipated there will have been a significant improvement in battery performance and thus in the range that electric vehicles can cover. This will require higher charging capacity.
- Depending on the availability of vehicles with the corresponding battery technologies, individual charging points on main traffic arteries will prospectively be configured with a charging capacity of up to 350 kW – with a corresponding improvement in grid connection/expansion.
- In terms of power generated from renewables, legislation stipulates an increase to a share of 40 to 45 percent of the electricity consumed in Germany by 2025.

Normal charging – ramp-up in the publicly accessible charging infrastructure stagnating

The “commuter” and “two-vehicle owner” user groups usually have access to normal charging points at home and/or in initial stages at work. However, there are still legal uncertainties regarding the installation and use of charging points in both building regulations and tenancy law and with regard to employers. Employers in particular have a range of user groups and billing regulations to deal with, which makes the legal uncertainties in this area particularly significant and prevents further expansion from being pursued at speed.

There is high demand in major cities and in parts of towns where there is a great deal of pressure on parking. There are more than 5,000 electric vehicles in Germany’s 10 largest cities. This number will only grow if people who do not have their own parking space can find an adequate charging solution nearby, such as special parking bays with charging facilities or on-street charging options. At the same time, multi-storey car parks should be equipped with charging points and an opportunity should be created to make e-carsharing charging infrastructures available to the public under certain circumstances.

When it comes to publicly accessible facilities for normal charging, it is essential that viable business models are developed so that the charging infrastructure can be expanded in line with demand. Customers expect the charging infrastructure to be easy

to use and have a high public profile, which is why the NPE is also discussing how it can be linked up to parking management, which will require a major commitment from local authorities.

The normal charging infrastructure for e-carsharing fleets and electric vehicle drivers who do not have their own parking space is inadequate. What's more, the example of the Netherlands shows that PHEV owners frequently also use the publicly accessible infrastructure, as their vehicles are extremely economical when running on electric power. That is why development in a number of major German cities is being accelerated through the use of tenders and funding initiatives.

Berlin:

Up to mid-2016, 400 AC charging points and 20 DC fast charging stations that meet the Berlin model are being set up in public and semi-public spaces. Their locations are being stipulated by the Berlin state authorities. At the start of 2016, an additional expansion phase for up to 1,100 AC charging points and 40 DC fast charging stations will be launched that will run up to 2020. The number of charging facilities and the technology used will then depend on the demand that has emerged. Funding is being provided for both the construction and operation of the charging infrastructure. The contracts run to 30 June 2020. The subsidy requirement amounts to a maximum 6.5 million euros.

Hamburg:

By the end of 2016, the number of charging points in the Hamburg city region will be ramped up from 140 today to a good 590, 70 of which will be DC fast charging stations. This move will ensure that the growing number of electric vehicle owners can access new facilities at 227 additional locations spread across all seven districts of Hamburg. The Free and Hanseatic City of Hamburg is providing a total of some 5.3 million euros in regional funding for this project.

Munich:

The Integrated Action Plan for Promoting Electric Mobility in Munich (Integriertes Handlungsprogramm zur Förderung der Elektromobilität in München, or IHFEM) incorporates measures for creating up to 200 additional publicly accessible charging points. These will be supported with just under 4 million euros in funding. Suitable locations and technology (i.e. normal or fast charging) are being chosen based on the results from the "E-Plan" showcase project, among other things. The integrated action plan is being conducted on the basis of creating intermodal links with the local public transport network and electric carsharing, which will serve as a catalyst in the initial phase and ensure the infrastructure has a basic level of capacity utilisation.

Stuttgart:

At the end of 2013, the Stuttgart region already had more than 500 AC charging points (22kW) and offered free parking for electric vehicles, both of which created the conditions that allowed Stuttgart to roll out the world's largest purely electric carsharing fleet, with 500 smart electric drives. This made Stuttgart the first major city in Germany to offer a widespread charging infrastructure. Thanks to funding from the

Baden-Württemberg State Ministry for Transport and Infrastructure, its operation is guaranteed until mid-2018. The Stuttgart region will present a master plan for the coordinated development of a (direct current) fast charging infrastructure by spring 2016. In the meantime (mid-2015), there are more than 570 charging points available in the Stuttgart region.

Consequently, Germany's three biggest cities are providing a good 14 million euros for the ongoing expansion of the publicly accessible charging infrastructure.

In contrast to the trend at national level, there has been a noticeable increase in the development of the normal charging infrastructure at state level. This dynamic must be extended to more cities. To date, only a concept development phase can be seen. Similar initiative in other cities should be supported.

Table 2: Expansion planning for charging points in major cities (AC up to and including 22 kW)

City	Actual (2014)	Target (>2015)
Berlin	Approx. 250	650
Hamburg	Approx. 140	590
Munich	Approx. 80	280
Stuttgart ¹	Approx. 570	800

¹ and region

6

What next?

Areas of activity

In principle, both the private and publicly accessible charging infrastructure require more private investment and public sector incentive funding.

More favourable conditions make it easier to establish charging infrastructure. The NPE therefore recommends the following package of measures for developing a needs-based, customer-friendly charging infrastructure.

Building regulations and tenancy law:

- With regard to the **publicly accessible charging infrastructure**, private car park operators could be required to install charging points in a minimum number of their publicly accessible car parks. Parking management models are suitable for financing.
- When it comes to existing commercial buildings, such as multi-storey car parks, direct subsidies could be provided to cover investment costs in the publicly accessible charging infrastructure, insofar as the conversion measures satisfy certain minimum standards. The parking place provisions of regional planning regulations could be amended to include obligations for setting up charging infrastructure or cabling during new-build and conversion projects.
- Similar to the initiative launched by the federal ministries regarding the procurement of electric vehicles, consideration should be given to a commitment to establish charging infrastructure at car parks and multi-storey car parks that are owned by the state. These include car parks for public buildings, motorway service stations, railway stations, airports and housing complexes.
- With regard to the **private charging infrastructure**: The enforcement of minority positions in apartment buildings should be legally regulated. Enforcement options ought to be created in tenancy law for tenants vis-a-vis landlords, so that structural alterations such as installing private charging points can be carried out. In residential property law, the supply of EV (electric vehicle) power should count towards the safeguarding of power supplies and the assumption of costs should be regulated. It is also appropriate to make it a legal requirement for new buildings to be fitted with the electrical systems for corresponding charging options.
- Modify the Land Use Act and trade law regulations so that the operation of charging points and the supply of electricity are, to a certain degree, exceptions not defined as commercial activities, e.g. by using minimal thresholds or exemptions.

Tax regulations and energy law:

- Insert a legal definition for charging points into energy law, which clarifies that a charging point is not part of the power grid and that the operator of a charging point is not obligated to transmit electricity on a non-discriminatory basis.
- The provision of charging infrastructure for private use with a company car should be classed as tax-free income under income tax law.
- It should be possible to reimburse electricity costs incurred by employees charging their company cars at home on a lump sum basis.
- Thanks to mobile billing technology, billing can now be accurately broken down by participant and transaction, so that there are no additional technical obstacles for determining the non-cash benefit.

Calibration regulations:

- Steps should be taken to obtain legal clarification of whether time-based charging using a normal charging system amounts to an exception under the calibration regulations (based on the current interpretation of the calibration regulations). As batteries get bigger in size and the amount of energy required per charge increases, particularly in the case of fast charging, it may become more important from both an ecological and economic perspective for billing to be accurate to the kWh.
- In the case of DC charging, the challenge lies in ensuring measurements comply with the calibration regulations, which has not been possible to date. At present, when not billed on a lump sum basis, DC charging processes are billed by time. This is primarily because there are no calibrated meters for measuring the direct current that is supplied to the electric vehicle. What's more, billing based on the unconverted power as measured on the input side is problematic due to consumer protection considerations. The calibration requirements for DC charging points should be regulated on a legal basis.

Plan charging solutions from the viewpoint of the user – create solutions at a local level

- While pursuing concepts for developing the charging infrastructure, local authorities can adopt a demand-based approach when choosing where to locate charging stations, such as for on-street parkers and carsharing fleets. For example, in an approach similar to that used in the Netherlands (see box), Berlin residents will in future be able to contact their local authorities to ask about the locations of municipal charging stations and nearby charging stations run by retailers. This will improve the capacity utilisation of charging stations.
- A new funding guideline from the model regions that has been tailored to local authority development programmes aims to support electric mobility concepts in local authority areas. Charging solutions can also be funded when they are linked to the electrification of the vehicle fleet. It would also be possible to support local authority e-carsharing projects aimed at, for example, reducing the number of two-car households in new-build areas or improving mobility in rural areas.
- The process of developing local authority charging infrastructures is described in detail on the online platform www.starterset-elektromobilitaet.de, which is a well-founded tool for local authorities and public services.

Development of the charging infrastructure in the Netherlands

The E-Laad foundation was established in 2009 by several Dutch grid operators with the aim of supporting electric mobility by providing public charging facilities. E-Laad made it possible for electric vehicle owners to get a public charging station installed close to their home for free. As the market ramp-up gathered pace, E-Laad ceased operating. It is now down to local authorities and the market to drive the ongoing development of the public charging infrastructure. That is why Allego developed the open market model and the website openbaarladen.nl for the demand-based development of the charging infrastructure. Residents of a partner community can register on the website and lodge a request for a public charging station. Once the location has been checked and declared suitable, the publicly accessible charging station is quickly installed for the customer.

There can be no progress without financial subsidies

Over the past five years, the NPE has looked at a whole host of funding options for charging infrastructure. It has always been accepted that private investors and the public sector will have to finance infrastructure development in partnership. At the current time, it is clear that programmes are needed to establish fast charging stations at transport links/trunk roads and in major cities and that the normal charging infrastructure in local authorities also has to be boosted. In its progress report, the NPE has calculated that the required financing amounts to 193 million euros for 7,100 fast charging stations and 346 million euros for 70,000 normal charging points. A call for bids to develop the fast charging infrastructure up to 2020 should be considered. This will help to reduce the amount of funding required, provided that legislators have determined the legal classification of charging stations and how they fit into the competitive environment of the market economy.

Operating publicly accessible charging stations is still a loss-making affair, and not just because demand is still insufficient. The overall investment costs and the expenditure associated with running and maintaining charging infrastructure vastly exceed the potential returns from selling electricity. The charging infrastructure in the public traffic areas of cities and local authorities has not as yet been developed to an adequate and viable standard.

A focussed “10,000 station programme” in the near future would create the right impetus in terms of gearing development towards the needs of users and providing a clear commitment to electric mobility.

The “10,000 station programme”

To keep the need for financing as low as possible, an infrastructure concept for 10,000 publicly accessible normal charging stations should be presented that will run from 2015 to 2017.

The total investment for building and installing a publicly accessible AC charging station with two charging points and for the charging station itself currently stands at around 10,000 euros. As production numbers increase over the next few years, it is anticipated that these costs will drop to around 7,500 euros per location in 2020.

The total costs for building 10,000 publicly accessible normal charging stations by the end of 2017 will run to around 100 million euros and should be shared between private and public funding sources. The proposed funding is a lump sum of 5,000 euros for each AC charging station with two charging points. Taking this funding into account, the initial investment for the next three years would be approximately 50 million euros from the public sector and 50 million euros from the private sector. The private sector would also have to meet the running costs.

**“10,000 station programme”:
Criteria for using investment aids**

1. The publicly accessible charging infrastructure to be developed satisfies the stipulations of the EU Directive for alternative fuels as a minimum requirement. A firmly attached charging cable (e.g. in subterranean parking garages) can be tested to find out more about customer acceptance.
2. Non-discriminatory access (ad-hoc authentication and payment) is guaranteed.
3. The interoperability of the charging infrastructure is guaranteed (due to the network of the charging infrastructure. Keyword: eRoaming).
4. The operator guarantees the long-term maintenance and operation of the charging infrastructure. The operator undertakes to operate the charging point for at least five years and, if necessary, concludes contracts to that effect with private location partners or local authorities.
5. The funding is available to all potential operators of publicly accessible charging infrastructure in order to ensure the market ramp-up is geared as closely as possible to demand.
6. Individual investors should be able to lay claim to no more than 20 percent of the total funding volume. Funding should take into account that the infrastructure should be nationwide.

There should be intensive efforts to investigate a model for publicly accessible parking areas as a framework for local authority responsibility and with the ultimate aim of securing an infrastructure that offers consistent levels of availability across Germany. Financing and operational considerations should be investigated as regards implementing a publicly accessible charging infrastructure in parking areas that are managed by local authorities. It is the responsibility of the cities and local authority areas to reach a decision on factors such as cross-subsidisation.

I) Charging at publicly accessible parking facilities that are managed:

The model is feasible in the private sector under the management of private-sector operators. The charging stations could be financed via an integrated business model, with costs apportioned to parking fees.

II) Charging at publicly accessible parking facilities that are not managed:

Setting up charging infrastructure can be a short-term measure that helps companies such as retail outlets and restaurants boost customer loyalty. Depending on demand, normal charging could become part of the publicly accessible and thus far unmanaged parking facilities for the medium and longer term. If this private sector customer loyalty tool ensures sufficient use is made of parking spaces, the charging infrastructure may also be able to attract financing from additional revenues.

The ramp-up in the charging infrastructure must not generate load imbalances in the power grid.

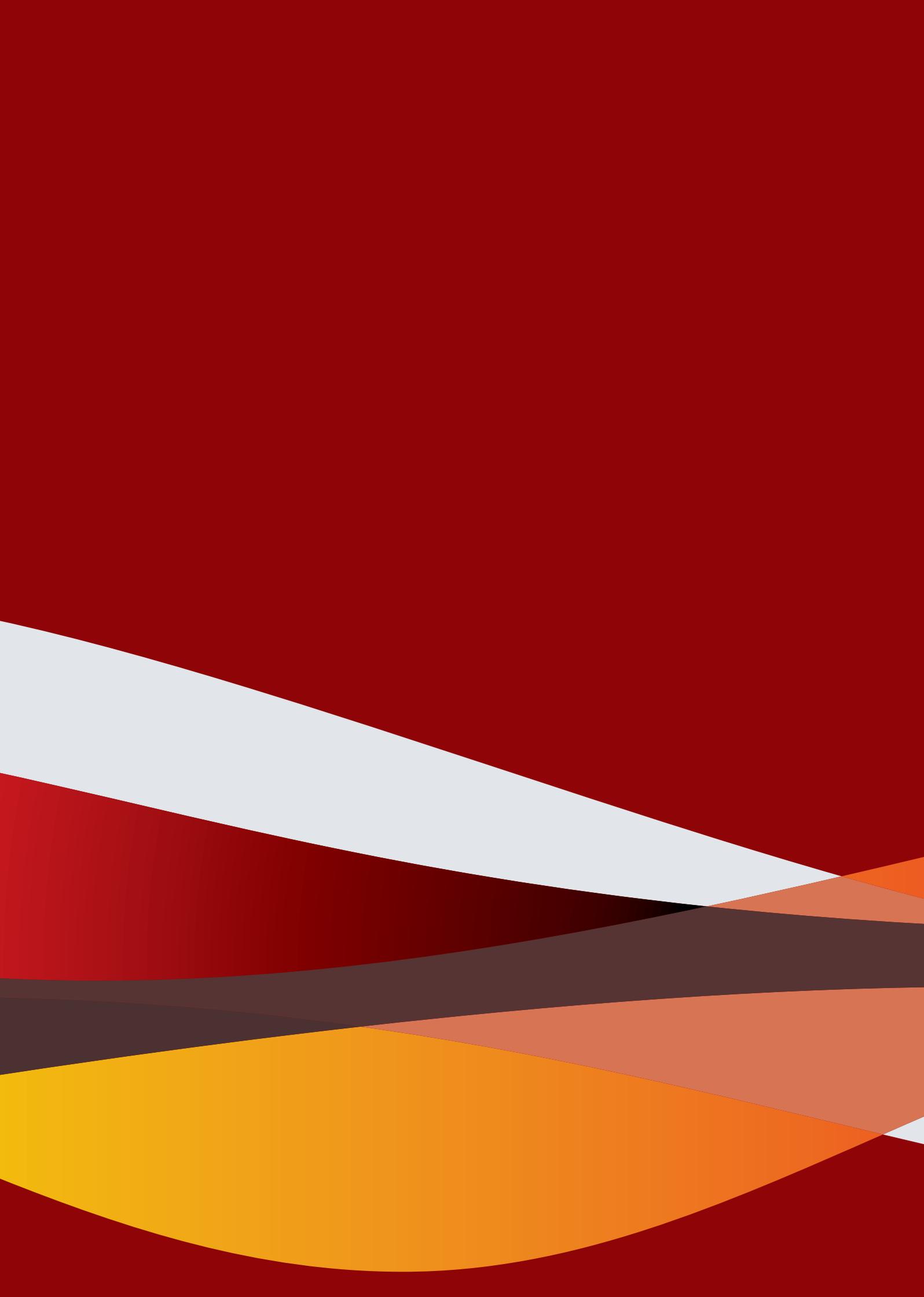
The NPE has discussed potential load imbalances caused by charging electric vehicles and has the following recommendations to make:

To ensure compatibility with other equipment and consumers connected to the grid, such imbalances must be kept within a permissible range. Technical Connection Conditions (Technische Anschlussbedingungen, TAB) / VDE AR-N 4102 stipulate that the single-phase operation of an individual consumer must not exceed 4.6 kVA in terms of power rating. This regulation applies to each connection to the distribution grid, i.e. on a per-household connection basis, not on a per-consumer basis.

As a result, two electric vehicles with a single-phase 3 kVA charger would breach this criterion if they were connected to the same phase in the same garage. When fitting charging facilities, installers should ensure these loads are divided between phases. This can be achieved by making sure installers are given appropriate training and information (similar to when heat pumps and PV plants were introduced for private households). If more than three charging stations are being installed, the symmetry of a three phase power supply system at the connection point should be ensured by putting in place a load management system.

The aim should be, prospectively, for all electric vehicles to be designed on a three-phase basis so that customers benefit from maximum convenience and short charging times while optimum grid utilisation is ensured.

Higher charging capacities of up to 350 kW and, if necessary, voltage levels mean that vehicles must offer download compatibility and impacts on the stability of the power grid need to be investigated – issues that will be examined in greater depth in WG 3 and the sub-working group for power grid integration as high-performance fast charging continues to expand.



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