
Critical software

# Electric Vehicle Charging: The Next 10 Years

How do you solve a problem like managing power demand from EVs?

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# The EV-olution of the automotive market

*The paper will provide a greater understanding of the EV charging challenges facing the UK and Europe triggered by the increase in EV use, as well as the timescales involved. It proposes solutions to manage these challenges and enables informed choices to be made.*

By 2031, a large proportion of new car sales in Europe and especially the UK will be made up of electric vehicles (EVs). In the UK, this is driven by Government legislation. Plug-in electric vehicles (PEVs) and hybrids will replace internal combustion engine (ICE) vehicles in all new cars from 2030 onwards; they will also become more commonplace in the secondhand market.

In the rest of Europe, many countries are offering incentives to their population to purchase EVs and install chargepoints.

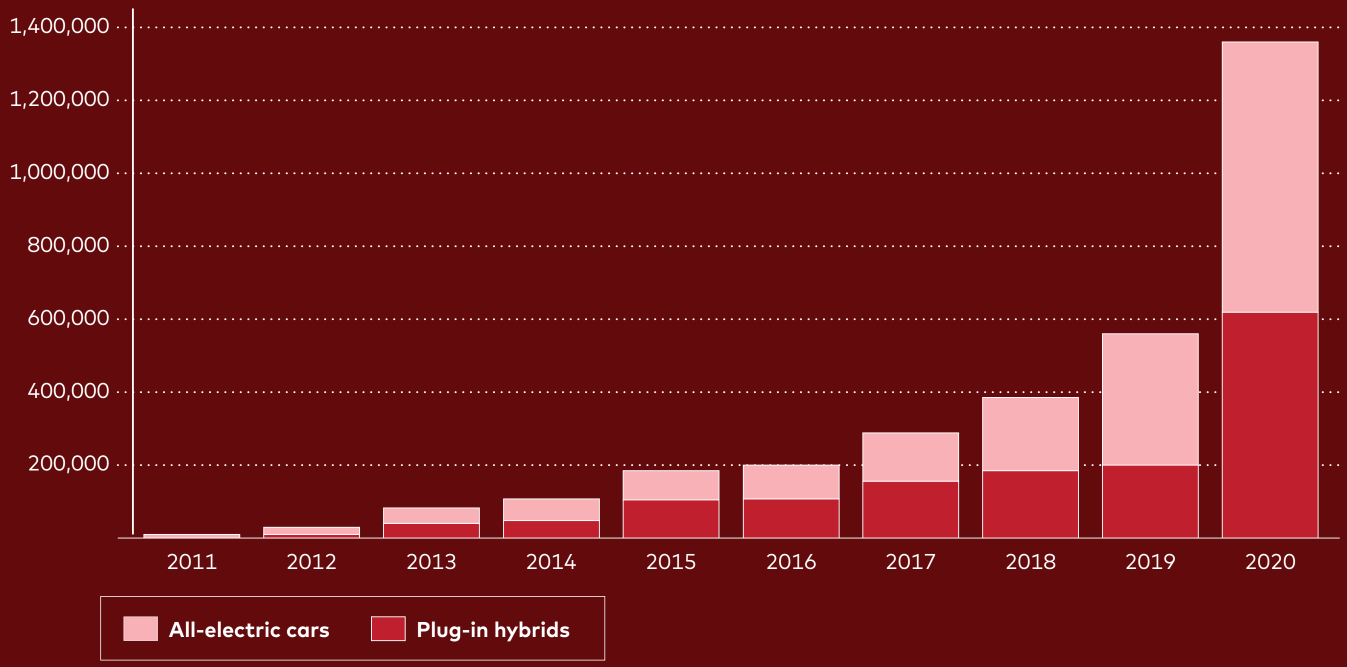
The rapid change from conventionally powered vehicles to electrically powered vehicles will impact the ability of countries' electricity networks to supply the power demanded by the consumer. Energy suppliers and distribution network operators (DNOs) will face an increase in load with no increase in network capacity. They will also have to manage the transition of electricity sources from traditional generation methods to increased quantities of renewable energy sources, each of which have different generation profiles.

The traditional method of meeting demand by increasing capacity is economically and environmentally unattractive. An alternative method would move some peak electricity consumption to times of the day where generation capacity is available thus providing a more balanced demand.

This paper explores how to manage electricity provision to the home and kerbside to safely enable growth in use of electric vehicles over the next ten years.

This paper will consider:

- Where the UK market is heading
- Where the European market is heading
- The scale of change over the next 10 years
- EVs' impact on electricity generation and distribution systems
- The situation regarding increasing power demand from EVs
- Managing increased demand from EVs
- How Critical Software can help today
- The future of powering EVs



# Where is the UK market heading?

**There has been an increase in new EV vehicle sales year-on-year, with battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) having a total market share of 10% in 2020.**

This increase in numbers is sure to continue as the UK Government has agreed to continue to meet European Union (EU) car CO2 regulations. EU legislation requires car manufacturers to meet emission standards, suggesting that EVs would need to represent 15% of cars sold in 2021 to enable Member States to hit their targets. Failure to meet these targets would incur financial penalties. The UK aspires to continue to meet emission targets when they become more stringent in 2025 and 2030 respectively.

Increased EV sales in the UK can also be attributed to the upcoming UK government ban on sales of new petrol and diesel cars by 2030. In a UK Government announcement on Wednesday 18th November 2020 it was stated that a 2-step process will be used:

**STEP1**
The phase-out date for the sale of new petrol and diesel cars and vans brought forward to 2030.

**STEP 2**
All new cars and vans will be zero emission at the tailpipe from 2035.

Between 2030 and 2035, new cars and vans can be sold if they have the capability to drive a significant distance with zero emissions (for example, plug-in hybrids or full hybrids, although this distance has not been specified at the time of writing). The exact dates have not yet been provided by the UK Government.


ELECTRIC
VEHICLES
ONLY
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# Where is the European market heading?

The European market has experienced year-on-year increases in EV sales. Germany and France are each selling a similar number of EVs as the UK, but with a higher percentage that are BEV rather than PHEV. Growth in this area is driven by many factors, primarily EU and country specific legislation.

France plans to ban all petrol and diesel cars by 2040 whereas Germany does not have a clear pathway to a ban. Rather, they are encouraging people to buy EVs and install chargepoints through financial incentives.

Norway currently exempts fully electric vehicles from the taxes imposed on traditional fossil fuel vehicles, and as a result BEVs now make up 54% of new car sales.

Car manufacturers have also announced they will stop manufacturing petrol and diesel-powered models, encouraging purchases of EVs. Volvo, Jaguar, Ford of Europe and Bentley will all move to an all-electric line-up by 2030, while others such as Volkswagen Group and General Motors will offer a majority of zero-emissions vehicles by 2035.

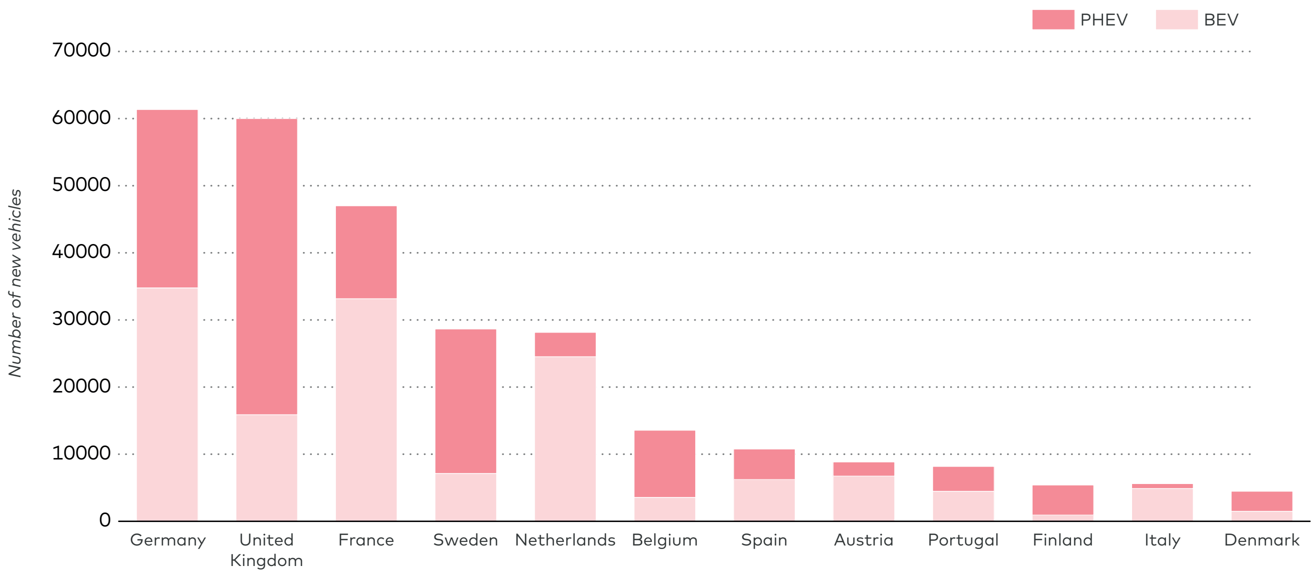


**Figure 2** EV sales breakdown across the EU by country and vehicle type.

# The scale of change over the next 10 years

Understanding the scale of change over the next decade depends on 6 key facts:

• The European market for new car sales is approximately 15M annually. Of these, approximately 2.3M are sold in the UK.

• Today, Germany has 45M cars on the road, France 32M, Italy 37M and the UK 33M.

• There are, in total, 280M cars in Europe.

• The average lifespan of a vehicle is 13 years.

• In the UK, all new cars on sale from 2030 onwards must include some batteries and from 2035 must be purely electric.

• To meet the EU car CO2 legislation and avoid fines, most car makers will need EVs to represent 15% of their sales by 2021 and with more stringent legislation expected in 2025 and 2030 this percentage is likely to rise.

For the UK in 2021, EV sales are predicted to be 15% of all new car sales (345,000 vehicles), requiring just under 50,000 new chargepoints. Over 10 years, at this level there will be 3.5M new EV's requiring just under 500,000 new public chargepoints, a significant increase from today's numbers.

Sales of EVs in Europe in 2020 were over 1.4M, requiring 200,000 new public chargepoint installations to satisfy charging demands. This is calculated on the basis that one new public chargepoint is required for every seven new EVs.

With more stringent EU CO2 legislation coming into force in 2021, it is estimated that European new EV sales will be 2.25M with an associated increase in public chargepoints of 321,000. If taken over a ten-year period this would equate to 22.5M new EVs with a requirement of 3.21M new public chargepoints.

Looking at the longer term, all 280M ICE vehicles across Europe will be replaced by EVs over the next 25 years. This would require 11M cars to be replaced annually with a requirement for 1.6M new public chargepoints per annum.

Several other important factors need to be considered during this period. For all of these, the impact is not yet fully understood:

• COVID-19 may permanently change working practices; the long-term need to travel to work is not guaranteed.

• Advances in autonomous driving vehicles will affect how cars will be purchased and used.

• Manufacturers are likely to cease production of conventionally powered diesel and petrol vehicles before any ban comes into force to prevent unsold inventory existing.

• The car leasing market has a medium-term view on cars, with average use for a rental car being between 3 and 4 years. Leasing companies provide a large quantity of vehicles to business users which may cause a migration to PEVs by the middle of this decade.

# EVs' impact on electricity generation and distribution

Currently, ICE vehicles are refueled away from the home. The change to electrically powered vehicles creates an additional demand on both electricity generators and distributors by refueling at the home or kerbside.

The existing local network has been configured to provide an average home with approximately 3,500 kWh of energy a year equal to c.10 kWh per day. This is spread over the whole day with the peak occurring between 4pm and 8pm.

A single EV may consume 3,000 kWh of energy in a year equating to c.8 kWh per day. This charging is normally spread over a few hours and unless managed it will likely be during peak demand on return from work. Home charging may double or triple the current demand on the home power supply.

Kerbside charging will also increase pressure on electricity infrastructure depending on location, type of use and vehicle ownership. Examples of use types include charging overnight where people do not have home charging, long distance driving recharging and daytime charging whilst people are at work or shopping.

Kerbside charging currently tends to be faster than home charging and may recharge more vehicles per day, thus having disproportionately greater impact on the power grid than home charging.

# The increased power demand from EVs

How do we manage the anticipated increase in demand for energy at home or kerbside? Do we increase the energy supply by building new power stations, building local wind or solar generators, or do we make better use of existing generating capacity?

Adding additional sources of energy such as power stations, wind turbines or solar panels requires time and investment. These additional sources will only be used at peak times to service short-term demand, which is wasteful, expensive and generates additional carbon emissions.

The real issue raised here is not one of lack of capacity but of peak demand.

There is plenty of capacity locally; a house with a 100A circuit can theoretically allow a continuous 24kW supply.

The bottleneck is the generating and distribution capacity of the system. In general, electricity networks understand that maximum demands of all loads connected to a generation source don't happen simultaneously. Instead, demands of various loads occur at different periods of times during the day.

The large-scale adoption of EVs will place a large long-term additional load on the electricity generation and distribution system. If this additional demand for energy coincides with normal peak demand, the supply system may not be able to provide enough power, causing brownouts or blackouts.

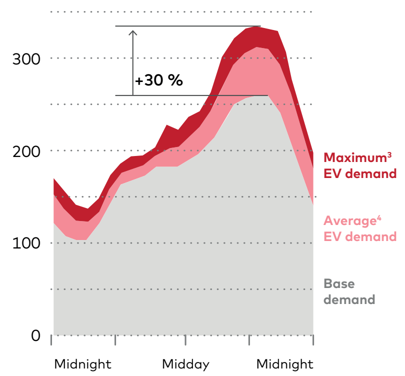


**Figure 3** Unmanaged EV charging profile.

Figure 3 shows:

• Daily electricity demand where EV charging is unmanaged. The grey area indicates the base electrical load of a domestic electricity network over a 24-hour period. The light red is the additional power required for recharging EVs on an average day, with the dark red showing the potential peak demand (+30%).

• A large increase in demand during the early evening where EV users plug in and draw power immediately from the network. In this case, the electrical supply system is required to generate more power to meet the demand therefore requiring more generating capacity.

• The minimum base electrical load at 3am is 40% of the maximum base load at 6pm. The difference indicates there is significant available generation capacity available overnight. Using this capacity to charge EVs would reduce peak demand, allow generation capacity to run at an ideal level throughout the day and prevent the need for large increases in generation capacity to satisfy a higher peak demand.

To take advantage of this available capacity the behaviour of EV users will need to be changed, which may entail:

• Requesting EV users to plug in at a specific time.

• Setting EVs to charge at a specific time.

• Rewarding EV users financially to charge at a specific time.

Of these, the most attractive is likely to be financially rewarding the EV user. This will require a charging system that is intelligent enough to decide the most economic time to charge the vehicle.

# Managing increased demand from EVs

**Let's explore the options available to DNOs, energy suppliers and chargepoint operators which can assist in managing their EV charging devices.**

## OPEN CHARGE POINT PROTOCOL (OCPP)

The increase in EVs will drive the demand for public charging points. Initially, it is believed that the installations will be in metropolitan areas where on-street parking is common. New operators of charging networks are likely to purchase and install charging points as quickly as EVs demand it, and the users will want to be able to charge without any apparent limitation.

OCPP is a worldwide standard which is well established for domestic and non-domestic EV charging points. OCPP provides easy integration between charge station management systems and chargepoints in a network where all parts meet the OCPP standard. Using OCPP will provide interoperability between devices and networks from different brands. This provides a chargepoint operator with multiple equipment supplier options, ease of integration between equipment types, and competition between suppliers reducing costs.

OCPP, when used in conjunction with OpenADR, can turn electric vehicles into demand response assets. By aggregating participating charging stations the OCPP central server will translate OpenADR event signals into valid OCPP smartcharging messages and send those to the relevant charging stations on its network. These dynamic price signals encourage end users to modify their usage patterns to save money and thus optimise energy efficiency.

## STANDALONE AUXILIARY PROPORTIONAL CONTROLLER (SAPC)

There may be times when an electricity network cannot support the demand placed on it and action needs to be taken to prevent overload.

SAPC is an 'action of last resort' where high-power devices attached to a smart meter are proportionally controlled to reduce load. Typical examples of these devices are EVs, heat pumps and battery energy storage systems (BESS).

SAPC functionality provides the ability to set an output to a connected device at any level between 0% and 100% of the maximum allowable load. When requested, the SAPC will communicate with the connected device to reduce the demand. The communication to the SAPC is controlled by the energy supplier but is of interest to the DNO who is responsible for the supply of power within a geographic region.

# The future of powering EVs

Electricity use and supply in the next decade will become a complex interplay of energy sources, with a general increase in demand likely; the introduction of time of use tariffs; and users who may or may not have smart metering equipment. Examples of technologies that may affect EV charging are:

### VEHICLE-TO-GRID (V2G)

A system in which electric vehicles communicate with the grid to enable demand response services, either returning electricity to the grid or throttling their charging rate. V2G can allow EVs to store and discharge electricity in concert with the fluctuating output of renewable energy sources such as solar and wind that depends on weather and time of day.

### BATTERY ENERGY STORAGE SYSTEMS (BESS)

Devices that store electricity locally for later consumption. These are typically based on lithium-ion or lead-acid battery technology controlled by intelligent software handling the charging and discharging process. The batteries can be charged using energy generated by on-site solar panels during the day or overnight from the grid at off-peak prices. The BESS can be enabled for demand response to return electricity to the grid or throttle its charging when requested by the grid.

EV use is increasing and for those in the UK, 2030 marks a deadline for when new cars must be either fully or partially electric..

For Europe the timescale is currently driven by the EU CO2 legislation and subsidies which are encouraging the uptake of EVs.

The installation of chargepoints, both at home and the kerbside, is required to and will support the rollout of EVs. Chargepoints based on open standards such as OCPP will allow large EV charging networks to be installed quickly and SAPC and OpenADR will assist energy suppliers to manage electricity demand safely.

The impact of the extra demand on the electricity supply network is so real, so large and is likely to take place over such a short period, that doing nothing is not an option. It needs a concerted effort by electricity suppliers and DNOs to understand and quantify the problems, seek solutions, and implement them rapidly.


EVBOX

# How Critical can help

Critical Software has been working on the challenges identified in this paper and has solutions already available. These cover both of the following:

• Open Charge Point Protocol (OCPP) for the charging station.

• Standalone Auxiliary Proportional Controller (SAPC) for UK electricity smart meters.

## OPEN CHARGE POINT PROTOCOL (OCPP) FOR CHARGEPOINTS

Critical Software has created an Open Charge Point Protocol (OCPP) solution for chargepoints, compliant with OCPP V1.6-J. The OCPP solution for chargepoints offers a communication protocol making data sharing and communication between charging points and central stations easy and instantaneous in response to user demand. This OCPP stack can be integrated into charging devices to provide communications with any OCPP compliant back office.

The OCPP stack has six functional areas: core, firmware management, local authentication, reservation, smart charging and remote trigger.

A security profile may also be included that is fully compliant with OCPP V2.01.

## STANDALONE AUXILIARY PROPORTIONAL CONTROLLER (SAPC)

Whilst SAPC is not yet mandated, smart meters in Great Britain will require SAPC to control the charging of, amongst other devices, EVs.

Critical Software has created the first Standalone Auxiliary Proportional Controller (SAPC) end-to-end implementation that fully complies with the GBCS 4.0 and SMETS2 V5.0., following the release of the November 2020 Smart Energy Code (SEC). The Critical SAPC implementation:

• Works with the home area network (HAN).

• Allows secure control of auxiliary loads using up to five Auxiliary Controllers.

• Supports the complete set of features including Calendar, Set, Limit and Boost, with the Boost function allowing a user to request a temporary increased charge rate to their EV.


To find out more about our work, please get in touch:
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**We are CMMI Maturity Level 5 rated.**

For a list of our certifications & standards
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