35th International Electric Vehicle Symposium and Exhibition (EVS35)
Oslo, Norway, June 11-15, 2022

A data-driven charging infrastructure forecast and EV charging trends assessment for the decade ahead

Claudio Vittori[1], Darshak Parikh[2], Graham Evans[3]

[1]*Senior Analyst, Supply chain & technology, Automotive,*
IHS Markit (S&P Global Mobility), Claudio.Vittori@spglobal.com

[2]*Senior Analyst, Supply chain & technology, Automotive,*
IHS Markit (S&P Global Mobility), Darshak.Parikh@spglobal.com

[3]*Director, Supply chain & technology, Automotive,*
IHS Markit (S&P Global Mobility), Graham.Evans@spglobal.com

Summary

The rate of electric vehicle (EV) adoption will undoubtedly depend on the installation of EV charging infrastructure that is both sufficient in quantity and matches consumer expectations. While numerous charging technologies are available, it becomes challenging to arrive at an accurate EV charging infrastructure forecast that takes into consideration vehicle technology trends, customer expectations, and charging infrastructure type and capabilities. This study estimates the charging infrastructure deployment rate in the major global regions and further outlines the installation of charging infrastructure by type, level, and location for the coming decade. The results suggest that, while home charging is the most preferred option across the globe, the forecast penetration of public and semi-public infrastructure varies considerably across major regions. The figures suggest that annual installations will gradually increase to 2026 in Europe and stabilize after that.

Keywords: EV (electric vehicle), Charging, Infrastructure and EVSE (Electric Vehicle Supply Equipment)

1 Introduction

Vehicle electrification is one of the most impactful and long-term trends in the automotive industry. For OEMs to comply with impending carbon dioxide (CO_2) legislation and regional emissions targets, alternative propulsion vehicles are increasingly becoming a part of OEM product portfolios. The automotive industry is transitioning away from the conventional powertrain, with a medium- to long-term aim to make a complete transition to zero emission vehicles.

IHS Markit has a wide experience in data management and forecasting with more than 100 years of experience in the sector and is actively providing intelligence in the automotive business to all of the global OEMs and more than 90% of tier-1 suppliers. Our Supply Chain & Technology's E-Mobility team conducts a routine analysis of existing and future expectations on product development, supply chain dynamics, and regulations on all the aspects of the electrification business including batteries, electric powertrains, power electronics, and charging infrastructure, offering its clients a unique and holistic view, on how the vehicle is going to evolve in term of battery chemistries, voltage architecture, charging expectations and thermal strategies, among others.

Increasing penetration of plug-in electric vehicles (PEVs) — which include plug-in hybrid vehicles (PHEVs) and battery-electric vehicles (BEVs) — will drive the demand for domestic and public charging infrastructure; the former will aid in routine charging and the latter can facilitate out-of-the-ordinary charging applications for PEVs. At the same time, an adequate number of PEVs will make the charging infrastructure more viable, increasing their utilization rate, and, incentivizing the electric vehicle supply equipment (EVSE) manufacturers and charging point operators/e-mobility providers (CPOs/EMPs) to manufacture and deploy more charging stations.

In this paper, we have defined a data-driven approach to develop an EV charging infrastructure forecast[1] by tracking the vehicle level technology changes as well as EV charging technology trends across major global regions and leveraging an e-mobility consumer preference survey and regulatory and investment momentum, among other important macroeconomic factors.

2 Methodology

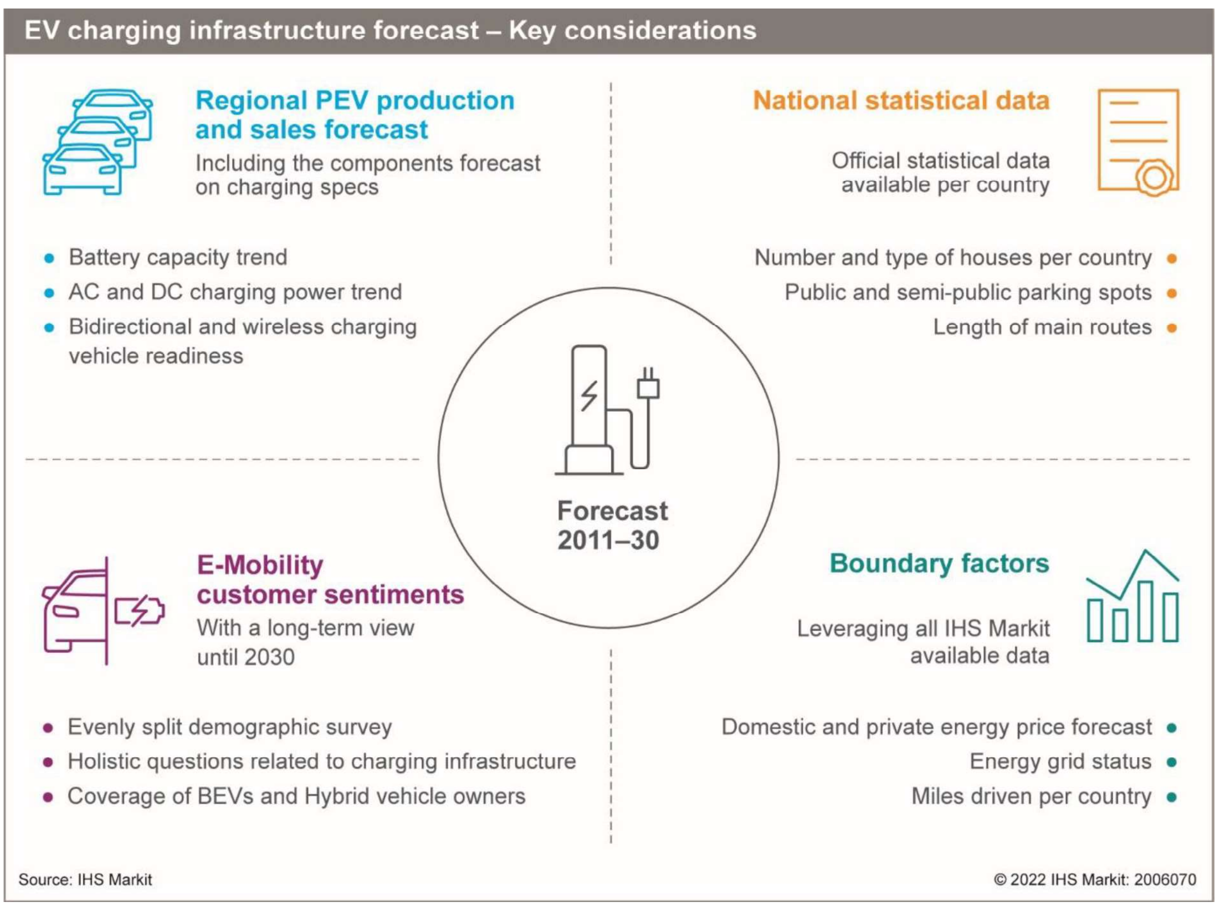

Figure1: EV charging infrastructure forecast – Key considerations

An accurate EV charging forecast is a function of factors such as vehicle-side technology trends, customer preferences, charging infrastructure technology trends and regional regulatory frameworks and incentives, coupled with the understanding of investment momentum. Our research takes into consideration each of these aspects to holistically arrive at the charging infrastructure forecast for the next 10 years.

$$C\_Infra(t) = \int_t f(c, v, r, i) * VO(t)\, dt \quad (1)$$

Where C_Infra is the total charging infrastructure in a given region at a given time. The function variables c,v,r, and i represent customer preference, vehicle technology trends, regulatory frameworks, and infrastructure technology trends respectively. The VO represents the total plug-in vehicles in operation at any given time.

The customer preferences for the type and location of the charging infrastructure are remarkably different across the major regions, for example, customers living in countries with dense populations, limited parking spots and limited residential parking are more inclined toward public charging, whereas customers living in affluent countries with adequate parking spots and dedicated residential parking, with multiple vehicle ownership, are more inclined toward a home charging infrastructure.

To understand consumer sentiment toward IHS Markit forecast technologies, our IHS Markit E-Mobility research team conducts an annual consumer survey that serves as a quantitative input to the forecast. By asking hybrid/EV owners and intenders a series of questions to gauge buying decisions, charging time, method preferences, willingness to pay for charging, and brand influences, IHS Markit analysts are able to develop indices related to consumer confidence and willingness to pay that are then factored into the E-Mobility forecasts.

During the recent IHS Markit E-Mobility consumer survey, a sample of 8,062 adult respondents aged 18 and older was evenly split across eight countries—the United States, Brazil, mainland China, India, Japan, South Korea, the United Kingdom, and Germany—to represent established and emerging markets alike and serve as reasonable proxies for other markets in that region while also reducing regional biases. IHS Markit analysts used a quota system in gathering samples for this survey to develop a representative sample of the region being studied. Quotas varied by country based on local demographics with gender, age, PEV ownership, and region, with splits being applied where necessary.

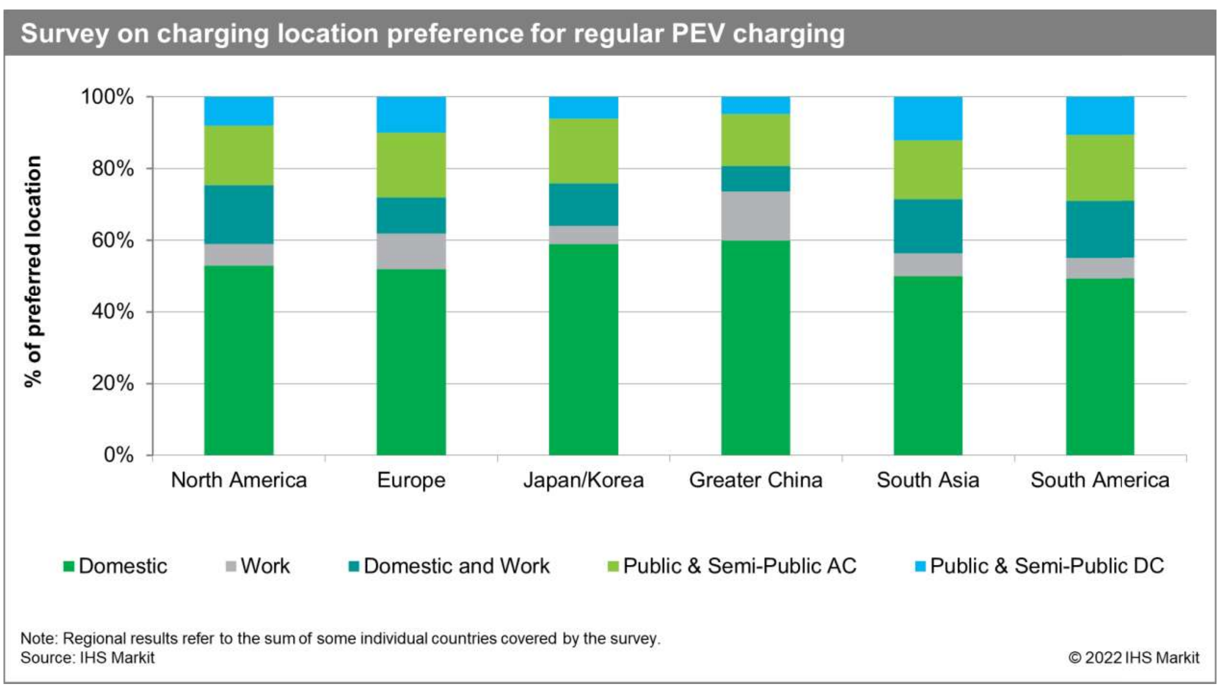

Figure2: Survey on charging location preference for regular PEV charging

Our survey results indicated that a large majority, 75% of responders worldwide, showcased a strong preference for domestic and workplace charging for regularly charging their vehicles. About 17% of responders preferred charging via AC public charging stations and a mere 8% of the responders preferred to charge via DC public fast-charging stations for regular charging needs. While regional factors influence the charging preference, domestic and workplace charging remains the most preferred charging means for regular use.

Penetration of various propulsion systems in a given region dictates the type and level/mode of the charging infrastructure. The charging time is driven by the allowable charging rate by the BMS and on-board power electronics capabilities. In case the on-board power electronics is not capable of handling power at a higher rate, the charging time will increase, placing the burden on the availability of the charging infrastructure. It should therefore be noted that charging power received is rarely linear.

For the purpose of the EV charging infrastructure forecast, we have defined the Levels/Modes of charging as follows. Level 1 or Mode 1 is the slowest type of charging equipment and refers to charging from the regular household 120V AC outlet, supplying power output up to 2.4 kW. Level 2 or Mode 2/3 refers to the charging from the 220–240V outlet or a dedicated wall-mounted domestic installation supplying average power output of 7 kW to 19 kW. Level 3 or Mode 4 charging refers to DC charging with power levels ranging from 25 kW to 300 kW.

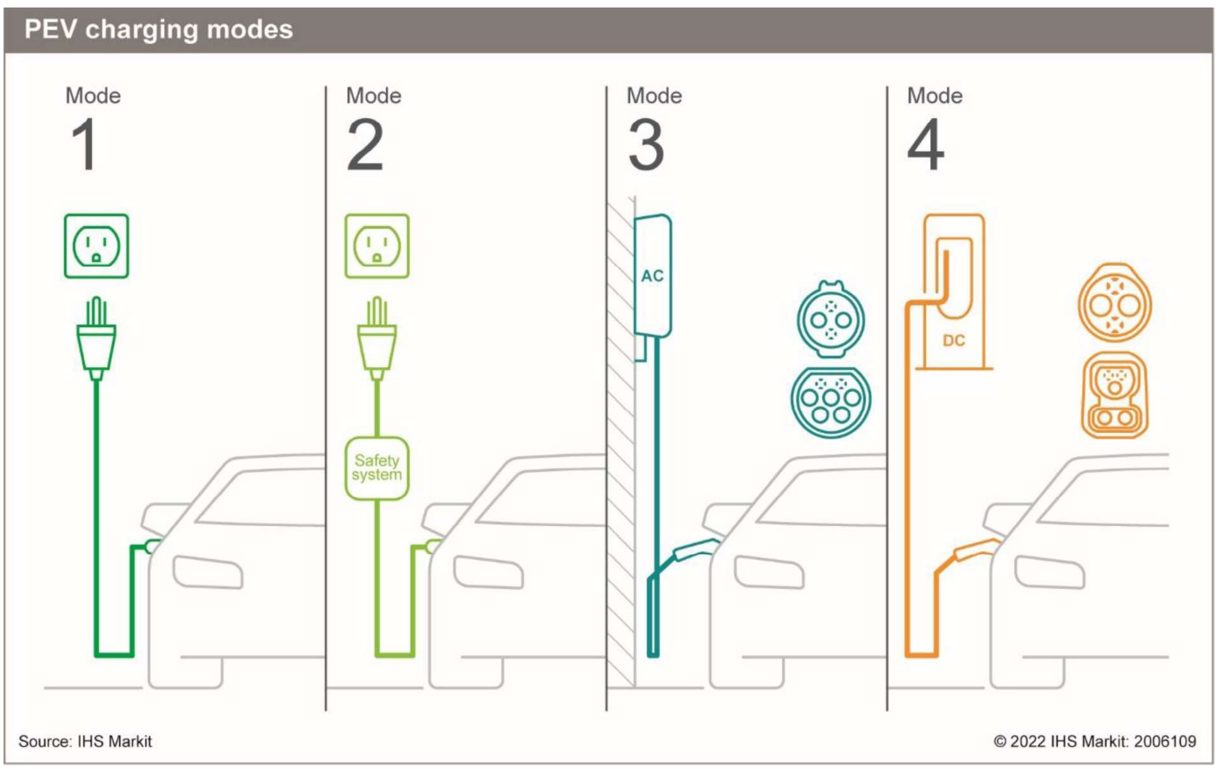

Figure3: PEV charging modes

Research concerning vehicle-side charging technology trends has been undertaken to understand the trends in battery voltage architecture, on-board charger (OBC) charging capabilities, etc, and has been reflected in the IHS Markit power electronics forecast[2]. This has then been used as an input parameter in the EV charging infrastructure forecast.

Apart from the customer sentiments and the vehicle-side charging technology trends, regulatory frameworks such as capital incentives, tax credits, rebates, and grants coupled with installation mandates and investment momentum expedite the deployment of EV charging infrastructure. An index reflecting the regulatory framework of different regions has been prepared for the forecast period and used as an input factor in the forecast.

The IHS Markit forecast takes regional 2021 charging station installations as defining parameters and one of the boundary conditions for the research. Additionally, IHS Markit has data on the deployment of EV charging stations for all the regions under consideration starting from 2011 to 2020 and leverages this information to further validate the forecast model.

It is important to note that the research accounts for EVSE stations and therefore simultaneous charging opportunities, rather than for plugs, piles, connectors, or locations. At any individual station, it is possible that the number of plugs available can exceed the number of vehicles that can charge simultaneously and might present a misleading picture of the region's charging infrastructure availability. Furthermore, it has been assumed that any charging station, either captive or non-captive, available to the public is considered as public and no distinction has been made to distinguish between public and what might be termed semi-public charging stations, which have some restrictions on usage.

In terms of forecast modeling, statistical time-series forecasting models such as moving average models, autoregressive moving average models, autoregressive moving average models, and autoregressive integrated models are inadequate for the forecasting purposes as these models heavily rely on the historical data to forecast future requirements. Considering the dynamic nature of the EV charging infrastructure market, and a wide range of factors influencing their deployment, it is important to consider these in the modeling algorithm to derive a reasonably accurate forecast.

To give an example, the EV charging infrastructure deployment forecast is not only dependent on the number of PEVs on road in the vicinity of the charging station but would be influenced by the number of people residing in that region and the percentage of those deciding to opt for a PEV in the future, vehicle ownership patterns, availability of parking spots, customer charging preferences, vehicle driving cycle and duty cycle patterns, average vehicle battery size, on-board charging capabilities and economic factors among others.

For example, in Greater China, public charging infrastructure represents 39% of the total charging stations installed by 2021 in the region, whereas in equally mature EV markets such as Europe and North America, the public charging infrastructure is a mere 8% and 16% of the total charging infrastructure in the region respectively. Such diverse deployment can be attributed to a multitude of factors mentioned in the previous paragraph.

3 Vehicle side charging technology trends

The charging infrastructure forecast model is based on the IHS Markit data underpinned by vehicle sales and production data, consumer survey results and the granular analysis that the E-Mobility team conducts daily on existing and future expectations on product development, supply chain dynamics, and regulations impacting the EV development. Some of this information concerning charging aspects are made available to define the future outlook on charging infrastructure.

The researched aspects of the vehicle-side charging technology cover both AC and DC charging capabilities for existing and future vehicles, the market deployment of charging connectors, as well as the emerging technologies such as wireless charging adoption, the bidirectional capability of vehicles in AC charging, as well the battery swapping technological ramp-up.

The upcoming infographic highlights the various coupling approaches available for PEV charging, and the components involved in the charging process. During the Level 1 & 2 (Mode 1,2 and 3) charging process, the incoming AC power from the grid is converted into DC power by the OBC and supplied to the battery pack. Since OBCs are constrained by the size, cost, and weight, they might not be capable of converting all the AC power coming from the grid and might act as a bottleneck during the AC charging process.

In the AC charging process, the OBC plays an important role, and usually presents a bottleneck in Level 2/Mode 3 AC charging, when the wallbox power output is higher than the peak OBC power output, the vehicle will charge at peak OBC power rate, limiting the speed of charging. For this reason, an accurate understanding of future accessible power might be worth knowing when we look at charging infrastructure deployment.

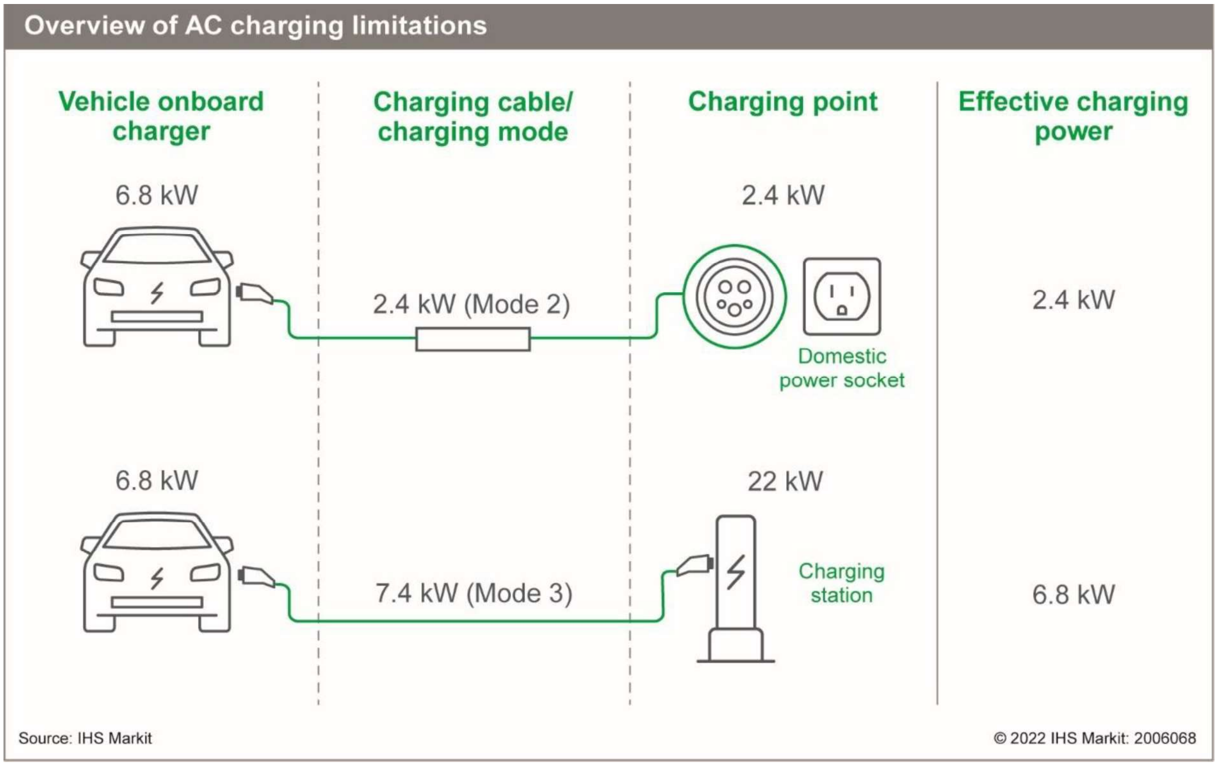

Figure4: Overview of AC charging limitations

Our research suggests that more than 50% of the PEVs manufactured in 2021 were equipped with OBCs with peak charging power below 8kW.

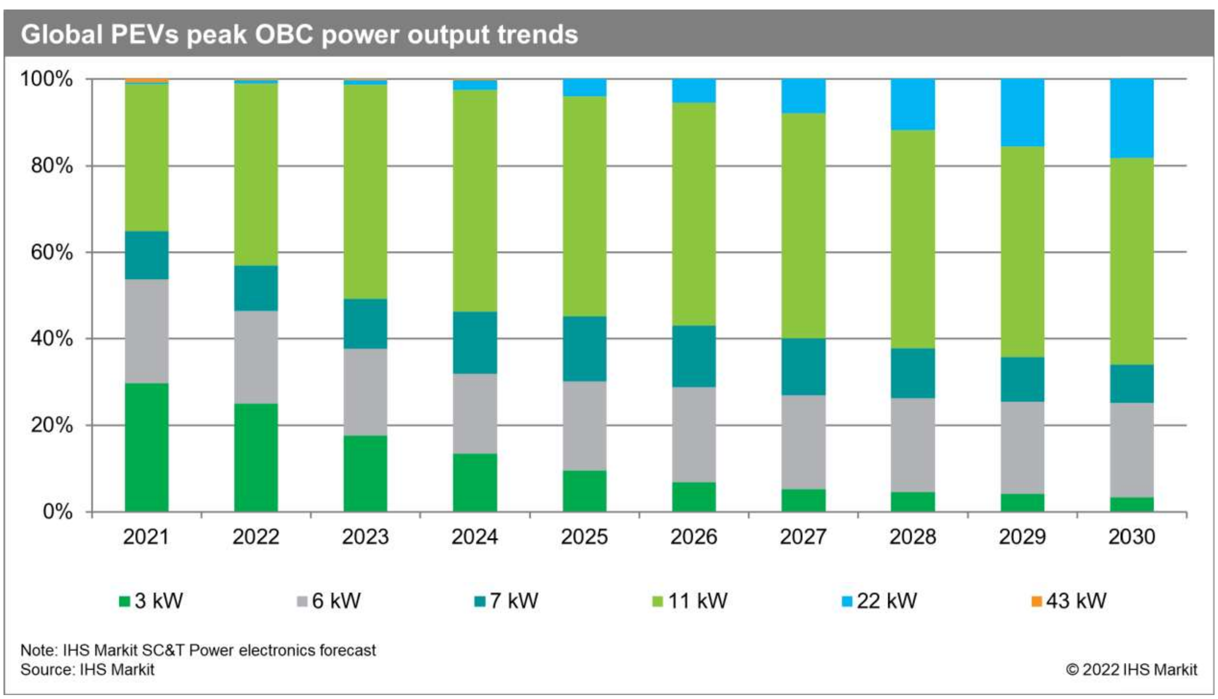

Figure5: Global PEVs peak OBC power output trends

IHS Markit power electronics forecast suggests that deployment of 11kW peak charging power OBCs will become the most preferred solution and will account for more than 50% of the component demand in 2027 and about 55% of the BEVs produced in 2030. Although the 22kW peak OBC power is still a niche application today, IHS Markit forecasts that about 23% of BEVs manufactured in 2030 will be equipped with 22kW OBC peak power, most likely deployed in premium long-range BEVs.

In the DC charging process, the grid AC power is converted into DC power by the external DC Fast Charging (DCFC) equipment and is then directly supplied to the battery pack. DC fast charging process bypasses all the limitations of the OBC and provides the DC power directly to the battery. Since the DC charging process isn't constrained by the OBC, the charging speeds can be considerably higher, although limited by the maximum energy battery can absorb, depending on battery chemistry, type and size.

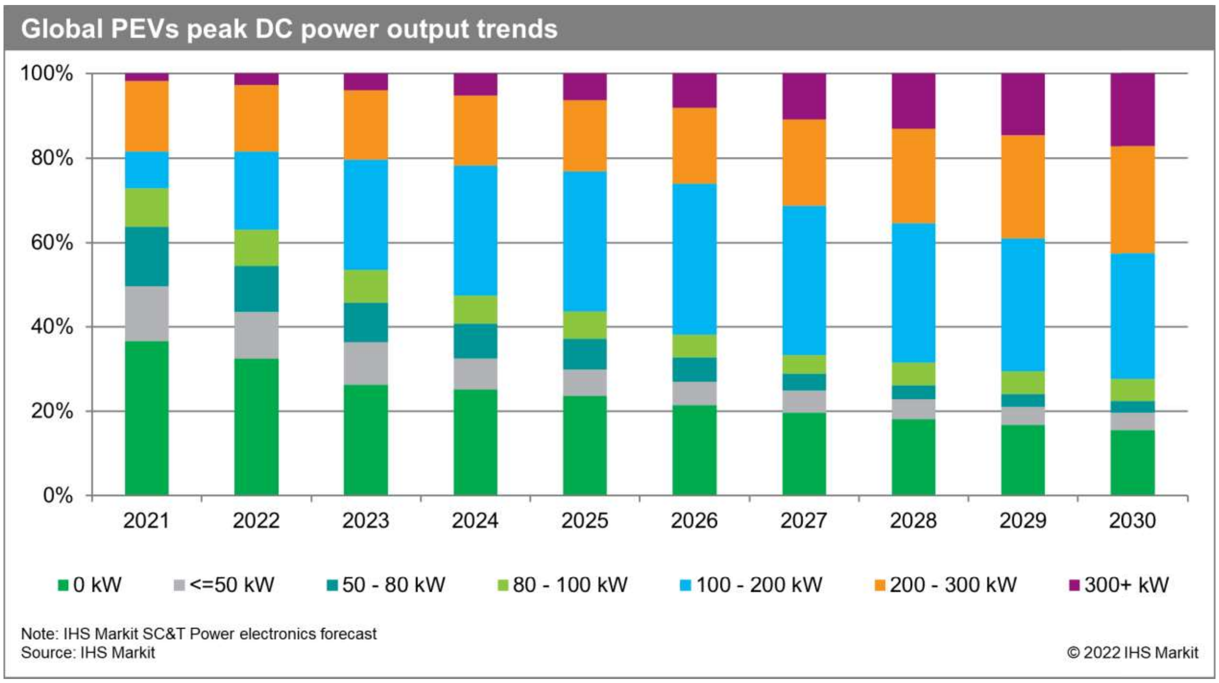

Figure6: Global PEVs peak DC power output trends

The DC fast charging rate varies significantly from 50 kW to about 300kW at present for the light vehicle segment, and the market remains fragmented. By 2025, we estimate that the majority of vehicles will be able to charge at 100–200 kW and that 200–300 kW DC fast charging will be gaining momentum across a broader swathe of the market and more mainstream vehicle sectors by 2030.

Based on our research, about 40% of the BEVs manufactured in 2021 were capable of peak DC charging above 100 kW. IHS Markit forecasts 150 kW to be the most regularly deployed fast-charging rate out to 2025, and about 50% of the BEV production in 2030 will be able to charge at or about 200 kW.

The DC fast charging at or about 300 kW is expected to remain a niche application during 2020–30 and will largely be limited to certain premium vehicles such as Porche Taycan, with the majority of the BEVs having ~400V system voltage, limiting the fast-charging rate to 150 kW. In the short-to-medium term, vehicle charging performance will be a challenge for faster consumer acceptance of PEVs until vehicle technology catches up with performance improvements on the infrastructure side.

Our research suggests that automakers have been looking at high-voltage architectures to address the concerns associated with range anxiety. Some of the recent introductions such as Porsche Taycan and Audi E-tron GT are based on the 800V electric powertrain architecture. The 800V architecture provides significant benefits in terms of faster charging, compact and lightweight wirings, improved performance and efficiency, and better energy regeneration during braking.

IHS Markit light vehicle powertrain forecast suggests that more than 2.5 million BEVs produced in 2030 will have a system voltage of around 800V which would support ultra-fast DC charging beyond 300kW. It remains feasible, however, that with economies of scale such high voltage architectures could move down market to volume sectors, with OEMs such as Hyundai-Kia acknowledging that 800V will be deployed on their vehicles this decade.

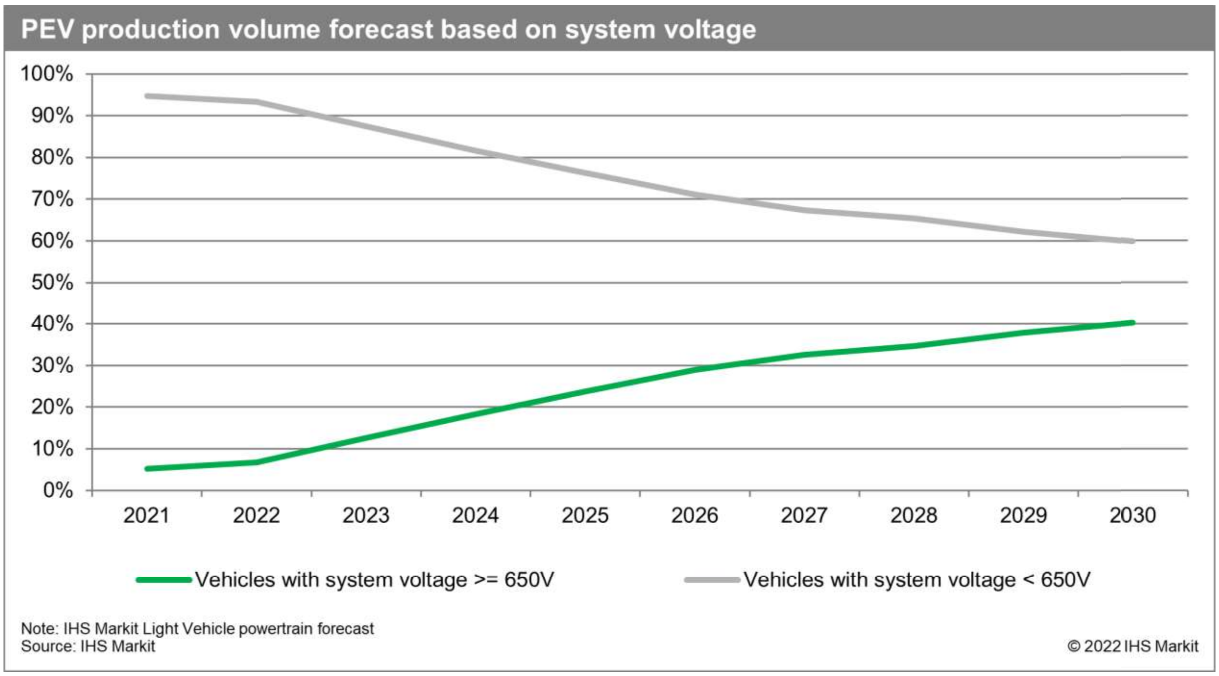

Figure7: PEV production volume forecast based on system voltage

In terms of the connector type used, for both AC and DC charging, the connectors used are driven by geographical preference. In Europe CCS Type 2 and CHAdeMO make up most chargers in Europe. CCS Type 1, Tesla Supercharger, and CHAdeMO make up most chargers in North America. GB/T has been the connector of preference in Greater China. An important development in the DC fast charging domain is the introduction of the ChaoJi connector, which will combine CHAdeMO and GB/T connectors into a single CAN-based connector. ChaoJi standard increases the maximum power transfer to 900 kW, using the liquid-cooled cable that can handle current up to 600A and enable bidirectional charging capability, with backward compatibility with CHAdeMO and GB/T.

The Greater China region is witnessing a transition from the GB/T connector to the ChaoJi connector, and our research suggests that more than 80% of vehicles produced in 2027 will be equipped with ChaoJi connector. On the other hand, the North American region is witnessing an increasing deployment of vehicles with CCS Combo 1 connector, reducing the relative % of Tesla connector deployment, but this is largely driven by the increasing PEV volume from automakers other than Tesla. Europe is largely relying on CCS Combo 2 connector, ensuring broader commonality.

An important benefit of the transition from conventional to electrified powertrains is that the vehicle, if equipped with an OBC that offer bidirectionality, can supply energy back to another vehicle, home, or grid. While not all the BEVs are equipped with a bidirectional charging feature, IHS Markit estimates that more than 50% of BEVs produced in 2030 will be equipped with bidirectional charging feature, compared to less than 10% in 2020.

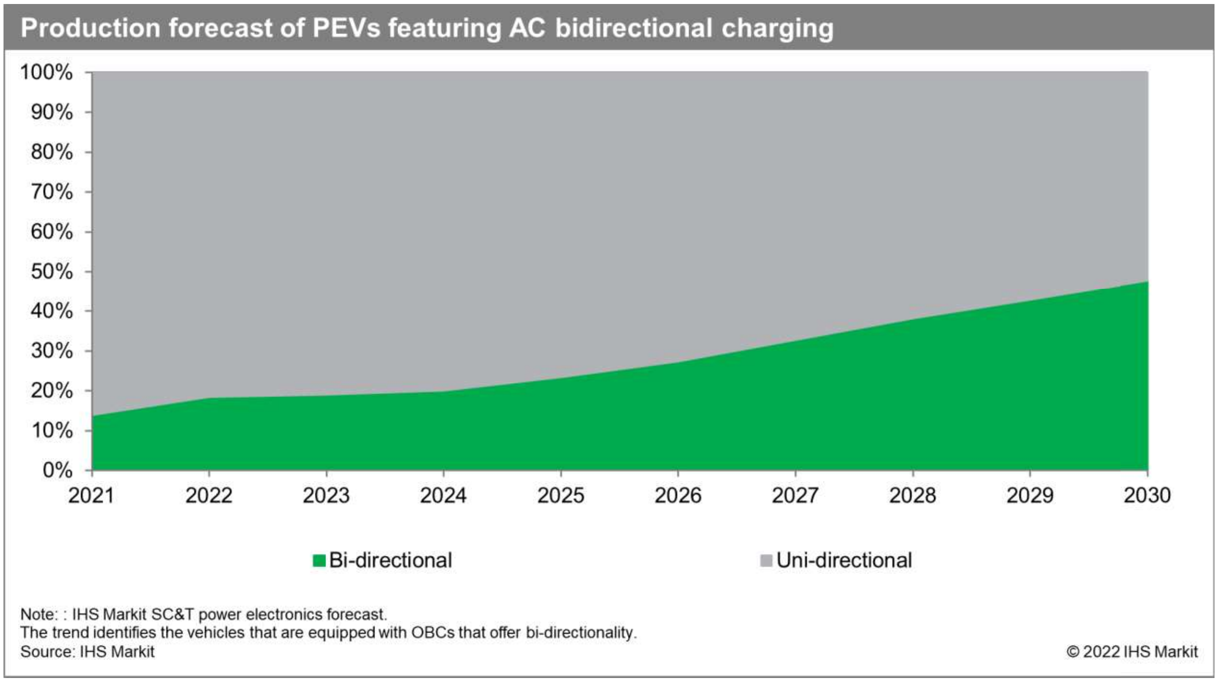

Figure8: Production forecast of PEVs featuring AC bidirectional charging

Although wireless charging is not prominent today, our research suggests that its deployment will increase marginally by 2030. About two in every thousand PEVs by 2030 will be equipped with a wireless charging system, compared to less than 0.5 PEVs per thousand today. Similarly, battery swapping is also currently gaining momentum in Greater China. The implications of battery swapping, and wireless charging on demand for conventional plug-in charging need to be accounted for, whilst considering the differing charging infrastructure deployment across regions.

4 Charging infrastructure trends

Depending on the location of the charging apparatus, the infrastructure can be categorized as domestic and public/semi-public. Domestic charging is the simplest form of charging EVs. Domestic charging refers to any charging station deployed in a private residence or multioccupancy building, and the use of the station is limited to the owners of the charging station.

Regional factors influence the charging infrastructure deployment significantly, largely driven by customer preference and infrastructure readiness. The type and location of EV charging infrastructure vary across the major regions. The Greater China and European regions are leading in terms of both PEV deployment and EV charging infrastructure deployment. By 2020, circa 21% of the global AC charging stations and more than 70% of the global DC charging stations were concentrated in the Greater China region.

As indicated in the following chart, Greater China, Japan, and South Korea have witnessed higher penetration of public charging infrastructure compared to Europe and North America. In the Greater China region, about 39% of the charging stations are available publicly, compared to just 16% in North America and only 8% in Europe. The stark difference in terms of charging station deployment can be attributed to a lack of adequate parking and charging spaces in domestic areas in densely populated Asian countries, leading to higher reliance on the public and semi-public charging stations.

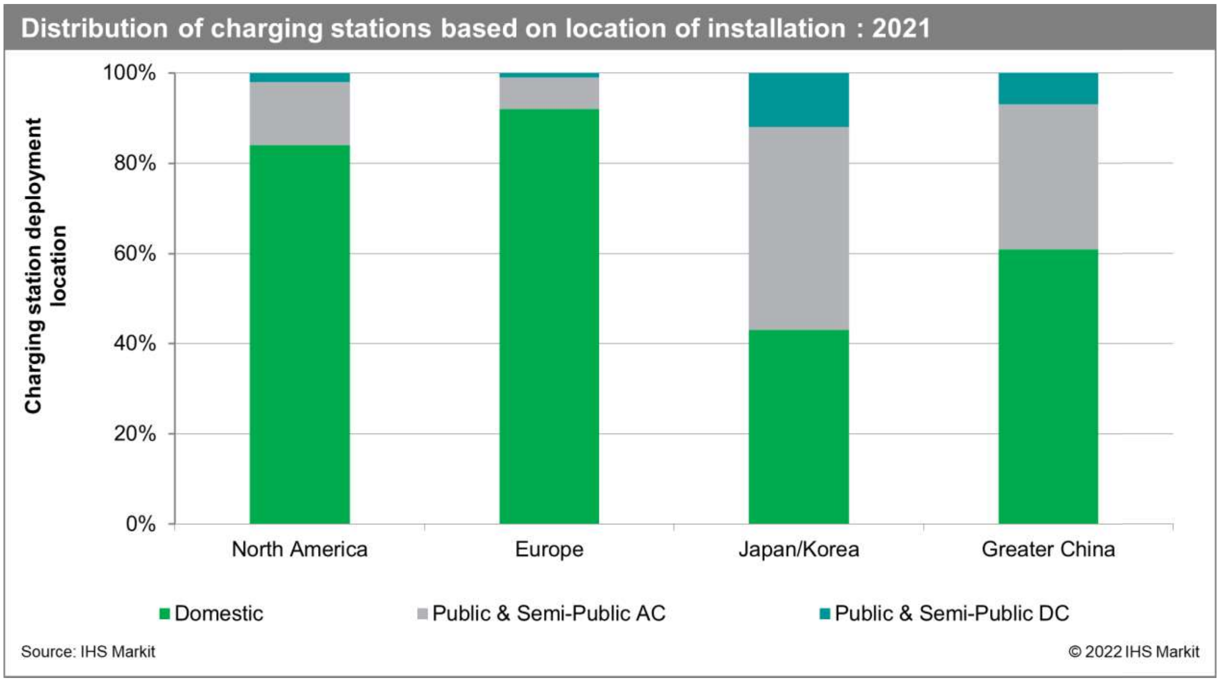

Figure9: Distribution of charging stations based on region & location of installations, 2021

The deployment of DC charging stations was more widespread in Greater China compared to other regions, whereas in Europe, the deployment of AC charging stations has been more typical to date by virtue of consumers adopting wallboxes for domestic applications. . Europe is home to about 57% of global AC charging stations yet accounts for only about 10% of the global DC charging stations deployed cumulatively.

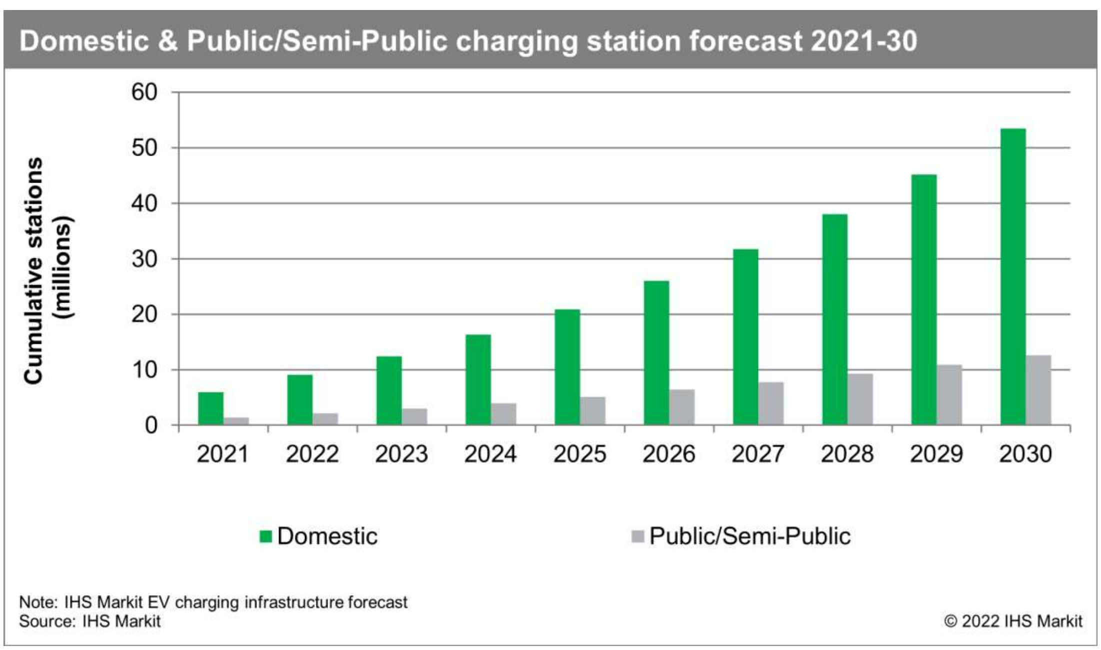

Figure10: Domestic & Public/Semi-Public charging station forecast 2021-30

Our research suggests that a total of 4.2 million AC charging stations were deployed globally by 2020, of which 3.6 million stations were installed at home, and the remaining were public/semi-public charging stations. IHS

Markit forecasts that, by 2030, the cumulative deployment of AC charging stations will increase to 65 million units, a massive 31% compound average growth rate (CAGR). Of the 65 million forecasts in 2030, circa 53 million stations are expected to be domestic and the rest public/semi-public locations.

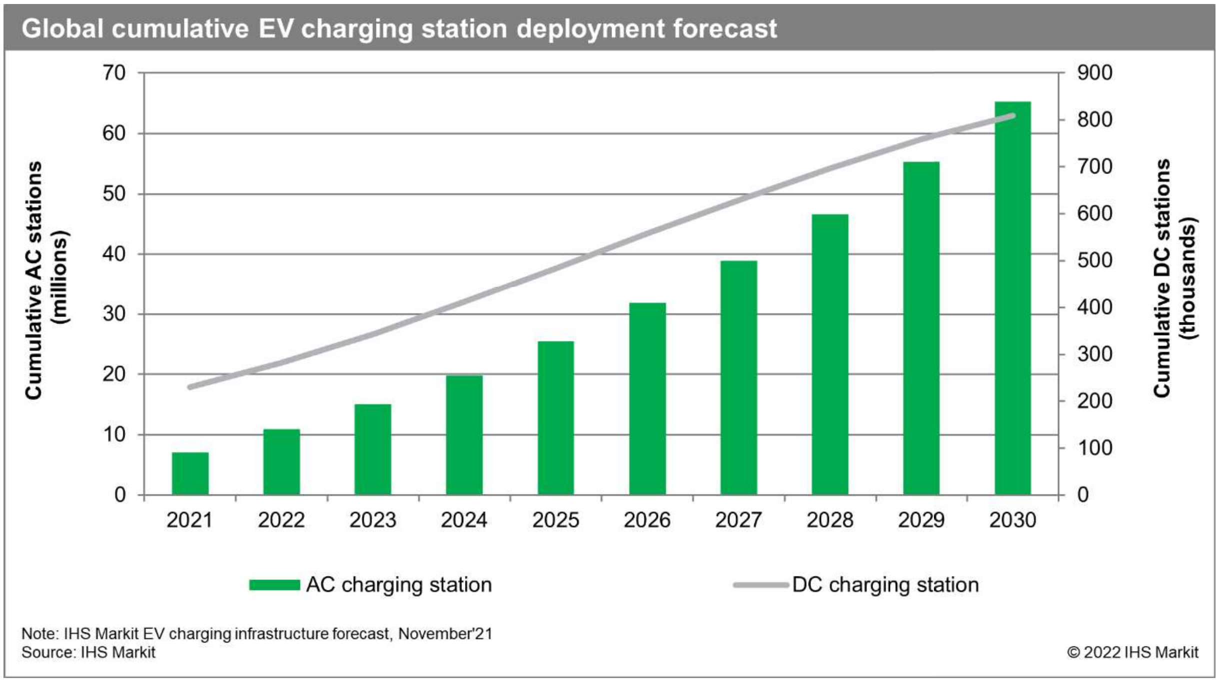

Figure11: Global cumulative EV charging station deployment forecast

Similarly, the cumulative DC charging stations deployed globally was around 200,000 by 2020 and will quadruple to more than 800,000 units by 2030, growing at a relatively modest 14% CAGR. This can largely be explained by the increasing range of electric vehicles, allowing customers to store more energy in the vehicle via domestic overnight charging, and in turn, reducing the need of expensive DC public charging.

5 Conclusion

Increasing penetration of PEVs will drive the demand for domestic and public charging infrastructure; the former will aid in routine charging and the latter can facilitate out of the ordinary applications. At the same time, an adequate number of PEVs will make the charging infrastructure more commercially viable, increasing their utilization rate, and hence, incentivizing the EVSE manufacturers and CPOs/EMPs to manufacture and deploy more charging stations.

According to the IHS Markit EV charging infrastructure forecast, the global deployment of EV charging stations will increase from 2020 at a massive 31% CAGR to more than 66 million units by 2030. The preferences for the type and location of the charging infrastructure are remarkably different across the major regions, with the mainland China region expected to account for more than 60% of the global public charging stations by 2030.

The increasing deployment of charging infrastructure, along with the developments on the vehicle side, will influence the EV ecosystem. The 800V electric powertrain architecture will allow charging rates as high as 350 kW, further reducing the charging time to about 20 minutes. The upcoming Chaoji standard, which is an integration of both GB/T and CHAdeMO standards, is expected to hold a leading share of the DC connector market by 2030. Additionally, majority of the BEVs produced in 2030 are expected to be capable of AC charging up to 11 kW and DC charging at or above 100 kW.

The methodology employed here to build a forecast of electric vehicle charging infrastructure reflects the application of a broad array of what might be termed ‘top down’ forecast inputs, such as GDP per capita and housing type, married to ‘bottom up’ research of individual vehicle specifications, such as onboard charger power level and system voltage. These, married to IHS Markit Supply Chain and Technology (S&P Global Mobility) forecasts of both vehicle sales and production, help identify demand.

At IHS Markit Automotive (S&P Global Mobility), we continue to broaden and refine this methodology through increased application of external inputs, acknowledging the changing landscape over time driven by factors such as increased EV ranges, alternative vehicle use cases, local needs and applications of shared mobility. Superior methodologies and more granular data will support a broader array of use cases and more accurate forecasting in future iterations.

6 References

[1] IHS Markit Charging infrastructure forecast

[2] IHS Markit Supply Chain & Technology power electronics forecast

[3] IHS Markit Light Vehicle powertrain forecast

Authors

Claudio Vittori is a Senior Analyst at IHS Markit, working within the Automotive division and focusing on supply chain analysis and components technology assessments. His research interests lie in Electric Vehicle components and charging infrastructure. Prior to joining IHS Markit, Claudio has worked, in the last nine years, on some of the largest European electric vehicle projects in Switzerland, Germany and Italy with tasks ranging from researching, project management, consultancy and business planning. His expertise also includes a work experience in an international electric vehicle start-up.

Darshak Parikh is a Senior Analyst working with the Automotive Supply Chain and Technology team at IHS Markit. He is responsible for the primary and secondary research on technologies and market developments entailing Electric Mobility, with specific interests in electric powertrain, EV charging infrastructure, and BEV start-ups. Prior to joining IHS Markit, he was part of the engineering team at Mahindra & Mahindra’s R&D unit, leading the development of BEVs in the South Asia region, and is actively involved in the EV ecosystem in India. His experience ranges from product development, strategy, and product planning to market research. Darshak holds a Master’s degree in Automotive Engineering from IIT Gandhinagar, India.

Graham is Director, Supply Chain and Technology within the Automotive department at S&P Global Mobility. He leads and manages the global research practice for Propulsion, Battery, Charging and Thermal Systems component forecasting, comprising fifteen analysts based in major automotive markets. Previously employed within Engineering, Graham has 10 years’ experience in Powertrain Development and Noise, Vibration and Harshness (NVH) having previously worked for Ricardo, Bentley Motors and Jaguar Land Rover. He joined IHS Markit in 2016. IHS Markit merged with S&P Global in March 2022. Graham graduated from Loughborough University in the UK with a Master’s Degree in Automotive Engineering and is a Chartered Member of the Institution of Mechanical Engineers.