The long and winding road

Fast-charging infrastructure for EVs

Edison themes

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Road transport accounts for c 16% of global carbon dioxide emissions so widespread adoption of electric vehicles (EVs) is essential if governments are to achieve their net zero ambitions. This report explores how the roll-out of EV rapid-charging infrastructure is central to EV adoption and how battery-buffered rapid-charging systems from companies such as ADS-TEC Energy ensure that rapid-charging infrastructure is available everywhere drivers need it, regardless of the condition of the local power grid.

EV charging infrastructure key to achieving net zero

The International Energy Agency (IEA) calculates that to achieve its Net Zero Emissions by 2050 Scenario, the global EV car fleet needs to expand to over 300m by 2030, with EVs accounting for 60% of all new car sales. Since the adoption of EVs has been held back by the higher purchase cost and the availability of publicly available rapid-charging points, governments keen for their citizens to transition to EVs are making material investments in charging infrastructure.

Infrastructure enhancements required

The IEA expects only a modest increase in total demand for electricity associated with EVs by 2030. However, the distribution infrastructure in rural areas is typically sized for low loads and slow predicted load growth so it may not have the capacity required to support a motorway service station with multiple fast-charging points. One option for a potential charge-point owner is to apply for the local power grid to be upgraded, which is a lengthy process requiring high capital costs. The alternative is to deploy battery-buffered charging points such as those from ADS-TEC. Here, an integrated battery storage system charges slowly from the grid power available, even if it is low, and stores the energy until needed. These battery-buffered charging points can be installed quickly and relatively inexpensively. Since a battery-buffered system can charge outside peak tariff times, the operating costs of battery-buffered systems are typically lower than for non-battery-buffered systems as well.

Investing in EV charging infrastructure

There are investment opportunities at every level of the charging infrastructure supply chain: critical materials; power electronic components; equipment providers; charge-point operators; and investment trusts. This report focuses on companies supplying charging systems. These systems can be split into DC-based fast-charging systems, which may potentially be battery-buffered, and AC wallboxes for residential use. In our opinion, fast-charging systems provide more opportunity to create differentiated high-margin product than consumer wallboxes.

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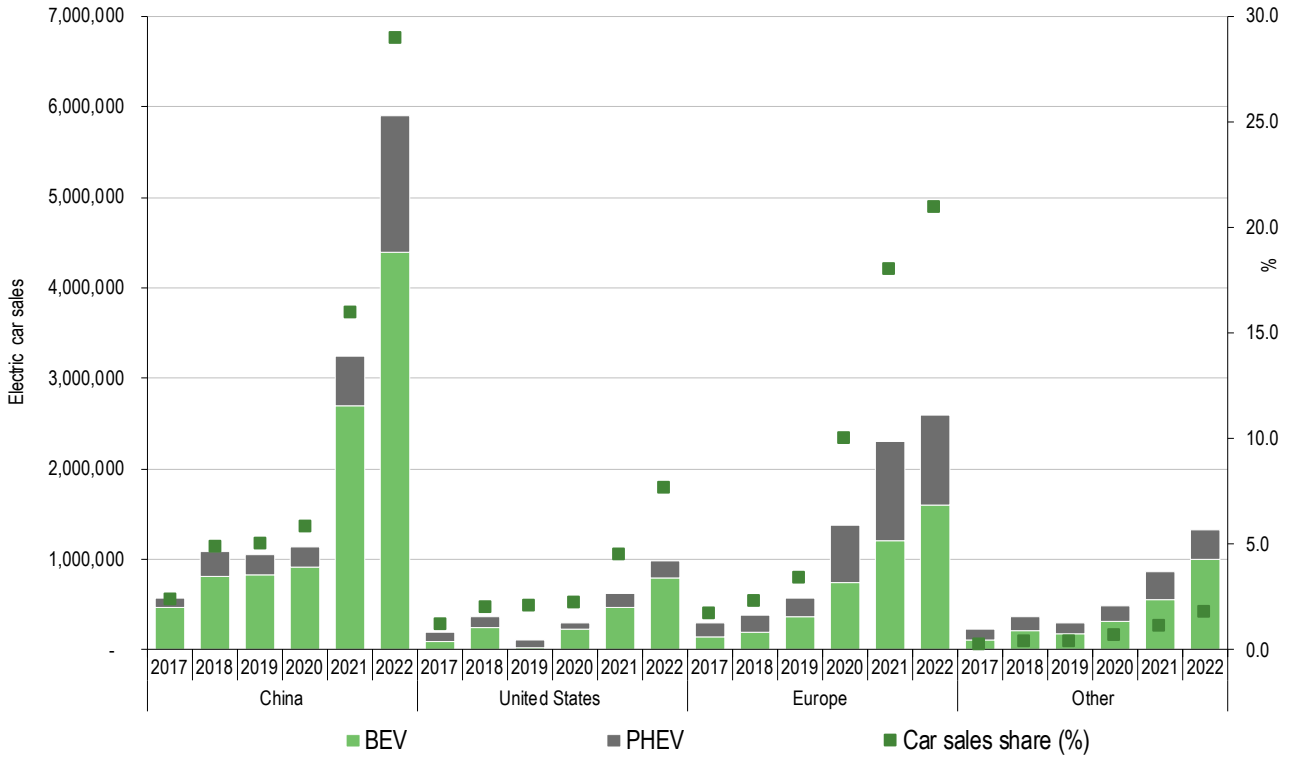
Expansion of EV charging infrastructure critical for achieving net zero

According to the IEA, road transport accounts for 16% of global carbon dioxide (CO_2) emissions, so a widespread adoption of EVs is essential if governments are to achieve their net zero ambitions. The IEA calculates that to achieve its Net Zero Emissions by 2050 Scenario, the global EV car fleet needs to expand to over 300m by 2030, with electric cars accounting for 60% of all new car sales. This compares with global EV sales of 10.5m in 2022 (source: EV-volumes), which was a 55% year-on-year increase and represented 13% of global light vehicle sales. EV-volumes predicts sales of 14.3m EVs in 2023 (ie year-on-year growth of 36%), taking the number of EVs in operation globally to 40m.

Government targets for EV adoption

Governments across the globe have set targets for EV adoption. For example, in August 2021, US President Joe Biden signed an executive order setting an ambitious target to make 50% of all new vehicles sold in 2030 zero-emissions vehicles (ie battery electric, plug-in hybrid electric or fuel cell electric vehicles). Achieving this target would facilitate reaching the president's goal of cutting net greenhouse gas emissions nationally by 50–52% compared to 2005 levels by 2030 and getting to net zero by 2050. As part of the European Union's 'Fit for 55' package, which is intended to enable the region to reduce its net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels and to achieve climate neutrality in 2050, the EU announced regulations in March 2023 specifically for major automotive manufacturers. The new regulations require a 55% reduction in CO_2 emissions for new cars from 2030 to 2034 compared to 2021 levels and a 100% reduction in CO_2 emissions for new cars from 2035, which in effect bans the sale of conventionally powered cars from that point.

Exhibit 1: Electric car registrations and sales share in selected countries, 2017–22



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Greater adoption of EVs has also been promoted by governments as a way of reducing reliance on oil imports from Russia, which many Western governments consider desirable both as a short-term response to the invasion of Ukraine in February 2022 and as a longer-term strategic move. The IEA's 10-point plan for advanced economies to cut oil usage by 2.7bn barrels per day over a four-month period shortly after the invasion included reinforcing the adoption of electric and more efficient vehicles as a way of saving around 100,000 barrels per day.

Despite these government initiatives, adoption of EVs has been held back by the higher purchase cost and the availability of charging infrastructure.

Fast-charging infrastructure a prerequisite for EV adoption

At present, most EV owners charge their vehicles at home or at their place of work. But for EV adoption to accelerate at the rate required for governments to meet their net zero targets, access to public charging networks will need to improve. The ubiquitous availability of public charging points will encourage a switch to EVs by consumers who sometimes need to make long journeys by car, or who are not able to charge a vehicle at home because they have to park on the street.

The top-selling battery EV in 2022 was the Tesla Model Y. It is equipped with a CATL LFP60 battery with 60kWh nominal capacity, having an estimated range of 150 to 310 miles, depending on the external temperature and whether the vehicle is being driven in a city or at a constant speed on an open highway. The battery takes nine hours and 15 minutes to charge fully at home, unless the property has a three-phase grid connection, in which case the charge time reduces to six hours and 15 minutes. The battery capacity means that a driver cannot travel from London to Edinburgh, a distance of 400 miles, or from Munich to Berlin, a distance of 365 miles, without stopping at a fast-charging point during the journey. The time taken to charge at a fast-charging point is around 25 minutes.

Government support for fast-charging network roll-out

The US administration's 2021 Infrastructure Investment and Jobs Act allocates $7.5bn funding to support the buildout of a national public EV charging network. In February 2023, the US Department of Transportation announced the National Electric Vehicle Infrastructure (NEVI) programme, a $5bn initiative to create a coast-to-coast network of EV chargers focused on major highways. The initiative supports the president's public commitment to build a convenient, reliable and user-friendly national network of 500k EV chargers by 2030. Concurrently in February 2023, the Federal Highway Administration (FHWA) unveiled new national standards for federally funded EV chargers, including NEVI-funded chargers, which cover connector types, payment methods, data privacy, speed and power of chargers and reliability (97% uptime required) so that charging is predictable and dependable on whatever EV is being driven. The FHWA also announced that all EV chargers funded through the 2021 Infrastructure Act must be built in the United States. Tesla is to open a portion of its US Supercharger and Destination Charger network to non-Tesla EVs in support of the NEVI programme. This action will make at least 7,500 chargers available for all EVs by the end of 2024. Tesla's accessible chargers will include at least 3,500 new and existing 250kW Superchargers along highway corridors as well as Destination Chargers at locations such as hotels and restaurants in urban and rural locations. All EV drivers will be able to access these stations using the Tesla app or website.

In October 2022, the European Parliament adopted minimum requirements for EV charging infrastructure that require member states to build EV charging points at least every 60km on main roads. Under this Alternative Fuels Infrastructure Regulation, member states have until the end of 2025 to install the charging points required for passenger cars and the end of 2030 to install charging points for trucks. In October 2021, the European Investment Bank and European Commission signed an agreement making over €1.5bn in EU grants available by the end of 2023 for alternative fuels infrastructure, including electric fast-charging stations.

In March 2022, the UK government announced plans intended to increase the number of public EV charge points in the UK market to 300k by 2030, which is roughly five times the number of fuel pumps in operation at present. £500m will be invested in public charge points for communities across the UK, of which £450m is allocated to the Local Electric Vehicle Infrastructure fund, which will boost projects such as EV hubs and on-street charging to give charge point access to drivers without their own driveways and therefore no potential for installing a charge point. This is in addition to the existing £950m Rapid Charging Fund, intended to support the roll-out of at least 6,000 high-powered super-fast charge points across England's motorways by 2035.

Exhibit 2: ChargeBox fast-charging point at Aral site in Germany

Source: ADS-TEC Energy

Exhibit 3: ChargePost fast-charging point in Limburg, Germany

Source: ADS-TEC Energy

EV charging infrastructure market growth

EU

An analysis published by McKinsey in November 2022, conducted for the European Automobile Manufacturers' Association, noted that there were around 375k charging stations in the EU in 2021 and suggested that, even in the most conservative scenario, the EU-27 would need at least 3.4m operational public charge points by 2030. This figure excluded the estimated 29m private charging stations that homeowners, apartment building managers and workplace parking operators would have to install. This scenario would require an acceleration from about 1,600 installations of public charge points a week in 2021 to 6,000 a week by 2025 and more than 10,500 a week in 2030. The report calculated that the infrastructure required to support EV roll-out would cost a cumulative total of €240bn for hardware and installation by 2030. This includes installing new public charge points (c 20% of the total), installing new private charge points (c 40%), upgrading the grid (c 15%) and increasing renewable-energy generation capacity (c 25%).

US

A report from PWC published in September 2022 predicted that the number of charge points in the US would grow from about 4m at that time to an estimated 35m in 2030, of which single-unit and multi-unit residential segments would account for 22m and 6m charge points, respectively. It also predicted that the US EV equipment supply market would grow from $7–8bn in 2022, of which 46% related to hardware and a negligible proportion to software, to $16–19bn in 2025, of which 35% related to hardware and a negligible proportion to software, and to $88–107bn in 2040, of which 20% related to hardware and 5% to software.

Enhancements required to infrastructure

Additional electricity demand linked to EVs modest

According to the IEA's Global EV Outlook, electricity demand from EVs currently accounts for less than half a percent of total final electricity consumption worldwide. The organisation predicts that by 2030, electricity demand for EVs will account for at least 2% of final electricity consumption globally. Electricity demand is also likely to increase as consumers switch from gas to electric heating or start to use air-conditioning to combat the effect of climate change. Assuming that governments are serious about reducing greenhouse gas emissions, this additional demand will be met from

renewable sources. This means that in addition to dealing with a potential increase in demand overall, utilities will need to cope with the challenges of balancing supply and demand as an increasing proportion of generation is attributable to renewable sources, which are by their nature intermittent (see our report on battery energy storage systems). Achieving this balance will be even more difficult when the sudden spikes in demand when fast-chargers are activated are taken into consideration.

Demand spikes from fast charging more problematic

The IEA concludes that fast charging will have to be carefully managed to avoid exceeding peak load capacity. The organisation recommends that time-sensitive consumer tariffs should be used to incentivise drivers to charge their EV when it does not stress the network or when output from renewables is high. Similarly, the McKinsey analysis cited above notes that EVs will put less strain on the grid in residential neighbourhoods because while many vehicles could be charging simultaneously, for example in preparation for morning commutes, these neighbourhoods would be able to rely mainly on relatively slow AC chargers drawing as little as 3–11kW. In contrast, if a driver wants to charge their EV within minutes, the charging point needs to be able to deliver a high charging power of around 300kW. This means that motorway rest stops with public fast-charging points could experience extreme peak loads at busy times. Since the distribution infrastructure in rural areas is typically sized for low loads and slow predicted load growth, it may only be able to provide around 60kW and thus not have the capacity required to support a motorway service station with multiple fast-charging points.

Grid limitations favour battery-buffered solutions

One solution for a potential charge-point owner, for example a supermarket or someone operating a fleet of electric delivery vehicles, is to apply for the local grid to be upgraded. This could take at least a year and cost between $0.1–2m per megawatt, depending on how far the location is from a medium-voltage sub-station (see below). The alternative is to deploy a battery-buffered charging point. Here an integrated battery storage system charges slowly from the grid power available, even if it is low, and stores the energy. When an EV is being charged, the power available from the local grid is supplemented with power from the energy storage system to achieve the maximum charging power needed to fully charge the EV in a few minutes. Ideally the charging point should have energy management software linking it to the grid, providing information to help determine whether additional generation capacity needs to be brought on stream, and allowing the integrated energy storage system to export energy to the network if not required for charging purposes. The IEA envisages smart networks where parked EVs can export surplus energy to the grid at times of peak demand to reduce the amount of energy-generation capacity required.

Rolls-Royce subsidiary mtu provides a cost analysis for a charging hub in rural Germany with two fast chargers (150kW) and six slow chargers (22kW), which is intended to service approximately 40 cars per day, requiring on average 30kWh per car. The low-voltage grid at the charging station cannot provide the high-charging power of 22kW required and the site is 5km away from the nearest medium-voltage (1,000V) substation. mtu estimates that reinforcing the local grid by installing a transformer and cables to connect to the medium-voltage substation would cost €321,050, of which €275k is attributable to the cabling. This compares with €160k upfront costs to install one of its 250kW/267kWh battery energy storage systems. The operating costs for both options are similar, €25,700 per year for grid reinforcement, €23,300 for the battery energy storage system. The operating costs for the battery energy storage system option are 10% lower because many grid operators apply demand charges based on their highest peak load over a billing period. Having a battery energy storage system means that the charging hub operator may reduce the amount of energy purchased during periods of peak demand (peak shaving), cutting the total energy cost.

Since non-battery buffered ultra-fast chargers are less expensive than battery-buffered ones (Pod Point notes average revenues of £1,609/unit), they are typically deployed at locations where the local grid can provide sufficient power. According to charge-point operator Fastned, supermarkets, high-rise office buildings and large warehouses are routinely connected to the medium-voltage grid with connections of 1MW or 2MW. Non-battery buffered ultra-fast chargers may also be more economic at locations such as central charge parks or motorway service stations if the number of drivers paying for fast charges throughout the day is sufficient to cover the cost of a grid upgrade. ADS-TEC believes there is a significant opportunity for providing ultra-fast charge points in locations such as commercial and industrial premises, delivery fleet depots, car dealerships and apartment blocks where high charge rates are not required continuously (see Exhibits 4 and 5).

Investing in EV charging infrastructure

There are investment opportunities at every level of the supply chain:

- **Critical materials** (see our March 2023 report on the critical materials market).
- **Components for power electronics**: Infineon Technologies (IFX:DE), Rohm (6963:JP), Wolfspeed (WOLF:US).
- **Charge-point providers**: ABB (ABBN:SW), ADS-TEC (ADSE:US), Blink Charging (BLNK:US), Engie (ENGI:FP), Lincoln Electric (LECO:US), Luceco Group (LUCE:LN), Pod Point (PODP:LN), Tritium (DCFC:US), Wallbox (WBX:US).
- **Charge-point operators**: Allego (ALLG:US), Blink Charging, ChargePoint (CHPT:US), EVGo (EVGO:US), Fastned (FAST:AS), Pod Point (PODP:LN).
- **Investment trusts**: Triple Point Energy Transition (TENT:LSE)

This report focuses on companies supplying charging systems. As discussed above, these systems can be split into DC-based fast-charging systems, which may potentially be battery-buffered, and AC wallboxes for residential use. In our opinion, fast-charging systems provide more opportunity to create differentiated high-margin product than consumer wallboxes. We note that the complexity of the supply chain (see above) means that deployment of charging systems will be affected by the availability of critical metals such as copper and, in the case of battery-buffered systems, lithium, as well as the availability of power electronics chips and other electronic components.

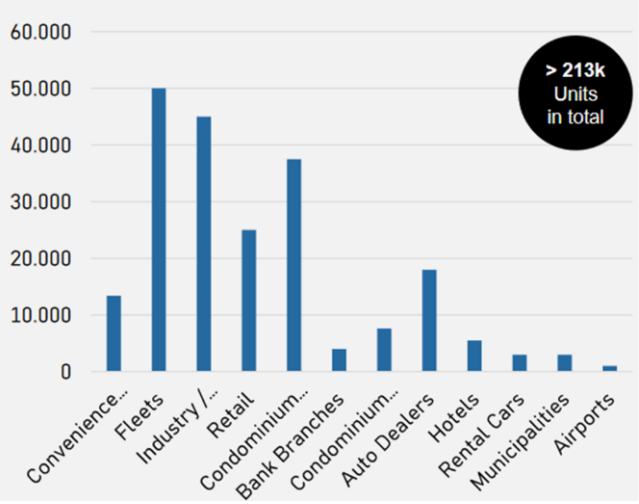
Battery-buffered ultra-fast charging on power-limited grids

ADS-TEC has sold over 450 units of ChargeBox, its flagship product. A ChargeBox unit can dispense 320kW of power from a single dispenser, or 160kW from two dispensers, and is certified for use in mainland Europe and the US. It can dispense sufficient charge for a typical EV to travel more than 100km (60 miles) in the time it takes to fill the petrol tank of a conventional car. ChargeBox is designed for installation with limited space, as the footprint of the storage unit is only 1.3 × 1.3 metres and the charge dispensers have a footprint of 0.4 × 0.4 metres. Importantly the charge dispensers, one or two per storage unit, can be located up to 100m from the charge storage unit, giving additional flexibility for small spaces. The product is almost silent, making it suitable for installations in residential areas and therefore attractive to facilities managers of apartment blocks. ChargeBox is targeted at service stations, operators of vehicle fleets, logistics companies and public transport operators. ADS-TEC's newer ChargePost product deploys an energy management system, which means that the unit not only stores energy that may have been generated on-site from renewable sources, but can also feed energy back into the grid, thus supporting grid services such as frequency management. The ability to return stored energy bidirectionally to the grid opens up entirely new business models for charging-point operators. ADS-TEC has an established

manufacturing site in Germany and is constructing one in the US, enabling its customers there to take advantage of funding delivered under the 2021 Infrastructure Act.

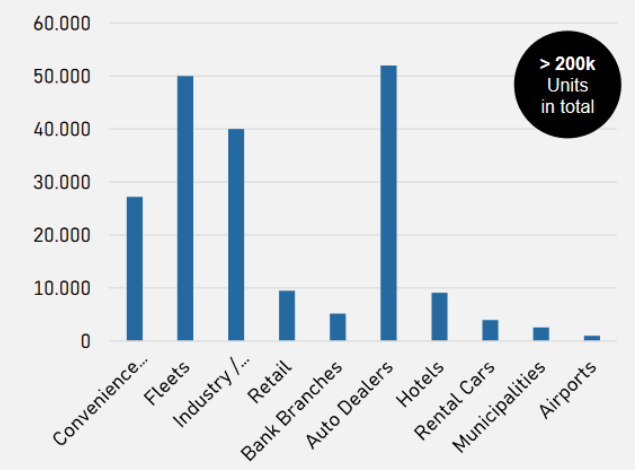
Other companies providing battery-buffered fast-charging systems are e.on, FreeWire (based in California), mtu and Powerstar (headquartered in Sheffield, UK). mtu is the only one of ADS-TEC's competitors that offers dispensers that can be sited a distance from the charge storage unit. mtu's smallest product has a larger footprint (3.3m × 2.2m) than either of ADS-TEC's products.

Exhibit 4: US TAM for battery-buffered systems



Source: ADS-TEC

Exhibit 5: EU market for battery-buffered systems



Source: ADS-TEC

ADS-TEC calculates that the total available market opportunity (TAM) for battery-buffered fast-charging units in the US is $43bn, which represents over 210k fast-charging units. It also calculates that the market opportunity in the EU is $40bn, which represents over 200k units.

Non-battery buffered grid-connected ultra-fast chargers

Companies offering non-battery buffered options include ABB, Blink, EVBox (part of Engie), Evercharge, Lincoln Electric, Pod Point, Schneider Electric, SK Signet (part of SK Corp), Tesla and Tritium. Tritium has sold over 10,000 DC fast chargers globally. Tritium states that its fast chargers are the only fully liquid-cooled fast DC chargers commercially available. The modular, liquid cooling system allows its chargers to be fully sealed, which the company notes results in up to 37% total cost of ownership reduction over 10 years compared to air-cooled systems.

AC wallboxes

As the number of EVs on the road increases, the number of AC wallboxes sold for home charging is likely to increase as well. While home charging in principle reduces the usage of public charging points, in practice the two address different customer requirements and could be considered to be complementing each other rather than competing. Companies offering EV charging points for residential use include Blink, Enel, EVBox, Evercharge, Pod Point and SyncEV (acquired by Luceco Group in March 2022). As well as offering AC charging points for residential use, Wallbox offers AC charging points for businesses that require employees to access the charger with a radio frequency identification (RFID) card. EVBox offers a hardware accessory for its home charging station that monitors power consumption elsewhere in the house and reduces the charge rate if required to ensure that total power consumption remains within pre-set limits, thus avoiding blackouts or circuit overload.

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