Title: The Electric Vehicles (Smart Charge Points) Regulations 2021	Impact Assessment (IA)
IA No: DfT00428	**Date: 14/07/2021**
	Stage: Final
RPC Reference No: RPC-DfT-5075(1)	**Source of intervention:Domestic**
	Type of measure: Secondary Legislation
Lead department or agency: Department for Business Energy and Industrial Strategy (BEIS)	**Contact for enquiries:** EVEnergyTeam@beis.gov.uk
Other departments or agencies: Office for Zero Emission Vehicles (OZEV**),** Department for Transport (DfT)	

Summary: Intervention and Options

RPC Opinion: GREEN

Cost of Preferred (or more likely) Option (in 2019 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
£500m	-£120m	£6.3m	Qualifying Provision

What is the problem under consideration? Why is government intervention necessary?

The technology and business models for electric vehicle smart charging are still in their infancy – both in the UK and internationally - and there are a variety of different technical approaches to delivering it. The diversity in business models and practices of this early market, whilst important for innovation, also risks a proliferation of smart chargepoint (CP) systems developing with varying standards and functionality. Without clear requirements and standards set for the industry, it's unlikely that the market will deliver smart CPs that provide sufficient grid and consumer protection, at least in the short term.

What are the policy objectives and the intended effects?

The Government's aim is to maximise the use of smart charging technologies, to benefit both consumers and the electricity system, whilst supporting the transition to EVs. To meet this aim we believe we need to encourage consumer uptake of CPs that have smart functionality and provide appropriate protection for consumers and the grid and meet the following objectives: grid stability, cyber and data security - safety and data privacy and interoperability.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base

- Option 1 – Mandatory requirements for all new private CPs sold in the GB covering smart requirements, and other device-level requirements for cyber and data security grid stability and supplier interoperability – 'The Electric Vehicles (Smart Charge Points) Regulations 2021' (the preferred option, as per the Government Response)
- Option 2 – Similar to policy Option 1, but with additional interoperability and charging current requirements – presented at consultation.
- Option 3 – Voluntary compliance with smart functionality and other device-level requirements for all new private CPs sold in the GB.
- Option 4 – Including smart requirements within Government grant schemes, instead of legislation.

Government has considered the options outlined above and determined Option 1 will meet Government's overall policy aim to maximise smart charging uptake, whilst delivering some appropriate protections against smart charging risks. The other options risk either intervening on policy issues where there is currently a lack of supporting evidence (option 2) or they would not deliver an appropriate level of protection for consumers and the energy system (option 3 and 4).

Will the policy be reviewed? Yes **If applicable, set review date:** By 2025.

Does implementation go beyond minimum EU requirements?		N/A		
Is this measure likely to impact on international trade and investment?		Yes		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** -3	**Non-traded:**	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: ______________ Date: 13/07/2021

Summary: Analysis & Evidence

Policy Option 1

Description:

FULL ECONOMIC ASSESSMENT

Price Base Year 2021	PV Base Year 2021	Time Period Years 30	Net Benefit (Present Value (PV)) (£m)		
			Low: £0	**High:** £1,100	**Best Estimate:** £500

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£50		-£5	**-£10**
High	£80		£10	**£260**
Best Estimate	£60		£5	**£130**

Description and scale of key monetised costs by 'main affected groups'

The introduction of our regulations will increase the technical complexity of EV chargepoints. The main costs that have been considered are the additional production costs to chargepoint manufacturers. A learning rate has been applied to the unit costs associated with adding smart functionality to account for technology cost reductions over time. Other costs associated with meeting our requirements have been accounted for. These are typically 'capitalised' and therefore not applied on a per unit basis.

Other key non-monetised costs by 'main affected groups'

- Additional customer service
- Reduction in consumer choice
- Perceived cost of relinquishing personal control over charging arrangements and provision of personal information
- Personalised default settings
- Enforcement

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low			£0	**£300**
High			£70	**£1,100**
Best Estimate			£40	**£700**

Description and scale of key monetised benefits by 'main affected groups'

The increased uptake of smart charging results in electricity system benefits. Greater demand flexibility leads to a reduction in system cost through more efficient use of network infrastructure and generation assets.

Other key non-monetised benefits by 'main affected groups'

- Enhanced grid stability
- Enhanced cyber security.
- Enhanced consumer charging experience

Key assumptions/sensitivities/risks **Discount rate** 3.5

Key assumptions; level of smart CP uptake, proportion of demand which can shift, costs to manufacturers, sensitivity of consumers to chargepoint price movements, adjustments to the learning rate, accounting for a greater level of compliance. Sensitivities and scenarios have been tested to account for uncertainty in the key assumptions listed above have been run on these key assumptions. The analysis indicates that the proportion of demand that can shift is a key driver of electricity benefits.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: 6.9	**Benefits:** 0.0	**Net: 6**.9	£31.3

1. Policy Rationale

Policy background

1. In April 2021, the UK government announced targets to reduce greenhouse gas (GHG) emissions by 78% by 2035 compared to 1990 levels[1]. This will bring the UK more than three-quarters of the way to reaching its commitment of net zero emissions by 2050 and will require extensive decarbonisation of all sectors of the economy and the deployment of GHG removal technologies to address any residual emissions. In 2019, road transport accounted for 24% of all UK GHG emissions with cars and light commercial vehicles (LCVs) accounting for 79% of this total[2]. While other sectors (notably electricity) have made significant progress, GHG emissions from transport have remained largely unchanged since 1990[2].

2. The UK electric vehicle (EV) market is growing at pace. In January 2021, 6,260 new battery electric vehicles (BEVs) and 6,124 new plug-in hybrid electric vehicles (PHEVs) were registered in the UK, representing a 54% and 28% increase in sales relative to the same month the previous year[3]. There are now more than 500,000 plug-in vehicles on the road as of the end of April 2021[4] and we expect demand to continue to grow rapidly in response to the Government's announcement to end the sale of new petrol and diesel cars and vans by 2030, with all vehicles being required to have a significant zero emissions capability (e.g. plug-in and full hybrids) from 2030 and be 100% zero emissions from 2035[5].

3. Decarbonisation of road transport will significantly increase electricity demand as EVs replace the internal combustion engine (ICE) as the standard power source for the vast majority of cars and LCVs. Mechanisms are in place to ensure the electricity system is prepared to meet future demand and costs to consumers and businesses are minimised. This includes the Capacity Market, network price controls (such as RIIO) and the Contracts for Difference scheme which drive investment in electricity networks and low carbon generation and ensure there is enough capacity to meet demand[6]. While these mechanisms to ensure sufficient investment are important, it is crucial that the electricity system also has the ability to adjust supply and demand to keep the system balanced.

4. Currently, most EV charging is done at home and we expect this trend to continue given it is often the most convenient and cost-effective form of charging[7]. Analysis of real-world

---

[1] HMG (2021) – *'UK enshrines new target in law to slash emissions by 78% by 2035'* - https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035

[2] HMG (2021) – *'Final UK greenhouse gas emissions national statistics: 1990 to 2019'* - https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019

[3] SMMT (2021) – *'EV & AFD Registrations'* - https://www.smmt.co.uk/vehicle-data/evs-and-afvs-registrations/

[4] ZapMap (2021) – *'EV Charging Stats 2021'* - https://www.zap-map.com/statistics/#EVs

[5] HMG (2020) – *'The Ten Point Plan for a green industrial revolution'* - https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

[6] The Capacity Market provides a payment for reliable sources of capacity, alongside their electricity revenues, to ensure they deliver energy when needed. Contracts are issued via a competitive auction process and encourage the investment we need to replace older power stations and provide backup for more intermittent and inflexible low carbon generation sources. Contracts for Difference incentivise investment in renewable energy by providing developers of projects with high upfront costs and long lifetimes with direct protection from volatile wholesale prices, and they protect consumers from paying increased support costs when electricity prices are high. Price controls (such as RIIO) are a method of setting the amount of money (allowed revenue) that can be earned by the network companies over the length of a price control.

[7] A number of studies show that the vast majority of current EV owners charge their car at home. These findings are summarised in: Hardman, S, et al (2018) - *'A review of consumer preferences of and interactions with electric vehicle charging infrastructure'*, Transportation Research Part D: Transport and Environment (Volume 62).

charging event data[8] indicates that domestic charging during the week is likely to occur during existing system peak times (such as between 5pm and 7pm, although these may shift overtime) when many people arrive home from work. Similarly, charging at workplaces, which we expect will be vital for some consumers, may coincide and add to the existing morning peak in electricity demand. The potential impacts on the electricity system of charging behaviour have been highlighted in several EV charging trials such as 'Electric Nation'[9], which was the largest home charging trial when launched.

5. Smart charging, defined as the ability to delay or modulate charging in response to an external signal,[10] allows charging load to be controlled either directly by the user or through a third party (e.g., an electricity aggregator[11]). This form of demand side response (DSR) enables EV charging can be shifted to periods when there is low demand on the electricity system such as overnight, or to times of high renewable energy generation. This flexible form of charging can reduce or defer costly investment in additional electricity generation capacity and network reinforcement and help balance the electricity system.

6. For owners of smart chargepoints (CPs) this control enables users to take advantage of low-price periods and can significantly reduce the total cost of charging. External studies estimate that smart charging could currently save an EV owner approximately £200 on average per year relative to unmanaged charging[12]. Additionally, many smart CP models currently on the market provide scheduling functionality and remote access which allow for greater personalisation of charging routines. At workplaces, managing charging load via smart charging could reduce the need for costly network connection upgrades.

7. To access the full range of benefits from smart charging, CPs need to be able to receive and send information so that they can adjust the rate of charging dynamically (these communications are known as 'load control signals'). It is also vital that consumers and the energy system are protected from the potential risks posed by smart CPs which will likely become more prevalent as the number installed across the UK grows. Such risks include grid stability, cyber and data security and a lack of smart interoperability[13]. Grid stability issues can occur where large numbers of smart CPs start or stop charging simultaneously such as in response to a price drop. This could lead to issues for network operators when balancing the electricity system. Similarly, cyber-attacks, such as hacking of CP control systems, could threaten the stability of the electricity system if large numbers were manipulated simultaneously. Interoperability will also be essential for a competitive market, and to ensure consumers are not unfairly disadvantaged by their choice of smart CP. Government considers that suitable protections for these issues are required now, to ensure appropriate mitigations are in place ahead of a large number of smart CPs being deployed over the coming years.

---

8 Element Energy for National Grid ESO (2019): *Electric Vehicle Charging Behaviour Study* - http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/04/20190329-NG-EV-CHARGING-BEHAVIOUR-STUDY-FINAL-REPORT-V1-EXTERNAL.pdf

9 Electric Nation (2019): *'Customer Trial Final Report'* – https://electricnation.org.uk/resources/smart-charging-project/

10 Such as an instruction from the Distribution System Operator (DSO) and/or market price.

11 Aggregators are defined as third party intermediaries specialising in coordinating or aggregating demand response from individual consumers.

12 There are a number of key factors that determine the annual savings associated with smart charging such as half-hourly electricity prices and amount of charging load supplied in peak and non-peak times. This estimate is from RightCharge - https://rightcharge.co.uk/what-is-smart-charging/ and assumes the average driver in the UK drives 7,400 miles per year and uses around 2,000 kWh to charge their car. It also assumes that all charging is completed during the off-peak period (with an assumed rate of 5p/kWh – in line with the current Octopus Aglile Tariff structure). The counterfactual assumes the user is on a standard variable tariff and pays 17p/kWh.

13 Defined in the 2019 smart charging consultation as a consumer being able to switch chargepoint operator or supplier without the chargepoint losing its smart charging functions and without a visit to the premises to restore it.

The 'Electric vehicle smart charging' consultation

8. The 'Electric vehicle smart charging consultation'[14] opened on 15 July 2019 and closed on 7 October 2019. During this period government consulted businesses and individuals on implementing smart charging requirements under the Automated and Electric Vehicles (AEV) Act[15] with particular consideration of important issues like cyber security and interoperability. The aim of the public consultation was to outline the government's approach and objectives for smart charging of EVs; seek views on the first phase of regulations ("phase 1"); gather evidence on a second phase for a long-term solution ("phase 2"), on which we will look to consult in 2022; and gather evidence on how best to use the AEV act power on the transmission of CP data.

9. In the consultation, Government stated that its overarching aim was to maximise the use of smart charging technologies and proposed four objectives to underpin smart charging policy: consumer uptake, innovation, grid protection and consumer protection. Many respondents agreed with the proposed aim and objectives, with some respondents also suggesting additional objectives. In May 2020 Government published a summary of responses[16] to the consultation, which restated the Government's overall aim to maximise the use of smart charging and mandate that all new private CP must be smart.

10. This legislation is part of a broader work programme underway within Government to ensure the ICE phase out dates are achieved, and that the energy system adapts to meet the increased demand from EVs and wider electrification. Government has committed to further work beyond this legislation, to drive the uptake of smart charging and deliver a smarter, more flexible energy system.

Problem under consideration

Consumer uptake and use of smart CPs in the UK.

11. The UK market for CPs is growing with an estimated 90 - 100 manufacturers active in the market ranging from pure eMobility specialists to incumbent electrical manufacturers[17]. It is estimated that there are between 900 and 1100 different CP models currently on sale in the UK that are suitable for domestic and/or workplace installation which could support residential, employee and depot based EV charging.

12. Approximately 800 models are currently approved by the Office for Zero Emission Vehicles (OZEV) under the Electric Vehicle Home-charger Scheme (EVHS) or the Workplace Charging Scheme (WCS) both of which provide financial support to EV owners and businesses for the cost associated with installing a CP. Manufacturers who wish to apply for authorisation for CPs under these schemes must ensure units comply with certain technical specifications[18]. Since 2019, these technical requirements required all CPs authorised under EVHS to be capable of receiving and processing information, react to

[14] HMG (2019) *Electric Vehicle Smart Charging Consultation* - https://www.gov.uk/government/consultations/electric-vehicle-smart-charging

[15] HMG (2018) *Automated and Electric Vehicles Act 2018* - https://www.legislation.gov.uk/ukpga/2018/18/contents/enacted

[16] HMG (2020): *Electric Vehicle Smart Charging Consultation: Summary of Responses* - https://www.gov.uk/government/consultations/electric-vehicle-smart-charging

[17] Market intelligence provided by Delta-EE, informed by their EV Charging Player Database and analysis of EVHS and WCS model lists.

[18] HMG (2020) – '*Electric Vehicle Homecharge Scheme: minimum technical specification'* - https://www.gov.uk/government/publications/electric-vehicle-homecharge-scheme-minimum-technical-specification

information received by adjusting the rate of charging or discharging and monitor, record and transmit energy consumption data, and include appropriate security measures. CPs authorised under the WCS must meet a different set of technical standards.

13. Despite the relatively large number of manufacturers with a retail presence in the UK, 3 CP manufacturers dominate the sales of private CPs[19] suitable for residential installation. PodPoint, Rolec and BP Chargemaster (now BP Pulse) account for approximately 85% of EVHS installations since the support scheme began in 2014. However, market concentration has changed over time as the market share of the top 3 manufacturers has gradually decreased from 95% in 2014 to approximately 70% in 2020. Installations under the WCS are more varied relative to the EVHS. Despite this, more than half of total installations are attributed to the top 3 manufacturers: (Rolec, PodPoint and EO Charging) since its introduction in 2016. Similar to the EVHS, market concentration has declined over time with the share of total installations from the top 3 manufacturers decreasing from 65% in 2017 to 55% in 2020[20]. This market data indicates that there is a wide range of models currently available to consumers providing them with a good level of choice. However, the increasing diversity of manufacturers and increasing number of CP models available means there is significant risk of variation in the design and capabilities of CPs.

14. Currently, the installation of a CP at a domestic property could cost a consumer approximately £1,000[21]. This covers the cost of the unit, wiring and installation, however, is likely to vary significantly depending on several factors such as the make and model of the unit and the amount of electrical and physical installation work required. Data gathered as part of Energy Systems Catapult's 'Vehicle-to-Grid Britain' report indicates that there is a £100 - £400 cost difference between a like-for-like smart and non-smart CP unit[22].

15. Data on the number of CPs sold and installed in the UK is not widely available. However, Delta-EE estimate that as of end 2019, there are 140,000 private EV CPs installed in residential properties and 20,000 installed at workplaces and depots to support employee and fleet charging[23]. According to consumer research conducted by Delta-EE[24], around 50% - 70% of all dedicated CP units currently installed at residential properties have 'internet connectivity'. This is considered a good indicator of whether a CP has smart charging capability as an internet connection facilitates external control of charging load[25]. As illustrated in Figure 1 below, the proportion of smart CPs sold has increased over time to around 70% - 100% of total CP sales in the first quarter of 2020[26]. This is due to a variety of factors such as the introduction of smart requirements within the EVHS as mentioned in the previous section. The data also shows the error bars narrowing over time

19 "Private charge point" means a charge point which is not provided for use by members of the public.

20 Internal analysis of EVHS and WCS installation data collected by OZEV. Data at January 2021

21 This value aligns closely to estimates provided by a report by Cenex (2020) 'Domestic Chargepoint audits' provided to DfT. This does not include current government support (e.g. EVHS)

22 Energy Systems Catapult (2019) – *Vehicle-to-Grid GB: Decarbonising Britain* - https://es.catapult.org.uk/case-studies/vehicle-to-grid britain/#:~:text=V2GB%20%E2%80%93%20Vehicle%20to%20Grid%20Britain,and%20a%20smart%20energy%20system. This reflects the cost of a single new residential installation rather than an upgrade to an existing connection. Range reflects 2 variants of smart CP which differ in terms of capability. Cost differential is relative to a 7kW AC residential charger. Cost does not include any fee paid for the existing of an aggregation service.

23 Delta-EE (2020): *European EV CP Forecasts* - https://www.delta-ee.com/downloads/1-research-downloads/63-electric-vehicles-electricity/2591-forecasting-whitepaper.html

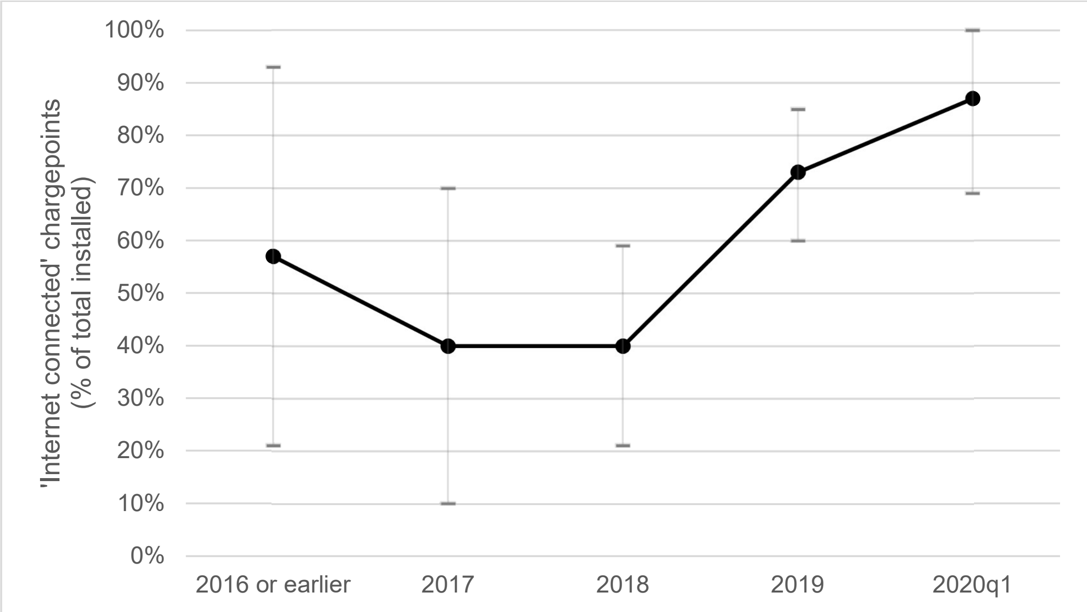
24 Delta-EE (2020) – '*Who is the EV customer and how do they charge?* – Report only available via subscription service

25 This categorisation provides us with a good understanding of the amount of connected load. However, further data is required to assess the exact capabilities CPs currently installed across the UK as additional functionality may be required to perform certain tasks.

26 The range reflects how representative the sample of respondents is to the general EV population. For example, a wider range reflects the fact that the level of respondents is low and/or have very similar characteristics (e.g. demographic). This range has narrowed over time as EV owners have become more diverse.

as the survey sample represents a broader range of the total EV population and increases our confidence in the results.

Figure 1 - Proportion of CPs installed in residential properties that have 'internet connectivity'.



16. There is less data available and subsequently greater uncertainty around the proportion of CPs that are installed at workplaces and depots that have smart charging capabilities. However, many CP models in scope of these regulations are suitable for both domestic and workplace installation[27]. Furthermore, load shifting solutions (such as smart charging) may be more of a priority in this market.

17. Despite the growing trend in the installation of smart CPs, the level of load control can vary significantly between models. This variation is not captured in the data in Figure 1, and additional functionality may be required for a CP to perform specific tasks. In its simplest form, the CP may have the ability to start and stop vehicle charging in response to an external signal, such as a price signal or direct user command. When combined with a static time-of-use tariff (TOUT)[28] financial benefits can encourage the user to shift their charging demand from 'peak' periods to 'off-peak' periods.

18. More sophisticated CP units can modulate the charging power up and down in response to external signals. Although basic on/off functionality may be effective in encouraging some smart charging behaviour (for example when electricity price patterns are predictable), the CP will not be able to modulate load and respond to short term changes in market conditions. This will become more important over time as the number of EVs and associated electricity demand increases.

19. In addition to this, despite an increase in the penetration of smart CPs, it is uncertain how this could change over time when EVs become mass market. As the average price of EVs fall (in particular through the second-hand vehicle market) the upfront cost of the CP might represent a higher proportion of total cost meaning that consumers may be more sensitive to the additional cost of a smart CP. Furthermore, despite the overall savings that smart charging could offer them, prospective EV owners may be less inclined to pay the extra

[27] The majority of CP models approved under the EVHS are also approved under the WCS – HMG (2021): *Electric Vehicle Homecharge Scheme approved chargepoint model list - https://www.gov.uk/government/publications/electric-vehicle-homecharge-scheme-approved-chargepoint-model-list*

[28] An electricity tariff that offers two or more rates for electricity at fixed times of the day, for example, daily and overnight.

upfront cost to install a smart CP and use alternative forms of charging (e.g., public infrastructure or charge at home via a charging cable connected to a three-pin plug).

20. To ensure that the benefits of smart charging are realised, consumers need to be incentivised to engage with smart charging. There is limited data on current uptake of smart charging offers amongst EV drivers (e.g., TOUTS), but without high level awareness of the benefits, uptake will likely be low. Without government intervention, it is unlikely that smart charging will be taken up at the rate required to achieve the full benefits for consumers and the electricity system during the mass transition to EVs.

Risks to the electricity system and the consumer from non-standardisation

21. The technology and business models for smart charging are still in their infancy – both in the UK and internationally - and there are a variety of different technical approaches to delivering it. The diversity in business models and practices of this early market, whilst important for innovation, also risks a proliferation of smart CP systems developing with varying standards and functionality. As mentioned in the previous section, the technical specification of CPs can vary considerably, such as differing standards on cyber. Without clear requirements and standards set for the industry, it's unlikely that the market will deliver smart CPs that provide sufficient grid and consumer protection, at least in the short term.

22. Risks to the electricity system

- **Grid stability -** If large numbers of EVs start or stop charging simultaneously, this has the potential to create sudden spikes or drops in electricity demand that could cause issues with balancing the electricity system. The recent smart charging trial 'Electric Nation'[9] observed a sudden surge in demand at 22:00 for drivers who had chosen to delay charging (i.e., charge smartly). This surge was greater than the normal end-of-rush-hour peak. Although the surge did not reach the overall limits for a substation during this trial (likely as non-EV energy demand was low), the paper does note that this *could* be an issue for the electricity system in the future. The consultation proposed to mandate that all smart CPs have a function that randomly delays how quickly it responds to a signal over a period. A randomised offset function has already been implemented by the Smart Metering Equipment Technical Specification – version 2 (SMETS2) and a similar approach has been adopted by the Publicly Available Specification 1878 (PAS) for smart appliances (including smart CPs). Consultation respondents largely supported introducing this requirement as it assists with grid stability, especially when recovering from power outages. There were concerns expressed about that impact on consumer experience, therefore a maximum delay time of 10 minutes will be implemented as a default, with the ability for consumers to override the delay if desired.

- **Cyber and data security -** As we transition to a smart, flexible energy system, increasing numbers of energy smart appliances - including CPs - will lead to an increased risk of cyber-attack. The internet-connected nature of these devices is likely to make them more vulnerable to threat actors, and the hacking of individual devices or their control systems could be used to destabilise the electricity system. Smart CPs pose a particular risk given the size of the load they draw from the grid and Government's view is that suitable protections should be in place to mitigate this risk by 2025. Consultation respondents generally agreed that cybersecurity requirements were necessary to meet the additional risks posed by smart CPs.

23. Risks to consumer

- **Interoperability** – Government recognises that interoperability offers important benefits for consumers and can help drive a competitive smart charging market. A smart CP should not unfairly disadvantage those consumers switching between energy suppliers. In addition, the consultation proposed mandating CP operator interoperability. Most respondents supported interoperability requirements, and many cited a positive consumer experience as an important justification for Government acting in this area. However, some respondents urged caution in requiring CP operator interoperability, with a small number considering CP operator interoperability unnecessary.

- **Data and safety -** There is an existing safety and data privacy framework that will apply to smart charging. However, the consultation proposed to ensure that if needed, appropriate measures are taken for potential issues that could arise specifically from smart charging. Consultation respondents agreed that the safety and data of CPs was an important issue. However limited evidence of smart functionality specific issues were described.

24. The Government needs to act now to deliver the consistency and common standards required to ensure appropriate consumer and electricity system protections. Additionally, intervention in an early market will avoid a more costly and potentially more disruptive intervention at a later date. In particular, Government is keen to avoid a scenario where excess retrospective action is required, where existing infrastructure in a developed market would need to be brought in line with new requirements. It will also allow the UK to influence international approaches to help increase alignment. The Government's approach to regulation is to set minimum standards to appropriately mitigate the above risks, creating space for continued innovation.

Rationale for intervention

25. The uptake of smart CPs increases the amount of flexible EV demand on the system allowing electricity consumption to be shifted away from peak periods. This will result in lower costs to the electricity system of meeting electricity demand through utilising less expensive forms of electricity generation and avoiding network reinforcement/upgrades benefiting all electricity consumers.

26. Having a smart CP will reduce costs at the individual level by enabling the consumer to shift their demand and access lower electricity prices. However, there is also a significant positive externality, at a societal level there will be a reduction in costs due to the avoided infrastructure expenditure that would be required in the absence of flexibility technologies, with the ability to shift peak demand. Furthermore, the introduction of standards will help protect wider society from the emerging risks associated with increased use of smart CPs.

27. The overarching rationale behind government intervention is to support these social benefits (positive externalities) associated with the development and uptake of smart CPs and provide sufficient protection against emerging risks to the electricity system and consumers. Below is a list of the market failures that exist which act as barriers to maximising these social benefits.

- **Bounded rationality and uncertainty -** When purchasing a CP, private consumers (businesses and EV owners) may only consider a finite number of factors and have a short-term focus. As such, they may not undertake a full lifetime value for money assessment that weighs up the additional upfront unit cost of a smart CP against the electricity bill savings that could accrue over the lifetime of owning the product.

- **Information failure and consumer confidence -** Purchasing decisions may be complicated by the fact that smart CPs are an emerging technology and there may be a lack of awareness of the value of the private benefits associated with smart charging. The variation in design and capability of existing CPs shows that there is currently not an agreed standard for smart CPs, which adds to complexity for consumers. Furthermore, consumers may have concerns over the safety (cyber and physical) of connected devices which could deter them from purchasing.

- **Limited financial incentives for consumers -** Due to the positive externally the societal benefits of smart changers are greater than the private benefits, therefore without government intervention the take-up of smart CPs would be below the social optimum. In addition, market developments may be required to for consumers to access the full private benefits of smart charging. This includes the introduction of half-hourly settlement and electricity prices that are reflective of system costs (e.g., TOUTs).

- **Public good -** Widespread uptake of smart charging devices increase the threat of cyber-crime which could have significant implications for the electricity system and wider society. Mitigating against this threat via the provision of cyber security would benefit all of society (non-excludable). For example, a cyber-attack that resulted in a full or partial failure of the electricity grid would have significant economic and social costs. However, this will not be provided by the market alone because the private cost of providing such a service would exceed the private benefit. Cyber security could therefore be viewed as a public good that should be legislated for.

- **Market power and co-ordination** - As explained in the ‘Problem Under Consideration’ CP installations are currently dominated by a small number of firms. These market conditions may incentivise firms to prevent compatibility across products (interoperability) in order to leverage market power. Even without dominant firms, there is a risk that market participants may not be capable of identifying an implementing an efficient solution to technical standards. If firms are unable to co-ordinate effectively, this could result in a fragmentation of standards with limited interoperability across products.

Policy objectives

28. The Government's aim is to maximise the use of smart charging technologies to benefit both consumers and the electricity system, whilst supporting the transition to EVs. To meet this aim we believe we need to encourage consumer uptake of CPs that have smart functionality and provide appropriate protection for consumers and the grid by meeting the following objectives:

- **Grid protection:**

    i. **Cyber and data security** – CPs must include robust cyber security measures to mitigate the risk that EV smart charging presents to the stability of the grid, in addition to protecting individual consumers.

    ii. **Grid stability** – CPs should have controls to prevent of outages on the grid caused by erroneous smart operation.

- **Consumer protection:**

    i. **Safety and data privacy** – CPs should have data and safety controls beyond the standard framework if smart functionality presents specific new risks.

    ii. **Interoperability** – interoperability is essential for a competitive smart CP - a smart CP should not unfairly disadvantage those consumers switching between energy suppliers. As the CP and EV market evolves, we will need to ensure that consumers are not excluded from accessing alternative smart charging services or tariffs.

Options considered (including the counterfactual)

29. Below is a list of the options that have been considered as part of the policy development process.

Option 0 – Do Nothing (the counterfactual)

30. Government takes no action to mandate that private CPs must be smart and meet certain device-level requirements. Industry may develop their own requirements/standards, either in line with or different to the Government's policy objectives on interoperability, data privacy, cyber and grid stability, but at a slower rate and with greater variation than if government intervened.

Option 1 – Mandatory requirements for all new private CPs sold In Great Britain (GB) covering smart requirements, and other device-level requirements for cyber and data security, grid stability and supplier interoperability – 'The Electric Vehicles (Smart Charge Points) Regulations 2021' (the preferred option, as per the Government Response)

31. From the enforcement date[29] all new private EV CPs sold in Great Britain must be smart and meet device-level requirements. This includes the following:

- **Smart functionality -** A CP has smart functionality if it is able to send and receive information and respond to messages by increasing or decreasing the rate of electricity flowing through the CP and shift the time at which electricity flows through the CP. A smart CP should also be able be capable of supporting DSR services.

- **Personalised default settings -** A relevant CP must invite the user to set default charging hours before it is first used. The device must be pre-set with a charging schedule that does not charge EVs at peak times.

- **Cyber and data security -** A CP must have appropriate basic security measures to ensure that its functions are resilient to cyber-attack. Furthermore, a CP must be designed and manufactured to provide an adequate level of protection against physical damage to the charge point.

- **Randomised delay function -** A CP must be configured in a way which ensures that when it responds to information received and adjusts the rate of electricity flowing through it, it applies a randomised delay of up to 10 minutes; and permits the user of the CP to override the random delay.

- **Assurance** – Any person/organisation selling a CP must provide a statement of conformity and a technical file, at the request of the regulator.

- **Supplier interoperability** – CPs must not be designed in a way that means they lose functionality when a consumer switches supplier.

- **Monitoring and recording energy usage** – A CP must measure or calculate the electricity consumed and/or exported, the time the charging event lasts and provide a method for the consumer to view this information.

- **Safety** – CPs should operate in a way that prioritises safety over smart charging behaviour.

***Option 2** – Mandatory standards for all new private CPs sold or installed in Great Britain covering smart requirements, cyber and data security, grid stability, and CP operator interoperability (option presented at consultation).*

32. In addition to the requirements under Option 1, this would include further requirements such as mandating a requirement for CP operator interoperability to ensure consumers could change CP operator, and a requirement for a minimum current or power to address concerns that on some occasions a CP may turn off before the vehicle has finished charging.

[29] This will be six months after the legislation is laid for all requirements apart from cyber security (expected May 2022). Cyber security requirements will be enforceable 12 months after the laying date (expected November 2022)

Option 3 *– Voluntary compliance with smart functionality and other device-level requirements for all new private CPs sold in Great Britain.*

33. Instead of requiring mandatory compliance with legislation, Government could set out in guidance requirements for CPs to have smart functionality and meet other device-level requirements and encourage voluntary compliance. This would entail similar device-level requirements as set out in Option 1 and 2 above but have no regulatory backing.

Option 4 *– Including smart requirements within Government grant schemes, instead of legislation.*

34. This option would entail introducing and / or building on smart related requirements within existing grant schemes for private CPs, for example the EVHS and WCS.

Rationale behind chosen approach.

35. Government has considered the four options for intervention outlined above and a full assessment of the effectiveness of each our options in achieving the policy objectives is provided in the Annex. A high-level summary has been provided below.

36. Government will be implementing Option 1. A regulatory approach is required to ensure smart CPs are installed ahead of mass uptake of EVs, maximising the potential of smart charging to reduce the need for network reinforcement and benefit consumers by reducing EV running costs. A phased regulatory approach to achieving Government's aims and objectives for smart charging policy received a high-level of support amongst respondents during the 2019 consultation.

37. Option 2, which would set regulatory requirements in line with the 2019 consultation, will not be pursued. Since consulting, the smart charging market has developed significantly, although is still in a nascent stage. Given this, and considering the responses to the consultation, there is limited evidence for mandating specific solutions that meet all of Government's smart charging policy objectives in 2021. Our intention is to instead mandate a minimum set of requirements this year, to support the smart charging market in this early stage, ahead of a further intervention, described in the consultation as phase two. In addition, the consultation identified a key risk of the phased approach is a scenario where industry invest in developing products to meet Phase One requirements, only for those requirements to be changed to align with the future framework developed under Phase Two. The risk of this wasted investment is potentially higher under option 2, while until phase 2 is complete consumer benefits would not be realised in any event.

38. Option 4, where smart device requirements are set as part of chargepoint grant schemes, has already been partly implemented in the UK. The current OZEV EVHS grant requires all CPs to be smart and meet high level outcomes on issues such as cyber security and monitoring energy consumption. Whilst in the short term this intervention has successfully driven uptake of smart charging and requiring such conditions as part of other grants in the future could drive uptake, there are two key reasons why this approach has been deemed

insufficient. First, the aim of Government is to create a mature EV chargepoint installation market for workplace and domestic settings that does not need grant funding to sustain it. An approach independent from the continuation of grants is therefore necessary to meet the Government's aims and objectives for smart charging in the long term. Second, the diversity in business models and practices of this early market risks a proliferation of smart CPs with varying standards and functionality. Without clear requirements which are regulatory and hence enforceable, it is unlikely that the market will deliver smart CPs that consistently meet Government's objectives.

39. A voluntary option as described under Option 3, without regulation, would not achieve Government's consulted on aims and objectives for smart charging policy as this would lead to high levels of variation amongst industry in how requirements are delivered, given it is unlikely all relevant players would voluntarily implement requirements or agree to the same approach, particularly as the smart charging grows.

40. Government recognises that further legislation will be needed in the future to appropriately deliver our policy objectives, including consideration of other smart charging business models, such as smart charging via the EV itself.

2. Costs and Benefits

Methodology

41. This section begins by establishing the counterfactual. This is an important stage of the analysis as it provides us with a benchmark so that we can isolate and identify the impacts of our regulation. To do this, we assess the capability of existing private CPs and then estimate how many will be sold each year from now until 2050, assuming there is no further Government intervention in this market. This stage of the assessment is based upon internal market research as well as evidence received from direct engagement with CP manufacturers, market research organisations and Distribution Network Operators (DNOs).

42. We then assess the impact our regulations could have on the number of compliant CPs sold and installed in Great Britain with consideration for the impact our regulations could have on the price of a CP. Finally, we use our estimation of additional compliant CPs installed, over and above that would have been installed in the 'do nothing' counterfactual to model the total cost and benefits of our regulation.

43. The scenarios tested in this section constitute the 'Core Analysis'. The appraisal period covers years 2021 – end 2050 (30 years) in order to capture any long-term costs and benefits associated with the introduction of the regulation. Given the uncertainty in this area, sensitivities have been run which vary some of the key assumptions, the results from which can be found in the 'Sensitivities' section.

Option 0 – Do Nothing (the counterfactual)

44. As explained in the 'Problem under consideration', it is estimated that approximately 160,000 CPs were installed in Great Britain at the end of 2019 to support domestic, employee and depot-based charging[23]. It is assumed that these CPs are privately owned (either by an individual or business) and therefore within scope of our regulations.

45. There is limited evidence on the technical specification and capabilities of CPs that are currently installed across Great Britain. Table 1 below contains an assessment of the extent to which existing CPs meet the requirements as defined in our regulations. This is based upon direct engagement with CP manufacturers, market research organisations and DNOs.

Table 1 – Assessment of existing CP capability

Device Level Requirement	Qualitative assessment of the extent to which existing CP models satisfy each requirement
Smart functionality	Approximately 50% - 70% of CPs currently installed at residential properties have 'internet connectvity'[26]. Many of these models are suitable for commercial use at workplaces and depots[27], however, there is greater uncertainty around the proportion of CPs that are installed with smart charging capabilities in these locations. Over time, smart CPs have become a greater proportion of total CP sales, representing 70% - 100% of total CP installations in the first quarter of 2020[26]. How this will change over time is uncertain and there are many factors that could increase or decrease this proportion. The exact capabilities of smart CPs can vary across models. Feedback from industry indicates that a large proportion of models do meet this requirement, however, it has not been possible to gather robust evidence in this area.
Personalised default settings	Feedback from industry stakeholders indicated that very few models on the market currently meet this requirement.
Cyber and physical requirements	CPs currently installed in the UK are likely to include some basic cybersecurity measures, but these are unlikely to be consistently or widely applied enough to mitigate the major cybersecurity risks. There is evidence that some CPs include basic cybersecurity vulnerabilities[30]. Some models do include physical protections, but these tend to be at a lower level than the proposed requirements.
Randomised delay function	Feedback from industry stakeholders indicated that very few models on the market currently meet this requirement.

46. Future demand for CPs is dependent on a number of different factors such as price, consumer preferences, feasibility (e.g. access to off-street parking) and the availability of alternative charging infrastructure (e.g. public). It is very uncertain how these factors will

[30] For example, see Kaspersky's research into one chargepoint model here: https://media.kasperskycontenthub.com/wp-content/uploads/sites/43/2018/12/13084354/ChargePoint-Home-security-research_final.pdf

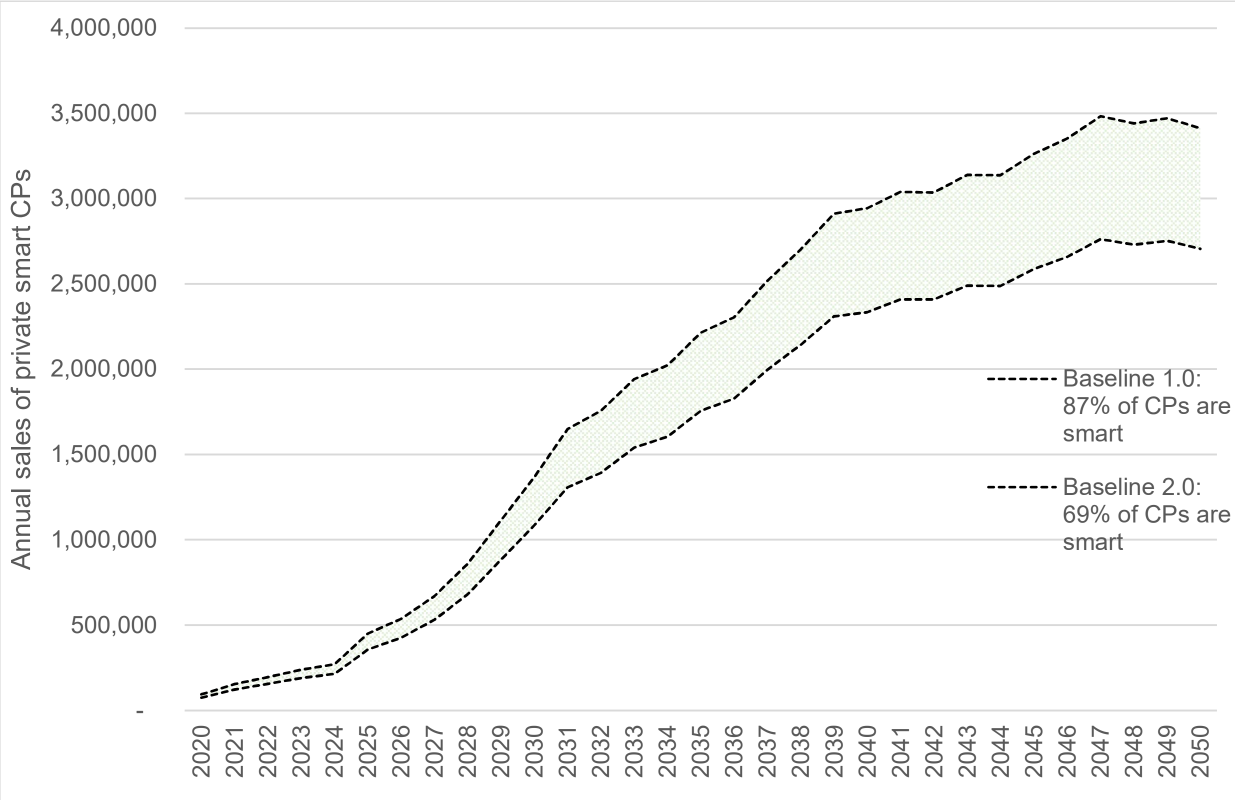
change over time making accurate forecasting difficult, however, it’s clear that EV ownership is likely to be a key driver of future CP demand. Given the announced ending of new petrol and diesel cars and vans sales by 2030, we expect this to significantly increase year on year.

47. Figure 2 represents the assumed baseline trajectories of annual private smart CP sales where Government takes no action to create or actively support the development of industry standards. These trajectories have been constructed for the purposes of appraising the impact of the introduction of our intervention. Sales of residential off-street CPs have been developed using assumptions on EV ownership, access to off-street parking, multiple EV ownership and the CP replacement cycle. Workplace and depot CPs have been calculated using additional assumptions on consumer charging preferences, average mileage, and CP utilisation. Due to the market failures described in the previous sections, it is assumed that non-smart CPs remain an option to EV owners and businesses. As such, these models continue to be installed and represent a proportion of total sales. These assumptions are subject to a high degree of uncertainty; therefore, baseline trajectories represent indicative scenarios rather than accurate forecasts.

48. As discussed, the proportion of CP sales that have smart functionality now and in the future is highly uncertain. To account for such uncertainty, two baselines have been considered which vary the level of smart CP uptake in absence of our regulation. These assumptions are based upon the range observed in the consumer research produced by Delta-EE of a sample of EV owners[31]. Due to the myriad of factors that could change this proportion over time, we have held this assumption constant. The projections in Figure 2 show annual sales, rather than cumulative out to 2050. To clarify, the total number of CPs sold in both scenarios is the same and is based on internal modelling that aligns with DfT EV uptake projections in line with Net Zero and the proposed ICE vehicle bans. The only difference between the two projections is the proportion of total CPs that are assumed to have smart functionality.

[31] According to the research, 87% of CPs installed in residential off-street properties in the first quarter of 2020 had internet connectivity. However, this could be as low as 69%.

Figure 2 – Smart CP projection (Baseline 1.0 and 2.0)



49. Due to limited evidence and for the purpose of carrying out this IA it is assumed that all smart CPs currently installed in Great Britain as defined as having ‘internet connectivity’ meet the smart functionality requirement as defined in our regulation[32]. Feedback from industry indicates that this is a reasonable assumption to make, however we cannot be certain this applies across all makes and models. Furthermore, it is assumed based on the research summarised in Table 1 that no CPs currently installed in Great Britain meet the remaining requirements.

50. It should be noted that there is significant uncertainty surrounding the assumptions driving this projection. These projections are based upon one set of assumptions reflecting consumer charging behaviour, technology change and EV uptake. Further information on the assumptions underpinning these projections can be found in the Annex.

Option A – Introduction of The Electric Vehicles (Smart Charge Points) Regulations 2021 (the preferred option)

51. Due to the enforcement of the regulation, private EV CPs that do not comply with our regulations can no longer be sold in Great Britain. As such, this regulation will directly influence the capability of private EV CPs that are sold and subsequently installed.

52. Table 2 below sets out the potential costs and benefits associated with purchasing a private CP that is compliant with our regulations vs one that does not comply. Where appropriate, each impact has been attributed to the specific device level standard.

[32] As mentioned, this is not a perfect proxy because we are not able to assess the exact capabilities of existing smart CPs installed. Feedback from industry indicates that the vast majority of smart CPs will meet the smart requirement in our regulation. However, we can’t be confident this is reflective of the entire market.

Table 2 - Identification of impacts (compliant vs non-compliant CP)

	Costs		**Benefits**	
	Monetised	Non-Monetised	Monetised	Non-Monetised
Consumers (EV owners, businesses)		• Reduction in CP model choice • Smart requirements may lead to perceived cost of relinquishing personal control over charging arrangements and provision of personal information. • Personalised charging settings may impact the consumer experience. • Increased cost of smart CPs to those consumers who switch	• Smart requirements may reduce the cost of charging for the user if combined with a TOUT or other DSR service (this value is captured in the electricity systems modelling)	• Smart requirements may reduce the cost of charging for the user if combined with a TOUT or other DSR service. • Increased consumer protection. • Increased control and personalisation of charging arrangements.
Producers (CP manufacturers)	• Increased manufacturing costs associated with complying with the regulations, including one-off product development costs. • Reading, disseminating information on the regulation (familiarisation costs) and proving compliance (assurance costs)	• Increased customer service because of these regulations due to the increased consumer interaction associated with the installation of smart technology		• Increased future export potential from increased manufacturing of compliant CPs.
Wider Society (Taxpayers, all electricity consumers)		• Enforcement of the regulation	• Smart requirements will increase the proportion of CPs installed that are capable of smart charging, gradually increasing system flexibility as the uptake of TOUTs or other forms of incentives increase,	• Cyber security requirements will reduce the risk of cyber-attack and avoid the costs of subsequent grid instability. • Smart requirements and randomised delay function will

			leading to lower power system costs. • Personalised charging settings will increase the amount of off-peak charging.	reduce the risk and costs of grid instability

Number of compliant CPs sold and installed in Great Britain each year.

53. To understand the total costs and benefits of our regulation we need to assess the impact the introduction of our regulation will have on the number of compliant CPs that are sold and installed across Great Britain. The introduction of our regulations provides certainty that from the date our regulations are enforced, all new private CPs will have smart functionality and additional requirements necessary to comply with the regulation. However, we also need to consider that removing non-compliant CPs from the market is likely to increase the upfront cost of installing a CP for some consumers who may have previously considered a non-compliant model[33].

54. The impact our regulation will have on the cost of manufacturing a CP and the extent to which any cost increase is passed through to consumers is discussed in detail in the next section.

55. For the purpose of this IA, we have assumed that the introduction of our regulation increases the price paid by the consumer for a non-smart CP by £100 - £400[22]. This is in line with the existing price differential observed in the market and reflects the increased cost to the manufacturer of adding smart functionality to a CP unit which is as discussed in the next section.

56. How consumers respond to a price rise is highly uncertain. Some consumers may be willing to incur the higher price and decide to purchase a CP that is compliant with our regulations, whilst others may be more sensitive to a price change and choose to avoid incurring the higher price and rely on alternative types of charging infrastructure (e.g. charging cable[34] via a 3 pin plug or public infrastructure). Below are a list of the core scenarios used in this analysis[35]. The Baseline (1.0) assumes that 87% of private CPs sold or installed in Great Britain have smart functionality. This is based upon the central estimate from Delta-EE's EV consumer research[26]. In the Central (1.1), Low (1.2) and High (1.3) scenarios 100% of CP sales are smart however we have varied the assumption on the sensitivity of consumer demand to price changes and subsequently amount of smart charging infrastructure installed. For workplace and depot, we assume that all non-smart CP demand transfers to smart CPs. This is due to the lack of alternatives forms of charging infrastructure available to these users.

57. With regards to existing smart CPs, we assume that our regulations do not significantly increase the price paid by the consumer. This is based on industry feedback, though there is some uncertainty over the additional manufacturing cost incurred to comply with our regulations and the extent to which this would be passed through to the final price paid by consumers.

---

[33] This is an important factor that determines CP demand and is explored in more detail in the 'Costs' section.

[34] Market research indicates that a significant proportion EV owners with access to off-street parking currently use this form of charging opposed to a dedicated CP (Delta-EE, UKPN)

[35] All assumptions as assumed the same across all scenarios until the regulation enforcement date.

Core Scenarios

Baseline 1.0

- 87% of private CPs sold or installed in Great Britain have smart functionality. This is assumed constant over time.

Central 1.1

- 100% of private CPs sold or installed in Great Britain have smart functionality. This is assumed constant over time.
- 75% of demand for non-smart private CPs is transferred to smart private CPs, 25% of demand is transferred to charging cables. The proportion transferred to smart CPs increases over time as the cost differential between smart and non-smart CPs falls.

Low 1.2

- 100% of private CPs sold or installed in Great Britain have smart functionality. This is assumed constant over time.
- 50% of demand for non-smart private CPs is transferred to smart private CPs, 50% of demand is transferred to charging cables. The proportion transferred to smart CPs increases over time as the cost differential between smart and non-smart CPs falls.

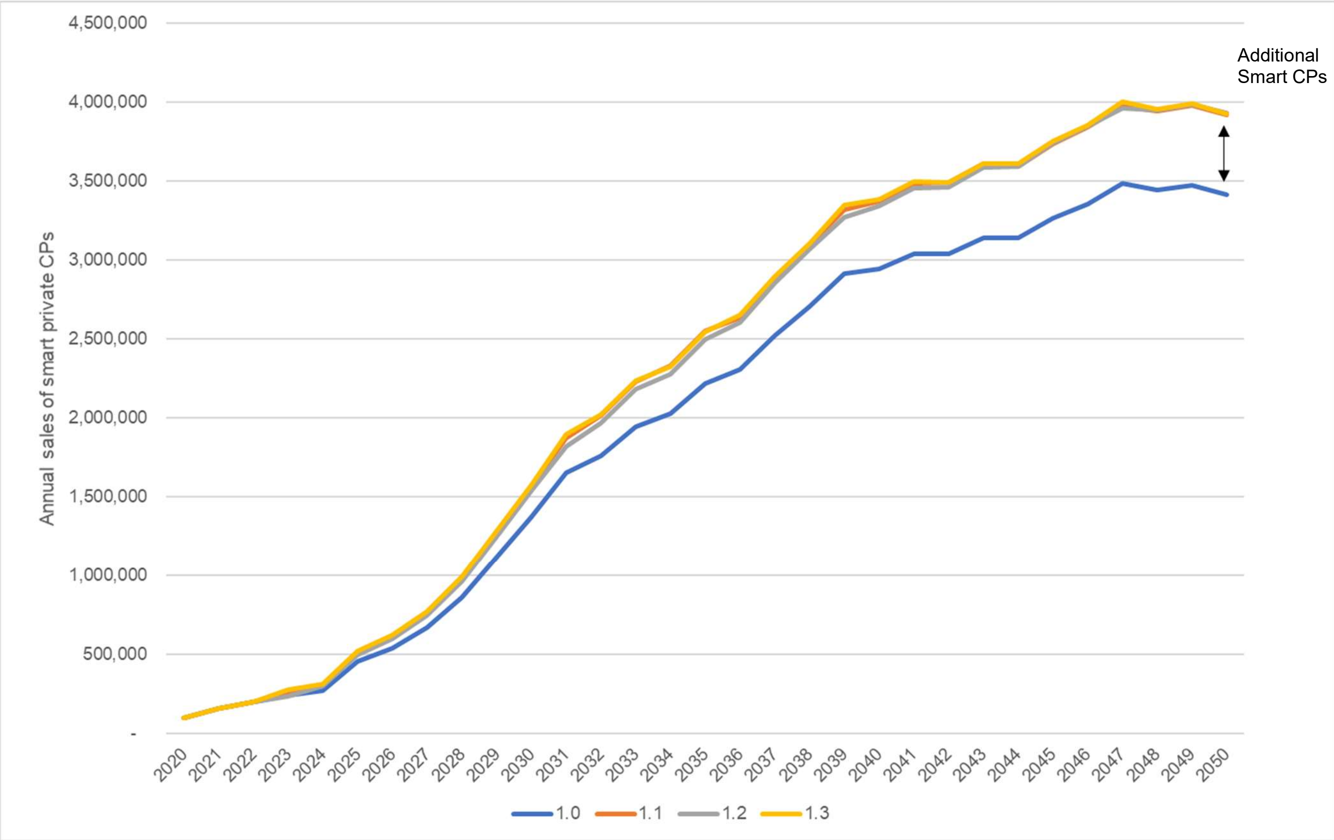
High 1.3

- 100% of private CPs sold or installed in Great Britain have smart functionality. This is assumed constant over time.
- 100% of demand for non-smart private CPs is transferred to smart private CPs, 0% of demand is transferred to charging cables.

58. Figure 3 below shows the impact our regulations will have on the sale of private EV CPs once non-smart CPs are removed from the market. As illustrated, the difference in smart CP sales varies across our scenarios but the impact is small. This is because the demand for non-smart CPs is already very low in the Baseline (1.0), representing 13% of total CP sales. Therefore transferring 75% (in Central (1.1) or 50% (1.2) of this demand to smart CPs represents a very small number of consumers. This analysis illustrates that even if we account for a reasonable range of assumptions on consumer reaction, overall projections of smart CP demand remain broadly stable.

59. In the 'Sensitivity' section of this IA we show the results from testing Baseline (2.0) which considers a lower penetration of smart CPs (69%) in the 'do nothing' counterfactual. This value represents the lower bound of the confidence range from the Delta-EE consumer research. The results from this sensitivity ('Sensitivity 3') are broadly similar to those in the core analysis, although the benefits associated with the policy intervention are greater. As there are less smart CPs in Baseline 2.0, the intervention results in a bigger comparative increase in smart charging and greater electricity system benefits.

Figure 3 - Smart CP projection (all scenarios)



Costs (Monetised)

Unit costs for CP manufacturers

Methodology

60. The costs captured in this IA reflect the additional costs of producing a compliant CP over a non-compliant alternative, multiplied by the change in sales over and above the counterfactual because of the policy intervention. We then add 'capitalised' costs that manufacturers are likely to face in order to arrive at the final cost net present value (NPV)[36].

CP manufacturing costs (Compliant vs Non-compliant CP)

61. It is estimated that there are approximately 900 – 1100 private CP models currently available on the market[9]. These models can vary significantly in their design and capability leading to a wide range in manufacturing cost per unit. However, there are a list of components associated with the production of a CP that are common across all models.

[36]This analysis focusses only on the additional and avoided costs of production, we are not attempting to calculate any profit that may be made (or that would have been made in the baseline) by manufacturers.

These include CP housing, cabling, power supply, switching components, safety components (e.g. RCD[37]) etc[38].

62. The average manufacturing cost of a non-compliant CP is approximately £280 per unit[39]. This reflects the hardware cost associated with a 3.7kW wall-mounted CP typically installed in a domestic property. Table 3 below lists the additional components (e.g. software and hardware) and development that would be required to make an existing non-compliant CP comply with our regulations. This evidence is based upon engagement with CP manufacturers and includes illustrative costings which are used for the cost assessment.

Table 3 – Additional costs to manufacturers of complying with the regulations

Additional Requirements	Description	Illustrative Costings[40]	Occurrence
Smart functionality	**Additional hardware** is required when manufacturing a smart CP. This includes: • **Communications module** so that the CP can send and receive data. This will enable remote access and allow the CP to receive and respond to instructions. This cost will depend on the type of module (e.g., Wi-Fi, GPRS[41], ethernet). • **Additional processing power and RAM** There are also **additional development costs** that need to be considered. These include: • **Development of bespoke firmware** so that the CP can perform additional functions. The cost will depend on whether this is sub-contracted. • **Additional testing and certifications**	Additional hardware: £40 per CP Additional development costs: £300k	Ongoing One-off

37 Residual Current Device protection. The purpose of an RCD is to automatically disconnect the supply if there is a certain difference between the current in the supply and return (line and neutral) conductors of a circuit.

38 This does not include additional components that vary across units including displays, interfaces, apps, etc.

39 Steer (2018) 'Research of EV Chargepoint Wiring', report provided to the Department for Transport (DfT). This cost does not include installation and wiring costs which are assumed not to be incurred directly by the manufacturer.

40 Undiscounted, real prices

41 General Packet Radio Service

	• **Additional customer support if an end-to-end system is included**		
Personalised default settings	Feedback from industry indicated that **no hardware modifications** would be necessary to meet this requirement. Instead, this would require **software development / adjustments** and the **subsequent internal training** and **documentation updates**. It may also require **additional customer support**.	£20k - £30k	One-off
Cyber and physical requirements	Feedback from industry indicated that hardware modifications may not be required. However, fully complying with the ETSI will require new **firmware** and **software development.** **Annual review/check-up** and **security testing**.	£100k - £300k £50k - £100k	One-off Ongoing
Randomised delay	Feedback from industry indicated that this is a relatively **simple firmware feature.** Additional training and documentation as well as **additional customer support** may be required.	£20k	One-off
Assurance	Feedback from industry indicated that this may require external testing, however this is not mandated in the regulations so would be at the discretion of the organisation. Also likely to require **annual updates** and **audits**.	External Product testing: £30K Annual updates / audits: £10k	One-off Ongoing
Familiarisation Costs	Feedback from industry indicated that there would be costs associated with **reviewing the requirements**, **planning** and **implementation.**	£20k - £80k	One-off

63. The evidence provided in the table above indicates that adding smart functionality could increase the cost of manufacturing a CP by £40 per unit reflecting the cost of additional hardware and software required. It is very difficult to apply the remaining costs on a per unit basis as the majority of these costs will be dependent on the number of units sold (capitalised) and therefore likely to vary across manufacturers. However, the evidence included in Table 3 indicates that for some manufacturers, meeting the requirements in our regulation could add a one-off (transition) cost of up to £550k - £870k to their total cost of production in addition to £60k - £110k that would be incurred annually[42].

[42] Undiscounted, 2021 price base.

64. In practice, the total cost to the manufacturer will depend on the extent to which they already meet the requirements in our regulations. For example, it's likely that the cost of compliance for manufacturers that already produce smart CPs will be significantly lower as they may not incur the full cost of developing smart charging technology.

65. Based on the evidence provided, we have assumed that the introduction of our regulations will increase the cost of manufacturing a non-smart CP by £40 per unit. For reasons set out above, we have not applied the remaining costs on a per unit basis. Instead, we have assumed that the introduction of our regulation costs every manufacturer an additional one-off £550k - £870k and an additional £60k - £110k each year (i.e. all CP manufacturers incur the full cost of compliance.) We believe that this is a very conservative approach as a large proportion of CP manufacturers already produce smart CPs. However, we don't have data that enables us to accurately identify manufacturers already producing smart CPs. This uncertainty is addressed in the 'Sensitivities' section as 'Sensitivity 1' assesses the impact on costs if we assume varying proportions of manufacturers already meet the smart requirement in our regulations.

Estimated unit cost reduction trajectories.

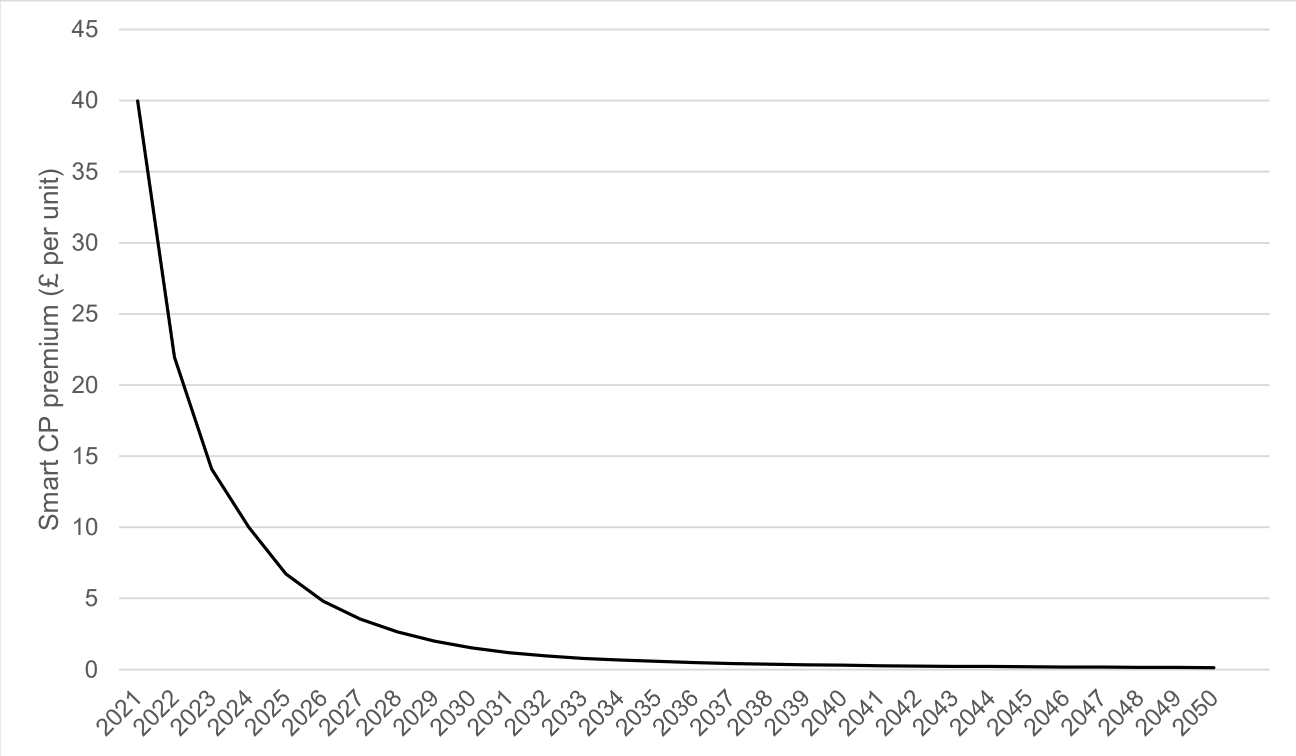
66. Given the rate of change in this market, it is expected that significant developments will be made that will allow these technologies to be produced more economically as production expands. To account for this, we have used "learning rates[43]" to estimate cost decreases over time. How costs will change over time is dependent on many factors making accurate forecasting difficult. Due to the infancy of the market, it is not possible to determine these rates from historical trends. Instead, a learning rate has been inferred from historical rates observed from a similar, but more mature product. In this analysis we have assumed a 51% learning rate for the smart components of a smart CP[44]. This means that the cost of adding smart functionality is assumed to decrease by 51% for every doubling of cumulative production. This value reflects general learning rates for computers, which are assumed most representative of the added software and hardware which makes an appliance "smart". Sensitivity 2 in the 'Sensitivities' section tests the impact of other learning rates.

67. Figure 4 below shows the impact the application of the learning rate has on the cost of adding smart functionality over time. As you can see, it is assumed that the cost differential between a smart and a non-smart CP will fall rapidly as production increases.

Figure 4 –Projected smart CP premium

[43] The rate at which a technology becomes cheaper as production increases - Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy (2011): Using the Experience Curve Approach for Appliance Price Forecasting - https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/experience_curve_appliance_price_forecasting_3-16-11.pdf

[44] Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy (2011): Using the Experience Curve Approach for Appliance Price Forecasting - https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/experience_curve_appliance_price_forecasting_3-16-11.pdf



Retail mark-up

68. Feedback from industry has indicated that the introduction of our regulations is unlikely to increase the price of an existing smart CP. However, as explained above, this may differ by manufacturer as it is dependent on sales figures. Conversely, the cost of adding smart functionality is expected to be passed through to consumers. Market evidence indicates that meeting this requirement could increase the price of a non-smart CP by £100 - £400[22]. However, we would expect this price differential to fall over time in line with decreasing costs, as explained above.

Results

69. Table 4 contains information on the number of CPs sold each year in each of our scenarios based on the projection explained in the previous section (Figure 3). Table 5 then illustrates the additional cost to manufacturers. To complete the cost assessment, we add the capitalised costs which are applied to all CP manufacturers in the market. The final cost to manufacturers is presented in Table 6.

Table 4 – CP Sales ('000s, annual, rounded to the nearest 10)

Scenario	**Type**	**Total number of CPs sold**				**Change in number of CPs sold, relative to the Baseline (1.0)**			
		2021	**2030**	**2040**	**2050**	**2021**	**2030**	**2040**	**2050**
Baseline (1.0)	Smart	150	1,370	2,940	3,410				
	Non-Smart	20	200	440	510				
	Total	**180**	**1,570**	**3,380**	**3,920**				
Central (1.1)	Smart	150	1,570	3,370	3,920	0	+200	+430	+510

	Non-Smart	20	0	0	0	0	-200	-440	-510
	Total	**180**	**1,570**	**3,370**	**3,920**	**0**	**-<10**	**-10**	**-<10**
Low (1.2)	Smart	150	1,540	3,340	3,930	0	+170	+400	+520
	Non-Smart	20	0	0	0	0	-200	-440	-510
	Total	**180**	**1,540**	**3,340**	**3,930**	**0**	**30**	**-40**	**+10**
High (1.3)	Smart	150	1,570	3,380	3,920	0	+200	+440	+510
	Non-Smart	20	0	0	0	0	-200	-440	-510
	Total	**180**	**1,570**	**3,380**	**3,920**	**0**	**0**	**0**	**0**

Table 5 – Manufacturing Costs (£m, cumulative, 2021 prices (real), discounted, rounded to nearest 10m)

Scenario	**Type**	**Total manufacturing cost**				**Change in total manufacturing cost, relative to the Baseline (1.0)**			
		2021	**2030**	**2040**	**2050**	**2021**	**2030**	**2040**	**2050**
Baseline (1.0)	Smart	50	1,350	5,210	9,160				
	Non-Smart	10	200	770	1,360				
	Total	**60**	**1,550**	**5,980**	**10,530**				
Central (1.1)	Smart	50	1,520	5,930	10,460	0	+170	+720	+1,300
	Non-Smart	10	10	10	10	0	-180	-760	-1,350
	Total	**60**	**1,530**	**5,950**	**10,480**	**0**	**-20**	**-40**	**-50**
Low (1.2)	Smart	50	1,490	5,830	10,350	0	+130	+620	+1,190
	Non-Smart	10	10	10	10	0	-180	-760	-1,350
	Total	**60**	**1,500**	**5,840**	**10,360**	**0**	**-50**	**-140**	**-160**
High (1.3)	Smart	50	1,540	5,970	10,510	0	+180	+760	+1,350
	Non-Smart	10	10	10	10	0	-180	-760	-1,350
	Total	**60**	**1,550**	**5,980**	**10,530**	**0**	**1**	**1**	**1**

70. As illustrated in Table 4 above, in our Central scenario (1.1) it is estimated that the introduction of our regulations will increase the number of smart CPs sold by 197,000 and reduce the number of non-smart CPs sold by 204,000 in 2030, relative to the Baseline (1.0). As explained in the previous section, although the demand for smart CPs has increased, the total number of CPs sold has fallen by 7,000 units. It is assumed that this small number of consumers have switched to alternative forms of charging (e.g. charging cables via a 3 pin plug) due to the increase in CP price.

71. In the Low (1.2) scenario 169,000 more smart CPs are sold relative to the Baseline (1.0) in 2030. This is a smaller increase relative to the Central (1.1) scenario because we have assumed that a greater proportion of EV owners now switch to alternative forms of charging in response to the CP price rise. In the High (1.3) scenario 204,000 more smart CPs are sold relative to the Baseline (1.0). This is a greater increase relative to the Central (1.1) scenario because we assume that all demand for non-smart CPs transfers to smart

CPs. As discussed in the previous section the difference in CP sales between our scenarios is small. This is because non-smart CP sales represent only a small proportion of total CP sales, therefore transferring a proportion of this demand to smart CPs or cables only captures a small number of consumers. In all scenarios, sales of non-smart CPs are 0 from the date at which the regulation is enforced.

72. Table 5 shows the cost implications for manufacturers. Our Central scenario (1.1) estimates that the additional cost of producing smart CPs (£1,300m) will be more than offset by the avoided cost of not producing non-smart CPs (£1,350m)[45] in 2050. This is driven by the fact that total CP demand is lower relative to the Baseline (1.0). Table 6 below shows the final impact once adding the capitalised costs to all manufacturers in the market[46].

Table 6 - Change in total cost (unit costs and capitalised cost) relative to the Baseline (1.0) (cumulative, £m, 2021 prices (real), discounted, rounded to nearest 10m)

Scenario	Capitalised Cost Range	2021	2030	2040	2050
Central (1.1)	Low	0	+70	+80	+100
	High	0	+130	+170	+210
Low (1.2)	Low	0	+40	-20	-10
	High	0	+100	+70	+100
High (1.3)	Low	0	+90	+120	+150
	High	0	+150	+210	+260

73. In summary, our analysis estimates that our intervention will increase the cost to CP manufacturers by **£100 - £210 million up to 2050 (NPV, 2021 prices)** in our Central (1.1) scenario. This illustrates that despite the reduction in CP demand offsetting the additional unit costs of smart CPs, the inclusion of the upfront capitalised costs results in the regulations creating a cost to CP manufacturers. The results from our Low (1.2) and High (1.3) scenarios indicate that this cost could be as low as -£10 million[47] or as high as £260 million. In the low scenario (1.2) between 2030 and 2040 avoided costs from not producing non-smart CPs outweigh the costs associated with producing smart CPs, but from 2040 to 2050 the costs of producing smart CPs outweighs the avoided costs. This explains why the cumulative costs decrease to -£20m before rising again to -£10m.

Key Caveats and Limitations

74. Below are a list of the key caveats and limitations associated with the cost assessment:

- **It is assumed that all CP manufacturers incur the full cost of meeting all requirements in the regulations -** Data is not available on the extent to which

[45] It should be noted that this benefit is purely an avoided production cost – we cannot say whether manufacturers revenue or profit would be increased or decreased compared to our baseline.

[46] It is assumed that the capitalised costs are incurred in 2023 when the regulation is enforced.

[47] In this scenario the avoided cost associated with reduced CP demand offsets the increased capitalisation costs and leads to an overall benefit to manufacturers.

manufacturers meet the requirements in our regulation, however given that there are a number of manufacturers that already produce smart CPs we know that not all will incur the full cost. As such, the results from this analysis should be treated as an upper bound.

- **Some additional costs may be incurred regardless of whether the regulations are introduced (i.e., in the baseline)** - This is because in some cases it is a good investment; adding a communications module to their CPs, for example, can incentivise sales by providing consumers with access to their data and analytics. Additionally, manufacturers are likely to compete with one another on the specifications and features of their CPs, which will require incurring at least some of the capitalised investment costs we have described.

- **Unit costs are very sensitive to changes in the learning rates** – A key component that determines technology cost reductions is future sales volumes. In this analysis the learning rate is applied for every doubling of UK rather than global CP production. In isolation, this may suggest that our learning rate we have applied may underestimate potential cost savings. However, it should be noted that a proxy technology (computer components) has been used. Given that the market for these products may be larger and more competitive it could be argued that our learning rate overestimates potential CP cost reductions.

- **Cost assumptions are based on residential CPs only** – It is assumed that the cost of adding smart functionality would be similar for workplace or depot CPs. The unit cost of the non-smart components may change (potentially higher power output at depot CPs, for example), but it is assumed that smart enabling components (such as a comms module) would not need to be changed significantly from residential CPs to function with workplace or depot CPs.

Unmonetised Costs

75. As identified in Table 3, there are several additional costs associated with the introduction of these regulations that we have been unable to monetise and therefore include in the final NPV calculation. This section describes each of these impacts in turn.

- **Increased customer service -** Customer service costs may increase because of these regulations due to the increased consumer interaction associated with the installation of smart technology. This cost would likely fall on the manufacturer; however these costs have not been included in this assessment as they are very difficult to accurately quantify and monetise.

- **Reduction in consumer choice** – There are already a broad range of CPs models available on the market which include smart and non-smart versions. These models vary in terms of design, functionality, and price. By removing non-smart CPs from the market, we would not expect this to significantly reduce the number of models available to the consumer. As set out in the costs section, the additional features required to make a CP smart are mainly software-related, as such we would not expect smart CPs to look different in appearance to a non-smart version.

- **Perceived cost of relinquishing personal control over charging arrangements and provision of personal information** – Qualitative research conducted as part of the Consumers Vehicles and Energy Integration (CVEI) programme[48] observed that some forms of smart charging (e.g., supplier managed[49]) required a substantial degree of trust in the supplier on the part of the consumer. In particular, there were concerns that the supplier would not deliver the required state of charge by the required time or would fail to pass on a fair share of the cost savings. There was also concern that a commercial organisation would have knowledge about the users' daily schedules, information that could be considered personal. A related issue for supplier managed charging is that many participants were reluctant to relinquish personal control over the timing of their charging, some even expressing this in terms of a loss of personal freedom. The 2020 Ofgem Consumer Survey[50] of over 4,500 electricity consumers found that 62% of respondents would be uncomfortable with an external company controlling appliances. These regulations will not mandate that consumers must engage with third party managed charging; they will only mandate that smart CPs must have the enabling functionality for this service. In addition, the regulations will increase security of CPs and ensure the smart requirements can be overridden by the consumer, which could strengthen the protection offered and help address these concerns, if consumers opt into such services.

- **Personalised charging settings** – The legislation will mandate that CPs must by default be pre-set so EVs do not charge at peak times. This could be confusing for users, if they are unaware of the setting and instead think their CP is faulty. To mitigate this, the regulations will mandate that consumers must be informed of this setting during first use of the CP and given the opportunity to edit or remove the setting. There are also exceptions to this requirement whereby the CP seller can implement an alternative approach.

- **Enforcement** – The cost of assurance and proving compliance has been considered in the total cost to manufacturers. If a CP manufacturer fails to comply with the regulations, they could face a maximum civil penalty of £10,000 per CP, or a £500,000 cost if they fail to cooperate with the enforcement body. The Office for Product Safety and Standards (OPSS, the potential enforcement body) may have to pursue action in the county courts if a civil penalty is appealed and challenged. The OPSS would likely incur additional costs associated with the implementation and on-going running of the enforcement regime, these have not been monetised. OPSS are predominately funding by government through BEIS central funding, therefore any additional costs would not be a cost to business. Manufacturers of non-compliance could incur enforcement costs such as penalties and associated legal costs, however the costs to non-compliant businesses is not in scope of the Business Impact Target.

[48] E Delmonte et al. (2019): *What do consumers think of smart charging? Perceptions among actual and potential plug-in electric vehicle adopters in the United Kingdom* - https://www.sciencedirect.com/science/article/pii/S2214629619301422 - This evidence was derived from interviews with 60 drivers (with and without experience of owning an EV). This study aimed to explore users' experiences of charging, their charging behaviours, and their responses to smart charging.

[49] The consumer specifies how much charge they require by a certain time and leaves the EV plugged in and available to be charged, for a time window longer than the time required to charge it to the desired level. The supplier manages the timing and duration of charging within the time window.

[50] OFGEM 2021: Consumer Survey 2020 - Decarbonisation Insights - https://www.ofgem.gov.uk/publications/consumer-survey-2020-decarbonisation-insights

Benefits (Monetised)

Electricity System Benefits

Overview

76. EV smart charging is a form of DSR which allows charging load (demand) to be controlled either directly by the user or through a third party in response to an external signal. DSR services and other flexible technologies such as electricity storage and interconnection are particularly important for balancing electricity supply and demand in real-time and ensuring a secure and stable electricity system. Adjusting when electricity is supplied and consumed can help reduce peaks in demand leading to a greater utilisation of existing generation capacity and reducing the curtailment of renewable generation. This process can lower the carbon intensity of the system[51] and help reduce costs to electricity consumers by avoiding additional investment in new generation capacity and network reinforcement.

77. With regards to EV smart charging, there are two important pre-conditions that determine the amount of charging load that can be shifted throughout the day. These factors are explained below and need to be considered and addressed before we can expect to unlock the full benefits of smart charging.

- **Amount of smart charging infrastructure installed** – Widespread EV demand shifting is most likely to be achieved when using a smart CP[52]. As explained in the 'Problem under consideration' it is estimated that around 50 – 70% of residential CPs currently installed in Great Britain have smart functionality[26]. Evidence on the prevalence of smart charging at workplaces and depots is not widely available.

- **Consumer attitudes** - A consumer's willingness to shift demand is likely to be influenced by whether they can access the financial benefits associated with smart charging (e.g. through a TOUT or through an aggregator)[53] and their charging behaviour (i.e. where and when they charge). It is estimated that currently around 40% of EV owners are able access the benefits of smart charging through a form of TOUT[26][54]. Evidence from the Consumers Vehicles and Energy Integration Consumers Charging Trials Report[55] showed that despite having access to financial incentives, there is still a portion of EV load that consumers are not willing to shift their charging. This is likely to reflect periods when financial incentives are not strong enough to motivate behaviour change (for example, if a driver requires the vehicle at a certain time of the day).

---

51 This is because peaking generators tend to be less efficient than baseload generators.

52 Smart charging can technically be achieved through other means such as via EV itself in response to a signal or manually by the user using a timer. However, these alternatives are either in an earlier stage of development or not seen as viable long term solutions vs smart charging via a dedicated smart CP.

53 This factor is likely to be contingent on a number of further pre-conditions such as completion of the smart meter roll out and market wide introduction of half-hourly settlement.

54 Consumers, Vehicles and Energy Integration Project (2019) – Market Design and Systems Integration - https://es.catapult.org.uk/reports/consumers-vehicles-and-energy-integration/

55 CVEI (2019): Consumer Charging Trials Report: Mainstream consumers' attitudes and behaviours under Managed Charging schemes for BEVs and PHEVs - https://es.catapult.org.uk/reports/consumers-vehicles-and-energy-integration/

78. It is expected that the introduction of our regulations could have a positive impact on the two factors described above leading to more system flexibility. As illustrated in previous sections of the IA (Figure 3), mandating all CPs to have smart functionality is expected to increase the amount of smart charging infrastructure connected to the system. In addition to this, the 'personalised charging settings' requirement could have a positive impact on consumer behaviour by encouraging charging during off peak periods, especially for the segment of the market that don't currently engage with smart charging offers.

Methodology

79. In order to estimate the costs and benefits of our regulation to the electricity sector we used BEIS' Dynamic Dispatch Model (DDM)[56] to test our scenarios. Within the model EV charging demand is allocated to 6 different charging locations; residential off-street, workplace, residential on-street, destination, rapids and depot based upon assumptions on consumers charging preferences. Demand at each location is then distributed across the day based on assumptions of when EV drivers are expected to charge their vehicle. To account for potential demand shifting (smart charging), the model includes an assumption on the proportion of load that is available to shift at each charging location within a set time window.

80. In order to provide a robust appraisal of the impacts associated with the introduction of our regulations we were required to make adjustments to the existing EV modelling assumptions contained within BEIS' 2019 'Reference Cases[57]' which are two illustrative pathways to Net Zero reflecting differing levels of electricity demand and capacity mixes[58]. Details of the evidence base used to inform these assumptions can be found in the annex.

81. In order to estimate the total costs to the system, we used BEIS's electricity Distribution Networks Model (DNM) to quantify the costs of reinforcing and maintaining Great Britain's electricity distribution network up to 2050. The DNM runs electricity power flow analyses across its 10 representative regional networks to estimate future distribution network constraints – these are then fed into an investment model that estimates the costs of reinforcing the distribution network at the national level. The DNM's projections of distribution network costs are combined with the DDM's estimates and together provide a complete picture of future costs to the electricity system.[59]

Assumptions

82. Below are the load shifting assumptions that we have used to represent each of our scenarios and test the impact introducing the regulation could have on the electricity system. Specifically, these values represent the proportion of peak residential off-street EV

[56] For further background information on the DDM please see: https://www.gov.uk/government/publications/dynamic-dispatch-model-ddm

[57] These adjustments included; EV demand, split of demand by charging infrastructure and demand shifting to reflect the best available evidence since the publication of the 2019 Reference Cases. All other modelling assumptions are consistent with the 2019 Reference Case

[58] HMG (2019) 'Updated energy and emissions projections: 2019' - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/947439/energy-emissions-projections-2019-annex-o-net-zero-power-sector-scenarios.pdf)

[59] The electricity transmission network consists of ~15,000 km of underground cables and overhead lines. The cost of reinforcing and maintaining these is calculated within the DDM. However, the electricity distribution network is much larger (~800,000 km of underground cables and overhead lines today) and requires the use of a separate model (the DNM) to quantify load related and non-load related distribution network costs for each scenario.

load that is available to shift up to 8 hours between 16:00 – 22:00. Separate assumptions were also constructed to represent load shifting at workplace and depot locations[60].

Table 7 – Load shifting assumptions (Residential off-street charging), rounded to nearest 5%

Scenario	EV Demand available to shift (% of daily peak demand)[61]				Change in available load shifting, relative to the Baseline (1.0)			
	2021	2030	2040	2050	2021	2030	2040	2050
Baseline (1.0)	15%	30%	60%	65%				
Scenario 1 (1.1)	15%	35%	70%	75%	0%	+5%	+10%	+10%
Scenario 2 (1.2)	15%	30%	70%	75%	0%	+0%	+10%	+10%
Scenario 3 (1.3)	15%	40%	70%	75%	0%	+10%	+10%	+10%

83. As illustrated in Table 7 above, the proportion of EV load that is available to shift each year increases over time in all scenarios. This is to reflect the fact that it is expected that over time consumers will have greater access to financial incentives from smart charging as these markets develop (e.g., TOUT or other aggregation services). Recent market behaviour[26] indicates that a signficant proportion of consumers using a 3-pin plug. In this analysis it is assumed that over time the amount of charging that is supplied through a dedicated CP, rather than 3 pin plug increases. The amount of load available to shift never reaches 100% as it is assumed that there is always a proportion of load that is inflexible, accounting for periods whereby charging is required during peak times.

84. In the Baseline (1.0) it is assumed that 87% of CPs have smart functionality. This is held constant over time. To account for signficant levels of uncertainty in this developing market, a secondary Baseline (2.0) has been modelled which varies the underlying level of shifting in the 'do nothing' scenario. The results from using Baseline 2.0 can be found in the 'Sensitivities' section.

85. In all our scenarios it is assumed that 100% of CPs sold and installed in Great Britain have smart functionality. The difference between the assumptions used in each scenario is driven by two impacts associated with the introduction of our regulations:

- The price differential between a smart and non-smart CP falls over time meaning over time a greater proportion of load is supplied through a smart CP rather than a 3-pin plug (an alternative form of charging). As explained in the previous section, we assume that 75% of the demand for non-smart CPs in our Baseline (1.0) is transferred to smart CPs in our Central (1.1) scenario. In our Low (1.2) scenario we

[60]Evidence of demand shifting at workplaces and depots is not widely available. Assumptions have been made in this analysis purely for the purposes of testing the potential impact of introducing our regulation. Going forward, these assumptions will be refined as the implementation of smart charging at workplaces becomes more widespread and further evidence is gathered on consumer charging behaviour (e.g. electricity supplied per charging event) and the practical arrangements (e.g. dwell times of vehicles) of smart charging at workplaces.

[61] It should be noted that assumptions reflect the amount of load that is available to shift during a given time. The amount of load that actually shifts is determined within the model and is dependent on system conditions.

assume 50% is transferred, whilst in the High (1.3) we assumed that all demand is transferred to smart CPs.

- Personalised charging settings increase the amount of load that is available to shift from consumers currently without a financial incentive (e.g., a TOUT). There is no reliable evidence to reference in this area, so a sensitivity approach was taken to test the potential impact. In the Central (1.0) it is assumed that an additional 10% of load from consumers without incentives is available, whilst the Low (1.2) assumes 0% and the 'High' assumes 25%.

86. Abated greenhouse gas emissions are monetised using the existing central carbon value series[62]. The value placed on changes in GHG emissions is currently under review, now the UK has increased its domestic and international ambitions. Accordingly, current central carbon values are likely to undervalue GHG emissions, though the scale of undervaluation is still unclear. The potential impact of placing a higher value on GHG emissions can be illustrated by using the existing high carbon values series, in addition to the prescribed central values. HMG is planning to review the carbon values during 2021.

87. All other assumptions in the model are held constant between our scenarios and it is assumed that the introduction of this regulation has no direct impact on the take up of electric vehicles[63], nor does it have any impact on where EV owners charge their vehicle. These variables are held constant between the baselines and all scenarios.

Results

88. This section presents and explains electricity system modelling results. As mentioned, the model uses demand load curves to allocate daily demand between half-hourly periods. In total, there are 21 sample days with distinct load curves that the model uses to replicate a full year. For illustrative purposes, a business day in winter has been used in the figures throughout this section to aid the explanation of results.

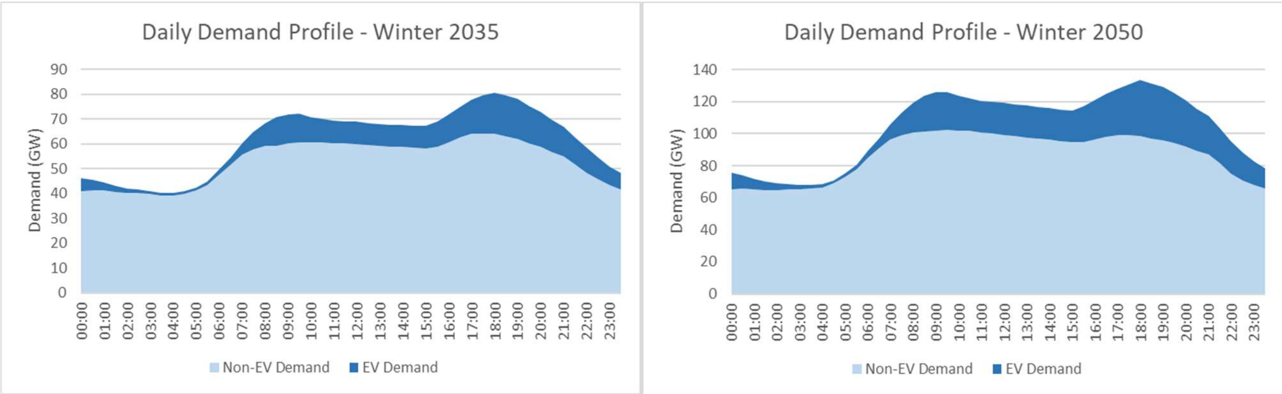
89. Figure 5 below shows half-hourly electricity demand for our sample day, before any demand has been shifted and not accounting for any additional smart charging. This demand profile illustrates that as road transport is electrified over time, EVs represent a greater proportion of overall electricity demand. EV charging makes up between 13% and 15% of all electricity demand in 2035, increasing to 15% to 20% in 2050 – this is based on the lower and higher demand net zero scenarios and low and high EV uptake scenarios. In isolation, it could be expected that demand shifting would therefore have larger impact on reducing the system peak over time. However, this does not account for how the daily demand profile changes; in future years, the roll-out of EVs and heat pumps contribute to increasing demand during the mid / late morning period. This is significant, to a point at

[62] We also tested how applying the central carbon value impact the results of our analysis. A high carbon value led to a modest increase (c£100m) in electricity system benefits at the top end of our range. As the policy intervention reduces power sector emissions in relation to the counterfactual a higher carbon value would increase the benefit of this emissions reduction.

[63] For prospective EV owners with access to off-street parking, this intervention will not increase the total upfront cost of owning an EV because the owner will always have the option of avoiding the cost increase and using a charging cable via a 3-pin plug. For prospective fleet managers we would not expect this intervention to reduce EV uptake as the cost increase is only likely to represent a small proportion of the total cost of electrifying a fleet. We also don't expect this intervention to increase EV uptake because smart CPs are available to buy on the market already.

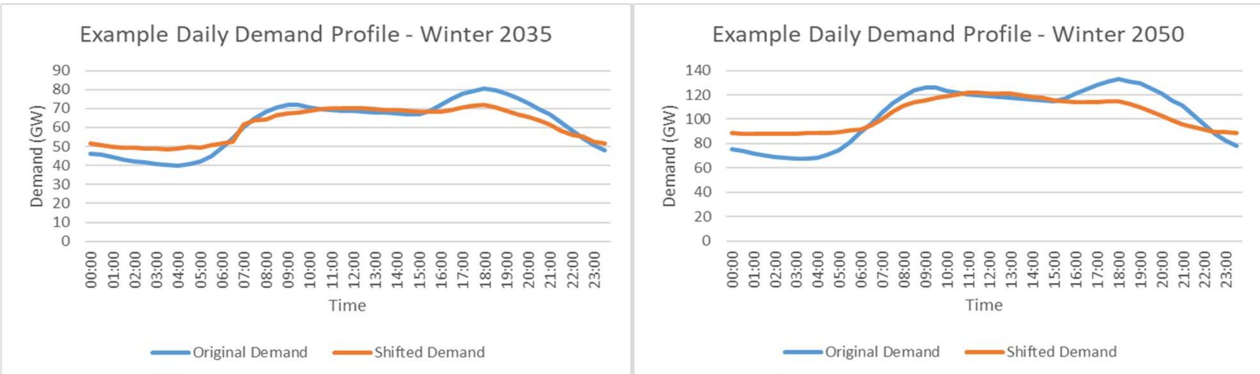
which demand between 09:00 – 11:00 becomes much closer to the overall daily peak – which is typically 18:00. This change in profile limits the extent to which smart charging can reduce overall peak system demand in later years, as the mid/late morning demand profile is already broadly flat and the assumed time period allowed for workplace demand shifting is relatively narrow.[64].

Figure 5: Comparison of half-hourly EV and non-EV demand (pre-shifting) on an example business day in winter 2035 and 2050



90. Figure 6 below compares the demand curves for unshifted and shifted demand in Scenario (1.1) and have been included to illustrate how demand shifting affects the reduction of the overall daily peak over time in a single scenario. This shows that for this given day type, smart charging is estimated to reduce peak demand by 11% in 2035 and 9% in 2050[65]. Figure 6 also shows that once demand shifting has taken place the daily demand curve is broadly flat, with the overall system peak now in the middle of the day. Increasing the amount of demand that can be shifted beyond the levels in Scenario 1.1, such as in Scenario 1.3, will not significantly reduce the new peak in the middle of the day due to the limitations on workplace shifting. This results in some scenarios offering negligible benefits when compared with the baseline.

Figure 6: Half-hourly demand profiles before and after load shifting on an example business day in Winter 2035 and 2050.



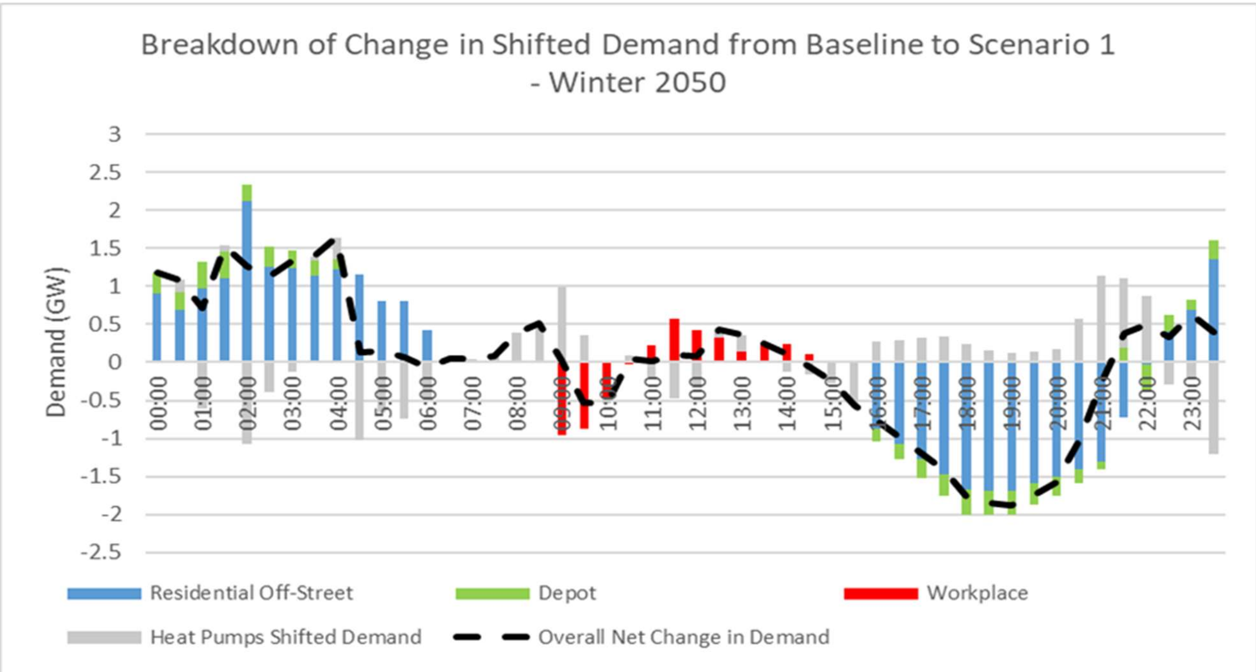
64 Real-world charging data[8] indicates that EV charging demand at workplaces peaks in the morning period (09:00 – 11:00) and falls sharply from 18:00 onwards. Evidence of typical demand shifting at workplaces is not widely available, so assumptions need to be created. If we assume that the majority of EVs plug-in at 09:00 when they arrive at work and plug-out at 18:00 (as per the real-world data), this provides a window of 9 hours during which charging events can occur. Information on the duration of a charging event is then necessary to calculate the extent to which the event can be shifted. For example, if the charging event is expected to last 7 hours the latest the event could start is 11:00 for it to complete by 18:00. Data on the average duration of charging events at workplaces is not available and is dependent on several highly variable factors such as the speed of the charger and the required state of charge. In this modelling we have assumed that workplace charging events that start between 09:00 – 13:00 can be shifted up to 2 hours. This is a narrow window but is ensures that a charging event that would have started at 13:00 now starts at 15:00 providing that user with 3 hours of charge time.

65 This applies to other seasons and other day types, but the relative reduction in the peak varies based on the characteristics of the season or day – for example, lower total demand in summer and less EV workplace demand on non-business days.

91. Figure 7 shows the additional amount of demand that is shifted in our Scenario 1.1 over and above the demand shifted in the Baseline (1.0). The results from the modelling indicate that due to increases in the amount of residential off-street and depot smart charging, more electricity demand is shifted from the evening period to the overnight period relative to the Baseline (1.0)[66]. Despite this, the level of additional demand that is shifted is small relative to the demand that has already been shifted in the Baseline (1.0). As can be seen in the graph, on this example day in 2050 there is an additional 2GW of demand reduction at the 18:00 peak over and above the 17GW of demand reduction in the Baseline (1.0).

92. Similarly, due to more smart charging at workplaces, more demand is also shifted from the mid-morning period (09:00 – 10:00) to the late morning / early afternoon period (11:00 – 14:00)[67] relative to the Baseline (1.0). However, the magnitude of shifting in this period is lower relative to the evening period. As explained above, this is partly due to the narrow shifting window, and because the demand curve over this period (09:00 – 14:00) is broadly flat, additional demand flexibility cannot further flatten the demand curve. In this example only an additional 0.5GW is shifted in Scenario 1.1 over and above the 8GW shifted in the Baseline (1.0).

Figure 7: Half-hourly breakdown of shifted demand by type on an example business day in 2050



93. As part of this modelling a wide variety of demand levels and shifting assumptions were tested to account for the range of uncertainty. The results from our analysis indicates introduction of our regulations will reduce costs to the power system by £300m - £1,100m up to 2050[68], relative to the Baseline (1.0). These benefits will accrue to and are distributed across electricity consumers, producers, and wider society.

66 Figure 7 shows that the shifted demand of Heat Pumps is affected by the increased shifting of EVs. This is due to the DDMs prioritisation order in the shifting algorithm. It is prioritising shifting the additional EV demand, so where more EV demand is shifted, less HP demand is shifted and vice versa.

67 This change is smaller relative to residential off-street charging as the Workplace shifting window is narrower.

68 Net Present Value (NPV), 3.5% discount rate, 2021 prices.

94. In scenarios that offered significant net benefits, the savings are primarily in infrastructure (capital) and generation costs. Where overall peak demand is reduced by a substantial enough margin, less unabated gas and battery capacity is deployed than in the Baseline (1.0). This leads to decreased generation from unabated gas as more generation is met by renewables or interconnectors which reduces overall generation costs. The results also showed a reduction in carbon emissions relative to the baseline, especially during the period up to 2035 when there is more carbon intensive generation on the system. A key finding from the modelling was that when using the assumptions chosen for this analysis, increasing the prevalence of workplace EV charging has a significant impact on the size of the morning peak. In later years (2040 onwards) this limits the amount by which load shifting can reduce the overall daily peak leading to diminishing benefits of increasing shifting over time.

95. The DDM results also showed that some scenarios offered negligible benefits over the appraisal period. In these scenarios, the increase in smart charging capacity above the baseline did not lead to significant system changes, specifically no reduction in overall capacity. The DNM results showed that the benefits on the distribution network can be impacted by small differences between scenarios in the amount of distribution connected gas plant and battery capacity. These small differences can in some cases diminish the network benefits, especially in scenarios where load shifting in the overall daily peak is limited by the prevalence of workplace EV charging in the morning.

Caveats and limitations

96. Below are a list of the key caveats and limitations associated with the electricity system modelling. These caveats reflect the significant uncertainty associated with the power sector modelling; however the broad conclusions taken from this modelling are consistent with other analysis in showing the value of flexibility in the power sector. In reality the magnitude of these benefits will be determined by the extent to which the policy intervention increases the number of smart CPs and consumer change their behaviour. However, it shows that the relatively small increase in smart CPs assumed in the core scenarios provides system benefits that outweigh the costs of the regulation.

- **Financial savings for owners of smart CPs -** A portion of the power system costs will be passed through to electricity consumers, however it is not possible to disaggregate this saving across different users. For owners of smart CPs, smart charging could significantly reduce the cost of charging an EV when combined with a TOUT or another DSR service such as via an energy aggregator. This benefit is included within the modelling above; however as mentioned above it is not possible for us to estimate the benefit that can be attributed specifically to smart CP owners. External studies estimate that smart charging could currently save an EV owner approximately £200[12] on average per year relative to unmanaged charging, however this estimate is likely to be highly sensitive to the assumptions chosen. EV owners may be able to secure extra revenues from offering flexibility services to the grid via an aggregator.

- **Inherent uncertainty around EV assumptions** – A range of scenarios and further sensitivity analysis has been produced to investigate the impact of different levels of EV demand shifting. However, it should be noted that the results included in the Core Analysis are based on one set of EV assumptions: EV uptake, charging preferences and daily load curves. There is significant uncertainty surrounding how these assumptions levels could change in the future as they depend on the provision of infrastructure, charging behaviour and technology improvements.

- **Smart charging behaviour** – In our modelling all smart CP users are treated equally. This means that we have implicitly made the assumption that someone that buys a smart CP directly because of the introduction of our regulations is just as likely to use the smart charging functionality as someone that currently owns one.

- **Modelling of DSR** - In our modelling, DSR minimises the difference between demand and supply (net of intermittent generation). This approach reflects 'implicit DSR' – consumers changing behaviour in response to prices but not actively participating in markets (i.e., ancillary services or balancing). When modelling demand shifting due to DSR, the DDM uses unshifted demand levels as a proxy for price. The DDM cannot know the price of electricity for an upcoming day before it begins the process of shifting demand. Demand is a good proxy for price, but the two are not perfectly correlated, so demand shifting may vary slightly in reality.

- **Net Zero references cases are two illustrative scenarios** - Our electricity system modelling is based on two illustrative net zero scenarios – other scenarios, with potentially materially different power sector demands and carbon emissions are possible.

- **DDM modelling includes a simplified representation of wholesale and balancing markets and is sensitive to small changes in underlying assumptions** - We recognise that the simplified representation may not reflect all business models for flexibility technologies that could exist in the future, including where a single provider may offer multiple services such as constraint management and frequency response.

- **The results from our DNM modelling can be sensitive to small changes in the underlying assumptions**, in particular, the distribution of EV loads across the model's representative feeder types at the Low Voltage level. Our assumptions are in line with the best evidence available to us, however there is inherent uncertainty over future location of EV CPs.

- **The benefits of this intervention are contingent on several pre-conditions which are assumed to materialise in all scenarios -** This includes the completion of the smart meter roll out and introduction of market wide half-hourly settlement.

Unmonetised Benefits

97. As identified in Table 3, there are several additional benefits associated with the introduction of these regulations that we have been unable to monetise and therefore include in the final NPV calculation. This section describes each of these impacts in turn.

- **Cyber benefits** – Strengthening cyber security and data security could increase consumer confidence in the technology (as discussed in the unmonetised costs section). In addition, improved cyber security of CPs can reduce the risk of a cyber-attack on a CP, and reduce the risk of widespread impacts from an attack on the energy system and wider economy. However, it should be noted that this 2021 legislation sets basic cyber requirements only. Further requirements are needed in a future phase of legislation to mitigate cyber security risks posed by smart charging.

- **Grid stability benefits** – Most of the benefits of grid stability are expected to come from two requirements: randomised delay function, and CPs being capable of providing “request” DSR services. Randomised delay function is a device level requirement that delays a CP from charging for a random time between 0 and 10 minutes from the time it is set to charge. This means that when multiple CPs receive the same signal to start charging (e.g. at the beginning of a low price tariff window) they do not all start drawing power from the grid at once and cause a surge. In addition, given it will be mandated that a CP must be capable of providing DSR services, e.g. via an energy aggregator, who is providing a service to a DNO, charging could be modulated or shifted to help maintain grid stability. We have not monetised these benefits - our modelling is designed for large scale changes and cannot pick up small effects such as CPs shifting their charging by a few minutes. Additionally, we cannot model “request” DSR mode charging. This is because it is done in response to one off or unpredictable events and whilst the legislation will embed DSR capability in CPs, it will be a consumer choice as to whether they use such services. This means that the benefits that our regulations may have by increasing grid stability are not monetised.

- **Export opportunities** – This is explained in the Wider Impacts section

- **Enhanced consumer charging experience -** Evidence gathered from the CVEI - Consumer Charging Trials Report[69] found that overall perceptions of smart charging were generally positive or neutral with the vast majority of participants reported being either very satisfied, satisfied or neither satisfied nor unsatisfied. When given the choice between smart and non-smart charging, over 85% of participants across the trials indicated that smart charging would be there preferred choice in the future. It is difficult to disentangle the main reason for this, but in addition to the financial benefits it is expected that this could be driven by the increased control and personalisation of charging arrangements.

Business Impact Target Calculations

Societal Cost / Benefit Summary

69 CVEI (2019): *Consumer Charging Trials Report: Mainstream consumers’ attitudes and behaviours under Managed Charging schemes for BEVs and PHEVs.* 127 ‘mainstream consumers’ were recruited and provided with an EV for 8 weeks over a summer and winter period. The trials measured charging behaviours under two forms of smart charging (user and supplier managed), and compared with charging behaviours when not participating in an smart charging scheme. It also measured preferences among mainstream consumers for various charging schemes after experience of smart charging in the trial.

98. Table 8 below presents the total costs and benefits to society for each of our scenarios, relative to our Baseline (1.0). All impacts are in 2021 prices and discounted at the social rate of time preference (3.5%) in accordance with HMG Appraisal Guidance[70].

99. The results from this analysis indicate that the wider electricity system benefits from the introduction of our regulations more than offset the increased manufacturing costs leading to a positive NPV in all scenarios. **To summarize, this analysis estimates that the introduction of our regulation could benefit society by £0m - £1,100m up to 2050.**

Table 8 – Societal Cost / Benefit Summary, (Millions, 2021 prices, 2021 base year, costs rounded to nearest £10m, benefits rounded to nearest £100m)

	Low	**High**
Costs (discounted)		
Total Costs	-£10	£260
Benefits (discounted)		
Total Benefits	£300	£1,100
Summary		
Net Present Value[71]	£0	£1,100

Direct Cost / Benefit to Business Summary

100. Whilst the NPV to society is positive, the net present value to business is negative. In reality, we expect businesses will be able to pass through many of the costs they incur to consumers, thereby recovering some of the benefits gained. In a competitive market, we'd expect the amount of cost recovered to be dependent on the price elasticity of demand.

101. However, under Business Impact Target (BIT).accounting rules governed by the Better Regulation Framework, where a regulation increases the cost of production (shifting the supply curve upwards), we must consider this cost as being entirely on the business in order to capture the regulatory burden in the Business Impact Target. These Business Impact Target accounting rules also require specification of whether the costs and benefits to business as "direct" or "indirect". Costs and benefits are likely to be direct where they are an immediate and unavoidable consequence of the regulation. As such, for the purposes of Business Impact Target accounting, we have considered all familiarisation costs and increased manufacturing (ongoing and one-off) costs as **direct** cost to business. There are benefits that are likely to accrue to electricity consumers (including businesses), however these are indirect and not accounted for in the BIT.

[70] HMG (2020) 'Green Book: Appraisal and Evaluation in Central Government' - https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

[71] The 'Low NPV' is calculated by subtracting the 'High' cost from the 'Low' benefit and vice-versa.

Sensitivity Analysis

102. The analysis included in this IA has relied upon several assumptions in order to quantify and monetise the impact of the introduction of our regulations. Within the Core Analysis a set of scenarios were constructed to account for uncertainty associated with some of our key assumptions such as the impact an increase in CP price will have on demand and the impact personalised charging settings will have on the amount of smart charging behaviour. The assumptions chosen to reflect the best evidence currently available to us, however, due to data limitations and inherent uncertainty over the future development of the market and consumer behaviour the final results should be treated with caution.

103. This section estimates the impact on our results of varying further key assumptions. These assumptions have been chosen as they are highly uncertain and would likely have a significant impact on the results. The results are explained below.

Sensitivity 1 - A proportion of the market already manufacture smart CPs and therefore do not incur the full cost of compliance.

104. In our Core Analysis it is assumed that all CP manufacturers incur the full cost of complying with all requirements in our regulations. In practice, the impact our regulations will have on CP manufacturers will depend on the extent to which their products already meet our requirements. For a manufacturer that does not currently sell any smart CPs, adding hardware to a CP unit to enable smart functionality could increase the unit cost by £40, whilst an additional £300k may also be incurred in development costs. For a manufacturer that already produces smart CPs, it’s likely that the majority of these costs could be avoided as adjustments to existing smart technology may only be required.

105. This sensitivity tests the impact on our results if we assume that a proportion of the market already produce smart CPs and therefore avoid the cost of adding smart functionality to their products. Two key assumptions are used:

- **The one-off cost of compliance for a manufacturer that does not currently manufacturer smart CPs:** £550k – £870k. This includes the full cost of upgrading a CP to comply with all requirements in our regulations.

- **The one-off cost of compliance for a manufacturer that does currently manufacturer smart CPs:** £250k - £570k. This does not capture the cost of adding smart functionality, which are assumed to have already been incurred by these manufacturers.

106. The results from this sensitivity test show that if 75% of manufacturers already produced smart CPs and didn’t face the full cost of compliance, this could reduce the total cost to business from £100m-£210m in our Central (1.1) scenario to £80m-£190m, relative to the Baseline (1.0).

Sensitivity 2 – Adjustments to the ‘learning rate’.

107. In our Core Analysis it is assumed that the additional cost of a smart CP falls by 51% for every doubling of cumulative demand. If this cost reduction was slower, then costs would be increased overall as each smart CP would cost more to produce. Here we have tested a learning rate of 15%, meaning that the unit cost of a smart CP decreases by 15% for every doubling of cumulative production[22]. this could increase the total cost to business from £100m-£210m in our Central (1.1) scenario to £150m-£260m, relative to the Baseline (1.0).

108. We have also tested the impact on our results if the cost of a non-smart CP also falls. This analysis shows that if the cost components of a non-smart CP fall by 30% with every doubling of production[72] this could increase the total cost to business from £110m-£250m in our Central (1.1) scenario to £150m-£260m, relative to the Baseline (1.0)[73].

Table 9 – Summary of cost sensitivities (£m, NPV[74], rounded to the nearest 10m)

Sensitivity	Description	Scenario	Change in total costs relative to Baseline 1.0 (cumulative up to 2050, £m)	Change in total costs relative to Core Analysis - Central 1.1 (cumulative up to 2050, £m)
0	Core Analysis (pg. 28)	Central (1.1)	£100 - £210	
1	25/100 (25%) manufacturers currently produce smart CPs		£90 - £200	Up to -£10m (-10%)
	50/100 (50%) manufacturers currently produce smart CPs		£80 - £190	Up to -£20m (-20%)
	75/100 (75%) manufacturers currently produce smart CPs		£80 - £190	Up to -£20m (-20%)
2	'Smart' learning rate reduced to 15% (non-smart learning rate held at 0%)		£150 - £260	Up to +£50m (+50%)
3	'Non-smart' learning rate increased to 30% (smart learning rate held at 51%)		£150 - £260	Up to +£50m (+50%)

<u>Sensitivity 3 - Smart CPs represent a smaller proportion of total sales in the baseline</u>

109. In our Core Analysis it is assumed that smart CPs represent 87% of total CP sales. Given the uncertainty in this area, this sensitivity estimates the introduction of our regulation if only 69% of private CPs sold in Great Britain currently have smart functionality[75] (Baseline 2.0).

110. The impact on infrastructure installed is significant. In 2035, for example, smart CP sales increase from 1.8m to 2.6m from 2.0 to 2.1 compared with 2.2m to 2.6m from 1.0 to 1.1.

[72] This learning rate is a proxy that is used in the following analyses: HMG (2018): *Proposed primary regulation of smart appliances: consultation stage impact assessment* - https://www.gov.uk/government/consultations/proposals-regarding-setting-standards-for-smart-appliances and Energy Systems Catapult (2019) – Vehicle-to-Grid GB: Decarbonising Britain - https://es.catapult.org.uk/case-studies/vehicle-to-grid britain/#:~:text=V2GB%20%E2%80%93%20Vehicle%20to%20Grid%20Britain,and%20a%20smart%20energy%20system

[73] We have kept the learning rate for smart components at 51% in line with the core analysis. A 30% learning rate is an average of other white appliances from: Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy (2011): Using the Experience Curve Approach for Appliance Price Forecasting - https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/experience_curve_appliance_price_forecasting_3-16-11.pdf

[74] Discounted, 2021 prices (real)

[75] This is based on the lower bound of the confidence interval from the Delta-EE study – 'Who is the EV owner and how do they charge?

As illustrated in Table 10 below, the total cost of our intervention has decreased, and the benefits have increased relative to the results from the Core Analysis which utilises Baseline 1.0. The cost decrease can be explained by the larger number of people who now switch to cables which represents a larger avoided cost for manufacturers from not producing these CPs. Benefits have increased because there are less smart CPs in Baseline 2.0, and therefore there is a bigger comparative increase in smart charging. It should be noted that it is the comparative benefit that has increased; overall benefits to the system will be the same.

Table 10 – Summary of sensitivity analysis using Baseline 2.0 (£m, costs rounded to nearest £10m, benefits and NPV to the nearest 100m)

	Low	**High**
Costs (discounted)		
Total Costs	£20	£130
Benefits (discounted)		
Total Benefits	£1,300	£1,900
Summary		
Net Present Value	£1,100	£1,900

3. Risks and unintended consequences

111. There are several potential policy risks that have been considered in relation to the legislation. These include:

- **Efficacy and enforcement**: ensuring requirements are enforceable has been a key consideration for Government when determining the policy approach for this legislation. If requirements are hard to enforce, the level of compliance within industry would be difficult to determine. Government is likely to appoint OPSS as the Enforcement Authority for EV smart CPs, subject to final agreement. OPSS is an established regulator of products and has a breadth of enforcement experience and technical expertise, including in relation to public charging infrastructure for EVs. We have worked closely OPSS, to include appropriate enforcement powers within the legislation and to ensure the requirements can be enforced against.

- **Innovation** – since Government consulted in 2019 the smart charging market has developed significantly, yet it is still in a nascent stage. Regulating a market at this early stage could reduce the number of innovative smart charging offers and solutions developed. We are therefore mandating a minimum set of requirements in 2021 that will support the market by driving the uptake of smart charging offers amongst EV drivers. Since consulting we have also reassessed the evidence for mandating specific solutions to address potential smart charging risks. Our revised approach will not be mandating requirements for all objectives in 2021, to help ensure the legislation encourages rather than hampers future innovation.

- **Installation** – the legislation will apply to the sale of CPs only and will not place any obligations on CPs installed in Great Britain. Theoretically EV drivers could purchase non-smart CPs from overseas, and import them into Great Britain for installation, if they did not want a CPs with smart functionality. However, the expected impact of this on smart charging uptake is low, given the added complexity this would present to a consumer. The legislation also mandates that the consumer must be able to override or turn-off smart related functionality, so whilst CPs will be capable of smart charging, it will be a consumer choice as to whether they charge in a smart way and utilise this functionality.

112. The main unintended consequence that has been discussed in this IA is the potential impact that the introduction of our regulations could have on the demand for CPs. In our modelling we have tested a number of different scenarios that account for consumers that seek alternative forms of charging (e.g., using a charging cable connected to a 3 pin-plug) in light of a rise in the price of a CP.

113. Overall, we determine the likelihood and impact of the risks as being low, given the mitigations that have been described above. With regards to uncertainties, the extent to which consumers modify their behaviour is key to delivering the benefits of these regulations, and further work is underway within Government outside of this legislation to encourage consumers to make these changes. For example, the Government is helping drive the uptake of smart charging offers by taking steps to ensure that consumers are informed and have confidence in the smart charging market.

4. Wider impacts

Innovation Test

114. The smart charging market is nascent and at an early stage of development. The rate of innovation within the market is high, with new smart charging offers and services being marketed by energy suppliers and other organisations.

115. Many energy suppliers are already offering a range of tariffs specifically targeted at EVs, including smart tariffs. In the future, we expect to see a shift towards smart offers being more widely available as the incentives for smart charging and uptake of EVs increases. This regulation provides increased certainty to the market on how CPs will be regulation. It is possible that increased certainty could support innovation, if market participants were hesitant to develop their products when the direction of regulation was uncertain.

116. Maintaining the high-level of innovation within the market is a key objective for smart charging policy within Government. We have considered the impact of the legislation to ensure it does not stifle innovation, yet critically still provides appropriate levels of protection to both the energy system and consumers from smart charging.

117. The legislation specifies the minimum requirements needed to deliver appropriate protections, whilst avoiding being overly prescriptive about how CP sellers must deliver the approach. The legislation will also be kept under review, and it is anticipated changes may need to be made in the future to keep pace with future innovations in the market.

118. We have worked closely with industry and consumer groups to ensure we develop an approach which helps shape the future market and maintain the UK's leadership on smart energy, while leaving space for innovation. This includes consideration of impacts on SaMBs and trade, as outlined in the below sections of the impact assessment.

Small and Micro Business Assessment

119. This section identifies the anticipated impact of any policy intervention on small and micro businesses (SaMBs). The scale of the impact is assessed, along with the assumptions used to establish the impact before possible measures to mitigate these costs are discussed.

Consideration of CP manufacturers (SaMBs)

120. It is estimated that there are currently between 90 – 100 manufacturers with a retail presence in Great Britain for workplace/domestic suitable EV CPs. Between 25 – 30% of these companies are registered in Great Britain and between 15 – 20% of the market are classified as SaMBs (less than 50 full time employees).

121. As described in the 'Costs' section, the impact our regulations will have on CP manufacturers will depend on the extent to which their products already meet our requirements. For a manufacturer that does not currently sell any smart CPs, adding hardware to a CP unit to enable smart functionality could increase the unit cost by £40, whilst an additional £300k per business may also be incurred in development costs. Smart CPs are currently £100 - £400 more expensive that a like-for-like non-smart model which indicates that the cost associated with adding smart functionality is passed through to consumers. For these businesses updating their products to meet the requirements could open up new opportunities. It would bring SaMBs into the scope of grant schemes, such as the EVHS, this could benefit a SaMB by increasing demand for their products.

122. For a manufacturer that already produces smart CPs, it's likely that the majority of these costs could be avoided as adjustments to existing smart technology may only be required. However, there are several additional costs that are incurred related to meeting the remaining requirements in our regulations. The impact these costs will have on final unit costs will differ by manufacturer according to their sales volumes. Feedback from industry indicated that these costs are not likely to increase the price of a current smart CP.

123. Detailed data is not available on the extent to which the 20 SaMBs operating in the market meet the requirements in our regulations. As such we have taken a scenario-based approach to understand the cost implications. The table below presents the cost to SaMBs which has been estimated by multiplying the number of SAMBs by the cost of complying with the regulation. As per the 'Sensitivities' section we have assumed that the one-off cost

of compliance for a manufacturer that does not currently manufacture smart CPs is £550k - £870k, whilst the cost to a manufacturer that does produce smart CPs is £250k - £580k.

Table 11 - Total cost to SaMBs (£m, rounded to nearest 5m[76])

Number of SaMBs assumed to currently produce smart CPs (% of all SaMBs)	One-off (2023)		Including ongoing (up to 2050)	
	Low	High	Low	High
15/20 (75%)	+5	+10	+25	+50
10/20 (50%)	+5	+15	+25	+50
5/20 (25%)	+10	+15	+30	+50

124. The table above indicates that the introduction of our regulations could impose an upfront cost to SaMBs of between £5 - £15m on aggregate, relative to the Baseline (1.0). This range is based on the proportion of SaMBs that are assumed to already produce smart CPs. As indicated by the cost assumptions above, the more SaMBs in the market already producing smart CPs, the lower the total cost. There are also ongoing costs that would need to be factored in. Our analysis shows us that if the ongoing costs are incurred annually this could impose a total cost to SaMBs of £25 - £50m up to 2050. This figure is highly sensitive to the appraisal period chosen.

125. We expect that SaMBs will be able recover the ongoing costs by passing on the increased cost of smart CPs to customers, therefore this is unlikely to create a disproportionate burden to smaller businesses. The one-off compliance costs are likely to result a higher burden for SaMBs than to large businesses as these costs may require specific skills (e.g. legal costs) and the cost will make up a larger proportion of their cost base. However, we do not have any evidence to suggest that SaMBs are less likely than large businesses to produce smart CPs, and we expect the one-off cost for those business already manufacturing smart CPs to be lower.

Mitigations considered

126. The recommended policy option will apply to small and large CP manufacturers in the same way, as these are market wide product regulations. Exempting small and micro businesses could potentially distort the market and undermine the intention of the policy. Additionally, many of the policy objectives, such as grid stability and cyber security require adoption by the entire market in order to receive the expected benefits.

127. Below is a list of mitigations that have been considered for SaMBs:

- **Full exemption** – to ensure the successful deployment of smart chargepoints and effective mitigation of risks such as cyber security, a consistent market wide approach is needed and therefore an exemption for SaMBs is not viable.

[76] Discounted , 2021 prices

- **Partial/temporary exemption** – the requirements in these regulations are deemed "minimal" and therefore partial exemption would means policy objectives are not met. A "softer" enforcement approach for SaMBs has also been considered. The overall regulatory approach taken is already tailored to business size through provisions for the regulator to issue warnings ahead of penalties, and the ability for the size of the penalty to be adjusted by the regulator taking size of business into account.

- **Extended transition period –** the transition period set out in the regulations has already considered the time needed for businesses to comply with each requirement and therefore takes a staggered approach, allowing 6 months for some requirements and 12 months for others. Whilst large businesses may be able to comply quicker than SaMBs, the transition period has been designed to allow sufficient time for all businesses to comply.

- **Direct financial aid** - given the expected minimal additional costs, it is our view that this would be disproportionate to initially consider, as other methods would be more appropriate at targeting any additional costs.

- **Opt-in and voluntary solutions** – the table in the Annex considers voluntary compliance and a grant scheme as alternative policies to regulation, however, to ensure Government achieves the uptake of smart charging technology needed for the transition to EVs and to ensure risks such as cyber security are mitigated, market-wide compliance is necessary.

128. As discussed, the cost of our regulations will apply across all CP manufacturers, however the magnitude will differ depending on the extent to which they already meet the standards. SaMBs have been engaged throughout the development of these regulations and as a result of the feedback received, these regulations are taking a staggered approach to compliance where some parts of the regulations will allow 6 months and some 12 months, depending on how long businesses need to be ready to comply with different requirements. Due to the relatively large proportion of SaMBa manufacturers (15-20%), applying mitigations could result in a large proportion of potential products not being compliant with the regulations and would not meet the policy objectives. We will continue to work with the chosen regulator to ensure that enforcement and compliance guidance is also appropriate for all SaMBs.

<u>Consideration for Small and Micro businesses (consumers)</u>

129. Feedback from CP manufacturers indicated that the introduction of these regulations will not significantly increase the price of an existing smart CP. However, given the current price differential between a smart and non-smart CP, removing non-smart CPs from the market via the introduction of our regulations could directly increase the upfront cost to a business looking to provide charging infrastructure for their employees (e.g., workplace) or electrify their vehicle fleet. As mentioned previously, an EV owner could avoid this additional cost by choosing alternative forms of charging (e.g. 3 pin plug or public infrastructure) however, this may be less attractive or suitable to a business.

130. It is uncertain how an increase in CP price could impact the purchasing decisions of SMEs who are likely to be cost sensitive and driven by short term benefits. However, there is no concrete evidence to indicate that SaMBs have ever shown a preference towards non-smart CPs for cost reasons or otherwise. Our conclusion is that we would not expect the introduction of our regulations to significantly increase the cost of electrifying fleets or providing CPs. This is due to the following reasons:

- The cost of adding smart charging is relatively low when compared with the additional vehicle and infrastructure costs. It is estimated that the cost associated with wiring and installing a single CP could range from approximately £600 - £3,860, depending on the building type. This excludes the cost associated with acquiring a network connection which could cost an additional £1,300 - £3,000[39,77]. Additional network capacity which can be very costly, and the cost of larger future-proofed upgrades can run into many millions. As explained in the 'Costs' section we also expect the price differential to fall over time which could benefit those transitioning later.

- Despite greater upfront unit costs, smart charging can offer financial savings relative to non-smart charging. In particular, reducing peak demand could reduce the size of network connection required, and by shifting demand to off-peak times in combination with a TOUT consumers could benefit from lower electricity costs. There are also additional benefits that could accrue in the future from providing contracted demand side response. Over time, we expect knowledge of these cost savings to increase.

Trade Impact

131. There are approximately 90-100 CP manufacturers that have a retail presence in the UK, of which 25% - 30% are registered in the UK[9]. Under the EVHS CP installs are dominated by three main suppliers, the rest of the market is made up of many manufacturers that vary from eMobility specialists, electrical OEMs[78] and automotive OEMs. Detailed data on the location of manufacturing facilities and the trade of CPs is not widely available. Without information on where CPs are manufactured and what models are traded makes accurately assessing the impact on trade difficult.

132. According to external data[9] two of the three largest CP manufacturers active in the UK market operate internationally. It is uncertain what proportion of the remaining manufacturers export CPs globally. Given the variety of organisations active in the UK, there is likely to be a mix of global and domestic players.

133. As a result of our intervention, CPs that do not comply with our regulations can no longer be sold or installed across Great Britain. This could have implications for organisations that currently export CPs to the Great Britain that do not comply with our regulations. External data suggests that upwards of 50% of the top 20 CP manufacturers import CPs to Great Britain[17] but given the low cost associated with upgrading a CP to meet our standards we would not expect the introduction of our regulations to significantly alter UK imports. It is

[77] These costs consider the cost associated with retrofitting CPs to different building types, including; off-street private, multioccupancy surface, multioccupancy underground and multioccupancy multi-storey. This evidence is used in HMG (2019): Impact assessment: residential charging infrastructure provision - https://www.gov.uk/government/consultations/electric-vehicle-chargepoints-in-residential-and-non-residential-buildings

[78] Original equipment manufacturer

also the case that smart requirements are already set out under the EVHS grants, so the impact of the legislation is likely to be small given the direction of travel is already set toward smart charging overall.

134. With regards to UK exports, the new regulations do not preclude the sale of non-smart CPs to foreign markets. This means that a UK-based manufacturer that currently sells CPs internationally may not be adversely affected by these regulations even if they do not comply with Great Britain based regulations. However, without a domestic market to sell to this would become a less profitable endeavour for these manufacturers. Larger CP manufacturers who already produce smart CPs as well as non-smart would be expected to absorb any increase in the average cost of manufacturing a charger, as this would likely be offset by future increases in demand.

135. In terms of future trade, introducing a minimum requirement for EV CPs places the UK as a global leader in smart charging. While it is assumed many existing UK-based manufacturers operate internationally, it is expected that UK companies could further benefit from being "first movers" in this space by enhancing their competitive advantage, and that as the rest of the world progress with their respective EV rollouts these companies can benefit from increased overseas demand for their CPs.

136. In summary, we would expect that raising the minimum technical specifications for CPs installed in Great Britain may have consequences for CP manufacturers who import CPs to Great Britain as they must now ensure they adhere to the new regulations. However, given that smart charging is expected to become the international standard and the costs of upgrading to smart from non-smart are relatively small we would not expect this to lead to significant implications for the value or volume of imports rather it would potentially represent a future export opportunity for UK based CP manufacturers as, internationally, the rollout of EVs gathers pace.

5. Post implementation review

1. **Review status:** Please classify with an ‘x’ and provide any explanations below.

	Sunset clause		Other review clause		Political commitment	X	Other reason		No plan to review

Regulations to be reviewed at least every five years to ensure continued suitability. In the short term, it is likely a review will be necessary ahead of the five-year standard review cycle. This is to ensure the legislation remains aligned with the Phase Two intervention planned to be implemented ahead of 2025. Specific requirements including the default charging mode will also be kept under review, to determine if market conditions still necessitate their inclusion.

2. **Expected review date** (month and year, xx/xx):

0	4	/	2	7	Five years from when the Regulations come into force

3. **Rationale for PIR approach:**

Circle the level of evidence and resourcing that will be adopted for this PIR (see Guidance for Conducting PIRs):

Describe the rationale for the evidence that will be sought and the level of resources that will be used to collect it.

- **Will the level of evidence and resourcing be low, medium or high? (See Guidance for Conducting PIRs)**
- **What forms of monitoring data will be collected?**
    - This can be found in the monitoring and evaluation plan below.
- **What evaluation approaches will be used? (e.g. impact, process, economic)**
    - This can be found in the monitoring and evaluation plan below.
- **How will stakeholder views be collected? (e.g. feedback mechanisms, consultations, research)**
    - This can be found in the monitoring and evaluation plan below.

Rationale for not conducting a PIR:

Describe the rationale for why a PIR will not be conducted and why this is deemed to be the suitable route to follow.

Outline of policy requirements and rationale (theory of change)

The Government's aim is to maximise the use of smart charging technologies, to benefit both consumers and the electricity system, whilst supporting the transition to EVs.

To meet this aim we believe we need to encourage consumer uptake of CPs that have smart functionality and provide appropriate protection for consumers and the grid by meeting the following principles:

- **Safety and Data privacy –** CPs should have data and safety controls beyond the standard framework, if smart functionality presents specific new risks.
- **Interoperability** – interoperability is essential for a competitive electricity market - a smart CP should not unfairly disadvantage those consumers switching between energy suppliers. As the CP and EV market evolves, we will need to ensure that consumers are not excluded from accessing alternative smart charging services or tariffs.
- **Cyber and data security** – CPs must include robust cyber security measures to mitigate the risk that EV smart charging presents to the stability of the grid, in addition to protecting individual consumers.
- **Grid stability** – CPs should have controls to prevent of outages on the grid caused by erroneous operation of ESA

The following device level standards will be mandated in order to contribute towards the above objectives. From the enforcement date, all new private EV CPs sold or installed in Great Britain must be smart and meet device level standards. In order to comply, all CPs must meet the following operational requirements and standards.

Summary of requirement	Theory of change: how do we envisage the requirement will help achieve our objectives?
Smart functionality A CP has smart functionality if it is able to send and receive information and respond to messages by increasing or decreasing the rate of electricity flowing through the CP and changing the time at which electricity flows through the CP.	This requirement contributes towards the objective of maximising the use of smart charging. All private CPs will have to have this capability, whereas currently not all do.
Personalised default settings Government will mandate that, during setup, chargepoints must require EV drivers to set charging preferences and schedules. In addition, these schedules must be pre-set to not charge at peak times.	This requirement contributes towards the objective of maximising charging during off peak periods.
Interoperability Government will require that chargepoints must not be designed so as to prevent compatibility with any energy supplier.	The requirement will help mitigate the risk that the user's choice of smart chargepoint means they are unable to switch energy supplier without purchasing a new device or losing smart functionality.
Cyber/physical security and data privacy A CP must have appropriate security measures to ensure that its functions are resilient to cyber-attack. Where relevant, requirements in line with the ETSI EN 303 645 standard will be mandated to achieve this. Furthermore, a CP must be designed and manufactured to provide an adequate level of protection against physical damage to the charge point.	This requirement contributes towards the objective of cyber security and data privacy.
Randomised delay function A private CP must be configured to randomly delay how quickly it responds to an external signal, adjusting the rate of electricity flowing through it, with a delay of up to 10 minutes; and permit the user of the chargepoint to override the random delay, in certain charging scenarios.	This requirement contributes towards the objective of grid stability. If many consumers have similar incentives to smart charge (for example a time of use electricity tariff that offers cheaper rates after 12am) then there could be a sudden spikes in power draw from the grid at these times. The randomised delay function proposes to partially address this by staggering the response across CPs.
Monitoring and metering of energy consumption The chargepoint must measure or calculate the electricity consumed	This requirement contributes towards the objective of maximising the use of smart charging: it will make it more convenient for the consumer to view information related to their charging electricity usage.

and/or exported, the time the charging event lasts, and provide a method for the consumer to view this information.	
Safety Government will mandate that chargepoints should operate in way that prioritises chargepoint safety over smart charging behaviour.	This is a first step towards mitigating any potential smart related safety risks to consumers that may occur from including smart functionality within chargepoints.

Scheme monitoring: Monitoring metrics will be developed in order to assess the overall scheme's progress and feed into evaluation activity. Some monitoring activity is already being undertaken for the purposes of the EVHS (Electric Vehicle Homecharge Scheme), but new data sources will need to be established.

Metrics may include but not be limited to:

- The number of licensed EVs,
- Sales/uptake of CPs vs cables (the standard non-smart charging cables that come with an EV),
- Prices of CPs (and cables) and how they change over time,
- Uptake of time of use tariffs or other smart charging incentives,
- Smart charging behaviour (the proportion of load that consumers charge in smart charging mode),
- Consumer awareness of/attitudes towards EVs and smart charging,
- Consumer awareness of/ attitudes towards personalised default settings,
- Data on grid stability and any issues faced by system operators, charging aggregators etc. relating to EV charging,
- Data on cyber security, any evidence of security breaches,

Other factors which may not have easily defined metrics but which still need to be monitored may include but not be limited to:

- Rollout of smart meters and half hourly settlement (these could affect the availability of smart charging incentives),
- Changes to the EVHS grant
- Development of the flexibility services market and incentives to smart charge by CPOs

Evaluation: Process and impact evaluations will be used to assess the programme's delivery and effectiveness and expand on the Impacts Map (annexed).

These evaluations will consider several high-level evaluation questions:

Process evaluation

- How effective and efficient has the rollout of the regulations been? Have there been any issues for different stakeholder groups? (CP manufacturers, CP installers, charging aggregators, system operators, end consumers)
- What parts of the regulations work/don't work and why?
- Are the current mechanisms appropriate to meet the longer-term objectives?
- What can we learn from the initial rollout to inform Phase 2 and wider EV policy?

Impact/economic evaluation

- What has been the impact of the regulations? How did they affect different stakeholder groups? (CP manufacturers, CP installers, charging aggregators, system operators, end consumers)
- To what extent have the regulations increased smart Charging behaviour?
- How effective were measures on cyber security and grid stability?
- What were the impacts on sales / uptake of smart CPs?
- What are the implications of the findings for the future of EVs and smart charging in the UK?

An interim process evaluation soon after rollout will examine whether the regulations are being delivered as intended, predominantly through the collection and analysis of qualitative evidence (e.g., interviews with CP manufacturers and users of compliant smart CPs). Findings from this interim evaluation will be used to inform smart charging policymaking, and to inform further evaluation of these regulations and any adjustments that may be made to them as a result.

A separate impact evaluation in 2024/5 will assess whether the programme has achieved its intended outcomes. The evaluation will provide learnings to inform the Phase 2 legislation, which is expected to be implemented by 2025.

The regulations may need to be adjusted in line with Phase 2 legislation.

Given the large number of external factors which could affect smart charging behaviour, it is likely that multiple factors will have to be looked at in context to assess to what extent these device level regulations have contributed to smart charging behaviour. At a minimum, the evaluation will provide a qualitative indication of:

1. The amount of smart charging behaviour enabled by the regulations (including the effect of personalised default settings).
2. The level of cyber security and grid stability enabled by the regulations.

These will be evaluated through stakeholder interviews if the multiple factors prove difficult to quantify.

Economic evaluation could also be used to assess the regulations’ value for money. At a minimum we would aim to understand what the costs are to consumers and industry and whether they are significantly different to what was expected.

6. Annex

1. **Options appraisal**

2. **Assumptions log**

3. **Rounding**

Options appraisal vs policy objectives

	Option 0 – Do Nothing (the counterfactual)	Option 1 – Mandatory standards for all new private CPs sold or installed in Great Britain covering smart requirements, cyber security and grid stability (the preferred option)	Option 2 – Mandatory standards for all new private CPs sold or installed in Great Britain covering smart requirements, cyber security, grid stability, data security and interoperability.	Option 3 – Voluntary standards for all new private CPs sold or installed in Great Britain covering smart requirements, cyber security, grid stability, data security and interoperability.	Option 4 – Government chargepoint grants include smart requirements, covering cyber security, grid stability, data security and interoperability
Maximise the use of smart charging technologies	Non-smart CP models continue to be sold and installed by consumers in Great Britain. As such, smart CP uptake is sub-optimal, reducing the level of potential flexibility on the system. Use of smart CPs to shift charging load is solely reliant upon the development of other markets, including; half-hourly settlement, development of TOUTs, smart meter roll-out etc.	Choice of purchasing non-smart CPs is removed from consumers. Mandating smart technology in CPs will ensure that all new CPs sold in Great Britain from spring 2022 have **smart functionality,** increasing the amount of flexible assets on the system. By the late 2020s, all CPs installed will have smart functionality. Use of smart CPs is reliant upon the development of other markets, including; half-hourly settlement, and market provision and uptake of smart charging offers. However, **default charging settings** will encourage consumers to charge at off peak times.	Same outcome as Option 1. However, default off peak charging settings would be implemented per the consultation proposal, with no requirement for them to be confirmed by the EV driver. This may increase the prevalence of off-peak charging, but would likely negatively impact the user experience.	Some sellers of CPs adopt voluntary smart requirements, and may only offer smart CPs to consumers. Leads to a higher level of smart charging uptake compared to the counterfactual. Voluntary approach takes longer to influence uptake than Option 1 and 2. Unlikely any unified default off peak charging mode is achieved across the smart charging market.	Most CP models on the market conform with grant scheme requirements, with sellers commercially incentivised to do so, assuming most EV drivers with domestic charging/workplaces wish to claim the grant. Leads to a higher level of smart charging uptake compared to the counterfactual.

Data Privacy	Some data privacy requirements could be met under this scenario, especially as existing data protection regulation (GDPR) places obligations on data "controllers and processors". However GDPR covers "personal data" only and therefore other data, such as energy consumption, may not be protected. The objective for consumer protection would not be sufficiently met.	Smart chargepoints will meet some device-level requirements for data privacy, namely the secure storage and transmission of data. This assists with meeting the consumer protection objective for smart charging. Consumer protection is greater than the counterfactual.	The smart charging consultation proposed to mandate compliance with the BSI standard PAS 1878 for Energy Smart Appliances, which includes requirements for data privacy. This would require that smart chargepoints securely store and transmit data. This assists with meeting the consumer protection objective for smart charging. Consumer protection is greater than the counterfactual.	Some data privacy requirements could be met under this scenario, especially as existing data protection regulation (GDPR) places obligations on data "controllers and processors". Equally, there would be inconsistency across the chargepoint market in the way data privacy aims are met leading to a varied consumer experience. The objective for consumer protection could only be partially met for smart charging.	EVHS and WCS would contain data privacy requirements for smart chargepoints, similar to option 1. Compliance with these data privacy requirements would be mandatory if a manufacturer wanted their chargepoint to be eligible for the grant scheme. However, it would not be a legal requirement and therefore some chargepoints may still be sold in Great Britain without meeting data privacy requirements. The objective for consumer protection could only be partially met for smart charging.
Interoperability	Not protected against	Some protection, as supplier interoperability is mandated. Consumer protection is greater than the counterfactual as CPs must operate with any energy supplier.	The smart charging consultation proposed that smart chargepoints should be capable of retaining smart functionality if the chargepoint operator were to be changed, without requiring a visit to the premises.	Interoperability objectives are unlikely to be fully met under this scenario. In the absence of technical requirements on chargepoint devices, it is unlikely that the market would voluntarily deliver interoperability in a consistent manner.	Chargepoints installed under the EVHS/WCS would be required to use the Open Charge Point Protocol (OCPP). OCPP can facilitate a degree of interoperability, though likely not to the same extent as "full" chargepoint interoperability – for example, some technical changes would likely be

			This approach could improve consumer protection, but this could not be achieved within our existing legal powers. Further regulation would likely be necessary.		required by the new operator, and a visit to the premises might be necessary. In addition, some chargepoint models are sold outside the EVHS and so would not be interoperable to the same extent, if at all.
Cyber Security	Some cybersecurity protections could already apply to private EV chargepoints if the chargepoint is operating with a smart meter. However, we are not aware of any chargepoints currently routing communications through the smart meter.	Smart chargepoints will meet relevant cybersecurity requirements derived from ETSI EN 303 645, a European cybersecurity standard for Internet of Things devices. This will include requirements on encrypted communications and the use of unique passwords. These requirements assist with meeting the cybersecurity objective for smart charging by ensuring good “cyber hygiene” for all chargepoints. Further legislation under phase 2 is required for this objective to be met.	The smart charging consultation proposed that smart CPs meet outcome-based security requirements as well as technical security characteristics set out in BSI standard PAS 1878. This approach would meet our cybersecurity objectives but would potentially require significant modification/reversal depending on the longer-term approach taken to smart charging under phase 2 legislation.	This scenario would see some industry stakeholders following PAS 1878, ETSI EN 303 645 or other cybersecurity standards voluntarily. This would deliver some degree of cybersecurity protection. However, patchy implementation would still leave large numbers of chargepoints vulnerable to compromise by threat actors. Those manufacturers not meeting standards could still be targeted for cyber-attacks, which could destabilise the grid if sufficiently large. Allowing voluntary compliance would mean the objective for cybersecurity would not be met.	Compliance with security requirements from ETSI EN 303 645 would be required for eligibility for grant schemes. This would produce a similar outcome to option 3: some protection of the grid would be afforded by those chargepoints sold under the schemes, but others would still pose a considerable risk.

Grid Stability	A random delay function, which assists with grid stability, could already apply to private EV charging if the chargepoint is operating with a smart meter, as SMETS2 contains its own randomised offset function. However without this functionality being implemented consistently across the GB market, smart chargepoints may cause issues for grid stability if large numbers chargepoints switch load at the same time. The objective for grid stability would not be sufficiently met.	A **randomised delay function** is mandatory, which will help avoid large simultaneous increases or decreases in load on the electricity network. This could be caused by multiple CPs turning on/off at the same time (e.g. in response to a price movement) or chargepoints turning back on after a power outage. Implementing this functionality assists with meeting the grid stability objective for smart charging.	Same outcome as Option 1.	This scenario would see some of industry following PAS 1878 voluntarily. PAS 1878 makes provision for a randomised delay function, similar to the approach SMETS2 and the smart charging legislation would take. There is a risk that not enough of industry would take up these standards and therefore grid stability issues could still arise from large numbers of chargepoints switching load at the same time. Allowing voluntary compliance with this functionality would mean the objective for grid stability would not be sufficiently met.	A randomised delay function would be required for eligibility for the grant schemes. This would produce a similar outcome to option 3 where there is partial take up of this requirement by industry. There is a risk that not enough of industry would take up these standards if they chose to not utilise the grant scheme and therefore grid stability issues could still arise from large numbers of chargepoints switching load at the same time. The objective for grid stability would not be sufficiently met.
Risks	Government may not be performing its role in delivering grid and consumer protections, if no action is taken. Risk that smart CPs do not develop/are not taken up by consumers.	Consumer and grid risks won't be mitigated in full. Further intervention would be required to appropriately mitigate these issues.	Same outcome as option 1, although with a potentially lower consumer and grid protection risk due to implementation of more prescriptive device requirements under this option.	Government may not be performing its role in delivering grid and consumer protections, if voluntary standards are not adopted by sellers of smart CPs. Risk that smart CPs do not develop/are not taken up by consumers.	Government may not be performing its role in delivering grid and consumer protections, if not all smart CP sellers or manufacturers comply with grant requirements. Risk lower levels of smart CP uptake than option 2 and 3.

Summary

1. Government will be implementing Option 1. A voluntary option as described under Option 3, without regulation, would not achieve Government's consulted on aims and objectives for smart charging policy. A voluntary approach would lead to high levels of variation amongst industry in how requirements are delivered, given it is unlikely all relevant players would voluntarily implement requirements or agree to the same approach, particularly as the smart charging grows. It is therefore unlikely progress towards meeting Government's policy objectives will be met.

2. A regulatory approach is required to ensure smart CPs are installed ahead of mass uptake of EVs, maximising the potential of smart charging to reduce the need for network reinforcement and benefit consumers by reducing EV running costs. In addition, the 2019 consultation proposed a phased regulatory approach to achieving Government's aims and objectives for smart charging policy, and this received a high-level of support amongst respondents.

3. Option 2, which would set regulatory requirements in line with the 2019 consultation, will not be pursued. Since consulting in 2019, the smart charging market has developed significantly, yet is still in a nascent stage. Given this, and considering the responses to the consultation, there is limited evidence for mandating specific solutions that meet all of Government's smart charging policy objectives in 2021. Our intention is to instead mandate a minimum set of requirements this year, to support the smart charging market in this early stage, ahead of a further intervention, described in the consultation as phase two. In addition, the consultation identified a key risk of the phased approach is a scenario where industry invest in developing products to meet Phase One requirements, only for those requirements to be changed to align with the future framework developed under Phase Two. The risk of this wasted investment is potentially higher under option 2, while until phase 2 is complete consumer benefits would not be realised in any event.

4. Option 4, where smart device requirements are set as part of chargepoint grant schemes, has already been partly implemented in the UK. The current OZEV EVHS grant requires all CPs to be smart and meet high level outcomes on issues such as cyber security and monitoring energy consumption. Whilst in the short term this intervention has successfully driven uptake of smart charging and requiring such conditions as part of other grants in the future could drive uptake, there are two key reasons why this approach has been deemed insufficient. First, the aim of Government is to create a mature EV chargepoint installation market for workplace and domestic settings that does not need grant funding to sustain it. An approach independent from the continuation of grants is therefore necessary to meet the Government's aims and objectives for smart charging in the long term. Second, the diversity in business models and practices of this early market risks a proliferation of smart CPs with varying standards and functionality. Without clear requirements which are regulatory and hence enforceable, it's unlikely that the market will deliver smart CPs that consistently meet Government's objectives.

Assumptions log

Market Overview

Assumption	Description	Confidence	Source
Number of UK based CP manufacturers	Market intelligence provided by Delta-EE and informed by their Chargepoint Manufacturer database	High	Delta-EE
Number of CP models	Market intelligence provided by Delta-EE and informed by their Chargepoint Manufacturer database	High	Delta-EE
CP Market share (by model, manufacturer)	Analysis of EVHS and WCS grant data	High – Based on internal records from the schemes	OZEV
Number of private EV CPs currently installed in Great Britain	Delta-EE's CP database which is segmented by three locations: (1) home, (2) workplace, (3) public	Medium	Delta-EE – European Chargepoint Forecast (2020)
Smart vs Non-Smart CP price differential	This reflects the cost of a single new residential installation rather than an upgrade to an existing connection. Range reflects 2 variants of smart CP which differ in terms of capability. Cost differential is relative to a 7kW AC residential charger. Cost does not include any fee paid for the existing of an aggregation service	Medium - There is inherent uncertainty, however this aligns closely with other sources that have been considered.	Energy Systems Catapult (ESC)
Smart CP installs (as % of total)	Proportion of CPs installed that have internet connectivity.	Low - There is significant uncertainty surrounding this number and how it will change over time. **Ranges tested through scenario or sensitivity analysis**	Delta-EE's EV Owners Survey – 'Who is the EV owner and how do they charge?'

Chargepoint Projections

The CP projections used in this analysis are derived from an excel-based modelling tool that has been developed. This tool takes a 'top down' approach, using assumptions around EV uptake, future charging behaviours and the development of CP and vehicle technology to estimate the number of CPs required in different charging locations to support a given number of EVs on the road in the UK for any given year. The table below contains information on the key assumptions used.

Assumption	Description	Confidence	Source
EV Uptake	Number of EVs (by year, vehicle type, powertrain)	Medium	Internal DfT projections
Access to Off-street Parking	Proportion of EV owners with access to off-street parking (by year, classification)	Medium	National Travel Survey (2018)
Likelihood of installing a dedicated residential CP	Proportion of EV owners with access to off-street parking that install a dedicated CP (by year, vehicle type, powertrain)	Medium	Delta-EE's EV Owners Survey – 'Who is the EV owner and

			how do they charge?'
Multiple EV ownership	Proportion of households with more than one vehicle. Likelihood of household currently without a CP buying a first CP with their second EV. Likelihood of household currently with a CP buying a second CP with their second EV.	Low	Delta-EE – European Chargepoint Forecast (2020)
Driver charging preferences	Proportion of total charging demand supplied (by year, vehicle type, powertrain, location)	Low	ICCT (2021) – Charging Gap UK
EV mileage	Average annual mileage (by year, vehicle type, powertrain)	Medium	DfT Licencing Statistics & National Travel Survey (2018)
Battery efficiency	Average battery efficiency (by year, vehicle type, powertrain)	Medium	Internal DfT modelling
Electric mode	Proportion of total miles in electric mode (by year, vehicle type) – applicable to PHEVs only.	Medium	Internal DfT modelling
Plug-in start time	Proportion of total charging events starting (by hour, location)	Low	DfT (2017) – Electric Chargepoint Analysis
Plug-in duration	Median plug-in duration per charging event (by year, vehicle type, powertrain, location)	Low	DfT (2017) – Electric Chargepoint Analysis
Charge supplied	Median charge supplied per charging event (by year, vehicle type, powertrain, location)	Low	DfT (2017) – Electric Chargepoint Analysis
Replacement cycle	Lifetime of the CP	Medium	Delta-EE – European Chargepoint Forecast (2020)

Cost Assessment

Assumption	Description	Confidence	Source
Manufacturing cost of non-smart CP unit (£)	DfT commissioned consultants, Steer, to estimate the costs of elements of charging infrastructure. Through desk research and stakeholder engagement they were able to identify and provide approximate estimates for four elements of charging infrastructure, 'Ducting', 'Cabling', 'Hardware' and 'Grid Connection' costs.	Medium – Estimates align closely with feedback received from CP manufacturers.	Steer, provided to DfT
Additional cost of producing compliant CP (£)	Illustrative costings per requirement provided by CP manufacturers.	Low – Small number of respondents, however evidence showed good consistency despite difficulty in providing accurate estimates. **Ranges tested through scenario or sensitivity analysis**	Primary evidence collected from CP manufacturers
Learning rate of smart components (% reduction)	A learning rate is the rate at which a technology is assumed to decrease in cost as production expands, due to factors such as economies of scale. We have consulted with BEIS engineers on possible learning rates for both smart and non-smart components of CPs.	Low – Based on historic data **Ranges tested through scenario or sensitivity analysis**	Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Benefits Analysis

Assumption	Description	Confidence	Source
Annual EV electricity demand (TWh)	This comes from DfT projections and modelling and is aligned with other government policies.	Medium – there is significant uncertainty in many areas, but this projection is aligned with other Government policy.	Internal DfT projections
Consumer charging preferences (% of total charging load)	There are significant differences in charging behaviour depending on the type of infrastructure that consumers use (e.g. residential off-street, workplace etc.). For our modelling it is necessary to assume the % of an EV's energy that is charged at these different infrastructure locations. We have used projections from the ICCT: this data shows good alignment with Element Energy's charging splits that were measured using data on millions of real charging events. However, there is still a large amount of uncertainty regarding these preferences as they will be heavily influenced by multiple factors going forward such as infrastructure provision, electricity prices and behavioural trends.	Medium – there is significant uncertainty in this area given the factors mentioned. Testing these assumptions is beyond the scope of this IA but is an area that we are monitoring	ICCT (2021) – Charging Gap UK
Daily load curves (% of peak demand)	Half-hourly electricity demand. Pre shifting, it is assumed that demand at residential off-street and depot locations peaks in the evening and demand at workplaces is assumed to peak in the morning.	Medium – confidence that these assumptions reflect what is happening currently, but there is uncertainty as to how they will change into the future. Assumptions align closely with other charging studies	DfT (2017) – Electric Chargepoint Analysis

Shifting assumptions (% of daily peak demand available to shift)	There are several assumptions that affect the final amount of load shifted. 1. Capability - The % of load supplied from dedicated CPs (as opposed to basic 3 pin plug cables). Our starting figure assumption comes from Delta-EE's consumer research, with a projection for cable usage to fall over time. 2. Motivation - The % of load from CPs that is incentivised to be shifted. Currently, these incentives are primarily in the form of time of use tariffs (TOUTs) where consumers receive different electricity prices during different periods of the day. Our starting figure is from Delta-EE's customer research, with incentives uptake assumed to rise significantly over time. This is due to multiple factors, such as the smart meter rollout which will enable more consumers to receive load shifting incentives and the development of other incentive forms in the market. 3. The % of incentivised load that is allowed to shift and not overridden by the consumer. Even with smart charging capability and incentives, not all load is shifted. This is because not all consumers respond to the incentives but also because sometimes consumers need their EVs sooner and therefore charge during higher priced periods out of necessity. Our figure for this has been derived from a smart charging trial as part of the CVEI project that looked at the behaviour of mainstream consumers (those who do not plan on purchasing an EV in the next few years	Low – Data and evidence in this area is not widely available. We are relatively confident on the starting assumptions based on the evidence that has been considered, but there is signficant uncertainty over how these factors will change over time. We are confident in our starting **Ranges tested through scenario or sensitivity analysis**	Delta-EE – European Chargepoint Forecast (2020) Delta-EE's EV Owners Survey – 'Who is the EV owner and how do they charge?' CVEI – Charging Behaviour Trial

Rounding

How we have rounded costs and benefits is described below.

Total costs and annual benefits have been rounded to the nearest £10m where possible; this is to avoid spurious accuracy, given the extent of the uncertainties present in trying to model these changes over the next 30 years.

Total benefits have been rounded to the nearest £100m. This is because we used two models, the DDM (Dynamic Distribution Model) and DNM (Distribution Networks Model), to model the benefits of these regulations. They model the entire power sector and the outputs are of a scale that requires them to be rounded to the nearest £100m when undertaking analysis.