CHARGE

Refuelling Tomorrow's Electrified Transport

Network Innovation Competition 2018

Project Summary

1.1 Project Title	**Charge: Refuelling Tomorrow's Electrified Transport**
1.2 Project Explanation	**Charge** aims to accelerate the connection of charging infrastructure by: • Combining Transport planning and electricity network planning; • Trialling innovative solutions to maximise and accelerate the connection of charge points; • Developing interactive tool(s) to allow customers to identify the most cost-effective location and method to connect to the network.
1.3 Funding licensee:	**SP Manweb Plc**
1.4 Project description:	The electrification of transport will require careful management, particularly for the energy sector. A clear and transparent strategy is essential to help facilitate this transition at the lowest overall cost for customers. Crucially, this strategy needs to tie together the needs of a range of stakeholders with the capacity on the electricity networks to develop a system that is safe, flexible, and cost-effective. Our stakeholders are telling us they want to be able to connect to our network in the most efficient and timely manner, this project will go some way towards developing and trialling new innovative connections solutions, greatly improving the visibility of network capacity and accelerating the electrification of transport across the region for all. **Charge** will: • Engage with a wide range of stakeholders and perform detailed transport planning to understand customer needs; • Overlay charging requirements with network capacity planning to create a strategic plan for a licence area, using SP Manweb (SPM) as an example; • Deploy a number of targeted network trials to bring forward flexible connections for public charging equipment, including on-street charging and complex destination charging; • Co-create an interactive future transport plan for a licence area via an online software tool (ConnectMore), which can be applied to other distribution networks in GB. **Charge** will support the Low Carbon Plan and uptake scenarios presented in the UK Government's Fifth Carbon Budget by identifying flexible coordinated solutions to facilitate the connection of EV charge equipment onto the distribution networks, at the scale needed for the wide scale adoption of EVs. **Charge presents a positive and realistic business case. It could save GB customers over £795m, in addition to reducing carbon emissions by 5.66 mtCO_2 by 2050.**

1.5 Funding

1.5.1 NIC Funding Request (£k)	£6,850	1.5.2 Network Licensee Compulsory Contribution (£k)	£772
1.5.3 Network Licensee Extra Contribution (£k)	£250	1.5.4 External Funding – excluding from NICs (£k):	£571
1.5.5. Total Project Costs (£k)	£8,545		

1.6 List of Project Partners, External Funders and Project Supporters (and value of contribution)	• Project Lead: SP Energy Networks • Project Partners: EA Technology (£299k), Smarter Grid Solutions (£150k), PTV Group (£123k) • External Funders: Councils, RSAs • Project Supporters: Councils, RSAs, etc. (Appendix K for details)

1.7 Timescale

1.7.1. Project Start Date	January 2019	1.7.2. Project End Date	December 2022

1.8 Project Manager Contact Details

1.8.1. Contact Name & Job Title	Nicol Gray	1.8.2. Email & Telephone Number	Nicol.gray@spenergynetworks.co.uk 01416141263
1.8.3. Contact Address	SP Energy Networks, 320 St Vincent Street, Glasgow, G2 5AD		

1.9 Cross Sector Projects (only complete this section if your project is a Cross Sector Project, i.e. involves both the Gas and Electricity NICs).

1.9.1. Funding requested the from the [Gas/Electricity] NIC (£k, please state which other competition)	None
1.9.2. Please confirm whether or not this [Gas/Electricity] NIC Project could proceed in the absence of funding being awarded for the other Project.	N/A

1.10 Technology Readiness Level (TRL)

1.10.1. TRL at Project Start Date	5	1.10.2. TRL at Project End Date	8/9

2 Project Description

2.1 Aims and Objectives

Charge aims to accelerate the connection and planning of charging infrastructure at the lowest possible cost to GB electricity customers by maximising the use of existing assets through development and deployment of innovative approaches to connecting and managing the uptake of Electric Vehicles (EVs) across a broad geographical area. It will combine learning from other projects with expertise from the world of transport planning. This learning will be coupled with a targeted selection of innovative EV chargepoint connection trials for a range of practical situations.

This innovative approach will form a blueprint for other GB DNOs to make best use of their existing assets, plan for future upgrades and signal to the industry where network capacity or other flexible solutions are needed.

It is essential that DNOs help facilitate this transition, becoming the enablers of EV adoption and helping Government to meet climate change targets. For this reason, **DNOs need to be at the heart of the discussion, facilitating the timely and optimised connection of future EV charging infrastructure** to avoid delays and developing clear guidance and connection standards to expedite the uptake of EVs.

2.1.1 The Problem(s) to be resolved

Within the UK there is a clear policy drive from UK Government towards encouraging the uptake of Ultra-Low Emission Vehicles, which is driving sales of EVs. This increasing demand will exert additional strain on electricity networks across multiple voltage levels; accelerating the need to develop new connections solutions and improved ways to deliver network flexibility.

This will manifest in two ways:

A) Domestic charging, which is installed without prior notification, will reduce spare capacity on existing assets and, as uptake progresses, lead to overloads on circuits requiring reinforcement solutions; currently paid for by all customers.

B) New connections for public chargepoints in various forms will be requested by customers, leading to increased upstream reinforcement to facilitate the transition to electrified transport

A significant concern is the **lead time for bringing new capacity on line**. Larger schemes can take up to five years to gain permissions, plan and implement. We wish to avoid the situation whereby we cannot satisfy customer needs for extended periods of time, enabling the shift to electrified transport.

There is a need to **accelerate the readiness of the network**, in the long-term interests of customers, but this needs to be achieved in a defined manner, against a robust strategic analysis of customer and stakeholder needs into the future.

Currently, public chargepoint infrastructure is being rolled out in a **piecemeal and incremental** way as was the case for renewable generation connections. This carries the risk of a more fragmented, slower and ultimately more expensive approach to implementing additional capacity.

Customers, currently, have **little ability to balance their connection capacity** requirements to the expected costs of connection. In some cases, lower cost connections may be achievable by dispersing their requirements across a wider geographic area rather than a single connection or by looking towards flexible solutions. This is difficult to plan without good visibility of the network and its existing capacity. More generally, stakeholders such as Local Authorities, are not currently able to understand network capacity requirements to fulfil their transport strategies. A deeper understanding is required, and this is likely to vary across the different organisation types (e.g. Local Authorities, Local Enterprise Partnerships, etc., versus tactical customers such as petrol forecourt operators and car park operators, etc.). Essential to this is also developing a streamlined connections process to facilitate timely connections at the lowest cost for customers.

To achieve the 2050 carbon targets, the UK needs to reach non-fossil fuelled transport. Whilst this could be achieved through a variety of transport solutions (e.g. Transport/Mobility as a Service), this means ensuring every household and business needs to be considered, and suitable connection options developed, not just those households with a driveway. According to the English Housing Survey 2015, **roughly one third of all households do not have off-street parking** – it is therefore a key area to address.

Most projects to date have focused on residential charging behaviour and solutions, there is a **lack of knowledge of how non-residential charging infrastructure** will be implemented and used in the future; a key enabler of universal adoption of EVs. From a network perspective, this knowledge gap leads to conservatism when assessing installations for network capacity requirements. In particular, a key issue is the lack of understanding of diversity of chargepoint usage for installations with multiple points, which can have a dramatic effect on the capacity needed, cost to connect and the availability of chargers in a given location.

It is recognised that vehicle technology is evolving rapidly (faster charging rates, vehicle ranges and, further into the future, autonomous driving modes) which impact when, where, and how much network capacity is needed. For this reason, DNOs must ensure they understand the direction in which the EV industry is travelling and **take a long term view on the charging requirements** for different users, otherwise there is the risk that inaccurate assumptions may lead to poor investment decisions and create stranded network assets.

*2.1.2 The **Charge** Solution*

The correlation between the road network and the electricity network is not well understood, where there is transport capacity, it does not necessarily mean there is electrical capacity as both transport and power networks have been developed entirely independently. For the first time in GB, we intend to **merge the disciplines of transport planning and electricity network planning** to create an overarching plan of where chargepoints will be required and how the network would be impacted from these chargepoints. This will facilitate better planning of electricity networks and will provide vital information for all sectors involved in helping GB transition to low carbon transport.

Our strategic road networks are designed with the aid of transport planning software tools, which allow the mapping of driver journey details to understand the expected usage and benefits of new roads and new road layouts. A key innovative aspect of this project is in using the information gleaned from this mapping of driver behaviour to predict where customers are likely to need chargepoints.

We will also use driver behaviour and journey statistics to form a view of the likely demand draw from multiple chargepoint installations in various uses (e.g. car park, forecourt, destination), helping the DNO to assign more appropriate design values during the connection process.

The main legacy of the project will be an online self-service tool for customers to allow them to understand whether their connection requirements can be met by the existing network. The service will also alert customers to planned reinforcement work, or what network flexibility options could be adopted, which may be a factor in whether they proceed with their connection, when and at which location.

The software service will cater for connections from 11kV down to the distribution substation to cover a large range of EV chargepoint connection use cases from a single unit to multiple ultra-rapid chargepoint sites.

2.2 Technical Description of Project

Charge will achieve the outcomes through three Methods:

- **Method 1:** Strategic transport and network planning
- **Method 2:** Tactical solutions to support EV connections
- **Method 3:** The development of the 'ConnectMore' software tool

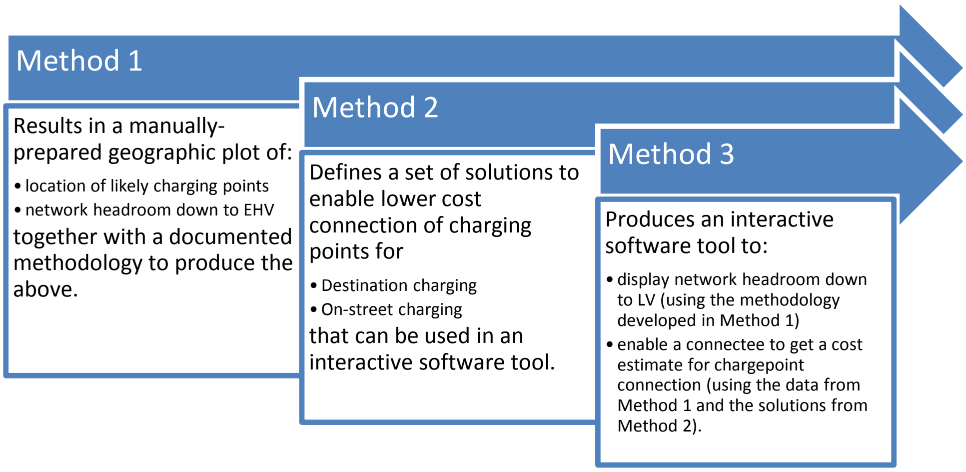


Figure 1 Overview of Charge project method outputs

2.2.1 Method 1 – Strategic Transport and Network Planning

Method 1 will use PTV's state of the art Visum transport planning software to map out the future electric transportation needs of the SPM License area to 2050. We will work closely with the key stakeholders in the region to provide an evolving picture of EV usage as uptake progresses and provide an informed view of the likely connection requirements on the electricity network.

The impact of future charging solutions and how different customer types will interact as, for example, EV battery capacity and range improves will also be assessed. This learning will inform the design of the trials in Method 2 and the development of the online connections tool in Method 3.

The scenario planning framework will consist of the following variables as a minimum:

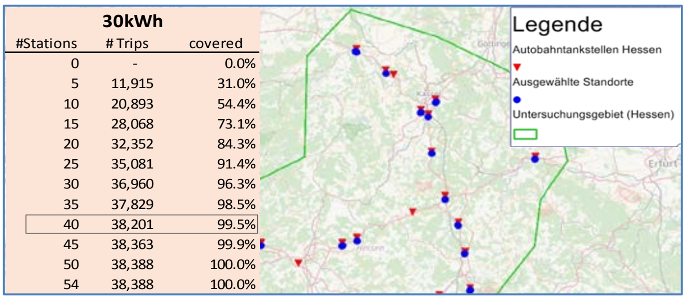
- A range of future years scenarios from 2020 until 2050:
- Consideration of electrification of private cars, commercial and freight vehicles;
- Scenarios for uptake rates. These will evolve gradually, and certain areas of the region will accelerate faster than others;
- Various battery ranges for different vehicle types and the ability to adapt the vehicle capability as it varies over time;
- Time of day charging will be an important variable to reflect by different segment groups.

We will also build on the existing network capacity heat map work undertaken within our business to begin to overlay how the charging requirements impact the electricity network, driving out important knowledge on the:

- Ability to absorb charging requirements within the capabilities of existing assets;
- Likely need for new capacity or network flexibility within tightly bounded geographic areas;
- The timescales by which new capacity or flexibility will be needed, providing market players with signals on likely future DNO [DSO] needs.

The Method will be complemented by extensive stakeholder engagement. The work will be used to help inform a range of stakeholders, particularly Local Authorities, on likely driver needs in the future to allow them also to consider how best to meet those requirements, potentially enabling significant private investment well within the timescales of the project.

Transport modelling for a similar use case has been conducted before in Germany. Figure 1 shows results of a modelling exercise for Frankfurt, indicating the optimal location of chargepoints and the proportion of trips that can be accommodated with varying levels of charging infrastructure (top left).



30kWh		
#Stations	# Trips	covered
0	-	0.0%
5	11,915	31.0%
10	20,893	54.4%
15	28,068	73.1%
20	32,352	84.3%
25	35,081	91.4%
30	36,960	96.3%
35	37,829	98.5%
40	38,201	99.5%
45	38,363	99.9%
50	38,388	100.0%
54	38,388	100.0%

Figure 2: Optimal Charging Locations Study performed by PTV for Frankfurt, Germany

We recognise that the plan will change over time, and to cater for this the software will be built with editable fields such that the scenarios can be altered as uptake progresses and forecasts change. This will allow changes, for example, to uptake rates or proportion of where charging takes place (e.g. home vs. public) to be made.

As a by-product, the work will enable third-party investors in the chargepoint supply chain to understand likely usage of chargepoints by location and therefore recognise where chargepoints could be financially self-sufficient i.e. be installed without Government subsidy. This work may therefore also be a useful source of information to highlight when and where chargepoint grant schemes become unnecessary.

In this case, the DNO benefits from an early indication of customer needs, allowing them to meet those needs against a solid plan and third parties benefit from lower connection costs. Details are provided in 17.1 of Appendix E.

2.2.2 Method 2 – Tactical Solutions for Public Chargepoints

Method 2 will carry out targeted trials to determine the lowest lifecycle cost options for two unanswered issues:

- Charging solutions for residential properties without a driveway (i.e. both terraced streets and flats/apartments)
- Charging solutions for destinations (e.g. shopping centres, events venues, etc.) and en-route locations (i.e. service stations)

Charge will consider a range of novel and conventional solutions in isolation, and in combination, to develop guidance in preparation for mass deployment.

There are several different approaches that could be used to defer or avoid reinforcement, and these range in terms of complexity and cost to the user (and network operator). Management strategies to be explored as part of this demonstration project include:

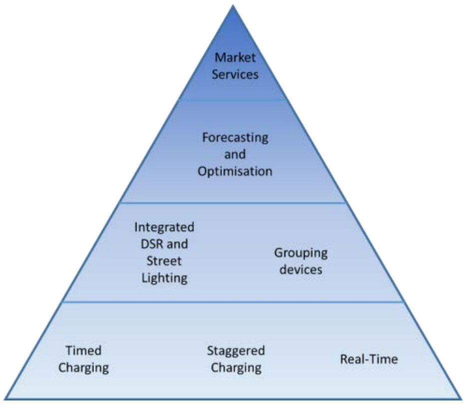


Figure 3 Smart management strategies to be trialled, rising in complexities

The following interventions will be tested:

- **Charging Strategies**: Due to the lack of off-street parking, a new combination of charging strategies and behaviours will be explored as part of this trial. The charging behaviours explored will be linked to the types of constraint experienced in the network e.g. voltage, thermal, fault level etc. Potential charging strategies include Timed or Fixed charging schedules, staggered charging on a street by street basis, or real time charging based on network limits. A summary of how charging solutions link to constraints and charge behaviours will be made.
- **Integration with Street Lighting and Domestic Scale Storage**: building upon the charging strategies explored, these will be combined with variable load schemes such as small-scale storage and street lighting. The trial will explore if there are ways that various charging strategies can be successfully supported by having additional flexible load, and if there are benefits to some or all parties involved in the process. This demonstration will produce

recommendations for ways in which additional resources can be integrated in to EV charging schemes.

- **Flexibility Services**: Building on the technologies demonstrated, this part of the demonstration will try to link commercial services to the technology solutions. The commercial services demonstrated will depend on progress made by SPEN external to the project as part of the DSO transition.

The methodology is as described in Figure 4 below and further detail is provided in Appendix E.

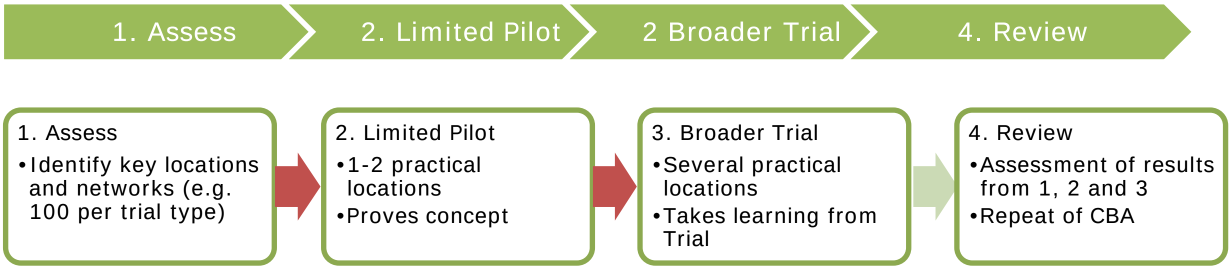


Figure 4: Overview of the trial approach (NB. managerial stage-gates between 1 & 2, and 2 & 3, shown as red arrows)

The **Assess Phase** of Method 2 will survey a range of real network areas with different characteristics to define both constraints and optimal solutions considering:

- The capacity that the existing local network has, to accommodate new EV chargepoint connections.
- The feasibility of connecting energy storage systems both at the substation and downstream on the feeder.
- The benefit of managed charging schemes to alleviate capacity constraints and potential flexibility options.
- The likely network connection options and local solutions to be installed.
- The feasibility of installing various forms of charging points, such as on-street slow charging, rapid chargers and wireless charging systems.

The **Limited Pilot** will focus on one or two focused sites, which will be determined by the outcome from the Phase 1 assessment. This phase of the trial will be used to demonstrate the concepts, and to perform any minor changes that may be required to the technology used in the trial. This trial will be the first time to test the ability of the management platform to successfully communicate with the third-party charging applications (individual charge posts or via aggregators), and to demonstrate compatibility of multiple devices in helping to resolve network issues. Potential case study example locations have been included in Appendix G.

The **Broader Trial** will be expanded to include several practical locations within the areas identified during the assessment in Phase 1 and expand upon the learning from the Limited Pilot. This will look to recruit a large volume of stakeholders for participation in the trial to demonstrate some of the more complex management strategies – including optimisation, forecasting, schedules and real-time dispatch and flexibility services.

In order to create a significant data set and results, the trials will run for 12 – 18 months. During this time, a variation of smart management approaches will be trialled, depending on the use cases for each trial location.

The **Review Phase** will report on the trials, capturing the learnings and outcomes from both the Pilot and the Trial. It will include the way in which stakeholders were engaged and the uptake of EVs that was achieved as part of the trial. The Cost Benefit Analysis that was performed in the initial assessment will be updated based on new information from the trial and re-run to compare the outcomes.

Method 2 will produce the following outputs:

- Robust financial case for the range of smart management solutions explored
- Policy information to support DNOs and chargepoint manufacturers in the process to facilitate the increase of EVs on their networks
- Customer messaging strategies that will support and encourage the use of electric vehicles in a manner which will benefit both the customer and energy networks.

Results from the desktop assessment and trial phases will be incorporated into the software tool of Method 3.

2.2.3 Method 3 – The "ConnectMore" Online Connections Tool

Method 3 will develop an interactive tool (ConnectMore) to enable a range of non-engineering stakeholders to assess optimum locations for connection of EV charge points, taking account of the needs of users (defined by transport planning) and the existing capacity of the electricity network. The connections tools will encompass both 11kV and LV to cover a wide range of possible connection options, from low volume charging installations to large recharging centres catering for multiple ultra-rapid charger installations.

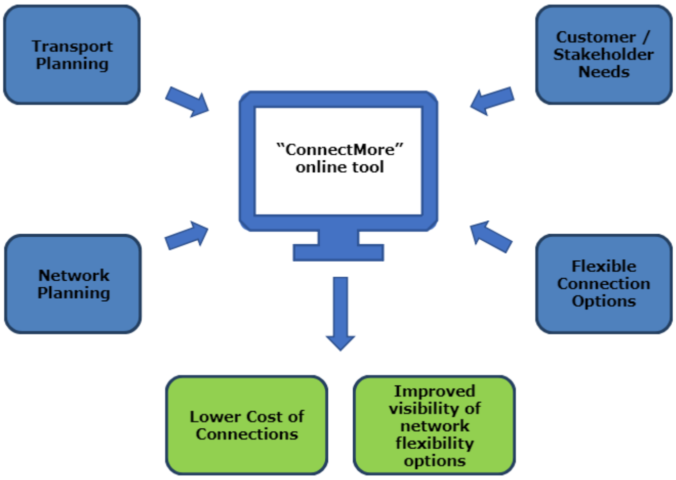


Figure 5: Overview of the Charge 'ConnectMore' Solution

Public EV chargepoints have different characteristics to many other types of network connection:

- The likely maximum draw from the network will be lower than the total installed capacity. For example, it is unlikely that a connection of ten rapid chargers would all be used simultaneously;
- In many instances, there can be locational flexibility on the connection point;

- The usage of the chargepoints will dramatically change with time as uptake progresses;
- There is an opportunity to make more efficient use of our existing assets through careful consideration of the connection options

This means there is scope for a different approach, whereby potential customers are presented with options for their connection upfront, allowing them to adapt the location or size to reduce the connection cost.

Improvements in data sources and building on the work of other innovation projects, such as our Accelerating Renewable Connections (ARC), Northern Powergrid's Customer-Led Network Revolution and WPD's Electric Nation, now mean that we can develop innovative methods of providing customers with this information without submitting a connection request beforehand.

In the early years, we believe connections will mostly be about making best use of existing capacity as funding is dominated by public sources in many areas. Moving on, there will be more interest from third party commercial organisations for capacity and service provision, this is expected to lead to significantly increased volume of connection requests, similar to the rush to connect onshore wind and Photovoltaics (PV) witnessed several years ago. During this time, each DNO was receiving hundreds of new connection enquiries each week, sometimes requests for capacity for the same patch of land by several installers. We wish to innovate to meet this scenario in advance to better prepared the industry and improve the experience for connecting customers.

It will also be beneficial to highlight to customers where the DNO is intending to build new capacity or tender for flexibility, as that might be an influencing factor on their plans and timescales. We will also provide functions for customers to register their interest in capacity in an area to help the DNO to get the capacity needs correct when designing reinforcement. This was a significant issue as the penetration of renewable generation connections applications reached its peak – had a number of customers highlighted their interest in developing in an area upfront, the DNO may have been able to negotiate a case to roll out a different solution (e.g. 33kV instead of 11kV) to uplift the capacity by a greater margin.

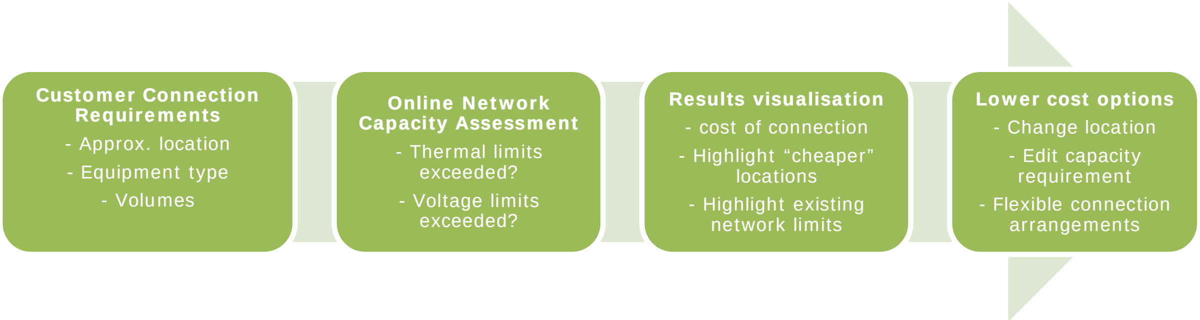


Figure 6: Customer Journey Flow chart for the ConnectMore software tool (HV connections)

ConnectMore will allow customers to select their requirements and approximate location. A capacity assessment will be undertaken to understand the rating of assets in the area and likely demand from existing connections. The customer will be presented with information on the ability of the local network to accept that connection with approximate costs. The tool will provide:

- A visual indication of the ability of the local network to absorb the connection

- The locality of existing assets, allowing the customer to modify the location to lower the cost of connection

Where the location would require upstream reinforcement, the tool will provide:

- A visualisation of nearby areas where there is sufficient network capacity to absorb the connection
- Guidance on actions the customer can take to reduce the cost of connection, such as changing the location, modifying the request (e.g. reducing the number of chargepoints) or proceeding with a flexible connection offer (developed as part of Method 2)

The tool will also highlight areas where we are planning on upgrading the infrastructure as a result of forecast EV demand or other needs. By signposting where reinforcement is scheduled, this allows stakeholders to adapt their plans in synergy with the network operator (which tends to have a longer lead time). A critical part of this work package is to bring the learnings from Method 2, and other projects such as Electric Nation, and if available, UKPN's Optimise Prime project.

Customers will have the ability to register their interest in capacity in an area which will help us to ensure that we are considering customer needs better as we plan new infrastructure. This will become more important and EV uptake progresses.

Recognising the rapidly changing landscape, the models will be readily configurable for input of new scenarios and changing parameters, including:

- DNO default "most likely" option (used by the customer-facing tool)
- High case, low case and alignment with others' EV uptake forecasts
- Use of demographic data to align uptake rates to local areas more likely to switch to EVs faster

ConnectMore will be developed to be readily transferrable to other licence areas. We will liaise with other DNOs on their plans for network data sources to ensure that the tool is developed such that it can be interfaced with common data formats, whether that be Common Information Model or other common proprietary systems. We will also regularly update key industry personnel on our plans and progress so that each can consider how our work could also provide benefits to them.

2.3 Changes since Initial Screening Process (ISP)

2.3.1 The scale of the Project, funding required, or Partners

Charge remains in line with the submission made at ISP. The following changes have been made as part of the Full Bid Submission to further strengthen the project.

- Name change from "Refuelling Tomorrow" to "**Charge**: Refuelling Tomorrow's Electrified Transport" following stakeholder feedback
- Amended total project budget from £7.2m to c£8.55m, an increase of 19% and the NIC funding request from c£6.5m to c£6.85m, an increase of 5%
  - o This recognises the greater external funding being provided by SPEN and project partners; reaffirming the support for the project.

2.3.2 Cross Industry Venture

Agreement with UKPN on areas for collaboration between **Charge** and their Optimise Prime bid, including:

- The switch in **Charge** to focus solely on on-street and destination charging, to complement UKPN's focus on fleet charging though Optimise Prime
- The use of EV fleet data that may be generated by UKPN trials in the ConnectMore tool(s)
- Collaborative effort with UKPN on development of guidance documents and draft ENA Engineering Technical Standards and/or Engineering Recommendations
- Regular knowledge sharing and combined dissemination events

2.3.3 Ofgem feedback following the ISP

A review of Method 1, to define those areas which are Business as Usual (BaU) activity to SPEN and those which need to be carried out by the project. The budget has been adjusted to suit. This includes:

- **Stakeholder consultation**: SPEN are already progressing with significant stakeholder engagement activity as part of BaU and this has established a growing appetite for a coordinated approach to facilitate the electrification of transport. However, we recognise that work is required regardless of the success or otherwise of **Charge** and therefore our award-winning stakeholder engagement team will be leveraged with benefit in kind support.
- **Future Scenario Planning**: Following submission of the ISP and subsequent stakeholder engagement we recognise that focusing on future scenario planning will not provide significant learning due to the large body of work from other organisations available. These sources, such as National Grids Future Energy Scenarios, will be leveraged and combined with transport and future technology advancements to provide an evolving picture of the likely impact on the electricity network
- **Charge point usage:** SPEN has committed to self-fund an EV car club, if required, to ensure chargepoint usage can provide realistic and statistically relevant results. This cost has been included as additional licensee contribution.

3 Project business case

See Appendix A1: Financial Benefits Table, A2: Capacity Released, A3: Carbon Benefits Table and A4: Explanatory Notes.

Charge will facilitate the uptake of EVs on the scale demanded by society. If rolled out across GB, **Charge** has the potential to deliver capacity for the connection of EV chargers, provide environmental benefits and net financial benefits to customers as follows:

- Total financial benefit of **£135m by 2030** and **£795m by 2050**
- Reduce CO_2 emissions by **0.9M tonnes by 2030** and **5.66M tonnes by 2050**

3.1 Overview

The electrification of transport is a key policy driver of HM Government in achieving the nation's 2050 carbon targets, and 2015 Paris Climate Change Agreement. Indeed, the Carbon Plan can only be met through the mass transition to Ultra Low Emission Vehicles, with electric cars and vans being the most likely solution, to reach the 2050 transport emission target of 0gCO_2/km. The Government's Fifth Carbon Budget identified electric vehicles, (BEV / PHEV combined) to be 6% of new sales by 2020 and rising to 61% by 2030 in their central scenario, as shown below.

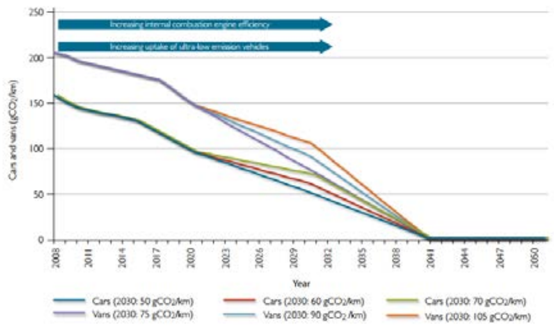


Figure 7: Vehicle emission targets from the Carbon Plan. NB. the 2040 target of 0gCO2/km can only be achieved through a 100% switch from hydrocarbon-based fuel to another energy vector (source: The Carbon Plan: Delivering our Low Carbon Future, HM Govt, Dec 2011)

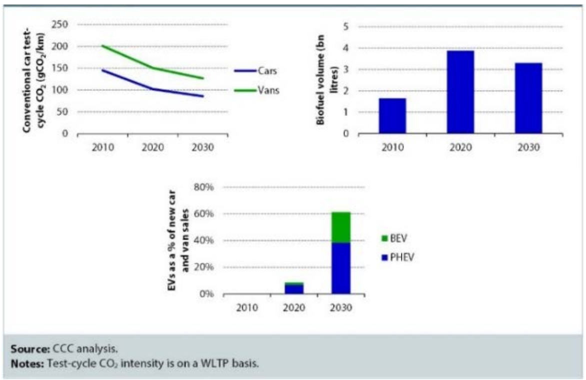


Figure 8: Carbon Budget key transport indicators (source: The Fifth Carbon Budget - The next step towards a low-carbon economy, Committee on Climate Change, Nov 2015)

The Government's policy agenda has sharpened since publication of the Carbon Plan, with a recognition that EVs are a solution for both low carbon and a means to improve air quality, with air pollution in the UK's towns & cities responsible for 40,000 premature deaths per annum. In 2017 government crystallised the aspirations of the Carbon Plan and announced that all new cars and vans would be zero emission by 2040, with tighter targets set for some regions, e.g. 2032 in Scotland, with some metro Mayors considering similar timescales.

3.2 Alignment with DNO strategies

Charge draws on innovation strategies within SPEN, in GB and abroad. In doing so, the project addresses a range of issues outlined in innovation strategies and develops outcomes to facilitate the rollout of charging infrastructure.

As part of a global group, benefitting from experience internationally, we are working to assess the network impact across a range of future EV uptake scenarios in the UK. It is clear from our assessment that the network needs to be upgraded and reinforced to deal with the forecast uptake of EVs. In this regard it is essential electricity Network Operators are at the heart of decision making for EV charger rollout to ensure it maps effectively to existing network capacity. Upstream impacts on Transmission networks must also be considered, and as only 1 of 2 integrated Transmission and Distribution Businesses in the UK, and the only electricity Network Company to operate across Scotland, England and Wales, SPEN is uniquely placed to analyse, respond and manage these impacts.

3.2.1 SPEN Innovation Strategy

SPEN believes innovation is critical to deliver the energy networks of the future, which can facilitate the changes in how the network is being used whilst providing value for money to our customers. **Charge** will directly address the three core priority areas as identified by our stakeholders in our recently updated innovation strategy[1].

- Delivering Value to Customers
- A Smarter Flexible Network
- Sustainable Networks

Charge will directly address a key priority for our stakeholders; addressing the impact of EVs on the network – *developing cost effective management and smart network solutions to enable and facilitate the transition to electrified transportation*.

3.2.2 GB Network Operators Innovation Strategy

The Energy Networks Association (ENA) has recently published a collaborative innovation strategy[2] and outlined 5 innovation themes. By considering the current level of innovation and future innovation opportunities across the 5 themes, a set of priority outcomes have been identified. **Charge** will directly (8) and indirectly (3) address these priorities enabling networks operators, key stakeholders and customers to better understand new solutions, helping to identify new opportunities and speed up wider the rollout of chargers.

3.3 Construction of the business case

This project intends to enhance the operation and planning of distribution networks to better facilitate electric transport. However, the project significantly benefits connectees to the network, i.e. EV users and the general bill payer. As described in Appendix A4 **Charge's** business case benefits are categorised as follows:

- **Cost reductions resulting from strategic alignment / deployment**: **Charge's** strategic transport and network planning activity is expected to have a combinational effect of both stimulating the market for EV rollout and increasing the speed of connection for customers in areas that are aligned to both the transport needs and capacity on the network. The business case is

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[1] SP Energy Networks Innovation Strategy 2018 https://www.spenergynetworks.co.uk/userfiles/file/SPEN_Innovation_Strategy_SP.pdf
[2] Energy Networks Association Innovation Strategy March 2018

based on the direct benefits to customers in guiding them towards sections of network which have capacity to fulfil their needs[3].

- **Reduced connection costs**: **Charge's** trials for destination and on-street charging will develop guidance and tools for specific solutions that will reduce the connection costs in these localities. The business case is based on flattening the demand curve using a range of techniques for residential properties without driveways.
- **Process efficiencies for EV connections:** This benefit falls into two areas:
  - ***Reduced Assessment & Design (A&D) fees**:* providing customers with the ability to see network capacity and test different areas of the network will reduce the number of abortive connection requests, reducing costs to connectees.
  - ***Avoided costs of DNOs:*** from not having to increase the number of staff in connections teams to support the mass electrification of transport.

The benefits map to the Methods as outlined below:

Table 1: Mapping of benefits to project Methods

Benefit	Method 1	Method 2	Method 3
Cost reductions resulting from strategic alignment / deployment	££	£	£££
Reduced connection costs	n/a	£££	£
Process efficiencies for EV connections	£	n/a	£££

The presented benefits are primarily aligned to each Method, however there are some combinational effects (denoted as a single '£') that could further increase the benefits above those presented.

3.4 Financial benefits

The learnings from **Charge** will improve GB DNOs network planning and operational approach by considering smart and controllable connection solutions. This will reduce network investments across the distribution system and provide better utilisation of assets, which results in lower network charges paid by customers. The financial benefits of each Method have been considered with further detail provided in Appendix A4:

- **Method 1:** Strategic transport and network planning **£9m**
- **Method 2:** Tactical solutions to support EV connections **£666m**
- **Method 3:** The deployment of the 'ConnectMore' software tool **£120m**

3.5 Capacity Released

Charge will generate the following capacity benefits across each of the Methods as detailed in Appendix A4.

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[3] This benefit is split across Methods 1 and 3: Method 1 will be a manual process focussing on the higher (but less granular) voltages of 132kV and 33kV; Method 3 will automate the process developed in Method 1, allowing assessment on 11kV and, ultimately, LV networks.

Table 2: Charge Capacity Benefits (GB level)

Method	Benefit (MW)		
	2030	2040	2050
Method 1 Strategic transport and network planning	335	335	335
Method 2 Tactical solutions for flats/terrace streets	632	1,007	3,021
Method 3 ConnectMore tool for network visibility	1,437	1,437	1,437

3.6 Environmental benefits

The transition to electrified transportation will result in significant benefits for society and will, when coupled with low carbon generation, lead to a significant reduction in carbon emissions as conventional combustion engines are replaced with electric. For our benefits case we use the recognised Ofgem Cost Benefit Analysis (CBA) tool and start with the counterfactual assumption of achieving 20% share of EV by 2030, which is the mid-range of BEIS projections and identified through SPEN stakeholder engagement as currently most probable, and a peak rate of 90% achieved by 2050.

Using an innovation adoption lifecycle model4, Carbon Benefits have been calculated by accelerating the expected baseline EV uptake by 2030, by 1 year. As the counterfactual assumes that the EV transition will progress regardless (to meet government 2040/50 targets) the benefits of **Charge** will reduce over time as the transition happens. In reality, this means the number of additional EVs (and corresponding reduction in conventional vehicles) compared to the counterfactual will peak early 2030 before falling back in later years. The acceleration of 1 year has the effect of increasing the proportion of EVs in the UK from 20% to 25% by 2030 and in line with the upper targets of Future Energy Scenario (FES) 2018 (Consumer Evolution & Community Renewables).

The increase in uptake of EVs, as a result of **Charge**, will offset conventional combustion engines and therefore provide a carbon saving through reduced emissions when compared to the baseline position. This assumption is based on studies which indicated the availability of charging infrastructure is statistically linked to EV uptake[5]. Moreover this idea is reinforced in the UK Government's recently published Road to Zero Strategy[6], which sets out plans to enable a massive expansion of green infrastructure across the country, reduce emissions from the vehicles already on the UK's roads, and drive the uptake of zero emission cars, vans and trucks. In addition, the increased availability of infrastructure directly addresses the two most commonly identified reasons for not adopting EVs, [1] range anxiety [2] charger availability[7].

[4] CC BY 2.5, https://en.wikipedia.org/w/index.php?curid=11484459

[5] Emerging Best Practice for Electric Vehicle Charging Infrastructure, International Council on Clean Transportation, 2017, P36, https://www.theicct.org/sites/default/files/publicPations/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

[6] https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy

[7] Public attitudes toward electric vehicle: 2016, Department for Transport

However, we recognise the **Charge** solution will not provide the incentive for all consumers and have therefore scaled the benefits to those who have indicated that convenience of recharging would encourage them to buy an electric car or van (19%) [10]. A detailed methodology of the savings identified is provided in Appendix A3.

3.7 Additional Benefits not quantified

In addition to the financial, capacity and carbon benefits identified above, **Charge** will help others' understand the impact of EVs on other factors, such as:

- **Land Use:** Although the **Charge** project will not be able to pinpoint the exact plots of land that will be optimal EV charging locations, there could be a chance to identify plots of land at or, in the vicinity of, suggested areas that could suitable for chargepoint development. This is likely to increase the value of such land and make it more amenable for development. The opposite may also happen. Optimal locations may be identified in geographical regions that form mostly green areas or already developed land that could not easily accommodate charging locations. Hence, the project can help identify challenges with EVs that will need further research to tackle.
- **Patterns of Travel:** Drivers with EVs that will have a need for charging their EVs more frequently may change the way they travel or break en-route or travel to new destinations in order to recharge. The **Charge** project will look at such changes in behaviour and explore how people might spend their time en-route or at destination while waiting for their EVs to recharge and how this could open new business opportunities and regeneration.
- **Technology Advancement:** Shorter battery ranges currently limit the usage of EVs to short range trips and mostly in cities. The **Charge** project findings around optimal charging locations will help accelerate the take up of EVs for the longer-range trips via optimal en-route charging. This could give further confidence to government authorities to change their EV and transport policies to encourage faster EV take up. It could also give confidence to the energy and automotive industry to be more confident in the investment on EVs and their charging to accelerate their take up by the public.
- **Cross industry collaboration: Charge** will establish an enduring legacy of collaboration between the transport and electricity networks sector that doesn't currently exist.

3.8 Project Risks

A detailed risk register can be viewed in Appendix D. The register is based upon the risks we have identified through discussion with key stakeholders, Project Partners, internal stakeholders and our previous experience of delivering NIA and NIC projects.

4 Benefits, timeliness, and partners

Charge is consistent with the national carbon reduction targets within the Carbon Plan and aims to facilitate a low carbon transport future by enabling customers to transition from conventional internal combustion engines to cleaner EVs sooner by facilitating the rollout of charging infrastructure at the lowest overall cost for customers.

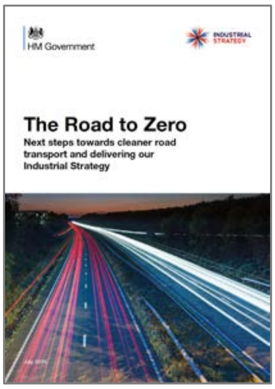
4.1 Criterion (a): Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers

At time of writing, EV sales and overall volumes are progressing well as more vehicle OEMs release new models to the market as they too come under increasing carbon target pressure. Battery prices are tumbling, ranges are extending, and customers are waking up to the world of EVs.

The Road to Zero strategy (July 2018) encourages a further acceleration of EV sales. As stated: "*The Clean Growth Strategy set out a broad range of possible ultra-low emission vehicle uptake levels in 2030 (30-70% of new car sales and up to 40% of new van sales).* ***Our ambition is to reach the upper end of these ranges.*** *We want to see at least 50%, and as many as 70%, of new car sales being ultra-low emission by 2030 to improve the air we breathe, help ensure we meet our future carbon budgets and to build a new market for zero emission vehicle technologies in the UK*."

Feeding into the Road to Zero strategy are several key stakeholder forums including the BEIS/Ofgem Smart Systems Forum and OLEV's EV Energy Taskforce. The project team has representation on both, and notes that the following have been identified as critical matters to be resolved to support this strategy:

- The need for standardised ways to deploy infrastructure across the UK to ensure a more consistent user experience, particularly as EV drivers move from one location to another;
- Safe, secure and low-cost solutions to enable deployment of on-street and destination charging – noting that they are both needed, and have very different user requirements;
- Effective ways to signal network capacity to potential investors to encourage infrastructure investment in the right places



Supporting the development of one of the best electric vehicle infrastructure networks in the world

The transition to zero emission vehicles does not just require the vehicles to be available and affordable. An infrastructure network needs to be in place that is easy for current and prospective drivers to locate and use, and is affordable, efficient and reliable. This is part of our wider plans to have high quality infrastructure to support economic growth and prosperity across all regions of the UK. We will support the development of the infrastructure for electric vehicles as well as for hydrogen fuel cell electric vehicles, where the market is at a much earlier stage of development.

Figure 9: Relevant points from the Road to Zero strategy

Given the above, the DNO needs to act as facilitator to the connection and charging of EVs, and not a blocker. This remains essential in unlocking a critical element of the Carbon Plan, whilst simultaneously facilitating customer choice.

Market based solutions sit comfortably alongside conventional solutions in delivering this change, simultaneously supporting the transition from DNO to the neutral market facilitator world of a Distribution System Operator (DSO).

Charge seeks to tackle many of the above, addressing areas identified in the Road to Zero strategy where there has been limited research and trials to date.

Charge yields financial benefits of **£795m** as outlined in Section 3.4.

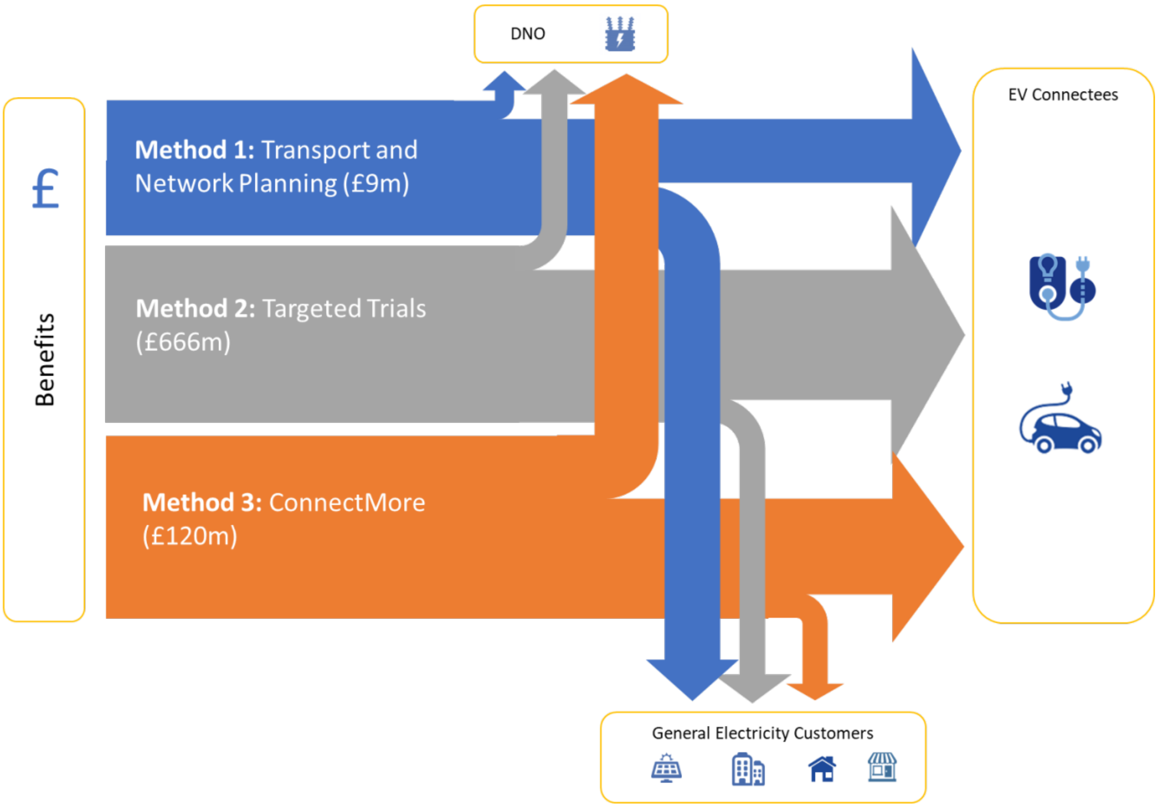


Figure 10: Benefits flow for each Method in the Charge project

The GB rollout scale carbon benefits are provided in Table 3.

Table 3: GB rollout scale carbon benefits

Benefit (t CO_2)	2030	2040	2050
Method 1 Strategic transport & network planning	91,733	530,900	565,801
Method 2 Solutions for challenging EV conns	183,466	1,061,800	1,131,602
Method 3 ConnectMore software tool	642,131	3,716,301	3,960,607
Total	**917,330**	**5,309,001**	**5,658,000**

Further details of the benefits of **Charge** are provided in Appendix A.

4.2 Criterion (b): Provides value for money to electricity distribution Customers

Charge provides excellent value for money to the electricity distribution customer. It has been designed to be delivered in an economically efficient manner and to maximise the potential benefits, without inflicting unnecessary costs on SP Manweb or GB electricity customers.

Since successfully passing ISP, all project partners have been involved in the development of this bid at their costs. SPEN recognise the specific skillsets that each brings to the table and of their necessity in delivering distinct elements of this project.

In addition to the above we have:

- Engaged with PTV Group for their consultancy services in the transport planning space. PTV Group is part of the Porsche SE Group (who also own VW Group) and are market leaders in the provision of transport planning and optimisation software and services. Their software is used to optimise over 2,500 cities worldwide, including several in the UK. The Vissim and Visum software products are also widely used by many transport consultancies to forecast future transport demand and plan transport networks.
- Identified in-kind contributions from all Project Partners as part of the bid as described in Table 6.
- EA Technology have led the development of this bid as part of their in-kind contribution
- Identified Project supporting roles, which will be tendered following signing of Project Direction.
- Compared the costs of **Charge** with other SPEN projects and other similar NIC/NIA/LCN Fund projects.
- Liaised with UKPN to coordinate activity with their Optimise Prime bid, reducing any unnecessary duplication and strengthening the potential learning and dissemination routes from both projects.
- In addition, we have clarified what will be funded within the **Charge**, and what we will be looking for from the public/private sector (e.g. charging infrastructure), further increasing the financial leverage of the project (Table 28 of Appendix K).

4.2.1 Project Benefits

Table 4 outlines the cumulative benefits of **Charge** in discounted NPV terms if rolled out across GB.

Table 4: Cumulative benefits in discounted NPV terms

Cumulative Benefits (£m)	2030	2040	2050
Method 1 Strategic transport & network planning	£8.6	£8.6	£8.6
Method 2 Solutions for challenging EV connections	£7.0	£548.5	£666.4
Method 3 ConnectMore software tool	£119.7	£119.7	£119.7
Total	**£135.3**	**£676.8**	**£794.7**

The NIC funding request for **Charge** is c£6.85m, which if successfully delivered across all three Methods has the potential to yield a benefit of £795m.

Table 5: Ratio of funding to benefit from other successful LCN Fund / NIC projects

Project	GB Net Benefit (£m)	NIC Funding Request (£m)	Benefit: Funding Request Ratio
CELSIUS	583	4.7	123:1
FALCON	659	12.3	53:1
Smart Street	692	8.4	82:1
OpenLV	595	4.9	123:1
Charge	795	6.85	116:1

Project cost

4.2.2 Project cost

The total cost estimate of the project is constructed based on our initial stakeholder engagement and potential number of trial sites considered.

A breakdown of the project costs against each participant and work packages can be seen in Figures 12 & 13. The total project costs summate to c£8.55m. The Project costs reflect input from our partners. Each Method has been developed at a scale which is essential to ensure it will deliver the required learning. This learning will be captured and disseminated in such a way that other DNOs can adopt these Methods quickly and effectively. The following key points show that a robust methodology has been employed to estimate costs:

- Costs have been calculated using a bottom up and top down methodology;
- Estimates from multiple potential suppliers has enabled SPEN to validate cost estimates;
- The methodology employed to estimate overall projects has drawn on the significant experience within the project consortium from other innovation projects; and
- Potential project suppliers have provided budgetary estimates of the equipment and associated services.

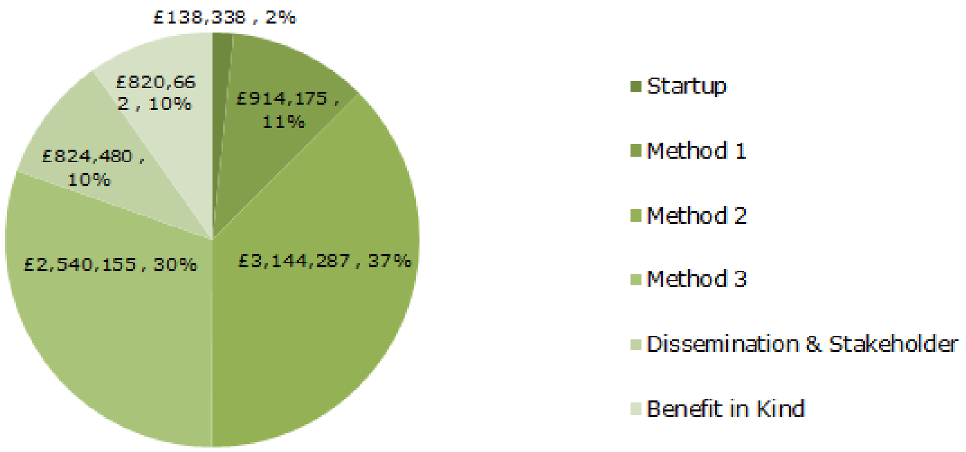


Figure 11: Charge Project cost breakdown by Activity

[redacted]

Figure 12: Charge Project Cost Breakdown by Partner

The following table below outlines the costs split per method by project partners.

[redacted]

Table 6: Project cost split by method and Partner

*Includes proportion of dissemination costs (websites, materials, etc.), which will be subcontracted

It is planned to carry out a competitive procurement to identify other project suppliers who could provide both equipment and monetary contribution towards the live network trials. We also plan to collaborate with other parties to build upon the learning provided by relevant projects; such as FUSION and the ENA Open Networks projects.

All the required services and equipment are available from multiple sources, making competitive selection the most appropriate route for this Project to ensure best value.

4.3 Criterion (d): Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

Each year SPEN releases an Innovation Challenge which is open to all. The purpose of the Innovation Challenge is to work in partnership with industry and academia to identify innovative solutions to the biggest challenges that we face across the transmission and distribution networks and aligned to the SPEN Innovation Strategy.

A total of 46 innovative ideas were received to the 2018 call which were assessed against the NIC funding criteria and SPEN's priority areas for innovation. EA Technology and Smarter Grid Solutions each provided proposals in line with the SPEN strategic priority of supporting the electrification of transport. **Charge** is a combination of project ideas submitted by both organisations and was submitted as such at ISP.

4.3.1 First time that transport and network planning have attempted to be integrated

The project is globally innovative in its ambition and scope to combine transport planning, network planning and stakeholder requirements with the deployment of innovative connection solutions. Experience of demonstrating the interdependencies of different energy vectors will generate significant learning and develop new standards to facilitate, and accelerate, the transition to a low carbon economy.

Previous innovation projects have explored the impacts of EV integration at a domestic scale. However, none have investigated the impact of EV integration across multiple customer groups nor sought to combine transport and network planning for strategic gains across a licenced area. There is also little understanding of how the transport sector can be integrated with the future DSO which has huge potential to be a key DSO enabler.

4.3.2 These trials have not been done before

There is a strong need for innovative solutions for the connection of high power EV chargers. Utilities must understand how these can be managed both efficiently and economically and develop control systems and connection standards to manage these high intensity and potentially bi-directional resources intelligently. There is a strong need to develop new technical and commercial charging solutions for customers without access to slow/fast domestic chargers.

Each of these requires innovative solutions and none currently have the proven business case which is required. Furthermore, a review of the key learning of past and present projects complete in the UK, completed in collaboration with UKPN's Optimise Prime proposal clearly identified where **Charge** sits; demonstrating the additionality of the project over and above the current state of the art (Appendix J).

4.3.3 Finding better ways to engage with potential connectees

Modelling and demonstration of such infrastructure comes with an inherent risk while the demand for such capability does not yet exist and EV penetration is low. Access to a wide range of EV charging facilities is a clear enabler of EV uptake and without a clear strategy for developing a charging infrastructure, the EV market is unlikely to grow at the rate required to hit carbon reduction targets. The market requires innovative charging management and control solutions, and the relevant demonstrators to prove and enable the deployment of such infrastructure for connectees. Until these risks are mitigated through projects like **Charge**, the business case for commercial deployment, and the technical ability to do so while safe guarding the network, will remain unknown.

4.3.4 Seeking to affect widespread deployment during the project

Charge will seek to engage with stakeholders whilst the project is in flight, success will be getting more chargers deployed during the project (as part of a much wider deployment under BAU – with others' money, than planned). SPEN has engaged extensively with stakeholders prior to building this proposal and we intend to carry on with this route to ensure that it remains fit for purpose given the rapid pace in this sector.

4.4 Criterion: (e) Involvement of other partners and external funding

Our stakeholders have informed the development of **Charge,** highlighting the need for a collaborative approach as key to the facilitating the rollout of charging infrastructure. To make well-informed project decisions, a wide ranging and well-rounded consortium of Project Partners and project stakeholders both local to the trial area and Partners working across the GB energy market has been assembled to form a detailed project. Each partner brings extensive experience and understanding to the project, with significant commitments shown to develop the proposal at their costs and to continue to provide generous in-kind benefit during the project.

Further details of the partner experience are available in Appendix I.

Table 7: Charge Partners

Partner	Project Role	Support & Funding
EA Technology	• Principle Technology Development partner for Method 3 • EA Technology worked closely with the SPEN team to create and shape **Charge** including the ISP and this bid document	Bid preparation Consultation benefits-in-kind
PTV Group	• Principle technology partner for Method 1	Software licence
Smarter Grid Solutions	• Principle technology partner for Method 2	Consultation benefit-in-kind

In addition to Project Partners a significant number of stakeholders have been identified who will benefit from the project deliverables and will be key to ensure that **Charge** meets expectations and delivers benefits. From key stakeholder the project will establish a Stakeholder Panel who will be outside of the core project team to ensure **Charge** is delivering value to their stakeholders, businesses and citizens.

4.5 Criterion: (f) Relevance and timing

Given the recent push towards low carbon transport we also believe the timing of the project is right and will deliver new tools & systems which will be critical enablers of a low carbon transport future. This project will deliver innovative solutions which have not been demonstrated before within GB.

The project is extremely timely before the network begins to experience significant strain from the connection of EV's.

The transition from fossil fuelled vehicles to low carbon transport is widely accepted to be a critical factor in reducing both greenhouse gas emissions and improving air quality in densely populated areas. All vehicle manufacturers have, or are bringing out, bigger and better electrified cars and vans, and consumers are accepting these as a viable alternative to liquid fuelled vehicles. The evidence is building that these vehicles are here to stay, and that our electricity networks will have to accommodate the changes in demand that come with this transition.

The sector is moving at pace, the right solutions need to be agreed quickly to ensure Britain's electricity networks are an enabler, and not a blocker, to this transition.

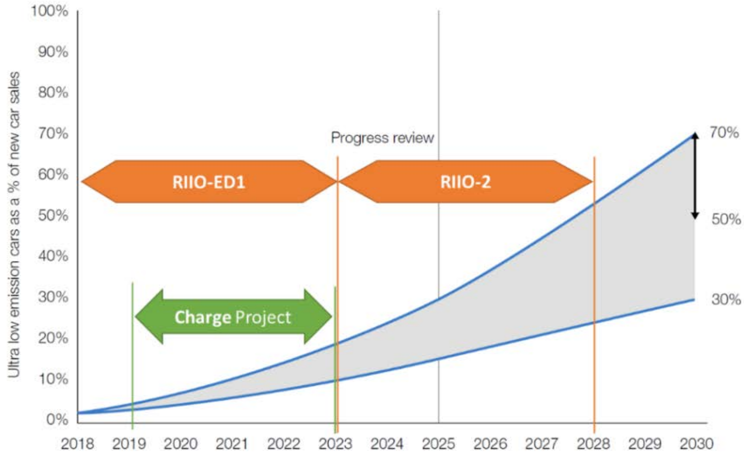


Figure 13: Charge in the context of the Government's Road to Zero strategy[8]

Both OLEV's Road to Zero[9] strategy, and the National Infrastructure Commission's National Infrastructure Assessment[10] are now looking into accelerated EV adoption, with between 50-70% new cars sales being EV by 2030. The National Infrastructure Commission goes further, recommending:

- *that government, Ofgem and local authorities should enable the roll out of charging infrastructure sufficient to allow consumer demand to reach close to 100% electric new car and van sales by 2030;*
- *That Ofgem should commission electricity network operators to work with chargepoint providers to identify potential anticipatory investments required to accommodate pubic charging infrastructure. With opportunities for investment identified by summary 2019.*

If these recommendations are delivered, the profile of public charging deployments will resemble Figure 14, below.

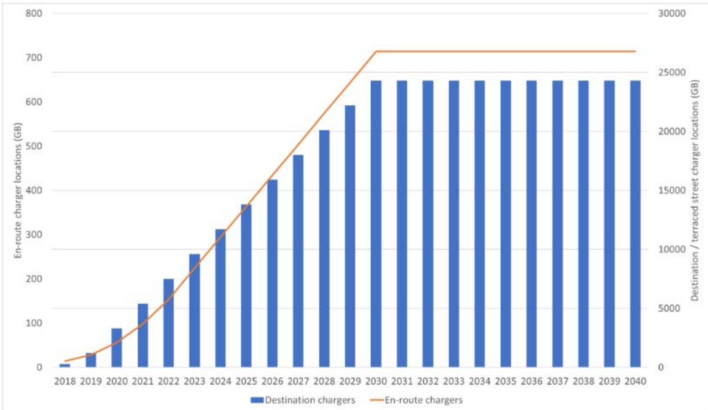


Figure 14: Ramp-rate of charger volumes across GB in line with CCC and National Infrastructure Commission recommendations

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[8]Extract of Figure 1: "Illustrative ultra-low emission car uptake trajectory as a percentage of new car sales", from the Road to Zero, over-laid with this project and forthcoming RIIO Price Control periods

[9]Road to Zero: Next Steps towards cleaner road transport and delivering our Industrial Strategy, HM Government, July 2018

[10]National Infrastructure Assessment, National Infrastructure Commission, July 2018

Charge will provide network companies and stakeholders with the tools and visibility needed to enable the uptake of EVs in a cost efficient and timely manner. It also aims to facilitate the uptake of EVs by demonstrating the benefits of innovative technical and commercial charging solutions and developing the policies to support widespread adoption. This will provide commercially viable solutions for connectees. Its timing allows outputs to be fed into the RIIO-2 process:

- **Inform long term network investment plans:** the methodology used to create and maintain a DNO licence level Master Plan (Methods 1 & 3) is designed to inform the network investment plans required by each DNO during future price control periods. This detailed roll out plan will give confidence that investment plans provide the lowest cost solutions and justification for the just-in-time investment decisions required to accommodate EVs.
- **An informed long-term view on load related reinforcement:** across the distribution network will also ensure that capacity is made available for EV charging as soon as possible removing any delays that may hamper the uptake of low carbon transport.
- **A clear strategy and Future Transport Master Plan:** across the licenced area, which is coordinated across all stakeholders, would bring the DNO to the heart of the transition to a low carbon transport sector and ensure access to charging for EVs is made available to customers at lowest possible cost. As demonstrated by the uptake of Photovoltaics, a disjointed and fragmented approach often does not represent value for money and leads to a slower and a more costly uptake for customers.

5 Knowledge dissemination

5.1 Learning Generated

Charge will deliver significant new learning which will reduce the costs of connection and accelerate the deployment of EV charging for both connectees and network operators in their business as usual approaches.

In developing **Charge**, we have worked closely with DNO colleagues from UKPN and SSEN who are taking forward Optimise Prime, leveraging work packages and dependencies to ensure a coordinated and cost-effective approach can be utilised. Although both of our respective projects are unique in what they are seeking to trial, we acknowledge that there are some complementary activities that can be coordinated and delivered where practicable to release greatest value to UK electricity consumers.

In addition, all the GB Electricity Networks have met via the ENA to discuss the 2018 NIC submissions. The GB Electricity Networks Operators presented their proposed project and discussed the scope to ensure that there was no duplication. In terms of collaboration, where appropriate Network Operators have partnered on certain projects, and have agreed to input and share the learning throughout the course of the projects.

The following key results and learnings from the project are captured below as 'Quick Wins' that will be disseminated during the project:

Terraced Streets: We'll look at typical terraced streets in the UK and answer key questions such as how many EVs can we feasibly connect to lamppost charge points? Is there any space to install additional chargepoint infrastructure? And are these solutions really a cost-effective way to facilitate the domestic EV roll out?

Destination: We will explore the feasibility and cost of installing additional storage or other DER devices in destination locations. Is there space for it? Is there a cost-effective way to manage large volumes of EV chargers? Do we gain much more from having additional DER devices to flex the charging of EVs or provide flexibility services to the DNO?

Information for EV Charge Point Operators: Quick wins from the analysis in M1 and M2 will identify areas of the network which have the network capacity and the land capacity for EV chargepoint locations.

5.1.1 Outline of incremental learning

Charge will generate new knowledge in the following ways:

- Improved understanding of charging profiles and ADMD for EVs in the following locations; residential with no off-street parking (both terraces and apartments / flats), destination and en-route chargers.
- Improved understanding of customer flexibility. This includes the appetite and ability of different customers groups in different locations to trade charging speeds for availability and pricing.
- Technology connections options. Proven techniques and guidance for wide scale deployment of EV chargers addressing the identified networks types. Including flexible connection options in areas of network constraint.

Method 1:

- Understanding of how to align the needs of transport planning with electrical network planning
- Identification of early investment requirements and methods to signal to interested parties to accelerate adoption
- Identification of current and future network flexibility requirements based on customer's needs, technology ramp rates and existing network capacity.

Method 2:

- Outputs from the Assessment Phase: Least-regrets solutions for immediate deployment; defined activity for trials; smart solution tool box and cost benefit analysis
- Output from Limited Pilot: installation guidance documents; learning for next stage of trials
- Outputs from Broader Trial: Refinement to installation guidance; data and analysis from deployment of smart solution tools; extensive data set and statistically robust results on user behaviour.
- Outputs from Review Phase: Robust financial case for a range of solutions; policy support information; customer messaging strategies; guidance and workshops around Business as Usual adoption of solutions and approaches

Method 3:

- The provision of integrated tools to support customers and connectees with future connection applications
- A future proofed software tool that allows new solutions to be deployed at scale as they become available.

5.2 Combining learning from other projects

Charge builds on learning available from other network innovation projects; this is a key process in the GB network innovation model adopted by Ofgem, and highlights the interaction of SPEN with other DNOs, and progressive nature of innovation within SP Manweb.

We have recognised the potential link between UKPNs NIC proposal, Optimise Prime, and **Charge**. Through our discussions to date, it is clear that each project is distinct and complementary. Optimise Prime we see as distinct, by focusing on commercial EVs and gathering operational data from a significant number of fleet vehicles it will create a unique new dataset that will add to the global body of knowledge in this area. Whereas **Charge** will be focusing on the Transport and Network Planning and solutions to accelerate the connection of critical charging infrastructure.

Through collaborative discussion with UKPN the following radar plot of the current level of understanding (TRL level) has been assessed.

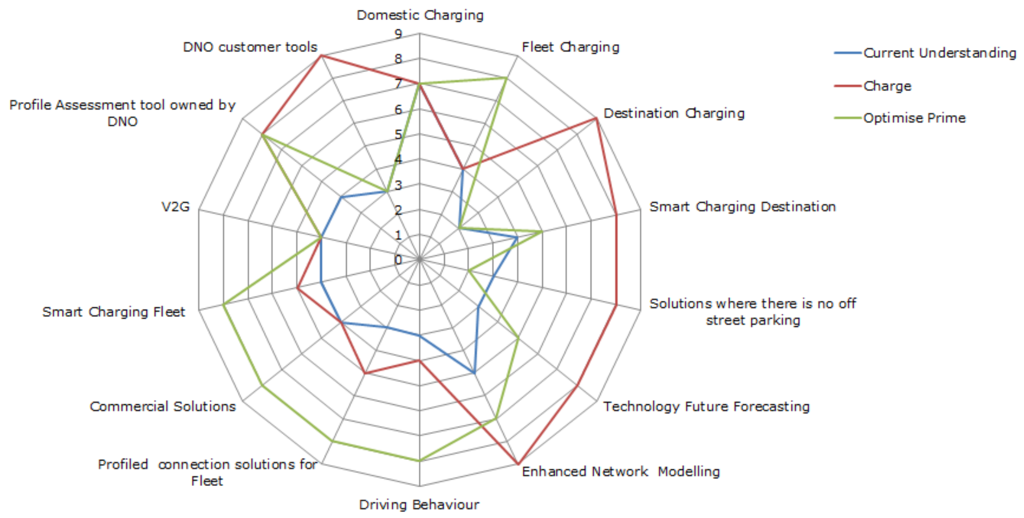


Figure 15: Radar plot of Charge in the context of current industry knowledge (TRL) and UKPN's Optimise Prime bid

5.2.1 Applicability of new learning to other DNO licensees

Charge will provide valuable inputs to the RIIO-2 process, providing DNOs, investors and Ofgem with mitigation solutions and strategic plans to accelerate EV roll out in a safe and secure manner:

- The learning from Method 1, linking the approaches from transport and network planning, will be applicable to all other licence areas.
- The trials identified in **Charge** have been structured to target gaps of existing NIC/NIA projects in this space, including UKPN's Optimise Prime bid.
- Whilst, SP-Manweb is being used as the trial location we will be seeking to engage with other licence areas as part of the desktop analysis (Method 2), to ensure we target issues that are common with other licence areas – making the outcomes highly replicable.
- The ConnectMore software will be built in such a manner to enable new solutions to be dropped into the tool as and when they become available. This ensures a degree of future-proofing, to incorporate the current state of art.

5.3 Learning Disseminated

Learning and knowledge dissemination derived from the project will be tailored to suit the interests, objectives and relevance of each stakeholder group identified. Our approach to learning and knowledge dissemination will draw upon experience and activity undertaken through our ongoing innovation portfolio ensuring that material developed is pragmatic, simple, regular and targeted and makes use of a variety of mediums to engage and impart knowledge to a range of stakeholders.

Our aim is to continually improve how we engage with key stakeholders across all aspects of our business, allowing them to influence and guide our activities, enabling us to better deliver the outputs and benefits of **Charge**.

Our strategy is based upon the globally recognised AA100 SES, the three principles of which are:

1. **Inclusivity:** Our customers' opinions matter to us and we are committed to achieving better outcomes based on their insight and those of all affected by the work of SP Energy Networks
2. **Materiality:** We pinpoint the issues that are most relevant to us and our stakeholders and prioritise effectively
3. **Responsiveness:** We respond to feedback from our stakeholders and take action to improve performance

5.3.1 Stakeholder engagement

Our dissemination activity will be managed through our Stakeholder and Knowledge Dissemination work package. The key role here is to ensure that the most appropriate information is provided to the most relevant stakeholder group that will be delivered through a range of communication channels. Whilst some of the learning will only be generated towards the backend of the project timeframe, learning will be disseminated as soon as the appropriate analysis and/or trials have taken place and the learning generated has been rigorously assessed.

We will use a range of mediums to engage with industry stakeholders, a summary of which are detailed below:

- Six Monthly Progress Reports
- Multimedia, Podcasts, Social Media
- External Partners and Stakeholders Steering Group
- Internal dissemination
- Conferences and Targeted Dissemination Workshops (National & Trial Area Specific)
- Press Releases
- Closedown Report

In addition, our communication strategy will include the following:

- **Charge website**: A dedicated webpage will be established for **Charge** with the primary aim to raise awareness and provide access to all material and outputs. Interested parties will be encouraged to interact with the website helping to share information and receive feedback based on existing learning from other parties.
- **Technical Recommendation papers**: **Charge** will provide an opportunity to establish new engineering recommendations which will be submitted to the ENA for review. This will improve the industry's understanding of the impact of charging options from destination to en-route charging and the potential impact on the network.
- **Joint dissemination events with UKPN**: To leverage best value for the customer and to ensure that learning can be clearly disseminated annual joint collaboration events will be arranged between ourselves and UKPN. This will provide an opportunity for interested stakeholders to learn about the projects and latest developments.
- **LCNI conference:** We will present the learning of **Charge** during the LCNI conferences that will take place throughout the course of this project as highlighted in the project plan.

- **Webinars**: in order to reach a wider audience and provide opportunity for external stakeholders to learn about the project a number of webinars will be hosted by SPEN and the project partners covering different aspects of the project.

5.3.2 Intellectual Property Rights (IPR)

Charge will conform to the default IPR principles as defined in v3.0 of the Electricity Network Innovation Competition Governance Document. It is not anticipated that the project will develop foreground IPR that will fall outside the default IPR requirements.

5.3.3 Intellectual Property needed to deliver the project

The main Background IP that will be brought into the project from the Partners is:

- PTVs Visum and Vissim software packages;
- EA Technology's NPADDS HV modelling methods (mostly developed as part of the CLNR project) i.e. Royalty-free, non-exclusive for DNOs;
- EA Technology's DEBUT network assessment software;
- Smarter Grid Solutions' ANM Strata solution as outlined in Appendix E.

Each of these products will be uniquely configured and developed further for this project to ultimately create significant Relevant Foreground IP which can be deployed to other DNO licence areas.

5.3.4 Roll out model

The principles, methodology and functionality used in **Charge** will be readily accessible, and can easily be transferred, read, and even modified and extended, by all GB energy market stakeholders.

The software produced can be deployed according to the following model:

- The software developed by PTV Group for the project will be made available to other transport planning organisations, allowing replication for other parts of GB
    - There would be additional costs to adapt the analysis to the specific locality of each DNO as a service offered by PTV or transport planning consultancies experienced in using PTV software
- The ConnectMore software developed in the project will be available as a no-charge licence to GB DNOs. However, there would be additional costs for:
    - Integration with DNOs datasets
    - Configuration of the tool to work with differing data approaches
    - Alignment with each DNO connection policies
    - Setup, hosting and support fees

6 Project Readiness

The requested level of protection against cost over-runs and unrealised direct benefits is 0%.

6.1 Can be started in a timely manner

The following points provide the evidence that this Project is ready to start in January 2019. Sufficient time has been incorporated at the start of the project to get commercial agreements in place and mobilise the Project Partners.

6.1.1 Key Partners are engaged

SPEN has recognised that it needs professional support to deliver **Charge** and has engaged with three key organisations:

- **EA Technology** a world-leader in products and services which enhance the performance, reliability, safety and cost-efficiency of electrical power networks.
- **Smarter Grid Solutions** a world-leading DERMS software provider, serving Distribution Utility, System Operator and Energy Asset Operator customers around the world.
- **PTV Group** who improve mobility and transport by using world-class software, data and scientific know-how gained from four decades of experience in planning and optimising the movement of people and goods.

The collective project team has a strong track record in delivering the sorts of complex projects within consortia in line with the Network Innovation Competition and LCN Fund, as detailed in the Appendix.

Each organisation has committed to work together to deliver the project.

6.1.2 Key stakeholder and letters of support

Key stakeholders have been actively involved during the process of developing this proposal. From the initial concept, through the Initial Screening Proposal stage, to full development, stakeholders have shaped and influenced **Charge**. This will continue to be the case and we are confident in their ongoing support for the project. A full list of the project partners and stakeholders can be viewed in Appendices I & K.

If successful a full engagement strategy will be developed early in the project to ensure that existing and new stakeholders can actively get involved with the project.

6.1.3 Senior Management commitment from SPEN and the Project Partners

Directors from SPEN along with EA Technology, Smarter Grid Solutions and PTV Group are fully engaged with the project. The Board of SPEN, and the Partners are briefed on the Project, its scope and drivers.

6.1.4 Building on previous IFI, LCN Fund, NIC & NIA projects

SPEN, along with key Partners (EA Technology), have experience of taking innovation projects from inception to successful completion and final closedown. The valuable lessons learnt from working on other innovation projects will be fed into the **Charge** NIC project.

SPEN is recognised as one of the most innovative network companies and has successfully delivered, and transitioned, into Business as Usual, a range of internationally recognised projects; including wide scale deployment of Active Network Management in Dumfries and Galloway (IRM). EA Technology is currently working in collaboration with several DNOs on NIC and large NIA projects. The experience gained through the successful and valuable output from these projects will help to ensure that the project starts in a timely way. A key learning point in the seamless transition from bid to delivery in both SPEN and EA Technology's previous LCN Fund projects has been dovetailing the Bid Delivery team with the Project Delivery team.

On this basis, the key personnel from both organisations that have developed the Full Submission Pro-forma will also be responsible for project delivery.

6.1.5 Effective commercial / governance arrangements

The project will be commercially structured as shown in Figure 16.

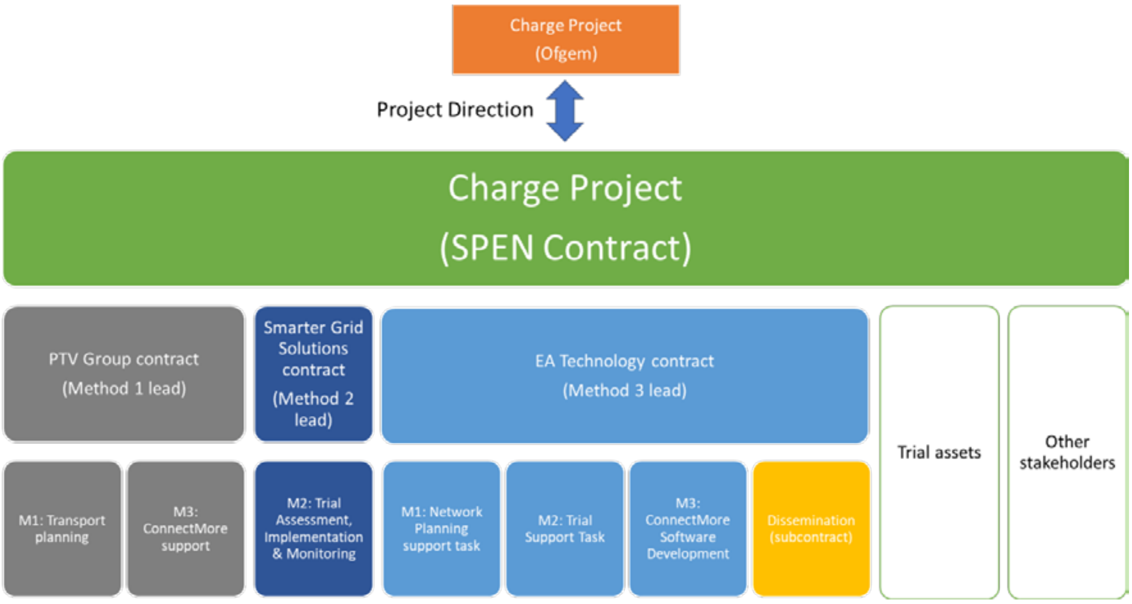


Figure 16: Charge project contractual structure

SPEN will act as principal contract holder, managing the relationship with Ofgem, and contracting with the three identified Project Partners.

This approach blends the project delivery arrangements from projects such Flexible Networks and Accelerating Renewable Connections.

Charge will follow the project teams experience in delivering innovation projects with the development of a Management & Delivery document. This will be common across all Partners and will support the delivery and management of the project in line with Ofgem requirements. The Management & Delivery document will:

- Create an agreed governance structure for the project;
- Outline common project controls for the project including the internal reporting and approval processes, and the gateway review and escalation processes;

- Support the consistency of delivery across projects throughout SPEN's innovation programme and enable visibility of the project to the SPEN Innovation Manager in line with existing projects in the programme;
- Support reporting to the senior management team and Project Sponsor; and
- Assist with the coordination between projects where appropriate, facilitating continuous improvement and ensuring compliance.

The project governance includes:

- a Project Board comprising SPEN Senior Management and Partners, key stakeholders, and SPEN's senior management;
- a Project Stakeholder Group comprising key members of the Project team together with a range of external interested parties.

Both roles are described in more detail in Section 6.1.6.

6.1.6 Experienced Project delivery team

The project team has the resource and experience to deliver the **Charge** project. The figure below outlines the organisational structure of the delivery team.

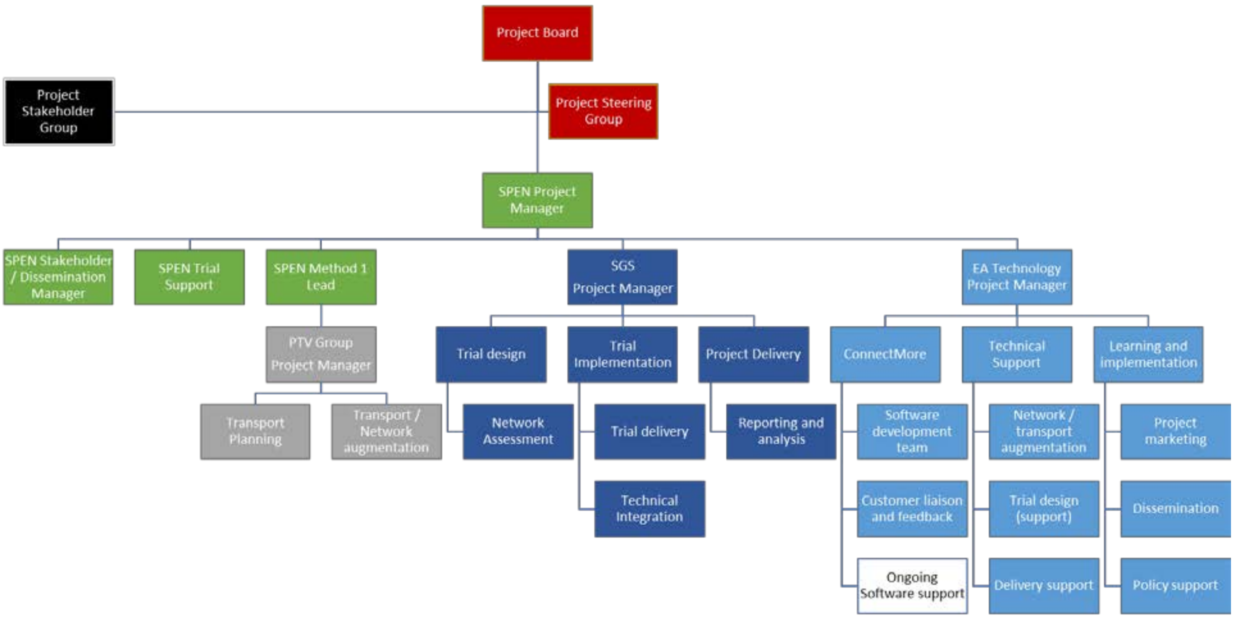


Figure 17: Charge Organogram

The resources are of a sufficient size and quality to be reasonably expected to ensure the project's delivery. The key roles required to deliver the project are:

- **Project Board:** Made up of key representatives from each of the Project Partners. Its purpose is to ensure the project is suitably resourced to deliver in line with the project bid, meeting on a quarterly basis. It will be chaired by the Project Sponsor, a Director of SP Energy Networks.
- **Project Stakeholder Group:** A wider set of interested parties to steer and shape the project, including identification of trial locations, funding routes and as a route for dissemination. We intend to tie into the existing SPEN stakeholder sessions to leverage existing contacts and relationships, expanding these where possible. We will invite Ofgem and OLEV to sit on this group.

- **Project Steering Group:** This will be an operational group consisting of the SPEN project manager and the working teams from each Project Partner. It will meet on a minimum of a monthly basis to ensure delivery is maintained, and issues addressed.
- **SPEN Project Manager**: The person appointed by SPEN to ensure the project delivers in line with this bid, including management of budgets and reporting progress to Ofgem.
- **SPEN Stakeholder/Dissemination Manager**: The person appointed to support the project with Stakeholder engagement and dissemination.
- **SPEN Task Managers**: A person responsible for managing the interface between SPEN and the Project Partners for key tasks.
- **Partner Project Managers**: The appointed person from the Project Partners responsible for managing delivery within their organisation.

Further detail is available on request.

6.1.7 Streamlined procurement process and selecting Project collaborators

All Partners requiring subcontractors to deliver **Charge** will operate an open and competitive procurement process for the services and equipment required to deliver the project.

This will follow tried and tested processes from other NIC/NIA projects, with evidence provided to SPEN to demonstrate value for money to customers.

6.1.8 Project logistics and the Project Plan

A Project Plan with key milestones and deliverables is available in Appendix C and provides a firm footing for detailed design activities to take place in a timely manner.

The project will be delivered using the following principles: 1) Mobilise & Procure, 2) Design, 3) Build, 4) Trial and 5) Consolidate & Share.

We have incorporated a project mobilisation and design phase at the start of the project. On previous projects this has been found to significantly de-risk the construction phase of the Project, allowing the equipment installation activities to begin as scheduled and with reduced uncertainty.

6.2 Measures to be taken to minimise cost overruns

The following key points outline the measures that SPEN has employed to minimise cost overruns and shortfalls in direct benefits:

- The costs have been calculated using a bottom-up and top-down methodology;
- Costs for commodity items have been used where possible to provide a greater level of certainty;
- In line with the development of the model and the Trials, the project has been broken down into separate and distinct work packages to provide a detailed overview of each area;
- Strong governance, that is already in place, will be used with project tolerances and KPIs monitored by SPEN senior management;

- Through a detailed design phase, uncertainty in the project will be reduced at an early stage;
- Risk management processes will be implemented throughout the project: In keeping with standard innovation project risk management processes, every risk will be assigned an owner, based on the risk rating and the ability of the individual to manage the risk. The initial Project Risk Register is available in Appendix D.

6.3 How the Project plan will still deliver learning in the event of fewer Trials

The project trials defined in Method 2 have been constructed with stage-gates that will be managed as part of the project governance.

- Before moving to trial, the project will undertake detailed desk-based assessments of a broad range of real networks to understand the likely challenges and cost-benefits to deliver accelerated EV adoption in each target area.
- The trials will be based on an assessment of replicability, likely learning as well as ease to deploy.
- The project team has already engaged with many local councils and stakeholders on potential trial locations and will continue to work with these parties to establish trials.
- If any of the individual trials are cancelled for any reason, the Project plan will still deliver learning from deploying best available learning of customer behaviour into the model development. In this way, each of the field trials is a standalone item on which the success of the entire project is not dependent.
- A measure of success of the project will be to encourage the private sector to fund large scale deployment, during the project timescales.

Key project risks have been identified in the Project Risk Register. This will be a living document which will be updated throughout the course of the project.

6.4 Process to identify circumstances to suspend the Project

The following processes are in place to identify circumstances where the most appropriate course of action will be to suspend either an individual trial or the entire Project, pending permission from Ofgem, that it can be halted. This approach will give all the parties involved clarity and consistency from the outset.

6.4.1 Gateway Reviews

To ensure that the Project proceeds smoothly, gateway reviews have been incorporated at critical stages in its lifecycle, which are clearly indicated in the Project Plan. These include review points between the Work Packages.

The aim of each gateway review is to assess whether the Project can progress successfully to the next stage. They provide assurance that the Project is on track and being run in an efficient and cost-effective manner and give further assurance to stakeholders and Project team members alike that the Project can proceed.

The gateway review is a snap-shot at the point at which the review takes place. As such, recommendations are based on the documents provided and the review process is intended to be supportive and forward looking.

Senior Management from SPEN and the Partners will assign a status in the form of a Delivery Confidence Assessment. This assessment will then provide the Project team recommended actions. Actions fall in the following categories:

1. **Critical (Do Now):** to increase the likelihood of a successful outcome, it is of the greatest importance that the Project should act immediately;
2. **Essential (Do By):** to increase the likelihood of a successful outcome, the Project should act soon. Whenever possible, essential recommendations should be linked to Project milestones and/or a specified timeframe;
3. **Recommended:** The Project would benefit from the uptake of this recommendation. If possible, recommended actions should be linked to Project and/or a specified timeframe;
4. **Halt the Project:** The Project has exceeded the tolerances set and agreed at Project initiation and the situation is deemed to be irrecoverable. The Project is to be halted and SPEN senior management will contact Ofgem to discuss and agree the way forward.

6.4.2 Regular Project Review Meetings

Senior Management from SPEN and the Partners, together with the appointed SPEN Project Manager, will:

1. Be briefed on Project progress;
2. Review the Project Plan, cost model and the Risk, Assumptions, Issues and Dependencies (RAID) log;
3. Approve key outputs and milestones since the previous meeting;
4. Assess delivery against the Successful Delivery Reward Criteria;
5. Discuss and recommend Project changes;
6. Document and review actions;
7. Assign an overall Red/Amber/Green (RAG) status to the Project, where red means the Project has severe delays affecting output, amber means the Project has delays affecting output or additional cost are required to deliver outputs on time and green means the Project is on time and budget.

6.4.3 Proactive risk management

Our project risk controls are a subset of the overall risk management. The risk management objectives are to:

- Ensure that risk management is clearly and consistently integrated into the project management activities and evidenced through the project documentation;
- Use SPENs risk management processes and any governance requirements
- Anticipate and respond to changing Project requirements.

These objectives will be achieved by:

- Defining the roles, responsibilities and reporting lines within the team for risk management;
- Including risk management issues when writing reports and considering decisions;
- Maintaining a risk register;

- Communicating risks and ensuring suitable training and supervision is provided;
- Preparing mitigation action plans and contingency action plans;
- Monitoring and updating risks and risk controls on a regular basis.

6.5 Verification of all the information included in the proposal

It is confirmed that:

- The Project proposal has been prepared by SPEN in conjunction with EA Technology, with information provided from other potential project collaborators and equipment suppliers;
- The bid has been prepared by an experienced team of engineers, in partnership with dedicated Project Managers from SPEN, EA Technology and other Partners;
- The proposal has been independently checked and peer reviewed to ensure the accuracy of information;
- The technical sections of the Full Submission Pro-forma have been reviewed by experts, which were not directly involved in the bid formulation;
- Information from Partners, service providers and equipment suppliers has been reviewed by SPEN to ensure accuracy;
- The Project submission has been reviewed following the Data Assurance Guidelines (DAG) and signed off by Directors of each Partner company.

7 Regulatory issues

Charge is within the scope of Ofgem NIC governance and industry regulations. It is not anticipated that the project will require any derogations, exemptions or changes to the regulatory arrangements.

At the heart of **Charge** lies the willingness to work collaboratively with a range of stakeholders to develop new connections solutions and standards and to maximise existing capacity within the distribution network; enabling customer's greater choice and a streamlined connection process. The development of the ConnectMore tool will enable greater visibility of network constraints, EV chargepoint connection solutions and flexibility requirements, and aligns closely with Ofgem's stated objective to make the electricity system more flexible, removing potential barriers that may prevent the system to benefit from the full value of flexibility.

Under the **Charge** project it is not the intention for SP Energy Networks to own or operate chargepoint infrastructure.

7.1 Derogations

No derogations will be required to deliver the Methods outlined in the **Charge** project.

7.2 Licence consent

Charge does not require any additional Licence consents for the three project Methods.

7.3 Licence exemptions

Charge does not require any licence exemptions

7.4 Longer term regulatory impact

As the UK transitions towards the electrification of transport, the connection of chargepoint infrastructure will become increasing complex as networks become more highly constrained. **Charge** will develop new learning and engineering recommendation to expedite the connection of chargers whilst ensuring that the network continues to be resilient to meet current and future requirements.

Charge intends to work closely with fellow GB DNOs, the Energy Networks Association (ENA), Ofgem and key stakeholders to provide recommendations to changes that may be required to the relevant connections and charging codes. Outputs from the project will likely provide learning and technical understanding around network access and charging arrangements and the benefits of using the network at different times and locations. This will be essential to encourage customers to use the network at times or places where there is spare capacity, and so reducing the need for new investment. **Charge** will provide solutions and technical guidance to connect to the network, providing new arrangements to enable better allocation of capacity.

8 Customer Impact

8.1 Interactions with Customers

8.1.1 Customer Engagement and Data Protection Strategies

We will take best practice from other projects such as SSEN's My Electric Avenue or WPD's Electric Nation to develop Customer Engagement and Data Protection Strategies early in the project. This will be carried out well before any customer recruitment activities are undertaken and shared amongst Project Partners and other subcontractors to ensure we protect and safeguard the interests of our customers.

8.1.2 General Stakeholder Engagement

The success of **Charge** will be hinged on the ability to engage positively with a wide range of stakeholders, ensuring that deliverables meet expectations and outputs develop solutions which can realise significant benefits for all customers. We will therefore ensure that clear information is developed, and responses provided to any customer enquiry in a timely manner.

As part of all Stakeholder Engagement activity, we will consult with stakeholders on the data we collect and be mindful of our need to comply with obligations under GDPR.

We will discuss with stakeholders on the details before publication of any output as it is understood that information we generate can be sensitive to the organisations we consult with.

We will develop clear Terms of Reference for all Stakeholder Engagement activity to define the process and approach in detail and describe our procedure for handling the relationship, information we share and data we collect.

8.2 Direct impact the Project may have on Customers

Charge will demonstrate innovative connection solutions at a range of case study locations. The solutions will be installed using SP Energy Networks' standard policy and procedures, minimising the impact of local customers and minimising interruptions of supplies. **Charge** will not adversely affect the service that any distribution connection customer receives currently.

The trials may vary charging rates on public charging infrastructure. It will be vital that this is communicated with customers in an upfront manner allowing them to assess whether the equipment will meet their needs. We will work closely with chargepoint manufacturers, land owners and installers to ensure that appropriate information is passed to customers before their charging transaction begins.

The Project, with the deployment of smart charging solutions will have an overall positive impact on customers, potentially delivering additional EV chargepoint capacity with no additional connection costs.

8.2.1 Trial Testing Process

To minimise the risk to the distribution network and customers' charging being unduly interrupted, all technology solutions deployed under the Project will undergo thorough testing prior to installation on to the network. We will work closely with our standards team and fellow network operators to ensure the testing covers all aspects critical to the reliability, resilience and safety of the solutions.

The process will follow other projects of similar nature:

- User, safety and resilience requirements are defined and agreed;
- A testing specification for Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) is defined and agreed;
- The FAT is conducted and issues log raised. Either pass issues onto SAT or rerun FAT;
- Conduct SAT to ensure the equipment is operating as expected in the site location.

8.2.2 Treatment of data

Any data published as part of the learning reports, will be anonymised to protect the commercial interests of all parties participating in the trial unless prior agreement is provided by the customers that information can be made available.

We will discuss and agree the publication of data and communication preferences with all stakeholders in advance to ensure good relationships are maintained throughout the project. We will ensure full GDPR compliance, specifically detailing how all project partners manage data security and governance.

Information on SP Energy Networks Data Privacy Policy can be found by using the following link https://www.spenergynetworks.co.uk/pages/privacy.aspx

8.2.3 EV drivers behaviour impact assessment

The project may trial innovative techniques to reduce the network capacity requirements of EV chargers. This may involve real time reductions in charging rate and/or temporary suspension of charging. Where this is the case as part of our trials, we will ensure clear communication with customers and agreement so they are aware of the trail, its aims and the likely impact to their charging station.

8.2.4 Customer Behaviour

It is recognised **Charge** will impact both the EV chargepoint connectees and end user in different ways, therefore the potential impact on customer behaviours will be explored for the three methods and complemented through input from the stakeholder steering group. More information on how this will be captured is included within Appendix F.

8.3 Protection from Incentive Penalties

Charge will require no protection from incentives penalties.

9 Project Deliverables

9.1 Summary of Project Deliverables

#	Project Deliverable	Method	Deadline	Evidence	NIC funding request (%, must add to 100%)
1	Transport and Network Model – interim report	1	31/12/2019	1. Transport / Network Mapping interim report 2. Identification of trial sites 3. Initial specification and architecture to allow other GB DNOs to replicate	9%
2	Transport and Network Model – final report	1	31/12/2020	1. Transport / network mapping complete 2. Dissemination events with stakeholder consultation report and analysis 3. Documentation of methodology	6%
3	Identify suitable EV connection solutions for different locations	2	30/09/2019	1. Completed assessments of candidate networks in SPM and other licence areas 2. Updated Cost Benefit Analysis for each network study (each report detailing the impact of EV growth, the traditional reinforcement solution, smart solution options and the cost benefit analysis outputs of all solutions suitable at the network location) 3. Stage Gate report which will determine the scope for trial deployment, and likely pilot trial locations.	8%
4	Pilot Trial Interim Report	2	28/02/2021	1. Learning from Pilot trials: connection issues, deployment options, etc. 2. Stage Gate report which will determine if there is scope for a Broader Trial deployment, and identify a likely location for the two trial types.	16%
5	Pilot Trial Completion / Broader Trials Interim Report	2	31/12/2021	1. Learning from Broader Trials: connection issues, deployment options, robust data set etc. 2. Robust financial case for the range smart management solutions 3. Policy information to support DNOs and chargepoint manufacturers in the process to facilitate the increase of EVs on	15%

				their networks 4. Customer messaging strategies that will support and encourage the use of EVs in a manner which will benefit both the customer and the energy networks.	
6	Final Report on Network Trials	2	31/12/2022	1. All trials complete with statistically representative analysis established 2. Finalised draft Engineering Recommendations / policy support with peer review 3. Customer Market and customer behaviour research. 4. Stakeholder review consultation and report 5. Documentation and characterisation of solution set to enable it to be used in an automated tool.	6%
7	ConnectMore Online Tool - Spec	3	31/03/2020	1. Documented User Requirements & Specification for ConnectMore tool 2. Documented Data plan for ConnectMore tool	11%
8	ConnectMore Online Tool - Prototype delivery	3	30/06/2022	1. Publicly assessable online connections tool with capacity visualisation and guidance 2. Ability to highlights likely customers' needs and capacity changes over time	25%
9	Project Close Down	N/A	31/03/2023	1. Stakeholder consultation report 2. Decommissioning of all trial equipment or transfer of ownership 3. Publication of web based tool and all public domains trial data 4. Issue of Project Close down report	4%
N/A	Comply with knowledge transfer requirements of the Governance Document.	N/A	End of Project 31/03/2023	1. Annual Project Progress Reports which comply with the requirements of the Governance Document. 2. Completed Close Down Report which complies with the requirements of the Governance Document. 3. Evidence of attendance and participation in the Annual Conference as described in the Governance Document.	N/A

Appendices

#	Appendix Title	Description
A1	Financial Benefits	Financial benefits table
A2	Capacity Released	Capacity Released table
A3	Carbon Benefits	Carbon benefits table
A4	Explanatory Notes	Explanatory notes for appendices A1 to A3
B	Costs	Detailed cost spreadsheet showing the complete cost of the project and the spend per regulatory year
C	Project Plan	GANTT chart detailing the project activities and timelines
D	Risk Register & Contingencies	Document capturing the project risks, their severity and suitable mitigation plans
E	Project Methods	Technical description of the three project Methods
F	Trial Design & Replicability	The network types planned for trial, and an overview of how the project will gain insight of end-customer behaviours and user experience.
G	Case Study Locations	Example case study location for Method 2
H	Learning Dissemination	Method of dissemination and approach
I	Delivery Experience	Organisational experience of key parties in delivering projects of a similar nature
J	Innovation project mapping	Overview of other LCN Fund / NIC projects that have common themes to **Charge** and the learning used to inform this project
K	Stakeholder Engagement	Information related to charging points to be installed during the course of the project and letters of support provided by organisations that see value in this project.
L	**Charge** Counterfactual	An illustration of what is likely to happen with and without this project
M	Direct Impact	How **Charge** addresses the Direct Impact definition in the NIC Governance criteria
N	Table of changes made for this resubmission	A summary of changes made to this document following questions with Ofgem and their Expert Panel

10 Appendix A1: Financial Benefits

The following tables outline the cumulative financial and carbon benefits of **Charge** for licence and GB roll out scale.

Table 8: SPM Licence scales cumulative benefits in discounted NPV terms

Cumulative Benefits (£m)	2030	2040	2050
Method 1: Strategic transport & network planning	£0.6	£0.6	£0.6
Method 2: Solutions for challenging EV connections	£10.8	£45.6	£53.3
Method 3: ConnectMore software tool	£8.6	£8.6	£8.6
Total	**£20.0**	**£54.8**	**£62.5**

Table 9: GB scale Cumulative benefits in discounted NPV terms

Cumulative Benefits (£m)	2030	2040	2050
Method 1: Strategic transport & network planning	£8.6	£8.6	£8.6
Method 2: Solutions for challenging EV connections	£7.0	£548.5	£666.4
Method 3: ConnectMore software tool	£119.7	£119.7	£119.7
Total	**£135.4**	**£676.9**	**£794.8**

11 Appendix A2: Capacity Release

Table 10: Capacity Released

<table>
<tr><th rowspan="2">Scale</th><th rowspan="2">Method</th><th colspan="3">Benefit (MW)</th><th rowspan="2">Notes</th></tr>
<tr><th>2030</th><th>2040</th><th>2050</th></tr>
<tr><td rowspan="3">Post-trial solution</td><td>Method 1 Strategic transport & network planning</td><td>24</td><td>24</td><td>24</td><td>Provides visibility of where network capacity is needed against transport needs (132kV and 33kV only)</td></tr>
<tr><td>Method 2 Solutions for challenging EV connections</td><td>0.0</td><td>0.0</td><td>0.0</td><td>Limited trial, unlikely to yield significant benefits beyond the life of the project</td></tr>
<tr><td>Method 3 ConnectMore software tool</td><td>103</td><td>103</td><td>103</td><td>Provides visibility of network capacity needs down to 11kV and LV</td></tr>
<tr><td rowspan="3">Licensee scale (SPM)</td><td>Method 1 Strategic transport & network planning</td><td>24</td><td>24</td><td>24</td><td>Provides visibility of where network capacity is needed against transport needs (132kV and 33kV only)</td></tr>
<tr><td>Method 2 Solutions for challenging EV connections</td><td>7</td><td>60</td><td>282</td><td>Based on the peak number of events generated from the Transform Model with the SPM dataset</td></tr>
<tr><td>Method 3 ConnectMore software tool</td><td>103</td><td>103</td><td>103</td><td>Provides visibility of network capacity needs down to 11kV and LV</td></tr>
<tr><td rowspan="3">GB rollout</td><td>Method 1 Strategic transport & network planning</td><td>335</td><td>335</td><td>335</td><td>Provides visibility of where network capacity is needed against transport needs (132kV and 33kV only)</td></tr>
<tr><td>Method 2 Solutions for challenging EV connections</td><td>632</td><td>1,007</td><td>3,021</td><td>Based on the peak number of events generated from the Transform Model with the GB dataset</td></tr>
<tr><td>Method 3 ConnectMore software tool</td><td>1,437</td><td>1,437</td><td>1,437</td><td>Provides visibility of network capacity needs down to 11kV and LV</td></tr>
</table>

12 Appendix A3: Carbon Benefits

Table 11: Carbon benefits

<table>
<tr><th rowspan="2">Scale</th><th colspan="3">tons CO_2</th><th colspan="2">Cross-references</th></tr>
<tr><th>2030</th><th>2040</th><th>2050</th><th>Sensitivities</th><th>Key Assumptions</th></tr>
<tr><td>Licensee scale
(If applicable, indicate the number of relevant sites on the Licensees' network.)</td><td>61,146</td><td>353,879</td><td>377,143</td><td>Assuming increase in EV uptake is consistent across all geographical areas

Appendix A 12.2</td><td rowspan="2">1. Car ownership will maintain current levels
2. Assuming current level of technology
3. Based on expected levels of CO_2 from national generation sources
4. Miles per kW/h remains consistent - assumed current rate of mile per/kWh
5. Internal combustion engines emissions based on EU2020 emission limits 95g/km</td></tr>
<tr><td>GB rollout scale
(If applicable, indicate the number of relevant sites on the GB network.)</td><td>917,331</td><td>5,309,002</td><td>5,658,009</td><td>Assuming increase in EV uptake is consistent across all geographical areas

Appendix A 12.2</td></tr>
</table>

13 Appendix A4: Benefits Calculation Explanatory Notes

13.1 Calculation of Financial Benefit

As described in Section 3.3 **Charge's** business case benefits are categorised as follows:

- **Cost reductions from strategic alignment / deployment**: The business case is based on the direct benefits to customers in guiding them towards sections of network which have capacity to fulfil their needs[11].
- **Reduced connection costs**: The business case is based on flattening the demand curve using a range of techniques for residential properties without driveways.
- **Process efficiencies for EV connections:** This benefit falls into two areas:
  - ***Reduced Assessment & Design (A&D) fees****:* providing customers with the ability to test different areas of the network will reduce the number of abortive connection requests, reducing costs to connectees.
  - ***Avoided costs to DNOs:*** from not having to increase the number of staff in connections teams to support the mass electrification of transport.

The benefits map to the Methods as outlined below:

[11] This benefit is split across Methods 1 and 3: Method 1 will be a manual process focussing on the higher (but less granular) voltages of 132kV and 33kV; Method 3 will automate the process developed in Method 1, allowing assessment on 11kV and, ultimately, LV networks.

Table 12: Mapping of benefits to project Methods

Benefit	Method 1	Method 2	Method 3
1. Cost reductions from strategic alignment	££	£	£££
2. Reduced connection costs	n/a	£££	£
3. Process efficiencies for EV connections	£	n/a	£££

The main benefits are discussed with each Method, however there are some combinational effects (denoted as a single '£') that could further increase the benefits above those presented.

13.1.1 Method 1: Cost reductions from strategic alignment / deployment resulting from strategic alignment / deployment

This section considers the benefits that could be gained through a more strategic and holistic deployment of EV chargers, aligning the transport needs with network capacity.

The benefits of strategic alignment between transport and electricity planning are split between Methods 1 and 3:

- Method 1: a manual exercise to focus on the smaller number of larger connections to the less granular 132kV and 33kV networks. This is likely to capture only the very large en-route charging locations.
- Method 3: an automated exercise to deal with connections of EV charging points to the extensive 11kV and LV network. This will build on the output from Method 1, combining the transport plan with the detailed network topology of the DNO, and will naturally lend itself to connections for destination chargers or those on terrace streets (described in 13.1.3).
- The Road to Zero strategy states that key findings from the Committee on Climate Change for the public network are that:
  - *To meet long distance en-route rapid charging requirements, and maximise carbon emission reductions, the number of rapid chargers located near the major roads network needs to expand to 1,170 by 2030 (from 460 in 2016). The number needed may not need to increase in line with the rate of EV uptake given longer battery ranges, new charging technologies and a greater proportion of EVs able to use faster rapid charging technologies; and*
  - *the number of public chargers required to meet the 2016 level of demand for 'top up' charging while parking around towns and local areas is estimated to rise from 2,700 in 2016 to over 27,000 by 2030*

The numbers of chargers are then assumed to plateau at these volumes, on the basis that visible infrastructure is needed in the early years to support consumer uptake.

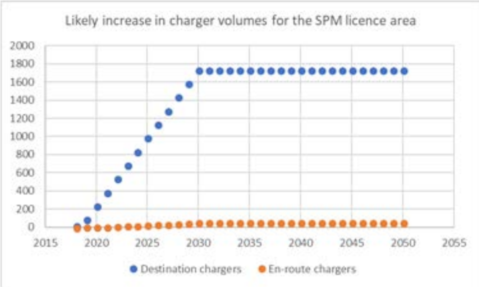
It is reasonable to assume that there will be the following new EV chargers in the SPM network, based on 1/14th of the GB figure (as one of fourteen licence areas):

Table 13: New chargers likely in SPM in line with CCC projections

Charger type	Additional National Volumes by 2030	Additional Volumes in SPM by 2030
Public/destination charging	24,300	1,736
En-route charging	710	51

It is reasonable to assume that there will be distinctive characteristics for each location:

- **Public / destination charging**: e.g. fast AC chargers of 7kW each, likely to be deployed in groups of 5-20. An assumed total demand of 35kW-140kW per site
- **En-route charging**: e.g. rapid DC chargers of 50kW-150kW[12] each, likely to be deployed in groups of 5-10+. An assumed total demand of 250kW-1.5MW per site



Whilst LV connections can be relatively straight-forward where capacity exists, they can soon become costly if HV reinforcement is triggered. The challenge is that it is very difficult for a connectee to see where the network capacity is, and how this might align to their needs.

SPEN's published connection charging methodology[13] shows a range of example connections for different loads and generation, along with their typical costs. All connections consist of both reinforcement (those used to knit the connection into the network) and extension assets (those used solely by the connectee). Extension costs are generally fully funded by the connectee, with reinforcement costs apportioned depending on connection voltage and sharing arrangements.

To cater for a new EV charging connection, it is reasonable to assume that these costs align with examples in the Connection Charging Methodology:

Table 14: Relevant examples from the SPEN Connection Charging Methodology

E.g.	Description	Cost	Customer contribution
1	Connection of a single domestic premises	£1.1k	£1.1k
2B	Connection of 200 homes and 250kVA (interconnected) • Reinforcement • Extension • **Total**	 £48k £170k **£218k**	 £29k £170k **£199k**
3	600kVA commercial connection (no reinforcement) • Reinforcement • Extension • **Total**	 £0k £54k **£54k**	 £0k £54k **£54k**
4	Additional load to commercial premises (from 200->800kVA) • Reinforcement • Extension • **Total**	 £124k £52k **£176k**	 £10k £52k **£62k**

Based on these actuals, it is conservative to assume the following for EV charging:

- En-route charging (250kW-1.5MW)

[12] A current CHAdeMO rapid charger is 62.5kW @ 500V dc

[13] STATEMENT OF METHODOLOGY AND CHARGES FOR CONNECTION TO SP DISTRIBUTION PLC AND SP MANWEB PLC'S ELECTRICITY DISTRIBUTION SYSTEMS, SP Energy Networks, June 2018 https://www.scottishpower.com/userfiles/document_library/SPEN_Connection_Methodology_June_2018.pdf

- Typical cost of connection without reinforcement (from 3) £54k
- Typical cost of connection with reinforcement (from 4) £176k
- Destination / public charging (35kW-140kW)
  - Typical cost of connection without reinforcement (25% of 2B) £42.5k
  - Typical cost of connection with reinforcement (25% of 2B) £54.5k

The Method 1 benefits assume that this is only applied to en-route charging locations, with an estimate that 25% of these connections will trigger upstream reinforcement. This would result in a direct saving as described below:

Table 15: Method 1 Benefits for SPM

Charger type	New chargers that could trigger reinforcement	If reinforcement was triggered	No reinforcement	Gross Benefit
En-route	**13**	**£2.2m**	**£1.4m**	**£0.8m**

The present value of this benefit to 2030 (at which point it flattens off) is £0.6m for SPM. Noting that this is a total saving which would benefit both the connectee (via apportionment) and the general electricity customer.

If we assume SPM to be typical of other licence areas, this potential benefit can be scaled up to £8.6m in present value terms across GB (excluding deployment costs to replicate the transport / network planning exercise to other licence areas).

This benefit significantly increases when automated, allowing it to be deployed across a wider variety of electricity networks and for different charging types, as described in Method 3.

13.1.2 Method 2: Reduced connection costs

Flexible connections for EV charge points will be implemented as part of the project. These are likely to include methods to defer capacity requirements to times of the day where conventional demand has dropped off, or install technology, such as energy storage, to trim demand peaks. All these effects help to smooth the demand curve, maximising the average utilisation of our assets and removing the need for conventional reinforcement solutions.

To quantify the financial benefit arising from being able to deploy solutions at street level to assist with the managed charging of electric vehicles, we have utilised the industry-leading Transform Model. The Transform Model is composed of various 'representative circuits' that have been judged by the industry to be a sufficiently robust view of the networks found at lower voltages.

The Transform Model (for both SPM and for GB) was executed without any smart charging being available. This gave a base case from which to work (utilising the high uptake level of EV provided by central Government that most closely aligns with anticipated rate of uptake in recent publications). The model was then re-executed using a smart charging approach like that utilised in other innovation projects such as WPD's Electric Nation and SSEN's Smart EV. The difference in investment on the circuits in question (those supplying terraced streets and apartments) represents the savings in investment available through having managed charging at these locations to avoid or defer network upgrades.

- The potential cost of flexibility can vary depending on the location and responsiveness and is therefore not a straightforward value to determine, however following discussions with stakeholders we have based this cost on WPD Dynamic Flexible Power initiative for services for winter 2018 / 2019[14]. Assuming this flexibility is required for 10% of the year provides an annual potential cost of flexibility per LV feeder in the region of £460.

Table 16: WPD Payment rate summary for flexibility

	Arming	Availability	Utilisation
Secure	£75/MW/h or £118/MW/h	N/A	£150/MWh
Dynamic	N/A	£5/MW/h	£300/MWh
Restore	N/A	N/A	£600/MWh

- We have changed the assumptions to reflect the fact that different conditions will manifest in different decades.
- Initially, there will be fewer instances where the EV charging demand presents a problem, and hence we have a shorter amount of time per affected day that the managed charging will be necessary (1.5 hours), which increases as EV penetration increases (3 hours per day in 2030s and 4 hours per day in 2040s).
- We keep the number of affected days constant throughout the analysis at 10% of the year.
- The number of chargers per feeder also increases through time to reflect the increased uptake of EVs. This begins at 5 chargers per feeder and increases over time to 15 chargers per feeder.
- The cost in terms of availability and utilisation of flexibility has been set to be constant over time. This is because, although greater levels of flexibility will be needed going forward (and hence payments could be thought to increase), the number of market participants willing to contribute such flexibility will also increase. Hence it is anticipated that the market value remains constant as these two effects balance.

The results are summarised as follows:

Table 17: Method 2 Benefits to 2050 (SPM level only)

SPM licence area (£m)	to 2030	to 2040	to 2050
Reinforcement cost	£10.9	£45.8	£65.5
Flexibility cost	£0.13	£0.24	£12.2
Net Benefit	**£10.8**	**£45.6**	**£53.3**

Table 18: Method 2 Benefits to 2050 (GB level)

GB-wide (£m)	to 2030	to 2040	to 2050
Reinforcement cost	£22.1	£1,094.4	£2,349

[14] https://www.flexiblepower.co.uk/FlexiblePower/media/Documents/Winter-2018-Summer-2019-EOI-Document.pdf

Flexibility cost	£15.1	£545.9	£1,683
Net Benefit	**£7**	**£548.5**	**£666.4**

The benefits realised are modest at first (to 2030). This is because there are a relatively small number of feeders where reinforcement would be required that could otherwise be deferred to any significant length of time by the smart charging solution. In other words, as these cases are driven by clusters of early adopters, the level of charging demand can be such that the 50% reduction we assume is only sufficient to 'buy' one year's worth of capacity before the traditional network reinforcement is triggered. Hence the level of benefits realised tends to be only associated with one or two year's saving before performing the reinforcement (on a discounted calculation).

As we move through time and the spread of EVs becomes more evenly distributed, there are far greater numbers of circuits which can benefit for longer periods through the managed charging solution. We see a significant increase in cumulative benefits to 2040, aligning with the steepest portion of the projected curve for uptake of EVs. The additional benefits that are then realised over the next decade to 2050, are smaller by comparison as the rate of uptake begins to tail off and the benefits have largely been accounted for already.

We note that in SPM, the benefit to 2030 is greater than that in GB. The reason for SPM being something of an outlier in this regard is due to the meshed nature of its LV network, which is adjudged within SPEN's Transform Model (which is the version used for their ED1 submission and has not been modified for this analysis) to have greater amounts of capacity available. There are therefore fewer cases of LV reinforcement needed and greater opportunity for the managed charging solution to assist in those cases where reinforcement would otherwise be triggered.

It is instructive to consider that, while the overall benefits within SPM to 2050 may seem modest at £53m, this is against a counterfactual case of investing some £65.5m in the affected circuits. Therefore, the saving to customers is some 80%. Similarly, over a shorter timescale of 2030, the counterfactual case suggests an investment of £11m while the required investment arising due to the managed charging solution is less than £130k, representing significant savings to customers. Across GB, the level of saving varies across time horizons from 50% - 66% against the counterfactual case.

Despite modest benefits to 2030, the project is still timely as it is necessary to initiate the market that will permit such benefits to be realised. It is vital that this market is in place and customer acceptance of this approach has been achieved before the large-scale benefits through the 2030s can be realised.

13.1.3 Method 3: ConnectMore Software

Method 3 has five major benefits to customers:

- Customers will be able to lower their connection costs through visibility of the capacity of the network and the ability to modify their connection (an expansion of Method 1)
- Customers will be able to gain an early view of the likely feasibility of their required connection with no Assessment and Design (A&D) fees. They will only pay A&D fees after they are presented with information on the likely connection costs

- DNOs will avoid the need to build large connection teams to deal with the bow-wave of new connection enquiries associated with the mass electrification of transport
- DNOs will be able to schedule network reinforcement to bring capacity online as it is needed, reducing lead times for connection of public charging infrastructure
- It enables a joined up approach whereby all likely needs are assessed within a given locality, allowing DNOs to find the least cost approach to satisfy all customers.

The first three bullets are considered in this assessment.

3a: Cost reductions resulting from strategic alignment / deployment:
Further to the explanation in Section 13.1.1 for Method 1, the ConnectMore tool will automate the process to align transport and network planning, allowing it to be deployed at lower network voltages for a broader range of charging locations (e.g. destination chargers and for terrace streets).

A conservative estimate of the financial benefit was made by assuming that 10% of all public/destination chargers would trigger upstream reinforcement at HV without being guided to where network capacity exists. This would result in a direct saving of:

Table 19: Method 3a Benefits for SPM

Charger type	New chargers that could trigger reinforcement	If reinforcement was triggered	No reinforcement	Gross Benefit
Public/destination	**174**	**£18.9m**	**£14.8m**	**£4.1m**

The present value of this benefit to 2030 (at which point it flattens off) is £3m for SPM. Noting that this is a total saving which would benefit both the connectee (via apportionment) and the general electricity customer.

If we assume SPM to be typical of other licence areas, this potential benefit can be scaled up to £42.3m in present value terms across GB (excluding deployment costs to replicate the transport / network planning exercise to other licence areas).

3b: Process efficiencies for EV connections (reduced A&D fees): The electricity industry has faced a major challenge in processing new connection applications resulting from the race to deploy distributed generation and storage up and down the country. Speculative connection requests were rife as developers sought to secure network capacity and investment for their projects. By example, the ratio of completed HV connected distributed generation projects to connection requests fell to below 8%.

To tackle this and improve conversion rates and service provision, BEIS progressed changes to Statutory Legislation which allowed DNOs to introduce upfront A&D fees[15] for specific connections. SPEN currently levy a fee of £1,250 for each connection involving

[15] THE ELECTRICITY (CONNECTION OFFER EXPENSES) REGULATIONS 2018 (http://www.legislation.gov.uk/uksi/2018/254/made)

HV works up to 1MW – a level that would capture most non-domestic chargepoint connections.

The ENA business case argued that enabling DNOs to charge upfront A&D fees for connection applications would bring a range of benefits, including:

- Reducing speculative connection applications, thereby reducing costs for customers who do accept offers. DNOs estimate the volume of connection offers made could reduce by 40% as a result of reintroducing A&D fees;
- ensuring that a greater proportion of costs were recovered from those causing them to be incurred;
- DNOs would be able to devote more resource to improving customer service and the quality of offers; and
- Enhancing competition as Independent Connection Providers would be free to decide whether or not (and how much) to charge for similar services.

As per Table 13, it is conservative to assume that there will be 1,786 EV connections in the SPM licence area from 2018 to 2030, with the numbers of new connections plateauing at that point. It is reasonable to assume that the poor 8% conversion from connection application to delivered project has now increased following the introduction of A&D fees. We are assuming this is now 25% (i.e. a 4:1 ratio) as our counterfactual. At this conversion, there would be 7,144 connection requests, costing £8.93m in A&D fees for the one licence area.

Giving customers the ability to assess capacity and network reinforcement needs before they apply for a connection, is expected to increase the ratio of completed to requested to 50% as many speculative requests would be avoided (a 2:1 ratio of applications to successes). This would give a saving of £4.47m in A&D fees for customers in the SPM licence area.

The present value of this benefit is £2.9m by 2030 (with no increase beyond this point).

Assuming SPM to be typical of other licences this would produce a direct customer benefit of £40.6m in present value terms across GB.

3c: Process efficiencies for EV connections (avoided costs to DNOs): In addition to the direct customer benefit, there is an efficiency saving to DNOs. If DNOs had to resource up to provide connection requests as today, this would likely cost a further £500k-£1m p.a. Even with support arrangements, the use of the ConnectMore tool is likely to yield a saving of £300k+ p.a. just for the SPM licence.

Giving a present value benefit of £2.6m for SPM which if scaled to GB would equate to £36.8m by 2030

Total benefits for Method 3 are therefore a combination of 3a, 3b & 3c:

Table 20: Summary of Method 3 financial benefits

PV of benefit to 2030	SPM	GB
3a: Strategic alignment to lower voltages	£3.0	£42.3m
3b: Reduced A&D fees to connectees	£2.9	£40.6m
3c: Avoided DNO costs	£2.6	£36.8m
Total	**£8.6m**	**£119.7m**

13.2 Calculation of capacity released

13.2.1 Method 1 - Strategic transport and network planning

Method 1 will enable network operators to better 'target' or guide developers as to where to connect chargers which should maximise existing asset utilisation, avoiding the need for new infrastructure.

As described in Table 13, the Committee of Climate Change estimate a significant ramp up of chargers as part of their Plugging the Gap document[16].

- En-route charging: 710 new chargers across Britain by 2030 (from 2016 figures)
- Destination charging: 24,300 new chargers across Britain by 2030

Given the volume of petrol stations currently in the UK and typical numbers of petrol pumps per site[17], it is reasonable to assume that each of the chargers as outlined are locations and will consist of more than one charger. Indeed given the speed of charging and diversity, there is likely to be many more charging points than petrol pumps in a future 'filling station' catering for 100% electrified transport.

As described elsewhere, Method 1 is concerned with the smaller number of larger charging units envisaged for en-route locations.

Method 1: Capacity benefits		
- En-route charging locations:	SPM – 51	GB - 710
- Per charger capacity:	63kW (e.g. CHAdeMO)	
- Number of chargers assumed per location:	30	
- Total capacity required:	SPM - 96.4MW;	GB – 1,342MW
- Avoided reinforcement from this Method:	25%	
- Total capacity released:	SPM – 24MW	GB – 335MW

NB. Capacity release figures were not previously provided for Methods 1 and 3, as the results are highly sensitive to the assumptions. However, we recognise that by NOT including a figure we risk suggesting that the benefits are all at arms-length from the Method - they are not. The sensitivities include:

- The number of charging sites
- The number of chargers per site
- The likely location of sites within a DNO licence area
- The ability to 'encourage' chargers to relocate: network capacity, social aspects, local planning, NIMBYism, etc.
- % avoided reinforcement per site

Charge will seek to quantify these sensitivities to refine the answer.

[16] "Plugging the Gap: An Assessment of Future Demand for Britain's Electric Vehicle Public Charging Network – Summary of Findings", Project 105852, January 2018

[17] There were 8,407 petrol stations in the UK in 2017[17], serving some 35m vehicles. If each petrol station assumed to have eight pumps on average, this means there are 67,256 petrol pumps

13.2.2 Method 2 - Tactical solutions for flats/terrace streets

Method 2 is about the deployment of non-traditional solutions on the networks for feeders of terraced streets and flats/apartments. We have used the outputs of the Transform Model runs for both SPM and GB to assess the numbers of times this would be called upon and multiplied this by the capacity released for each feeder type.

As the favoured solutions are dominated by demand response type solutions, we have extracted the peak requirement in each decade, rather than a cumulative figure at the end of each decade. This accounts for instances where the DSR solution successfully defers reinforcement, but nevertheless reinforcement is ultimately needed. The results are presented in Table 10.

We recognise that other solutions are in development which could offset these benefits – we will review the capacity benefits as part of **Charge**, and of course, report on this as part of the Close Down.

13.2.3 Method 3 - ConnectMore software tool

As described previously, Method 3 will take the outputs of the transport plan and apply this to the 11kV and LV networks in an automated way. This will be better suited for the higher volume of smaller charging units envisaged for destinations (e.g. car parks, hotels, etc.) and terraced street locations.

Method 3: Capacity benefits		
- Fast charging locations:	SPM – 1,736	GB – 24,300
- Assumed split of chargers between destination and terrace streets:		70:30
3(i): Destination charging		
- Per charger capacity:	40kW (e.g. smaller CHAdeMO)	
- Number of chargers assumed per location:	20	
- Total capacity required:	SPM – 972MW;	GB – 13,608MW
- Avoided reinforcement from this Method:	10%	
- Total capacity released:	SPM – 97MW	GB – 1,361MW
3(ii): Terrace Street charging		
- Per charger capacity:	7kW (e.g. domestic fast charger)	
- Number of chargers assumed per location:	15	
- Total capacity required:	SPM – 54.7MW;	GB – 765.5MW
- Avoided reinforcement from this Method:	10%	
- Total capacity released:	SPM – 5MW	GB – 77MW

13.3 Calculation of Carbon Benefit

Carbon benefits have been calculated using the Ofgem CBA template and attributed to the whole project.

Table 21: SPM rollout scale carbon benefits

SPM Licence (t CO_2)	to 2030	to 2040	to 2050
SPM Default	822,744	12,123,625	32,683,540
SPM Accelerated	883,890	12,477,504	33,060,682
Net Benefit	61,146	353,879	377,143

Table 22: GB rollout scale carbon benefits

GB Licence (m t CO_2)	to 2030	to 2040	to 2050
Default	12.3	181.9	490.3
Accelerated	13.2	187.2	496
Net Benefit	**0.92**	**5.3**	**5.7**

13.3.1 Electric Vehicle uptake predictions

To establish the baseline EV uptake projection up to 2050 we have compared the FES scenarios for the SPM area with other data sources to verify their suitability, as is shown in Figure 18. During stakeholder engagement the projections according to the Scottish Government were judged to be the most feasible (Figure 18). Stakeholders concluded they did not think there was a big difference between the EV uptake in the SPEN and the GB average, although range anxiety for rural areas, and the frequent bad weather could be a deterrent.

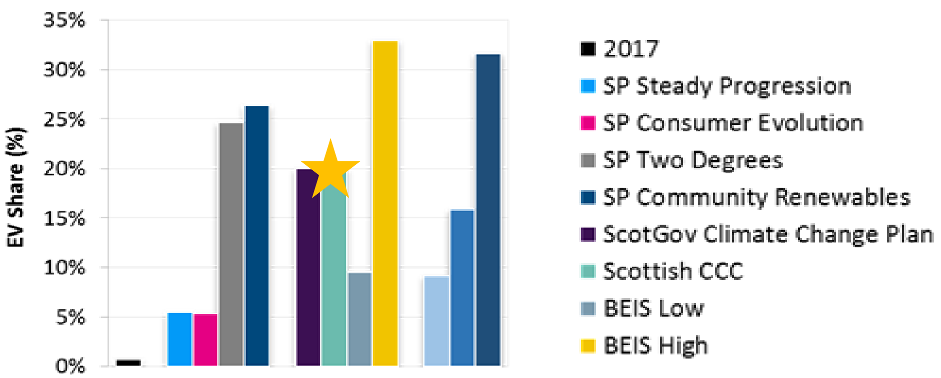


Figure 18: EV as a % of total cars in the UK by 2030

(Stakeholder preferred option marked with star)

Using figures for the SPM licence area[18] the uptake of EVs is assumed to follow an Innovation Adoption Lifecycle model[19]. The innovation adoption lifecycle is a sociological model which describes the adoption or acceptance of a new product or innovation. It illustrates the adoption of a technology over time as a 'bell curve', indicating that a new technology will initially be accepted by innovators and early adopters, before it will be taken up by the majority of consumers. For the uptake of EVs in the SPM area we assume that EV clusters remain until the end of the early adopter phase, after which

[18] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/623742/veh0105.ods

[19] CC BY 2.5, https://en.wikipedia.org/w/index.php?curid=11484459

they will start to spread towards equal distribution at the end of the early majority phase. Due in part to the uncertainties around a number of key factors such as technology improvements, EV adoption rates and future ownership models the following assumptions have been made;

- Car ownership will maintain current levels
- Assuming current level of technology
- Based on expected levels of CO2 from national generation sources out to 2050
- Miles per kW/h remains consistent
- Internal combustion engines emissions based on EU2020 emission limits 95g/km

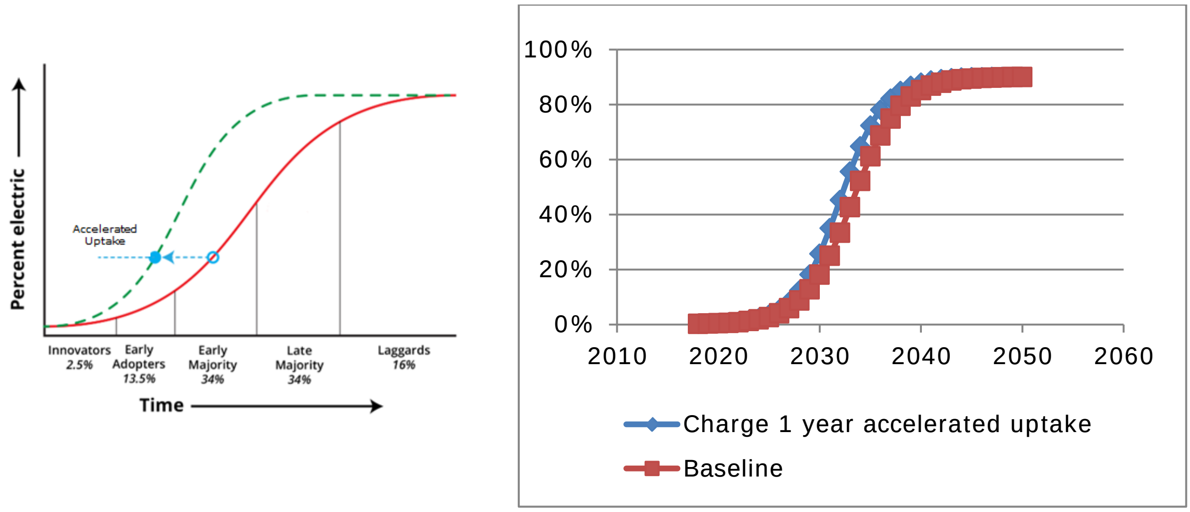


Figure 19: Innovation adoption

13.3.2 Carbon benefits methodology

Due to improved availability of chargers and improved consumer confidence we have assumed that the baseline adoption rate curve will be accelerated by a modest 1 year; this seems proportionate to the scale of the project and should be seen as a conservative, yet realistic, assumption. The acceleration of 1 year has the effect of increasing the proportion of EVs in the UK from 20% to 25% by 2030 and in line with the upper targets of Future Energy Scenarios (FES) 2018 (Consumer Evolution & Community Renewables).

The focus of **Charge** is on delivering solutions for customers without off street parking, therefore to ensure a representative analysis the potential benefits have been scaled, recognising that the **Charge** solution will not provide the incentive for all consumers. Based on Public Attitudes towards Electric Vehicles[20], a survey completed by the Department for Transport, the scaling factor of 19% has been set by those who responded that convenience of recharging would encourage them to transition to EV.

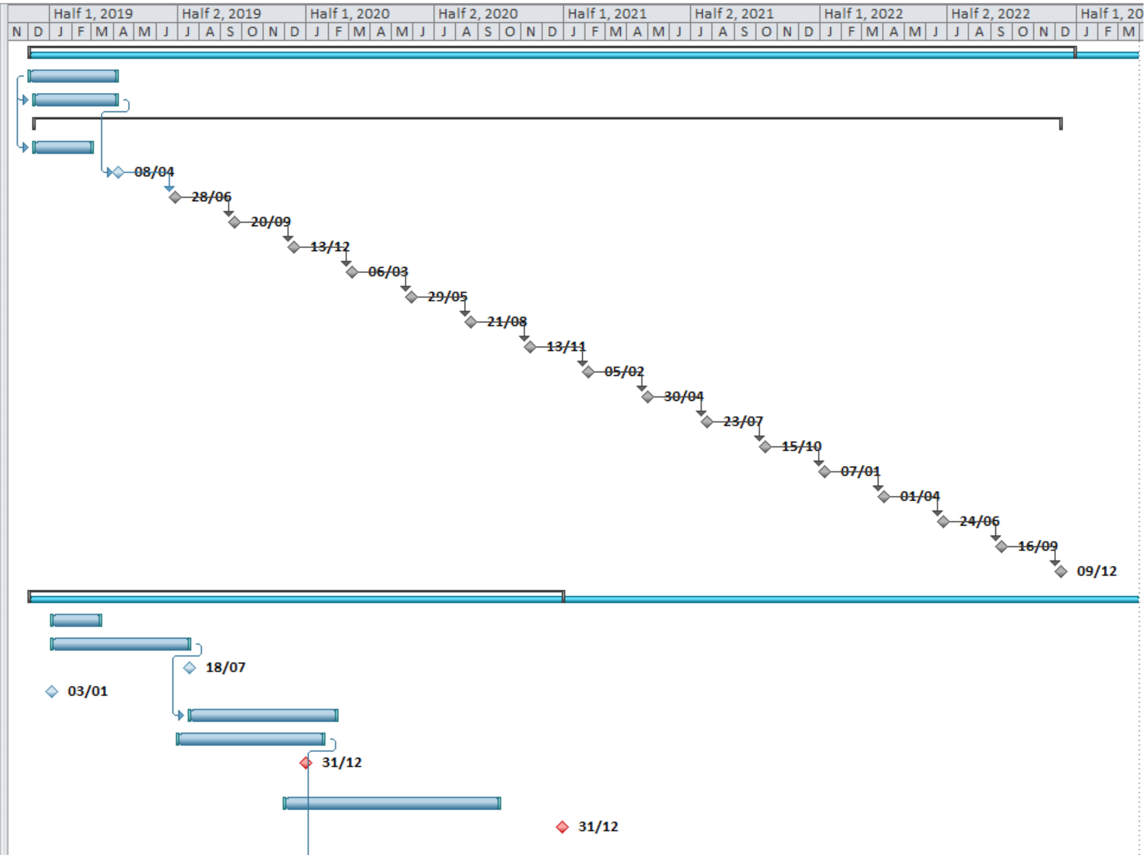
[20] Public attitudes toward electric vehicle: 2016, Department for Transport

14 Appendix B: Costs

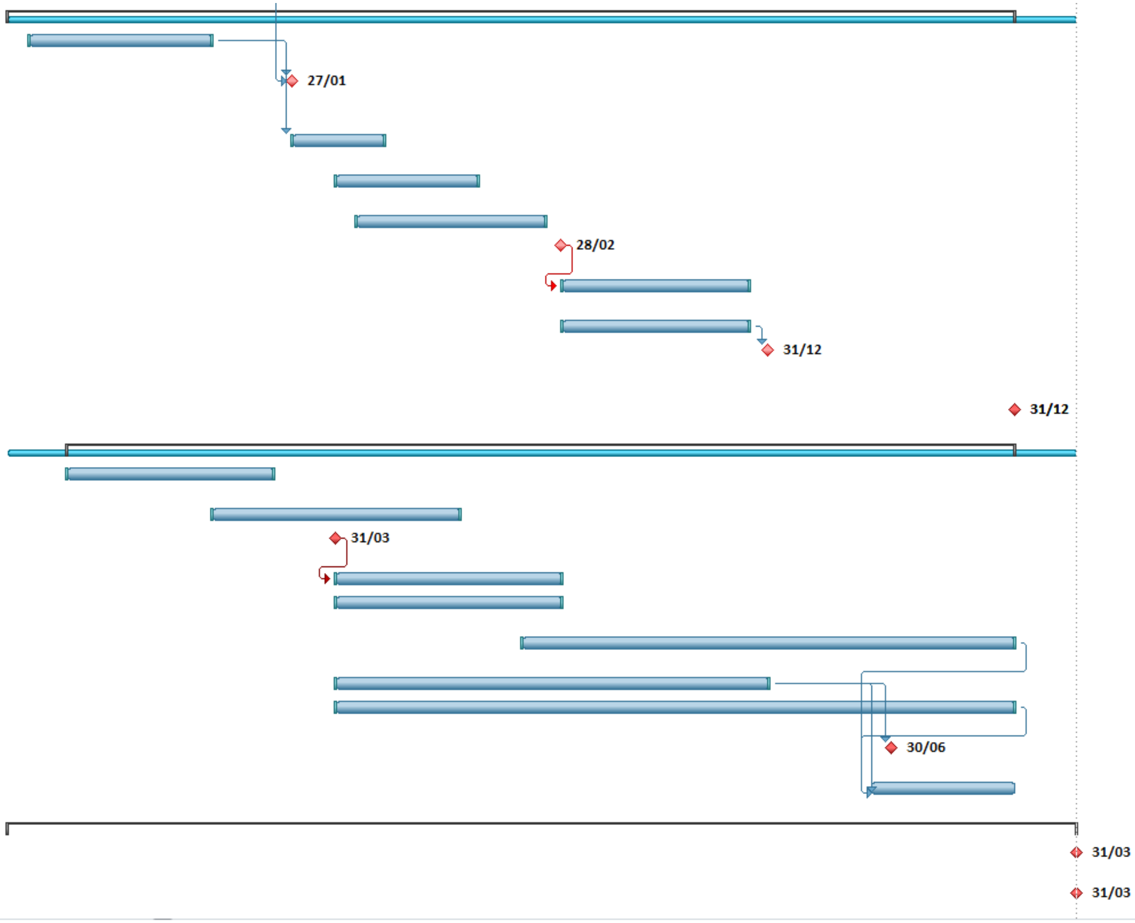
[redacted]

15 Appendix C: Project Plan

	Task Name	Duration	Start	Finish
1	**Project Duration**	**1065 days**	**Mon 03/12/18**	**Fri 30/12/22**
2	Project start up and direction	90 days	Mon 03/12/18	Fri 05/04/19
3	Collaboration agreement	85 days	Mon 10/12/18	Fri 05/04/19
4	**Stakeholder forum**	**1045 days**	**Mon 10/12/18**	**Fri 09/12/22**
5	Establish stakeholder forum	60 days	Mon 10/12/18	Fri 01/03/19
6	Stakeholder forum meeting	0 days	Mon 08/04/19	Mon 08/04/19
7	Stakeholder forum meeting	0 days	Fri 28/06/19	Fri 28/06/19
8	Stakeholder forum meeting	0 days	Fri 20/09/19	Fri 20/09/19
9	Stakeholder forum meeting	0 days	Fri 13/12/19	Fri 13/12/19
10	Stakeholder forum meeting	0 days	Fri 06/03/20	Fri 06/03/20
11	Stakeholder forum meeting	0 days	Fri 29/05/20	Fri 29/05/20
12	Stakeholder forum meeting	0 days	Fri 21/08/20	Fri 21/08/20
13	Stakeholder forum meeting	0 days	Fri 13/11/20	Fri 13/11/20
14	Stakeholder forum meeting	0 days	Fri 05/02/21	Fri 05/02/21
15	Stakeholder forum meeting	0 days	Fri 30/04/21	Fri 30/04/21
16	Stakeholder forum meeting	0 days	Fri 23/07/21	Fri 23/07/21
17	Stakeholder forum meeting	0 days	Fri 15/10/21	Fri 15/10/21
18	Stakeholder forum meeting	0 days	Fri 07/01/22	Fri 07/01/22
19	Stakeholder forum meeting	0 days	Fri 01/04/22	Fri 01/04/22
20	Stakeholder forum meeting	0 days	Fri 24/06/22	Fri 24/06/22
21	Stakeholder forum meeting	0 days	Fri 16/09/22	Fri 16/09/22
22	Stakeholder forum meeting	0 days	Fri 09/12/22	Fri 09/12/22
23	**Method 1**	**544 days**	**Mon 03/12/18**	**Thu 31/12/20**
24	Model specification	50 days	Thu 03/01/19	Wed 13/03/19
25	Scenario planning	140 days	Thu 03/01/19	Wed 17/07/19
26	Scenario Planning workshop 1	0 days	Thu 18/07/19	Thu 18/07/19
27	Scenario Planning workshop 2	0 days	Thu 03/01/19	Thu 03/01/19
28	Validation and data collection	150 days	Thu 18/07/19	Wed 12/02/20
29	Development of tool kit	150 days	Mon 01/07/19	Fri 24/01/20
30	Deliverable 1: Preliminary result reporting	0 days	Tue 31/12/19	Tue 31/12/19
31	Network transport plan integration	220 days	Sun 01/12/19	Thu 01/10/20
32	Deliverable 2: Transport & Network Model Final Report	0 days	Thu 31/12/20	Thu 31/12/20



33	**Method 2**	**1065 days**	**Mon 03/12/18**	**Fri 30/12/22**
34	Phase 1: Modelling and Assessment	193 days	Thu 03/01/19	Mon 30/09/19
35	Deliverable 3: Identification of suitable solutions for different locations	0 days	Mon 27/01/20	Mon 27/01/20
36	Phase 2: Trials Specification & Design	100 days	Mon 27/01/20	Fri 12/06/20
37	Phase 2; Deployment & Commissioning	150 days	Wed 01/04/20	Tue 27/10/20
38	Phase 2: Limited Trial Operation	200 days	Fri 01/05/20	Thu 04/02/21
39	Deliverable 4: Pilot Trial Interim Report	0 days	Sun 28/02/21	Sun 28/02/21
40	Phase 3: Deployment and Commissioning	200 days	Mon 01/03/21	Fri 03/12/21
41	Phase 3: Broader Trial Operation	200 days	Mon 01/03/21	Fri 03/12/21
42	Deliverable 5: Pilot Trial Completion / Broader Trial Interim Report	0 days	Fri 31/12/21	Fri 31/12/21
43	Deliverable 6: Final Report on network trials	0 days	Sat 31/12/22	Sat 31/12/22
44	**Method 3**	**1001 days**	**Fri 01/03/19**	**Fri 30/12/22**
45	User requirments & Model Specification	218 days	Fri 01/03/19	Tue 31/12/19
46	Data Extraction	262 days	Tue 01/10/19	Wed 30/09/20
47	Deliverable 7: ConnectMore Tool Specification	0 days	Tue 31/03/20	Tue 31/03/20
48	Network capacity assessment	240 days	Tue 31/03/20	Sun 28/02/21
49	Transport interface development	240 days	Tue 31/03/20	Sun 28/02/21
50	Implement flexible connection mechanisms and smart solutions	521 days	Fri 01/01/21	Fri 30/12/22
51	Solution testing	458 days	Wed 01/04/20	Fri 31/12/21
52	Publication and guidance documentation	718 days	Wed 01/04/20	Fri 30/12/22
53	Deliverable 8: ConnectMore Online Tool - Prototype Delivery	0 days	Thu 30/06/22	Thu 30/06/22
54	Assessment of benefits and update CBA	153 days	Wed 01/06/22	Fri 30/12/22
55	**Dissemination activiities**	**1130 days**	**Mon 03/12/18**	**Fri 31/03/23**
56	Deliverable 9: Project Closedown	0 days	Fri 31/03/23	Fri 31/03/23
57	Comply with knowledge transfer requirements of the Governance	0 days	Fri 31/03/23	Fri 31/03/23



16 Appendix D – Risk Register

The following rigorous risk register has been developed using well established SPEN methodologies, and demonstrates rational and effective risk management and appropriate risk mitigation measures to ensure the successful delivery of **Charge**.

Key for New Technology Risk Register

Financial impact	
Score	**£k**
1	<10
2	10-100
3	100-500
4	500-1000
5	>1000

Probability of risk occuring	
Score	**Probability**
1	V. Low
2	Low
3	Medium
4	High
5	V. High

Overall Impact	
Score	**Impact**
0-9	Low Risk
10-29	Medium Risk
30-40	High Risk

Reputation Impact	
Score	**Impact**
1	Minor: Department awareness
2	Medium: Company awareness
3	Major: National awareness

				Inherent Risk					Residual Risk			
Risk	**Issue**	**Risk Description**	**Potential Impact**	**Probability (1-5)**	**Financial Impact (1-5)**	**Reputation Impact (1-3)**	**Overall Risk (2-40)**	**Control Measure(s)**	**Probability (1-5)**	**Financial Impact (1-5)**	**Reputation Impact (1-3)**	**Overall Risk (2-40)**
Method 1 - Transport Planning and Network Planning												
1.1	Integration of network planning and transport planning	Project unable to integrate network and transport planning data sets	Potential delays to method 1 Negatively impacting project deliverables	4	3	2	20	1. Project partners have extensive knowledge and understanding in areas of expertise 2 Detailed project plan with key interactions identified	2	3	2	10
1.2	Presentation of outputs	Form of outputs is too complex for third parties and investors to effectively engage	project unable to encourage third parties to invest in key locations resulting in fragmented rollout	4	5	3	32	1. Creation of stakeholder panel to review direction and outputs of project 2. Early engagement with stakeholders during project bid development 3. Project will seek to engage positively with additional stakeholder during project lifecycle (e.g. specific investors, charge point installers, vehicle OEMs etc)	2	5	3	16
1.3	Forecasting accuracy	EV take up in reality may be different to assumptions made and assessed	May result in a lack of accuracy in EV charging location optimisation	3	3	3	18	Assumptions will cover a wide range of scenarios between optimistic and pessimistic EV take up.	3	2	2	12
1.4	Investment decision	Investment made at locations suggested by the project is not sucessful	This will cause waste of resources	3	5	3	24	The optimal charging locations will be indicated as a generic geographical area and will not be pinpointed on a map.	2	5	1	12
1.5	Network constraints	Identification of issues that are currently hidden e.g. lack of network capacity in certain parts of the DNO licence area	Resulting in the need for additional investments not previous considered for ED1 or RIIO 2 price controls	3	5	3	24	1. Output from method will identify possible flexibility requirements or options 2. Method 2 will explore alternative connection solutions	3	2	2	12
Method 2: Trials												
2.1	Validity and replicability of trials	Solutions becomes too specific to a single licence area affecting the ability to rollout to GB	Increased complexities for assessment introducing increasing levels of variables	1	2	2	4	1. Solution will be developed to be flexible to changing technologies to ensure that an evolving picture can be established 2. Robust desktop assessments for a number of specific location to ensure solutions are fit for purpose 3. Desk-top assessment to other licence areas ensuring solutions are not solely designed to cater for SPM network	1	2	2	4
2.2	Loss of key stakeholders	Trial location stakeholders withdraw and the potential trial locations are lost	Inability to carry on with proposed trial site resulting in lost learning and inability to deliver learning outputs	2	3	3	12	1. We have strong support from our trial partners, as outlined by the letters of support, and funding is already committed by them to develop these sites	1	3	3	6
2.3	Higher trial costs	Cost of innovative solutions is higher than anticipated	Exceedance of project budget and risk of halting some / all trials	2	4	2	12	1. Modular aspect of trials reduces overall risk. 2. Extensive experience with the project team delivering innovation project and trials 3. Project Partner with strong history delivering similar trials in UK	2	3	2	10
2.4	Implementation of trial schemes	Trial schemes cannot be implemented as specified in the technical design work packages	Failure of scheme to demonstrate the planned functionality, project does not deliver its objectives, additional costs incurred to resolve the issues	2	4	2	12	1. SPEN design team to review technical specifications of schemes 2. Demonstrate the feasibility of schemes through desktop studies for selected trial sites	1	3	2	5
2.5	Integration to NMS	The equipment provided does not comply with the security requirements and communication protocols used by SPEN corporate systems	Delay in the project delivery resulting in additional costs to redesign and procure fit-for-purpose technical solutions	3	3	1	12	1. Early engagement with IT 2. Provide clear guidance and requirements for SPEN NMS as part of tendering documents	1	1	1	2

2.6	Charger station usage	Not enough use is made of the charging stations	Limited learning to provide statistically representative conclusions , leading to inability to deliver outputs	3	3	3	18	1.Provide subsidised EVs to ensure that charge station usage is strong 2. Strong stakeholder engagement with SPEN team allocated with stakeholder and dissemination work package as SPEN contribution to project	1	3	3	6
2.7	Cost escalation in moving from trial to BaU	Slow transition from trial to BaU result in the projects continuing to fund deployment when the market should have taken over	1. Increase in project costs 2. Benefits are not realised to wider stakeholders or to GB customers	4	5	3	32	1. Recognition of limits of NIC funding in niche trails and not BaU 2. Engagement with potential investors to identify alternative long term funding routes 3. Creation of stakeholder panel to provide direction and support for the transition to BaU 4. Collaboration with UKPN to ensure replicability with other GB licensees	2	3	2	10
2.8	Data quality	Insuffient or poor quality data from chargepoints	This will reduce the benefits that can be captured from EV charge post management and may reduce the learning disseminated for the project	4	3	3	24	1. Engagement with EV charge point manufacturers to understand data available in advance of the trials 2. Alignment of trial expectations and reporting based on information gathered in stakeholder engagement ahead of trials	2	3	2	10
2.9	Data management	High volumes of data could lead to IT issues	Unable to store all data during a trial period leading to loss of data, time wasting, and reduced learning capture from the project	3	3	3	18	1. Ensure specification of tools, resources and data meets the needs of the project trials 2. Experience from previous management platform deployments means we have an understanding of the volumes of data involved in the trials, and the appropriate data management processes to ensure no loss of data	1	3	2	5
2.10	New tools and processes	Development of new tools and processes for EV connection design involves some complexity and time/cost risk	Increased complexity may increase cost to the business, and low stakeholder engagement leading to lack of benefit gained from the trial	2	3	3	12	1. Recognition of the complexity that may be involved in the tool development and accounting for this in the project plan 2. Engagement with stakeholders to understand attitude towards different levels of complexity in tools, which can then be used to assess most suitable solutions for trials 3. Review of existing tools in the market for EV and other DER management to compare approaches and ensure best options are trialled	1	2	2	4
2.11	Procurement	A risk that procurement of technology to facilitate trials could delay the project	Impact on cost and inability to successfully deliver outputs from M2	4	3	2	20	1. SPEN have already engaged with Local Authorities who are open to having input in to the procurement process to ensure they can purchase the correct charge points and participate in the trial	2	3	2	10
2.12	Desktop studies	Network evaluation finds that network triggers are difficult to categorise and constraints in trial locations are not as prominent as first thought	Reduced value from the trials, leading to reduction in the benefits captured from the NIC funded project	3	3	3	18	1. Desktop studies and analysis will provide guidance on where to deploy solutions in network areas with the most concern. 2. Constraints or network issues can be simulated on the network using software solutions, and the operation cabailities and benefits of the software can still be demonstrated	2	3	3	12
2.13	Policy	Changes to EV policy influences EV landscape	Reduced EV uptake and removal of funding/incentives for EV chargepoint deployment resulting in low stakeholder engagement and reduction of benefits	2	3	3	12	1. Trials will continue as regardless of rate of growth, the need to facilitate new EV connections and manage these will still be required	2	2	3	10
2.14	Knowledge	Knowledge import from other projects	Insufficient sharing of knowledge between this project and other projects happening in the EV sphere.	4	3	3	24	1. SPEN to have regular update discussions with UKPN regarding EV project works 2. Have participants from other active EV projects sitting on the project steering/stakeholder board to ensure two way communication between this project and others	2	3	3	12
2.15	Communications	There are communication issues with telecoms platform meaning that some areas cannot be covered by ANM	Communications issues could result in the inability to manage devices are therefore put the success of the trials at rise	2	4	3	14	1. SPEN to confirm communications already in place in trial locations 2. Engage with SPEN comms provider (Vodafone) to minimise risk of unknowns and uncertainties. 3. Engage with EV Chargepoint to understand comms requirements 4. SPD will carry out site surveys and specify telecoms that will meet the needs of the trial area 5. In worst case scenario, SPEN can resort to BaU and lay fibre cable for comms	2	3	2	10
Method 3: Connect More												
3.1	Lack of end-customer engagement	Third parties and/or investors do not find the ConnectMore tool useful or interesting	Full Method 3 benefits cannot be realised	4	5	3	32	1. Creation of stakeholder panel to review direction and outputs of project 2. Early engagement with stakeholders during project bid development 3. Project will seek to engage positively with additional stakeholder during project lifecycle (e.g. specific investors, charge point installers, vehicle OEMs etc)	3	4	3	21

3.2	Supplier lock in	Single provider of Connectmore software	1. Cost increase outside the control of SPEN 2. Risk to the broader deployment by other DNOs	3	3	3	18	1. Agreement of IP upfront (i.e. royalty free licence for GB DNOs) 2. Software approach will be documented allowing other third parties to replicate through an open tendering process	1	2	2	4
3.3	Method 1	Method 1 fails to develop a suitable assessment methodology for incorporation into ConnectMore	Method 3 outputs cannot be achieved	2	2	3	10	Ensure that the modelling methodology developed in Method 1 is fully documented as part of Method 1	1	2	3	5
3.4	Method 2	Method 2 fails to define a suitable list of solutions to lower connection costs	Full Method 3 benefits cannot be realised	2	2	3	10	Use solution set from other projects e.g. My Electric Avenue, Electric Nation	1	2	3	5
3.5	Data quality	Poor LV and HV network quality prevents the ConnectMore tool being applied at these voltages	Method 3 outputs cannot be achieved	4	2	3	20	1. Clearly specify required data quality as part of the learning from Method 1 2. Develop methods to fix common problems with network data and include in Method 3	2	2	3	10
3.6	Scalability	Data processing for ConnectMore tool cannot be scaled up to national level	Full Method 3 benefits cannot be realised	3	3	3	18	Ensure that the modelling methodology developed in Method 1 is documented and tested for scalability as part of Method 1	1	2	3	5
3.7	Regulatory uncertainty	Changes are made to the way in which connections are charged that renders the functiontionality in ConnectMore redundant	Method 3 benefits cannot be realised	2	2	3	10	Maintain a watching brief on the outcome of the Ofgem Charging Futures consultation and amend system functionality accordingly.	1	2	3	5
General Risks												
4.1	Project Partners	Delivery issues with key partners	1. Failure to deliver in line with project time scales as new partners are engaged 2. Potential of increased costs 3. Difficulty to deliver outputs in timescales of project	2	4	2	12	1. Partner selection based on track record 2. Proposal from key partners developed in line with project bid 3. Senior management commitment from each partner	1	2	2	4
4.2	Resources	Sufficient resources are not available in SPEN to deliver the project	Delay in delivery of the project and impact on quality of deliverables	2	3	2	10	1. Effective engagement with Director level in SPEN to provide clear understanding about the project size and resource required 2. Use complemented external resources where necessary	1	2	2	4
4.3	Higher project costs	Cost to complete Methods increases	Exceedance of project budget and risk of halting some or all of the project	3	5	2	21	1. Extensive learning from SPEN and project partners delivering innovation projects 2. Modular aspect of proposal to reduce overall risk	2	2	2	8
4.4	Cyber	The innovative connection solution at risk to of disruptive cyber attacks	1. Sensitive stakeholder or customer information is stolen 2. Control of flexible connections solutions id overridden by hostile agents	2	3	3	12	1. Dialogue with internal cyber security experts is opened early in the project and maintained throughout 2. Precautionary measures and procedures are developed and diligently followed by all project partners throughout 3. Standard resilience procedures are followed in the event of a cyber attack	2	2	3	10
4.6	Project dissemination	High level of dissemination events from DNOs and other do not provide value for money	Reduces the overall impact of the project	2	1	3	8	1. Stakeholder panel to test dissemination methods and to focus outputs to key groups / audiences. 2. Combined dissemination event with UKPN to leverage value for customers 3. LCNI conference to ensure wide stakeholder involvement	1	1	2	3

17 Appendix E – Detail on the Project Methods

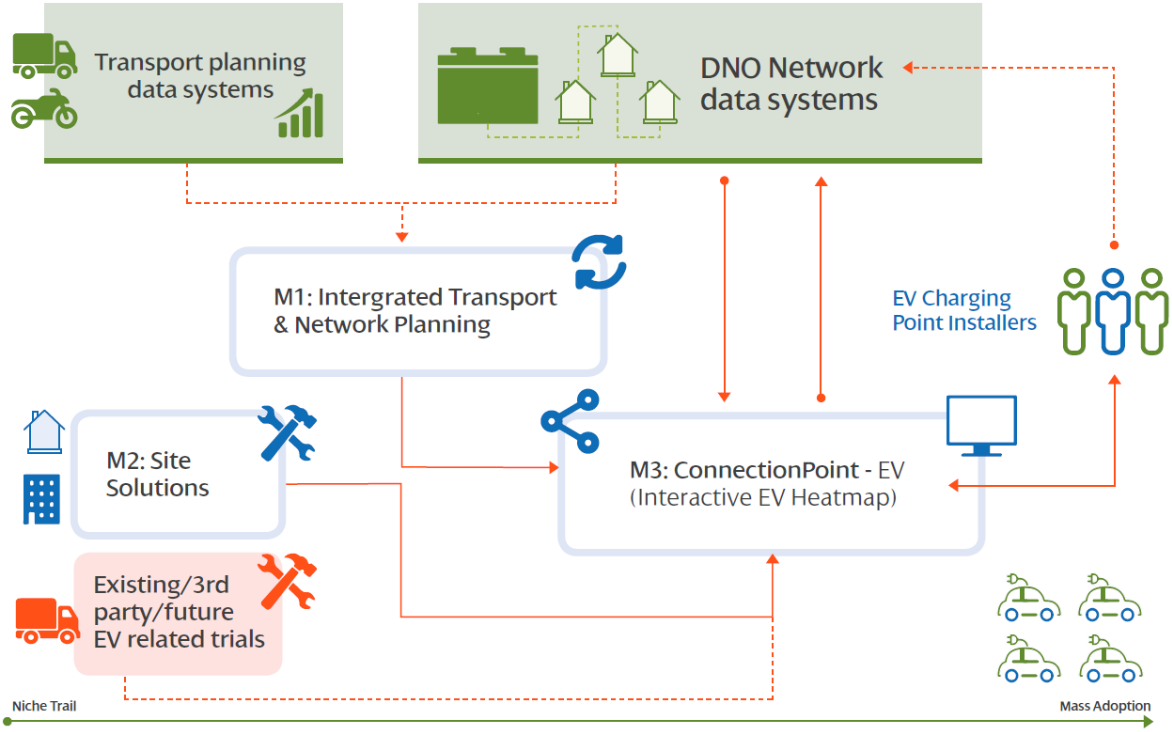


Figure 20: Overview of the Charge Methods, and their linkage to key stakeholders

17.1 Method 1: Strategic transport and network planning

It is the intention to populate a scenario planning framework that will support the development of Method 1 with all variables and considerations, so that the most appropriate combinations of assumptions can be considered in Method 3. This will also provide the specification of the transport planning tool ensuring passive provision for features that could become necessary in its development.

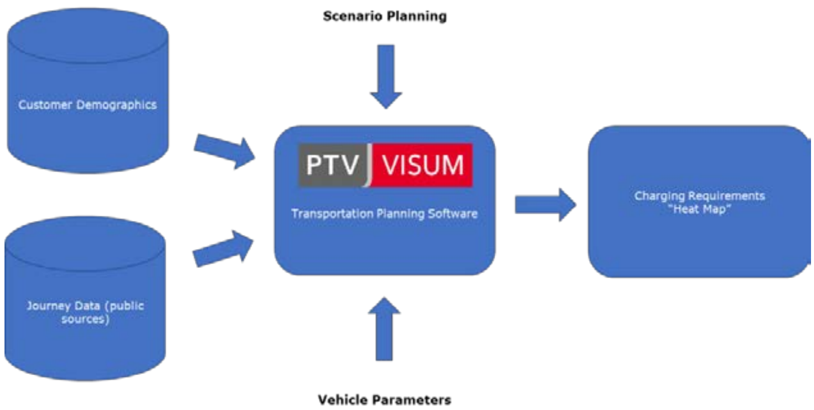


Figure 21: Method 1 overview

The Scenario Planning Framework will yield the full range of variable combinations possible for EV take up and travel behaviour. These will be filtered down to remove duplicate scenarios to reveal FIVE key scenarios to take forward. The filtering process will also be supported by desktop analysis using the Validate UK transport model. The calibrated model, with the capacity to make forecast calculations, will contain information on car and truck volumes, in addition to:

- A zonal representation of geographical locations with demographics and transport data
- A good coverage of the UK road network
- An origin destination matrix of passenger car and freight traffic
- Vehicle kilometres between the geographical zones and for each origin and destination zone
- A representation of the distribution of trips length and average speed for each origin zone
- With additional demographics data that can be obtained the model can also identify the share of home-based trips and returns (e.g. home-work-education) which can help yield estimates for home and destination-based charging
- It will be possible to create sub-models to enable the fast, low-cost production of regional or local transportation models

This assessment of the different scenarios that will be developed in conjunction with the transport model will highlight the most influential variable parameters, and also the most benign. Understanding the elasticity of the variables will also help us manage the results analysis stage and the degree of confidence we can take from the results. It will also allow us to plan sensitivity tests against the most volatile parameters to smooth the results.

Subsequently, the overall objective of Method 1 will be to inform the selection of trial sites in Method 2 and for the delivery of Method 3.

Basic Scenario Definition

The biggest variable to be considered is the EV adoption rate across the different target groups. These will be derived from traditional transport modelling segmentation groups (such as household type & journey purpose) and energy customer target groups as discussed and agreed with the Charge project team. We anticipate no more than SIX segmentation groups.

To fully understand the impact, we propose to test SEVEN adoption rates of E-Mobility (for example, 3%, 5%, 10%, 15%, 20%, 30%, 50% - to be agreed during early inception meetings) across the five chosen scenarios to be assessed with each of the segmentation groups. This will total a possible 210 sets of outputs

Aside from adoption rates there are other variables that may be considered as a result of stakeholder engagement or as industry learning evolves. Three examples include:

- Different charging patterns (where and when will vehicles recharge, and how: e.g. many short stops or few long stops)
- Different E-Vehicle pool composition (how many short-distance/long-distance EVs)
- “Detour-willingness-factor”: accepted length of detour to reach a charging station.

The scenario planning framework in combination with the transport model will form the two main tasks within Method 1 and will help deliver:

- Optimal charging locations across the urban and strategic road network to cater for transient charging of electrified vehicles.
- Electric energy demand from EVs that will inform distribution requirements (for charging at home, work etc.)

17.2 Method 2: Tactical solutions for challenging connections

Method 2 will focus on Tactical Solutions to support EV Connections. Through a targeted trial, Method 2 will determine the lowest lifecycle cost options for two key issues:

- Charging Solutions for residential properties without a driveway
    - Terraced housing, flats/apartments
- Charging solutions for destination parking and en-route locations
    - Shopping centres, event venues, concert halls, service stations

To determine the options, Method 2 will consider both novel and conventional solutions – firstly in isolation and then using a combinatory approach to develop guidance for mass deployment of EVs. To demonstrate the potential for smart solutions to manage charging on the network, the project team will use a number of tools and techniques

1. Power Systems analysis to understand the scope and potential for certain smart solutions to support the connection and use of EVs in particular use case areas.
2. Active Network Management in order to monitor, control and coordinate assets as part of the trial
3. Data processing to review the data collected during the trial phases and produce conclusions and guidance notes

An overview of the approach to Method 2 is presented in Figure 22 below:

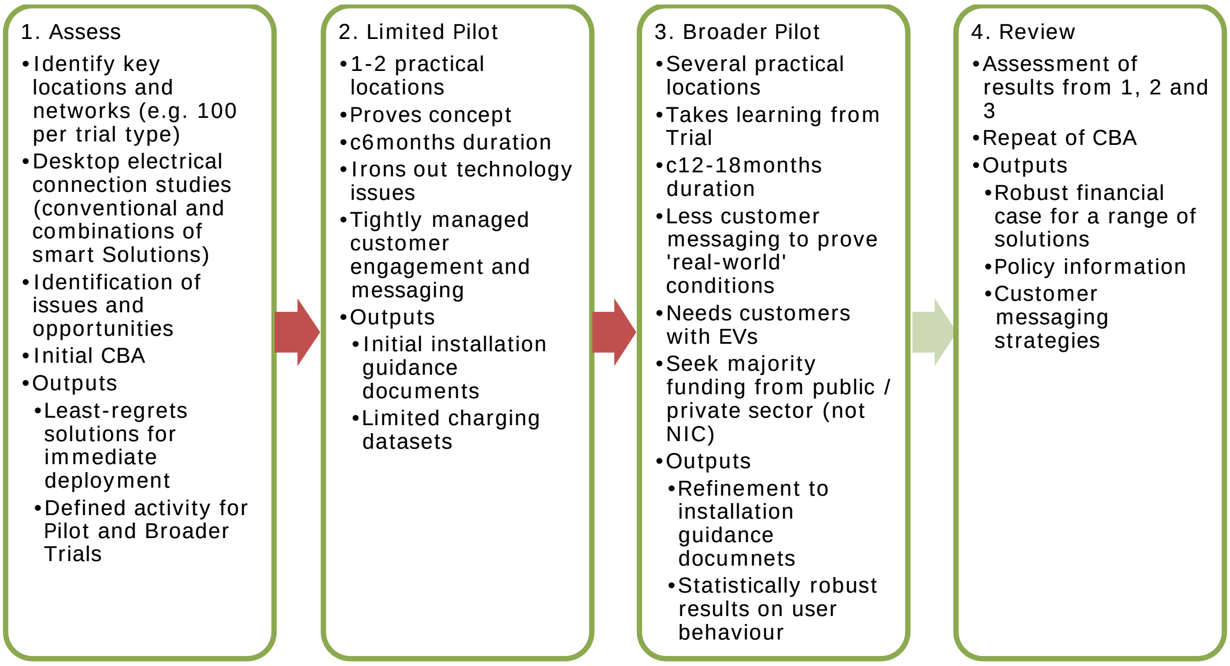


Figure 22: Overview of the trial approach (NB. Project stage-gates between 1 & 2, and 2 & 3, shown as red arrows)

Outputs will be delivered at each phase of this Method, which will allow DNOs, investors and other key stakeholders to implement learning whilst the project is in progress.

The funding landscape is changing rapidly and therefore we propose a flexible funding arrangement whereby we can leverage external funding as far as possible to maximise value for money. For example, funding sources which can play a part of this project may include:

- OLEV grants for chargepoints;
- Various local authority led environment grants;
- Chargepoint installers' funding chargepoints through their normal course of business; and
- Innovation funding, in particular the InnovateUK support for on-street and wireless charging innovations, recently announced.

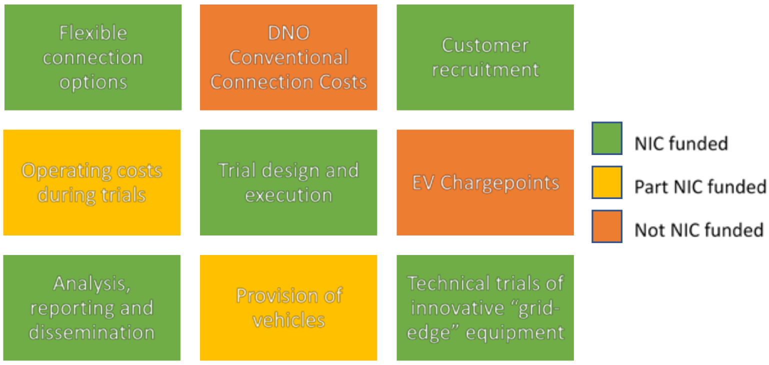


Figure 23: Overview of elements of the trial and whether they are eligible for NIC funding

17.2.1 Phase 1: Modelling and Assessment

The first Phase involves an assessment of a high volume of LV networks. Through this assessment, we will gain an understanding of the typical capacities available in the network and the implications of deploying a large volume of EVs in each area. In parallel with the initial assessment of LV capacity, we will develop a tool box of options that can be deployed to manage large volumes of EV chargers on the network. These options will comprise of both smart and conventional upgrade options.

For example:

- Smart Options: manage charging, scheduling, smart chargers, flexible charging times and rate of charge
- Conventional Options: Upgrading the network

This tool box can then be applied to different networks. A CBA helps us to measure the pros and cons of different solutions. It is recognised that there will be no single solution to allow the distribution network to accommodate public charge points. This is an emerging area so it is difficult to predict what the optimal solutions will be in the future. However, there are several location dependent constraints that will heavily flavour the type of solutions that can be deployed to help meet customer charging needs. For example, the industry does not currently understand the proportion of residential areas that can sensibly accommodate energy storage or post-type pavement installed charge points, which are often stymied by limited pavement widths.

To inform the industry, we will survey a large range of housing areas with different characteristics to define the constraints and what would the optimal solutions likely to be. We intend to conduct these surveys on 100 individual housing areas, including around 400 feeders, to ensure the results are statistically significant.

Table 23: Overview of Method 2 by volume

Network Type		Phase 1	Phase 2 & 3	
Type	**Nature**	**1. (Desktop) Assessment**	**2. Pilot**	**3. Trial**
On street charging	Terraced streets	**100** (50 - SPM; 50 other licence areas)	**4** (SPM)	**100** (SPM)
	Flats/apartments	**100** (50 - SPM; 50 other licence areas)		
Destination charging	commercial car park / destinations	**50** (25 - SPM; 25 other licence areas)	**4** (SPM)	**20** (SPM)
	En-route	**10** (5 - SPM; 5 other licence areas)		

17.2.2 Phase 1: Work Package Activities

Screening Suitable Network Areas: The work package will review candidate LV networks that share the following characteristics:

- On-street parking: residential areas without driveways;
- Destination charging: charging solutions for destinations and en-route locations.

Candidate areas will consist of LV networks that SPEN already has LV models of, and other network models that EA Technology can access that represent non-SP-Manweb LV networks. Through a process of screening the candidate areas, a number of different LV networks cases will be identified for each of the above types. The project team will work closely with the SPEN planning team to identify typical networks for study.

Data Collection, Model Build and Scenario Definition: The necessary time-series load profiles will be collected to reflect existing demand and anticipated EV charging behaviour. If necessary, LV network models will be updated to support the study of future scenarios, or to allow the implementation of analytical techniques (i.e. unbalanced load-flow simulations). For each LV network, the project team will develop a number of study scenarios for exploration. The scenarios will define the EV growth rates and charging behaviour for study. For each network type, up to 10 different use cases will be studied. The scenarios will be designed based on input from Method 1, and will explore different EV and load growth, and deployment of DSR, storage and other DER.

Baseline Analysis: The team will perform baseline analysis of each study scenario, identifying the conventional reinforcement that would be required to accommodate the forecasted EV growth. The team will initially work closely with SPEN planning engineers to ensure the reinforcement actions reflect BaU planning. The outputs of this analysis provide a baseline of conventional reinforcement as a point of comparison for future scenarios.

Smart Solutions Toolbox Definition and Analysis: The project team will define a series of smart solutions to be applied, characterising the solutions sufficiently to allow modelling and simulation of the solutions in the analysis environments. Analysis will be performed to simulate the impact of smart solutions in each study scenario. This will evaluate the capability of each solution to improve EV hosting, while observing likelihood of non-charging events or capacity restrictions.

Cost Benefit Analysis: The outputs of the baseline and smart solutions analysis will feed into a CBA for each of the study cases. This will evaluate the value of smart solutions and their capability to act as an alternative to conventional reinforcement.

Modelling and Stage Gate Reporting: The output from the CBA and network modelling will be documented in a short report for each network case study. Each report will detailing the impact of EV growth, the traditional reinforcement solution, smart solution options and the cost benefit analysis outputs of all solutions suitable at the network location. These individual reports will feed in to a final Stage Gate report which will determine if there is scope for a trial deployment, and also help to identify a likely location for the two trial types.

17.2.3 Phase 2 and 3: Approach and Management System

Modular Approach: For the Pilot and Trial, we propose to use a modular approach. The advantages of this modular approach are:

- We can fully explore all the possible solutions in the desk top analysis phase and understand the CBA of deploying these in particular locations of the network
- Enables a modular approach to trial design – we can build the trial up to the level that we consider appropriate based on the information gathered in the analysis phase and based on the stakeholder engagement.
- All possibilities are explored in the desk top study phase and this learning will form part of the outcomes whether deployed on the network or not.
- It allows us to select an area with the greatest potential for learning and development (and therefore of highest value to the consumer) of EV Charge Management Solutions

We understand the concerns/risks that might be associated with this approach and have detailed the appropriate mitigations in our risk register.

Solutions trialled: The following techniques and technologies will be trialled in Phase 2:

Techniques, (increasing complexity):

- Timed Charging
- Staggered Charging
- Real-Time capacity limits
- Integrated DSR and Street Lighting with Charging
- Grouping of devices e.g. EV Chargers + DER
- Forecasting and Optimisation, i.e. using forecasts of demand and local generation to flex charging and the use of local energy storage.
- Participation in Market Services

Technologies:

- Active Network Management
- Integration of third party assets in to the trial via various comms protocols
- Demand side response
- Optimization and Forecasting of demands and DER export.
- Scheduling and Dispatching of assets

Where possible we will look to demonstrate these solutions on the live network but this will depend on the trial participants and resources available. Alternatively, solutions can be simulated in a Hardware in the Loop (HIL) lab test.

Overview of technology solution: Across all trials, the same technology solution is proposed. This solution is scalable and flexible to accommodate a varying number of devices and charging strategies. The proposed technology solution is based on SGS leading Active Network Management (ANM)/Distributed Energy Resource Management System (DERMS) software platform, ANM Strata.

ANM Strata has the functionality to manage the network and/or assets autonomously and in real-time by monitoring selected network points and controlling key assets on a comprehensive platform in conjunction with other utility systems. ANM Strata contains sgs core and sgs comms hub. sgs core provides the application host for real-time algorithms (e.g. constraint management); sgs comms hub provides the communications gateway between the field devices and sgs core. This allows ANM Strata to deliver look ahead preventative and real-time corrective control in one comprehensive platform. SGS has deployed more than 10 solutions (innovation and BaU) based on the ANM Strata product in the UK, Europe and North America.

The trial will demonstrate the capabilities of the product to integrate between all elements of the system that are commercially available i.e. different charge manufacturers and aggregator technologies. Previously, ANM Strata was involved in Low Carbon London EV Trial. In this project, the project was connected to a local substation, and sent signals to EV Aggregators., The aggregators sent availability of the EVs to slow charge for demand reduction. This solution was not integrated with other technologies, did not demonstrate constraint management strategies and was simply a trial of the ability to send and receive signals to EV. There was no application to use cases.

Reasons for selecting ANM Strata for **Charge** include:

- There is currently no 'off the shelf' product specifically targeted at the management of the specific aspects we wish to demonstrate as part of this trial; monitoring the grid, managing DER, and demonstrating smart interventions
- ANM Strata is a standards-based platform – it can integrate with any other system or asset that is designed to any typical standards: DNP3, Modbus, IEC 104, web services with RESTful APIs as well as cutting edge standards such as SEP2.0, OpenADR and OpenFMB
- ANM Strata has demonstrated its ability to manage large volumes of DER in the UK (324 MW connected) including demand and storage
- SPEN have first-hand experience of this product and its ability to provide value for money in innovation projects through flexibility and extensibility.
- SGS has a strong track record of delivery in innovation projects
- No platform development will be undertaken as part of Method 2

Device Control: Due to the scale and distribution of devices, it is assumed that device control for the residential trial will occur via an aggregator. This aggregator is assumed to be the Charge Network Operator (CNO) which may or may not be the same as the charging equipment manufacturer. ANM will communicate with the CNO using a secure web interface. Devices can be grouped in reference to the network e.g. groups per feeder, or per primary. ANM Strata can then issue instructions to groups via the CNO based on real-time network information or predefined dispatch profiles/schedules

Technology Readiness Level: The core ANM Strata platform has a TRL of 9 but additional work is required to interface with new components and use constraint management and charge management strategies needed for this Project. ANM Strata is currently Business as Usual with a number of UK DNO's. There are currently 15 live schemes in the UK, managing 305 DER assets. These assets do not currently include any EV charging technology. Therefore, at the start of this project, ANM Strata will have a TRL of 7. Through the development and trial proposed as part of this project, the technology will move to TRL 9 by project completion.

17.2.4 Phase 2: Limited Pilot

Following the Phase 1 assessment/desk top study – and combining this with outputs from Method 1 – we can identify where to roll out a Limited Pilot, and then a Broader Trial based on the areas which could benefit most and demonstrate multiple solutions.

In the Pilot we will focus on 1 or 2 practical locations for a pilot site to prove the concepts explored in the desktop analysis phase. We will connect EV charge posts in to the Management Platform and configure any other assets we have as part of the Pilot – this will depend on the desire of third parties to install storage or other DER on the network.

We will then explore the management of these assets on the network and what can be done based on available network capacity. For example, aggregating charging posts using a third party e.g. charge master, and then issuing set points to the aggregator based on the level of available capacity in the network at any one time. Based on the learning from the limited trial, updates can be made to assumptions or configurations ready for a wider trial roll out.

17.2.5 Phase 3: Broader Trial

In a broader trial, we will look to build upon learning in the previous phase. This will involve a longer trial covering a wider network area and with more controllable assets (which could be charge posts or DER).

17.2.6 Benefits of Solutions

Benefits of the various charge management solutions proposed as part of Method 2 are summarised in Table 24. This table includes details of the benefits, restrictions and how they will be implemented in trials.

Table 24: Charging Solution benefits table

	Approach	What are the benefits?	What are the restrictions?	How is it implemented in the trial
Base Line Solutions	Timed Charging	This is a low tech, low cost option for the customer. It's simple, the customer understands exactly when they can and cannot charge	The customer is limited to specific charging windows, this lacks flexibility	Charging availability is fixed by the DNO through the ANM HMI. The value can be altered by the DNO if it needs to be updated for any reason.
	Staggered charging per street/estate	Simple for the customer to understand when charging is available on certain streets Low cost for the network operator and users.	This may lead to customers parking in certain areas at certain times There may be limits to the rotation depending on size and number of streets in particular groups.	The charging availability is rotated between groups of streets depending on network capabilities. This can be configured by the DNO
	Real time charging based on network measurements	Using the real-time capacity of the network based on measurements. May increase capacity at particular times of the day based on different topologies and user profiles	More complex for the user to understand when they can and cannot charge, may not have access to charge when they require it.	ANM Strata will receive real-time measurements from the network, process the information and then issue instructions to charge posts/aggregators as required based on pre-defined threshold limits.
Integration and groups	Group scheduling	Aggregating groups of chargers (or groups of groups) and combing with other devices such as storage can increase the amount of capacity for services or other needs e.g. giving a bigger source of demand response capability to relieve constraints	Groups may be limited by location i.e. can only group devices in the same feeder or substation group.	Building on the first three approaches, combining a number of devices in to groups and issuing a set point based on user defined or calculated schedules. The groups can be defined and edited by the DNO
	Integration with EVs with Street-Lighting, demand response, or DG	Introducing multiple stakeholders can increase flexibility and the capabilities of the scheme to meet customer demands and allowing others access to the network for different needs	Conflicting requirements may require there to be a hierarchy. The contractual arrangements to establish this can be complex.	Building upon the first three approaches, integration of street lighting or DSR may add a great level of flexibility
Optimisation	Forecasting and Optimisation	Can use optimization and forecasting to make the best use of the assets in areas of the network by setting objectives. This can increase network performance, improve charging capabilities and make increased use of renewable energy when available based on forecast. EV groups may set requirements on when they must have charge availability.	Increases complexity of the scheme, can be less transparent for EV charging customers, may lead to customers being unable to charge if optimization favours another objective.	Interface with forecasting and optimisation applications in order to reach desired objectives. This may be to minimise cost to the network operator, to enable particular services or to reduce constraints in particular areas of the network.
Market and services	Flexibility services	Creation of market services can benefit users and network operator. The network can avoid reinforcement by calling upon demand response or constraint management services when required	Can be complex to establish the commercial arrangements, and it may be difficult to do this without a Supplier as a project partner.	The way the service is defined will determine when particular devices must be dispatched. This can be via a set point instruction sent from the DNO, or a day ahead schedule sent to devices in advance.

17.3 Method 3: The development of the 'ConnectMore' software tool

This section outlines the key tasks required in the development of the ConnectMore tool. It is noted that the development will be carried out using a scrum software methodology, as outlined below.

17.3.1 User requirements & model specifications (4-6 months)

The key activities for this stage will be to:

- Define the data needed to support connections activity and the calculation of network capacity
- Ascertain the minimum data required to perform network assessments with varying degrees of data quality, ranging from the ability to perform detailed load flow analyses to using rule-based algorithms using design policies and rating information
- Define the process for dealing with data quality issues such that, where good information is available, the most accurate assessment approach is taken

The creation of User Stories

- We will carry out a variety of meetings with SPEN staff to develop a product backlog of User Stories, along with a high-level estimate of the cost to deliver
- Rank each user story to develop a minimum viable product (using MSCW[21] principles)
- Test these user stories with the Stakeholder Panel to ensure suitability with external party needs

Storyboard key User Story

- Develop wireframe mock-ups of priority User Stories to ensure these meet user requirements
- Test these user stories with the Stakeholder Panel to ensure suitability

The development of a Solution Architecture / Technical Specification

- Review of existing tools and existing datasets.
- Investigate load assessment tools to define the most appropriate way forward
  - o An investigation will include existing zero/low cost options (e.g. DEBUT, "hand" calculations), new low-cost options (e.g. OpenDSS) and new licenced options (e.g. CymDIST, EA "New" DEBUT). The approximate costs with the benefits and drawbacks of each approach will be summarised.
  - o There are several assessment approaches that may be undertaken to provide information of network capacity. We will look at the options available to SPEN with a broad assessment of costs
  - o The chosen approach needs to consider the cost, functionality and the flexibility in the tool to be able to be adaptable for future uses
- Identify major components and how they will interact

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[21] https://www.agilebusiness.org/content/moscow-prioritisation

- Define Non-functional requirements, e.g.: security, scalability, speed of operation, data protection/GDPR, etc.

Develop outline sprint plan for delivery: as the name suggests, this will be the more detailed plan of what will be developed and when.

17.3.2 Data extraction and processing (6 months)

This phase will:

- Identify data sources and format: size, type, frequency of update, etc.
- Design an ETL (Extract Transform Load) process to transfer data from one system to the ConnectMore tool
- Assess data connectivity and establish ways to create connectivity where it does not exist
- Convert into a model that is consistent with the load flow modelling tool
- Test plan to ensure data integrity (arrives correctly, and in the right format)

17.3.3 Network capacity assessments (6 months)

This phase will:

- Carry out integration of database to identified load flow tools at HV & LV
- Develop user interface for core functionality
- Identify a number of example networks to test and validate
- Conduct test and validation

Examples below from the “Network Assessment Tool” being developed with WPD for LV networks as part of the Electric Nation NIA project.

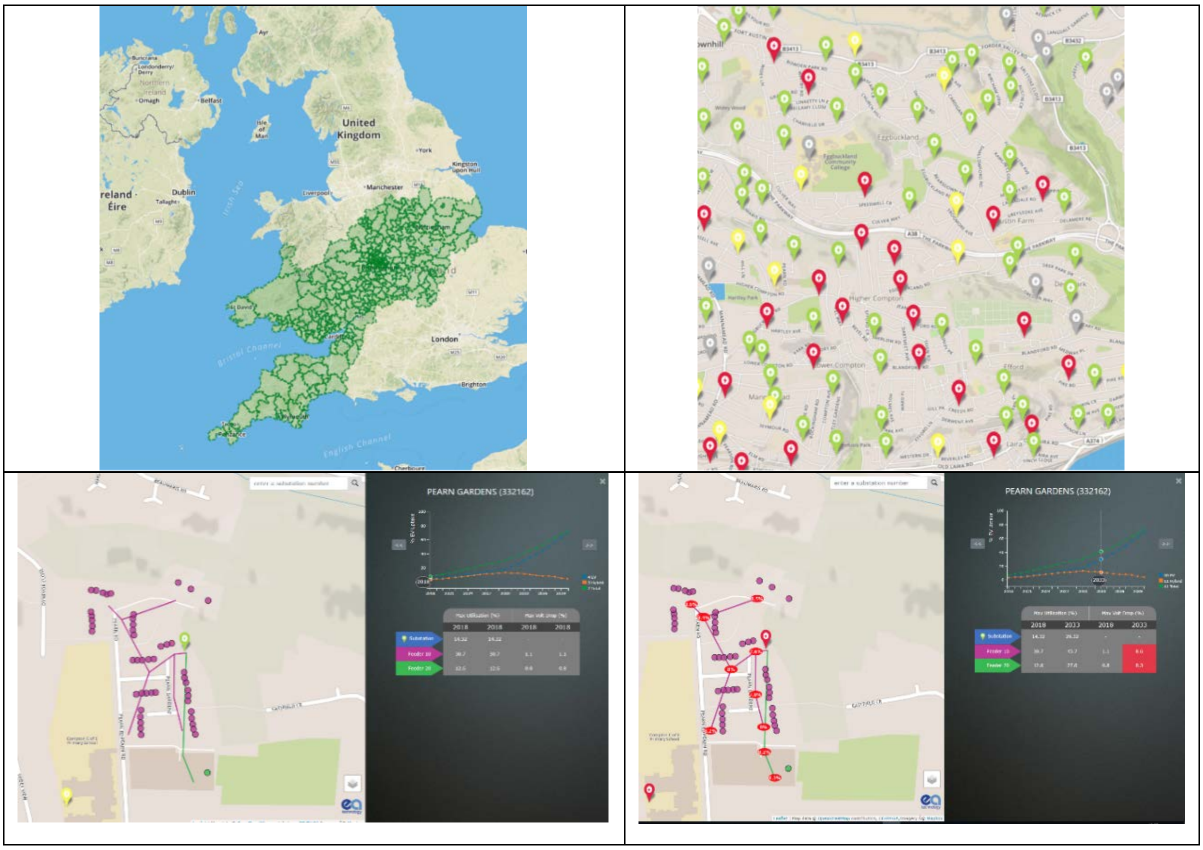

Figure 24 Network Assessment Tool prototype developed as part of Electric Nation NIA project

17.3.4 Transport Planning Integration (3 months)

This phase will:

- Assess the data requirements from the PTV software systems
- Design an ETL (Extract Transform Load) process to transfer data from one system to the ConnectMore tool
- Define display methods in ConnectMore software
- Conduct test and validation

17.3.5 Implement flexible connection mechanisms and smart solutions (2 months)

This phase will:

- Review likely outputs from trials
- Define data schema to allow new solutions to be dropped into the ConnectMore solution as they become available
- Define algorithms for processing and using this data
- Develop UI and database integration
- Conduct test and validation

17.3.6 Solution testing (3-4 months)

This phase will:

- User acceptance testing to ensure the outputs of the tool are providing answers in line with expectation
- Develop automated and exploratory testing
- Bug fixing

17.3.7 Prototype release and publication of guidance (2 months)

This phase will:

- Document the tool
- Document the user journey on how a third party would interact with the tool

We plan to release the product in several stages during the project to key stakeholders e.g. SPEN staff and the **Charge** Stakeholder Panel to gain user feedback on the tool.

17.3.8 Assessment of benefits (1- 2 months)

This phase will:

- Review the benefits of using the ConnectMore tool against the counterfactual
- Assess how this could be transferred to other DNO licence areas

Update the CBA carried out at the start of the project

18 Appendix F - Trial Design to ensure Replicability

18.1 Targeted Issues for GB electricity networks

18.1.1 Locations

As a proxy for GB, the English Housing survey 2015 showed that on third of householders in England do not live in properties with off street parking. For full transport electrification to happen, it is therefore critical that these groups are catered for in a cost-effective and publicly acceptable manner.

One of the key outputs of Method 2 will be to introduce a much greater level of understanding of demand profiles and ADMD for EV charging by segmenting user groups into 11 distinct categories which way expect to display quite diverse behaviours. Each of these demand profiles will be available for use in our model and freely available to all others. The 11 segments are outlined in Table 25.

Table 25: Likely charging locations linked to insight and information

Segment	Information Source
Residential – off street parking	Well understood, with further projects in flight to inform (ref. My Electric Avenue, Electric Nation)
Residential – on street parking	**Charge**
Residential – fuel poor	**Charge**
Workplace	Good information sources emerging
Fleet at depot	UKPN's Optimise Prime
Fleet left at domestic residence	UKPN's Optimise Prime
Private Hire	UKPN's Optimise Prime
Car Parks - shopping	**Charge**
Car Parks - Events	**Charge**
Trunk Roads	Possibly **Charge** – depends on outcome of M1
HGV / PSC	Immature – out of study timeframe

By segmenting demand profiles, we will gain a much fuller understanding of the reinforcement requirements likely to emerge once EV ownership becomes mainstream.

18.1.2 Network composition

Data from Transform Model shows that these network types combined make up just over 45% of the LV circuits in Great Britain. The SPM network has a slightly different network composition in comparison to the rest of the country. However, to ensure replicability of the approach, it is planned to trial it in other DNO licence areas. Clearly, the more licence areas that are tested, the stronger the case for replicability across the country. As a minimum, however, it will be possible to trial the approach in SPD as the sister licence area to SPM. This licence area is a lot more 'GB-like' in its composition and has over 35% of its networks falling into the categories described below. Therefore, this will act as a good proxy to ensure replicability across the country.

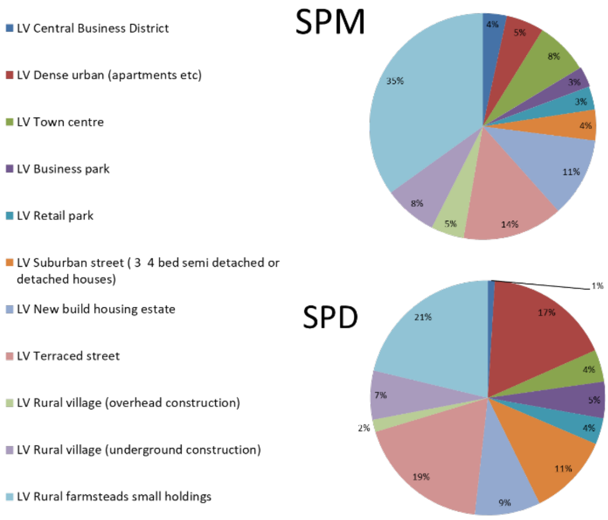

Figure 25: Networks Types as per Transform Model

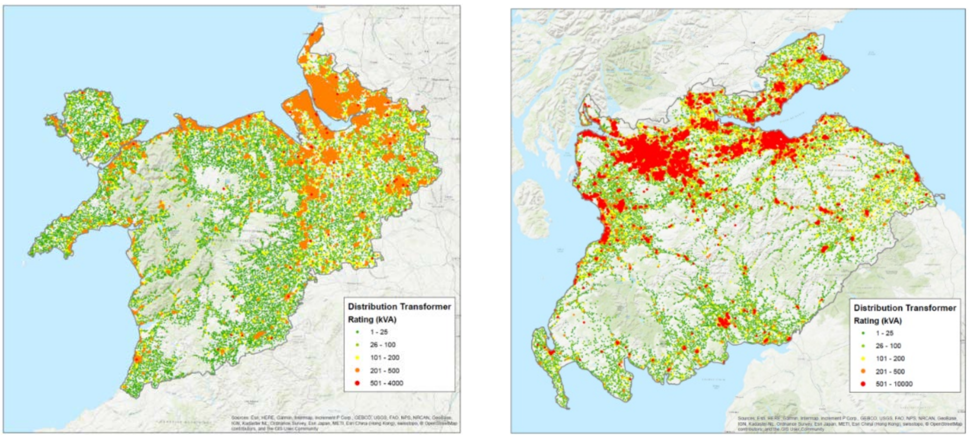

Figure 26: Heatmap of Transformer locations and sizes in SP Manweb (left) and SP Distribution (right) licence areas

18.2 Capturing customer behavioural changes and end-user experience

A key area of importance for Charge is the influence that solutions can have on both charger connectees and the charging behaviour of end customers. By employing our consistent four-step process, aligned with the AA1000SES best practice model, we will prioritise and identify our stakeholders effectively to ensure the right methods of engagement is carried out and ensuring that feedback and analysis can be turned into positive outcomes.

1. **Identify strategic risks -** identify and validate customer priorities, capturing the emerging themes through a variety of mechanisms including; panel sessions, working groups, customer's surveys & direct meetings.
2. **Identifying stakeholders and reaching further –** maximising our existing network of contacts to reach a broad and inclusive range of stakeholders by focusing on; surveys, social media, partnerships and building relationships.

3. **Informing and engaging stakeholders** – tailor engagement as appropriate to maximise benefits – including the use of face to face meetings, forums, focus groups and industry working groups.
4. **Recording feedback and taking action** – empowering our community of stakeholders and placing value in taking the right actions.

The potential impacts to customers behavioural as a result of the solutions investigated in **Charge** will be captured at various points throughout the project as outlined below. However, the exact methods will be explored in more as the detail as **Charge** progresses, incorporating the inputs of the stakeholder steering group and other key stakeholders such as EV users and chargepoint owners / operators.

Method 1: This will analyse EV take up behaviour at a strategic level. We will develop different scenarios of EV take up by different types of car users, destinations and geographical locations. This will help to test "what-if" scenarios of differences in behaviour. For example, we will carry out sensitivity testing for the provision of different number of charging locations over time and test how this can cater for different levels of EV charging demand over time. We will also look at changes in EV take up by geographical locations and destinations for example and how this may impact the optimal locations and numbers of EV charging stations over time.

Method 2: This will explore ways in which we can facilitate connection of EVs to the network through increased information to the connectee and using network management approaches. The aim of this is to reduce the connection cost and time for getting EV chargepoints connected to the network. We will explore whether savings in connection costs for EV charge-points can translate to behavioural changes of EV users. This may be changes in behaviour as a result of the flexible solutions trialled, or through pass through from the chargepoint owners.

The Pilot and Broader Trial will involve both chargepoint owners and EV customers. We will look to engage with customers to take part in the trial and will established a SPEN EV Car club if required to ensure that relevant data captured during the trial can be used to present results on how the chargepoints are being used and this data compared with EV trials from similar urban or suburban areas. Customer opinions around the trial will be captured through focus group and stakeholder engagement surveys/discussions. Questions that could be asked include queries around the ability of the charges to deliver desired volume of charge within customer timeframes, if the customer had a positive or negative experience, or if they have noticed that any form of 'managed' charging has taken place – could they tell the different from a 'normal' EV charging experience.

Method 3: By building on the learning established during Method 1 & 2, Method 3 will explore ways in which we can facilitate connection of EVs to the network through increased information to the connectee and through the use of network management approaches. The aim of this is to reduce the connection cost and time for getting EV Charge Points connected to the network. We will explore whether savings in connection costs for EV charge-points can translate to behavioural changes of EV users. This may be changes in behaviour because of the flexible solutions trialled, or through pass through from the Charge Point owners.

We will capture these changes by engaging with stakeholders involved in the connection process, and those using the charge points.

19 Appendix G – Case Study Locations

In preparation for this proposal a number of potential case study locations have been identified. These areas, along with others identified during the project, will be considered for the trial proposed in Method 2.

19.1 Case Study 1: Local network constraints

Case Study 1 focuses on a residential city centre location. There are a large number of high rise flats, with a number of small scale commercial and retail properties.

The network group is shown below. As is typical in the SPM network area, the grid group is meshed and the LV network is supplied via three 11kV substations.

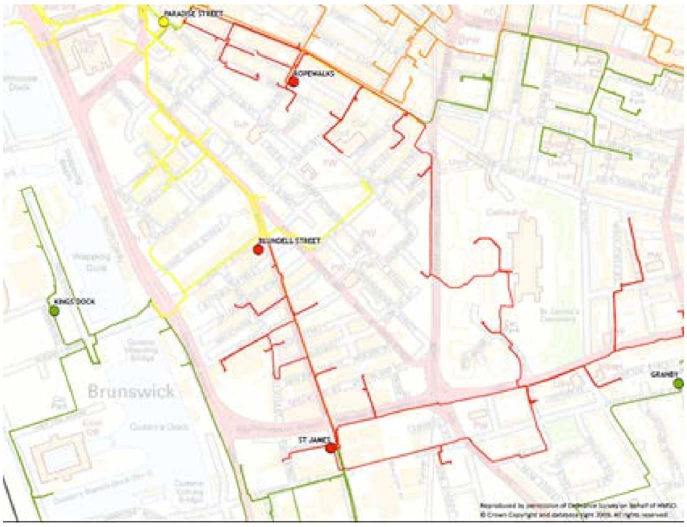

Figure 27: Network constraint issues (green = no constraint, Red = constrained network)

Demand in this network area is set to increase due to the large volume of planning applications submitted to the local council. These planning applications are for new residential apartments, and for new commercial properties (bars, restaurants, shops, etc.). The development work will not proceed until the network has been reinforced to accommodate the new load, however there is a risk to the network operator of over investment if the network is reinforced and development does not proceed for other reasons.

To further compound the issue, all previous studies of forecasted load growth have not considered the impact EVs might have on the local network. Based on the current applications there is no capacity left in the 11kV cables and primary substations.

Planning applications are developed in plots of 10 and 20, and the incremental load based on average kVA is 3.9MVA for 10 plots and 7.9MVA for 20 plots. Based on these average increments a new primary for every 15 to 20 planning applications would be required.

19.1.1 Connection Options

To facilitate the already planned development, and growth of EV charging infrastructure in the network, extensive reinforcements are required to the local network.

Previous assessments indicate that to upgrade the network, the following is required: building a new primary substation; building additional 33kV circuits across two groups; and 11kV circuit regrouping to reflect the new 33kV infrastructure. The cost per primary substation is approximately £1 million (including cabling costs to loop in new substations).

19.1.2 Potential Smart Interventions

To reduce the risk of standard assets and delay the construction of network upgrades when more development has been completed and connected to the network, Smart Interventions can be used as an interim solution. In line with the methodology proposed in this project, the solutions will explore a varying level of complexity to explore in each case if the benefits of a more complex solutions are justified by increased cost or timescale associated with deployment.

The follow Smart Interventions may be tested as part of this case study:

- **Charging Strategies:** Due to the lack of off-street parking, a new combination of charging strategies and behaviours will be explored as part of this trial. The charging behaviours explored will be linked to the types of constraint experience in the network e.g. voltage, thermal, fault level etc. Potential charging strategies include Timed or Fixed charging schedules, staggered charging on a street by street basis, or real time charging based on network limits. Varying levels of complexity will be explored and a comprehensive summary of how charging solutions link to constraints and charge behaviours as one of the key outcomes.
- **Integration with Street Lighting and Domestic Scale Storage**: building upon the charging strategies explored, these will be combined with variable load schemes such as small-scale storage and street lighting. The trial will explore if there are ways that various charging strategies can be successfully supported by having additional flexible load, and if there are benefits to some or all parties involved in the process. This demonstration will produce recommendations for ways in wish additional resources can be integrated in to EV charging schemes and identify from the Domestic Storage trial if customers are amenable to providing flexibility.
- **Flexibility Services:** Building on the technologies demonstrated, this apart of the demonstration will try to link commercial services to the technology solutions. Services to be explored include local constraint management and frequency response

There is the possibility to integrate EV charging with energy storage devices. The potential for this will be explored in more detail with project participants during the trial.

19.2 Case Study 2: Conference Arena

The arena has 3,000 car parking spaces available across three multi-storey car parks adjacent to the site. A fire at the venue in December 2017 has led to the car park being rebuilt, and network reinforcement work being carried out at the local substation.

Installation of EV charging facilities will increase the capacity required by each multi-storey unit. While the capacity at the substation will not present any problems, there may be local network issues that need resolved.

EV developers could apply for connection in the area, in order to install any number of charge points at the large car park. With this, there is a risk that the deployment of charging infrastructure is unguided and uncoordinated.

19.2.1 Connection Options

Due to recent reinforcement works in this proposed trial area there is sufficient capacity to connect new EV charging facilities. No work is required to increase the capacity of the 33kV substation however there may be some works required to increase local capacity at the point of connection of the multi-storey car parks.

The percentage of EVs using the car park initially will be a small percentage of the overall car park users but this is predicted to increase. The point at which the DNO will require to upgrade the network at least regret is unknown.

19.2.2 Potential Smart Interventions

There is the opportunity to explore a range of different solutions in this trial area due to the volume of spare capacity – this means that solutions deployed as part of the trial will not cause disruption if removed following completion of the trial. It also provides the opportunity to trial a number of different flexibility and management approaches because additional constraints can be simulated on the network without having a negative impact on local customers.

The follow Smart Interventions will be tested as part of this case study:

- **A campus style micro-grid facility**: Combining EV Charging with storage and renewable generation to meet local demand while minimising import from the bulk power system. This demonstration will provide evidence of the flexibility that can be provided by using a diverse mix of low carbon technologies to meet local energy requirements, and also, to support the wider network.

  EV Charge Management of Multi-storey car park facilities: Using different charge management approaches to identify which can provide the maximum benefit to the network operator and energy consumers. This demonstration will have input from specialists to identify typical charging patterns i.e. when the car arrives, how long does it stay for and where has it come from? This will be used to inform the best charging strategy and combinations of strategies for high volume EV charging.

19.3 Case Study 3: Out of town shopping centre

A large commercial shopping complex, with a local network at capacity; There is currently no available capacity for future demand growth.

The site has 2,500 spaces which are used on a rolling basis throughout the day – this case is unlike the example presented in Case Study 2 as the user profile is different. In this case, cars are arriving at different times throughout the day and staying for variable lengths meaning that different charging strategies will be appropriate here.

19.3.1 Connection Options

In order to facilitate increase future development aspirations, and growth of EV charging infrastructure in the network, extensive reinforcements would be required to the local network and adjacent networks.

19.3.2 Potential Smart Interventions

The nature of the constraints in the area opens up the potential to demonstrate a number of DSO style services that could be used to support the network while the case for further network reinforcement is made.

- **Flexibility Services**: In line with existing DSO strategies, flexibility services will be trialled. The demonstration will focus on the technical side of flexibility services and will be used to highlight the type of data and information that must be shared between the DSO and the charging devices in order to ensure a successful market approach.
- **Combination of Charging speeds and management approaches**: There are a number of combinations of charger speeds and capacities which can be deployed to large parking areas. This demonstration will look to identify if there are certain behaviours of characteristics which suggest particular combinations or numbers of chargers, and then, what is the most suitable charging management approach.
- **Integration of Storage**: Exploring the benefits storage can bring to the site in order to support the different charging strategies required, and if it can improve the services offered. The results of this demonstrate will be compared to Case Study 2 in order to identify the impact that charging behaviour has on the ability for EV to offer services while meeting customer requirements to charge a vehicle within a desired time frame.

19.4 Pseudo Case Study: Fuel Poor

For all the case studies discussed as part of this trial, consideration will be given to ways in which the tools and techniques can support those living in fuel poverty. Consideration will be given to:

- Incentives and schemes to provide electric vehicles to low income households. This might include car-club style services, where a small fleet is provided in local car parking or on street facilities. These EVs can then be used to provide services to the local network operator.
- Combining domestic demand response schemes with EV charging to provide a large aggregated load to provide network services. The demand response devices may be owned by a third party, and households participating in the scheme may receive a discounted energy tariff.
- Electric Heating – With a large number of high-rise flats using electric heating, there is an opportunity to improve the intelligence, visibility and control of electric heating devices to use them as smart storage devices e.g. Dimplex heaters or similar. A trial could utilise electric heaters as flexible storage devices, and in return for providing a degree of flexibility, the customer may be rewarded with a tariff discount, or the ability to use EV for a discounted fee.

20 Appendix H - Learning Dissemination

20.1 Key Stakeholders

As part of the project development we have identified the following key stakeholders and level of engagement required. This list will not be static and will be continuously updated as the project progresses to ensure the learning from the delivery of the project can be implemented on a wider GB scale. As well as those stakeholders referenced below, **Charge** will be of interest to a wider audience. As part of our project stakeholder engagement plan we aim to interact with a variety of interested stakeholders through various national and local workshops and forums. This will ensure that feedback on the development, aims, objectives and execution of the project receive the widest possible appraisal.

Table 26 : Stakeholders and level of engagement

High	High / Medium	Medium / Low	Low
Ofgem / BEIS / OLEV	Charge Points Installer	Vehicle OEMs	General Public
GB DNOs	Transport Planners / Highway Agencies	Electricity Consumers	Local Businesses
Local Authorities / Regional Government	EV owners and future EV owners	Aggregators	Academia
Local Enterprise Partnerships	Industry / Trade Bodies	Solution Vendors	Consultants
			Energy Suppliers

20.2 Method of dissemination and approach

Learning and knowledge dissemination derived from the project will be tailored to suit the interests, objectives and relevance of each stakeholder group identified. Our approach to learning and knowledge dissemination will draw upon experience and activity undertaken through our ongoing innovation portfolio ensuring that material developed is pragmatic, simple, regular and targeted and makes use of a variety of mediums to engage and impart knowledge to a range of stakeholders.

21 Appendix I – Delivery Experience

21.1 SP Energy Networks

SPEN has delivered several large-scale innovation projects and are well equipped with the knowledge and experience to successfully deliver **Charge** and embed the learning in business as usual.

- **ANGLE-DC:** This £14.8m NIC project is on-going, having started in 2016. To date we have fully demonstrated our capability to prepare technical specifications for a power electronic solution and conduct a competitive procurement between different suppliers. The project is meeting its aims and objectives within the planned budget.
- **Accelerating Renewable Connections (ARC):** In this £8m project, we demonstrated our capability to trial a real-time active network management system which required a reliable communication architecture and control strategy to adjust the outputs of generators. Several technical guidance and policy documents were developed which have assisted with full business adoption;
- **Flexible networks for a low carbon future (FLEXNET):** This £6.4m project completed in 2016. We have demonstrated our capability to deliver a multi-vendor project and trial different innovative solutions at various parts of distribution networks located in both SPM and SPD.

21.2 EA Technology Ltd

A 200 strong SME based in the North West of England. EA Technology have been delivering innovation activity since the late 1960s, when it was then the R&D facility for the nationalised industry focussing on electricity distribution and its use. Today, it focusses on the higher ends of the Technology Readiness Level spectrum to deliver, implement and embed the right solutions for its customers. Its vision is to be a recognised world leader in providing solutions to improve the resilience of energy, at lower cost: addressing the needs of these systems in supporting society for both today and tomorrow.

EA Technology has been activity involved in innovation projects since the introduction of the Innovation Funding Incentive. Since 2013 it has worked with DNOs to support them in implementing the outputs of the projects into day-to-day activity both during and after project delivery. EA Technology support software solutions to network operators around the globe as part of their core activity.

Key project experience includes:

- **My Electric Avenue (c£10m)**: The first of the competitive innovation projects to have been led, in entirety by a non-DNO. My Electric Avenue was developed in 2012 and delivered as a partnership project by EA Technology and Scottish & Southern Electricity Networks to establish the impact of EVs charging on Britain's networks in clusters, and to trial a new demand control solution to manage the impact. EA Technology created a new commercial model, and led the project including contracting with and managing over 11 delivery organisations, of all shapes and sizes. The project successfully completed in April 2016 and was the only project to receive a Second Tier Reward in 2018 for exceptional delivery.

- **OpenLV (£5.9m)**: Western Power Distribution (WPD) and EA Technology's 2016 NIC project to trial an open, flexible platform to provide benefits to the network, customers, commercial entities and research organisations. This mirrors the My Electric Avenue commercial model with EA Technology taking delivery responsibility for the whole project, including contracting with five principal delivery organisations. The project is still in flight and is due to complete in April 2020.

- **Electric Nation (c£4.8m)**: EA Technology established the Electric Nation project with WPD to build on the learning from My Electric Avenue to assess more sophisticated demand control solutions with a broader range of electric vehicles. Electric Nation is the customer-facing brand of the CarConnect Network Innovation Allowance funded project. WPD have two principal contracts in place: EA Technology (for network technology, analysis and development of software) and DriveElectric (for customer recruitment activities). The project started in April 2016 and will run for three and a half years.

- **Foresight (c£4.7m)**: EA Technology are working with Northern Powergrid to advance the techniques of cable condition monitoring to develop and test novel pre-fault detection and location techniques. These techniques will detect developing faults in LV feeders before the fault leads to a loss of supply event. The techniques will also locate the position within an LV feeder of a gestating fault. The aim of the project is to deliver devices and methodologies that can significantly reduce Customer Interruptions and Customer Minutes Lost resulting from supply interruptions due to LV cable faults. The project started in 2017 and will run until 2020

21.3 Smarter Grid Solutions

Smarter Grid Solutions is a world-leading DERMS software provider, serving Distribution Utility, System Operator and Energy Asset Operator customers around the world. Our flagship product, ANM Strata, is the only DERMS software that combines grid and market optimisation with real-time control. Over the last ten years, we have grown into a global company working with most of the largest Investor-owned utilities in the UK, New York, and California. We support our customers with a range of professional services including power systems analysis, DER strategy, consulting, integration and managed services. We offer several consultancy services to support developers, governmental agencies and utilities to develop strategy and assessment of DER. Our consultancy team is experienced and equipped to help with any challenge. We use various sophisticated in-house models and analytical techniques together with expert knowledge and real-world experience of DER grid integration to provide an excellent service. Key project experience includes:

- Accelerating Renewable Connections (ARC) – **SP Energy Networks:** To help with the challenges in integrating more generation without significant distribution and transmission reinforcement, SPEN partnered with Smarter Grid Solutions to deliver the ARC project. During this project, SGS and SPEN identified a number of cases where a single generator's connection was held up due to the costs of managing specific local constraints. Our ANM 100 product was rolled out to three critical Grid Supply Points to control connected generators in real time by managing voltage and power constraints on both the transmission and distribution networks. Each system operates autonomously and integrates seamlessly with existing communications, monitoring, protection and SCADA control infrastructure.

- **ENERGISE – Southern California Edison:** This project, supported by the U.S. Department of Energy, aims to demonstrate the technology and business rules required to bring extremely high penetrations of DER to the power grid in a controlled manner. SGS is providing professional services to leverage existing DER resource control algorithms and to design, test, and integrate the Distributed Control Architecture (DCA), to support the development and demonstration of some of the DER service use cases and to complete the M&V of the field trial and Cost Benefit Analysis of the project. SGS is also providing our ANM Strata control system platform to Edison in order to integrate the control algorithms for demonstrating the DCA and use cases.

- **Low Carbon London (LCL) – UK Power Networks:** The Low Carbon London (LCL) project explored the impact of a wide range of low carbon and ANM technologies on London's electricity distribution network. SGS delivered a system and trials to instruct a DNO-driven demand response using EV charging network operators, directly controlled generators and also via commercial aggregator services. DSR was delivered as an operational tool to achieve this by decreasing electricity consumption, shutting off power to non-essential loads or increasing power production from Distributed Generation within constrained zones at critical times.

21.4 PTV Group

PTV Group develops and distributes the standard software PTV Visum (strategic macro and meso multimodal modelling) and PTV Vissim (micro and meso simulation of vehicles, cyclists and pedestrians) both worldwide well-known standards and market leaders.

PTV Group staff have many years of experience in applying the PTV modelling solutions on large scale transport models worldwide. Having built an extensive knowledge base in modelling transport supply and demand PTV Group enjoys an excellent reputation worldwide and in the UK. This knowledge acquired by PTV Group is now used to enhance our software products and to use large transport models to gain insights and understanding of the impact and feasibility of future mobility concepts. Additionally, PTV is in constant communication with research and software users to improve the software and the best practice modelling methodologies.

With PTV Group's software solutions, you can already assemble plans and business models to meet forecast energy demand and for the prioritisation of network capacity enhancements.

- Offer 4 decades of experience in route planning and sequence optimisation
- Over 2,500 cities worldwide, who rely on our solutions for traffic modelling and simulation
- Leading real-time technology and expertise in the provision and integration of software components
- A unique network of cities, automotive manufacturers, data suppliers, public transport operators, international organizations and research facilities.

22 Appendix J: Innovation Project Mapping

The following review was carried out in conjunction with UKPN.

Project Names	Funding Type	Partners	Focus	Domestic Charging	Fleet Charging	Destination Charging	Smart Charging Fleet	Smart Charging Destination	Solutions where there is no off street parking	Profiled connection solutions for Fleet	Profiled connection solution for domestic	Technology Future Forecasting	Driving Behaviour	Commercial Solutions	Enhanced Network Modelling	V2G	Profile Assessment tool owned by DNO	DNO customer tools
CarConnect	NIA	WPD	Domestic Charging and V2G of early EV adopters	Primary				Minor output				Secondary			Secondary	Primary	Secondary	
Electric Boulevards	NIA	WPD	Charging of Bus fleet		Primary		Secondary			Primary				Secondary	Minor output			
LV Connect and Manage	NIA	WPD						Minor output							Primary		Secondary	
Smart EV	NIA	SSEPD & EA Tech	consultation on options	Primary				Primary							Secondary		Secondary	
Vehicle to Grid	NIA	NPg	Vehicle to grid	Secondary				Secondary				Secondary			Secondary	Primary	Primary	
Improving Demand Forecasting	NIA	NPg	EV demand									Primary						
Black Cab Green	NIA	UKPN	Fleet impact study		Primary												Primary	
LV Engine	NIA	SPEN	Solid State Transformer and DC circuits	Minor output			Minor output	Minor output		Secondary	Secondary				Secondary			
My Electric Avenue	LCNF T2	SSE, EA Tech, et al.	Impact on LV networks	Primary								Primary			Primary		Primary	
PowerLoop	Innovate UK V2G	Octopus energy et al (inc. UKPN)	V2g in domestic setting	Secondary												Primary		
e4 Future	Innovate UK V2G	Nissan et al (inc. UKPN)	V2G in fleet		Secondary											Primary		
SMARTHUBS Demonstrator	Innovate UK V2G	Flexisolar et al.	V2G / network integration					Minor output								Primary		
Smart Electric Urban Logistics	Innovate uk / OLEV	UPS (Inc. UKPN)	depot charging		Primary					Secondary							Minor output	
Low Carbon London	LCNF	UKPN	research network impacts									Secondary			Secondary			
EVolution	NIA	UKPN	Research study					Secondary			Minor output				Secondary			
Current TRL Assessment				7	4	2	4	4	3	3	2	3	3	4	5	4	4	3
			RATIONALE	Projects focusing on Domestic demonstration & research	Small scale pilot projects only	limited work in this area Research only	Small scale pilot projects only	Small scale pilot projects only	Potential technology solutions identified but limited small scale trials	Potential technology solutions identified but limited small scale trials	Technology solutions identified but no trials	Early research only	Research only with limited trials / studies in UK	Small scale trials	larger scale trials but with different applications	Several small scale trials	Small trials developed but for different applications	Research formulated but for different application
			Charge Focus Area		Minor output	Primary	Minor output	Primary	Primary	Minor output	Primary	Primary	Minor output	Secondary	Secondary		Secondary	Primary
			New TRL Level	7	4	9	5	8	8	5	9	8	4	7	9	4	8	9
			RATIONALE	No change to TRL	Link with UKPN project and transport planning	Demonstration on system with technical output	Link Transport Planning Method 1 with UKPN project	Demonstration on system with technical output	larger demonstration on trials		several demonstration on trials leading to technical guidance notes	Development of working solution	link with UKPN and WP1 - Transport planning	off street charging solutions for flexibility	Enhanced modelling based developing future transport master plan	No change to TRL	enhanced modelling, development of Future Transport Master Plan	Enhanced modelling based developing future transport master plan
			Optimise Prime Focus Area	Secondary	Primary		Primary		Minor output	Primary	Minor output	Minor output	Primary	Primary			Primary	
			New TRL	7	8	2	8	5	2	8	4	3	8	8	7	4	8	3
			Rationale	will look at domestic home charging for fleet	demonstration on system	no change to trl	Smart Charging Fleet trials	demonstration on trials for fleet	Minor commercial fleet solution	profile connection tool small demonstration on trials for fleet	limited to commercial fleet options	No change in TRL	large-scale telematics trial	advancement of fleet options	enhanced modelling for fleet	No change to TRL	enhanced modelling for fleet	No change to TRL

Key	
Primary	Primary Objective
Secondary	Secondary
Minor output	Minor output

23 Appendix K: Stakeholder Engagement

23.1 Declared stakeholder investment during the project

The following has been earmarked in letters of support to the **Charge** project from key councils and regions.

Table 27: Ringfenced investment for EV charging infrastructure within the timescales of Charge

Organisation	Ringfenced investment	Comments
Welsh Government	£1m - £2m	Currently £2m allocated by regional Govt across Wales, with a view that this will be evenly distributed between South and North/Mid Wales
Liverpool City Council	£160k - £1.16m	£160k for on street chargers, looking to increase by a further £1m for destination chargers at car parks, etc
Cheshire West and Chester Council	£200k - £600k	£200k currently allocated, with a potential to rise to £600k
Total	**£1.36m - £2.76m**	

23.2 Stakeholder Support

In addition, SPEN has been in extensive discussions with all the councils covered by the SP-Manweb licence area to understand the volume of charging points that are likely to be deployed within the timescales of the project. These have been summarised below, together with an estimate of the value of the investment.

Table 28: Summary of Stakeholder interest in Charge and plans for EV charger deployment by Government Region

Liverpool City Region Combined Authority	Liverpool City Council	Wirral Metropolitan Borough Council	Sefton Metropolitan Borough Council	Halton Metropolitan Borough Council	St Helens Borough Council	Knowsley Metropolitan Borough Council
EV Charging Point requirements in Planning Consent Applications	From April 2019 onwards	From April 2019 onwards	From April 2019 onwards	From April 2019 onwards	From April 2019 onwards	From April 2019 onwards
EV Charging Points in Local Authority Car Parks	10	20	No	10	No	No
Planned Future Connections in Local Authority Car Parks	200	100	10	50	20	10
Plans for EV Fleet Vehicles within Local Authority	Planned in 2019 – small vehicle trial	Planned in 2019 – small vehicle trial	Planned in 2019 for 1 vehicle	Planned in 2019 for 1 vehicle	Not decided yet	Not decided yet
Large Business Connections across Local Authority	Over 20	Over 20	Approx. 5	At least 6	Over 10	Approx. 5
Community Energy Projects with EV Charging included	1 project planned	2 existing and 1 project planned	Unknown	1 project planned	Unknown	Unknown
Estimated value of investment	£1m -£2m	£500k - £1m	c£100k	£100k - £500k	c£200k	c£100k

Wales	Wrexham County Borough Council	Flintshire County Council	Conwy County Borough Council	Gwynedd County Council	Isle of Anglesey County Council	Powys County Council	Denbighshire County Council	Ceredigion County Council
EV Charging Point requirements in Planning Consent Applications	Yes	Yes	Yes	Yes	Yes	From January 2019	Yes	From January 201
EV Charging Points in Local Authority Car Parks	40	20	20	50	20	10	Planned in 2019	Planned ir 2019
Planned Future Connections in Local Authority Car Parks	100	100	100	50	50	Planned in 2019	Planned in 2019	Planned ir 2019
EV Fleet Vehicles within Local Authority	1 small vehicle trial	EV Bin Wagons	10 operational with 20 planned	2 small vehicle trials	Likely to in 2019	Not decided yet	1 EV bus trial. Small vehicle trial in 2019.	Not decide yet
Large Business Connections across Local Authority	Over 20	Approx. 15	Approx. 10	Over 20	At least 10 planned in 2019	Approx 10	Planned in 2019	Planned ir 2019
Community Energy Projects with EV Charging included	2 existing with 2 planned	2 existing	3 existing	4 existing with 2 planned	None at present	4 existing with 1 planned	2 existing with 2 planned	1 existing with 1 planned
Estimated value if investment	£500k - £1m	£500k - £1m	£500k - £1m	£250k-£500k	£250k-£500k	£50k - £100k	TBC	TBC

Cheshire	Cheshire East County Council	Cheshire West & Chester Council	Warrington Borough Council	Shropshire Council
EV Charging Point requirements in Planning Consent Applications	Yes	Yes	From April 2019 onwards	From April 2019 onwards
EV Charging Points in Local Authority Car Parks	100	50	40	2
Planned Future Connections in Local Authority Car Parks	100	100	80	10
EV Fleet Vehicles within Local Authority	6 small vehicles with 10 planned	2 small vehicles with 4 planned	4 small vehicles with 4 planned	Planned in 2019
Large Business Connections across Local Authority	Over 20	Over 10	Over 20	Approx. 10
Community Energy Projects with EV Charging included	1 existing project	2 existing projects	1 existing project	None at present
Estimated value if investment	£1m	£500k - £1m	£400k - £750k	£50k - £100k

23.3 Letters of Support

The following quotes have been taken from letters / emails of support from some of the Project's key stakeholders. Further details are available on request.

23.3.1 Councils

Andy Challinor, Business Manager (Assessment), Regulatory Services at Cheshire West and Chester Council: *Cheshire West and Chester Council is currently planning for the electrification of the transport network within its Borough, specifically investigating electric vehicle charging requirements for the main transport routes in and around Chester and Ellesmere Port, which serve as major gateways for traffic from and to the Merseyside and Greater Manchester areas into North and Mid Wales. We are keen to continue and strengthen our existing partnership with SP Energy Networks to jointly prepare for future infrastructure requirements.*

The council has earmarked funding of £200k for the installation of EV infrastructure and we have recently submitted an expression of interest to OLEV for funding towards Taxi charging infrastructure. It is hoped that the Council funding will enable the Council to draw down an additional £600k through OLEV and other partners.

Colleen Martin, Assistant Director Supporting Communities, Liverpool City Council: *Liverpool City Council have funding from OLEV and other avenues to invest a minimum of £160,000 for a first phase of On Street EV Charging in various locations across Liverpool. In addition, the City Council may be spending up to £1 million to introduce and upgrade EV charging points in our main car parks, in part due to the potentially high costs of standard network reinforcement.*

Dafydd Munro, Head of Transport Decarbonisation, Welsh Government: *It was good to hear from you about your bid to Ofgem for Project CHARGE and to understand how it complements Welsh Government plans for an EV charging network to enable longer journeys by EV and promote their uptake in Wales.*

The Welsh Government is providing two million pounds of funding for the installation of electric vehicle charging points to help create a publicly accessible national network of rapid charging points across Wales. The focus will be on locations on/near our strategic road network, with a particular emphasis on enabling North-South and East-West journeys so it's safe to assume that a good proportion of this funding will be invested in Mid and North Wales. The first element of our scheme, to be completed by April 2019, is to perform a gap analysis to scope charging infrastructure needs. Understanding the challenges for the electricity network infrastructure will be an important consideration. The scheme will be delivered in full by the end of March 2020.

We would welcome the opportunity to work with you in partnership given the complementarity of the two schemes and the similarity in timescales.

Chris Hill, Economic Growth Service Project Manager, Shropshire Council: *Shropshire Council is preparing for the transition to Electric Vehicle Charging with focus on destination and on route charging at the main transport routes from the Midlands to North and Mid Wales. Working closely with SP Energy Networks to jointly prepare Shropshire for the transition to EV is of significant importance to us and we see real tangible benefits the SP Manweb EV Master Plan.*

Sadie Smith, Energy Conservation Manager, Flintshire County Council: *Flintshire County Council is preparing for the transition to Electric Vehicles (EV) and Charging Infrastructure by working closely with SP Energy Networks and other local authorities to identify the strategic charging infrastructure network required and to assess potential future operating models.*

By adopting this partnership approach and engaging in early consultation on potential networks, real tangible benefits are anticipated, which will ultimately benefit communities across Flintshire. In particular, the project will focus on tourist destinations across the County, as well as local authority owned car parks and premises.

Emma Williams, Transport and Facilities Manager, Wrexham County Borough Council: *Wrexham County Borough Council are currently embarking on an exciting project to develop an EV Charging infrastructure across the Local Authority area. The project involves installing charging points across key locations for Electric Car users* *across the County Borough. To add to the longevity of the project Wrexham County Borough Council see an involvement in the SPEN EV Master Plan for SP Manweb to be very useful in helping us determine where we focus our attention for developing the network of our charging points.*

Steven Teale, Facilities Manager, Conwy County Borough Council: *Conwy County Borough Council are planning for the introduction of electric vehicle charging across our County Borough, specifically looking at the requirements for EV Charging Points at all of the tourist destinations and council car parks in our area. Being prepared for the move to electrified transport will enable Conwy County Borough Council to take advantage of the economic benefits from the tourism industry whilst also working to achieve our wider 'Lower Emissions' targets and working with SP Energy Networks will help to align strategic investment requirements for EV charging infrastructure.*

23.3.2 Other Key Stakeholders

Dr Mary Gillie, Energy Local: *The rural communities that we work with are keen to gain the benefits of their local renewables resources and electric vehicles for tourism and tackling rural isolation. They are keen to provide the information on charging and usage pattern of EVs to SP Energy Networks. The distribution network could be the barrier to maximising the value to the local economy of generation and EVs.*

However, with Energy Local offering the financial incentive, domestic demand side response and routes to engagement we believe we that we can achieve the local balancing required to accommodate generation and new loads such as electric vehicles, integrating active network management and domestic demand side management.

Arwel Lloyd, Managing Director, Utilities Connections Management Ltd: *UCML fully supports the SP Energy Networks initiative submission associated with Electric Vehicle Charging (EVC). In addition to the impact EVC is anticipated to have on DNO's distribution networks, both existing and proposed, the resulting impact on Developers and in particular, those associated with Social Housing needs, is likely to be significant. In this regard, UCML is excited to be under consideration for a role as Partner to SP Energy Networks and looks forward to providing the necessary input to ensure a successful outcome.*

Mark Knowles, Head of Low Carbon Economy, Liverpool City Region LEP: *Working in partnership with SP Energy Networks to prepare the local electricity network for any required infrastructure improvements is of paramount importance to the City Region and we are committed to facilitate learnings from Project CHARGE to help SP Energy Networks become an enabler for the further electrification of the transport*

Robert Proctor, Business Development Manager, Community Energy Wales*:* *Working closely with SP Energy Networks is very important to us and we are very keen to improve upon the existing partnership to include electric vehicle charging opportunities in addition to all the renewable generation opportunities that have already been established.*

24 Appendix L: Charge Counterfactual

This counterfactual describes the likely implications of what could happen with an accelerated ramp-up of EVs across Great Britain and the impact this would have on our power networks, connectees and end users. It has been developed to explain how the Charge project will provide solutions to reduce these risks and improve user experience for new connections and end-users (the EV drivers).

We consider the following three use cases:
1. EV charging en-route
2. EV charging at destinations
3. EV charging on-street

24.1 Use cases 1 & 2: EV charging en-route[22] or at a destination[23]

Who: Private sector seeking to deploy charging points

Why: Two models are plausible:

- ***For commercial gain***: e.g. to generate direct revenue from the chargers, the captive market, and/or other energy related services (i.e. providing balancing services via an aggregator to the ESO, vehicle to grid services), or all the above
- ***Mandated***: e.g. petrol stations, or housing developers deploy EV infrastructure to comply with national or local legislation/planning requirements

What happens:

- Developer has an idea of where they want EV infrastructure, based on available land / locations
- They review an existing DNO heatmap
  - o It's unhelpful. They either see red everywhere (no capacity), or green, as based on ability to accommodate DER, they have not been built for EV connections
  - o It's not clear how to engage with the DNO, so they make multiple requests for connection in and around the areas of interest (see experience of PV and storage connections)
  - o They incur A&D costs for each application – a massive source of frustration, given the large number of connections they must submit
  - o Alternatively, the developer realises that the existing infrastructure can't support the full load, so they put in a group of rate-limiting chargers to keep the connection cost down and ensure that the service capacity is never exceeded. Tesla Superchargers already do this, although it is not widely known[24]. This is a suitable solution initially (when you have one or two cars charging simultaneously) however as the number of EV owners requesting charge increases, this becomes problematic – for both EV owners and charger operators.
- For the DNO, the connections clock starts ticking as soon as the request comes in

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[22] e.g. Service stations, dedicated charging locations on major trunk roads, typically 50kW+
[23] e.g. NCP Car parks, retail outlets, hotels, housing estates (via IDNOs), typically 7-50kW
[24] See "Sharing of available power" at http://teslapedia.org/model-s/tesla-driver/understanding-charging-rates/

  - The DNO has no understanding of diversity for these connections, so they assume the FULL capacity is required (e.g. 20x 40kW rapid chargers = 800kW to electrify a single petrol station)
  - The DNO unable to offer managed charging as a solution to mitigate the problem, so the full reinforcement cost is pushed back to the connectee
- The costs are prohibitively high as the connection request has triggered large volumes of deeper reinforcement
- The connection does not take place / there are vast inefficiencies in the process. Or the strong objections and protests from users and operators of fixed rate-limited charging hub results in an urgent need for expensive, unscheduled upgrades to the network. Depending on the connection charging regime (recently out for consultation), either the charging hub operator is hit with very high, unbudgeted reinforcement costs (unpopular), or the DNO has to bear these high costs and socialise them by raising DUoS charges (also unpopular).
- If it takes place, the reinforcement work will require disruptive works take place in city centres and at service stations which could result in further frustrations to other road/car park users and have a negative impact on the economies i.e. less people using service station or attending events/parking in particular areas.

Volumes / timescales: from now, initially low, but expected to ramp up dramatically during 2020s as developers/investors rush to deploy infrastructure to support the growing EV market

24.2 Use case 3: EV charging on-street[25]

Who: Councils look at low cost options to deploy chargers / encourage the private sector to deploy chargers in terrace street environments

Why:

- Councils are mandated – they need to be moving towards air quality targets but have a strong duty of care to **all** of their tax payers. This means that they are concerned about putting too much investment into infrastructure that might (a) be seen to favour the affluent areas which can afford EVs [i.e. being discriminatory to the less well off in their ward], or (b) create a legacy liability (e.g. street furniture that needs to be serviced/maintained). The council are seeking to make this as cheap as possible and involve the private sector.
- The private sector, as 1a: for commercial gain: e.g. to generate direct revenue from the chargers, the captive market, and/or other energy related services (e.g. providing balancing services via an aggregator to the ESO, V2G), or all of the above

What happens:

- The council wants to encourage electrification to support air quality initiatives. They know where they want a solution to be deployed based on this. Council asks their transport planning consultants to provide support.
- As per 1a: The transport planner then reviews an existing DNO heatmap

[25] E.g. "lamppost" chargers, typically 3.5-7kW

- It's unhelpful. They either see red everywhere (no capacity), or green, as based on ability to accommodate DER. The heatmap has not been built to serve commercial EV chargepoint installers.
- The heatmaps are very low resolution, so even though its "red", it might actually be possible to find a charging location there; alternatively, it might show "green", when in fact the nearby feeder is already overloaded.
- There's no easy way to find out where it might be possible to accommodate the charging points at the lowest cost: the informed connectee (such as the council) contacts the DNO directly to discuss the issue, the less informed (perhaps commercial EV chargepoint installer), makes multiple requests for connection in and around the areas of interest to the DNO
- The informed, while they maybe have obtained further detail from the DNO, are still subject to A&D fees in order to the DNO to produce a detailed study of connection capacity.
- The less informed incurs A&D costs for each application – a massive source of frustration, given the large number of connections they have to submit, and low conversion rates. This is very inefficient and drives up costs for the applicant and the DNO.

- For the DNO, the connections clock starts ticking as soon as the request is received.
  - The DNO is not provided with information regarding the diversity for these connections, so they assume the FULL capacity is required (e.g. 3.5/7kW for every lamppost on every street). Even with the information around diversity provided, it is likely the DNO would assume full capacity for a worse case network assessment and reduce risk of overloads – this is the standard approach to network design when visibility and control of assets is not available to the DNO.
  - The DNO has limited options to fix the problem, so the full reinforcement is pushed back to the connectee (if connection charges remain shallow);
  - Alternatively, if connection charges become deep (as per Ofgem's Charging Futures consultation[26]), the DNO will have to go ahead and provide the connection anyway. The potentially significant (and avoidable) reinforcement costs will then be socialised through increased DUoS charges, resulting in higher bills for customers.
- The costs are prohibitively high as the connection request has triggered large volumes of deeper reinforcement, and possibly a need to replace the local transformer.
  - Local reinforcement works will result in disruption to the local streets – with road works, limited parking available, and contra-flows in place which leads to disgruntled stakeholders.
- Either the connection doesn't take place, inhibiting the uptake of LCVs, or the connection goes ahead at great cost and this is ultimately borne by bill payers through increased DUoS charges (through no fault of their own).

[26] https://www.ofgem.gov.uk/system/files/docs/2018/07/network_access_consultation_july_2018_-_final.pdf

Volumes / timescales: from now (as 1), initially low, but expected to ramp up dramatically during 2020s as developers/investors rush to deploy infrastructure to support the growing EV market.

24.3 Stakeholder Experience - in all instances

Connectee experience:

- Slow to get connection
- Prohibitively expensive connection costs due to reinforcements required
- Frustrating – a game of 'pin the tail on the donkey' between developers/investors and the DNO.
- Missed opportunity to release "natural capital" from previously unidentified (but electrically attractive) development locations.
- There is no consistency between different DNOs and the solutions (and connection costs) appear random, depending on where you are in looking to connect in the country
- If the situation persists (which it will), the EV infrastructure developers will raise this up the political agenda with a message that the DNOs are acting a blocker to electrification of transport
- High costs and a lengthy wait for network upgrades to be planned and carried out in order to facilitate the connection

End user (EV driver) experience:

- Insufficient infrastructure available to charge vehicles other than at home (on driveways)
- Unexpectedly limited "rapid" charging at times of peak demand
- Weakened confidence in switch to EVs, despite a Government push (carbon and air quality) and an increasing cost for the alternative fuel types (petrol and diesel)
- Resulting in a slowdown in uptake levels, and frustration all around.

Chargepoint operator experience:

- Poor customer service/reputation from unexpectedly slow charging and/or queues to charge
- Risk to financial viability of chargepoint operator if they are exposed to significant charges for upgrades to connection
- Lack of coordination across the UK market, uncertainty around types of connection and costs, no uniform standard for requirements of chargepoint.

Impact on DNO:

- Poor user experience – a rubbish connections process; grumpy customers. This impacts on ability to meet objectives and KPIs set out in ICE plan.
- Sporadic network expansion – disjointed, uncoordinated, limited strategic plans/rollout, ineffective expansion plans for RIIO-2; slow to accommodate EVs
- Excessive, avoidable reinforcements costs: have to employ more people to deal with connections; having to carry out reinforcement that could have been avoided with a bit more advance information; rising cost to the general customer base via increased DUoS, reservations about deep reinforcements when the future is uncertain – knowing when to plan large reinforcement upgrades without knowing just how big the impact on demand might be.

- Across Social Media, on the front page of the papers (along with Ofgem) for holding up the transition to a low carbon economy. Examples from other countries and warnings from the UK are available in the footnote[27].

25 Appendix M – Charge's Direct Impact

The definition of Direct Impact is where the deployment of the Method will cause a measurable change in the operation of the Distribution System in a controllable way.

The provision of connections to the distribution network is a core function of a DNO. Any improvement in the ability of a DNO to provide connections in a timely and efficient manner would constitute a measurable Direct Impact.

- **Method 1** will deliver a Direct Impact by identifying how capacity on the existing electricity grid aligns to the needs of EV charging, both now and into the future. This will enable the operational and financial impact of EV charging to be correctly quantified and planned for.
- **Method 2** will deliver a Direct Impact by providing solutions for the connection and operation of charging points for some of the more challenging EV connections (e.g. terraced streets, destination charging).
- **Method 3** will enhance this Direct Impact by enabling both DNO *and their customers* to understand the available, highly localised network headroom for different types of EV charging solutions, enabling customers to make an informed choice between "fit-and-forget" connections or fully flexible connection provisions, according to their needs.

25.1 Detail on Methods 1 & 3

Method 1: The mass electrification of transport is one of the biggest disruptors to today's electricity grids. EVs will cause a change in the demand, which will require investment to resolve. We need to understand, in detail, by how much, where and when, to design and operate an efficient network.

- Charging stations can vary from 7kW to 150kW peak demand, for a single unit, depending on the speed of charging and nature of charging station, each representing a significant and potentially disruptive connection to the network.
- To provide such connections efficiently, it is necessary to understand where and how people charge (both the peak electrical demand [MW] and the energy to be used [MWh]). To do this, we need to understand how people move - this is not information that is currently available to DNOs. If this information is not available, connections will have to be sized for "worst case" scenarios – resulting in excessive connection costs that will have to be passed on to consumers.
- To date, projects like My Electric Avenue and Electric Nation have provided useful information on diversity for those households with off-street parking, but their scope does not include large-scale public charging. To achieve 100% non-petrol and diesel vehicles (a 2050 backstop, with a strengthening view of this being the

[27] https://cleantechnica.com/2018/09/25/fast-charger-infrastructure-in-iowa-limited-by-state-law-utility-rules/
https://www.fleetnews.co.uk/fleet-management/case-studies/farmdrop-s-pure-electric-ethos-under-threat-says-fleet-manager-david-brown
https://www.reminetwork.com/articles/a-blind-spot-in-new-ev-charging-station-rules/

case by 2040 or earlier), it is necessary to consider how citizens move today and tomorrow in ALL circumstances: urban, suburban, rural; charging at home, on streets, at work, on the move, etc.

- As we look into the next decade and beyond, EVs alongside other energy system innovation such as storage will add further layers of variability to what is already a complex and dynamic system. We believe innovative projects, such as Charge, will be key to accelerate the learning and understanding required to facilitate the transition to electrified transport, offer significant potential to maximise existing assets, providing improved flexibility and resilience to our system and delivering the lowest cost to solution for all customers.

Method 3: In addition to excessive costs, there is uncertainty around DNOs ability to provide connections to the network in a timely manner. The DNOs ability to keep up with a rapid uptake of EV connections will become an issue. We need to get better systems in place before the wave hits, ideally giving customers a set of simple-to-use tools to allow them to self-serve.

- The DER bubble saw an unprecedented increase in connection applications to DNOs. Across the SPEN licence areas, conversion rates from query to completed project dropped to 8% and additional staff had to be employed to accommodate the deluge of enquiries.
- There is evidence that DNOs are currently still struggling to reach time to connect targets[28]:

Table 2.1: DNO output performance, 2016-17

	Reliability and availability	Connections	Customer service[1]	Safety	Social obligations
ENWL					
NPgN		TTC targets missed			
NPgY		TTC targets missed			
WMID					
EMID					
SWALES					
SWEST					
LPN		TTC targets missed			
SPN		TTC targets missed			
EPN		TTC targets missed			
SPD		TTC targets missed			
SPMW	CI target missed (marginal)[2]	TTC targets missed			
SSEH					
SSES		TTC targets missed			

TTC = Time to Connect; CI = Customer Interruptions.

Figure 28 DNO Output performance extract (2016-17)

- A significant "wave" of charging connections is expected to come faster than previously anticipated, with increased government focus as identified in two documents launched in July 2018: DfT's Road to Zero strategy and the National Infrastructure Commission's National Infrastructure Assessment
- We are expecting to see an additional 25,000 charging installations for public and destination charging across Britain. This ignores the number of actual applications, which is likely to be significantly higher as connectees seek to identify capacity for their projects.

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[28] RIIO-ED1 Annual Report 2016-17 (https://www.ofgem.gov.uk/system/files/docs/2017/12/riio-ed1_annual_report_2016-17.pdf)

- Most of these connection applications will be deeply embedded in the distribution network (LV or 11kV), involving computational modelling to assess the impact, coupled with the all-important view of diversity as mentioned above.
  - Heatmaps, or even the tools developed under projects like ARC, are unlikely to suffice.
  - As Ofgem's own data shows, Connections are one of the few metrics where all DNOs are struggling
- Better solutions are needed - ideally giving customers a set of simple to use tools to allow them to self-serve

25.2 Links to Ofgem's consultation on network access and future charging

The proposals in Ofgem's consultation on network access and future charging arrangements provide strong evidence and support for this project.

The subsidiary document to the consultation "Assessing the current issues with electricity network access and charging" states that the first most material issue with current arrangements is "*Ensuring that access and charging arrangements for small users are ready for the uptake of Low Carbon Technologies (LCTs). Under current arrangements for small users, there is a risk that new loads like Electric Vehicles (EV) and Heat Pumps (HPs) create significant pressures on networks at peak times. This could lead to expensive reinforcement of the network, or potentially could lead to delays to uptake*." [p.5] On the subject of locational signals, the subsidiary document points out that there are "*Inefficient signals for capacity planning and network investment" and a "Lack of LV/HV locational signals*" [p.13]. These are precisely the issues we are proposing to address in Methods 1 & 3.

The objectives of the network access and future charging arrangements consultation include cost-reflective charges for network access, forward-looking charges that are simple, transparent and predictable and that the arrangements support timely and efficient network investment. The consultation acknowledges, however, that "*some complexity may be needed to support efficient outcomes [...] by providing high quality information about where and when new network capacity is needed*." [1.7 on p11]. Our project aims to comprehensively address these objectives.

Finally, the consultation proposes options to reform which can:

1. clarify access rights and improve choice for small users, including households
2. improve the definition and choice of access rights for larger users
3. improve the allocation of access rights, including establishing mechanisms to enhance the scope for markets in access. [3.3 on p29]

The consultation goes on to state that "*We think better understanding of consumers' likely behavioural response would be helpful and we would encourage the industry to work with us to consider whether trials may have merit."* [3.10 on p30]

We hope that Charge will be recognised as responding proactively to this important challenge.

26 Appendix N – Table of changes made for this resubmission

A summary of the changes made in this resubmission following feedback and questions from Ofgem and their Expert Panel on the **Charge** project.

26.1 Main Body

Section and original page reference	Change
2.2.4 (page 12)	**Customer behaviour summary:** please see section 8.3.4 and appendix F
3.4 (page 18-20)	**Financial Benefits:** Revision of the distribution of financial benefits between Methods 1 and 3
3.5 (pages 20)	**Capacity Released:** Revision of capacity released for each method
3.6 (page 20)	**Environmental Benefits:** Clarification of description – inclusion of carbon benefits table
New 3.7 (page 21)	**Additional Benefits:** section outlining additional benefits not considered in the business case.
4.1 (page 24)	**Figure 10:** updated as a result of modifications to section 3
4.2.1 (page 25)	**Table 5:** updated as a result of modifications to section 3
4.5 (page 31)	**Figure 14:** inclusion of ramp-rate of chargers volumes in line with CCC and National infrastructure recommendations chart
New 8.2.4 (page 46)	**Customer Behaviour:**
9 (page 47)	**Project Deliverables:** Minor modifications to Deliverable descriptions

26.2 Appendix

Section and original page reference	Change
Appendix A1-A3 (page 47-48)	Revisions to: financial benefits; capacity release benefits; carbon benefits tables
Appendix A4 (pages 49-57)	Revision to supporting explanation for project benefits to align with tables in Appendix A1-A3
Appendix C (page 59)	Project plan + critical path identification: MS Project plan showing further detail
Appendix D (pages 60-61)	Update to the Risk Register previously provided
Appendix E 17.2 (pages 65-71)	M2 expanded to include further information from SGS's briefing paper
Appendix F (page 76)	Additional section to outline how we will gather behavioural changes associate with each method
Appendix K (pages 88-92)	Expanded section to be retitled: "Stakeholder Engagement"
New Appendix	**Counterfactual:** An explanation of the counterfactual to the project in the 'do nothing' scenario
New Appendix	**Direct Impact:** Inclusion on the responses to various questions relating to how this project fulfils the criteria for Direct Impact.
New Appendix	**Table of changes performed in resubmission** This table
Removals: **Minor modification and removals have been completed throughout the document to avoid a significant increase in page count, e.g.** • **Appendix K - Letters of support, e.g. UKPN and Liverpool CC - *extracts used instead*** • **Appendix L - Document Tables and Figures**	