

Opportunities in Electric Vehicle Charging at Commercial and Industrial Sites



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1. Executive summary

Commercial and industrial (C&I) sites will have an important role to play in providing charging infrastructure for electric vehicles (EVs). In this report, we examine the future opportunities presented by C&I charging in Great Britain (GB) and Germany.

EV deployment and its implications for the energy system

- **The number of EVs in GB and Germany will grow rapidly.** Starting from 140,000 EVs in GB and 200,000 in Germany in 2018, Aurora's forecast sees 17m and 23m by 2040 in GB and Germany respectively. In a more ambitious outlook, the number of EVs could reach 29m in Germany by 2040. We also consider an especially ambitious scenario in which there are 35m in GB by 2040.
- **The large number of EVs expected will transform electricity systems.** The deployment of EVs will increase electricity demand, which will affect electricity prices, generation technology mix and carbon emissions. C&I charging of EVs could correspond to an annual energy demand of 11-15 TWh in GB and 13-17 TWh in Germany in 2040.
- **Smart charging of EVs decreases electricity price volatility.** Charging EVs when there is lower electricity demand (such as overnight) or excess supply (such as when wind or solar output is high) reduces the range of wholesale electricity prices. The price range on an average day could fall by about a third between 2018 and 2040 in GB in the high EV deployment scenario.
- **High EV deployment enhances the economics of renewable generation and enables greater renewables deployment.** Solar generation in GB would increase by c.20% in 2040 and wind generation in Germany would increase by c.7% in 2040 in a high EV scenario compared with a central EV scenario, as smart charging of EVs increases capture prices for renewables.
- **Emissions from cars could reduce by as much as 90% with electrification.** By 2040, high deployment of EVs combined with smart charging would reduce total emissions attributable to cars by 90% in GB and over 50% in Germany relative to a case with no electrification of cars.

The size of the opportunity for C&I charging

- **C&I sites will play a role in enabling the deployment of EVs.** In both GB and Germany, only about 60% of households have access to private parking at home. Availability of charge points on C&I sites such as workplaces, retail stores or motorway service stations would help enable mass electrification of transport.

- **The number of C&I EV charging outlets needed could reach 1m-3m in GB and 2m-4m in Germany** under a high EV deployment scenario. These will be spread across four main applications of C&I charging: fleet vans, workplace commuter charging, public car parks and motorway service stations.
- **The investment opportunity for C&I EV charging could reach £2bn-£6bn in GB and 3bn€-8bn€ in Germany.** This is the cumulative investment required to fund the total cost of equipment and installation of outlets to support deployment of EVs expected by 2040 in the high deployment scenario.
- **Financing products for EV charging infrastructure will be available for many commercial investments.** Asset finance, project finance, dedicated corporate facilities and general corporate facilities are potential options for senior debt financing of EV charging infrastructure.

Developing a profitable business case

- **Profitable business cases for C&I charging applications are possible when users pay for the electricity they use.** A premium of £0.05-0.10/kWh or 0.05-0.11€/kWh above retail electricity prices could enable positive returns for most examples considered for GB and Germany respectively, for projects started in 2030, assuming high utilisation rates. This is comparable to the pricing of today's commercial charging networks.
- **Commercial fleet electrification would enable charging infrastructure investment.** For light commercial vehicle fleets in GB and Germany, the business case for switching from internal combustion engines (ICE) to EVs and charging infrastructure is viable for medium vans if the total cost of ownership can be reduced by 8-15% compared with today. Recent cost reduction trends suggest this could happen in the next decade.
- **Workplaces with charging points can improve their economics by sharing each point between several cars.** Workplace charging can be profitable if drivers or employers are prepared to pay £0.09/kWh or 0.11€/kWh above retail electricity prices (for GB and Germany respectively) and to share each charging point between 4 cars that do all their charging on-site.
- **Car park businesses could charge a premium of £0.05/kWh (GB) or 0.03€/kWh (Germany) above retail electricity prices to reach a profitable business case.** Net Present Value (NPV) per charging outlet could reach £8,000 (GB) or €3,000 (Germany) at these levels of margin over 12 years (starting in 2030) in the examples we analysed, assuming utilisation of 6 hours per day. Retailers running their own car park charging can benefit from a further boost to sales, with some evidence suggesting a sales uplift of £5,000-7,000 per charge point per year.
- **Motorway service stations could charge a premium of £0.06/kWh (GB) and 0.05€/kWh (Germany) above retail electricity prices to achieve**

positive returns. NPV per charging outlet could reach £66k (GB) or €25k (Germany) at these levels of margin over 12 years (starting in 2030) in the examples we analysed. This assumes the outlets are used for 6 hours each day, which is dependent on a high level of future EV deployment.

Potential benefits from combining EV charging with other technologies

- **Adding vehicle-to-grid (V2G) capabilities or on-site energy storage or solar panels can enhance the business cases for C&I EV charging.** Each of these technologies requires further capital investment, but they could unlock savings on electricity costs, reduce the scale of network upgrades needed, and provide extra revenues from the capacity market or ancillary services.
- **V2G can improve the business case for commercial fleet charging.** For overnight charging of a fleet of vans at a business with high on-site energy consumption like a refrigerated warehouse, using V2G technology could improve NPV per charging outlet by £1,000 over 12 years (starting in 2030), reducing the total cost of ownership improvement needed to make fleet electrification viable to about 6% in the GB case.
- **Co-locating solar and energy storage systems alongside EV charging can provide a major boost to the business cases on appropriate sites,** either improving profits, supporting a lower consumer price for electricity or countering a fall in utilisation. For instance, in the motorway service station case in GB, solar and storage can contribute almost as much to the NPV over 24 years (starting in 2030) as a £0.06/kWh premium on the electricity sale price. This could keep the business case profitable even if the utilisation drops to just 4 hours per day for each charging point, rather than the 6 hours per day needed without solar and storage.



2. The outlook for EV deployment

- The Aurora central case forecasts EV deployment of 17m in GB and 23m in Germany by 2040

Electric vehicle (EV) deployment in Europe continues to grow, with sales figures for H1 2018 suggesting there are now over 1m electric vehicles across the continent, including both battery electric vehicles (BEVs) and plug-in hybrids (PHEVs).¹ We expect this will accelerate in the years ahead, driven by shifting consumer preference and ongoing government support.

2.1 Trends in EV deployment

In this report we focus on GB and Germany. Aurora's central forecast is for the number of electric cars to reach 17m in GB and 23m in Germany by 2040, as illustrated in Exhibit 1 (including Battery Electric Vehicles and Plug in Hybrids).

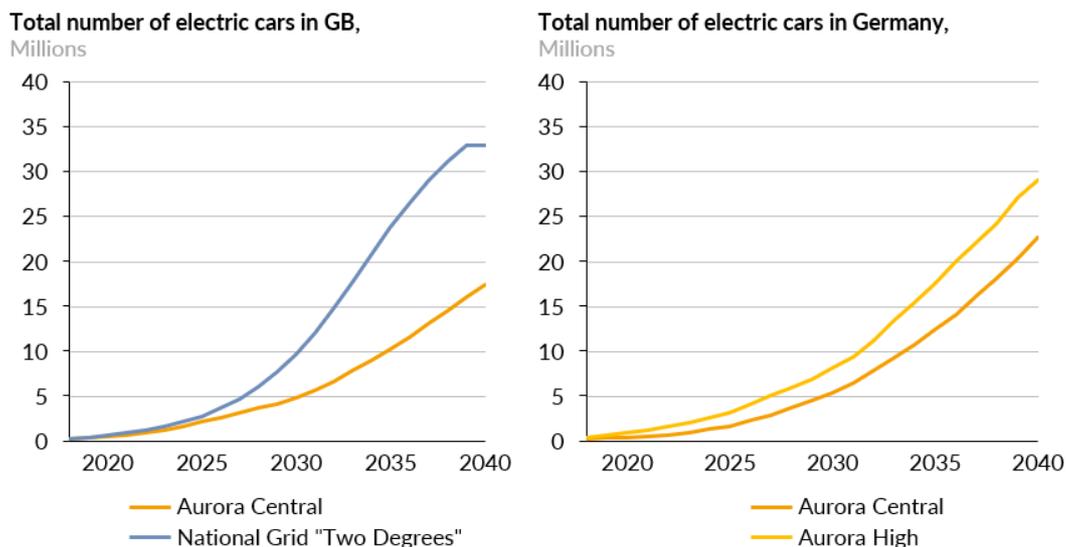


Exhibit 1

For Germany, we also show our high scenario for faster EV adoption. For GB, we show the especially ambitious projection from the "two degrees" scenario in the National Grid 2018 Future Energy Scenarios, which has EV deployment reaching 33m cars by 2040.

¹ EV Volumes, "Europe Plug-in Sales Results for 2018 H1", www.ev-volumes.com

The Aurora forecasts are based on an analysis of how total cost of ownership (TCO) will change for different cost brackets of electric cars over time, both for BEVs and for PHEVs. We project that on average, consumers will switch to electric cars once they become more economical than internal combustion engine (ICE) cars to own. We expect that PHEVs will account for most electric cars in 2020, but that BEVs will dominate from 2025 onwards.

2.2 Factors driving EV deployment

Taking a broader view, the acceleration in EV deployment has two main causes: EVs are becoming increasingly attractive for consumers, and governments are supporting the shift.

Rising consumer preference for EVs will result from approaching price parity with internal combustion engine (ICE) vehicles, improvements in range and more widespread charging access.

- Price parity: We expect BEV cars to become cost competitive with ICE cars in the next decade on a 3-year Total Cost of Ownership (TCO) basis, thanks to rising production scale and falling battery cost.
- Range: This will rise as battery size increases, allaying consumers' anxieties; we expect battery range for a £20,000 BEV to approach 400 miles by 2030.
- Charging access: Consumers, government and industry each have incentives to invest in infrastructure, and there are now roughly 17k public charging points in GB.² In this report we focus on opportunities offered by infrastructure on commercial and industrial sites.

Government support for EVs is driven by issues including local pollution, global climate change and considerations of industrial strategy.³

- Local pollution: Concerns over air quality and its impact on health will lead governments to promote EVs over ICEs – both at national and local/city level. For example, in 2017 parts of London breached the NO₂ hourly exceedance limit for the year within the first five days of January;⁴ the city is phasing in a zero emission zone between 2025 and 2050. Plans have also been set out to ban diesel vehicles in Copenhagen (2020), Paris (2024) and Madrid (2025).
- Global climate change: EVs can be used to cut emissions from transport; they have lower emissions than ICEs even at current grid carbon intensity,

² Zap-Map, <https://www.zap-map.com>

³ Sources for the list: Aurora Energy Research, Guardian, BMUB, McKinsey, COMEAP, Fleet News

⁴ EU NO₂ limit is for no more than 18 hours to exceed 200 µg/m³ per year. Brixton Road had 18 hours with NO₂ levels above this limit in the first five days of January 2017.



and the benefit of EVs will increase as the power system is further decarbonised. Bans on the sale of ICEs are planned in the Netherlands and India from 2030, Scotland from 2032, and France and GB from 2040.

- Industrial strategy: In the UK, the government has identified mobility as one of four “grand challenges” that will shape its industrial strategy; it hopes to improve public transport, and to capitalise on the UK’s existing strengths in the transport sector.

In addition, a range of emerging technologies are set to support the accelerating deployment of EVs. Smart technology that allows EV charging to be shifted to periods of lower demand makes EV ownership more economical and helps the network by reducing peak demand. V2G technology allows EV batteries to be discharged to provide energy for other purposes. This means EVs can deliver value to the grid by shifting load or providing ancillary services, in a similar way to a battery storage system. EVs can also complement the increasing penetration of variable renewable energy supply; as we shall see in section 3, EVs with smart charging can help renewables realise higher prices by “flattening” daily variations in demand.



3. Implications of EVs for the energy system

- **Solar capture prices in 2040 could be 20% higher with higher EV deployment and smarter charging than without, in both GB and Germany**
- **Solar generation in GB in 2040 could be 20% higher with higher EV deployment and smarter charging than without**
- **Emissions from cars in GB would be 90% lower in 2040 with near-full electrification than with an internal combustion engine car fleet**
- **Wind generation in Germany in 2040 could be 7% higher with higher EV deployment and smarter charging than without**
- **Emissions from cars in Germany would be more than 50% lower in 2040 with 29m electric cars than with an internal combustion engine car fleet**

Given the potential scale of future energy demand from electric vehicles, it is reasonable to ask what effects their deployment will have on the energy system. Looking at different scenarios for EV deployment, we find that prices develop smoothly over time, and smart charging is able to mitigate rises in peak demand. Increased supply from the future energy mix is enough to meet the increased demand from EV deployment.

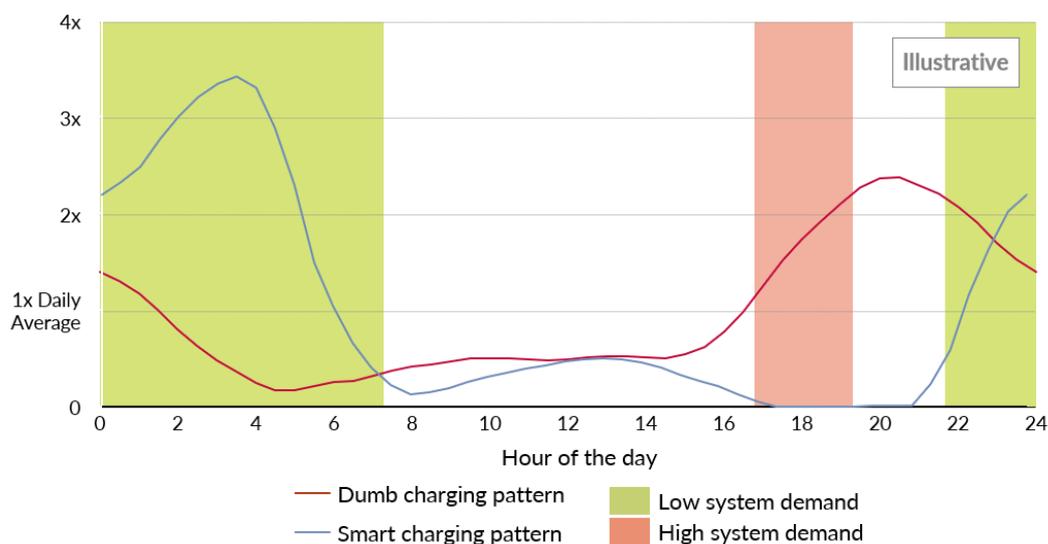
Scenarios with high EV deployment and smart charging tend to flatten the daily price profile. This leads to higher capture prices and capacity expansion for renewables. Consequently, renewables account for a higher share of generation in 2040 when charging is smarter. High EV deployment scenarios lead to lower carbon emissions, and smart charging reduces grid carbon intensity. Achieving high levels of smart EV deployment requires charge point availability; part of this will be on C&I sites.

3.1 EV charging behaviour

The effects of increasing EV deployment on the energy system in GB and in Germany depend both on the speed of deployment and on the extent to which charging is 'smart' or 'dumb'.

EV charging demand by hour (averaged over fleet)

GB, Multiple of daily average, 2035



Note: Status quo "dumb" charging pattern shows averaged profile from over 100 participants in UK Customer Led Network Revolution trial

Exhibit 2

The two main types of charging profile are illustrated in Exhibit 2.

- Experience to date shows that EV drivers typically charge their vehicles in the daytime and particularly in the early evening when they return home from a commute. This means peak charging coincides with peak demand in the early evening. If EV charging continues in this fashion, higher deployment could lead to power system issues such as an increased need for power generation capacity and investment in the power network.
- Conversely if charging is 'smart' then this implies that EV charging could be shifted to times of lower power demand (such as overnight). This would reduce the need for peak power generation capacity, make better use of available capacity at off-peak times, and reduce the need to upgrade power networks.

We model the range of possibilities by looking at four 2040 scenarios in each country: smart and dumb scenarios for a central deployment case, and smart and dumb scenarios in a high deployment case.

In Germany, EV deployment in 2040 reaches 23m in the central cases and 29m in the high cases. In GB, EV deployment in 2040 reaches 17m in the central cases. For the GB high cases we use the especially ambitious EV deployment numbers from the "two degrees" scenario in the National Grid Future Energy Scenarios, which has EV deployment reaching 33m cars (and a further 2m vans and motorbikes) by 2040. This allows us to understand the implications of having a high enough deployment of EVs to support progress towards the country's 2050 decarbonisation target.

In the smart scenarios, 80% of charging follows a smart charging pattern and 20% follows a dumb pattern; these proportions are reversed for the dumb scenarios.

3.2 Electricity prices

Scenarios with high EV deployment and smart charging tend to flatten the daily price profile. This leads to higher capture prices and capacity expansion for renewables.

Smart EV charging takes place at the times when prices are lowest, typically overnight. As EV deployment rises, this raises prices overnight relative to the rest of the day, flattening out the daily price profile. For the high deployment, smart charging scenario, by 2040 this could lead to prices at 3pm being the same as those at 5am, as illustrated in the average daily price profiles in Exhibit 3.

Average wholesale electricity price profile for GB in high smart deployment scenario,
Indexed to annual average price for the given year

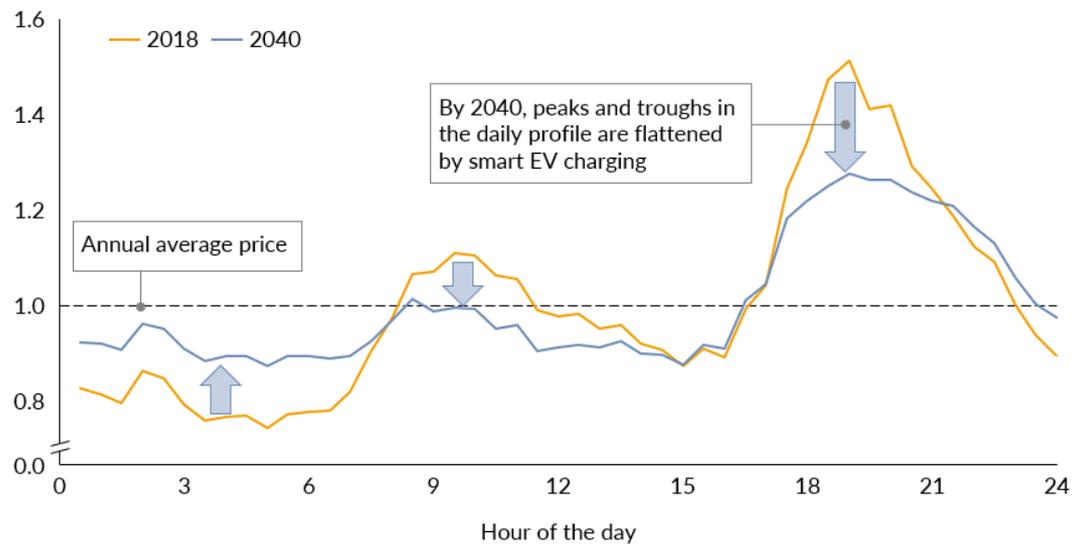


Exhibit 3

The effect is shown more dramatically if we look at price percentiles over the course of the year, as in Exhibit 4. Here, we see the 10th percentile of prices is over £40/MWh higher in GB in the high smart scenario than in the central dumb scenario: EVs charging overnight effectively “mop up” the lowest-priced electricity.

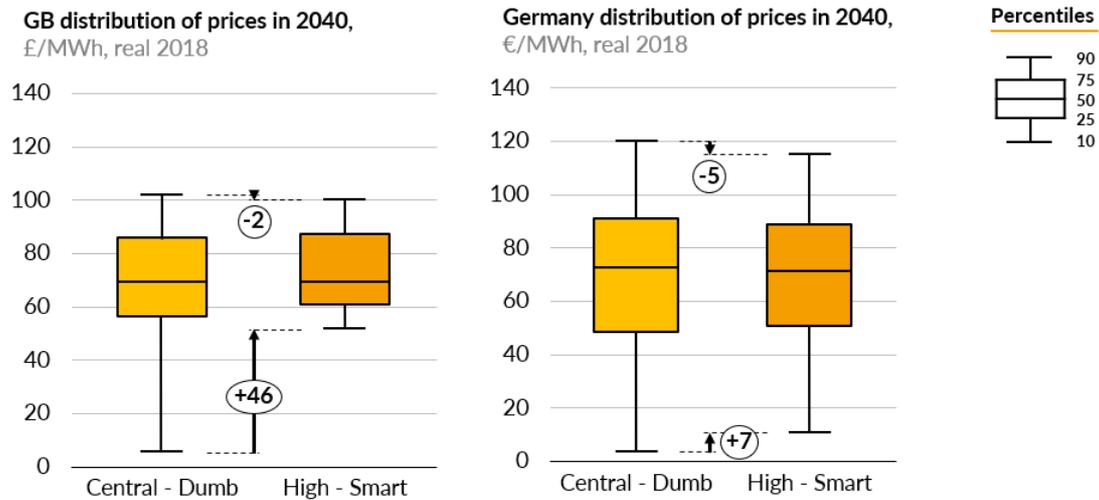


Exhibit 4

The removal of low-price periods means the prices achieved by renewables at the times they are generating (their “capture prices”) are usually higher in the high smart scenario compared with the central dumb scenario, especially for solar, which is less affected than wind by the relative decline of evening peak prices (see Exhibit 5). In Germany, we do not see increased capture prices for wind but we do see increased wind capacity deployment: effectively the smart EV charging is counteracting the cannibalisation effect we might otherwise see eroding capture prices as wind deployment increased.

Renewables capture prices and load factors in 2040

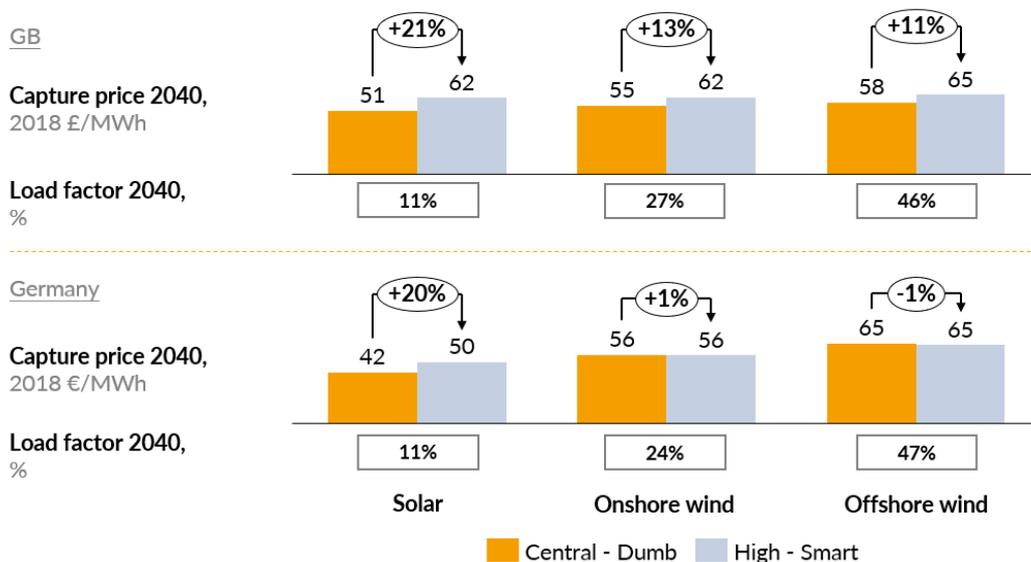


Exhibit 5

3.3 Generation mix

Smart charging and high EV deployment could enable a higher share of generation from renewables in 2040.

Deployment of EVs will add 10% to today's GB electricity demand and 7% to today's German electricity demand by 2040 in the Aurora central scenario. Overall system demand (including EVs) is expected to increase 8% in GB and 15% in Germany in the same time period.

In GB, we find that electricity demand in 2040 is about 10% higher in the high deployment cases compared with the central cases. In Germany, the difference is about 2%. Smart scenarios meet more of this demand with renewables because they tend to support higher renewables capture prices.

We show the projected generation mix for GB and Germany in Exhibit 6 and Exhibit 7. In GB, smart scenarios have 2-5 TWh (roughly 10%) more solar generation than dumb scenarios in 2040, as higher solar capture prices lead to more deployment. These scenarios also make more use of interconnectors, and less of CCGTs. In Germany, there is also less CCGT generation in the smart scenarios, although here it is wind that shows the greatest increase in generation.

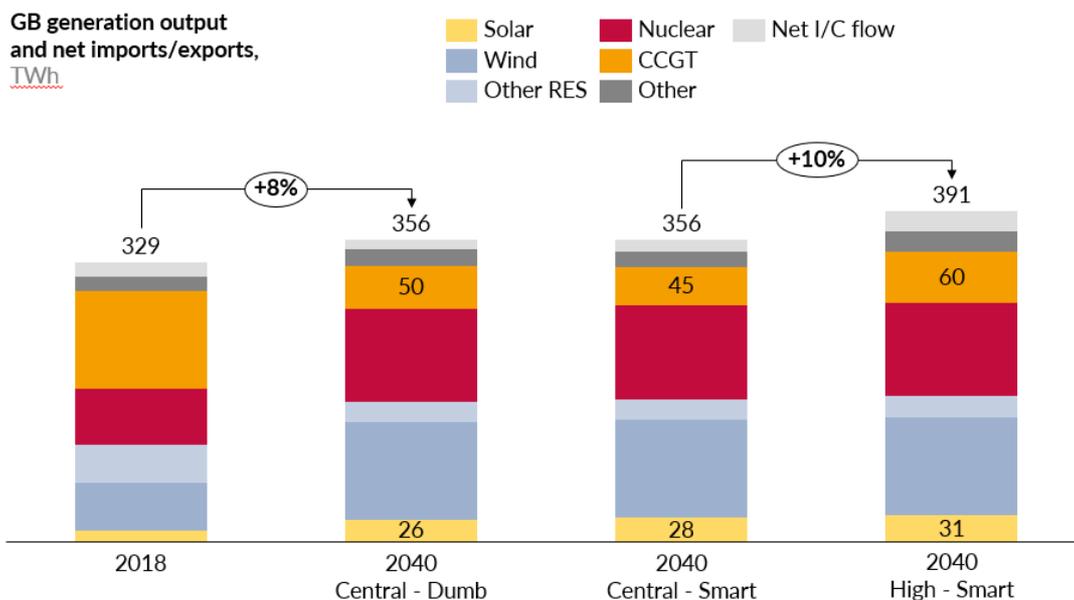


Exhibit 6

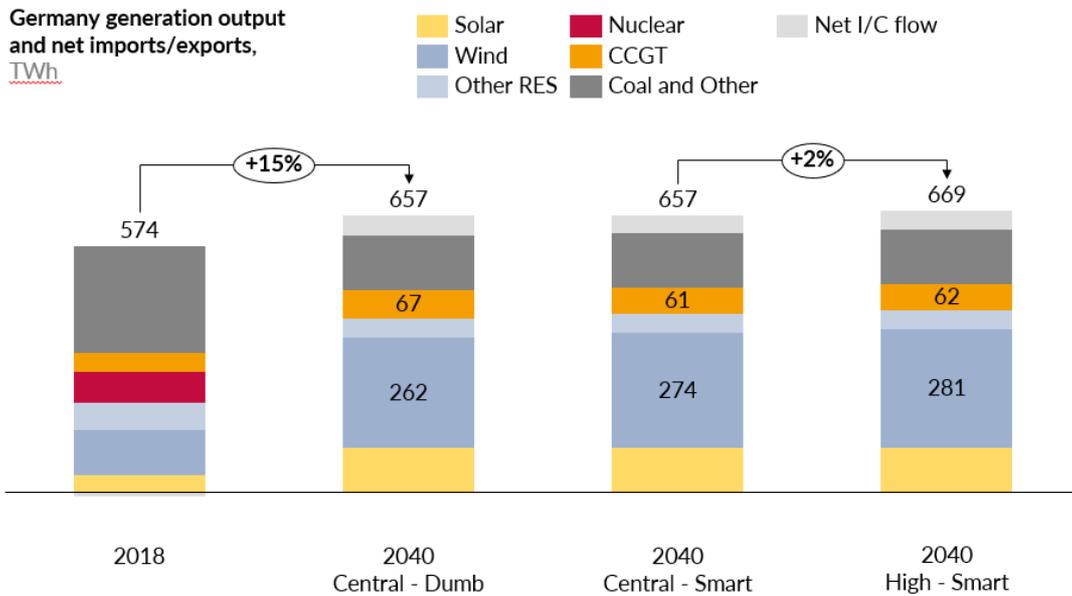


Exhibit 7

3.4 Carbon emissions and intensity

High EV deployment scenarios lead to lower carbon emissions, and smart charging reduces grid carbon intensity.

Even with today's grid generation mix, powering a vehicle with grid electricity emits less carbon overall than burning petrol or diesel in an ICE, so higher EV deployment leads to lower emissions. Exhibit 8 shows emissions from cars (including both ICE exhausts and the grid emissions attributable to electric cars). High EV deployment would reduce these by 90% in GB and over 50% in Germany relative to a case with no electrification of cars.

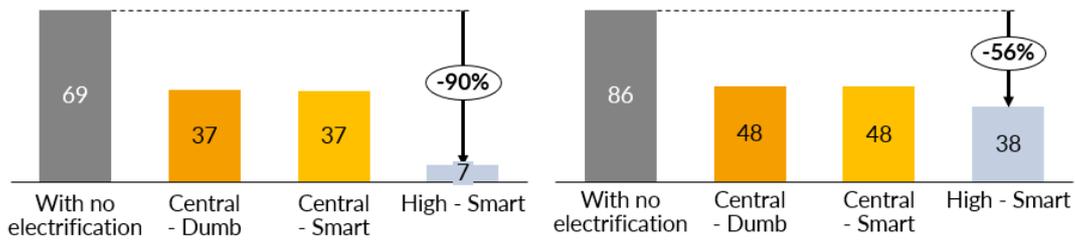
Smart charging improves the carbon intensity of the grid as a whole relative to dumb charging because of the increased proportion of generation coming from renewables. Carbon intensity is reduced from 70 to 62 gCO₂/kWh in the central smart scenario compared with the central dumb scenario in GB in 2040, and from 197 to 192 gCO₂/kWh in Germany.

Emissions from cars in 2040¹,

MtCO₂e

GB

Germany



1. Does not include CO₂ emissions during vehicle production or disposal. Assumptions for 2040: 33m cars in GB; 43m cars in Germany; average ICE emissions of 135gCO₂ per km; average annual driving distance of 15,000km.

Exhibit 8

3.5 Implications for charging infrastructure

Achieving high levels of smart EV deployment requires charge point availability; part of this will be on C&I sites.

To achieve the rapid EV deployment set out in the “high” scenarios we have considered, availability of charge points will be key. In the future, drivers may choose to charge predominantly at home or at work, and charge points on-street, at destinations or at converted petrol stations may play a larger or smaller role.

A mix of driver behaviours is likely, but charging at commercial and industrial sites will form a significant part of this mix because only about 60% of households have access to private parking at home, in both GB and Germany.⁵ Furthermore, in GB almost 30% of cars are not parked on private property overnight,⁶ and average cars spend over half their time away from home parked either on work sites or in public car parks.⁷

Ideally, the charge points installed to meet growing demand from EVs should enable smart charging, because this leads to a decarbonisation benefit for the network, as well as relatively low peak demand and network costs.

⁵ Department for Transport 2009, “Public experiences of and attitudes towards parking”; Destatis 2009, “Zuhause in Deutschland”

⁶ Department for Transport 2016, “National Travel Survey”

⁷ RAC Foundation 2012, “Spaced Out”

4. The potential scale of EV charging on commercial and industrial sites

- **There could be demand for 1-3 million charging outlets on commercial and industrial sites in GB by 2040 in a high EV deployment scenario**
- **EV charging at commercial and industrial sites could account for 11-15TWh of electricity demand in GB in 2040 (3%-4% of total demand) in a high EV deployment scenario**
- **There could be an investment opportunity of £2bn-£6bn in GB between now and 2040 for EV charging equipment on commercial and industrial sites, in a high EV deployment scenario**
- **There could be demand for 2-4 million charging outlets on commercial and industrial sites in Germany by 2040 in a high EV deployment scenario**
- **EV charging at commercial and industrial sites could account for 13-18TWh of electricity demand in Germany in 2040 (2%-3% of total demand) in a high EV deployment scenario**
- **There could be an investment opportunity of 3bn € - 8bn € in Germany between now and 2040 for EV charging equipment on commercial and industrial sites, in a high EV deployment scenario**

The main charging applications on C&I sites are fleet vans, workplace commuter charging, public car parks and motorway service stations. In a high EV deployment scenario, these could together require up to 1-3 million charging outlets in GB and 2-4 million in Germany. Current levels of government subsidy will fall as EVs become widespread. Businesses looking to install charging infrastructure could use commercial debt to help fund the investment. Deployment of EV charging infrastructure in new buildings or those undergoing renovation will be supported by new EU regulations.

Given the potential scale of electricity demand for EV charging by 2040, it is important to understand what charging infrastructure will be needed to meet it. This infrastructure will be in a mixture of locations: some will be on-street, while some will be on domestic, commercial or industrial sites.

The nature of the decision-making around installing charging infrastructure will vary across these types of locations. In this report, we focus on commercial and industrial sites, and examine the business cases that site owners and the investor community will need to consider to decide if and when to install charging points.

4.1 Overview of applications

The main charging applications on C&I sites are fleet vans, workplace commuter charging, public car parks and motorway service stations.

To size this market, we divide it into four main charging applications. The first two are about providing charging to employees at company sites; the last two are about providing charging to customers at public sites.

- **Fleet vans:** Charging for light commercial vehicles that drive for work during the day and are parked at a company site overnight. We focus on this as the biggest single application of fleet charging.⁸
- **Workplace commuter charging:** Charging for commuters who travel to a work site in the morning and park their car there during the day. This is likely to be the single biggest charging application for commercial and industrial sites in terms of national energy demand.
- **Public car parks:** This covers two types of parking that we collect together for the purpose of market sizing.
 - Car park businesses: Car parks run as standalone commercial enterprises for drivers visiting other destinations.
 - Car parks at shopping or leisure sites: Car parks offered as a service by a destination, such as a supermarket, shopping centre, sports venue or hotel.
- **Motorway service stations:** Charging for car or van drivers en route. A question remains about whether EV charging will be widespread at service stations on smaller roads, but we assume here that charging en route will mostly only be needed for the longest motorway journeys. This application typically needs more expensive, higher-powered charge points to minimise customer waiting time.

4.2 Market sizing

In a high EV deployment scenario, the main C&I applications could together require up to 1-3 million charging outlets in GB and 2-4 million in Germany.

Exhibit 9 and Exhibit 10 show our estimates of the market size in GB and Germany respectively in 2040 for each of the four applications, assuming the high deployment smart charging scenarios from section 3. The energy demand shown

⁸ There are several smaller applications (e.g. rental cars, taxis, emergency services vehicles) that we set aside for simplicity. Similarly, we do not account for heavy goods vehicles, which are likely to electrify much later than vans. The emergence of “transport as a service” models could increase demand for fleet charging at hub sites and decrease demand for charging of private vehicles elsewhere; we do not investigate this aspect of the market in this study.

is an annual figure; the numbers of outlets and total cost are cumulative figures for charge points to be installed up to 2040. We list the sources used to develop these estimates in the appendix in section 7.

Summary of market sizing estimates in GB, 2040
High deployment, smart charging scenario

| Application | Employees | | Customers | | Total |
|---|---|---|---|--------------------------------------|-------------|
| | Workplace commuters | Fleet vans | Public car parks | Motorway service stations | |
| Usage of application | 12m cars 182 visits/year 7.6h/visit | 0.6m vans 254 visits/year 12h/visit | 33m cars 164 visits/year 2.3h/visit | 99bn car & van miles/year | |
| Annual energy (TWh) | 5.9 - 8.3 | 2.6 - 3.4 | 1.8 - 2.4 | 0.7 - 0.9 | 11 - 15 |
| Number of outlets | 0.9m - 2.4m | 0.3m - 0.6m | 0.04m - 0.11m | 2k - 8k | 1m - 3m |
| Cost of equipment and installation per outlet | £1.8k, based on 3.3kW charge points | £2.2k, based on 7 - 20kW charge points | £2.2k, based on 7 - 20kW charge points | £25.6k, based on 150kW charge points | |
| Total cost of equipment and installation | £1.6bn - £4.4bn | £0.7bn - £1.3bn | £0.1bn - £0.2bn | £0.1bn - £0.2bn | £2bn - £6bn |

Exhibit 9

In GB, we expect demand for EV charging on commercial and industrial sites could reach 11-15TWh in 2040. This would require 1-3 million charging outlets and an investment of £2bn - £6bn, not counting network upgrade costs. For comparison, as of September 2018 there are roughly 17k publicly available charging outlets in GB.⁹ This figure includes on-street charge points, and does not include private workplace charge points, so it is not directly comparable to the numbers above, but it should still provide a sense of the scale of work needed.

In Germany, we expect demand for EV charging on commercial and industrial sites could reach 13-18TWh in 2040. This would require 2-4 million charging outlets and an investment of 3bn € - 8bn €, again not counting network upgrade costs.

For the estimates, we show a range to reflect different possibilities for consumer behaviour and utilisation rates. The limits of the range are not intended to be upper and lower bounds to the possible outcomes: there are significant uncertainties in many of the point assumptions that go into the overall estimates.

⁹ Zap-Map, <https://www.zap-map.com>



Summary of market sizing estimates in Germany, 2040
High deployment, smart charging scenario

| Application | Employees | | Customers | | Total |
|---|---|---|---|---------------------------------------|---------------|
| | Workplace commuters | Fleet vans | Public car parks | Motorway service stations | |
| Usage of application | 15m cars 182 visits/year 7.6h/visit | 0.7m vans 252 visits/year 12h/visit | 29m cars 164 visits/year 2.3h/visit | 114bn car & van miles/year | |
| Annual energy (TWh) | 7.8 - 11.0 | 2.8 - 3.8 | 1.6 - 2.2 | 0.6 - 0.8 | 13 - 18 |
| Number of outlets | 1.1m - 3.1m | 0.4m - 0.7m | 0.04m - 0.10m | 2k - 7k | 2m - 4m |
| Cost of equipment and installation per outlet | 2.0k €, based on 3.3kW charge points | 2.4k €, based on 7 - 20kW charge points | 2.4k €, based on 7 - 20kW charge points | 28.8k €, based on 150kW charge points | |
| Total cost of equipment and installation | 2.2bn € - 6.3bn € | 0.9bn € - 1.6bn € | 0.1bn € - 0.2bn € | 0.1bn € - 0.2bn € | 3bn € - 8bn € |

Exhibit 10

For workplace commuters the range is between a minimum where only commuters without private parking at home charge at work, and a maximum where the proportion of other commuters that charge at work is in line with the average proportion of time that commuters spend parked at work. At both ends of the range we assume charging points are shared: one for every 4 commuters that charge at work for the minimum, and one for every 2 commuters that charge at work for the maximum. As we discuss in the next section, this kind of sharing of charging points is important for achieving enough utilisation for a persuasive business case.

For fleet vans the range is between a minimum where some vans work in shifts or do some charging off-site during the day, and a maximum where there is one charger per company-owned van and they do all their charging on company sites.

For public car parks and motorway service stations, the range is between a minimum where each charge point is used for 6h per day, and a maximum where each charge point is used for 3h per day. The cases also take different assumptions for the proportion of their charging that drivers do at these applications.



4.3 Financing

Current levels of government subsidy will fall as EVs become widespread. Businesses looking to install charging infrastructure could use commercial debt to help fund the investment.

As we saw in section 4.2, the need for investment in equipment and installation for electric vehicle charging infrastructure on commercial and industrial sites could reach a cumulative total by 2040 of £2bn - £6bn in GB and 3bn € - 8bn € in Germany. The investment will come from a mixture of sources, including site owners themselves, charge point network operators, and third-party debt and equity providers.

In the early years, government incentives will form an important part of the investment. Various subsidies have been offered to promote on-street and home charging, but here we focus on charging infrastructure on commercial and industrial sites. For these sites, incentives have focused on workplace charging in GB, and on charge points available to the public in Germany.

For GB, the Workplace Charging Scheme is designed to provide support towards the upfront costs of equipment and installation. The government's contribution is up to 75% of costs, up to a maximum of £500 for each socket, for as many as 20 sockets across all sites for each applicant. In July 2018 a sum of £4.2m was set aside for sockets to be installed before the end of March 2019.¹⁰

For Germany, the Ministry of Transport and Digital Infrastructure (BMVi) has set aside funding of 100 m€ as part of a programme to support up to 12,000 new publicly accessible charging points in the years to 2020. This funding can be awarded to cover up to 40% of the cost of equipment and installation, with a maximum award of 5 m€ per investor. Some German states are prepared to supplement this funding to cover a further 20% of costs.¹¹

In both GB and Germany, these subsidies are intended to spur the early development of the EV market. However, they are likely to be phased out in the years ahead as EVs become more widespread, equipment costs fall, and charge point installation gains momentum. In our modelling in this report, we do not assume any continued subsidies for our business models.

Site owners planning to procure EV charging infrastructure directly can also seek commercial funding. There are different options for the form of this funding, and some of the characteristics of these options are set out in the box below. Technical definitions for the options are given in the appendix in section 9.

¹⁰ HM Government 2018, "The Road To Zero"

¹¹ Foerderdatenbank, "Ladeinfrastruktur für Elektrofahrzeuge in Deutschland"



Financing Options for EV Charging Infrastructure

Characteristics of key options for senior debt financing:

| Options: | Asset Finance | Dedicated Corporate Facility | Project Finance | General Corporate Facilities |
|------------------------------|--|--|--|------------------------------------|
| Security | ✓ | <i>In some cases</i> | ✓ | ✗ |
| Cost of borrowing | Driven by asset and corporate credit quality | Driven by asset and corporate credit quality | Depends on credit quality of cash flows within the project | Driven by corporate credit quality |
| Providers of finance | Banks, specialist asset finance providers, vendors or energy providers | Banks | Banks and institutions | Banks |
| Tenor | 3-7 years | 3-7 years | 7-10 years | 3-7 years |
| Asset ownership | Finance lease: company over time Operating lease: lessor | Company | SPV | Company |
| Project size and complexity | Small to mid | Small to mid | Mid to large | Large |
| Residual value risk transfer | Subject to type of asset finance product | No | No | No |
| Customer suitability | All | Small to mid | Sophisticated | Mid to large |

The table above does not cover subordinated debt or equity funding; these could be provided by infrastructure investors or the soon to be established government-sponsored Charging Infrastructure Investment Fund (CIIF).

Further features of the options above:

Counterparty debt financing (Asset Finance and Dedicated and General Corporate Facilities):

- Typically reliant on a mature income stream from an existing trading business, so borrowers need to demonstrate that existing income from the underlying business is sufficient to cover borrowing costs.
- Borrowers will need to ensure they have obtained all the necessary regulatory consents.
- Equity contributions of up to 30% of the project cost are common, subject to due diligence, assessed on a case by case basis.

Limited/non-recourse Debt Financing (Structured Asset Finance, Project Finance):

- Repayment is usually predicated on future cashflows from the project.
- Suitable for large scale deployment or refinance of EV charging infrastructure where the assets are business critical to the recipient of the funding and have an economic life beyond the funding term.
- Borrowers must demonstrate economic viability of the project, e.g. with long term revenue contracts.
- Operational risks must be mitigated, e.g. through maintenance contracts, warranties and insurance.
- Borrowers will need to ensure all necessary regulatory consents are in place prior to funding and will also need to demonstrate management and technical expertise in dealing with large projects.
- Technical, commercial and legal due diligence often feature as part of the risk assessment.

Information provided by NatWest and Lombard

4.4 Building regulations and charging infrastructure

Deployment of EV charging infrastructure in new buildings or those undergoing renovation will be supported by new EU regulations.

New EU rules regulating the energy performance of buildings have recently been endorsed by the European Parliament and will need to be incorporated in national legislation by 2020.

Under these rules, non-residential buildings that are new or undergoing major renovation and have more than 10 parking spaces will need to be equipped with at least one charging point and with power line ducting to allow later charge point installation for 20% of parking spaces.

By 2025, member states will have to set out a minimum number of charging points for non-residential buildings with more than 20 parking spaces, and measures to simplify deployment, e.g. by streamlining permitting and approval procedures.

These rules will help support the deployment of EV charging infrastructure: the ducting requirements will reduce installation costs by avoiding the need for trenching and resurfacing, and the requirements on simplification of deployment should reduce barriers for smaller businesses to install charge points.

However, there are aspects of deployment that are not addressed under the rules. One issue is that the number of charge points that will be needed on different sites by 2040 is uncertain, and for some types of site 20% of spaces may not be enough. E.g. if EV deployment approaches 100% in a high scenario and 30%-40% of people have no private parking, then some workplace car parks could need more spaces with charging access.

Also, setting requirements on numbers of charge points alone misses important characteristics of those charge points: for instance, smart connectivity is important to allow efficient use of the grid, and for some applications the power rating of the charge points is as important as the number of units.

A final consideration is that the capacity of a site's network connection is crucial for the viability of EV charging, so planning to support these connections will be an important element of future site development.

5. Business cases for investing in charging infrastructure

- **Selling electricity from charge points can be profitable with a combination of sufficiently high utilisation and appropriate pricing**
- **Business cases could be improved using vehicle-to-grid technology or co-located solar generation or energy storage, for suitable sites**
- **Electrification of typical van fleets, using on-site infrastructure for overnight charging, could become beneficial on a total cost of ownership basis over the next decade as technology costs fall**
- **Slow workplace charge points are likely to give positive net present value if they each supply four cars and set tariffs around £0.30 (in GB) or 0.40 € (in Germany) per kWh, in today's money, on a 2030 cost base**
- **Fast public and rapid service station charge points are likely to give positive net present value if they are used for 6 hours per day and set tariffs around £0.25 - £0.30 (in GB) or 0.35 € - 0.40 € (in Germany) per kWh, in today's money, on a 2030 cost base**

We have seen there is potential demand for millions of EV charge points to be installed on commercial and industrial sites by 2040, but what are the business models that will enable this demand to be met profitably?

In this section of the report, we will set out business cases for example sites in GB and Germany for each of the applications discussed in the previous section, and explain what it takes to make these profitable. We will see profitable business cases will be possible for each application given the right combinations of equipment utilisation, electricity pricing and technology cost reductions. V2G, storage and solar can further improve the results in some circumstances.

First, we will consider an example of a single charge point in GB to illustrate some of the uncertainties that site owners and investors must navigate.

5.1 General example

At a high level, the main drivers of the business case for most charging applications are: the up-front costs such as equipment and installation; the running costs such as maintenance and data management; and the total margin that can be derived from sales of electricity. Utilisation and pricing are crucial for determining the

margin. The overall business case can be improved with additional technologies like V2G, storage and solar in some circumstances.

Consider the economics for installing a set of 3.3kW or 20kW charging units on a commercial or industrial site in GB in 2030, roughly halfway along the route to the 2040 scenarios described above.

5.1.1 Costs

The main up-front costs are the charge point equipment itself, the installation, and any upgrades to the network connection. Running costs for a charge point include maintenance inspections, warranties, and charge point management services (e.g. access management, data processing and billing services). Ranges for each of these are shown in Table 1 below.

As discussed in section 4.3, government incentives are likely to be phased out as EV deployment increases, so we do not include them here. We factor in an expected decline in EV charging equipment costs of 20% between now and 2030.¹² For the 3.3kW case the sum of equipment and installation costs per unit is roughly £1.8k, in line with Exhibit 9. For the 20kW case we consider a dual-outlet unit and show values for the whole unit; note that this means the equipment and installation costs sum to twice the value per outlet of £2.2k shown in Exhibit 9. We show net present values (NPV) based on a real pre-tax discount rate of 7%, equivalent to a nominal pre-tax rate of approximately 9%.

Table 1: Typical costs for a 3.3kW or 20kW charge point¹³

| Cost type (£ k) | 3.3kW charge point | | | 20kW dual outlet charge point | | |
|-----------------------------|--------------------|------------|-------------|-------------------------------|-------------|-------------|
| | Low case | Mid case | High case | Low case | Mid case | High case |
| Equipment | 0.4 | 0.6 | 0.8 | 1.4 | 1.9 | 4.0 |
| Installation | 0.6 | 1.2 | 1.8 | 1.6 | 2.4 | 3.2 |
| Network upgrade | 0.3 | 0.5 | 0.8 | 6.5 | 13.0 | 19.5 |
| Running costs (annual) | 0.3 | 0.3 | 0.9 | 0.3 | 0.6 | 0.9 |
| Running costs (12-year NPV) | 2.1 | 2.4 | 7.1 | 2.1 | 4.5 | 7.1 |
| Total (12-year NPV) | 3.3 | 4.7 | 10.5 | 11.6 | 21.9 | 33.8 |

¹² GTM Research 2018, "EV Charging Infrastructure Development: EV and Infrastructure Market Sizing Forecast"

¹³ Sources: GTM Research 2018, "EV Charging Infrastructure Development: EV and Infrastructure Market Sizing Forecast"; Energy Saving Trust 2017, "Guide to Charging Infrastructure for Business Users"; UK EVSE Association 2015, "Making the right connections"; DOE 2015 "Costs Associated With Non-Residential Electric Vehicle Supply Equipment"; REA member data on network connection costs. Note we consider a design of dual outlet 20kW charge point that can supply 20kW to each of two EVs at once.

The installation cost and network upgrade cost are heavily site-dependent. A study in the US by the Idaho National Laboratory in 2015 found per unit installation costs between \$600 and \$12,700, with some sites requiring extensive boring or trenching work or electrical equipment upgrades.¹⁴ In GB, for sites that have spare capacity in their network connection, a small installation of charging infrastructure may not require a network upgrade at all, but large installations needing several MW of charging power can cost over £1m.¹⁵

5.1.2 Revenue from electricity sales

In order to pay back the installation and running costs, the simplest revenue channel is for the EV charging site to supply electricity to end consumers and make a margin between the cost of procuring electricity and the price at which this electricity is sold to end consumers. Later we will return to the possibility of making revenue from providing flexibility services to the grid, or of boosting the revenues from other services on-site (e.g. for shops).

We discuss electricity sales in terms of a price per kWh for ease of comparison; today in practice there are a variety of pricing schemes offered by different charge point operators which we will discuss in section 5.4. In some cases, pricing directly in kWh is impractical, either because of technical limitations in the charge point equipment or because of regulations around the sale of electricity.

Depending on a site's demand profile and scale of overall energy consumption, we expect the retail cost per kWh for C&I sites in the decade from 2030 will be between roughly £0.14 and £0.17. Selling to consumers at a price per kWh of £0.20 to £0.30 including 20% VAT would therefore give a margin per kWh of between roughly zero and £0.10. To capture this range, we will look at pricing cases where the margin per kWh is £0.02, £0.05 or £0.10.

5.1.3 Overall business case

The level of utilisation of the charge point is a crucial driver of profitability, since higher utilisation allows a given margin per kWh to pay off the fixed costs faster. We can think of utilisation in different ways: for employee parking, where a company might plan based on its number of staff, we can count the number of vehicles that a charge point provides all the energy for; for public sites it is more useful to look at the proportion of time that the each charging outlets is in use. Table 2 sets out the NPV for 12 years of margins in different utilisation and pricing cases, and highlights where there is a net benefit at different levels of cost.

¹⁴ Idaho National Laboratory (INL) 2015b. "How do Publicly Accessible Charging Infrastructure Costs Vary by Geographic Location?", cited in DOE 2015 "Costs Associated With Non-Residential Electric Vehicle Supply Equipment".

¹⁵ REA member data on network connection costs; interview with Flexisolar, August 2018.



Table 2 shows that positive NPVs are achievable with high utilisation when we are at the lower end of costs and the upper end of margins per kWh.

Table 2: Margin by utilisation and pricing for charge point

| Margin from Employee Parking at 3.3kW (12-year NPV, £k) | | | | | Margin from Public Parking at 20kW (12-year NPV, £k) | | | | |
|--|---------------|------------------------|-------|-------|---|---------------|------------------------|-------|-------|
| Utilisation (vehicles) | MWh / year | Pricing (margin / kWh) | | | Utilisation (hours / day) | MWh / year | Pricing (margin / kWh) | | |
| | | £0.02 | £0.05 | £0.10 | | | £0.02 | £0.05 | £0.10 |
| 1 | 1.7 | 0.3 | 0.7 | 1.4 | 2 | 29 | 5 | 12 | 23 |
| 2 | 3.4 | 0.5 | 1.4 | 2.7 | 4 | 58 | 9 | 23 | 46 |
| 4 | 6.9 | 1.1 | 2.7 | 5.5 | 6 | 88 | 14 | 35 | 70 |
| 6 | 10.3 | 1.6 | 4.1 | 8.2 | 8 | 117 | 19 | 46 | 93 |

Key: shaded cells indicate that revenues exceed costs in the low case, mid case or high case for costs.

These values can sometimes be enhanced further by using charge points with vehicle-to-grid (V2G) capabilities, or by co-locating energy storage systems or solar generation. Each of these technologies requires further capital investment, but they could unlock savings on electricity costs, reduce the scale of network upgrades needed, and provide extra revenues from the capacity market or ancillary services.

The value of each type of installation depends on the characteristics of the site and the timing of demand, and we will examine these in detail for different examples later. For now, we roughly extrapolate the benefit (per kWh of EV charging) to show the effect on profitability for our general example. We do this on a 24-year basis (with charge points and storage systems being replaced after 12 years) to reflect the longer lifetime of solar equipment. Note that for V2G, part of the benefit would have to be shared with consumers in exchange for the option of discharging their battery. We will discuss this point later.

In Table 3, we set out the 24-year NPV of the margin on electricity sales plus the benefit from V2G or solar and storage, accounting for these technologies' CAPEX and OPEX as well as for new revenues and savings. The costs reflect expected declines in solar and storage costs between now and 2030.

Table 3: Margin impacts from V2G, or from solar plus storage

| Margin from Employee Parking at 3.3kW (24-year NPV, £k) | | | | Margin from Public Parking at 20kW (24-year NPV, £k) | | | |
|--|------------------------|-------|-------|--|------------------------|-------|-------|
| Utilisation (vehicles) | Pricing (margin / kWh) | | | Utilisation (hours / day) | Pricing (margin / kWh) | | |
| | £0.02 | £0.05 | £0.10 | | £0.02 | £0.05 | £0.10 |
| 1 | 0.4 | 1.0 | 2.0 | 2 | 7 | 17 | 34 |
| 2 | 0.8 | 2.0 | 4.0 | 4 | 13 | 34 | 67 |
| 4 | 1.6 | 4.0 | 7.9 | 6 | 20 | 50 | 101 |
| 6 | 2.4 | 5.9 | 11.9 | 8 | 27 | 67 | 134 |
| Margin from Employee Parking with V2G (24-year NPV, £k) | | | | Margin from Public Parking with V2G (24-year NPV, £k) | | | |
| Utilisation (vehicles) | Pricing (margin / kWh) | | | Utilisation (hours / day) | Pricing (margin / kWh) | | |
| | £0.02 | £0.05 | £0.10 | | £0.02 | £0.05 | £0.10 |
| 1 | 0.6 | 1.2 | 2.2 | 2 | 10 | 20 | 37 |
| 2 | 1.2 | 2.4 | 4.4 | 4 | 21 | 41 | 74 |
| 4 | 2.4 | 4.8 | 8.7 | 6 | 31 | 61 | 111 |
| 6 | 3.6 | 7.2 | 13.1 | 8 | 41 | 81 | 148 |
| Margin from Employee Parking with solar and storage (24-year NPV, £k) | | | | Margin from Public Parking with solar and storage (24-year NPV, £k) | | | |
| Utilisation (vehicles) | Pricing (margin / kWh) | | | Utilisation (hours / day) | Pricing (margin / kWh) | | |
| | £0.02 | £0.05 | £0.10 | | £0.02 | £0.05 | £0.10 |
| 1 | 1.3 | 1.9 | 2.9 | 2 | 23 | 33 | 50 |
| 2 | 2.7 | 3.9 | 5.8 | 4 | 45 | 66 | 99 |
| 4 | 5.4 | 7.7 | 11.7 | 6 | 68 | 98 | 149 |
| 6 | 8.0 | 11.6 | 17.5 | 8 | 91 | 131 | 198 |

Key: shaded cells indicate that revenues added to contributions from V2G, solar and batteries exceed charge point costs in the low case, mid case or high case for charge point costs.

5.1.4 Uncertainties in the business case

Key sources of uncertainty in the future development of business cases for charging infrastructure on commercial and industrial sites:

- Development of equipment costs: Our modelling assumes a 20% decline in charging equipment costs by 2030; this might be faster or slower in practice. Our modelling also assumes a continued decline in costs for solar generation equipment and energy storage systems.
- Battery technology improvements: We assume continued improvements in EV efficiency, leading to a decline in the annual power demand per EV.
- Revenue streams from flexibility: Over time, technical development and regulatory reform could make new revenue streams available to charging stations, especially those with V2G technology, as they provide different forms of flexibility to local and national networks.
- Change in government incentives: We assume today's incentive programmes in GB and Germany will be withdrawn over time.
- Charge point technology development: High levels of utilisation may be enabled by new designs of charge point. For example, charge points with more outlets can allow more vehicles to plug in at once and charge either simultaneously or sequentially. For car parks with an attendant, "mobile chargers" have been developed: they are large battery packs on wheels that can be moved to charge a series of vehicles in sequence at a car park over the course of a day.¹⁶ In the future, car parks could even use autonomous mobile charging robots that are able to navigate to each car in turn and charge it up using a connector attached to a robotic arm.¹⁷ Alternatively, the hassle of attaching different vehicles to a charge point could be reduced by inductive charging pads: these sit on the ground and can charge up an EV parked over them without a physical connection.¹⁸
- Speed of EV deployment: The high utilisation rates needed for profitable charge point business models will become easier to achieve as a greater proportion of cars are electrified, so the speed with which this happens will affect how soon investors are ready to support charge point installation.
- Emergence of "transport as a service": consumers have increasing alternatives to owning a car, including digital services such as car clubs (subscriptions that allow them to book local cars to drive for flexible short periods). If this trend accelerates significantly, there would be more demand for fleet car charging at hub sites and less for charging of private cars elsewhere.

¹⁶ Freewire Technologies, "Case Study: Mobile EV Chargers for Workplace Charging"

¹⁷ Volkswagen 2018 news release, "CarLa charges the car"

¹⁸ Techradar April 2018, "Wireless electric vehicle charging explained"

- Charging behaviour of EV users: Utilisation rates and hence the strength of each business case will be affected by the mix of consumer behaviours: some will charge only at home or only at work; some will top up while shopping or running errands; and others will charge en route just as today's ICE drivers fill up with petrol. This choice will be influenced by the cost and convenience of different charging options, the battery capacity and range of future EVs, and constraints like whether a driver has private parking space at home where they can install a charge point.
- Cost of capital: As EVs become widespread and charge point utilisation rates become more reliable, investors are likely to become more confident in the technology and not demand as high a return.
- Network upgrade costs: The cost to upgrade any site will depend on activity nearby in the network; costs are likely to escalate as EV deployment broadens.

5.2 Business cases by application

Business cases for all the main applications will eventually be profitable under the right circumstances. For fleets, improvements in total cost of ownership for electric vans relative to ICE vans will make electrification worthwhile. For workplace commuter charging, the key is having enough employees that will pay a high enough price to charge at work. Public car parks and motorway service stations likewise rely on high utilisation; for retail sites, profitability may be boosted by increased customer spending in store.

Including V2G technology, on-site solar and storage can improve profitability under the right circumstances, and we review this in depth in section 5.3.

Given the importance of widespread EV deployment to drive utilisation, we expect some sites will make these business cases work in the 2020s; a greater number will see the economics work for them in the 2030s.

Here we present a range of examples of business cases to illustrate what can work under different circumstances. These are not designed to be “average” examples, but to demonstrate what it takes for EV charging to be economical.

We show currency amounts in real 2018 figures and use a pre-tax discount rate of 9% nominal (7% real) for the NPV calculations throughout. The details of sources used are shown in the appendix (section 8).

A question of interest to site owners is how soon it makes sense to install charging equipment: how soon could these business cases be profitable?

Utilisation rates are one of the main drivers of profitability and depend on the demand for C&I site charging; this will increase more or less in line with the deployment of EVs. C&I demand might grow slower because early adopters of



EVs are more likely to have facilities for charging at home, but C&I demand might grow faster because early EVs have shorter ranges and are more likely to need top-up or en-route charging than their successors.

In our analysis in this section, we model the business cases using electricity costs and equipment costs forecasts for the decade from 2030, since this is the period when most of the new supply will be needed. In the high deployment scenario introduced in section 3, the number of electric cars in GB rises from 10m to 33m during this period.

Our analyses are still relevant for sites considering installing charge points sooner: a substantial amount of infrastructure will still be needed between now and 2030.¹⁹ During this period we expect equipment costs to fall by around 20%²⁰, and we forecast wholesale electricity prices to rise by very roughly 1/5 in GB and 1/3 in Germany in real terms. The way these two effects net out for charge points depends on the tariffs applied to users and the utilisation levels, but ultimately the business cases could still be profitable in the 2020s if the applications can achieve the high utilisation rates set out here. It will be the largest and busiest sites that see the earliest value in these types of investments.

5.2.1 Overnight fleet charging

The business case for installing charge points for a company fleet is special because it is part of a broader decision about electrifying the fleet. The company's control over this decision removes the uncertainty around utilisation, so this application may be the first to be widely adopted. Depending on the types of vehicles in the fleet, electrification could be profitable between now and the late 2020s; using V2G technology as part of the charging installation could make the business case positive even sooner.

We consider an example of a site with dual-socket charge points providing 20 sockets at 7kW each, and assume these are used to provide the annual energy requirements for a fleet of 20 light commercial vehicles that are plugged in overnight from 6pm to 6am each working day.

To electrify its fleet, a company must believe it will save on the total cost of ownership (TCO). In Exhibit 11, we set out components of the difference in TCO for electric vans compared with ICE vans: negative values indicate the element is more expensive for electric vans than ICE vans, and vice versa for positive values.

¹⁹ Systra, Next Green Car, Cenex, 2018, "Plugging the Gap: An Assessment of Future Demand for Britain's Electric Vehicle Public Charging Network"

²⁰ GTM Research, "EV Charging Infrastructure Development: EV and Infrastructure Market Sizing Forecast", 2018



Net present value of cash flows for a 12-year lifetime

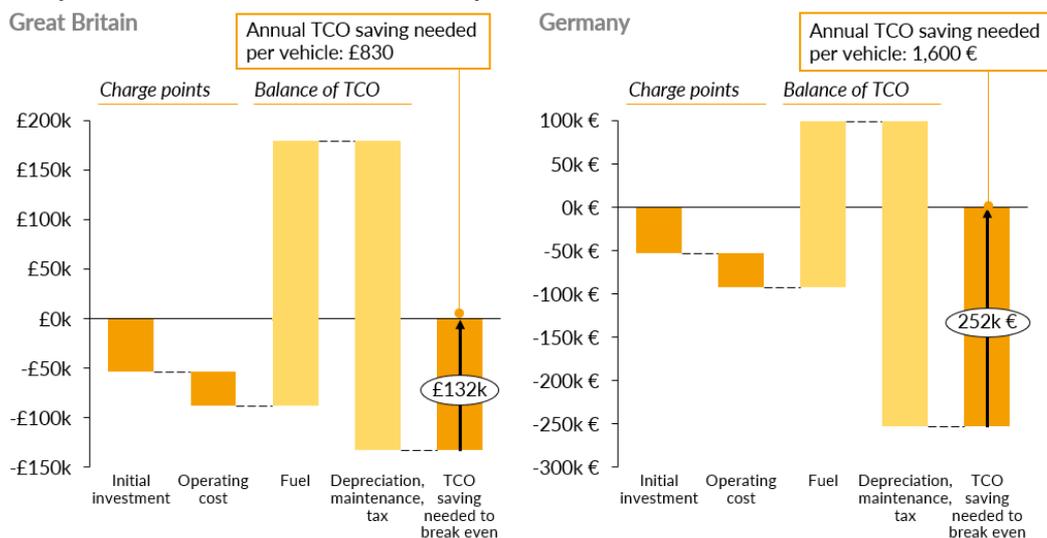


Exhibit 11

Charge points are one component of the difference: they are needed for electric vans but not for ICE vans, so they give a negative contribution. After the charge points, the balance of TCO is made up of insurance, fuel, depreciation, maintenance and tax. We assume electrification does not affect insurance and leave it out of the chart.

Fuel is already much more expensive for ICEs than for EVs. The average annual cost of electricity for an electric van today is around £800 in GB and 900 € in Germany, whereas the average fuel cost for a diesel van is around £2,700 in GB and 2,600 € in Germany.²¹

Between now and 2040, we expect both oil and power prices to trend upwards, and the efficiencies of both electric vehicles and ICEs to improve. Overall the fuel savings from EVs will remain large.

We take estimates of the depreciation, maintenance and tax components of TCO from a study by CE Delft²², using their values for medium electric and diesel vans in 2020. The depreciation element drives the difference, and is much higher for EVs. This is partly because retail prices for electric vans are higher than for diesel

²¹ Electricity cost uses a retail electricity price of £0.12/kWh in GB and 0.14 €/kWh in Germany including consumption and network charges (Aurora Energy Research estimate), and an annual van consumption of 6.6MWh (National Grid 2018 Future Energy Scenarios). Fuel cost is based on £0.13/mile in GB (HMRC advisory fuel rate), 0.13 € in Germany (differential from GlobalPetrolPrices.com) and an annual mileage of 20k miles.

²² CE Delft, 2017, "Van use in Europe and their environmental impact"

vans (over 40k € compared with around 25k €), and also because old electric vans lose value faster because of the pace of improvement in EV technology.

Overall, TCO for medium vans is currently more expensive for EVs than ICEs. For electrification to break even, we would need a saving on TCO per van per year of £830 in GB or 1,600 € in Germany.

How soon will this be achieved? Trends in ownership cost suggest the breakeven point for total cost of ownership (TCO) will be between now and 2030, with a central case for medium-size vans in 2025. Small vans are near cost parity already, while larger vans will take longer to become economical and require faster chargers because of their higher battery capacity.

For sites with significant electricity consumption other than EV charging, charge points with V2G capabilities can improve the business case and could lead to fleet electrification becoming viable sooner, as discussed in section 5.3.

5.2.2 Workplace commuter charging

As we saw in section 4.2, employee charging at workplaces is likely to account for most charging at commercial and industrial sites by 2040. We consider here an example of a site with ten slow (3.3kW) charge points, and assume that these are used to provide the full charging requirements for 4 electric cars each, so they are charging for just over 8 hours on each working day.²³

Net present value of cash flows for a 12-year lifetime

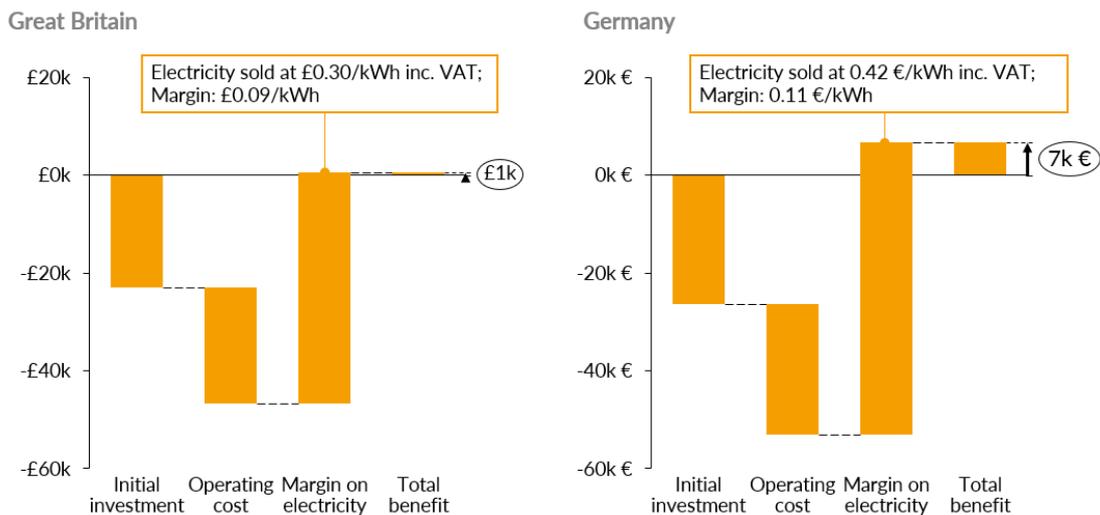


Exhibit 12

²³ We look at the decade to 2040 and project the annual consumption per car to be 1.7MWh.

A positive business case is possible for both GB and Germany if electricity is sold to the employees, as shown in Exhibit 12. The benefit looks narrow here, but is highly sensitive to the price: e.g. raising prices from £0.30 to £0.32 in GB would increase the total benefit to about £10k. We note that some companies may consider subsidising part of the sales price as an employee perk. Workplace car parks, where employee cars are parked during the middle of the day, are a natural candidate for on-site solar, and we will see in section 5.3.1 that the business case can be further improved by incorporating solar and storage on site.

How soon could an investor look to take advantage of this business case? This depends on what utilisation is possible. This business case assumes the site has 40 staff who both have an electric vehicle and will do all their charging at work. Staff with electric vehicles who have access to charge points at home are likely to prefer to charge at home where electricity is cheaper; in GB, around 60% of households have access to private parking at home and around 70% of cars are parked on private property overnight, so electric vehicle owners who charge at work are likely to be a minority.²⁴ Similarly in Germany, about 60% of households have access to private parking at home.²⁵

Smaller installations could realistically be profitable sooner. How soon it becomes realistic for 40 staff to charge on site each day depends on the size of the site, the overall rate of future deployment of EVs, the proportion of commuters that are willing and able to install charge points at home, and the company's level of influence over whether its employees electrify their vehicles.

We expect that large companies ambitious to pioneer EV charging provision will be the first to seek opportunities to make this kind of business case work. This will require either substantial progress along the deployment curves of Exhibit 1 to make the above utilisation rate realistic, or a faster than expected reduction in charge point equipment costs.

Logistics are also important. If each charge point provides all the charging for four electric vehicles, a system is needed for the vehicles to share charge points. An office looking to implement this could set up a rota system for staff to use charge points on particular days or times of day, or look to buy charge points with four sockets each: these have been developed for higher power charge points, but are not currently widespread for 3.3kW charge points.

5.2.3 Car park business

Offering EV charging is a natural model for car park businesses; gauging the likely future levels of utilisation will be essential to succeed.

²⁴ Department for Transport 2009, "Public experiences of and attitudes towards parking"; Department for Transport 2016, "National Travel Survey"

²⁵ Destatis 2009, "Zuhause in Deutschland"



We consider an example of a site with dual-socket charge points providing 20 sockets at 20kW each and assume these are used 6h per day on average. In practice, car parks are likely to provide a mix of charge points with different power ratings depending on the mix of customer lengths of stay they expect.

Net present value of cash flows for a 12-year lifetime

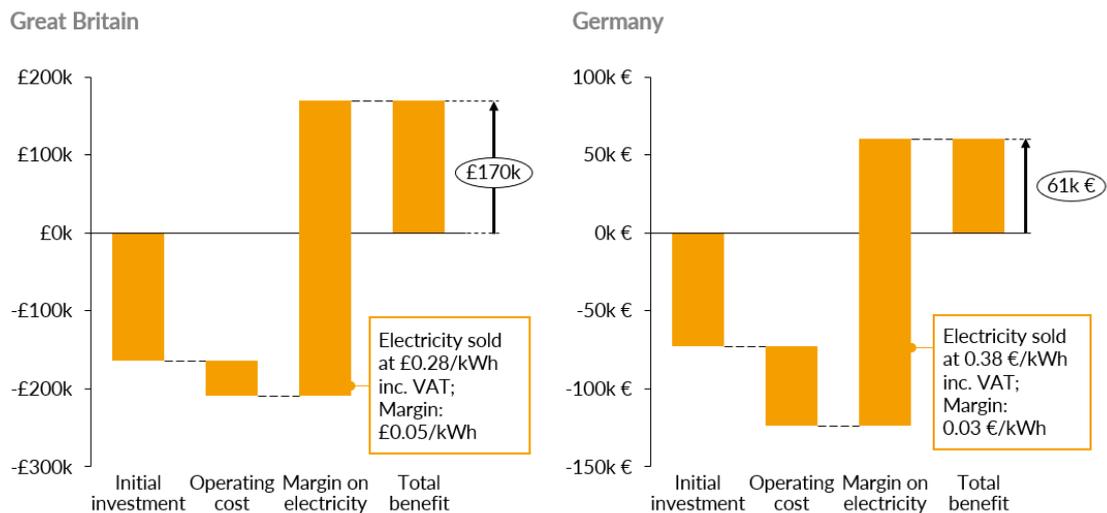


Exhibit 13

Achieving an average of 6h of use for each of 20 sockets will require both a high level of EV deployment and a pattern of consumer charging where people are often prepared to pay to use public charge points. With these factors the business case can be profitable (see Exhibit 13).

To achieve high utilisation, we expect car park operators will consider models where the price to park in a spot with a fast or rapid charger increases after the first hour or two, so that customers avoid taking up sockets when they are already fully charged.

5.2.4 Car park at a shopping or leisure site

Supermarkets, shopping centres, sports centres, cinemas and other destinations with their own car parks could install EV charge points to persuade consumers to choose them over competitor destinations and spend more time and money on site.

Early evidence of the effect of installing charge points at shopping locations suggests a sales uplift of £5k - £7k per charge point per year can be achieved.²⁶ This is likely to decline over time as charge points become more widespread (eroding their competitive draw) and EVs become more of a mass market product

²⁶ BBP Managing Agents Partnership, 2018, Savills Case Study; ChargePoint, 2015, "RetailCo" case study

(today's EV drivers are more affluent than average). We assume the revenue uplift is ~£3k per socket, and we assume a margin on these sales of 10% (in practice, margins would depend on the type of shops: for example, they would be lower for grocery retail, but higher for clothes stores).

For an installation of dual-socket charge points providing 10 sockets at 20kW each, and assuming a utilisation of 6h per day on average, we see in Exhibit 14 that a profitable business case is possible with consumer electricity prices of £0.25/kWh in GB and 0.35 €/kWh in Germany.

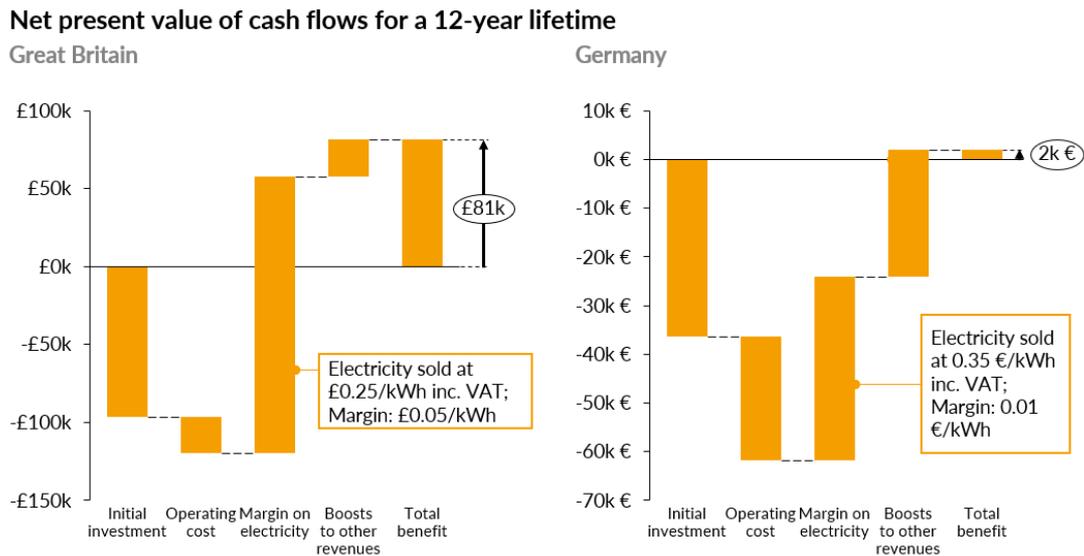


Exhibit 14

As in our other cases, utilisation is key: EV deployment and consumer willingness to charge at the site instead of at home both must be high. In this case, there is a further key assumption that the benefit from sales uplift is captured by the party investing in the charge points. That is likely to be true for a large retailer that is the only occupant of a site, but not for a shopping centre where the site owner leases units to retailers, unless the rent is calculated in a way that captures a portion of the sales uplift.

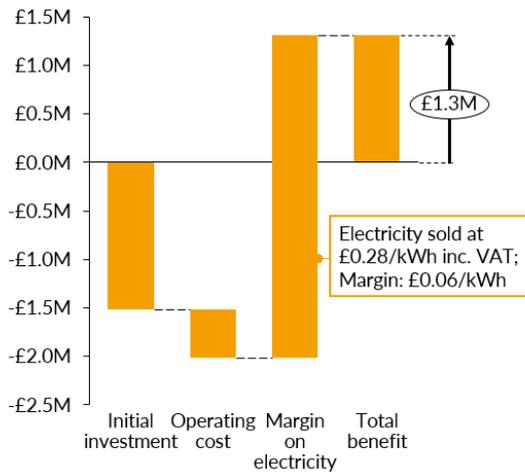
5.2.5 Motorway service station

Motorway service stations are the most promising sites for rapid charging for EV drivers in the middle of a journey.

As Exhibit 15 shows, a profitable business case can be achieved with a consumer price of £0.28/kWh in GB or 0.28 €/kWh in Germany. In section 5.3 we will demonstrate that profitability can be improved by including on-site storage and solar generation in an installation.

Net present value of cash flows for a 12-year lifetime

Great Britain



Germany

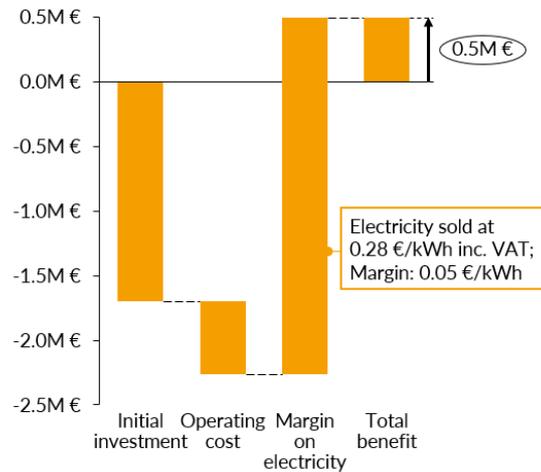


Exhibit 15

In this example we consider a site with multi-socket charge points providing 20 sockets at 150kW each. We assume each socket is occupied for 6h per day.

What must we believe for a utilisation of 6h per day to be plausible? EV deployment levels must be high, and EV drivers must have a need to charge en route. The latter depends partly on how battery size and vehicle range develop. Ranges today are over 200 miles for several EV models, and we expect battery EVs approaching 400 miles to be available at prices around £20k (in 2018 currency) by 2040. Whether these longer-range EVs will be widespread remains uncertain. There is a spectrum of possibilities: at one end, high popularity of high-range EVs may remove most of the potential demand for charging at motorway service stations; at the other, cars with smaller, cheaper batteries may prove most popular, meaning recharging stops at service stations are necessary for many motorway trips and making the 6h utilisation figure in this example more likely.

5.3 Business cases including V2G, Solar and Energy Storage

Business cases for EV charge point installation can be improved by complementary technology. Solar generation, energy storage systems and V2G technology can all lower the overall prices paid for electricity, and potentially reduce network connection upgrade costs by lowering EV charging demand during pricing peaks. They may allow further benefits to be derived from selling ancillary services to the network or participating in the capacity market. Solar installations can also lower the complexity and cost of charge point installation.

In this section we extend three of our GB business case examples to show the potential benefits of vehicle-to-grid technology, co-located energy storage and co-located solar generation.

We work with 24-year business cases and NPVs to reflect the typical lifetime of solar installations. We account for expected cost reductions in solar and in storage systems between now and 2030. We assume the costs of the equipment and installation for EV charging points and storage systems are repeated at the end of year 12.

5.3.1 Overnight fleet charging with V2G

V2G technology allows parked EVs to charge their batteries from the grid when electricity is cheap, then discharge to the grid or to co-located demand when electricity is expensive. This is called electricity market arbitrage. V2G could also in principle allow EVs to participate in ancillary services markets. Exhibit 16 sets out possible benefits from adding V2G capabilities to the fleet charging business case from section 5.2.1. Note that the column labelled “fuel, depreciation, maintenance, tax” gives the difference in cost for these items for an electric vehicle fleet as opposed to an ICE fleet, as discussed before.

V2G could allow this kind of business model to be profitable sooner, as it requires the TCO for electric vans relative to ICEs to improve against today’s values by only £690 per vehicle per year rather than £830.

Net present value of cash flows for a 24-year lifetime

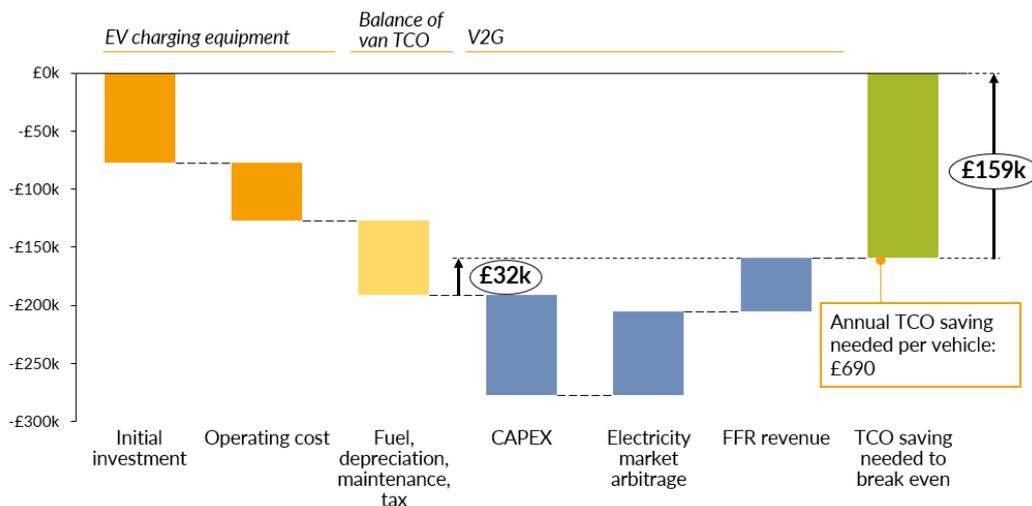


Exhibit 16

This accounts for faster battery degradation caused by V2G, assuming a battery lifetime of 1,500 cycles and accounting for declining battery costs over time. The degradation cost makes up most of the V2G CAPEX, the rest arising from the higher price of charge points: we assume a modest premium for bidirectional charge points of 40% of the cost of standard charge points.

The actual effect of V2G on battery degradation rates depends on the charging patterns followed, and a study last year found that optimal use of EV batteries within a smart grid could even extend their lifetime compared with a case without V2G.²⁷ Our estimate of V2G value may therefore be conservative.

For this example, we have assumed the site has a large peak energy consumption demand of 100kW. For instance, this could be a refrigerated warehouse or a small factory. This kind of site allows better use of electricity discharged from the EVs: it can offset purchase of electricity from the grid at retail rates instead of being sold to the grid at wholesale rates.

The electricity arbitrage revenues here assume the van batteries have just over 45kWh of storage each, twice their average daily consumption per working day. This means they still have enough charge left when they plug in at 6pm to be able to discharge half their storage capacity during the evening peak. They then fully recharge over the course of the night.

Revenues from firm frequency response (FFR) in our calculation amount to roughly £200 per vehicle per year. This reflects our expectation that saturation in the FFR market in GB will lead to a reduction of about 60% in FFR prices by the mid 2020s, to roughly £8 per MW per hour.²⁸ For comparison, a 2016-17 study in Denmark by Nuvve, Enel and Nissan found revenues of €1,400 per vehicle per year from frequency regulation services.²⁹ In this study, the vehicles were providing these services for a higher proportion of the time, and had higher power charge points, but most of the difference is driven by the market value of ancillary services: there was an average price of almost €27 per MW per hour for Danish frequency regulation during the study.

The uncertainty in future market prices for FFR is compounded by the regulatory uncertainty around which ancillary services markets V2G will be able to benefit from in future. Access to additional markets could improve the business case. We discuss regulation further in section 5.5.

Fleet charging applications like this are a straightforward use of V2G because both the EVs and the charging equipment are owned by the same company.

For public car park applications, it is unclear how the benefits from V2G will be shared between the vehicle owner and the charge point owner. These benefits are opaque to the vehicle owner, which gives most of the influence over this split to the charge point owner, so the question becomes: what is the smallest

²⁷ K. Uddin et al, "On the possibility of extending the lifetime of lithium-ion batteries through optimal V2G facilitated by an integrated vehicle and smart-grid system", Energy 133 (2017)

²⁸ This value represents the average annual price for 24/7 full suite response (primary, secondary and high).

²⁹ See section 5.6.5 for further detail.



discount to the usual charging price that a vehicle owner will accept for the use of their vehicle for V2G charging, and the associated degradation of their battery?

In the example above, the cost for battery degradation is £0.04 per kWh on average over the course of the project lifetime, accounting for future reductions in battery costs. In a public car park application, assuming similar battery degradation costs were borne by a consumer, we might then see the charging price discounted by £0.04 plus VAT per kWh, a reduction of roughly 15%-20% on a regular price of £0.20 to £0.30.

5.3.2 Workplace commuter charging with solar

A workplace site, where EVs park mostly during the day, is a natural candidate for co-located solar generation. By self-generating electricity in the middle of the day, the site saves on electricity consumption and network charges. Furthermore, there are potential “co-location savings” from installing the EV charge points and solar panels at once.

To be suitable for co-located solar installation, a workplace site needs exposed space for the panels, whether on the roof of an office building, in a nearby field, or as a canopy over an open-air car park.

Net present value of cash flows for a 24-year lifetime

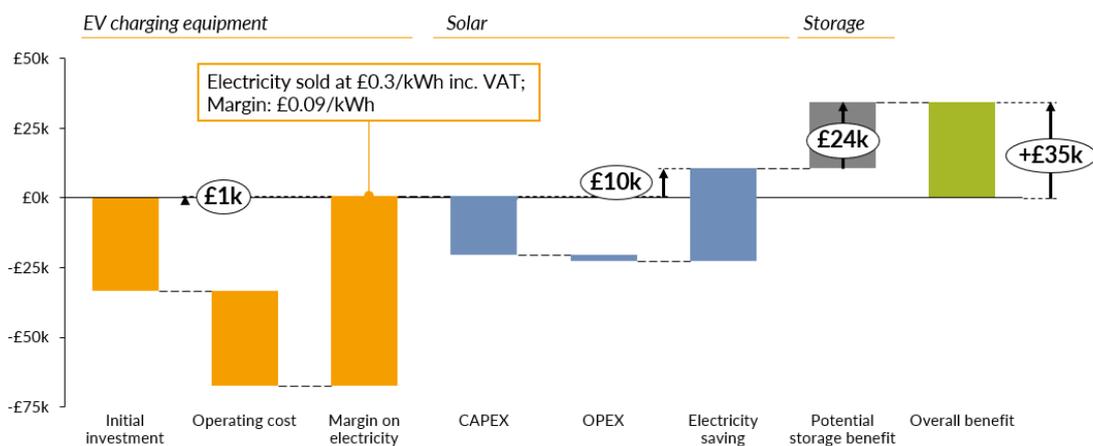


Exhibit 17

We consider our example case from section 5.2.2. The potential benefits of an accompanying 20kW solar installation, mostly from savings on the electricity price, are shown in Exhibit 17.

The main challenge with this setup is that the site does not use the solar power on weekends and bank holidays. For workplaces in town centres or near other shopping or leisure destinations, making the charge points available to the public on the weekends could add extra value. More directly, the issue could be

addressed by selling electricity back to the grid, or installing energy storage systems to store weekend solar energy for during the week.

Installing on-site storage has further advantages: it allows electricity market arbitrage, where the battery charges overnight and discharges at peak times to reduce electricity costs; in principle it allows participation in ancillary service markets such as the market for firm frequency response (FFR); and in principle the storage can also bid into the capacity market. This business case assumes the storage is installed in 2030, and that battery costs continue to fall over time.

5.3.3 Motorway service station with energy storage

Motorway service stations are likely to be busiest when the roads are busiest. The evening rush hour partly coincides with the network's peak evening electricity demand. The load-shifting capabilities of electricity storage systems are therefore a particularly good fit for EV charging at motorway service stations.

Net present value of cash flows for a 24-year lifetime

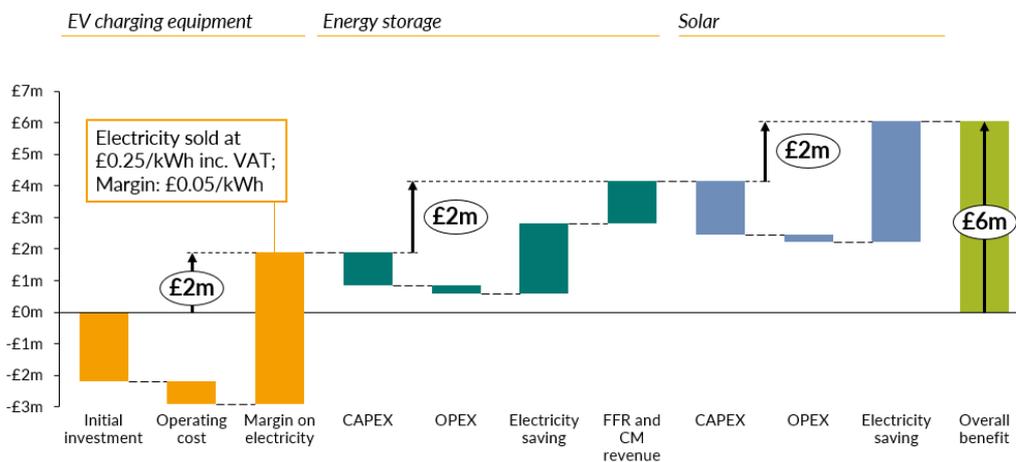


Exhibit 18

We consider an extension to the example business case from section 5.2.5, with a storage system including a battery with 4MW power capacity and 2 hour duration, plus a solar installation with 4MW generation capacity. The benefits from these additions are shown in Exhibit 18.

The largest part of the storage system benefit is from network savings, which arise from avoiding using electricity from the grid during the evening peak. We also assume the storage system is able to participate in the firm frequency response market and the capacity market.

For applications with high power demand like this one, energy storage has an important further potential benefit in that it can reduce the scale of network upgrades needed. New multi-MW network connections can cost in the order of

£1m, and using storage to shift demand away from the peak may reduce the maximum capacity needed from the connection by 10% or more.

The solar generation benefit is mostly from savings on the cost of electricity consumption. In this example we have chosen the maximum solar generation (4MW in summer at midday) to exceed the maximum demand from the EV charge points (3MW). This means that sometimes there is enough solar generation for the battery to charge during the day at no cost, rather than overnight at off-peak retail rates (which are lower than peak rates, but well above zero). This synergy is important for getting the most out of an installation with both solar and storage.

A 4MW solar installation takes up a lot of space. For “solar carports” with a canopy of solar panels over the parking spaces, peak generation is typically around 2kW per parking space, so this example would need 2,000 spaces at the service station. Some of the biggest GB motorway services are this size.

The overall NPV benefit of £6m shown in Exhibit 18 means the utilisation rates could be lower than our assumed 6 hours per day without making the business case unprofitable. A reduction to an average utilisation of 4 hours per day would reduce the benefit to about £3.5m.

5.4 Charge Point Network Operators

Site owners have some choice between arranging installation and operation of charge points themselves, or outsourcing to a charge point network operator (CPNO).

The extent of outsourcing can vary, and can affect the economics of charge points. Our business cases assume a CPNO is used to provide a charging point management system (CPMS) for data collection, access management and reporting services, at a flat rate of £60-£180 per charge point per year in GB; in Germany these services are built into the overall running costs in our source data.

In some cases, a CPMS is priced as a proportion of revenue instead of a fixed annual amount, which can help reduce the risks of low utilisation by moving this service out of the fixed cost base.

A CPNO may offer to source, install and maintain charge points as well as providing a CPMS. This could appeal to site owners that want to minimise management complexity. For example, the UK networks Pod Point and Chargepoint Services both offer this range of options.

Some CPNOs offer leasing or financing services: instead of paying an up-front cost to buy and install the equipment, the site owner pays a higher ongoing charge. For example, Chargemaster (which operates about half the charge points



at UK supermarkets³⁰) has offered to install and maintain charge points with no up-front cost for businesses open to the public. A CPNO might own the charge point installation and rent the parking space from the site owner.

Depending on the nature of the outsourcing arrangement, the CPNO might control the way electricity is priced for users and reimburse the site owner for the cost of the electricity consumed. CPNOs use several different models for pricing, including subscriptions, connection or admin fees charged for each visit, fees for time spent charging, per kWh fees, and supplements for using charge points with higher power ratings or located in particular areas. For example, according to the UK charging point platform Zap-Map, as of 2018:

- Chagemaster offers a subscription of £94 per year which gives free access to most points on its Polar network
- Charge Your Car allows site owners to determine their user tariff, which can be a flat rate per visit or a fee per kWh
- GeniePoint prices electricity at £0.30/kWh, plus a connection fee of up to £2.80, depending on the region and the speed of the charge point

For some CPNOs, home EV charge points are the main part of the business, and charge points on C&I sites provide a means to expand their public network and attract more home charging customers. This changes the business case because it means that C&I sites might reasonably be cross-subsidised by home charging.

5.5 Implications of electricity market regulations

The business cases discussed above will shift over time as regulations for the electricity market change. In GB, relevant changes are expected in the rules around network charges, the capacity market, the balancing mechanism and ancillary services. In Germany, evolving energy industry law and regulation could support the role of EVs in providing flexibility services.

From the system perspective, EVs have the potential to provide much-needed flexibility to support the growth of wind and solar as forms of generation. In general, to enable the ongoing acceleration of EV deployment, operators of smart charging equipment will need to be able to develop profitable business cases, and this can depend on appropriate compensation for the benefits they deliver. Finding the most effective way to provide this is an ongoing challenge for regulators.

³⁰ Zap-Map, <https://www.zap-map.com>



5.5.1 Regulatory developments in GB

Network charges form a significant part of electricity costs in our business cases. In GB, one of the advantages of co-locating storage or solar with EV charging demand is the so-called embedded benefit of reducing these network charges, in particular the Transmission Network Use of Service charge (TNUoS).

As of April 2018, the half-hourly demand tariff for demand residual TNUoS charges has been split into two parts: the embedded export tariff (EET) for payment to embedded generators, and the gross half-hourly demand tariff available to behind the meter (BTM) assets. Once this change is fully phased in by 2020, the value of the EET will have been reduced by around 90%, making it far less valuable to sell electricity back to the grid at peak times.

The current Targeted Charging Review run by National Grid is scheduled to run until early 2019 and is likely further to change the methodology for calculating TNUoS charges, moving away from using power demand during “triad” periods.

The new methodology could affect embedded benefits for the type of installations we have considered. One widely supported methodology is to set fixed charges by user, which would reduce the benefits we have described. Another option that enjoys some stakeholder support is charging based on ex-ante or ex-post capacity assessments: this would retain the benefits we have described, although it would depend on the introduction of half-hourly metering.

Capacity market revenues are another of the benefits from energy storage systems in our business cases. These could be affected by future decisions to further de-rate storage (i.e. to reduce the rate at which it can earn capacity market revenue). Also, potential future requirements for distribution-connected assets to have a firm connection to participate in the capacity market could raise network upgrade costs in our business models.

Planned reforms to other parts of the electricity markets could make it easier for small providers like EV parks to participate. These reforms include a proposed new classification of providers for the balancing mechanism, the standardisation of frequency response and reserve markets, a trial of day ahead auctions for ancillary services, and a review of ancillary service contract clauses.

Another important development is the transition of distribution network operators (DNOs) into distribution system operators (DSOs) with greater responsibility for managing network operability and costs through market-based flexibility solutions. The Open Networks Project launched by the Energy Networks Association at the end of 2017 is co-ordinating this transition. It could result in new market mechanisms and revenue streams that would reward EV charge point operators for the provision of local flexibility services.

Over the last five years, network companies across the UK have run a range of projects looking at topics including EV charging infrastructure, controlled charging



and smart grids, and the impact of EVs on the network. The Energy Networks Association notes that they have started to see benefits from V2G in providing flexibility services, and although the technology is currently at a low level of readiness, network operators are working to trial and progress it.³¹

5.5.2 Regulatory developments in Germany

Regulation in Germany has started to recognise the potential role of EVs and charging points for the wider power system. Questions about the legal framework and incentive structures for V2G in Germany remain to be settled with potentially significant implications for V2G business cases.

The revision in 2016 of section 14a of the Energiewirtschaftsgesetz (EnWG) (“law pertaining to the energy industry”) opened the possibility for EVs and charging stations to act as flexibility providers in the reserve markets. This could be a potential upside for EV charging stations. The revised law further establishes that the network fees charged by DSOs shall be reduced for flexibility providers, which explicitly includes EVs. The implementation of this reduction and its extent will need to be specified in subsequent legislation (as laid out in section 21i of the EnWG).

However, this regulation and the corresponding incentives for EV charging stations are not yet in place. Further legislation is needed to define support for the potential role of EVs and charging points in stabilising the Energiewende, as well as to decide how and to what extent DSOs might steer a flexibility asset.

The best way to implement this legislation continues to be discussed. For example, the BDEW, Germany’s association of the energy and water industry, called in 2017 for the introduction of an incentive structure paired with an intelligent measurement system that can determine the provision of flexibility capacity to the grid.³² It further recommended a capacity-based remuneration instead of reductions to network fees.

5.6 Case studies

5.6.1 Regulatory support in Norway³³

Norway has the highest market share of EVs of any country. The market share of EVs has grown rapidly since 2010, resulting in part from increasing availability of public charging points (see Exhibit 19). The transition to electrification has been supported since the early 1990s by a broad coalition of political parties. The

³¹ Energy Networks Association 2018, “Preparing for the electric vehicle revolution”

³² BDEW 2017, “Positionspapier – Ausgestaltung des §14a EnWG”

³³ European Alternative Fuels Observatory, The Norwegian Electric Vehicle Association



Norwegian Parliament has now decided on a goal that all new cars sold by 2025 should be zero emission (electric or hydrogen).

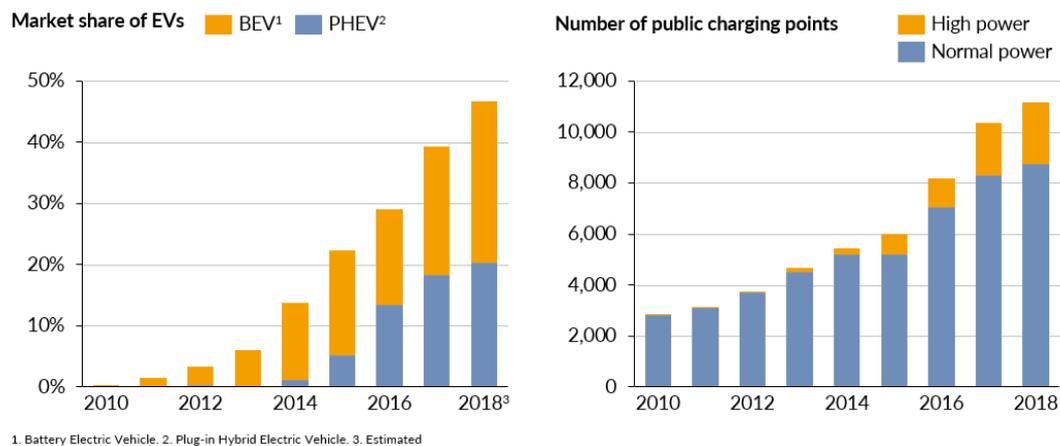


Exhibit 19

Support for Charging Infrastructure in Norway

- 2009-10: Funding scheme (NOK 50 million) for installation of 1800 normal chargers in public areas across the country
- 2010-14: Funding scheme (NOK 50 million) for installation of fast charging stations, operated mainly by local utility companies
- 2015-17: State company Enova develops rapid charging stations (22kW) in every 50km of the main road network (7500km)
- Prices for rapid charging (50kW) are set by the two national charging operators and start at NOK 2.5/minute, which results in about NOK 3 - 5/kWh (£0.3-0.5)
- In comparison, home charging costs around NOK 1/kWh, including taxes
- An open, publicly owned central database (NOBIL) has been developed to collect information on charging infrastructure availability

Other policy support for EVs since the 1990s

- Exemption from 25% VAT on purchase, no import taxes, low road tax
- Exemption from 25% VAT on leasing, reduced company car tax
- Reduced charges on toll roads and ferries, bus lane access, free municipal parking

5.6.2 EV infrastructure in retail locations³⁴

Real estate services provider Savills and its client The Crown Estate partnered to install 76 charging points in 29 retail parks and shopping centres. By installing EV charging infrastructure they aimed to increase revenues for retailers from higher dwell times, increase rental value for site owners and property value for investors, and improve sustainability credentials and marketing opportunities.

The installations used 7kW fast charge twin units. An “open charge” protocol allowed access through a mobile application, or 15 minutes of emergency charging for users with no access to the application. A management information platform was set up for usage monitoring, reporting, and administering user tariffs.

Most installations were funded by property owners. Charging is offered for free to vehicle owners, as a value-add service to attract shoppers. The running costs were about £6k across all locations in 2017/18, with an average of £0.52 per charge. For most sites, running costs are funded by occupiers through the service charge as part of the normal mechanism for external car park electricity.

As shown in Exhibit 20, customers charging their vehicles had a longer average dwell time; in a separate survey, Savills found higher spend among shoppers with longer dwell times.

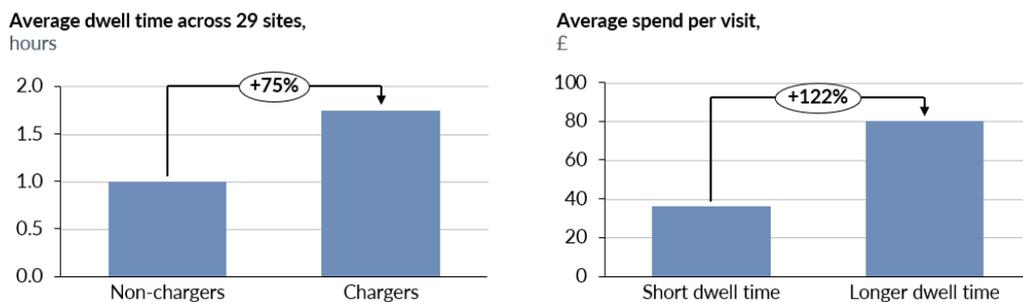


Exhibit 20

5.6.3 BP Chargemaster: the Polar network³⁵

Polar is the UK’s largest EV charging network, with over 6,500 existing charging points and plans to expand to 25,000 by the end of 2020. Over 80% of the rapid chargers added to the POLAR network in 2017 were supplied free of charge to site hosts, including installation, representing private investment of over £1.2 million. Rapid chargers on the POLAR network provide the three common charging connectors – CHAdeMO, CCS and Type 2 AC – making them compatible with all rapid charging EVs.

³⁴ BBP Managing Agents Partnership 2018, “Savills Rolls Out Electric Vehicle Charging Points for Shoppers”

³⁵ BP Chargemaster, Zap-Map

The network has charge points across different types of commercial sites, including IHG hotels, Asda supermarkets, Intu shopping centres and Q-Park car parks. Installation of charging points has also been offered to all 4,000 AA-inspected hotels and B&Bs. BP plans to roll out ultra-fast chargers (150 kW) in 1,200 service station forecourts across the UK over the next 12 months.

Two types of subscription services are available. The Polar Plus subscription service costs £7.85 per month (£94.2 per year), with the first three months of subscription offered for free. Subscribers are able to charge at no extra cost in 70% of the network, and pay 10.8p/kWh (including VAT) in the rest. The Polar Corporate subscription is designed for fleets and leasing companies, and offers centralised invoicing for multiple users, and access to a control panel where fleet managers can track use of public facilities.

For drivers without a subscription, a “pay-as-you-go” price is offered, with an admin fee of £1.20 per visit and a price of £1 per hour for 3kW units, £1.50 per hour for units between 3.6kW and 22kW, and £6 per 30 minutes for “rapid” (e.g. 50kW) units. This implies different per kWh prices for different types of visit:

- 6 hours at a 3kW unit: £0.40/kWh
- 1 hour at an 11kW unit: £0.25/kWh
- 1 hour at a 22kW unit: £0.12/kWh
- 30 minutes at a 50kW unit: £0.29/kWh

A Polar Plus subscriber with a £94.2 annual subscription and a typical annual consumption (in 2018) of about 2180kWh could be paying £0.04/kWh if they did all of their charging at Polar points. In practice, this would be very unusual because as of 2016, 93% of EV owners had off-street home charging.³⁶ If we instead assume a subscriber did 18% of their charging at Polar points (corresponding to the proportion of a typical driver’s parked time that is spent parked away from home³⁷), it would cost them about £0.25/kWh.

The business model for a company like Chargemaster is different from the site business models we have examined in this report because they have other sources of revenue besides selling electricity, such as from selling and installing home and workplace charging equipment and from providing management software. Having an extensive charging network can help drive higher sales in these other areas. The scale of the Polar network probably also means that the company’s equipment and installation costs per charge point are below what an individual site would pay.

³⁶ Systra, Next Green Car, Cenex, 2018, “Plugging the Gap: An Assessment of Future Demand for Britain’s Electric Vehicle Public Charging Network”

³⁷ RAC Foundation 2012, “Spaced Out”



5.6.4 ChargePoint: finance in the USA³⁸

The ChargePoint business model

ChargePoint is the largest global operator of EV charging infrastructure, with a network of more than 50,000 charging stations.

It does not own stations; it owns the underlying technology and sells stations to retailers, workplaces, hospitals, cities and others after developing and connecting the stations to its network.

While owners set their own charging rates, ChargePoint provides rate-setting services, and collects and remits payments from drivers to the station owner.

The stations can be accessed through a smartphone app. Drivers can use the app to locate nearby charging stations, determine availability, receive charge notifications and pay for charging.

ChargePoint has partnered with auto manufacturers to install ChargePoint software directly into vehicles. Daimler, BMW and Siemens own significant stakes in the company.

The “Net+” purchase plan

ChargePoint partnered with Key Equipment Finance in 2013 to create the Net+ Purchase Plan lease-to-own program.

The program offers payment plans over 3-7 years with no upfront costs and includes installation, service and warranty. Business owners pay from \$3 per day to lease a charging station that costs \$6,000 to install. The owners recouped costs by charging drivers a fee for the service.

The leases were structured as capital leases, allowing business owners also to claim a federal tax credit for charging stations, which was 30% for costs up to \$37,000 per address installed in 2013.

Key Equipment Finance buys the charging stations, checks creditworthiness of owners, works out lease terms and pays for electrical contractors for installations. ChargePoint manages the stations and the network.

5.6.5 Nissan, Enel and Nuvve: Vehicle to Grid³⁹

Nissan, Enel and Nuvve formed a partnership to develop and trial commercial V2G applications in Europe. They have developed pilot projects in Spain, Italy and France and two commercial projects in Denmark and the UK.

³⁸ ChargePoint, Key Equipment Finance

³⁹ Nissan, Western Power Distribution

Nissan provided the EVs and Enel the charging infrastructure; Nuvve provided software to aggregate the interfaces between vehicles and chargers and provide network services. The software optimizes power flow to and from the vehicles to ensure drivers' mileage needs are always met.

The project in Denmark uses 10 V2G units (10kW each) at the headquarters of Danish utility company Frederiksberg Forsyning. The project allows balancing services to be provided by the EV fleet, and has so far derived revenues around €1,400 per van per year from the Danish frequency regulation market.

The GB trial project uses 8 units at the Nissan Technical Centre in Cranfield in England. It is the first project in a rollout of 100 V2G chargers which will be installed at locations agreed by private and fleet owners of Nissan EVs, and it is among 21 projects being supported by the UK government through a £30 million Industrial Strategy funding scheme for V2G projects.

5.6.6 Park@Sol solar carports by Schletter in Germany⁴⁰

Schletter is a manufacturer of solar mounting systems. For large-scale carports, it produces the Park@Sol mounting system, in which small pre-cast concrete foundations are anchored onto micro-piles. This requires minimal construction works on the car park surface and is suitable for most types of subsoil.

For individual carports, it is possible to have double and single row parking, customised foundations and sub-decking for waterproofing; other optional accessories include advertising space, cable management, carport lighting, and drainage. The carports feature integrated charging pillars with multiple (2-4) outlets for electric cars, mopeds and bicycles.

Example projects

- Schletter GmbH company car park in Oberbayern: 260 parking bays, 500kW solar capacity; solar generation from the carport complements that from the PV installation on the factory roof, and is consumed onsite, with excess used for EV charging or exported to the grid.
- Sparkassen-Center bank in Bad Tölz: 0.3 MW solar capacity and 142 parking bays covering 2,000m²; free EV charging is provided to bank customers
- Eurospeedway in Lausitz: 1 MW solar capacity and 480 parking bays, with five EV charging stations

⁴⁰ Schletter, SSLEnergie, SMA, REC



6. Capturing the available value

Business cases with positive NPV at 9% nominal discount rate are possible for all the major applications of commercial and industrial charging infrastructure. These are based on high utilisation rates, and a pattern of consumer behaviour that sees enough drivers willing to pay for charging away from their home.

We have seen that prices per kWh of £0.20 - £0.30 in GB or 0.30 € - 0.40 € in Germany can work, based on expected costs for installation in 2030. Before then, wholesale electricity costs will be lower (so the same margin can be achieved at lower customer prices), but equipment costs will be higher.

Exactly when the business cases will make sense for particular sites remains uncertain; we expect site owners and potential investors will keep their prospective business cases under review as trends of EV deployment and use develop.

Fleet charging is a special case because the value of the investment is less dependent on uncertain future trends: a business can take a decision to electrify its fleet and be confident it will achieve a target utilisation for its charge points. As a result, we expect this could be the first application to take off, depending on how quickly total cost of ownership continues to improve for electric vans compared with ICE vans.

In practice, a decision to invest in EV charging infrastructure will depend not just on whether the business case has positive NPV, but also on the potential returns from alternative uses of the same capital. Investors will weigh up charging infrastructure against investments in more established technologies in renewable energy, grid-scale storage and other areas.

We have seen several steps that sites can take to maximise the value of their business cases:

- **Utilisation:** An installation returns more value if the charge points are running more of the time. At workplaces, using a rota system can support this, as can installing charge points with higher numbers of sockets. Emerging technologies for mobile or automated charge points could also help. Some fleets might stagger shift work to maximise charge point use.
- **Site design and installation approach:** This is important because of the size and wide variation in installation costs. Locating charge points in a way that minimises trenching work for cables and that allows wall-mounted equipment where possible will help. Co-ordinating installation with work to improve site energy efficiency can help reduce network upgrade costs.



- Energy storage systems: These add most value if EV charging will take place during the evening electricity demand peak. The value can be enhanced further if the system is provided with the network connection and market access to participate in ancillary services and the capacity market.
- Vehicle-to-grid: This is most likely to add value on sites where the existing energy consumption is large compared with the demand for EV charging; further technical development and clarity on battery degradation costs will be needed for it to become widespread.
- Solar: This requires high utilisation to provide maximum value, so it will be best-suited to sites that are either in use every day of the week, or where there is co-located energy storage. A solar car park canopy can be particularly effective at reducing the costs of charge point installation by allowing the charge points and cables to be mounted on the canopy framework, reducing trenching needs.
- Solar with storage: To make the most of this combination, the solar energy capture at peak times should exceed the EV energy demand by enough that the excess can be stored and fully meet the energy demand over the evening demand peak.



7. Appendix: source data used in market sizing

| Sources | Main information taken from this source |
|--|--|
| England and Wales Census, 2011 Scottish Household Survey, 2014 ONS Labour Force Survey, 2018 | <ul style="list-style-type: none"> Number of people driving to work in GB |
| RAC Foundation 2012, "Spaced Out" | <ul style="list-style-type: none"> Proportion of people driving to work that park at employer's car park Average length of stay while parked at work Proportion of time spent parked Proportion of time spent parked at public car parks Number of parking acts at public car parks per weekday |
| Department for Transport 2017, "Commuting in England" | <ul style="list-style-type: none"> Average trips to work per week Trend in number of car trips Trend in proportion of trips that go to work |
| Department for Transport 2009, "Public experiences of and attitudes towards parking" | <ul style="list-style-type: none"> Proportion of households with access to private parking at home |
| Department for Transport 2014-2016, "National Travel Survey" | <ul style="list-style-type: none"> Proportion of cars that are parked on private property overnight Average annual miles per car or van driver on trips over 100 miles |
| National Grid 2018 "Future Energy Scenarios" | <ul style="list-style-type: none"> Electricity consumption per car or per van each year to 2040 Numbers of electric cars and vans each year to 2040 Rate of electrification of cars and vans by 2040 Note that we use the "Two Degrees" scenario for our market sizing |
| Department for Transport 2017, "Vehicle Licensing Statistics" | <ul style="list-style-type: none"> Proportion of vans that are company-registered |
| Department for Transport 2017, "Road traffic estimates in Great Britain" | <ul style="list-style-type: none"> Motorway vehicle miles in 2017 Growth factor in motorway vehicle miles since 1993 |
| Destatis, Pressemitteilung Nr. 001 vom 02.01.2017 | <ul style="list-style-type: none"> Number of employees |
| Destatis 2016, "Gesamtwirtschaft Umwelt – Berufspendler" | <ul style="list-style-type: none"> Proportion of employees getting to work by car |
| Destatis 2009, "Zuhause in Deutschland" | <ul style="list-style-type: none"> Households with access to private parking |
| KBA | <ul style="list-style-type: none"> Number of LKW and PKW utilities (light commercial vehicles) by year to 2040 |
| Bast 2014, "Erhebung der Inländerfahrleistung" | <ul style="list-style-type: none"> Annual miles travelled by cars and vans |

8. Appendix: cost assumptions used in business cases

| Input | Cost estimate | Source | Notes on calculation |
|---|-----------------------------------|--|--|
| Equipment for 3.3kW charge point, per outlet (GB) | £750 (today) £600 (2030) | Energy Saving Trust, "Guide to chargepoint infrastructure for business users", 2017 GTM Research, "EV Charging Infrastructure Development: EV and Infrastructure Market Sizing Forecast", 2018 | Bottom end of range for 3.5kW - 7kW charge points Reduced by 20% for 2030 value (based on GTM report) |
| Equipment for 7kW or 20kW charge point, per outlet (GB) | £1,200 (today) £960 (2030) | GTM Research, "EV Charging Infrastructure Development: EV and Infrastructure Market Sizing Forecast", 2018 | Cost of public slow charge point, high case; converted at £0.8/\$; assuming two-outlet charge point; reduced by 20% for 2030 value |
| Equipment for 150kW charge point, per outlet (GB) | £25,000 (today) £20,000 (2030) | Adapted from interview with Flexisolar, August 2018 GTM Research, "EV Charging Infrastructure Development: EV and Infrastructure Market Sizing Forecast", 2018 | Flexisolar estimate of cost per charge point: £65k - £85k. We assume a triple outlet charge point and assign a cost per outlet of one third the mid-point of this range; reduced by 20% for 2030 value |
| Equipment premium for bidirectional charge point | 40% | Adapted from interview with Eaton, August 2018 | Based on expected future premium of 30%-40% once V2G is commercialised. |
| Installation cost for charge point under 7kW (GB) | £1,200 | Costs Associated With Non-Residential Electric Vehicle Supply Equipment, US DOE, 2015 (p17) Note these are within the ranges of the more recent GTM report, but they also cover the 3.3kW case. | Middle of installation cost range for level 1 EVSE, converted at £0.8/\$. |
| Installation cost for charge point 7-50kW (GB) | £2,400 | | Average value for level 2 EVSE, converted at £0.8/\$. |
| Installation cost for charge point of 50kW or more (GB) | £16,800 | | Average value for DCFC EVSE, converted at £0.8/\$. |
| Solar CAPEX, 2030 | £1000 - £1300/kW | Aurora Energy Research central forecast; solar CAPEX range validated in interview with Flexisolar, August 2018 | CAPEX is installed total system cost; range reflects variation by installation size. |
| Solar OPEX, annual, 2030s | £9/kW | | |
| Storage CAPEX, 2030 | £430/kW | | CAPEX is total system cost, with a 2-hour lithium ion battery |
| Storage OPEX, annual, 2030s | £10/kW | | |

| Input | Cost estimate | Source | Notes on calculation |
|--|--------------------------------------|---|--|
| Average annual running costs per 3.3kW charge point (GB) | £260 in first two years, then £310 | UK EVSE Association, "Making the right connections", 2015 | Maintenance inspection: £100 Warranty: £100 in years 2 and 3, then £150 for each year after Data connection and collection: £60 This is the bottom end of the range for fast charge points. |
| Average annual running costs per 7kW charge point (GB) | £358 in first two years, then £458 | | We take the average of the costs for 3.3kW and 20kW charge points. |
| Average annual running costs per 20kW charge point (GB) | £455 in first two years, then £605 | | Maintenance inspection: £150 Warranty: £175 in years 2 and 3, then £325 for each year after Data connection and collection: £130 This is the mid-point of the range for fast charge points. |
| Average annual running costs per 50kW charge point (GB) | £3030 in first two years, then £3330 | | Maintenance inspection: £1300 Warranty: £1550 in years 2 and 3, then £1850 for each year after Data connection and collection: £180 This is the mid-point of the range for rapid charge points. |
| Average annual running costs per 150kW charge point (GB) | £8730 in first two years, then £9630 | | We assume maintenance and warranties cost three times as much as for a 50kW charge point, and data collection and connection costs the same amount. |
| Network upgrade (GB): | | | REA member estimates |
| 10kW to 50kW | £5k | | |
| 10kW to 150kW | £10k | | |
| 10kW to 400kW | £120k | | |
| 100kW to 300kW | £75k | | |
| 100kW to 10MW | £1m | | |



| Input | Cost estimate | Source | Notes on calculation |
|---|---------------|---|--|
| Equipment for 3.3kW charge point (Germany) | 630 € | Nationale Plattform Elektromobilität, 2015: "Ladeinfrastruktur für Elektrofahrzeuge in Deutschland - Statusbericht und Handlungsempfehlungen" | "Smarte Ladebox >3.7kW" cost, including comms, energy management and billing system; 2020 forecast, reduced by 10% for a 2030 projection |
| Equipment for 7kW or 20kW charge point (Germany) | 2,250 € | | "Ladesäule" 11 or 22kW cost, including comms, energy management and billing system; 2020 forecast, reduced by 10% for a 2030 projection |
| Installation cost for 3.3kW charge point (Germany) | 1,000 € | | "Smarte Ladebox >3.7kW" cost, including approval, planning, location search, assembly, construction and signage |
| Installation cost for 7kW or 20kW charge point (Germany) | 3,000 € | | "Ladesäule" 11 or 22kW cost, including approval, planning, location search, assembly, construction and signage |
| Average annual running costs per 3.3kW charge point (Germany) | 500 € | | "Smarte Ladebox >3.7kW" cost; 2020 forecast |
| Average annual running costs per 7kW or 20kW charge point (Germany) | 750 € | | "Ladesäule" 11 or 22kW cost; 2020 forecast |
| Network upgrade cost per 3.3kW charge point (Germany) | 1,000 € | | "Smarte Ladebox >3.7kW" grid connection cost (midpoint of range) |
| Network upgrade cost per 7kW or 20kW charge point (Germany) | 2,000 € | | "Ladesäule" 11 or 22kW grid connection cost |
| Network upgrade cost per 150kW charge point (Germany) | 50,000 € | | Footnote to table 1 on net connection cost for 150kW charge points |

Where we do not have costs specific to Germany (e.g. 150kW equipment costs), we use the GB data instead. We convert currency at a rate of £1 to 1.125 €.

For our business cases, we use a real pre-tax discount rate of 7%, roughly equivalent to a nominal pre-tax rate of 9%. This is consistent with the weighted average cost of capital for a project funded by 40% equity at 15% nominal cost and 60% debt at 5% nominal cost.

9. Appendix: Senior Debt Financing Options - Definitions

| Solution | Description |
|------------------------------|--|
| Asset Finance | <p>Asset Finance is a solution whereby businesses obtain equipment from a lessor in exchange for a regular charge to use the asset over an agreed period, avoiding the full cost of buying outright. The most common types of asset finance are:</p> <ul style="list-style-type: none"> • Hire Purchase – A company makes lease payments to the lessor and at the end of the facility life the ownership is transferred to the lessee (at their option and against the payment of an option price) • Operating & Finance lease – A company makes lease payments to the lessor but the asset is never owned by the lessee <p>Note that due to new accounting regulation (IFRS 16) from January 2019, the balance sheet treatment of operating leases will change as the corresponding liability will now appear 'on balance sheet' similarly to the accounting already applied to finance leases.</p> |
| Project Finance | <p>Project Finance refers to the financing of long-term infrastructure using a non-recourse or limited recourse financial structure via Special Purpose Vehicles (SPV). The debt and equity used to finance the project are paid back from the cash flow generated by the project. Project financing is a loan structure that relies primarily on the project's cash flow for repayment, with the project's assets, rights and interests held as secondary collateral. Subject to the risk allocation, project finance can also be attractive to borrowers as it may be delivered off-balance-sheet.</p> |
| Dedicated Corporate Facility | <p>This option entails a company taking out a dedicated loan facility which is granted specifically to finance a pre-defined capital expenditure project. Repayment takes place either on a specific date (bullet maturity) or through regular instalments (amortising structure). Importantly, proceeds for debt service and repayment can come from the cash flows of the project or from the company's existing business operations.</p> |
| General Corporate Facilities | <p>A company can also contemplate the financing of specific projects through the use of their existing corporate borrowing facilities, which are typically granted for 'general corporate purposes'. In this scenario, the company could use bank facilities like a Revolving Credit Facility or a Term Loan; alternatively for large amounts, the company could use proceeds from Private Placements or Bonds. It is likely that only large, sophisticated companies will access these markets.</p> |

Information provided by NatWest and Lombard

10. For further information

The analysis in this report uses Aurora's standard market forecast and set of assumptions. For a complete description of the input assumptions and other aspects of the power market forecasting not included here, please contact Aurora at sales@auroraer.com to obtain a copy of our latest GB or German Power Market Forecast reports.

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