Take Charge

NIA Project Closedown Report

May 2023

Electricity Distribution

nationalgrid

Contents

1 Executive summary

The electrification of transport is a key enabler for the UK's decarbonisation target of net zero emissions by 2050, and the Government's Road to Zero strategy sets the ambition that almost every car and van will produce zero emissions by 2050. These policy ambitions will translate to a large increase in Electric Vehicle (EV) uptake across GB in the coming years.

Motorway Service Areas (MSAs) are locations where EV customers will require high power rapid charging services to quickly recharge their vehicles on longer journeys. However, MSAs currently have limited rapid charging capacity as their supply is derived either directly from the local Low Voltage (LV) network or via a distribution substation connected to the 11kV network. This means that MSAs will be unable to support largescale rapid charging demand in the future as uptake of EVs increases significantly.

The Take Charge project has specified, designed, tested and trialled a brand-new standardised package solution for delivering this much needed electrical capacity to MSAs. The new package solution has been developed and built by Brush, a leading manufacturer in switchgear and transformers, and installed at Exeter MSA operated by Moto in our South West licence area. It has been connected to the existing 33kV network within the vicinity of Exeter MSA, and provides capacity to supply both existing and new charging infrastructure. The installation at Exeter MSA is 12MVA, but the new solution can be deployed to provide up to 20MVA of capacity, and has been specifically tailored towards the requirements of the new rapid chargers.

The solution is innovative as we have developed a new form of substation that meets the needs of intensive energy users rather than domestic users. Acknowledging these differences allowed us to remove the need for: multiple transformers; additional switchgear and auxiliary equipment; a larger compound; and brick built switchroom. Because we removed these design constraints we were able to provide the required electrical capacity at much lower cost, reduced footprint and with significantly less disruption to the customer than the traditional solution (a new 33/11 kV Primary substation)

We anticipate that the solution offers a saving of £0.35m per site installation over the base case. This represents a total saving of £23.8m across the GB if rolled out to 75% of existing available MSA site locations.

The trial period has shown that the solution has met the original aims and objectives of the project, and the benefits and associated learning from the operation and use of the solution have been captured and documented. The duration of the project was 32 months, following extensions resulting from challenges in securing planning consent and agreement of terms of the lease between Moto and NGED.

The trial of the solution on a live network has provided significant learning both in terms of how the solution is optimally specified and designed, as well as how it is operated. This learning has been made available in the project documents and dissemination activities such that it has been shared with other DNOs and stakeholders to facilitate replication of the solution following the trial.

2 Project Background

The uptake of Electric Vehicles (EVs) has increased significantly in recent years with registrations of Battery EVs (BEVs) doubling during 2021[1]. The development and roll-out of rapid EV charging plays an important enabling role as it minimises the time and disruption associated with customers charging their vehicles, promoting further uptake. In addition, the Government's Road to Zero strategy sets the ambition that almost every car and van will produce zero emissions by 2050. It is therefore anticipated that EV uptake will continue to increase dramatically in the coming years as the UK transitions to Net Zero, increasing the demand for rapid EV charging facilities.

Motorway Service Areas (MSAs) have been identified as a specific location where rapid EV charging would need to be deployed on a large scale to allow simultaneous charging by multiple customers when undertaking long journeys. MSAs are currently supplied either directly via the local Low Voltage (LV) networks or via a distribution substation connected to the 11 kV network. However, the deployment of rapid EV charging at MSAs is likely to require a power supply capacity of up to 20 MVA to ensure that customers can simultaneously charge their vehicles at peak times.

Providing this level of capacity using traditional solutions would require the installation of a new 33/11 kV substation with associated transformers, compound, switchroom, switchgear and auxiliary equipment. The delivery of this solution using our standard design (built for networks that supply thousands of individual customers) would be expensive, time consuming, require a large area of land and often be far too complex for the needs of the customer.

Take Charge is a design and demonstration project that has developed a standardised solution that could be implemented at all major MSAs across Great Britain. The project has built on information previous innovation projects that investigated EV charging. This valuable information helped to specify, design, test and trial the new standardised package solution for delivering large capacity to MSAs in a far more cost and time effective manner when compared with the traditional solution.

Investigation and research of charging point data, vehicle movements and customer behaviours was conducted as part of the project to understand the optimal size, configuration and capability of the new package solution, which in turn was used to produce a detailed functional specification.

The new package solution was designed by Brush in conjunction with GHD and NGED Policy, and subsequently built by Brush. The solution has been installed at Exeter MSA operated by Moto on the M5 in our South West licence area. It has been connected to the existing 33 kV network within the vicinity of Exeter MSA, and provides capacity for both existing and new charging infrastructure. The installation at Exeter MSA is 12 MVA, but the new solution can provide up to 20 MVA of capacity with the design specifically tailored towards the requirements of new rapid chargers. In particular, the level of redundancy for this new design is based on the principle that a substation supplying rapid EV charging infrastructure can afford a different level of curtailment risk compared with a substation that supplies many individual domestic, commercial and industrial customers. This results in a lower overall capital cost and much faster connection timescales for rapid EV charging infrastructure.

The demonstration of a new packaged substation on the live distribution network provides the template for high capacity, low-cost solutions to ensure rapid charging can be deployed efficiently to serve future numbers of EVs.

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[1] https://www.smmt.co.uk/2021/12/battery-ev-uptake-doubles-but-new-car-market-remains-well-adrift-of-pre-pandemic-levels/

3 Scope and Objectives

The main objectives for Take Charge were to develop, construct and install a compact packaged 33/11 kV substation with a capacity expected to be in the range of 10-20 MVA. The new substation would be constructed at a suitable MSA based on applicability and the expected number of EV customers. The new packaged substation would be connected to existing 33 kV and 11 kV networks within the vicinity of the trial site and will provide supplies to EV charging infrastructure. The scope ranged from conducting preliminary research and analysis through to detailed substation designs and constructing and installing the equipment.

Table 1 provides a summary of the main objectives and their status following completion of the project. Further details explaining how these objectives were met can be found in Section 6.2.

Table 1 Take Charge project objectives

Objective	Status
Determine the optimal capacity for the new solution	✓
Select an appropriate site to install the new solution	✓
Produce a standardised design for large capacity, compact substations at MSAs	✓
Manufacture, install and energise the new solution at the trial site	✓
Measure and demonstrate the effectiveness of the new solution on the live network	✓
Analyse the findings from the trial and collate results that can be shared and disseminated across the industry	✓
Minimise disruption to Moto's business operation during the trials	✓

4 Success Criteria

The project successfully met the criteria specified in the original “NIA Project Registration and PEA document” dated July 2020. The success criteria for the project are summarised in Table 2 and further details explaining how these criteria were met can be found in Section 6.3.

Table 2 Take Charge Success Criterion

Success Criterion	Status
Analysis of information and data to inform the design of the new solution	✔
Selection of a suitable trial site for the installation	✔
Development of a design for the new package solution	✔
Installation and integration of the new package solution at the trial site	✔
Monitor and analyse information and data during the trial phase	✔
Dissemination of key results, findings and learning to internal and external stakeholders	✔

Substantial learning has been generated following successful completion of the research, analysis and design work along with the physical work to construct and energise the substation. Further details are provided in Section 6.3 of this closedown report.

5 Details of the work Carried Out

5.1 Introduction

The delivery of Take Charge was split into four separate work packages as detailed in the PEA and summarised in Table 3. Further details on the individual work packages are provided within the following sections of this report.

Table 3 Take Charge Work Packages

Ref	Description
1	System Capacity Optimisation
2	Develop and Design the Connection Solution
3	Build and Install the Connection Solution
4	Trial and Evaluation

5.2 Work Package 1 – System Capacity Optimisation

Work began on the System Capacity Optimisation Work Package following the project kick-off and data gathering activities in May 2020. This work package focussed on selecting a suitable trial site for the CCS and determining the required power supply capacity for that site.

5.2.1 Site Selection Methodology

In order to identify a suitable MSA to trial the new substation solution, a desktop study was carried out to assess each MSA against a set of criteria. The range of criteria was prepared to assess the technical suitability of each site, and to evaluate each site against the objectives to minimise costs, time and disruption associated with conducting the trial. In addition, the criteria also sought to maximise the learning from the trial in order to provide the best value to GB customers.

There are 13 MSAs operated by Moto within NGED's distribution licence area and each were evaluated against the criterion shown in Table 4.

Table 4 Scoring criterion for MSAs

Criteria	Description
Proximity to PoC	The proximity of the existing network at 33kV/132kV minimised the time and cost of connection. This distance was obtained using Electronic Mapping Utilisation (EMU).
Access to PoC	The access from the MSA to the nearest PoC was considered, based on this criterion, an MSA with few obstacles would be preferable, since this would reduce costs and time whilst also causing less disruption to the local community.
Network Capacity	The trial required up to 20MVA of capacity to meet the rating of the compact substation solution. As such, the PoC was assessed to ensure that the upstream network could facilitate this demand, ideally without system reinforcements.
PoC Configuration	The type of connection to the PoC for the MSA was rated, ensuring the connection to the network was as simple as possible and therefore, avoiding expensive extensions to the bulk Supply Point

Criteria	Description
	(BSP) and complex integration of circuits on existing OHL and cable networks.
MSA Space	The available space at the MSA was crucial to the success of the installation of new EV charging units, as a section of parking spaces would need to be converted into EV charging spaces. Additionally, an area of approximately 150m^2 was needed for the installation of the compact substation solution. This space was required to not encroach a detrimental impact on the number of people that use the MSA due to the disruption caused through site modification.
Visitor Usage	The annual footfall of the MSA was a considered factor, as increased visitor numbers would indicate greater potential for EV drivers to participate in the trial. It was noted that the configuration of the MSA had an important influence on footfall, for example the general road location and distribution of space.

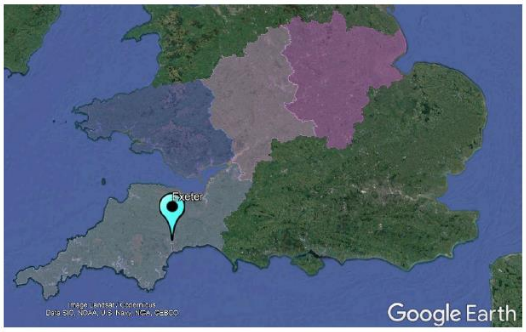
The sites were scored against each criteria and were then weighted in accordance to their relevance and impact. The MSA with the highest score was Exeter and an overview of the site evaluation is provided in Figure 1.

Exeter MSA

Overview:
Exeter MSA is located at Junction 30 of the M5 motorway, approximately 6.5km away from Exeter in Devon, England. The MSA can be accessed from both sides of the motorway and it is located near an industrial area. The MSA is located approximately 1.1km from the nearest BSP, Sowton 132/33kV. There are a number of 33kV circuits in close proximity to the MSA (<0.4km), however, the PoC has been chosen to be Sowton BSP as it is only a short distance away and would simplify the connection. There are no major obstacles to provide the 33kV connection to the MSA from the BSP.

Licence area: South West

Location:



Criteria Item	Answer	Score
Proximity to PoC (km)	1.1	3
Access to PoC	No Obstacles	3
Network capacity (MVA)	>20	3
PoC configuration	BSP Expansion	2
MSAs space (m²)	~75,576	3
Visitor usage (Million ppl/yr)	4.2	3
Weighted Total		**2.85**

Figure 1 Exeter MSA Site Selection Score

Important learning was generated during the process of selection of the preferred trial location, including building a range of criteria to consider as part of the methodology and review of system data. Further details of this can be found in the Site Selection Report published on the project website here.

5.2.2 System Capacity Optimisation

Work Package 1 also involved developing a methodology for the assessment of the required system capacity for rapid EV charging at MSA locations up to 2050. This comprised assessment of a number of factors that determine the required system capacity for each individual site. The range of factors that were considered is summarised below:

- EV uptake as a proportion of vehicles on the road;
- Traffic (historic count of vehicle flow past Exeter MSA; and regional and national projections of total vehicle journey miles);
- Customer behaviour (vehicle turn-ins at Exeter MSA; dwell time of vehicles stopped; proportion of vehicles that stop to refuel);
- Charging demand/profile (comparison of approximate EV rapid charging demand profile with Exeter MSA demand to assess level of complementarity);
- Network demand (comparison of approximate EV rapid charging demand profile with local network demand profile to assess level of complementarity);
- MSA infrastructure (numbers of existing conventional fuel pumps, EV fast charging units and car parking spaces); and
- Hardware (EV rapid charging units, 33/11kV transformer sizes, and potential for sharing of electrical equipment between EV rapid charging and solar PV and/or battery storage technologies).

The nature and relevance of each of the factors has been explained in the System Capacity Optimisation report, along with quantitative assumptions identified for application in the assessment of the required system capacity. The assessment used data made available through OZEV's Project Rapid, forecast data provided by charging point operators and EV charging data available from other innovation projects. Relevant assumptions corresponding to projections for the identified factors were applied using two approaches for assessment of the required capacity. These approaches provide projections based on the existing numbers of EV rapid charging points and conventional refuelling pumps, respectively. Results have been obtained for the required system capacity from each approach, as well as validation of them and a record of future considerations.

The approaches to the assessment are illustrated in Figure 2.

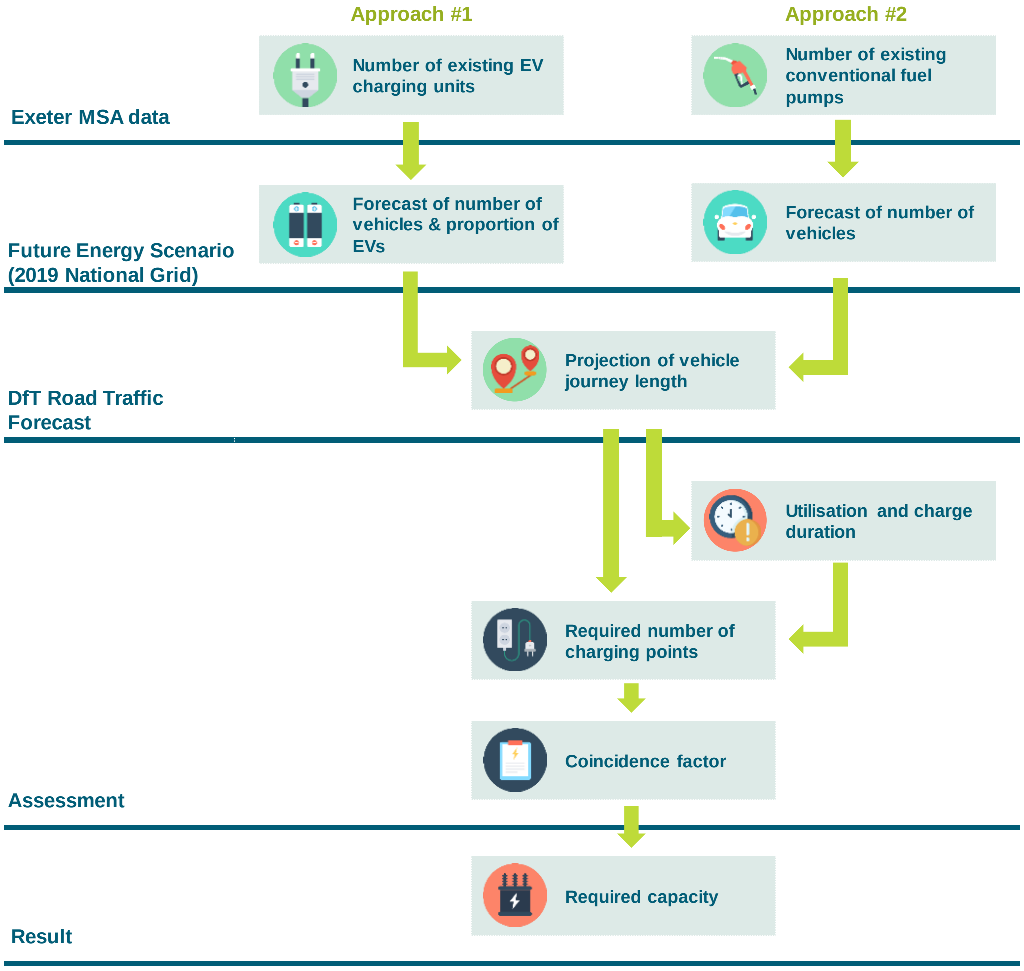


Figure 2 Approaches used for System Capacity Assessment

In approach 1, the scale of charging infrastructure required in 2050 far exceeded the available space within the MSA. Therefore, approach 2 was developed and deemed to be more accurate with the starting point providing a more realistic base for the calculation of future EV charging infrastructure requirements. Using approach 2, the calculated demand required for EV charging infrastructure at Exeter MSA is around 12 MVA until 2038, rising to approximately 18MVA by 2050 as shown in Figure 3.

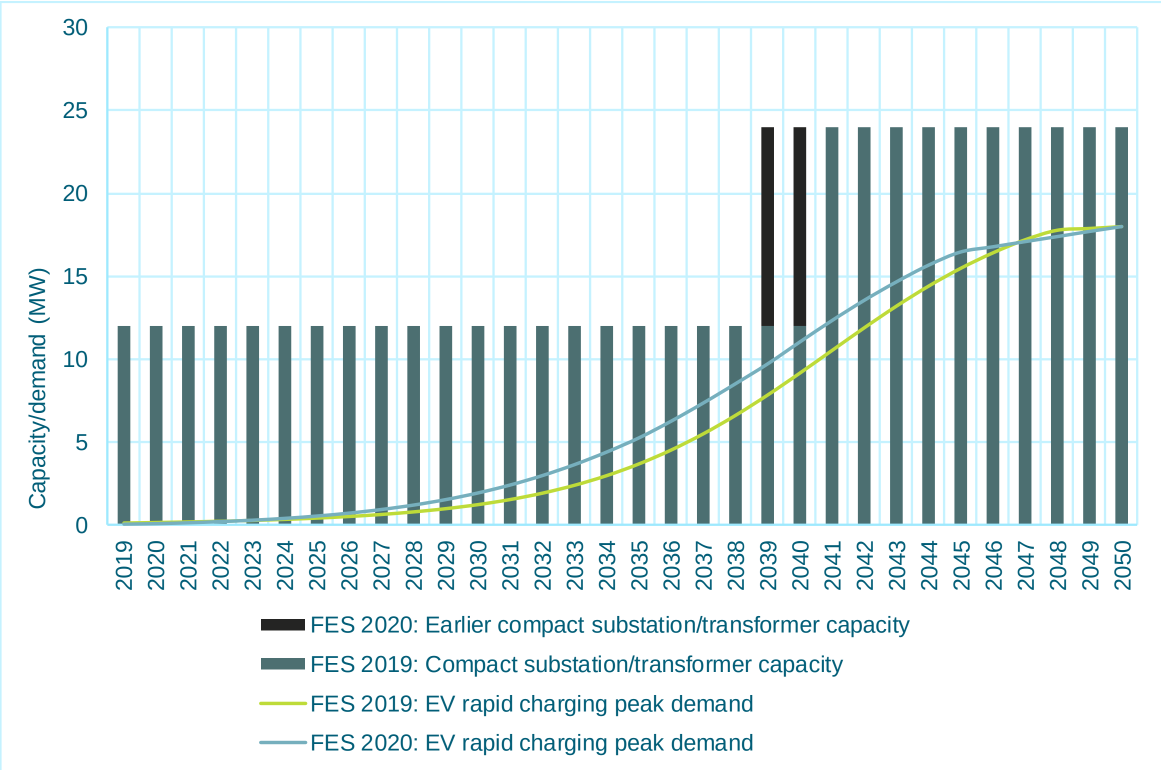


Figure 3 EV capacity projections for Exeter MSA

The output from the system capacity optimisation report highlights how the projections of EV uptake from the FES combined with road traffic forecasts, customer behaviour, charging profiles and hardware requirements can be used to calculate the charging requirements at MSAs. The results of the report were also used in Work Package 2 to determine the optimal capacity for the new substation at Exeter MSA. Further details can be found in the report on the project website here.

5.3 Work Package 2 – Develop and Design the Connection Solution

The main aim of the CCS was to produce a “plug and play” solution that can provide large capacity for rapid EV charging at a low cost. Delivering this required us to work closely with our project partner, Brush, a leading UK manufacturer in switchgear and transformers who design and supply equipment to energy companies all over the world.

5.3.1 Functional Specification

In the initial stages of the project, we held several design meetings with Brush and our policy teams to develop a Functional Specification for the CCS. This document formed the basis of the design, build and installation contract. The Functional Specification was developed from our existing standards and policies and outlined the key requirements for CCS across a number of topics as detailed below:

- **General Requirements** – including service conditions, nominal ratings, spares, reliability, documentation etc.
- **Transformer** – detailing the construction, connection types, tap-changer, losses and testing.
- **Switchgear** – details of the 11kV switchgear including the ratings, configuration, protection requirements and testing.

- **Enclosure** – outlines the requirements for the switchgear and ancillary equipment housing including access/egress, climate management, small power, lighting and transportation.

Extracts from the substation Functional Specification are shown below in Figure 4 and Figure 5.

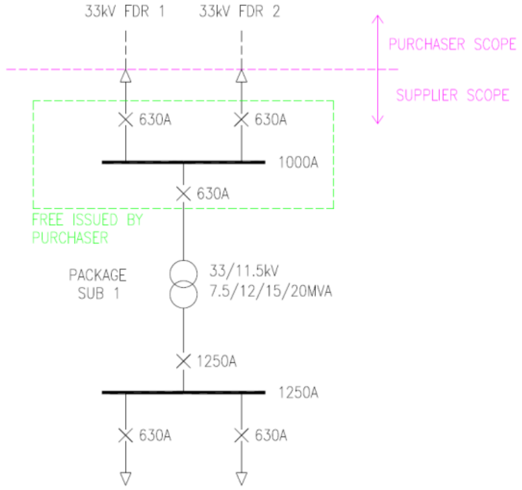


Figure 4 CCS Single Line Diagram

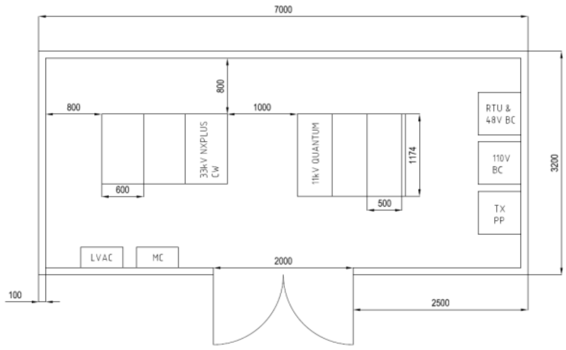


Figure 5 CCS switchroom layout

5.3.2 Design Coordination

During the initial scoping stage and following discussions with Brush, it was apparent that a number of components for the CCS should be free-issued by NGED. This arrangement would help deliver financial savings to the project due to our existing procurement contracts for such equipment. The free-issued components included the 33 kV switchgear, transformer and protection panel, Neutral Earthing Resistor (NER), Remote Terminal Unit (RTU) and 110 V/48 V auxiliary systems. Where possible, the project team aimed to use NGED approved equipment that was the most economically efficient and compact to maximise cost savings, retain as small a footprint as possible whilst maintaining the expected high levels of integrity and performance.

Weekly design calls between our team and Brush were established to help coordinate the successful integration of these free-issued components and ensure the design met the functional specification. These calls also provided an opportunity to discuss general progress, design challenges, risks and opportunities. Through this coordination we were able to finalise the design of the CCS and procure the free-issue items ready for the build phase.

5.3.3 Planning Permission

A planning permission application also had to be prepared during the design phase of the project. The requirement for submitting a planning application for new substations is dependent upon the size of the installation. Typically, any substation which is located on a new site which is over 27m³ will require planning permission and most substations connected at 33 kV will exceed this limit. The planning submission was dependent upon several surveys (including arboricultural and ecological assessments) and also contained information relating to the layout of the substation as shown in Figure 6 and Figure 7.

The planning permission for the new substation site was submitted to Exeter City Council in September 2021 and provisionally approved in December 2021. The approval was subject to the following requirement “Prior to the commencement of the substation installation, (including all preparatory work), a scheme for the protection of the retained trees, in accordance with BS 5837:2012, including a tree protection plan (TPP) and Arboricultural Method Statement shall be submitted to and approved in writing by Exeter City Council”.

Hence, it was not possible to start any site works until the TPP and had been prepared, reviewed and approved by Exeter City Council. The project team were able to prepare the Arboricultural Method Statement and submitted it for approval which was provided at the end of January 2022.

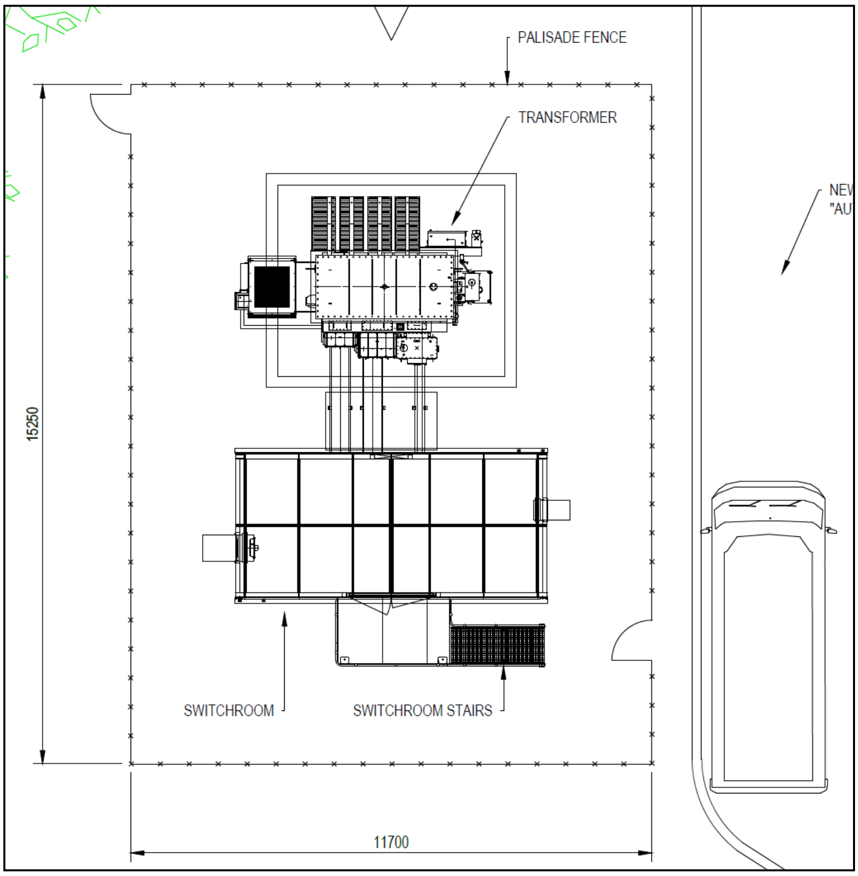


Figure 6 Planning application substation plan

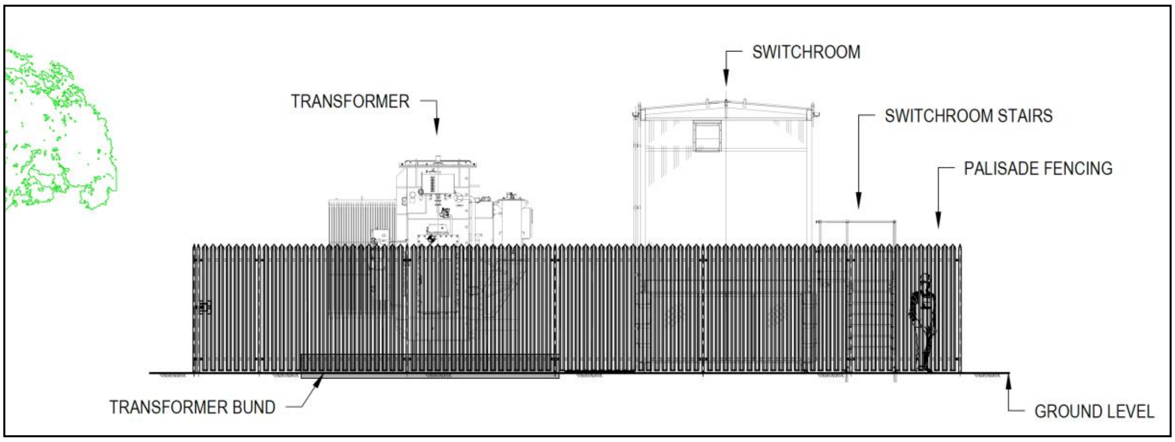


Figure 7 Planning application substation elevation

5.4 Work Package 3 – Build and Install the Connection Solution

This work package focussed on manufacturing, assembly and testing the equipment for the CCS and preparing the site at Exeter for the installation of the CCS.

5.4.1 33/11 kV Transformer

The first component to enter manufacturing was the 33/11 kV transformer which had the longest lead-time of all the components in the CCS. The transformer differed from standard primary distribution transformers as it was hermetically sealed (no separate conservator) with radiators directly attached to the tank and no forced cooling. In addition, it was equipped with the latest vacuum tap-changer (standard designs are oil-filled). These developments along with a standardised footprint for all available transformer ratings and “plug and play” secondary wiring, helped reduce the overall footprint of the transformer, minimise the overall maintenance requirements and fast track the installation on site. The build of the transformer was completed in September 2021 and the Factory Acceptance Test (FAT) was conducted and witnessed by NGED and GHD at Brush’s high voltage laboratory in Loughborough, UK.

All tests were completed successfully and met the requirements detailed in the specification. Figure 8 and Figure 9 provide photos of the transformer in the test facility at Loughborough.

Figure 8 33/11 kV transformer in test laboratory

Figure 9 33/11 kV transformer undergoing tests

5.4.2 Switchroom

The switchroom container was another key component of the CCS, housing the 33 kV and 11 kV switchgear and ancillary equipment. The aim of the containerised solution was to significantly reduce the time and effort to connect new supplies and also help reduce the footprint for the new substation. The switchroom container was manufactured by Bradgates and fitted out by ICS, an electrical engineering contractor appointed by Brush.

The container was equipped with low voltage wiring for small power, lightning, heating and ventilation at Bradgates and then was shipped to ICS for fit-out of the high voltage switchgear, protection panel, batteries, RTU and secondary wiring.

The fit-out of the equipment was completed in January 2022 and the FAT was successfully completed at ICS’s facility in Stoke in February 2022. Figure 10, Figure 11 and Figure 12 show pictures of the unit during the testing.

Figure 10 External view of switchgear container

Figure 11 View of 33 kV switchgear

Figure 12 View of 11 kV switchgear

5.4.3 33 kV Cable Installation

The chosen site for the installation of the CCS was approximately 1.5 km from the nearest connection point, Sowton 132/33 kV substation. A detailed route survey was initiated prior to tendering the cable installation to identify potential challenges and obstacles along different routes. The results of the survey were included within the tender package circulated to approved contractors. Following the evaluation of the tender responses, the contract was awarded to Kier in October 2021 who offered the best technical and commercial offer. The final route incorporated a Horizontal Directional Drill (HDD) to exit Sowton substation and a challenging route along a busy carriageway through Moor Lane industrial estate. Figure 13 provides and overview of the route.

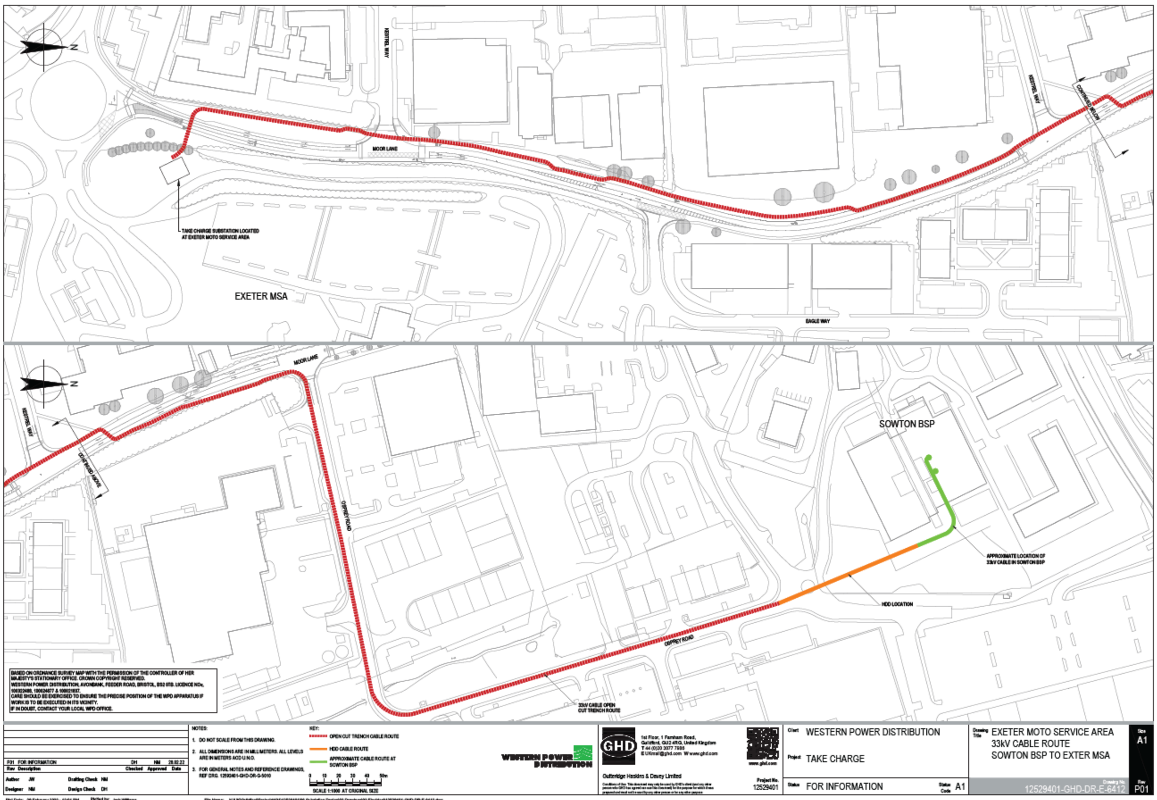


Figure 13 33 kV cable route drawing

Upon award of the contract, the relevant notices were submitted to the local highways authority to allow the installation works to begin. This included the relevant road notices and traffic management schemes along the entire route. Installation work began in January 2022 starting with the HDD from Sowton 132/33 kV substation to the junction of Osprey Road and Avocet Road. The work was completed in April 2022 with Figure 14 and Figure 15 showing photos of the installation along Osprey Road.

The typical timescales for planned cable works, such as the one for Take Charge, would be approximately 12 months from initial concept through to commissioning. This would include time to undertake a route feasibility survey, prepare and award the installation tender, submission of highway notices, cable lead time and installation. However, it should be noted that these timescales can vary substantially and are subject to project specific challenges (such as restrictions on traffic management, wayleaves, third-party utilities, ground conditions, ecology etc.).

Figure 14 Installation in progress on Osprey Road

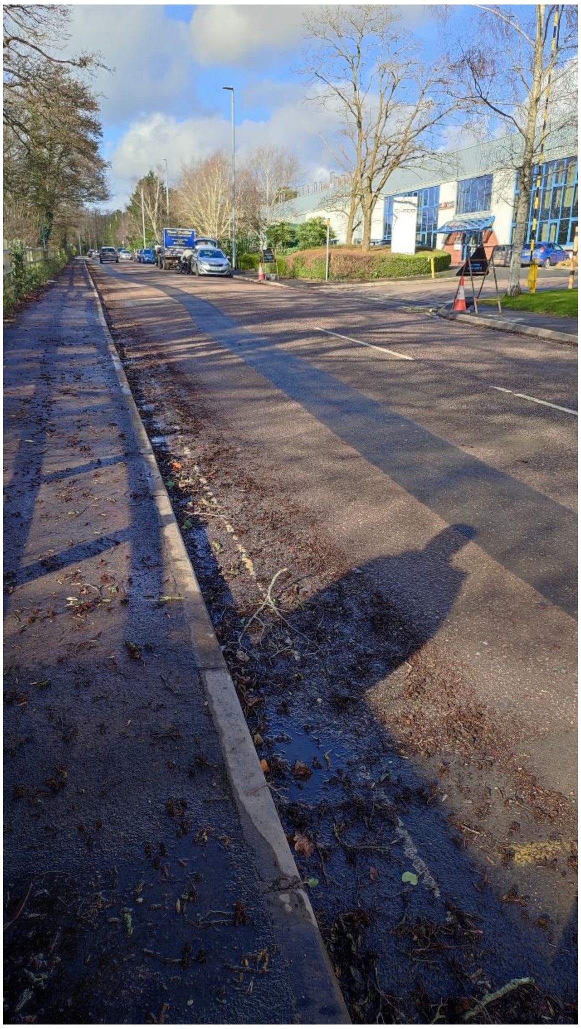


Figure 15 Completed installation towards Sowton

5.4.4 Civil installation work

The civil tender pack for the new substation site at Exeter MSA was completed and circulated to a number of approved NGED civil contractors in November 2021. The procurement process and evaluation confirmed that Bridge Civil Engineering Limited (BCEL) offered the best technical and commercial proposal and they were subsequently awarded the work in December 2021. Figure 16 shows an overview of the site and the extent of the work required.

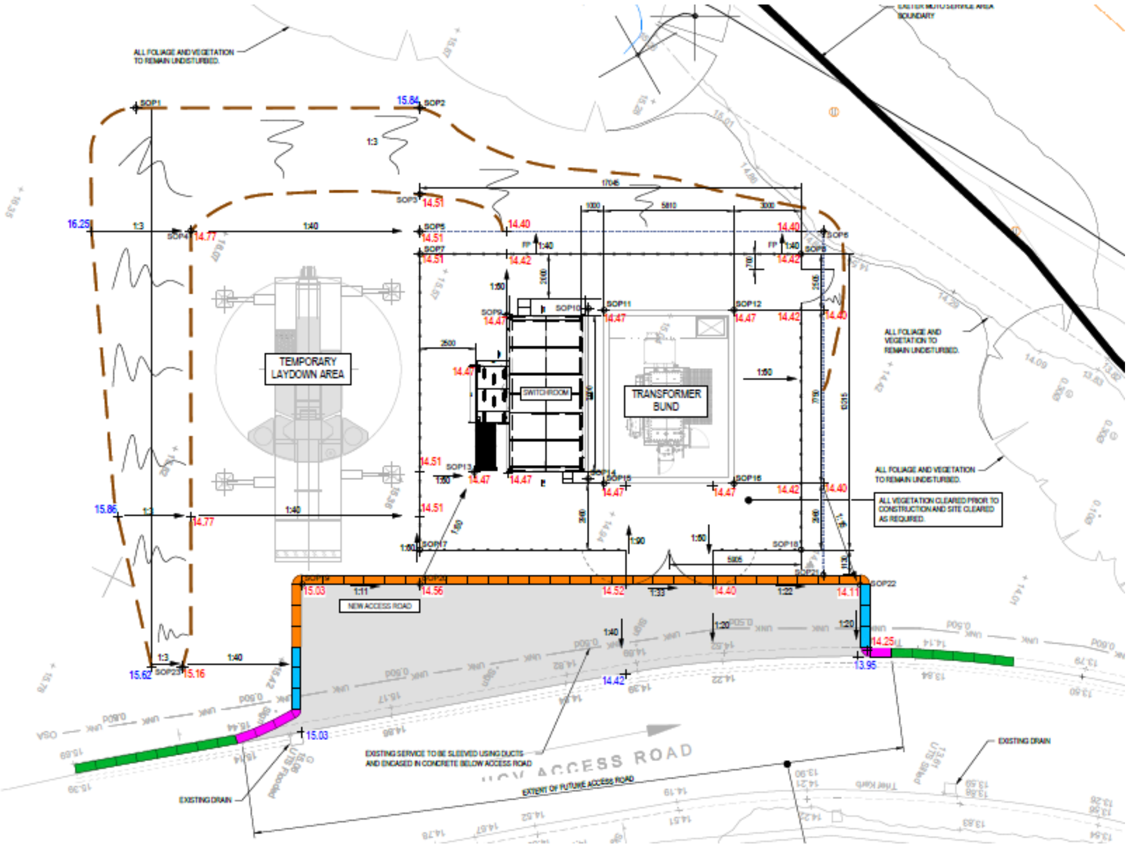


Figure 16 Overview of substation site

In addition to the compound housing the switchroom and transformer, a dedicated laydown area was established to help facilitate the groundworks and also provide a suitable location for a crane to offload the equipment, as well as a new layby adjacent to the access road. The laydown area does not form part of the area covered by the lease agreement for the substation compound and layby. However, the agreement provides ‘a right to enter and be upon the adjoining land’ for the purpose of ‘inspecting, maintaining, repairing, renewing, rebuilding and supplementing the property’. It is recommended that a similar arrangement be adopted where possible for future installations.

As discussed previously in Section 5.3.3, the civil works were unable to commence on site until the conditions of the planning permission were met. Immediately following the approval in late January 2022, BCEL were able to mobilise and begin the initial groundworks.

The main civil works took approximately two months to be completed allowing the equipment for the CCS to be delivered and offloaded in late April 2022. The delivery of equipment had to avoid the Easter holiday period as this is a particularly busy time for the MSA with high customer numbers passing through the site. Therefore, in coordination with Moto, the deliveries were scheduled for the week after the Easter holiday period.

Figure 17 shows the progress of groundworks to establish the site and Figure 18 shows the equipment being delivered in late April.

Figure 17 Vehicles removing material from substation site

Figure 18 Offloading the 33/11 kV transformer

5.5 Work Package 4 – Trial and Evaluation

Following successful delivery of the equipment in April 2022, work focussed on making the final connections to the 33 kV circuits from Sowton 132/33 kV substation and completing the commissioning and energisation of the CCS.

The existing outdoor 33 kV compound at Sowton 132/33 kV substation has been identified for condition-based replacement with a new indoor switchboard. As this replacement project was in the early planning stages at the start of Take Charge, the connection to Sowton 132/33 kV was provided by “banking” the new 33 kV circuits on to two existing 33 kV sealing end structures in the compound. This arrangement was fast to implement, taking less than a month to complete, allowing the Take Charge project to progress without any impact due to the replacement project. Provision has been made in the new Sowton 33 kV design to connect the two new 33 kV circuits to the indoor switchboard. If there was sufficient space and the switchboard was not identified for replacement, the plan would have involved extending the existing 33 kV outdoor compound at Sowton substation and adding two new switchgear bays, this would have taken around 9 months to complete.

The energisation of the substation was aligned with the summer outage period (April-October), therefore making the network access arrangements for the final 33 kV connections at Sowton relatively straight-forward. After completing the cold commissioning activities in May 2022, the substation was energised in June 2022. Figure 19 shows the substation fully installed and energised.

Figure 19 CCS installed and energised

In parallel with the CCS installation at Exeter MSA, both Tesla and Gridserve have been progressing with establishing new charging infrastructure at the site. Gridserve have recently established and connected a “High Power Electric Hub” at Exeter MSA comprising of 12 chargers with a capacity of up to 350 kW each as shown in Figure 20.

Figure 20 New High Power Electric Hub by Gridserve

Tesla have also begun installing their first chargers at Exeter MSA during the construction and installation of the CCS at Exeter. The new Tesla charging hub at Exeter will consist of 12 Tesla Superchargers which will be supplied from the new CCS. The work is currently in the final stages with the chargers expected to be energised in September 2022.

Since energising the CCS there have been no issues or faults with any of the equipment. As the substation is designed to have minimal maintenance, there has been no requirement to perform any intrusive activities on any of the equipment, therefore, the CCS has remained connected to the network.

Following the energisation of the CCS we have collected feedback from a number of stakeholders including Moto, charge point operators and internally within NGED. In addition, a meeting was held at Exeter with the Department for Transport (DfT), Office for Zero Emission Vehicles (OZEV), Ofgem, Moto and NGED. The meeting focussed on some of the barriers to accelerating the roll-out of high-power chargers across the Britain's motorway network. However, most of these points related to legislation and how, if tailored, it could help reduce the time and effort of providing these new connections. The team also praised the approach taken in Take Charge and were keen to see it replicated across other sites.

Throughout the course of the project we have also been capturing a number of lessons learnt. This was an important part of the process as we were trialling new equipment in a completely new configuration. The majority of the lessons we have noted relate to saving time, costs and space for the CCS build and install. These are captured in more detail in Section 9 of this report, and the original functional specification has been updated to reflect the outcomes of the manufacturing, testing and commissioning stages of the project. This has been reviewed by the NGED Policy team prior to publication for reference by other DNOs wishing to employ the CCS (634074 (nationalgrid.co.uk)

In addition, connection requests were received from two Charge Point Operators (CPOs) following energisation of the CCS. Physical provision of connections to customers was beyond the scope of the Take Charge project, which stopped at providing 11kV feeder tails from the new 11kV switchboard. However, the customer connection requests (following continued interest in the project) resulted in internal discussions about the ability to comply with the EREC P2/7 Security of Supply standard. For this single transformer site, connection of more than one customer means that the rules relating to group demand between 1-12 MW (Class B) are applicable. The rules require restoration of supply of the group demand minus 1 MW within 3 hours. However, the CCS design has been developed to provide capacity for EV charging in a faster and more cost effective manner, with the trade-off being a non-firm connection. The intention is that the CCS would be dedicated for EV chargers and not used to provide supplies to individual domestic, commercial or industrial customers. As such, it is proposed to incorporate demand side response into the connection agreements for these charge point operators, to allow for curtailment in the case of failure of the primary power source. It was also noted that NGED is engaging in wider industry discussions about prospective changes to P2 to overcome such issues, and a derogation request was submitted to meet the existing rules.

- In any case, it was acknowledged that a contingency plan is required for quickly replacing the primary substation switchroom and/or transformer if there is a failure. There is also a need to be mindful when carrying out maintenance on this equipment (i.e. agreeing shutdowns with the customers, minimising the duration / number of outages etc), however, the design of the CCS has sought to minimise maintenance where possible. For adoption of the solution in BAU, it was stated that one transformer unit and one switchroom with the same connections and footprint would be held in reserve. As such, complete replacement timescales would be extremely short due to the "plug and play" nature of the equipment and would likely only require around 5 days (assuming multiple shifts due to the emergency nature):
  - Day 1 - organise transport;
  - Day 2 - site prep and mobilise team for offload, install and commissioning;
  - Day 3 - offload at failed location;
  - Day 4 - reconnect, functional checks and tests; and
  - Day 5 - final commissioning and energisation.

We have also disseminated learning and information regarding the project since the initial project registration through project reports, LinkedIn posts and conferences. Table 5 provides a list of some of the key dissemination activities.

Table 5 Key dissemination activities

Event	Date	Description
NGED Innovation Showcase	1 December 2020	Live presentation to external stakeholders including DNOs, charge point operators, consultants etc. The presentation covered the site selection and system capacity optimisation outputs. There was also a dedicated Q&A session to allow stakeholders to ask questions and provide feedback on the project.
Energy Networks Innovation Conference (ENIC)	8-9 December 2020	Recorded presentation and live Q&A at the annual innovation conference held virtually due to covid restrictions. The presentation provided an overview of Take Charge, the aims and progress to date.
CIRED	20-23 September 2021	A technical paper entitled "Site selection and assessment of required system capacity for rapid EV charging and motorway service areas" was accepted, published and presented as part of the conference proceedings. This provided a great opportunity to widen the audience

Event	Date	Description
		for the project and obtain feedback for the future phases.
Energy Networks Innovation Conference (ENIC)	12-15 October 2021	Recorded presentation and live presence at the virtual innovation conference. The presentation disseminated the design activities that had recently been completed and the planned installation works.
CENEX LCV	7-8 September 2022	Presentation in-person describing all project phases and the learning generated. This presentation provided an excellent opportunity to engage with the EV community.

6 Performance Compared to the Original Aims, Objectives and Success Criteria

6.1 Overview

Take Charge successfully delivered against all the original aims, objectives and success criteria that were set out at the start of the project.

The successful delivery of the project has demonstrated that developing a compact solution for delivering high capacity to MSAs is technically feasible, reduces the time to connect, requires only a fraction of the footprint and provides substantial financial savings compared with the traditional method. The details contained within the various reports and material generated through this project provide valuable learning for future installations and other similar projects.

6.2 Project Objectives

The project successfully met all the original objectives as detailed in Table 6.

Table 6 Project objectives

Objective	Status	Performance
Determine the optimal capacity for the new solution	✔	Completed – Work Package 1 "System Capacity Optimisation" detailed how the selected capacity was calculated (12 MVA). The report detailing this is published on the project website **here**.
Select an appropriate site to install the new solution	✔	Completed – Work Package 1 also evaluated the available sites and concluded that Exeter MSA would be the optimal trial site for the installation. The report detailing this is published on the project website **here**.
Produce a standardised design for large capacity, compact substations at MSAs	✔	Completed – Work Package 2 involved developing and designing the Compact Connection Solution (CCS). The functional specification used for the design has been published on the project website **here**.
Manufacture, install and energise the new solution at the trial site	✔	Completed – The various components for the CCS were manufactured and passed all tests. Following completion of the site civil works, the CCS was subsequently installed and energised to the live 33 kV network.
Measure and demonstrate the effectiveness of the new solution on the live network	✔	Completed – Since initial energisation the CCS has remained connected to the network. A cost benefit analysis has been completed demonstrating the effectiveness of the new solution compared with traditional methods.
Analyse the findings from the trial and collate results that can be shared and disseminated across the industry	✔	Completed –The project team has actively shared progress updates and lessons during various webinars, conferences and updates to the project website. The original functional specification has been updated to reflect the outcomes of the manufacturing, testing and commissioning stages of the project. In addition, the outcomes and

Objective	Status	Performance
		lessons are being presented at CENEX LCV 2022 and are also detailed within this closedown report.
Minimise disruption to Moto's business operation during the trials	✔	Completed – Close coordination with Moto during the design and site installation work helped to mitigate any possible disruption. Hence, installation was completed without any disruption to the operation of the MSA.

6.3 Success Criteria

The project delivered against the success criteria as detailed in Table 7

Table 7 Project success criteria

Success Criterion	Status	Performance
Analysis of information and data to inform the design of the new solution	✔	Completed – data was gathered from internal sources, Moto, Ecotricity and Brush to inform the design of the new solution
Selection of a suitable trial site for the installation	✔	Completed – Exeter MSA selected as the trial site for the installation. The report detailing this is published on the project website **here**.
Development of a design for the new package solution	✔	Completed – The design was a collaboration between NGED and Brush and was finalised during Work Package 2. The functional specification produced has been published on the project website **here**.
Installation and integration of the new package solution at the trial site	✔	Completed – The CCS was installed at Exeter Moto Services and successfully energised to the 33 kV network.
Monitor and analyse information and data during the trial phase	✔	Completed – The substation has remained energised and is currently supplying EV charging infrastructure at Exeter Moto. Meetings have been held and data and information have been captured and analysed.
Dissemination of key results, findings and learning to internal and external stakeholders	✔	Completed – In addition to monthly website updates, 6 monthly reports and NIA annual reporting, the project has also been presented at NGED's Innovation Showcase event, two Energy Networks Innovation Conferences (ENIC), CIRED 2021 and CENEX LCV 2022.

7 Required Modifications to the Planned Approach during the Project

There have been two substantive change requests in which the project timescales and budget were modified). These were CR004 (17 December 2021) and CR005 (21 November 2022).

CR004 reflected the delay to obtaining Planning Permission for the new 33/11 kV substation. Permission was eventually granted and conditions were met allowing work to begin on site in late January 2022. The delays to the start of the civil installation required a change to extend the project end date to July 2022. In addition, the cost of materials and labour for the installation of the 33 kV cables and new substation were found to have increased significantly since the project budget was initially prepared. The original business case was reviewed and updated to confirm that the project would still deliver value for money. The revised business case demonstrated that, despite the increase in costs, the project would still deliver substantial value for money compared with the traditional solution. Following approval of the change request for increased funds (project budget increased from £1,380.0k to £1,847.7k) and a new end date (delayed to July 2022), the project was able to progress into the installation phase.

CR005 reflected the delay to the project end date due to protracted discussions relating to the lease agreement between NGED and Moto, as well as the delayed receipt of planning consent and limited availability of engineering staff to carry out the installation and jointing works. In addition, CR005 accounts for the increased cost of materials and installation of the 33 kV cables due to the prevailing market prices and poor ground conditions, respectively (project budget increased from £1,847.7k to £1,868.2k and end date delayed to January 2023).

8 Project Costs

Table 8 outlines the spend on the project against the revised project budget, which was approved in project change requests in January 2022 and December 2022.

Table 8 Project finances

Activity	Budget (£k)	Actual (£k)
Project Management and Design	345.6	345.6
Internal Project Review and Controls	5.3	5.3
Network Services	627.2	627.2
Equipment	619.4	619.4
Telecoms	45.5	45.5
Substation civil works	225.2	225.2
Totals	1,868.2	1,868.2

As described in Section 7, the revised project budget was agreed to accommodate significant increases in the cost of materials and labour for the installation of the 33 kV cables and new substation since the project budget was initially prepared. The original business case was reviewed and updated to confirm that the project would still deliver value for money. The revised business case demonstrated that, despite the increase in costs, the project would still deliver substantial value for money compared with the traditional solution.

Comments around variance

Costs have been expended in line with the revised project budget agreed in December 2022.

9 Lessons Learnt for Future Projects

The project team ensured that lessons from the project were captured on a monthly basis. Table 9 details the key learning that was generated from the project.

Table 9 Lessons Learnt

Ref	Area	Description
1	Studies	A number of the shortlisted sites in the site selection report have MSAs split across a motorway (such as Trowell North and South). Having evaluated the data for these sites it was confirmed that these the footfall and space were reduced compared to sites that are accessible from both sides of the motorway. Choosing an MSA located with access to both sides of a motorway (and near to large town or city) will provide more space and footfall that should result in greater participation in the trial (i.e. more EVs).
2	Studies	Initial discussions with chare point operators have revealed that existing charging patterns for EVs will not be reflective in future rapid charging. This is because most EV users charge their vehicles at home before embarking on a journey and hence don’t use public chargers on the motorway network that frequently. In addition, users behaviours at MSAs may change as rapid charging will allow them to charge their vehicles in a fraction of the time compared with standard chargers. This could mean that users are more inclined to charge their vehicles whilst they use the facilities at MSAs.
3	Studies	Data from EV charging stations are MSAs show that charging profiles generally follow the same trend as general “public” EV charging profiles. These profiles also align with traffic visiting MSAs and therefore can be used as a basis to calculate the capacity required for EV charging requirements in the future.
4	Studies	The configuration of rapid charging infrastructure on site is limited by interfacing with existing NGED standard assets (such as distribution transformers). For example, 350 kW rapid chargers are currently connected at LV and therefore only a maximum of three can be connected at one distribution substation if they are planned to be fully utilised. There are possibilities to connect more, however, control systems would be required to limit the output from chargers at peak times (the current approach by charge point operators).
5	Studies	There are a number of different approaches for calculating system capacity and the result can vary significantly depending upon the method used. The uncertainty of EV uptake will also have a significant impact on the rapid charging capacities required at MSAs up to 2050. Therefore, having a “modular” approach to adding capacity is preferred and also allows for greater security of supply in the future.
6	Studies	The System Capacity Optimisation work was based on EV uptake determined from the 2019 Future Energy Scenarios (FES). Following release of the FES 2020 document a check was performed to see if there were any substantial changes that would need to be reflected in our work. We found that the FES 2020 EV uptake was forecast to be slightly “faster” between 2020 and 2045, however, the ultimate number of vehicles was the same in 2050, therefore no changes to the calculations were required.

Ref	Area	Description
7	Design	The configuration of the switchroom enclosure for the new package substation has to be limited to 3.4m wide to allow for transportation without the need for special permits. The layout of the enclosure should also seek to provide space all around the switchgear to ensure that operatives can easily exit in an emergency.
8	Design	In some instances the CCS may be connected to the local 11 kV network to provide additional security of supply. To provide this facility an 11 kV busbar VT is required on the CCS switchboard to provide a voltage reference in the event of the incoming primary transformer VT being disconnected
9	Design	The CCS will be equipped with 2 no. 11 kV outgoing feeders to distribute the load to the EV charge points. The standard 11 kV feeder circuit breaker rating of 630 A was used as the alternative, 1250 A, would require a cable larger than 3x300mm² and this would not be able to be terminated into a standard distribution RMU.
10	Design	A number of possible locations were investigated at Exeter MSA for installing the CCS. The CCS should be located somewhere that is easy for personnel to access, requires minimal civil works and adjacent to the existing network infrastructure. The optimum location for the site was the main entrance to the carpark where the land is flat and is adjacent to where the 33 kV cables will be laid. In addition, it will offer ideal access to dedicated EV charging spaces in the future.
11	Design	The proposed connection arrangement at Sowton BSP involves a tee connection on to existing 33kV circuits to Exeter Science Park 33/11 kV substation. Due to the configuration of the CCS and the existing protection arrangements at Exeter Science Park, the 33 kV circuits to the CCS will need to be run open to prevent losing both circuits for a cable fault.
12	Design	Following discussions with NGED's property department it has been confirmed that any new substations over 29m³ require planning permission, therefore, a full planning application had to be developed for the CCS at Exeter.
13	Design	Siemens 36 kV switchgear (8DJH36) chosen for the CCS can supplied as a single unit (although it comprises of three individual panels). The use of this switchgear in this configuration helps avoid additional installation works within the container.
14	Design	11 kV switchgear was originally planned to have metering VTs and CTs. However, customers have indicated that they would like to be metered at HV RMUs further downstream. Removing the metering requirement from the CCS helped reduce the cost and complexity.
15	Design	It was originally proposed that the NER would be installed on the tank lid of the transformer, however, after preparing the initial designs it was apparent that safe access would be comprised. In addition, the NER on the lid increased the height of the overall installation dramatically. Therefore, the position of the NER was

Ref	Area	Description
		moved such that it was mounted on the side of the transformer tank (avoiding the need for a separate plinth).
16	Design	The new transformer design (hermetically sealed and midel filled) has changed a number of the standard Brush design principles. As such, the time to review has taken longer than normal. This is typical for an innovation project and the new “template” designs helped avoid further work in the future.
17	Design	The route feasibility study revealed all the critical underground services along the route of the 33 kV cable. It was discovered that there is a 1.35m diameter storm drain across the front of the entrance to Sowton 132/33 kV substation along with several HV and Extra High Voltage (EHV) cables. It was therefore decided to exit the substation at the opposite end to the entrance by using HDD. This helped avoid potential safety risks and also comprising the existing services at the entrance.
18	Design	Following initial discussions with Exeter City Council we discovered that all trees around the Motorway Service Area were covered by Tree Preservation Orders (TPOs). The trees are not a species of particular interest, however, it was apparent that the council want to retain as much green space as possible. In future for such sites, we would look to carry out a search of TPOs before starting with the design.
19	Design	The cable contractors have proposed the use of a vacuum excavator to remove soil and material from around trees protected by TPOs. The use of this technique helps to protect tree roots and prevents the need to remove or disturb trees.
20	Design	The fit-out of the switchroom container took much longer than originally planned. This is due to long-lead time materials and issues with contractor interpreting the design. For any new installation the following should be considered: i) changing Steel Wire Armour cables to those with standard insulation, ii) repositioning the RTU to provide bottom-entry access, iii) reducing the size of the marshalling cabinet to avoid all switchgear wiring being routed through it.
21	Design	A percolation test was required on site to understand whether a soakaway would be a suitable system to manage the drainage for the new substation. The test was delayed during mobilisation and performed after the construction started. This delay resulted in percolation test initially being performed in less than ideal conditions (after heavy rain). It is recommended that this survey should be completed in advance of any construction work to avoid any possible issues for future installations.
22	Design	The offload of equipment was successful, however, some updates to the design would have helped to improve the offloading procedure. The main update would be to increase the size of the crane pad area (only marginally) and swap the position of the transformer and switchroom such that the heaviest item was closest to the crane.

Ref	Area	Description
23	Design	The 33 kV switchgear was fully tested after being delivered to the contractors for fit-out (56 kV insulation test). After the secondary wiring and equipment was installed, the switchroom was then shipped to site and it was important to test that the integrity of the switchgear had not been compromised during transport. However, the manufacturer were averse to performing further tests as it may stress the switchgear. After consultation, another 56 kV test was performed and no defects were found. For future installations it is recommended that the final tests are performed on-site rather than at the contractors location.
24	Design	Following energisation a point was raised regarding the parking area and restrictions for the new substation. We have a dedicated layby for the substation, however, as the substation is located within the Moto site itself, parking is nominally restricted to 2 hours (otherwise staff have to report to the main Moto building to log their details). For future sites it would be worth considering where the site can be located external to the Moto Automatic Number Plate Recognition) ANPR area to avoid potential confusion.
25	Management	The timescales originally proposed for the project were extremely tight and did not allow for sufficient time to complete the various surveys and designs for a new primary substation. For future installations or projects, actual timescales for Take Charge can be used as a basis to develop a project programme.
26	Management	The planning application process for Take Charge has delayed the project for many months. As part of the dissemination activities we have highlighted to various stakeholders the need for improved planning processes to help accelerate applications that are required to help deliver net zero.
27	Management	The original business case for Take Charge had been prepared using estimates that were not fully up to date. For new projects, the latest estimating costs from CROWN should be used to ensure the business case is as accurate as possible. In addition, the business case should be prepared in conjunction with Network Services to ensure that the costs are realistic and accurate.
28	Management	There have been numerous activities relating to surveys and searches for wayleave purposes. These include further ecological surveys and land owner searches to ensure the route of the 33 kV cable can proceed as planned. These have been “ad-hoc” and were only highlighted to the project team at short notice. For future projects, any new asset installations should consider these aspects at the very start of the project.
29	BAU	The connection arrangements for the CCS have been investigated and it is proposed that non-firm connections are provided for EV Charge Point Operators. In addition, demand side response can be applied to help restore supplies in the event of a failure.

10 The Outcomes of the Project

Take Charge was delivered in four work packages as detailed in Section 5 of this report. The following sections outline the outcomes from each of the work packages.

10.1 Work Package 1 – System Capacity Optimisation

The first work package in Take Charge determined the optimal trial location for the CCS and the required capacity for the trial site.

The Site Selection Methodology report was produced as an output from this work package and explained the process created for determining the optimal location for the trial site. Figure 21 provides extracts from the published report.

Figure 21 Extracts from the Site Selection Methodology report

This report provides a clear and concise method for selecting suitable trial sites for such installations and could easily be tailored for future innovation projects. In addition, the report also captures a number of lessons learnt that would be attributable to other projects that involve establishing new substation infrastructure.

With the CCS now installed at the trial site, we are content that the process followed to determine the trial site was the correct one and no changes are required should it be implemented again for a different project.

The second key output from Take Charge was the System Capacity Optimisation report. This report considered the required power capacity of the CCS (peak MW) to provide for the needs of customers for charging at MSA locations up to 2050. We believe that the solution developed in this project will be essential bearing in mind that electrical plant has a service life of around fifty years and there is a need to ensure multiple network reinforcement is avoided in line with the Committee for Climate Change view of “touch it once till 2050”.

In a similar approach to the Site Selection Methodology, the System Capacity Optimisation report presented the process created for calculating the optimum capacity for EV charging across MSAs. The report considered two separate approaches and after analysis, recommended the optimum one for calculation of the capacity. Extracts from the report can be seen in Figure 22.

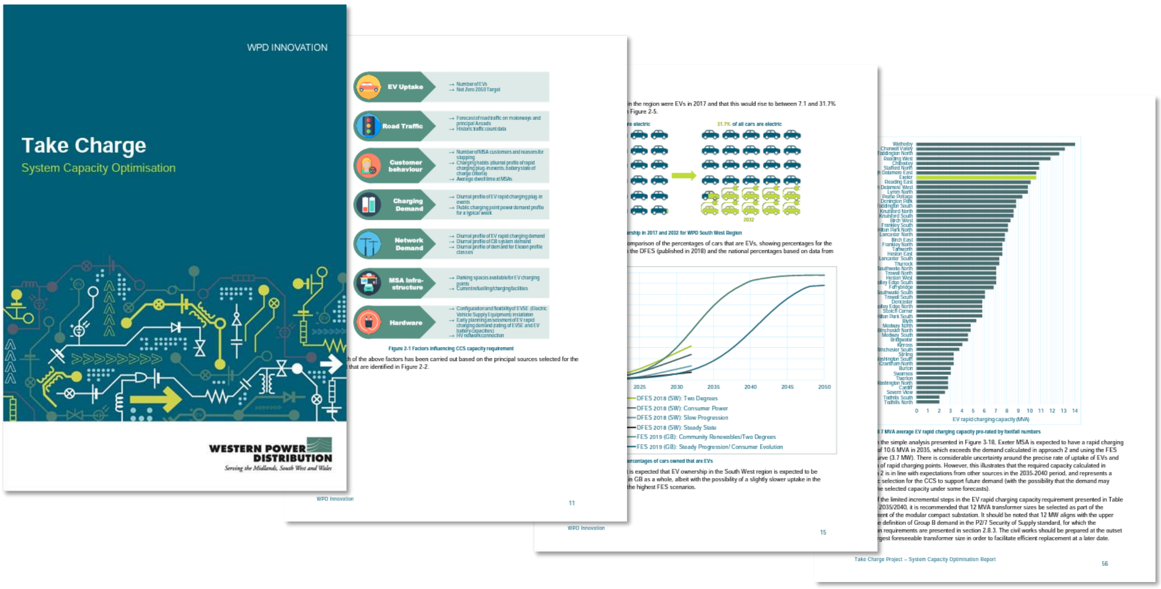


Figure 22 Extracts from System Capacity Optimisation report

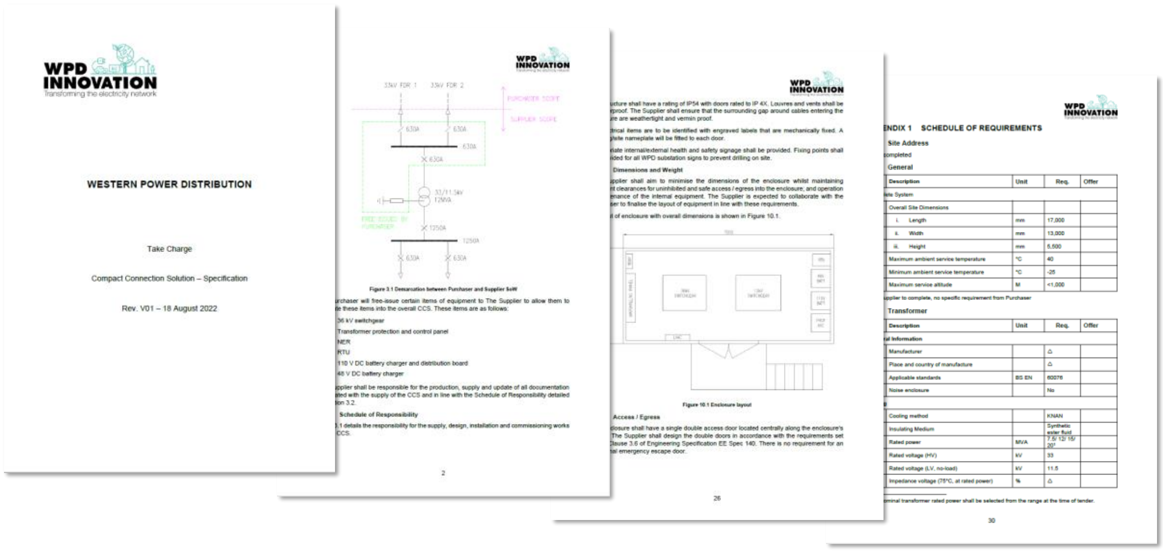
The report provides a replicable approach for calculating EV capacity and has been used to calculate the capacity across all sites in NGED’s licence area. The approach can also be updated for new information when available, such as visitor numbers, new FES data and traffic movements.

10.2 Work Package 2 – Develop and Design the Connection Solution

The main outcome from work package 2 is the specification documentation which provides sufficient detail to allow others to replicate the CCS for use in other locations and applications.

The specification documentation was prepared in conjunction with our policy engineers, equipment manufacturers and consultants and covers all the main elements of the CCS. It is recognised that some parts of the specification will have to be tailored to the specific arrangements of the network owner/operator. These arrangements generally focus on the interface of the CCS with existing infrastructure (for example, the Supervisory Control and Data Acquisition (SCADA) requirements) and preferences in relation to equipment manufacturers. However, the CCS is very well aligned with the requirements of UK distribution networks having been prepared based on Electricity Network Association (ENA) Technical Specifications and British Standards.

An initial functional specification was prepared at the start of the project and was used for contract purposes. However, as part of the project learning, we have updated this specification and produced an “as-built version”. This version captures the subtle changes that were integrated during the design and build phases and provides an accurate representation of what was installed on site. Figure 23 provides an overview of the specification.


WPD INNOVATION
Transforming the electricity network

WESTERN POWER DISTRIBUTION

Take Charge

Compact Connection Solution – Specification

Rev. V01 – 18 August 2022

Figure 23 Extracts from the CCS Specification

10.3 Work Package 3 – Build and Install the Connection Solution

The main outcome of this work package was the successful build and installation of the CCS at Exeter MSA. Although there were some minor design challenges and delays with gaining planning permission, the overall installation went very well with minimal changes on site and with no safety incidents.

Close coordination with all parties helped ensure that the impact on customers visiting the MSA was minimal, despite the site being very busy throughout the day. Including traffic calming and protection measures at the entrance to the site helped manage traffic flow and potential dangers from large, fast moving vehicles as shown in Figure 24.

Figure 24 Traffic calming measures adjacent to the site

In addition, the chosen substation location on the Exeter MSA site corresponded well with the existing and future EV infrastructure. As discussed in Section 0, both Gridserve and Tesla have established new high capacity chargers and these are located in the parking areas immediately adjacent to the CCS reducing cabling costs and disruption.

Finally, the delivery and offloading of the equipment for the CCS was carried out on schedule without any issues. The offloading process only took a matter of hours for all components. Figure 25 shows the last item, the switchroom container, being lifted into place.

Figure 25 Switchroom container being lifted into place

Throughout the design phase we ensured that offloading was a critical part of the strategy knowing the complications of such a busy site. However, there were some lessons related to the delivery and offloading and these are captured in Section 9.

10.4 Work Package 4 – Trial and Evaluation

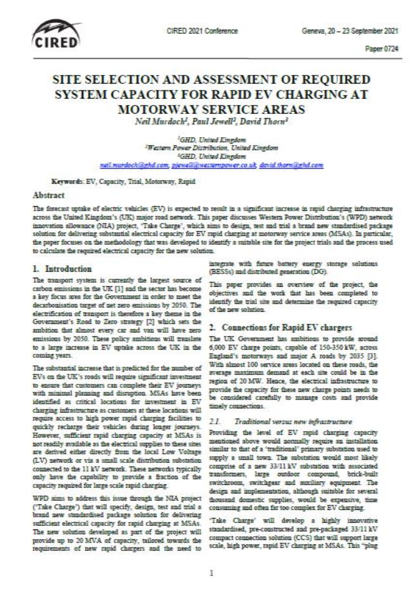
As explained in Section 10.3, following delivery and offloading of the CCS equipment work began on making the preparations for energising the substation and beginning the trial. In parallel, we were also consolidating the information, data and learning that had been gathered throughout the course of the project.

The energisation of the CCS went as planned following the final installation and commissioning activities. The pre-booked outages ensured that we had sufficient time to test the connections and equipment prior to the final energisation on to the 33 kV network fed from Sowton 132/33 kV substation.

We were pleased to note that there have been no issues following energisation, with the CCS remaining connected to the network and supplying the 11 kV network. As further new EV infrastructure is connected to the CCS we will continue to monitor the operational data, however, we are confident that there will be no issues in the performance.

We have also been sharing the learning generated by the project as part of the trial and evaluation work package. In particular, we have disseminated and engaged with stakeholders at a number of industry conferences, through social media platforms and through our defined project progress updates (monthly website updates, six monthly reports and annual NIA reports). Examples of these are highlighted below in Figure 26 and Figure 27.

Figure 26 Take Charge press release with local MP, Jane Hunt



CIRED 2021 Conference — Geneva, 20 – 23 September 2021

Paper 0724

SITE SELECTION AND ASSESSMENT OF REQUIRED SYSTEM CAPACITY FOR RAPID EV CHARGING AT MOTORWAY SERVICE AREAS

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Keywords: EV, Capacity, Trial, Motorway, Rapid

Abstract

The forecast uptake of electric vehicles (EV) is expected to result in a significant increase in rapid charging infrastructure across the United Kingdom's (UK) major road network. This paper discusses Western Power Distribution's (WPD) network innovation allowance (NIA) project, 'Take Charge', which aims to design, test and trial a brand new standardised package solution for delivering substantial electrical capacity for EV rapid charging at motorway service areas (MSAs). In particular, the paper focuses on the methodology that was developed to identify a suitable site for the project trials and the process used to calculate the required electrical capacity for the new solution.

1. Introduction

The transport system is currently the largest source of carbon emissions in the UK [1] and the sector has become a key focus area for the Government in order to meet the decarbonisation target of net zero emissions by 2050. The electrification of transport is therefore a key theme in the Government's Road to Zero strategy [2] which sets the ambition that almost every car and van will have zero emissions by 2050. These policy ambitions will translate to a large increase in EV uptake across the UK in the coming years.

The substantial increase that is predicted for the number of EVs on the UK's roads will require significant investment to ensure that customers can complete their EV journeys with minimal planning and disruption. MSAs have been identified as critical locations for investment in EV charging infrastructure as customers at these locations will require access to high power rapid charging facilities to quickly recharge their vehicles during longer journeys. However, sufficient rapid charging capacity at MSAs is not readily available as the electrical supplies to these sites are derived either directly from the local Low Voltage (LV) network or via a small scale distribution substation connected to the 11 kV network. These networks typically only have the capability to provide a fraction of the capacity required for large scale rapid charging.

WPD aims to address this issue through the NIA project ('Take Charge') that will specify, design, test and trial a brand new standardised package solution for delivering sufficient electrical capacity for rapid charging at MSAs. The new solution developed as part of the project will provide up to 20 MVA of capacity, tailored towards the requirements of new rapid chargers and the need to integrate with future battery energy storage solutions (BESSs) and distributed generation (DG).

This paper provides an overview of the project, the objectives and the work that has been completed to identify the trial site and determine the required capacity of the new solution.

2. Connections for Rapid EV chargers

The UK Government has ambitions to provide around 6,000 EV charge points, capable of 150-350 kW, across England's motorways and major A roads by 2035 [3]. With almost 100 service areas located on these roads, the average maximum demand at each site could be in the region of 20 MW. Hence, the electrical infrastructure to provide the capacity for these new charge points needs to be considered carefully to manage costs and provide timely connections.

2.1. Traditional versus new infrastructure

Providing the level of EV rapid charging capacity mentioned above would normally require an installation similar to that of a 'traditional' primary substation used to supply a small town. The substation would most likely comprise of a new 33/11 kV substation with associated transformers, large outdoor compound, brick-built switchroom, switchgear and auxiliary equipment. The design and implementation, although suitable for several thousand domestic supplies, would be expensive, time consuming and often far too complex for EV charging.

'Take Charge' will develop a highly innovative standardised, pre-constructed and pre-packaged 33/11 kV compact connection solution (CCS) that will support large scale, high power, rapid EV charging at MSAs. This "plug

1

Figure 27 CIRED 2021 Full Paper

In addition, Take Charge was shortlisted in the "Disruptor Award" category in the Utility Week Awards 2022. Despite very strong competition from other utilities, Take Charge won the award, helping highlight how important the project was in delivering a new approach that challenges traditional engineering solutions. Figure 28 shows the NGED project sponsor, Paul Jewell, with the award.

Figure 28 NGED Project Sponsor with Utility Week award

11 Data Access Details

The deliverables and associated information for Take Charge have been published on our innovation website.

Table 10 provides links to the reports and documentation that have been published.

Table 10 Published reports and documentation

Description	Link
Site Selection Methodology	https://www.nationalgrid.co.uk/downloads-view-reciteme/231505
System Capacity Optimisation	https://www.nationalgrid.co.uk/downloads-view-reciteme/231496
Functional Specification	https://www.nationalgrid.co.uk/downloads-view-reciteme/231508
As-built Specification	634074 (nationalgrid.co.uk)
6 Monthly Progress (Apr 20 - Sep 20)	https://www.nationalgrid.co.uk/downloads-view/204508
6 Monthly Progress (Oct 20 - Mar 21)	https://www.nationalgrid.co.uk/downloads/312370
6 Monthly Progress (Apr 21 - Sep 21)	https://www.nationalgrid.co.uk/downloads-view-reciteme/422434
6 Monthly Progress (Oct 21 - Mar 22)	https://www.nationalgrid.co.uk/downloads-view-reciteme/619015
NIA Annual Progress Report	https://www.nationalgrid.co.uk/downloads-view-reciteme/596509

12 Foreground IPR

New foreground IPR has been created as part of Take Charge, this includes the following:

- **Site Selection Methodology** – this report provides a framework for others to assess the suitability of a trial site for projects such as Take Charge;
- **System Capacity Optimisation** – this report outlines the methods that can be used to calculate the capacity required for new rapid EV charger sites; and
- **Functional specification and as-built specification** – provides third parties with the relevant technical detail to allow them to replicate the Take Charge solution.

13 Planned Implementation

Take Charge has successfully demonstrated that a compact substation for providing rapid EV charging capacity is cheaper to build, faster to install, more space efficient and delivers what stakeholders require. Through our dissemination activities, MSA operators have welcomed the new approach, stating that it will help accelerate the connection process and provide a cost effective solution for their rapid EV charging requirements. As such, we have already started to prepare for further implementations as part of Business as Usual. The modular approach for the design of the CCS mean that these further implementations can be planned with relatively low risk as the components can be redistributed to any site should sites become unavailable or capacity requirements change.

We are currently coordinating with MSA operators to discuss sites for new CCS installations and are using the output from our site selection and system capacity optimisation reports to help identify the sites where capacity is required, and where it could be easily deployed.

Through disseminating the success of Take Charge across the wider business, it has been recognised that the CCS could also provide benefits for other applications. For example, the compact footprint and “plug and play” nature would help accelerate connections and upgrades across our EHV/HV network. Therefore, work is currently underway to develop a CCS that would provide a “firm supply” (i.e. fully compliant with the requirements of Engineering Recommendation P2). An example of the solution is shown in Figure 29.

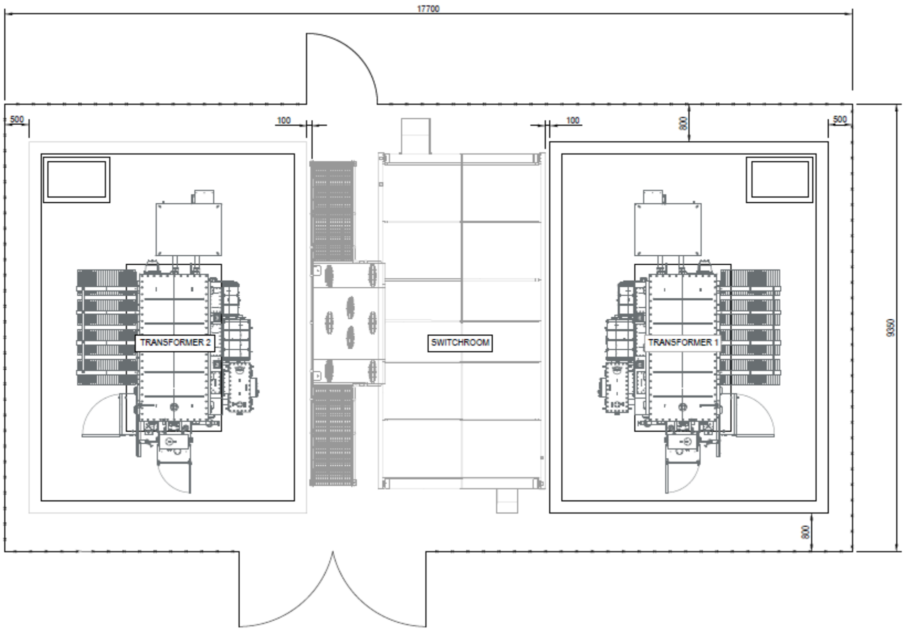

Figure 29 Example of a CCS for providing firm supplies

14 Contact

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Glossary

Acronym	Definition
ANPR	Automatic Number Plate Recognition
BCEL	Bridge Civil Engineering Limited
BSP	Bulk Supply Point
CCS	Compact Connection Solution
CIRED	International Conference on Electricity Distribution
COVID	Coronavirus Disease 2019
DC	Direct Current
DG	Distributed Generation
DNO	Distribution Network Operator
EHV	Extra High Voltage
EMU	Electronic Mapping Utilisation
ENA	Energy Networks Association
ENIC	Energy Networks Innovation Conference
EV	Electric Vehicle
FAT	Factory Acceptance Testing
FES	Future Energy Scenarios
GB	Great Britain
GHD	Gutteridge Haskins and Davey Ltd
HDD	Horizontal Directional Drill
HV	High Voltage
IPR	Intellectual Property Rights
LCV	High Voltage
LV	Low Voltage
MSA	Motorway Service Areas
MVA	Mega Volt-Amperes
MW	Mega Watt
NGED	National Grid Electricity Distribution
NER	Neutral Earthing Resistor
NIA	Network Innovation Allowance
NMS	Network Management System

Acronym	Definition
OHL	Overhead Line
OS	Ordnance Survey
OZEV	Office for Zero Emission Vehicles
PEA	Project Eligibility Assessment
PV	Photo-Voltaic
RAID	Risks, Assumptions, Issues and Dependencies
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
TPO	Tree Preservation Order
TPP	Tree Protection Plan
VT	Voltage Transformer

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