Charging ahead

A comparative analysis of charging infrastructure development in Germany and India

Agora Verkehrswende
Anna-Louisa-Karsch-Str. 2 | 10178 Berlin
T: +49 (0) 30 700 1435-000
F: +49 (0) 30 700 1435-129
www.agora-verkehrswende.de
info@agora-verkehrswende.de

13.12.2022

Author
Vanchhit Johri
vanchhit.johri@agora-verkehrswende.de

Project Management
Kerstin Meyer
kerstin.meyer@agora-verkehrswende.de

Imprint

Charging ahead

A comparative analysis of charging infrastructure development in Germany and India.

Study undertaken by

Agora Verkehrswende
Anna-Louisa-Karsch-Str. 2 | 10178 Berlin
T +49 (0)30 700 14 35-000
www.agoraverkehrswende.de
info@agoraverkehrswende.de

Project management

Kerstin Meyer
Senior Associate Green Vehicles
kerstin.meyer@agora-verkehrswende.de

Study by

Author: Vanchhit Johri, Guest Researcher

Vanchhit Johri is a German Chancellor Fellow of the Alexander von Humboldt Foundation (year 2021), who graciously funded his fellowship in Germany. This report is part of his research in the context of this Fellowship.

Unterstützt von / Supported by

Alexander von Humboldt
Stiftung/Foundation

Layout: Marica Gehlfuß
Proofreading: Lucais Sewell

ACKNOWLEDGEMENTS

This publication would not have been possible without the contribution of a number of key industry experts. We would like to thank the following people in particular: Claus Fest (EnBW), Eva Diess (Mer), Marc Anton (KfW IPEX-Bank) and Jennifer Carrasco Portaspana (Boston Consulting Group). We would also like to thank Amit Bhatt (ICCT) and Dr. Alexander Wanitschke (NOW GmbH) for their helpful comments. The conclusions reflect the opinions of Agora Verkehrswende.

Please cite as:
Agora Verkehrswende (2022): Charging ahead. A comparative analysis of charging infrastructure development in Germany and India.

www.agora-verkehrswende.de

Content

1 Introduction

India's vision of being a global leader in transport-sector decarbonisation has started to become a reality. In October 2021, the Government of India expressed its intentions to electrify 70% of all commercial vehicles, 30% of private cars, 40% of buses, and 80% of two-wheelers and three-wheelers by 2030 (Ministry of Road Transport and Highways, Govt. of India 2021). One month later, at the COP26 in Glasgow, the country reached another milestone in its commitment to transport decarbonisation when it pledged to achieve climate neutrality by 2070. There it also signed the COP26 Transport Declaration, vowing to sell only zero-emission cars and vans by 2040.

In view of its ambitious goals, India has initiated a collaborative approach in which central, state, and city governments work together to achieve the country's global commitments. The central ministries have supported the EV industry through introducing the FAME policy (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles), delicensing the public charging infrastructure (PCI) sector, instituting special electricity tariffs, passing vehicle scrappage legislation, and many other targeted interventions. The state governments and the municipal bodies have endeavoured to follow up central government policies with their own efforts, which have ranged from additional purchase subsidies to road tax exemptions.

Increasingly, industry players are also aligned with the national transport decarbonisation agenda. Major original equipment manufacturers (OEMs) and start-ups have made substantial investments across the EV value chain in manufacturing, in charging technology development, in charging stations network, and in allied services. Thanks to this multipronged effort, demand for electric vehicles, especially in cities, has witnessed a sharp increase. Nearly 90% of consumers in India are willing to pay a premium for buying an EV (Ernst & Young Mobility Consumer Index Survey 2021). There is also a growing realisation among the Indian consumers that despite a higher upfront cost, the total cost of ownership of electric vehicles is now very competitive with that of conventional vehicles.

The electrification of the Indian transportation sector will also require the installation of charging stations across India in order to create a charging infrastructure for electric mobility. Under the FAME II programme, the government has provided financial support for EV charging stations. But India's charging infrastructure is still in its infancy, which is often cited as the biggest barrier to widespread EV adoption in India (IRADe 2022). While private charging can cover most needs, public charging infrastructure is still necessary to reduce range anxiety among prospective buyers so that they will make the switch to electric vehicles (NITI Aayog 2021).

The global experience in scaling up charging infrastructure has shown that government subsidies and incentives like those currently used in India can catalyse the process but cannot maintain it. In more evolved markets such as Germany's, the participation of the private sector in the form of capital investments and network expansion has been crucial to sustain the ever-growing fleet of electric vehicles. This paper aims to analyse some of the success factors that have enabled a strong private-sector presence in Germany's charging infrastructure. It will also argue that by following Germany's lead, India can ensure that its public charging infrastructure does not become a bottleneck in the pursuit of its electric mobility goals.

2 India's public charging infrastructure – current status and future needs

It is estimated that by 2030, India's electric mobility targets will translate into some 102 million EVs and a support infrastructure of 2.9 million public charging points (CEEW Centre for Energy Finance 2020). But today India has only about 1,800 public charging stations in operation, with each station averaging 2.55 charging points (CEEW Centre for Energy Finance 2022). The Indian government has taken note and has implemented a slew of policy measures to rapidly expand the charging infrastructure. These include:

- Capital incentives for setting up charging and battery-swapping stations
- Licence exemptions for the installation of charging stations
- The reduction of the Goods and Services Tax (GST) on chargers from 18% to 5%
- The provision of government land for charging stations using a revenue-sharing model
- Tariff concessions for electricity supply to charging stations
- The priority roll-out of charging infrastructure in cities with over than 4 million inhabitants and along major feeder highways by 2025
- Provisions for charging infrastructure in urban planning and building codes

While the policies are encouraging, they fail to provide specifics. As of now, the state has yet to issue official targets, though the Ministry of Power has formulated charging infrastructure density recommendations in its 2021 Charging Infrastructure Guidelines and Standards (Ministry of Power, Govt. Of India 2022). These are as follows:

- At least one public charging station in every 3x3 km grid square
- One charging station every 25 km on both sides of highways
- One fast charger every 100 km on highways

The one critical enabler missing in India's public charging infrastructure market so far is robust private-sector interest. The economics of public charging infrastructure in India seems unable to attract the capital investment required for network expansion. Typically, the installation of public charging stations requires large outflows: upfront capital expenditures, grid connection costs, energy costs, debt servicing, land fees, and money for operation and maintenance. Private players need access to reliable and reasonably priced capital to invest in their network expansion plans. But the cash projections of financers are based on assumptions about the EV growth rate and charger utilisation, which, in turn, are highly dependent on national and state policies, the availability of vehicle models, consumer awareness, and the emergence of charging business models. The charging business model, in other words, faces significant uncertainty, which hampers the large-scale capital flow required in the sector.

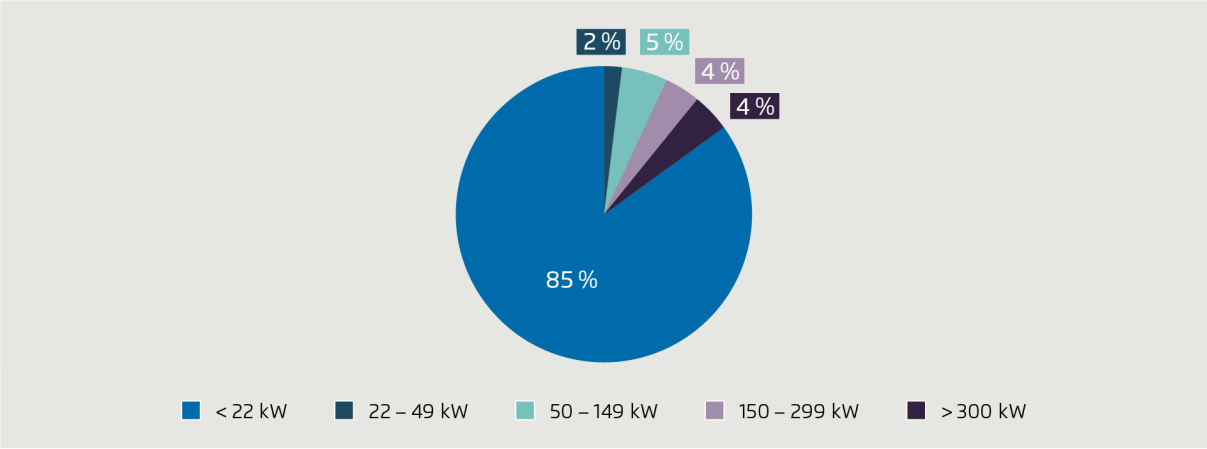
India's ambitious electric mobility goals are an unprecedented opportunity to charging infrastructure stakeholders such as equipment manufacturers, real-estate owners, charge point operators, and capital lenders. To capitalise on the opportunity, however, industry players must have access to financing. Interventions that make private financing available and affordable will be crucial in determining the pace, efficiency, and cost of the transition to EVs in India's transport sector. Important support for private-sector businesses will come from local authorities, as they are the ones responsible for public lands, parking, building codes, permitting, and inspection processes.

3 Public charging infrastructure in Germany – policy evolution and current status

As part of its roadmap for achieving climate neutrality by 2045, Germany wants to reduce it transport sector emissions from 150 million tonnes in 2020 to 85 million tonnes in 2030. The reduction will require aggressive decarbonisation, which includes putting 15 million electric cars on the road and installing a million charging points by 2030. In addition to the European Union's CO_2 standards, the German government's support measures include purchase incentives and fiscal incentives in the form of lower taxes for electric vehicles and company cars.

There are about 68 000 public charging points in Germany (Ladesäulenregister Bundesnetzagentur, September 2022). Some of the prominent players in the industry are EnBW Mobility, Allego, Charge-ON, EWE Go, and Westenergie Metering. Slow-charging stations (up to 22 kW) make up 85% of the total network (see figure 1), but many industry players are now committed to fast charging as the preferred mode of charging going forward. The German *Schnelladegesetz*, or Fast Charging Act, was enacted in May 2021 to roll-out a network of 1 000 fast-charging (at least 150 kW) hubs nationwide by 2023.

Charging power of publicly accessible charging points in Germany — Figure 1



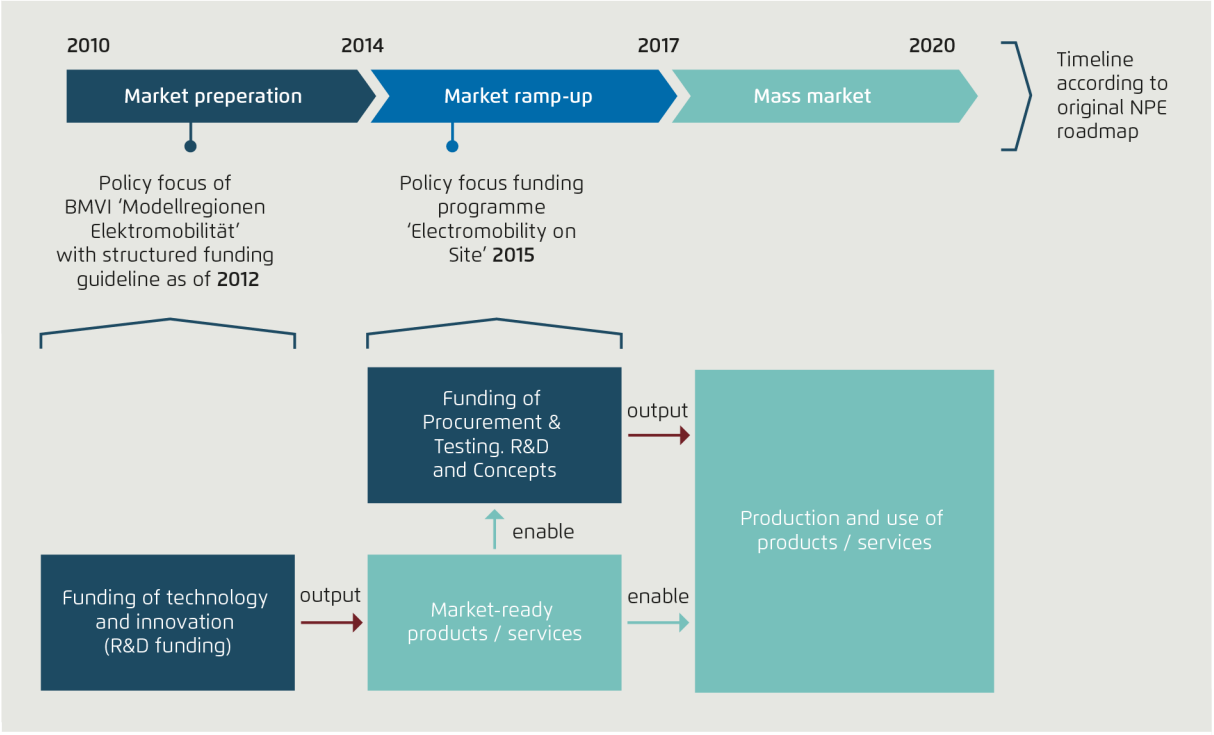
Agora Verkehrswende (2022) | Source: Ladesäulenregister, September 2022

The evolution of the charging infrastructure began systematically in 2010, when the National Platform for Electric Mobility (NPE) was founded as an interdisciplinary advisory board tasked with developing a plan to reach the joint government–industry goal of putting one million electric vehicles on the road by 2020. The original NPE roadmap outlined the first steps in moving from market preparation and market ramp-up to the creation of a mass market for electric passenger vehicles. Measures included support for research and development (R&D), standardisation, education, training, initial deployment, and demonstration (NOW GmbH 2020).

In 2016, the former Federal Ministry of Economic Affairs and Energy (BMWi) introduced the *Umweltbonus/ Kaufprämie*, a purchase incentive of up to €4 000 for electric vehicle buyers that was matched by support from carmakers. The incentive programme marked a gradual shift from

applied R&D funding in the "market preparation" phase to supporting the purchase of electric vehicles in the "market ramp-up" phase as per the original NPE roadmap (see figure 2).

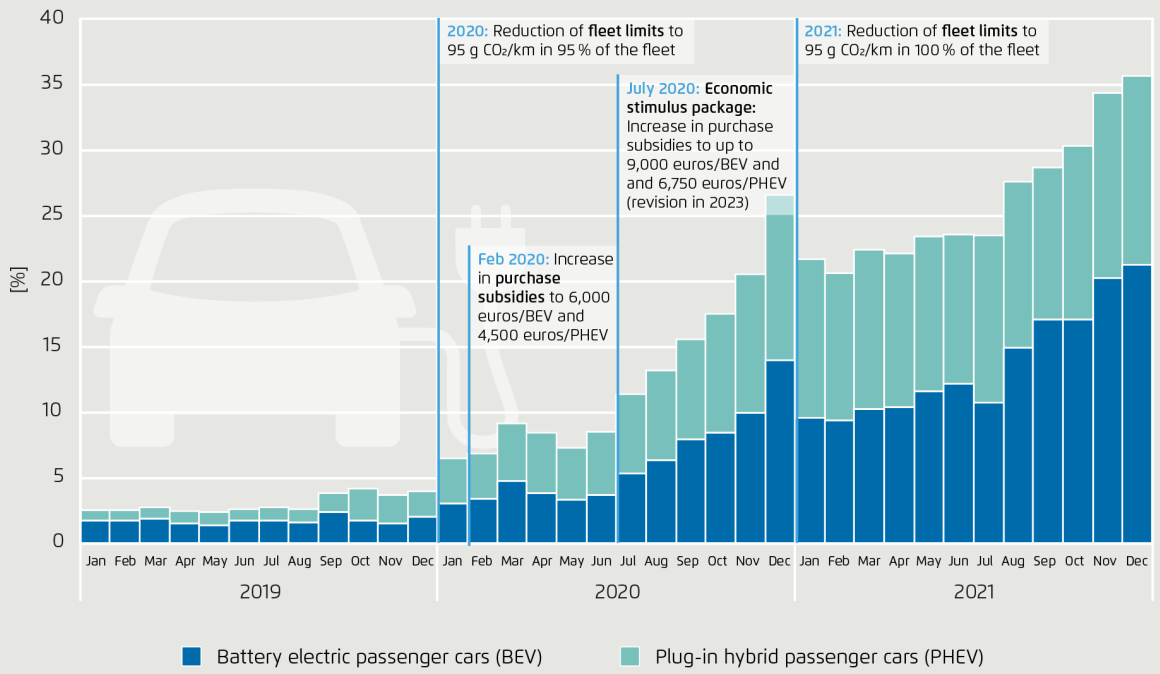
Original NPE roadmap for market development in Germany — Figure 2



Agora Verkehrswende (2022) | Source: NOW GmbH, 2020

While the original NPE roadmap anticipated the mass market phase to start in 2017, a steep increase in the numbers of newly registered electric cars could eventually be observed in 2020, when strengthened EU CO_2 standards for new passenger cars entered into force (see figure 3 on page 8).

Share of battery electric and plug-in hybrid in passenger car sales in Germany (2019 to 2021) Figure 3



Agora Verkehrswende (2022) | Data: Fleet limits are calculated annually based on the average CO_2 emissions of newly registered passenger cars per manufacturer. Penalty payments are due if the limit is exceeded according to EU legislation. Sources: Federal Motor Transport Authority, German government

In 2020, the incentive programme was further increased to €6 000 for battery-electric vehicles (BEVs) and €4 500 for plug-in hybrids (PHEVs). The COVID economic stimulus package in July 2020 increased the incentive to up to €9 000 for BEVs and €6 750 for PHEVs till 2022. The programme was amended in November 2022 to cover only BEVs and fuel cell electric vehicles (FCEVs) starting in 2023, and only EVs up to €45 000 starting in 2024. From January 2023, the purchase incentives are expected to be up to €6 750 for BEVs only while they are to be discontinued for PHEVs (BMWK 2022).

In 2019, the German federal government adopted the first Master Plan for Charging Infrastructure, which targets the installation of 1 million charging points by 2030, a sharp increase from the earlier target of 55 000 points. It introduced a €300 million incentive programme for small and medium enterprises (SMEs) in the retail, hotel and catering industry, and for small municipal utilities and local authorities, covering up to 80% of purchase and installation costs. The Federal Bureau for Administrative Services (BAV) is the designated agency for online tenders. It grants subsidies to the projects with the lowest cost per kW of charging capacity. BAV is also the tendering authority for the German Fast Charging Act, which funds up to 60% of the eligible costs.

The former Federal Ministry of Transport and Digital Infrastructure (now BMDV) distributed €200 million in 2021 through the state-owned development bank KfW *(Kreditanstalt für Wiederaufau)* under its KfW 440 programme, which gives German residents a €900 subsidy for the purchase and installation of a home charging point. KfW also offers companies credit for financing charging projects. Many German states have introduced their own commercial and residential charging

subsidy programmes either directly or through municipal authorities or the federal state banks *(Landesbanken).*

The federal government has established tax incentives to further encourage the expansion of the charging infrastructure. A number of incentives relating to company cars lead to a reduced tax load for the drivers of electric company cars until 2030.

A variety of businesses have started to invest in and build charging stations along German motorways, public roads, and other publicly accessible places. Without government funding, the public charging segment continues to have difficulty attracting large investments, but industry players have learned to identify niche business opportunities and revenue streams for favourable returns. Several large vehicle OEMs, power grid companies, and fuel station chains have found business models beyond standalone public charging and have started to target the private charging segment and co-located services (for example Electrive 2022, IONITY 2021, Shell 2022).

In October 2022, a second Masterplan Charging Infrastructure was adopted by the German government. The plan comprises 68 measures planned to facilitate the roll-out of charging infrastructure in Germany (BMDV 2022). Notably the government created an interministerial steering group for charging infrastructure (Interministerielle Steuerungsgruppe Ladeinfrastruktur - ISLa) lead by the Federal Ministry for Digital and Transport and the Federal Ministry for Economic Affairs and Climate Action. The task of this group is to coordinate the implementation of this Masterplan across different ministries. This inter-ministerial steering group seems like a promising approach to achieve policy alignment between different parts of government to further the charging infrastructure ecosystem.

4 Insights from the German public charging ecosystem

This section provides an overview of three key factors catalysing growth in the German PCI sector. These insights were generated through desktop research and a number of interviews between January 2022 and April 2022 with key stakeholders in the German PCI sector. However, this is not meant to be an exhaustive list and a detailed analysis of these factors is highly recommended. Although these factors are not directly comparable due to the predominance of light vehicles and a lower share of cars in India's vehicle stock, they are important for policy-makers and private-sector actors to consider.

4.1 A business model that targets specific use cases

The capex for a charging point primarily consists of the charging equipment itself, installation costs, plus any required upgrades to the local electricity grid, utility system, etc. A small charging site with several charge points can cost about €200 000 to €300 000 on average in capex, which can be as high as €1 million for a large fast-charging hub (see also Agora Verkehrswende 2022).

The labour costs for charging stations are quite low since they are typically unattended and self-servicing, and require less maintenance than fuel stations. But charging stations connected to local electricity grids are subject to capacity charges, which are used to offset the costs of the utility upgrades needed to accommodate them. Capacity charges are based on the highest expected load that a charging station may encounter, and are fixed and recurring (typically monthly) regardless of whether the peak load is reached (see also Regulatory Assistance Project, Agora Verkehrswende, Agora Energiewende 2021).

Four key lessons have emerged from this cost structure:

a. **Faster and bigger charging stations are more lucrative**
   PCI players have cited the securing of lucrative sites at reasonable rental terms as the biggest impediment to network expansion. Due to the increasing competition for land and improving battery capacities, there is now a better business case for faster and bigger charging stations despite the greater upfront costs. Currently, players in Germany are building stations with at least eight charging points and they expect the market to move to faster charging stations with even higher numbers of chargers per location in the future.
b. **Utilisation is key**
   Once an EV charging station is built, all costs besides electricity are essentially fixed, so utilisation is key to achieving a return on investment. In practice, the charging industry uses a conservative utilisation level in their business planning but even a very low utilisation level is likely to result in queues during busy hours. Fast-charging stations can service more vehicles while providing more availability, resulting in higher revenue and a better driver experience at the station.
c. **Overall cost to serve goes down as power increases**
   Although fast chargers are significantly more costly to build, their greater capacity means that their overall cost to serve (per kWh delivered) can compete with lower-capacity chargers even at lower utilisation levels. Empirical studies in Germany have shown that the number of charge events rises with station charging power (see Hecht, Figgener, Sauer 2022). This can be linked to lower average charging durations for fast chargers and shorter waiting times at the charging station.
d. **Separate markets for public and private charging**
   Rapid, third-party public charging stations are significantly more costly, both for PCI players and customers, than slow private charging at home or at work. Nearly all EV owners use private chargers whenever possible, so the overall charging market for public stations has remained relatively modest. Due to the high price premium for public charging, some industry experts expect it to become an entirely distinct market, where roadside stations compete among themselves for the public charging market, with little consideration of private charging use cases (PWC USA 2021).

Expected pathway for the public charging market

The share of private charging is expected to reach 76–88% by 2030 (NOW GmbH, 2020). For this share, slow AC chargers will be used, given that longer charging times don't matter. However, slow charging is not suitable for local destination charging – at supermarkets, shopping malls, movie theatres, etc. – because charging takes too long, and EV owners making short trips will rarely need to top up their batteries. By contrast, EV drivers travelling to further-away destinations

need to charge their batteries and are willing to pay more for fast DC charging to save time. For the en-route use case, consumers want a combination of convenience, speed, and competitive pricing.

The interview partners in Germany have identified four key competitive levers in the public charging market: convenience, price, customer loyalty, and quality.

People in a hurry are willing to pay a premium for fast charging, be it at highway stations or at urban charging points. They look for convenient locations with the fastest charging times and are not keen on scheduling charging sessions ahead of time via reservations apps. Some providers target these consumers by offering stations with rapid charging and high-capacity buffers. Charging at these points costs significantly more than at slow AC charging stations, but their customers believe that the added value they represent is worth the higher price. By contrast, price-sensitive consumers tend to go to slow AC charging stations in less convenient locations. They are also more willing to wait in queues, shop around, and reserve chargers.

When it comes to customer loyalty, many public charging players have launched programmes in recent years to keep people coming back. In fact, most of the e-mobility service providers (MSPs) on the German charging market require customers to sign a contract for specific services. And new bundles and other offerings are now emerging in which service providers and retailers use charging as an incentive to drive subscriptions, traffic, or other transactions.

Lastly, quality-conscious consumers prioritise charging brands that they perceive to offer high quality. Many providers offer a variety of charging products and services for competitive advantage. For example, almost all CPOs in Germany today offer green power from renewable sources, since this is also a condition for receiving public subsidies (BMVI 2021).

4.2 A diversified public charging value chain with specialised players

Market participants in Germany

A varied of players have entered the EV charging sector to leverage the business potential of a rapidly growing market. Some market participants are creating a niche in a specific link in the value chain; others have relied on integrated offerings to establish better control over their operations and secure bigger margins, though according to the interviews at the time of writing most business models are still unprofitable primarily due to low charger utilisation. Several approaches and business models have been launched to take advantage of evolving opportunities across the various segments of the value chain.

An illustrative value chain in Germany Figure 4

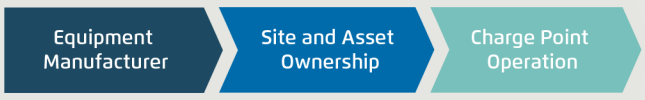
Agora Verkehrswende (2022) | Source: Authors' figure

- Equipment Manufacturer (EM) – designing, manufacturing, selling, and distributing AC and DC chargers
- Installation & Services – preparing the sites and installing, maintaining, repairing, and cleaning the equipment
- Site and Asset Ownership – investing in sites and chargers, and sourcing electricity from the utilities
- Charge Point Operators (CPO) – operating the charging points, ensuring that networks run smoothly, managing diagnostics and device maintenance, and handling station pricing and invoicing
- E-mobility Service Providers (MSP) – providing access to charging points within a specific geographic area, and offering charging services such as network maps, payment options, and roaming

Market participants in India

The market in India largely consists of vertically integrated players who combine multiple parts of the value chain such as hardware installation, charging point operation, and allied charging services.

An illustrative value chain in India Figure 5



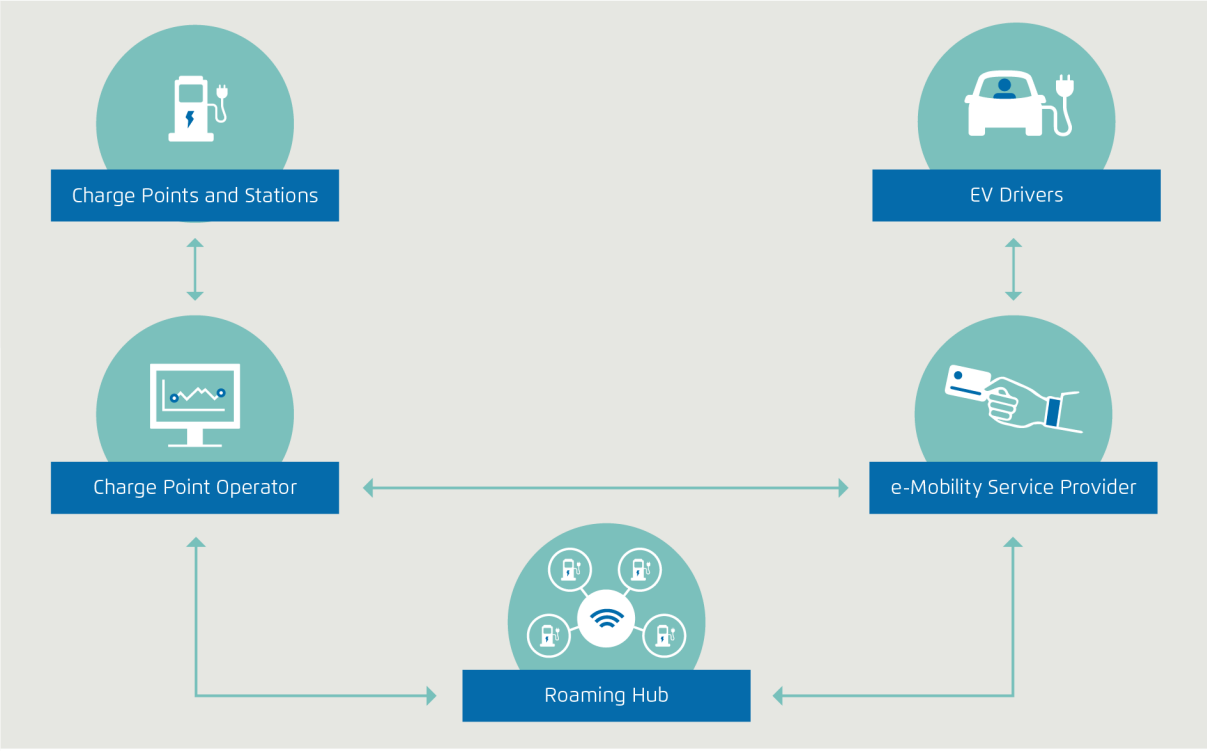
Agora Verkehrswende (2022) | Source: Authors' figure

Note that the above value chain reflects only the situation in India at the time of writing, where the public charging market is still in its infancy. Global experience has shown that a more diversified value chain with specialised offerings in different segments will emerge as the overall market evolves. Hence, the Indian market offers ample opportunities for global and domestic players to test innovative business models and create competitive advantage.

Today, one of the crucial gaps in the Indian market is the absence of specialised MSPs. This has resulted in a concentration of responsibilities and financial risks for CPOs, making the returns on their charging infrastructure investments risky. In more mature markets, CPOs and MSPs have

been the pillars of the EV charging industry, each with a different role in and approach to the market. A CPO owns the charging infrastructure, and an MSP manages end-users and their services. These roles can be separate, or one market player can act in both capacities.

Relationship between the charging infrastructure market participants Figure 6



Agora Verkehrswende (2022) | Source: Authors' figure simplified based on lastmilesolutions.com 2020

Role of a CPO

The main responsibility of a CPO is to ensure that its charging network is operational, available, and stable round the clock. A CPO can assume different roles in the market (BCG 2022):

- own and manage the charging infrastructure
- provide only the connection on behalf of the owners of the charging infrastructure
- offer both services at the same time

Moreover, the CPO role can be divided into commercial and technical tasks. At the commercial level, a CPO sets the pricing of the charging infrastructure, secures access for MSPs, and provides related administrative services such as point of interest (POI) data sharing. At the technical level, a CPO is responsible for the maintenance of its network, including diagnostics, customer support, and repair. Depending on business model and capability, CPOs play either one of the roles or both at the same time. Additionally, CPOs are responsible for scalability. They need to ensure that their charging points are compatible with the latest industry standards and protocols such as OCPP, OCPI, OCSP, and ISO 15118.

The CPO is one of the most important roles in the EV charging value chain and hence exerts significant influence on the charging infrastructure ecosystem.

- CPOs can influence market prices for end-users by negotiating large volume discounts resulting in reduced hardware costs. The cost price of charging hardware has dropped significantly in the past decade, mainly due to the adoption of e-mobility worldwide, in which CPOs have played a prominent role.
- CPOs can determine the charging capacity at a charging location. Within the physical or regulatory limitations, a CPO can create capacity flexibility in its platform with an interplay of charging dynamics such as load balancing, threshold values, delayed charging, and priority charging.
- CPOs define the base price model of charging at a certain location, which determines what MSPs and end-users pay. The base price model can be segmented into several components: a fixed starting fee, a usage-based connection fee for the charging minutes, a power-based volume fee for the kWh, and a dynamic component such as Time of Day (TOD) and Time of Use (TOU). Most price models make use only of one or two components. The volume fee is common practice in the EU and in the USA.

Role of an MSP

MSPs contract with EV drivers for the provision of charging and allied services. The most common services offered by an MSP are charge cards; native or third-party apps for charging station location and navigation; billing and invoicing; customer management; and determining end-user charging prices. Typically, MSPs serve only registered customers, but they may also grant access for unregistered users, as is sometimes mandated by local law (BCG 2022).

MSPs play a central role in promoting the charging infrastructure by providing access to third-party charging networks through roaming. Roaming capabilities are essential as they considerably improve the end-user experience by letting EV drivers charge their vehicles at other EV charging networks. Roaming also expands the potential user base of MSPs, as it opens their network to EV drivers registered with other networks. MSPs often collaborate with roaming hubs, which have platforms for exchanging information between CPOs and MSPs. In Germany, CPOs and MSPs have established more and more partnerships in order to link the multiple charge cards of EV drivers. For each driver, they offer unique contract IDs, verifiable whenever a user initiates a charging event at a charging station of any of the partnered MSPs.

Currently, MSPs often play a double role in the German market. For instance, some companies operate in the value chain while offering charge cards to its customers. Many EV OEMs, car-leasing companies, and fleet owners act as MSPs by bundling charge cards with complete end-user services. Some utilities who already supply energy to the homes or businesses of potential EV drivers offer MSP services to their customers. Finally, a number of CPOs have understood the upside of the MSP business and have sought to become one-stop-shops for their customers. The current EV charging ecosystem in Germany offers many MSP opportunities and many value chain actors have decided to take advantage of them.

The main influence that MSPs have on the charging sector is pricing. Charging sessions can vary from a usage-based per kWh price to monthly flat-rate subscriptions for unlimited amounts of power and unlimited numbers of charging sessions. Although the CPO determines the price for the use of charging points, MSPs set the price for the billing and for the use of the roaming network.

MSPs also influence the size of the roaming network and access to it. As a rule, they are incentivised to collaborate aggressively with new CPOs in order to expand their geographical coverage and build an ever-growing charging network. Rapid growth ensures EV drivers that they can charge their cars anywhere at their MSP rate.

Opportunities in the Indian market

The MSP market in India is new and still evolving, but it holds enough opportunities for new players to build successful long-term businesses. One of the advantages of MSPs is the relationship with the customer. Invoices and contracts provide a treasure trove of data on consumer behaviour and market development, which can be analysed to further improve user experience and target new customers. In view of recent advances in India's digital payments and consumer Internet sectors, huge enablers for the MSP services, the country offers sustainable business opportunities at the intersection of EV charging and digital products.

a. **Roaming**
   MSPs in the European Union are scrambling to access charging points in an effort to build larger charging infrastructure networks than their competitors. India offers a great opportunity for EV roaming in which drivers can access charging stations operated by different providers through a single platform. Strategic collaborations between parties via direct peer-to-peer connections, whitelisting, and roaming hubs will make it easy for MSPs to offer a wide range for charging.
b. **Pricing transparency**
   In the past, the confusing tangle of CPO tariffs, starting tariffs, kWh tariffs, and connection tariffs in Germany left users without a clear sense of what they were paying for a charging session. To create more transparency, many EU countries have since introduced legislation requiring that the price be indicated before the charging begins. One example is Germany's Price Indicative Ordinance (Preisangabenverordnung – PAngV). MSPs in India can learn from the EU experience and offer a superior customer experience from the outset by displaying pricing information at the station, on the website, or through an app.
c. **Value chain**
   A fast-growing market attracts many players, from large international incumbents and existing players to tech giants and local start-ups. For instance, some prominent automotive companies and energy utilities in the EU and the USA such as bp have entered the MSP business, which has led to the industry's backward integration (BP 2022). The ISO 15118 protocol for communication between charging stations and vehicles has opened new avenues for identifying viable business models. It will be possible in the near future to replace physical charge cards and apps with the vehicle itself. Accordingly, India's MSPs should be on the lookout for emerging technologies and work to identify their value to the market(s) and customer segment(s) they want to service.

It is important to consider, however, that the MSP business has its challenges. First, it requires continuous development to stay relevant, to be attractive, and to maintain market niches. Players need to be aware of ever-evolving customer needs to improve plug-and-charge solutions, implement the right payment models, and create a seamless charging experience for end users. Second, MSPs need to exercise care when finding partners for large roaming networks or for

services to make their work more effective. Given the low barrier to market entry, the partners of today can easily become the competitors of tomorrow.

4.3 A data-driven approach to network planning

NOW GmbH is a federal government-owned company tasked with the day-to-day implementation and strategic development of the funding guidelines of the Federal Ministry of Digital and Transport (Bundesministerium für Digitales und Verkehr – BMDV) and of commissions by other federal ministries. It is primarily responsible for the identification of focus areas for funding calls, the technical evaluation of funding applications, the coordination of electric mobility research, data collection, the critical evaluation of federal funding strategies, the strategic development of policy frameworks, and consulting for BMDV and other relevant actors nationally and internationally. In 2019, the National Centre for Charging Infrastructure (Nationale Leitstelle Ladeinfrastruktur – NLL) was set up under the NOW umbrella with the mandate to implement the charging infrastructure master plan.

As part of its data collection mandate, the NLL gathers data relating to national electric vehicle registrations and to public charging infrastructure installations and their use. The data is a combination of general national figures and specific information gathered from vehicles and charging stations co-financed by the funding programmes. The datasets contain information about the basic physical characteristics, geolocation, operational contexts, and trip data from installed data loggers and individual charging sessions. With its data-driven approach, the NLL has evolved into a critical player in the planning, funding, and development of Germany's electric mobility market.

a. New registrations of electric vehicles

The Federal Motor Transport Authority (Kraftfahrt-Bundesamt – KBA) publishes new vehicle registrations monthly. The NLL team co-ordinates with NOW to monitor the general development of the electric mobility market in Germany.

New registrations of vehicles in Germany by fuel type (October 2022) Table 1

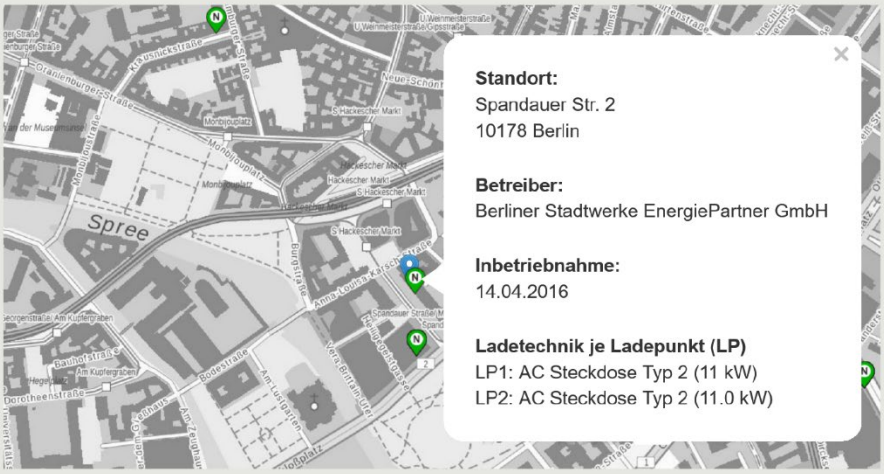
Fuel type	Number (Oct'22)	Market share (Oct'22)	Growth since October 22 (%)	Number (Jan'22 – Oct'22)	Market share (Jan'22 – Oct'22)
Petrol	66,676	32	3.1	726,257	35
Diesel	36,554	17.5	18.3	398,468	19.2
Battery Electric Vehicles (BEV)	35,781	17.1	17.1	308,254	14.8
Plug-in Hybrid Electric Vehicles (PHEV)	32,064	15.4	35.1	247,711	11.9
Hybrid Electric Vehicles (HEV)	36,469	17.4	32.1	381,172	18.4
Liquefied Petroleum Gas (LPG)	927	0.4	(7.2)	12,331	0.6
Compressed Natural Gas (CNG)	126	0.1	(23.6)	1,609	0.1

Agora Verkehrswende (2022) | Source: KBA website

b. Public charging points

The NLL also maintains an open registry of public charging points in Germany. At first, only fast charging stations (with more than 22 kW of power) had to be registered with the Federal Network Agency (Bundesnetzagentur – BNetzA). But since the Charging Station Ordinance (Ladensäulenverordnung) came into effect, in 2016, all publicly accessible charging points have to meet European regulations regarding standardised charging plugs and must be registered with the BNetzA (BMJ 2016). However, not all charge points are mentioned in the open registry, since some CPOs object to the publication of their data (see NLL 2022).

Extract of interactive map StandortTOOL — Figure 7



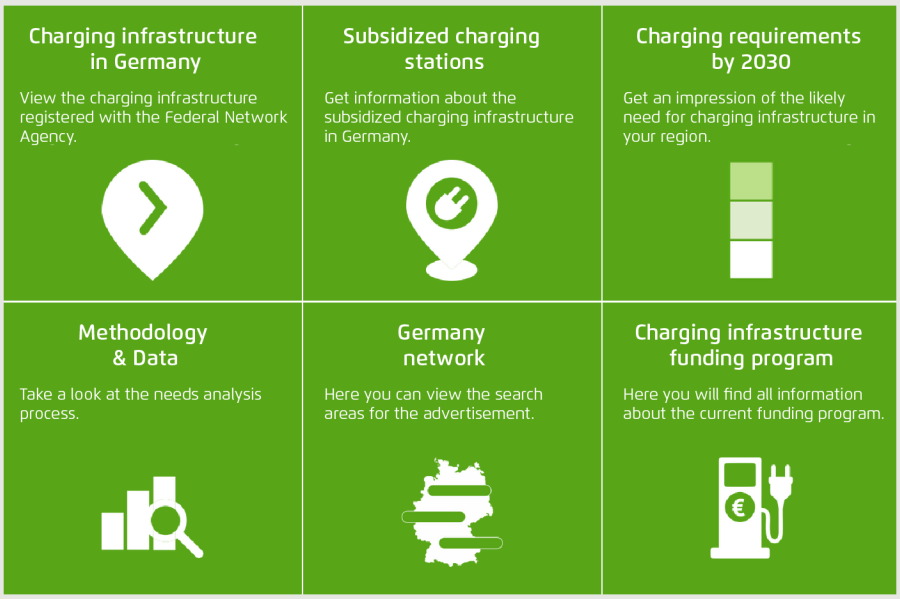
Agora Verkehrswende (2022) | Source: StandortTOOL (https://www.standorttool.de/), National Centre for Charging Infrastructure (https://nationale-leitstelle.de/en/)

Another authoritative data resource is the charging points register (*Ladesäulenregister*) of the German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft – BDEW). Figures in this register are generally higher than in the BNetzA register as it also includes semi-public charging points.

c. OBELIS – a platform for charging infrastructure data reporting

Operators of charging stations that received BMDV funding from charging infrastructure programmes are obliged to report a set of key data – including location, grid connection, charging power, access restrictions, installation costs, electricity use, and duration of charging sessions – every six months via the online portal OBELIS. The collected data are analysed by the NLL research team and the insights gained are then used in the NLL's location tool, StandortTOOL, for the strategic planning of the charging infrastructure roll-out. The StandortTOOL connects geographical distribution, technology choices, utilisation rates, and power grid loading to model the future development of Germany's charging infrastructure.

Overview StandortTOOL Figure 8

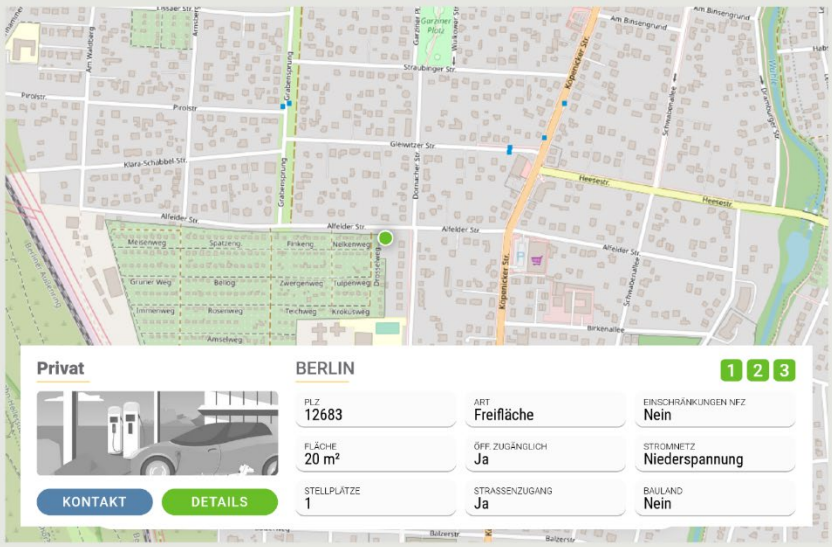


Agora Verkehrswende (2022) | Source: StandortTOOL (https://www.standorttool.de/), National Centre for Charging Infrastructure (https://nationale-leitstelle.de/en/)

d. FlächenTOOL – a software that identifies available sites for the charging infrastructure

In 2021, NLL launched FlächenTOOL, a locator tool that provides information on sites where charging infrastructure can be installed. Federal states, municipalities, businesses, and private individuals can use the platform to offer their properties to parties looking for suitable sites to invest in charging infrastructure. The interactive map provides a detailed site-level view of charging type, area, parking spots, road access, and grid connections.

Extract interactive map FlächenTOOL Figure 9



Agora Verkehrswende (2022) | Source: FlächenTOOL (https://flaechentool.de/), National Centre for Charging Infrastructure (https://nationale-leitstelle.de/en/)

5 Conclusions

Analysis of Germany's charging infrastructure and interviews with its major players show that the industry has learned and evolved over the past decade. This paper identifies four key takeaways for Indian stakeholders who want to boost their country's nascent public charging ecosystem.

- **Policymakers can work towards providing more data to enable the development of the Indian public charging industry.** A reliable and open data regime can be a significant enabler of India's public charging industry. The availability of quality data in Germany has helped the industry to expand its network as well as informing the research community and the general public. But India currently lacks similar public data repositories, and its businesses and start-ups must make do with limited captive user data, which is certain to result in suboptimal public charging services. To enable data-driven decision-making in the industry, Indian policy-makers can choose to also create a legislative framework that will lead to an open registry of public charging points as well as work to integrate a variety of data sources and make them available to industry players and the general public.
- **A national charging infrastructure masterplan, complemented by enabling policies, would be helpful in planning the infrastructure requirements accordingly.** A collaborative inter-ministerial group, similar to ISLa in Germany, can own this masterplan and define the role of policy interventions vis-a-vis the public charging market to avoid early market challenges such as suboptimal utilization, incompatible technologies, and lack of interoperability. This would improve the attractiveness of Indian public charging sector to private investors and support the national transport decarbonization targets.
- **Private players can build sustainable business models by specializing and picking their niche:** Due to the high upfront investments and traffic risks involved in the public charging business, businesses need to monitor usage patterns and customer behaviour proactively. The German experience so far demonstrates that faster and bigger charging stations are expensive to build but offer better returns on investment. By contrast, slow chargers are less expensive but need much higher utilisation levels to break even. In general, Indian companies seeking to establish a niche in the charging market will need to avail themselves of at least one of four competitive levers: convenience, price, loyalty, and quality. Businesses will have to tailor their strategies carefully since servicing all the use cases will not be economically feasible.
- **Indian charging industry can benefit by disaggregating the value chain:** Specialised entities catering to specific links in the charging value chain can build a strong foundation for India's public charging ecosystem. Unlike the current system in India, in which end-to-end integration predominates, a disaggregated value chain, as is the case in Germany, lowers business risk for individual players and results in mutually beneficial innovation thanks to synergistic effects. Because India's public charging market is still in its nascent stage, it offers opportunities for innovative business models, particularly so for charge point operators and e-mobility service providers.

6 References

Agora Verkehrswende (2022): Schnellladen fördern, Wettbewerb stärken. Finanzierungsmodelle für den Aufbau von öffentlich zugänglicher Ladeinfrastruktur für Pkw, URL: https://www.agora-verkehrswende.de/veroeffentlichungen/schnellladen-foerdern-wettbewerb-staerken/ (last verified: 30.11.2022)

Agora Verkehrswende, Agora Energiewende (2021): Ladeblockade Netzentgelte. Wie Netzentgelte den Ausbau der Schnellladeinfrastruktur für Elektromobilität gefährden und was der Bund dagegen tun kann, URL: https://www.agora-verkehrswende.de/veroeffentlichungen/ladeblockade-netzentgelte/ (last verified 30.11.2022)

BMDV (2022): Masterplan Ladeinfrastruktur II der Bundesregierung, URL: https://bmdv.bund.de/SharedDocs/DE/Anlage/G/masterplan-ladeinfrastruktur-2.pdf?__blob=publicationFile (last verified: 30.11.2022)

BMJ (2021): Preisangabenverordnung (PAngV), URL: https://www.gesetze-im-internet.de/pangv_2022/BJNR492110021.html (last verified: 29.11.2022).

BMJ (2016): Verordnung über technische Mindestanforderungen an den sicheren und interoperablen Aufbau und Betrieb von öffentlich zugänglichen Ladepunkten für elektrisch betriebene Fahrzeuge (Ladesäulenverordnung – LSV), URL: https://www.gesetze-im-internet.de/lsv/BJNR045700016.html (last verified: 29.11.2022).

BMVI (2021): Bekanntmachung der Förderrichtlinie „Öffentlich zugängliche Ladeinfrastruktur für Elektrofahrzeuge in Deutschland" vom 13. Juli 2021, URL: https://bmdv.bund.de/SharedDocs/DE/Anlage/G/foerderrichtlinie-oeffentlich-zugaengliche-ladeinfrastruktur.pdf?__blob=publicationFile (last verified: 29.11.2022)

BMWK (2022): Bekanntmachung der Richtlinie zur Förderung des Absatzes von elektrisch betriebenen Fahrzeugen (Umweltbonus) vom 17. November 2022, URL: https://www.bundesanzeiger.de/pub/de/amtliche-veroeffentlichung?3 (last verified: 12.12.2022)

Boston Consulting Group (BCG) (2022): Winning the Battle in the EV Charging Ecosystem, URL: https://web-assets.bcg.com/55/e0/d244623746dba6826873121c4960/bcg-winning-the-battle-in-the-ev-charging-ecosystem-may-2021-r.pdf (last verified: 30.11.2022)

BP (2022): "Hertz, bp collaborate to accelerate EV charging in North America", URL: https://www.bp.com/en/global/corporate/news-and-insights/press-releases/hertz-bp-collaborate-to-accelerate-ev-charging-in-north-america.html (last verified: 30.11.2022)

Council on Energy, Environment and Water (CEEW) Centre for Energy Finance, (2022): Public charging stations in India, URL: https://www.ceew.in/cef/intelligence/tool/electric-mobility/charging-stations (last verified: 30.11.2022)

Council on Energy, Environment and Water (CEEW) Centre for Energy Finance, (2020): Financing India's Transition to Electric Vehicles, URL: https://www.ceew.in/cef/solutions-factory/publications/CEEW-CEF-financing-india-

transition-to-electric-vehicles.pdf (last verified: 30.11.2022)

Electrive (2022): "Total establishes German subsidiary for charging infrastructure", original in German, URL: https://www.electrive.net/2022/10/20/total-gruendet-deutsche-tochter-fuer-ladeinfrastruktur/ (last verified: 30.11.2022)

Ernst & Young Mobility Consumer Index Survey (2021): "Electric Vehicle market moves into high gear", URL: https://www.ey.com/en_in/news/2021/07/electric-vehicle-market-moves-into-high-gear-ey-mobility-consumer-index (last verified: 30.11.2022)

Hecht, Figgener, Sauer (2022): Analysis of Electric Vehicle Charging Station Usage and Profitability in Germany, URL: https://arxiv.org/ftp/arxiv/papers/2206/2206.09582.pdf (last verified: 30.11.2022)

Integrated Research and Action for Development (IRADe) and Shakti Sustainable Energy Foundation (2022): Survey of EV Users and Prospective Buyers in Delhi and the Estimated Impact on EV Charging on the Grid in 2030, URL: https://irade.org/website/wp-content/uploads/2022/02/IRN-DelhiEVsurveyImpactonGridPaper.pdf (last verified: 30.11.2022)

IONITY (2021): Investment of EUR 700 million in charging infrastructure, URL: https://ionity.eu/_Resources/Persistent/c/3/9/0/c390f02c583f1bf8a615e70ec8c1f7b2a27d517b/20211124%20Pressemeldung_IONITY_Strat_D.pdf (last verified: 30.11.2022)

Ministry of Power, Government of India (2022): Charging Infrastructure for Electric Vehicles – Revised Guidelines and Standards, URL: https://powermin.gov.in/sites/default/files/webform/notices/Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.pdf (last verified: 30.11.2022)

Ministry of Road Transport and Highways, Government of India (2021): "Govt. plans 30% EV sales penetration for private cars by 2030", URL: https://auto.hindustantimes.com/auto/news/govt-plans-30-ev-sales-penetration-for-private-cars-by-2030-nitin-gadkari-41633688941964.html (last verified: 30.11.2022)

NITI Aayog, Government of India (2021): Handbook of Electric Vehicle Charging Infrastructure Implementation (version 1), URL: http://www.niti.gov.in/index.php/node/1579 (last verified: 30.11.2022)

NLL (2022): Öffentliche Ladeinfrastruktur, URL: https://nationale-leitstelle.de/verstehen/o-LIS-Report_der_Nationalen_Leitstelle_Ladeinfrastruktur/ (last verified: 29.11.2022).

NOW GmbH (2020): Using Real Data to Develop Targeted Government Support of the Electric Vehicle Market in Germany, URL: https://www.now-gmbh.de/wp-content/uploads/2020/10/FinalPaper_Ziem-Milojevic_Sabine.pdf (last verified: 30.11.2022)

PricewaterhouseCoopers (PwC) USA, (2021): Electric Vehicles and the Charging Infrastructure – A New Mindset?, URL: https://www.pwc.com/us/en/industrial-products/publications/assets/pwc-electric-vehicles-charging-infrastructure-mindset.pdf (last verified: 30.11.2022)

Shell (2022): "Shell and REWE build charging infrastructure in front of supermarkets", original in German, URL: https://www.shell.de/ueber-uns/newsroom/pressemitteilungen-2021/shell-und-rewe-errichten-ladeinfrastruktur-vor-supermaerkten.html (last verified: 30.11.2022)

7 Annex A: List of Interview Partners

Interview Partner	Organization	Date of interview
Claus Fest	Leiter Energiewirtschaft & Beschaffung at EnBW AG	16 February 2022
Eva Diess	Head of Plan and Build at Mer Germany GmbH	25 February 2022
Marc Anton	Assistant Vice President at KfW IPEX Bank	15 March 2022
Jennifer Carrasco Portaspana	Knowledge Expert & Team Manager at Boston Consulting Group	29 March 2022