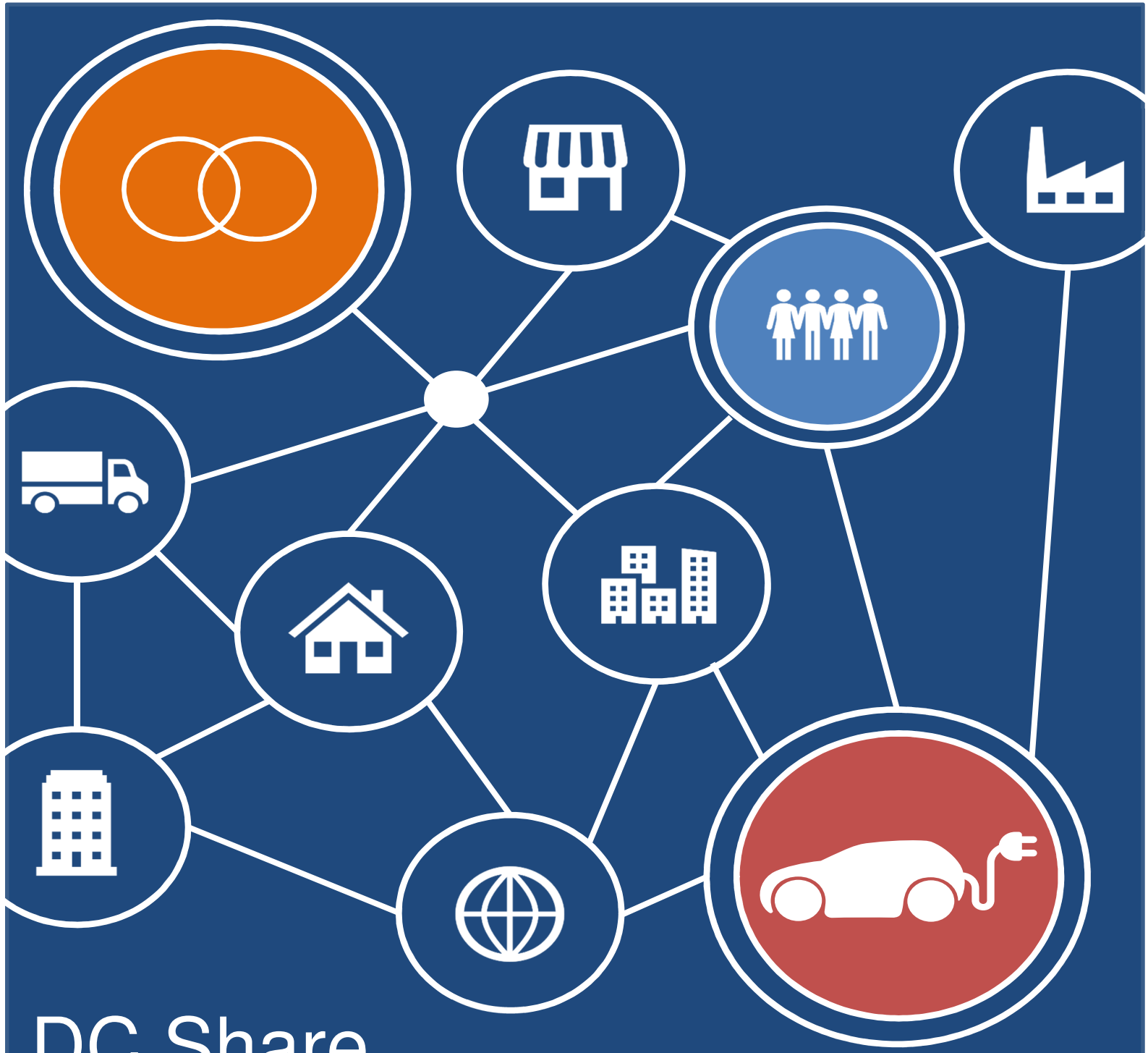

DC Share

Project Progress Report No.3

Jan – Jun 2021

ED 11196 | 1.0 | Date 21/06/2021

Customer:

Western Power Distribution

Customer reference:

Project Direction ref: WPD EMID / DC Share

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21 June 2021

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Ref: ED11196- 1.0

Table of Contents

1. Abbreviations

Abbreviation	Full Wording
AC	Alternating Current
BaU	Business as Usual
CPO	Charge Point Operator
DC	Direct Current
DNO	Distribution Network Operator
ENW	Electricity North West
EV	Electric Vehicle
EVCP	Electric Vehicle Charge Point
FAT	Factory Acceptance Testing
FDS	Functional Design Specification
FEED	Front End Engineering Design
FSP	Full Submission Pro-forma
GB	Great Britain
GTI	Grid Tied Inverter
GRP	Glass Reinforced Plastic
HMI	Human Machine Interface
IED	Intelligent Electronic Device
ICD	IED Capability Description
IP	Internet Protocol
LA	Local Authority
LV	Low Voltage
MCU	Measurement Control Unit
NDA	Non-Disclosure Agreement
NIC	Network Innovation Competition
PPR	Project Progress Report
REE	Ricardo Energy & Environment
TPS	Turbo Power Systems
WPD	Western Power Distribution

2. Executive Summary

2.1 Overview

The DC Share Project, "the Project", is funded through Ofgem's Network Innovation Competition (NIC) funding mechanism. The Project commenced upon receipt of Ofgem's Project Direction letter in December 2019 and is scheduled to complete in March 2023.

The Project will explore:

1. The utilisation of latent capacity in distribution networks, which is difficult to access using traditional means.
2. How distribution networks will provide rapid charging facilities at scale and in the locations where they are needed. These are required for those without access to charging facilities at home or work, and for on-route charging.

The Project will be delivered via five workstreams comprising nine tasks and seven deliverables, as defined in Table 1.

Table 1: DC Share Workstreams, Tasks and Deliverables

Workstream	Task	Deliverable
WS1 Hardware Development and Deployment	Task 1: Site Selection	Deliverable 1: Site Selection Report
	Task 2: Preliminary Design phase	
	Task 3: Final Design Phase	Deliverable 2: Final System Design Report
	Task 4: Procurement / manufacture	Deliverable 3: Factory Acceptance
	Task 5: Installation support and commissioning	Deliverable 4: Installation Complete
WS2 Trials and Analysis	Task 6: Trial design	
	Task 7: Trial – interim	Deliverable 5: Trial Interim Report
WS3 System Benefits	Task 8: Trial report	Deliverable 6: Trial Results Report and EV Charging Customer Experience
WS4 Learning and Dissemination	Input from all tasks	Mandatory Deliverable: Comply with knowledge transfer requirements of the Governance Document
WS5 Project Reporting	Task 9: BAU	Deliverable 7: Close Down Report. Final Conclusions and BaU recommendation Mandatory Deliverable: Comply with knowledge transfer requirements of the Governance Document

2.2 Overall Project Progress

This third Project Progress Report (PPR) details the progress of the Project during the six month period January – June 2021.

Work in the last six months has mainly focussed around progressing the various site based (construction) activities, finalising the site selection and routing design, securing contract award for the supervisory controller, gaining planning permissions for the placement of the car chargers, technical design of the Direct Current (DC) network, and the components within it, in particular the Grid Tied Inverters (GTI) and Electric Vehicle Charge Points (EVCP). The main activities progressed are:

- Developing a series of functional “use cases” defining how the supervisory controller will operate and manage the DC Share system
- Developing initial Human Machine Interface designs for the supervisory controller and finalising the system database
- Progressing interfacing issues associated with the IEC61850 implementation
- Ongoing reviews and revisions to the main GTI and EVCP technical specification documents
- Commence developing a procurement package suitable to embark upon a mini-tender exercise for the DC cable and associated materials
- Commencing works required to place a contract for the AC measurement system
- In an effort to minimise the DC cable routing (and hence trench dig and cable lay time and costs), the site selection design has been re-assessed on the understanding that substations that do not have spare LV ways can accommodate the GTIs using shared ways.
- Engaging with a specialist site surveying company to undertake and provide a detailed cable routing assessment
- Developing project understanding and site/construction activities requirements,
- Commence developing project detail design documents to cover the basic principles for system protection, design intent and earthing. This extends the conceptual work undertaken in 2020 towards development of design and installation level documentation.
- Developing a set of operational and safety management policies for DC systems
- Determine if EVCP require AC metered supplies to comply with Elexon requirements
- Ongoing engagement with Swarco, the Charge Point Operator (CPO), to discuss and develop commercial understanding and considerations
- Commencing work assessing requirements for management/application of connection offers

During the course of this reporting period travel restrictions caused by the COVID-19 pandemic have continued to affect the team’s ability to travel, conduct face-to-face meetings and visit site. However, the team have continued to work remotely utilising tools such as ‘Teams’ for virtual meetings between project partners.

2.3 Business Case

At the time of writing, there have been no changes to the anticipated benefits to be gained by the Project.

The subject of DC Share system operation, anticipated to be achieved during operation has however been subject to all-Party consideration, including discussions with the CPO. A report detailing the effects anticipated should the power network (or GTI/EVCP equipment) become curtailed has been prepared and circulated for review. This has been developed to provide a basic understanding of the preferred method of managing the EVCP under curtailment conditions.

Work is also currently underway to assess the anticipated financial benefits afforded by implementing a DC:DC solution rather than an AC:DC solution. The outcome of this analysis will be used to provide an understanding of the value proposition before construction and manufacture of a DC Share style implementation, especially when considered within constrained urban areas which present space constraints for building, or extending, HV substations.

2.4 Project Learning and Dissemination

Project lessons learned and what worked well will be captured throughout the project lifecycle. These will be captured through a series of on-going reviews with stakeholders and project team members and reported within Section 9 of this report.

To date we have recorded thirteen (13) lessons learnt, with ten (10) new ones introduced during this reporting period, as detailed within Section 9.

2.5 Risks

Two separate risk registers have been developed and are maintained for the Project.

One covers risks associated entirely with the COVID-19 pandemic whilst the other risk register concentrates on project-specific (eg non Covid-19) issues).

Each risk register is a live document and is updated regularly. To date, a total of 86 risks have been raised across both risk registers, of which 46 are now closed.

For each risk, a mitigation action plan has been identified and the appropriate steps then taken to ensure risks do not become issues wherever possible.

The risk registers are reviewed and revised on a regular basis, so the data within them will be subject to change.

3. Project Managers Report

3.1 Project Partners Main Activities

During this reporting period the Project Partners have concentrated efforts on progressing the following activities:

1) Western Power Distribution (WPD) has reviewed the main design documents, progressed design issues associated with the DC cabling and commenced work drafting an operational and policy intent document for DC meshed networks.
2) Ricardo Energy & Environment (REE) has, apart from managing the entire project and coordinating all Parties and works, contributed with reviews of the main design documents, awarded a contract to Lucy Electric UK (LEUK) for the Supervisory Controller (SC) system and supported WPD with selected site/construction activities.
3) Turbo Power Systems Ltd (TPS) have progressed and circulated the design documents associated with the GTI and EVCP equipment
4) Electricity North West Ltd (ENW) have provided second DNO oversight of the Project
5) Somerset West and Taunton Local Authority (SWT LA) have provided ongoing support and direction with regards the EVCP equipment locations at the three car parking hubs
6) Swarco have participated in technical discussions associated with the overall EVCP design and integration with the back office systems plus have contributed towards the ongoing analysis of curtailment scenarios and impact of charging availability on commercial considerations.

3.2 Project Background (Overview)

The aims of the Project remain unchanged since submission of the Full Submission Pro-forma (FSP).

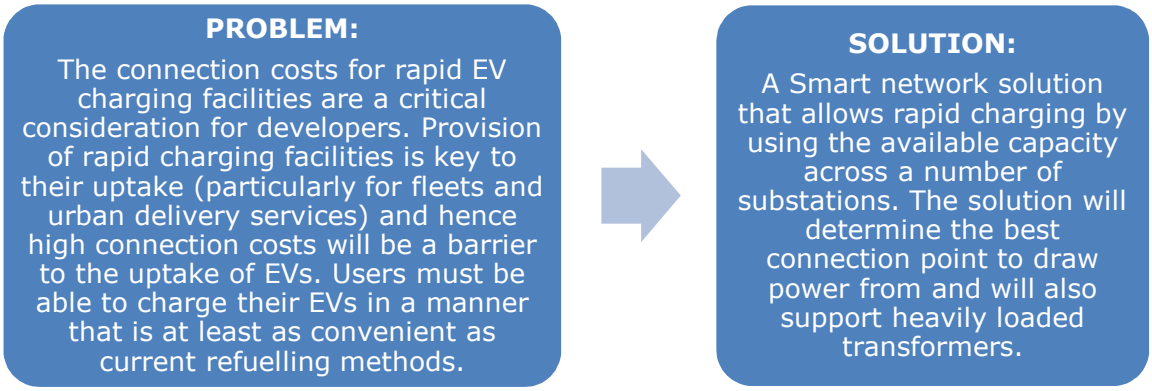
The aim is therefore to assist with rapid Electric Vehicle (EV) charging requirements by providing reliable facilities where they are needed, whilst making optimal use of the available network capacity without the need for immediate network reinforcement.

The aim is driven by the UK Government's Clean Growth Strategy which strives to ensure that hybrid and combustion engine vehicles are removed from sale by 2040 and that the uptake of replacement EV's is not hindered by the lack of rapid charging points throughout Great Britain (GB).

Essentially, rapid charging points will need to be installed in large-scale clusters to promote usage and customer confidence that they are able to arrive at a cluster site and rapidly charge their EV.

The problem the project aims to solve can therefore simplistically be shown graphically within Figure 1 below.

Figure 1: Project Problem & Solution



The Project will use an equalisation network to provide an alternative, cost-effective solution for rapid EV charging demands, more flexibly than a traditional AC reinforcement solution. The solution seeks to explore the comparative benefits of a DC network, where power flows can be actively managed, and fault level contained, over a traditional AC network reinforcement.

The Project will therefore use an equalisation network between four existing substations and make use of the differences in demand patterns to provide the required capacity. The Project will employ bi-directional power electronic converters to connect to each existing substation low voltage (LV) board and provide connections to vehicle charge points via a new high capacity DC cable network. The equalisation network balances demand such that transformers experiencing heavy demand receive support from those that are more lightly loaded. This offers benefits by evenly distributing loads between assets, reducing the probability of future stranded assets.

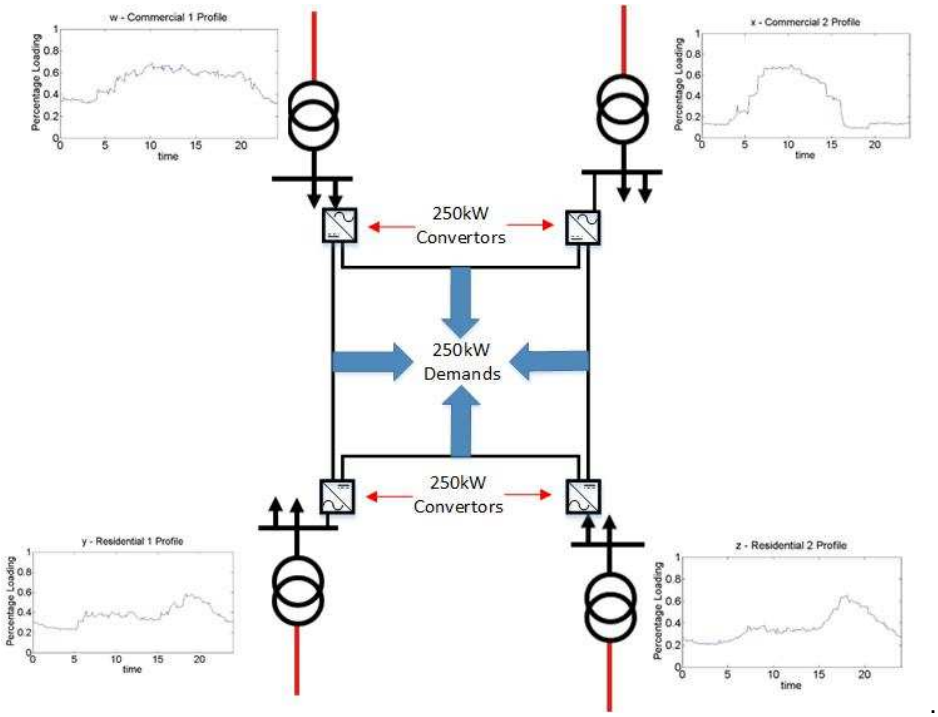
The Project will provide a means of sharing system capacity across AC secondary substations with different load profiles. Using a DC ring to provide the capacity for the rapid charging points leaves capacity on the existing LV AC cables for demand growth of the existing users.

Figure 2 below portrays the intended design solution. In total, a maximum of 1MW of latent capacity is planned to be extracted at any point in time and made available for network equalisation plus EV charging purposes.

Each AC secondary substation will have a bi-directional Grid-Tied Inverter (GTI) utilising specialist power electronic equipment to safely and efficiently convert up to 250kW of AC power to DC at 800V for injection onto a dedicated DC cable ring connecting all AC secondary substations together.

The EV rapid chargers (15 in total, comprising 10 x 50kW and 5 x 100kW) will be located in three geographically separated “hubs” each directly connected to the DC ring.

Figure 2: Intended Design Solution



Four areas of development will be undertaken.

1. A new control system will be required to manage the DC Share system, incorporating communication between the vehicles, the chargers and the substation converters. The system will autonomously assess the charging load, where to draw this demand from, and the level of equalisation possible. Management of the charging load and its impact on users will be investigated during the trial, to gain insights as to the optimum ratio of charging and converter capacity that should be installed to provide optimal system utilisation against capital expenditure.
2. DC Share will expand the equalisation concept into an equalisation network, balancing a wider area and offering broader benefits. DC Share will demonstrate this at LV, where the effects of aggregation are low (i.e. the number of connected customers is relatively small, and load generally reflects a distinct domestic or commercial/industrial profile) and the potential benefits are pronounced.
3. The AC-to-DC converters to be deployed in the trial will be an evolution of the “Soft Open Point (SOP)” technology developed by Turbo Power Systems Ltd in previous innovation projects. The new units will be smaller (and quieter) and will connect the DC bus to a cable circuit. The smaller unit means that siting devices within substations should be possible in more locations, although it must still be acknowledged that locating suitable substation sites will remain a challenge.
4. As existing commercially available EV rapid chargers are all AC network fed, new EV chargers that are fed from the DC network will be developed.

3.3 Project Plan

The Project Plan was revised prior to Contract Signature to take into account anticipated delays in the specialist equipment supply chains (namely the silicon carbide components from China) caused by the COVID-19 pandemic. Revised Contingency Milestone Dates are provided within Table 2.

The project programme has then been further revised to move the project milestones 4, 5, 6 and 7 back 12 months in order for the anticipated site construction workloads, which have yet to commence, to be successfully undertaken within their extended timeframe. These further revised Key Milestone Dates are detailed within Table 2 below.

During April 21, another site selection design was prepared, using a different blend of substations that are able to permit GTI connection to an in-service LV way. This has allowed a smaller “DC Ring” to be identified which should assist time and cost issues associated with trenching and cable lay works. Detailed planning of the site construction activities will follow a planned “walk-the-route” by a specialist external surveying company, resolution of any arising issues, and the ordering of the DC cable which will provide an understanding of the impact of the procurement lead-time.

The latest programme therefore makes assumptions for the above and addresses all known delays introduced to date associated with certain material procurements (eg Supervisory Controller, DC cable, AC measurement system etc) plus the requirement for to produce further documentation (network intent, protection philosophy, system operations, safety documentation etc).

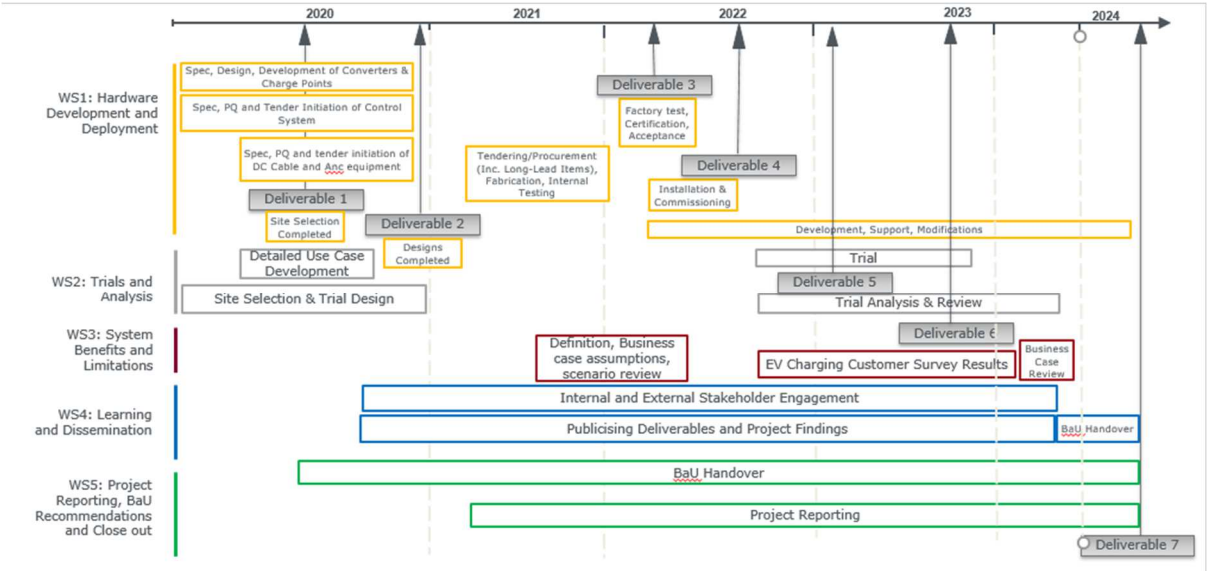
The FAT milestone date of 18 December 2021 is facing increasing pressure. During the most recent project review, the project steering group has challenged the project team to demonstrate that the date of the 31st of March 2022 for factory acceptance is still achievable whilst making acceptable allowance for the amount of design and delivery risk still carried by the project. This update is expected on the 25th of June 2023.

Table 2: Original, Contingency and Further Revised Key Milestone Dates

Reference	Project Milestone		Original Key Milestone Dates	Contingency Key Milestone Dates (*Estimated at time of Contract Signature*)	Further Revised Key Milestone Dates
WP 1	Site Selection Completed		31 May 2020	31 May 2020	Unchanged (Completed)
WP 2	Final System Design Report		30 Sep 2020	18 Dec 2020	Unchanged (Completed)
WP 3	Factory Acceptance		31 Mar 2021	18 Dec 2021	31 Mar 2022
WP 4	Installation Completion		31 July 2021	30 Apr 2022	29 July 2022
WP 5	Trial Interim Report		31 Jan 2022	30 Sep 2022	31 Jan 2023
WP 6	Trial Results Report and EV Charging Customer Experience		30 Nov 2022	30 Jun 2023	30 Nov 2023
WP 7	Close Down Report. Final Conclusions and BaU recommendation		31 Mar 2023	30 Oct 2023	29 Mar 2024
N/A	Comply with knowledge transfer requirements of the Governance Document		End of Project	End of Project	29 Mar 2024

The data in the above table has been further elaborated is shown graphically as per Figure 3 below.

Figure 3 – Project Plan and Further Revised Key Milestones



3.4 Progress During Reporting Period

During this PPR reporting period the project team have progressed the following activities:

3.4.1 Site Selection

Since the issue of the site selection report (Deliverable #1) on 29th May 2020 and its subsequent approval by Ofgem on 4th June 2020, we have been compelled to make several changes to the original scheme.

These changes have mainly been required due to unforeseen issues arising during the initial cable routing design works. For example:

- It has not been possible to route the cable via a Church of England (CoE) site due to the close proximity of an ancient monument and unmarked burial grounds. To progress this route would have required CoE approvals plus deployment of archaeologists during the trenching work who would have the authority to stop works should any burial remains be discovered, introducing unacceptable risk to time and budgets.

- Preliminary discussions with the County Council (CC) suggested that the trenching works associated with the original cable route design would prove problematic if not impossible in some locations (eg newly laid road surfaces mean there is an embargo on new digging works taking place in that location). We have therefore had to assess different routings which use a different combination of substations to avoid the roads affected. In undertaking this new assessment, we have also taken the opportunity to reduce the total cable routing to a minimum so that the time duration (and cost) for trenching works is reduced. The new cable routing will still need further discussions with the CC after the detailed site trenching survey works are completed to verify suitability. Any further refinements will made at that time.

- One of the chosen substations was subject to new legal issues raised by the landowner meaning that the ability to access site and/or progress the desired works would prove difficult to overcome within the project timescales.

- The initial site selection strived to include substations that had a spare LV way to facilitate connection of the GTI equipment. It transpires that one substation chosen no longer has a spare way. Notwithstanding this, WPD are now able to consider developing a jointing procedure which will permit a Tee off adjacent to the fuse pillar. This relaxation on initial site selection criteria has meant that a larger number of substations, which were originally excluded due to the unavailability of a spare LV way issue, now became open for consideration. The project intends to install monitors on the LV ways at the concerned substations to determine which LV way is best-suited for GTI connection.

The current design and choice of substations is therefore as shown in Figure 5 below. In summary, we shall now be using Works, Priory, Duke Street and Canon Street substations to place the 4 x GTI equipment and form the DC ring.

Two of these substations (Works and Canon Street) will require Glass Reinforced Plastic (GRP) enclosures to contain selected equipment. Potential issues associated with heat build-up within the GRP enclosures has been investigated by reviewing data for similar installations from other projects. Given the GTI equipment will emit heat will start to de-rate should ambient air temperatures exceed 50 Deg C, careful design considerations for the new GRP enclosures will be assessed and implemented.

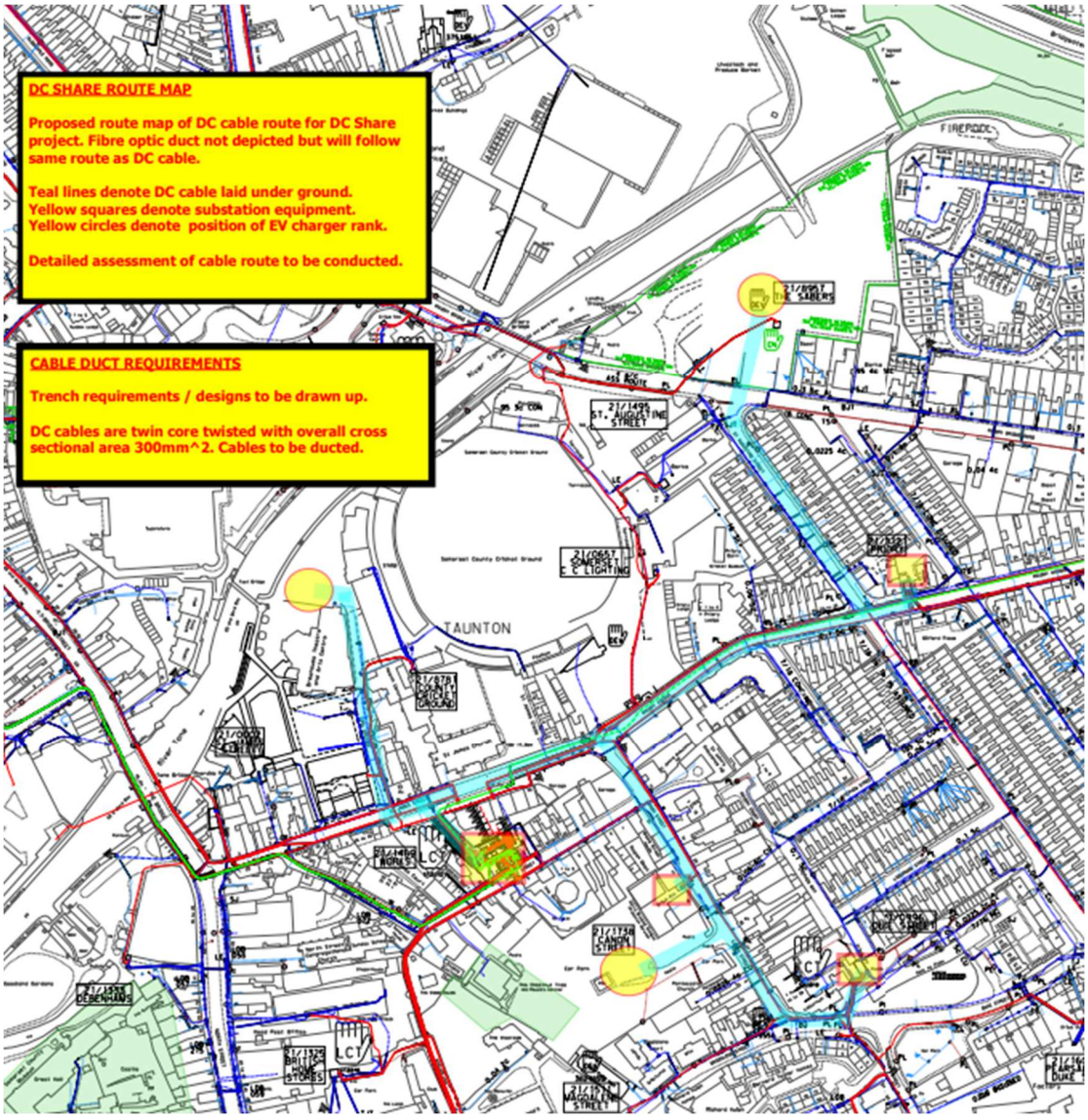
In addition to the above, we shall now be locating the DC Share supervisory controller within the Works Primary substation, which is adjacent to the Works distribution substation. This will permit a higher degree of physical security and provide an improved level of operator comfort.

One car park location (Coal Orchard) is currently subject to ongoing discussions with SWT-LA who have indicated that the original location for the DC Share parking bays may have to be moved to the furthest side of the car park, meaning that we may now have some major constraints in our ability to lay the infrastructure to them, especially if the DC system is required to be aligned with HV design and safety principles (eg requiring large HV joints and jointing pits). There has been a discussion concerning reducing the number of DC Share EVCP at this location from three (3) to two (2) in order to accommodate this constraint and discussions are on-going.

If we are required to remove a EVCP from Coal Orchard we would not look to install it within Canon Street or Firepool car parks due to the worsening effect of increasing power flows/loads on one quadrant of the DC ring.

Figure 5: Final DC Share Ring Design & EVCP Allocations

Location	Number of 50kw Chargers	Number of 100kw Chargers	Total Number of Chargers
Coal Orchard	2	1	3
Cannon Street	4	2	6
Firepool	4	2	6
Total	10	5	15



3.4.2 Technical Matters

Despite the general inability to travel during and convene face-to-face meetings and workshops during the Covid-19 pandemic, all team members have been successfully using virtual meetings to discuss and progress all project technical issues.

Prior to each conference call an agenda is circulated along with pertinent documents requiring review/comment/discussion.

All actions and resolutions are recorded and efficient progress through such matters has been achieved to the extent that the overall system design has essentially been agreed and detailed design documents for all the basic building blocks of the system submitted and are undergoing review.

A summary of the main equipment designs as progressed during the reporting period is summarised below.

a) GTI Equipment

Appendix A.2 provides a selection of graphics detailing how the GTI cubicles are intended to l be constructed. Discussions are ongoing with TPS to clarify functionality afforded by the DC Isolator box and the outcome of these discussions may impact on the overall GTI construction and build.

Full technical details relating to the GTI are provided with the GTI Technical Specification, Document No. 327-01-001, currently at Rev 5. The vast majority of technical issues are now resolved, mainly pending resolution of the “DC Isolator add-on box” (see notes below). Once all issues are resolved and the document further revised, it shall be subject to final approval and uploaded to the project website.

b) EVCP Equipment

Appendix A.3 provides a selection of graphics detailing how the EVCP shall be fabricated plus how the internal circuitry is arranged.

Full technical details relating to the GTI are provided with the EVCP Technical Specification, Document No. 327-02-001, currently at Rev 6. Once fully approved it will be uploaded to the project website.

c) Supervisory Controller

The functional and performance design for this system was specified within the suite of bidding documents and this has formed the baseline from which to commence the detailed design development during from Feb 21 onwards.

The indicative use cases provided within the bidding document have been subjected to extensive discussions between all project parties and all comments received discussed and incorporated where necessary. In addition, the database (“Data Dictionary”) has been developed and is now frozen and work has commenced on drafting the suite of Human Machine Interface (HMI) displays.

In order to facilitate the IEC61850 implementation, discussions between LEUK and TPS have commenced during this reporting period to coordinate the transfer of data between the respective equipment to provide the IED Capability Description (ICD) files. This, when combined with the IP addressing and agreed naming conventions for all connected equipment, shall form the baseline for the IEC61850 “database”.

Appendix A.4 provides a summary of the database and HMI as currently drafted.

d) Telecommunications Network

During this reporting period we have discussed the various options for connecting the GTI and EVCP to the fibre network and defined a preferred architecture.

e) AC Measurement Equipment

During this reporting period, we have started to finalise the functionality and required equipment to facilitate the AC measurement system, after which procurement can proceed.

Lucy Gridkey are able to provide two types of AC Measurement Control Units (MCU) with different technical and operational parameters. In order to determine the best-fit device, we have assessed the quantity of LV ways in the new substations and considered overall system latency and the requirement to interface to the Supervisory Controller.

Discussions are currently ongoing with Lucy Gridkey to determine the preferred method of AC data capture and how best to store it (via dedicated local data centre or offline/cloud based etc) prior to making the AC data available to the DC share Supervisory Controller.

Appendix A.6 details how this equipment will be connected and integrated into the overall scheme.

f) DC Isolator Equipment

The initial Pre-Qualification (PQ) and tendering exercise resulted in receipt of only one credible proposal for which the financial proposal was outside the budget. This resulted in the specified functionality being scaled back and upon re-tendering a financial proposal within budget was received. Discussions are currently ongoing with the bidder to clarify points associated with access/security, segregation of supplies, earthing and ability to integrate the points of isolation into a standard WPD policy document. Once these issues are concluded it is anticipated that procurement for the DC Isolator equipment will proceed.

g) Glass Reinforced Plastic (GRP) Enclosures

Given that some substations chosen for DC Share may require a GRP enclosure (either for the entire distribution substation or just for the GTI and telecommunications cubicle) an investigation was undertaken to assess the predicted heat build within such enclosures in order to determine the possibility of excessive internal GRP temperature rise and a subsequent de-rating effect on the GTI (currently the GTI starts to de-rate if ambient air temperature reaches 50 Deg C)

The objective of the analysis was to verify the likelihood (and scale) of GRP enclosure heat build, consequential impact on GTI operation and identification of GRP design measures that could be introduced to mitigate the potentially adverse effect of excessive heat build within the GRP enclosure. Design works are currently ongoing to provide a suitable enclosure.

h) EVCP Foundation Designs

With recourse to the EVCP technical specification, we have been able to determine the preferred method of EVCP positioning and cable access. In essence we shall provide two concrete foundation cubes upon which the EVCP upright support stands shall be securely bolted. There shall be “free ground” between these cubes allowing the DC, AC and fibre optic cabling to be presented for glanding without having to determine accurate positions for the ducting to ensure a straight point of entry to the cubicle.

i) Cable Access Designs

During this reporting period, discussions remain ongoing relating to how best to progress the site construction aspects associated with routing/terminating the various cabling to the EVCP and GTI locations.

The project is progressing approval of a cable system that is suitable for DC systems. This system intends to:

- Be based upon standard WPD cable systems as much as possible
- Be compliant with a WPD DC system safety policy

- Support HSG47 best practice
- Be of a size that can be practically installed

This is presenting a complicated set of interdependencies which the project is navigating.

For the fibre optic cabling it is intended to install buried chambers alongside each substation and EVCP hub from where the fibre optic ring can be terminated and thence connected to the GTI and EVCP equipment.

3.4.3 Procurement

The procurement activities progressed during this reporting period are as summarised below:

a) Supervisory Controller Equipment

The contract award for the supervisory controller was placed with LEUK on 23rd February 2021.

This was the result of a protracted open bidding exercise against which Ricardo received three credible bids. LEUK were awarded the contract on the basis of achieving the specified pass mark on technical issues and then providing the lowest evaluated cost.

b) AC Measurement System (Gridkey)

The project has commenced final discussions with Lucy Gridkey to procure a suitable AC measurement system. At time of writing, the finer details related to the scope of works are nearing completion.

c) DC Cable

The specification for the DC cable was developed in associate with a cable vendor during Q4 2020 but not subjected to procurement. Subsequently a general DC Cable technical specification has been developed suitable to proceed with a mini-tender to assure cost effectiveness.

3.4.4 Charge Point Operator (CPO) Issues

Swarco have continued to provide ad-hoc team support across a variety of subject matters including the following:

- Technical assistance to TPS in developing the EVCP design and user interface
- Guidance on standard testing procedures to verify communications between the ECP's and Swarco's back-office
- Viewpoint on expectations for a commercially viable system

3.4.5 Project Website

The Project website has been revised during this reporting period to :

- Upload the Final System Design Report (dated 18th Dec 2020)
- Upload the Project Progress Report July-Dec 2020.
- Advertise the fact that Swarco has been selected as CPO
- Advertise the arrival of DC ducting on site

Further uploads and addition of technical data is planned once the main equipment design documents are approved.

4. Business Case Update

At the time of writing, there have been no changes to the anticipated benefits to be gained by the Project.

5. Progress Against Plan

5.1 This Reporting Period

Table 3 summarises the progress in this reporting period against the project plan. Key issues progressed during the reporting period are provided in Section 3.4.

Table 3: Progress Against Plan

Reference	Project Milestone	Status	Original Key Milestone Due Dates	Revised Key Milestone Due Date *(Assessment from COVID-19 Impact)*	Further Revised Key Milestone Dates
WP 1	Site Selection Completed	Completed *(Ofgem Approved 5th June 20)*	31 May 2020	31 May 2020	Unchanged (Completed)
	Gateway Date (Planning Permissions Concluded)	*Completed (Ofgem Approved 30th Sep 20)*	*30 Sep 2020*	*30 Sep 2020*	*N/A*
WP 2	Final System Design Report	*Completed (Issued 18th Dec 2020)*	30 Sep 2020	18 Dec 2020	Unchanged (Completed)
WP 3	Factory Acceptance	Not started	31 Mar 2021	18 Dec 2021	31 Mar 2022
WP 4	Installation Completion	Not started	31 Jul 2021	30 Apr 2022	29 July 2022
WP 5	Trial Interim Report	Not started	31 Jan 2022	30 Sep 2022	31 Jan 2023
WP 6	Trial Results Report and EV Charging Customer Experience	Not started	30 Nov 2022	30 Jun 2023	30 Nov 2023
WP 7	Close Down Report. Final Conclusions and BaU recommendation	Not started	31 Mar 2023	30 Oct 2023	29 Mar 2024
N/A	Comply with knowledge transfer requirements of the Governance Document	In Progress	End of Project	End of Project	29 Mar 2024

5.2 Next Reporting Period

As indicated in the previous PPR's, due to the Covid-19 pandemic, there has been a delay in securing materials required to start GTI and EVCP fabrication and a delay in concluding the Supervisory

Controller contract award, due to bidding deadline Extension of Time (EoT) requests being received over the Christmas/New Year holiday period.

The net result of this is that the detailed design finalisation ("Functional Design Specification or FDS") for the Supervisory Controller was delayed at least one month. Furthermore, TPS have advised that their ability to progress EMC testing at their off-site testing facility is delayed due to backlogs caused by the Covid restrictions.

Regardless of the above, the combined team is striving to mitigate the delays by assessing how to fast-track the overall design and integration aspects, but it is currently expected there will be a delay in commencing the next main project deliverable, the Integrated Factory Acceptance Test (iFAT).
Progress with such efforts shall be reported upon within the next PPR.

The current intent remains to schedule completion of all site ground works (eg cable trench dig, cable lay, reinstatement, coiled terminations at each substation site etc) during 2022 so that when the equipment is ready for shipment it can be installed and connected on site without any further undue delay. In this manner, we plan to accelerate the equipment installation and commissioning period and commence with the site trials before 29th July 2022.

6. Progress Against Budget

Table 4: Progress Against Budget

Cost Allocation		Net funding (£)	Planned Spend (£)	Spend (£)	Variance (£)	Variance (%)
WPD	Labour : PM	137,681	57,419	58,313	894	1.6%
	Labour: NS & Tele	30,000	57,000	2,041	-54,959	-96.4%
	Labour – Engineering	268,742	44,190	190		
	Equipment	70,187				
	Installation	390,724				
	Telecoms	145,000		4,553	4,553	3%
REE	Contractors	2,407,518	1,534,889	1,475,925	-58,964	3.8%
	Equipment	1,113,550	558997	558,997		
Trial	Energy Costs	166,559				
ENW	Labour	103,816	44,808	44,808		
Trial	Contingency	509,959				
	Total	**5,293,737**	**2,269,822**	**2,144,637**	**-125,185**	**-5.52%**

Even allowing for Covid delay, the project is progressing at a slightly slower rate than forecasted. This is due to additional complexity encountered during the detail design phase. There is also a lag in reflecting the expenditure from WPD engineering cost centres.

7. Bank Account

The bank account statement for the project, for the reporting period is provided as a separate attachment within the submission email.

8. Project Deliverables

The project deliverables as defined within the Project Direction letter are as defined in Table 5 below.

Against each deliverable we have added a narrative describing current status and any challenges encountered.

Table 5: Project Deliverables

Deliverable Item No.	Project Deliverable Description	Original Deadline	Narrative
1	Site Selection Report	May 2020	Activity and deliverable completed. Report issued to Ofgem on 29th May 20 and formal; approval received back from Ofgem on 5th June 2020. Planning application process can commence.
	Gateway Date (Planning Permissions Concluded)	*September 2020*	*Activity and milestone completed. Documentation issued to Ofgem on 29th Sep 20 and formal approval received back from Ofgem on 30th Sep 20.*
2	Final System Design Report	September 2020	Deadline has been extended until 18th Dec 20 and we have issued the report to Ofgem for their review on this date.
3	Factory Acceptance	March 2021	*Not yet started. New deadline 31st March 2022 but this may be further delayed should we encounter further design and/or system integration issues*
4	Installation Complete	July 2021	Not yet started
5	Trial Interim Report	January 2022	Not yet started
6	Trial Results Report & EV Charging Customer Experience	November 2022	Not yet started
7	Close Down Report, Final Conclusions & BaU Recommendation	March 2023	Not yet started

The FAT milestone date is facing increasing pressure. During the most recent project review, the steering group has challenged the project team to demonstrate that the date of the 31st of March 2022 for factory acceptance is still achievable whilst still making commensurate allowance for the amount of design and delivery risk carried by the project. This update is expected on the 25th of June 2023.

9. Learning Outcomes

9.1 This Reporting Period

During this reporting period, we have identified ten (10) further “Lessons Learnt” as summarised below:

Site Selection Issues

It was proven difficult to converge on a set of existing substations that are appropriate to accept installation of a GTI. This is because a site’s suitability is influenced by:

- Space
- Capacity headroom
- Cable access
- Conditions inside the switchroom
- Spare ways in the LV pillar
- Legal permission

The key learning point here is there will rarely be a perfect substation that can accept connection of a GTI installation and that some form of compromise on one or more of these factors will probably be required.

GTI Located Inside GRP Enclosures

Concern has been raised regarding locating GTI equipment inside a GRP enclosure due to the possibility of excessive heat build leading to GTI de-rating (and eventual shut-down). This issue was not apparent during 2020 site surveying as the GTI derating information has only recently been disseminated by TPS. To mitigate the possibility of such de-rating occurring, the GRP enclosure will need to be designed with additional ventilation and/or some other form of physical segregation between the transformer and GTI. The key learning point here is that power electronic devices are not always compatible for installation in standard distribution substation buildings and enclosures.

DC Cable & Material

The technical parameters for the DC cable, together with its associated jointing and termination equipment and the procedures and policies required to effect the construction activities, did not previously exist and it has taken significant time to progress through all such issues, determine an approved construction techniques (eg do we use HV or LV safety rules as a baseline) and hence proceed to a procurement activity. The key learning point here is that developing a set of policies to enable a totally new class of DNO assets should be expected to take significant time and resource. .

Metering of EVCP AC Supplies

The original EVCP design provided a 6A power socket for maintenance staff use, inclusion of which meant that an AC meter would have been required in order to comply with Elexon directives. However, the provision of an AC meter within the EVCP was not foreseen and the cost of introducing such a facility was prohibitive and internal EVCP space restrictions also presented a physical barrier. The 6A power socket was ultimately removed from the EVCP. The lesson learnt is to understand the implications of all associated Regulatory Authorities requirements when designing items of equipment which consume power.

Project Management

With a project of this complexity it is preferred if "Key Staff" changes within the various Parties are kept to an absolute minimum whenever possible. Should unavoidable staff changes be required then there must be adequate time allocated for a robust project handover to the new incumbent in an effort to ensure a seamless transition.

Project Management

Innovation projects must be structured to be able to balance between gathering the right amount of engagement from operational departments without depending on them to the extent of diverting them from their core activities or asking them to exceed their expected mandate. Key learning is to engage with the operational departments at an early stage of the project proposal (FSP development) in order to appraise them of the project, request and agree their specialist contributions and/or seek alternative arrangements should circumstances so dictate.

FSP Preparation Stage

In order to determine if the overall DC Share was capable of achieving an integrated solution which aligned with DNO codes and would provide a safe and operationally viable functioning system, several additional simulations and documents were required to be prepared (Network Design Intent, Protection Philosophy, Earthing Strategy, System Integration etc) which were not originally foreseen or budgeted for.

The key learning point here is therefore that when embarking upon complex, new and innovative designs such as DC Share, appropriate consideration is given to all such specific DNO requirements that would be required as part of a Front End Engineering Design (FEED) package of works during the tender development stage so that appropriate costs can be allowed for.

FSP Preparation Stage

FSP requirement stipulated that the control system would be stand-alone and not required to be integrated with WPD's main control centre site. Subsequent to this, it has been determined that such integration/visibility should ideally be provided in order to provide network control with an understanding of the overall network running arrangements and its effect on the wider meshed network.

The key learning point here is therefore to ensure that whenever embarking upon an Innovation Project which includes an element of network monitoring and/or control, engagement with the WPD network control staff should be sought during project proposal preparation stage to understand and incorporate their specific requirements.

10. Intellectual Property Rights

10.1 Overall IP Statement

Table 6 provides details of the Background IP that will be brought to the Project.

As Foreground IP is created during the course of the project, then this will be discussed and entered as agreed within the Schedule 7 of the Contract and the template log for this is shown in Table 7 below.
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Table 6: Background IPR

Background IPR Name	Custodian of Background IP	Description
Implementation of Soft Open Point Electronic converter architecture using a plurality of bi-directional DC:AC converters with associated control platform.	TPS	Achieves the necessary functionality between multiple Low Voltage feeders: • Network power (real) balancing • Phase power (real) balancing • Reactive power support • Harmonic cancellation • Voltage support • Power factor correction
Implementation of isolated, dual bridge, resonant DC:DC converter with Silicon Carbide devices to achieve efficient, fast switching, light weight and small size high power conversion stage.	TPS	Achieves the necessary conversion of power between high voltage (~750-850V) DC bus and Electric Vehicle.
Grid Tied converter operation.	TPS	Enables safe and reliable synchronisation and connection with the Low Voltage (LV) using phase lock loop techniques.
Droop control to achieve paralleling of multiple converters with common source.	TPS	Ensures load sharing between a plurality of converters without using complex communications between units.
Power Electronic simulations, models, analysis and design documentation.	TPS	Necessary to evaluate the design and performance of Power Electronic and control systems.
Silicon Carbide semiconductor device modelling and switching technique implementation.	TPS	Enables converter technology to achieve: • High efficiency • Low size & weight • Low acoustic noise signature
Magnetics designs and models	TPS	Implementation of low loss, lightweight materials to achieve high efficiency, compact solutions for use

		in harmonic filters, EMC filters and transformers
Implementation of Soft Open Point converter using a plurality of independent leg modules to create controlled phase limbs and separately controlled neutral leg.	TPS	Necessary to achieve design modularity for ease of service, whilst achieving necessary phase equalisation benefits.

Table 7: Foreground IPR Log

Item No	Foreground IPR (created or in the process of being created)	Brief Description of Foreground IPR (for identification purposes)	Brief History of Foreground IPR (i.e. how it's been created Parties involved; % of involvement)	List all Relevant Background IPR required for use of Foreground IPR (including Relevant Background IPR owner identity)	Proposed breakdown of ownership of Foreground IPR (Party names and % of ownership)
1	Use Cases	Set of Use Cases describing the overall functionality and operational intent for the Supervisory Controller	REE created a complete suite of indicative Use Cases which was integrated into the Supervisory Controller bidding document. This has been a REE 100% activity		REE 100%
2					
3					
4					
5					
6					

10.2 Current Reporting Period

REE have logged Foreground IPR related to the Supervisory Controller Individual Use Case functional operation development works during this reporting period.

10.3 Overall IP Statement

It is expected that the project Parties will collectively start to record additional Foreground IPR as the project progresses during the next reporting period, especially for designs associated with novel and new functionality, equipment and systems.

11. Risk Management

Our 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;
- Comply with WPDs and Ricardo's risk management processes and any governance requirements as specified by Ofgem; and
- 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;
- ✓ Preparing contingency action plans; and
- ✓ Regular monitoring and updating of risks and the risk controls.

11.1 Current Risks

Two separate risk registers have been developed and are currently maintained for the Project.

One covers risks associated entirely with the COVID-19 pandemic whilst the other risk register concentrates on project-specific (eg non Covid-19) issues).

Each risk register is a live document and is updated regularly by the project management team.

To date, a total of eighty-six (86) active risks are raised across both risk registers, of which forty-six (46) have been closed.

Since issue of the previous PPR, we have :

- Identified thirty-nine (39) new project specific risks
- Closed seven (7) risks listed within the Covid specific register due to the risk being removed (eg staff availability now de-risked)
- Closed eighteen (18) project specific risks due to the risk being removed (eg risk associated with a substation identified as required for use within the original site selection report is now not being considered)

Two (2) risks are categorised as "severe" and five (5) risks categorised as "major". All are detailed within Table 8 below

For each risk, a mitigation action plan has been identified and the appropriate steps then taken to ensure risks do not become issues wherever possible.

The risk registers are reviewed and revised on a regular basis, so the data with them will be subject to change.

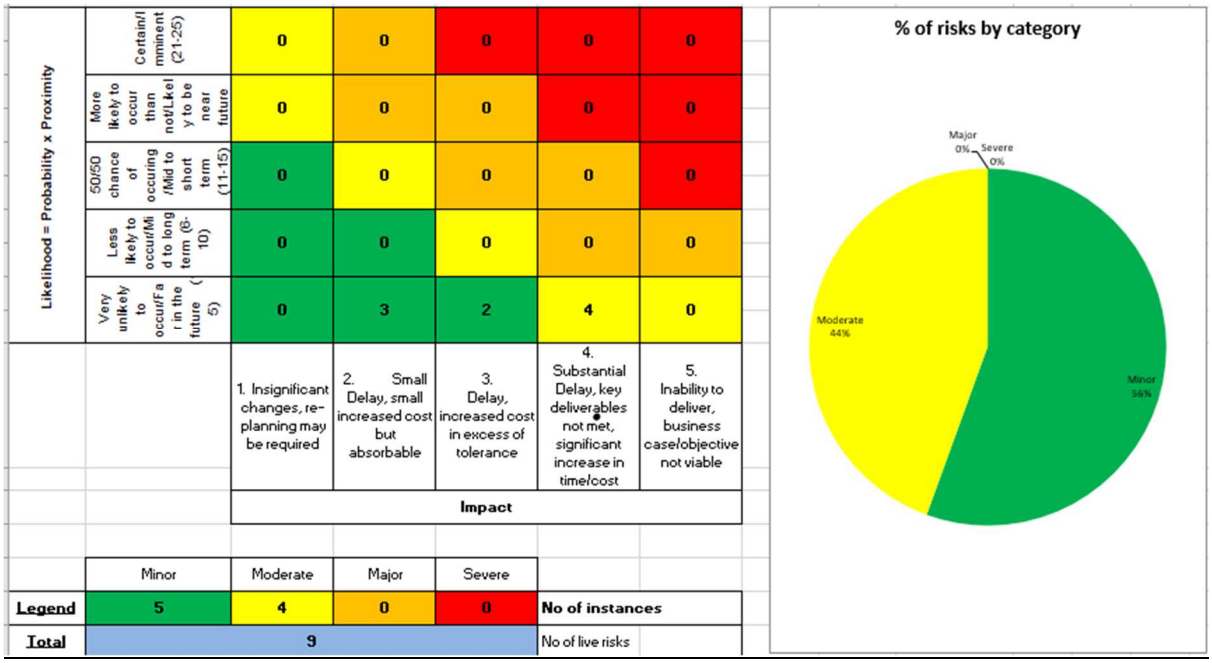
Figures 7 and 8 show graphically the split of risk categories across the respective registers.

Table 8 : Current Reporting Period “Severe & Major Risks”

RISK	MITIGATION
Severe Integration of the various systems introduces difficulties/issues that were not foreseen and/or are unable to be resolved within the timescales and budget of the project. 61850 implementation is a big concern along with overall system dynamics	1. Ensure that appropriate system integration activities are underway and supervised with appropriate skills/experience 2. Requirement for WPD technical sign off of FDS use cases 3. Strong leadership during specification of LEUK Controller independent FAT testing is required to prove through simulation that the controller acts as expected 4. Prepare contingency plans. Example plans could be to ensure that mesh can be ran split without need for control system to ensure EVCP operation can continue (thus gathering some learning) 5. Prepare contingency plan to ensure that if mesh needs to be run split acceptable loading is retained on transformers
Severe The present protection philosophy cannot provide adequate protection sensitivity in some conditions	Redesign of protection system, network and or GTI's or accept operational imitations with potential impact on customers
Major Delay in ordering DC cable has potential to compromise the overall schedule and result in end Key Milestone date being impossible to achieve (unless trial period is shortened). To order DC cable, preferred cable and jointing system needs to be understood and specified	Preferred cable solution needs to be understood
Major DC Cable route presents many challenges which can only be overcome by expending additional time, cost and effort	Undertake formal route proving to assess each cable route segment and resolve issues

Major Adverse effects experienced on WPD network due to introduction of the DC ring or AC interfaces	1. There needs to be sufficient analysis and rigour within the Power System Intent document to inform when unacceptable consequences are at risk of occurring and 2. There needs to be sufficient analysis within system integration and simulation tasks to provide advice to avoid consequences described in this risk and 3. There needs to be an on-site commissioning framework to ensure systems are configured correctly and 4. There needs to be operational advice that records how the Controller should be operated
Major Suitable enclosures cannot be designed to keep GTI's within thermal rating and atmospheric requirements	Prepare Network Concept document to formally document the design intent for the integration of the project into WPD's system

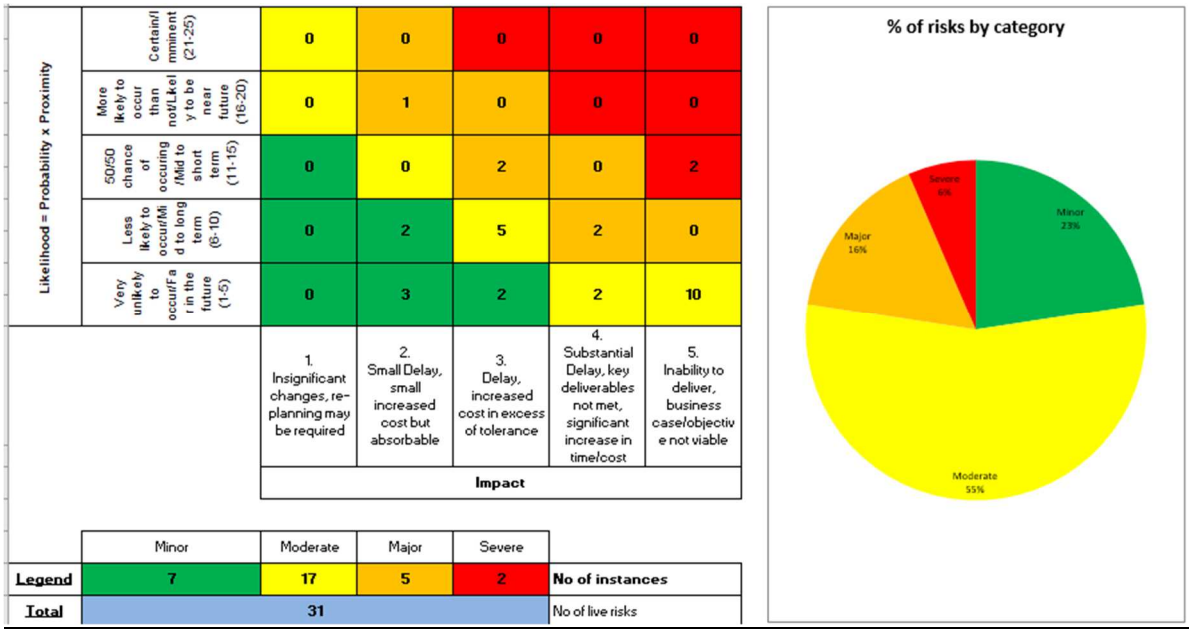
Figure 7: Risk Graphical Log (COVID-19 Issues)



Likelihood = Probability x Proximity	1. Insignificant changes, re-planning may be required	2. Small Delay, small increased cost but absorbable	3. Delay, increased cost in excess of tolerance	4. Substantial Delay, key deliverables not met, significant increase in time/cost	5. Inability to deliver, business case/objective not viable
Certain/Imminent (21-25)	0	0	0	0	0
More likely to occur than not/Likely to be near future (16-20)	0	0	0	0	0
50/50 chance of occuring /Mid to short term (11-15)	0	0	0	0	0
Less likely to occur/Mid to long term (6-10)	0	0	0	0	0
Very unlikely to occur/Far in the future (1-5)	0	3	2	4	0
	Impact				

	Minor	Moderate	Major	Severe	
Legend	5	4	0	0	No of instances
Total	9				No of live risks

Figure 8: Risk Graphical Log (Project Issues)



Likelihood = Probability x Proximity	1. Insignificant changes, re-planning may be required	2. Small Delay, small increased cost but absorbable	3. Delay, increased cost in excess of tolerance	4. Substantial Delay, key deliverables not met, significant increase in time/cost	5. Inability to deliver, business case/objective not viable
Certain/Imminent (21-25)	0	0	0	0	0
More likely to occur than not/Likely to be near future (16-20)	0	1	0	0	0
50/50 chance of occuring /Mid to short term (11-15)	0	0	2	0	2
Less likely to occur/Mid to long term (6-10)	0	2	5	2	0
Very unlikely to occur/Far in the future (1-5)	0	3	2	2	10
	Impact				

	Minor	Moderate	Major	Severe	
Legend	7	17	5	2	No of instances
Total	31				No of live risks

12. Accuracy Assurance Statement

This report has been prepared by the REE Project Manager (Michael Feasey) with contributions from the WPD Delivery Manager (Paul Morris).

It has been recommended by:

Yiango Mavrocostanti (WPD Innovation Manager)

and approved by:

Carl Ketley-Lowe (WPD Project Sponsor)

Both REE and WPD confirm that this report has been produced, reviewed and approved following our quality assurance process for external documents and reports.

13. References

1. DC Share WPD Press Release https://www.westernpower.co.uk/news-and-events/latest-DC Share Ricardo Press Release news/wpd-and-partners-trial-new-way-of-delivering-rapid-ev-charging-hubs
2. DC Share Ricardo Press Release: https://ricardo.com/news-and-media/news-and-press/western-power-distribution-and-ricardo-to-lead-innovative-rapid-ev-charging-trial
3. Ofgem Project Direction Letter dated 18th December 2019 https://www.ofgem.gov.uk/ofgem-publications/160387
4. NIC Full Submission Pro-forma Document https://www.ofgem.gov.uk/publications-and-updates/electricity-nic-submission-dc-share-western-power-distribution
5. NIC Initial Screening Proposal Document https://www.ofgem.gov.uk/publications-and-updates/electricity-nic-initial-screening-submission-2019-dc-share-wpd

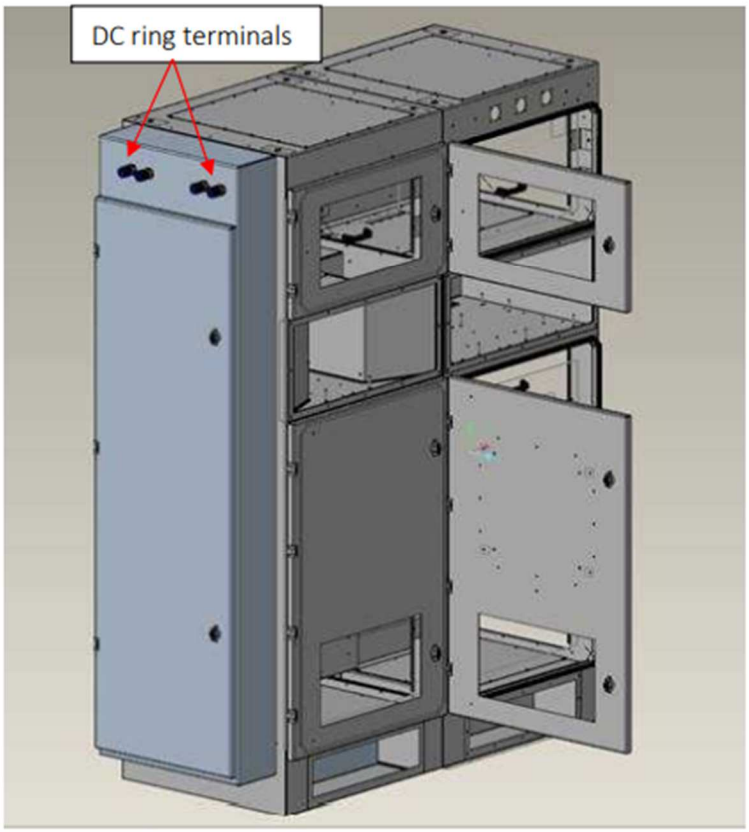
Appendices

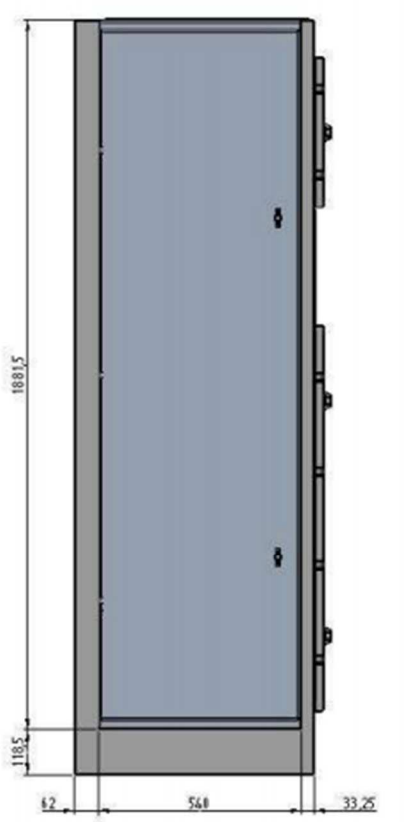
A.1 Bank Account (Confidential)

The DC Share bank account statement has been attached to the submission email as a separate PDF document.

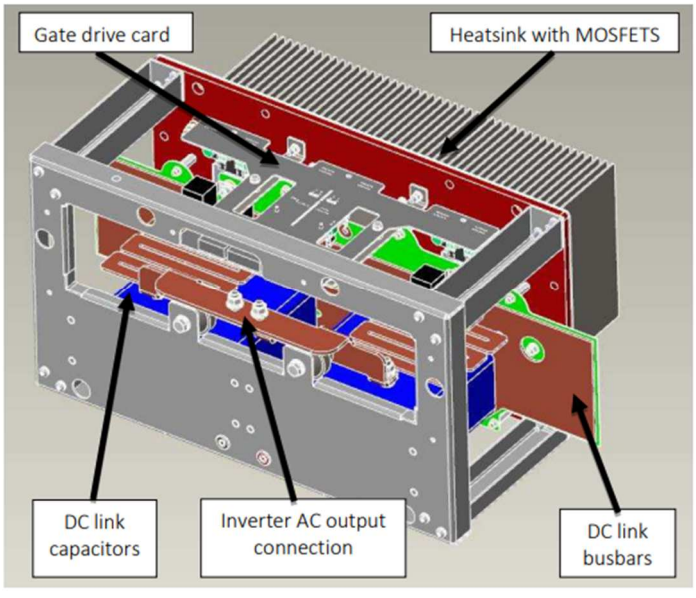
A.2 Grid Tied Inverter Summary of Design Details

Sectional Views

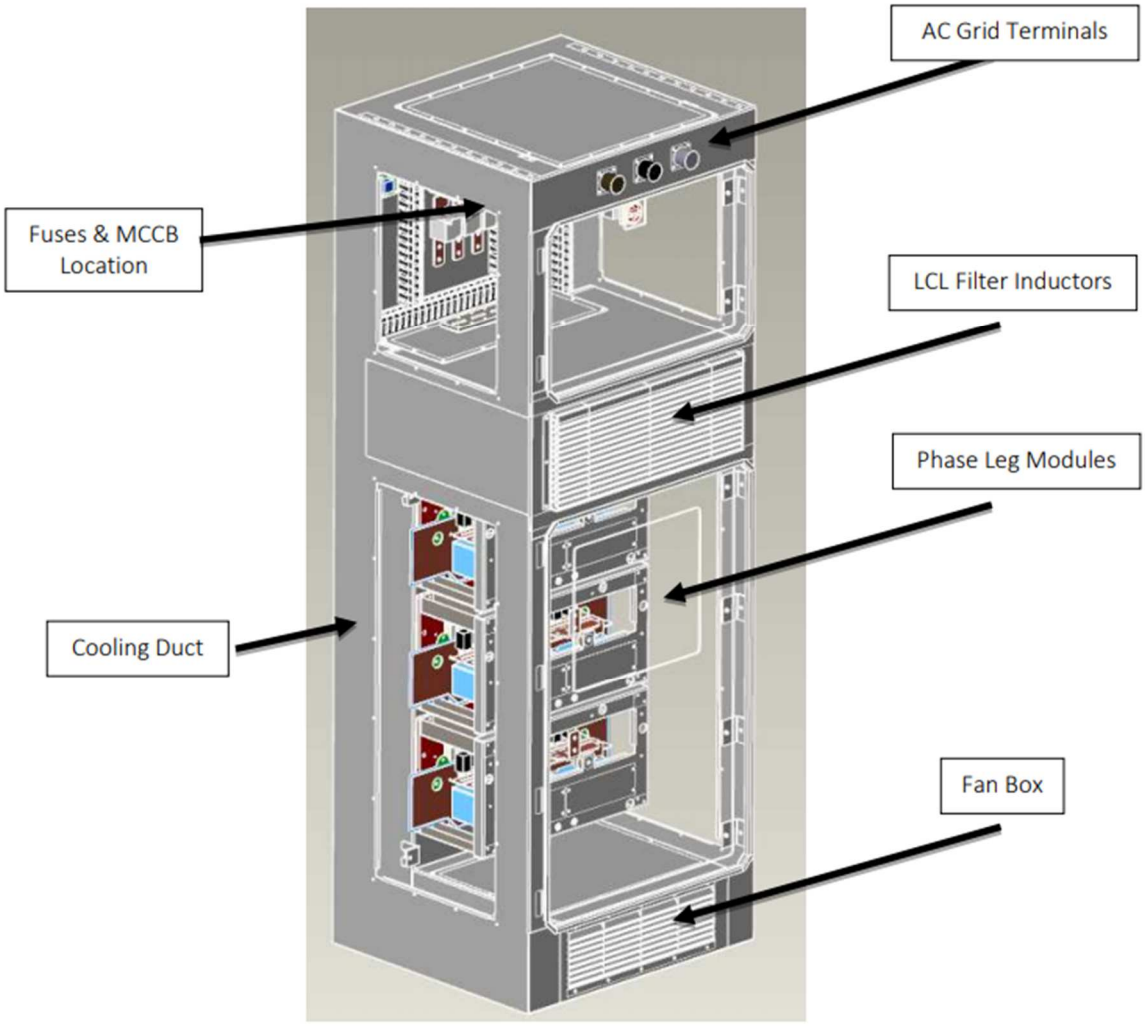




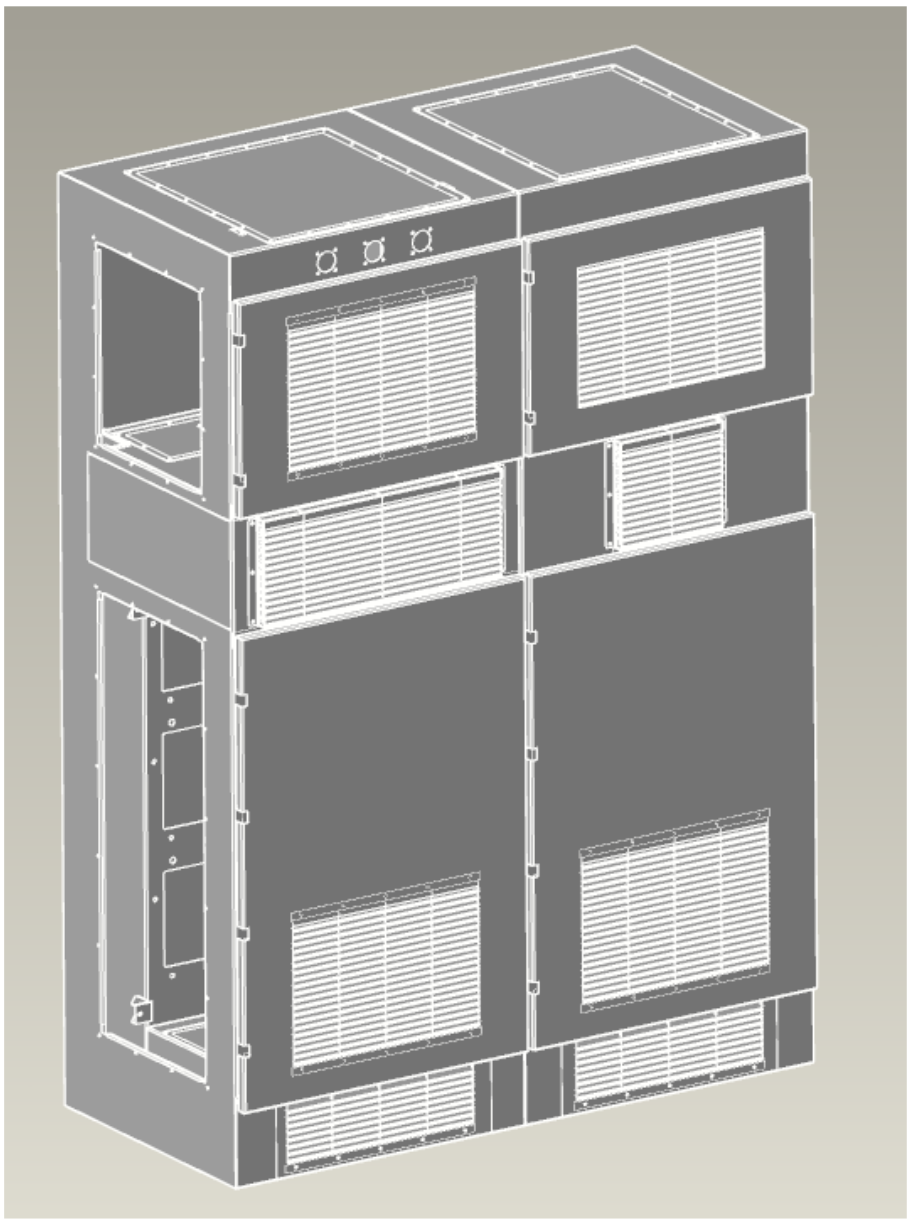
Inverter Leg Module



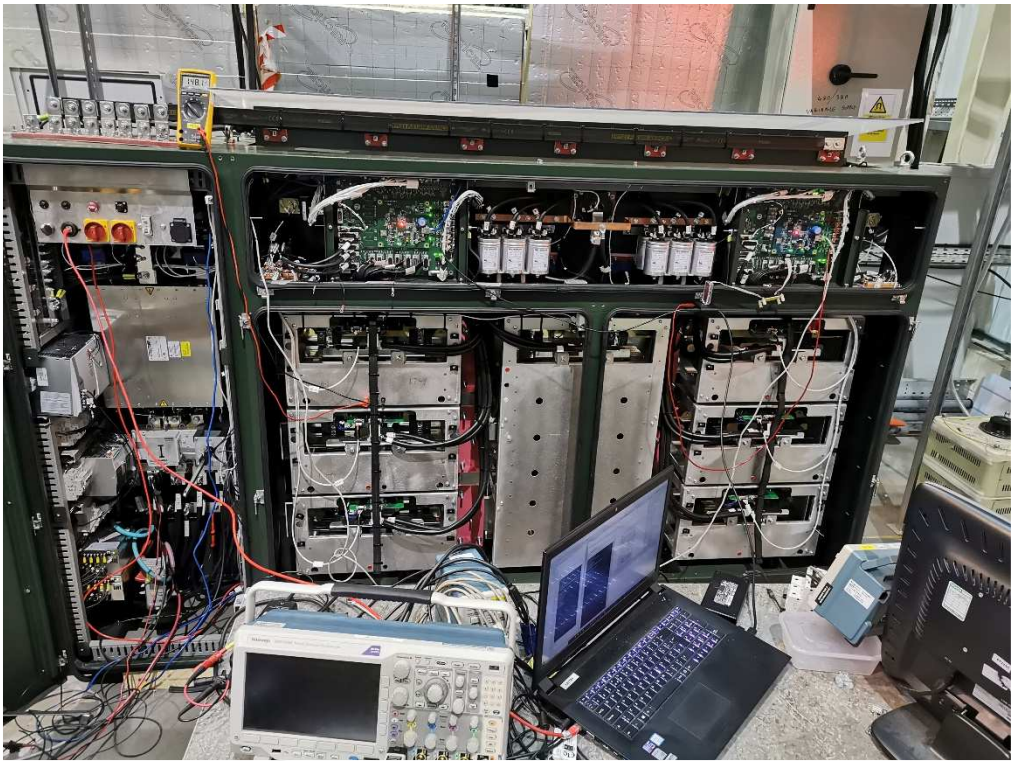
Inverter Enclosure Internal View

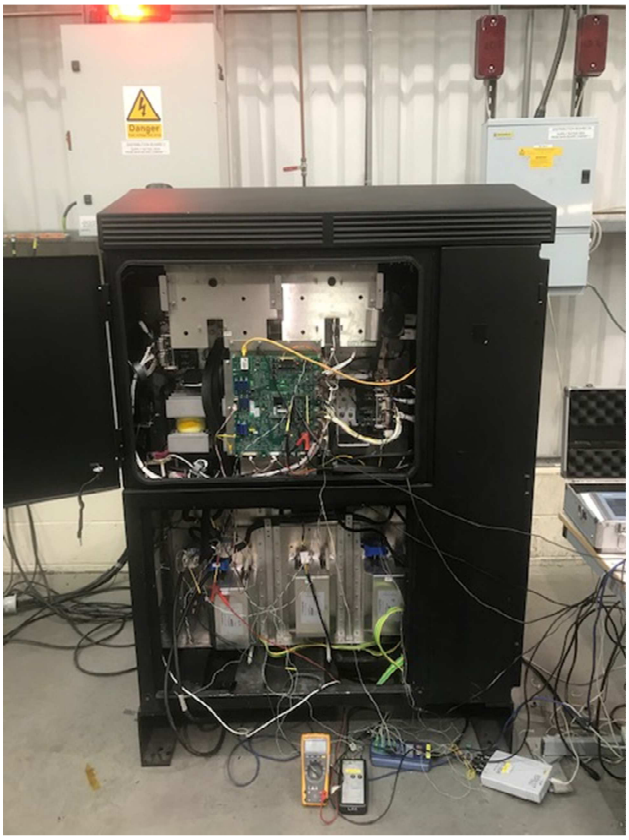


Complete GTI System View with Front Covers Fitted



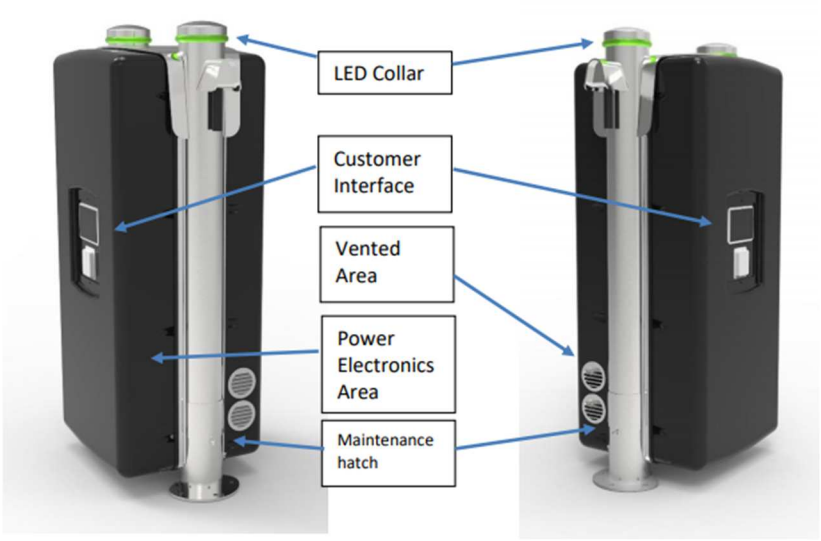
Example Equipment Undergoing Factory Testing (Previous Project)

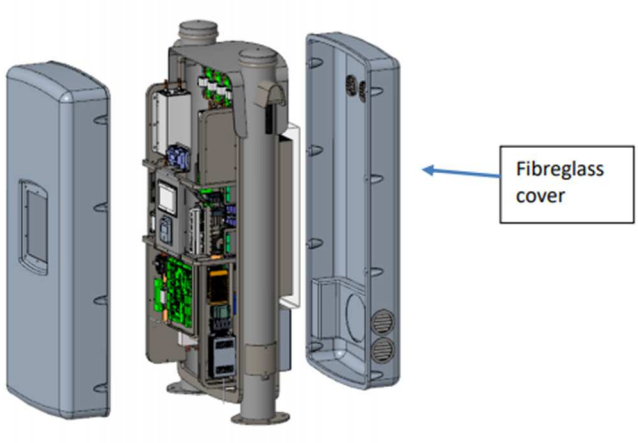


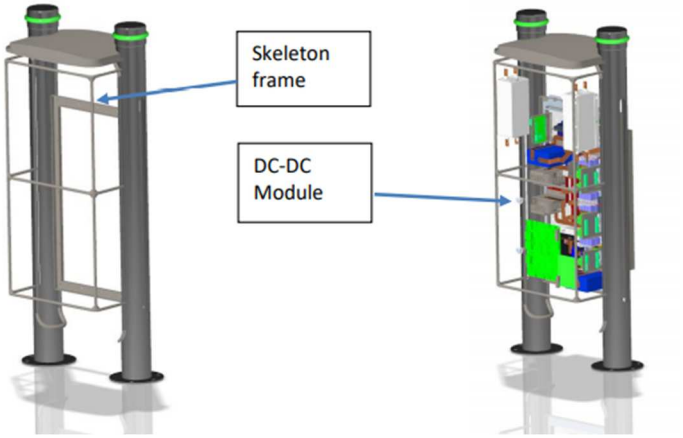


A.3 Electric Vehicle Charge Point Summary of Design Details

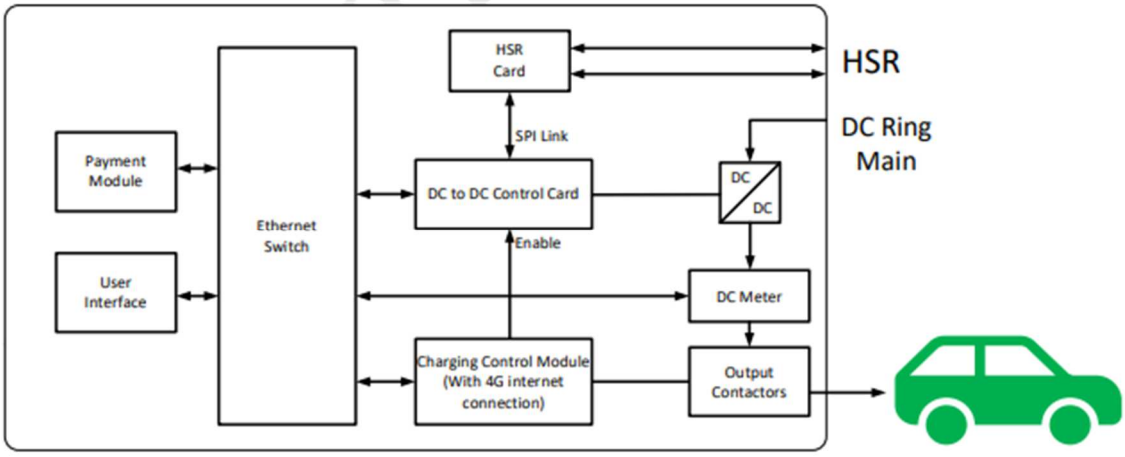
Sectional Views



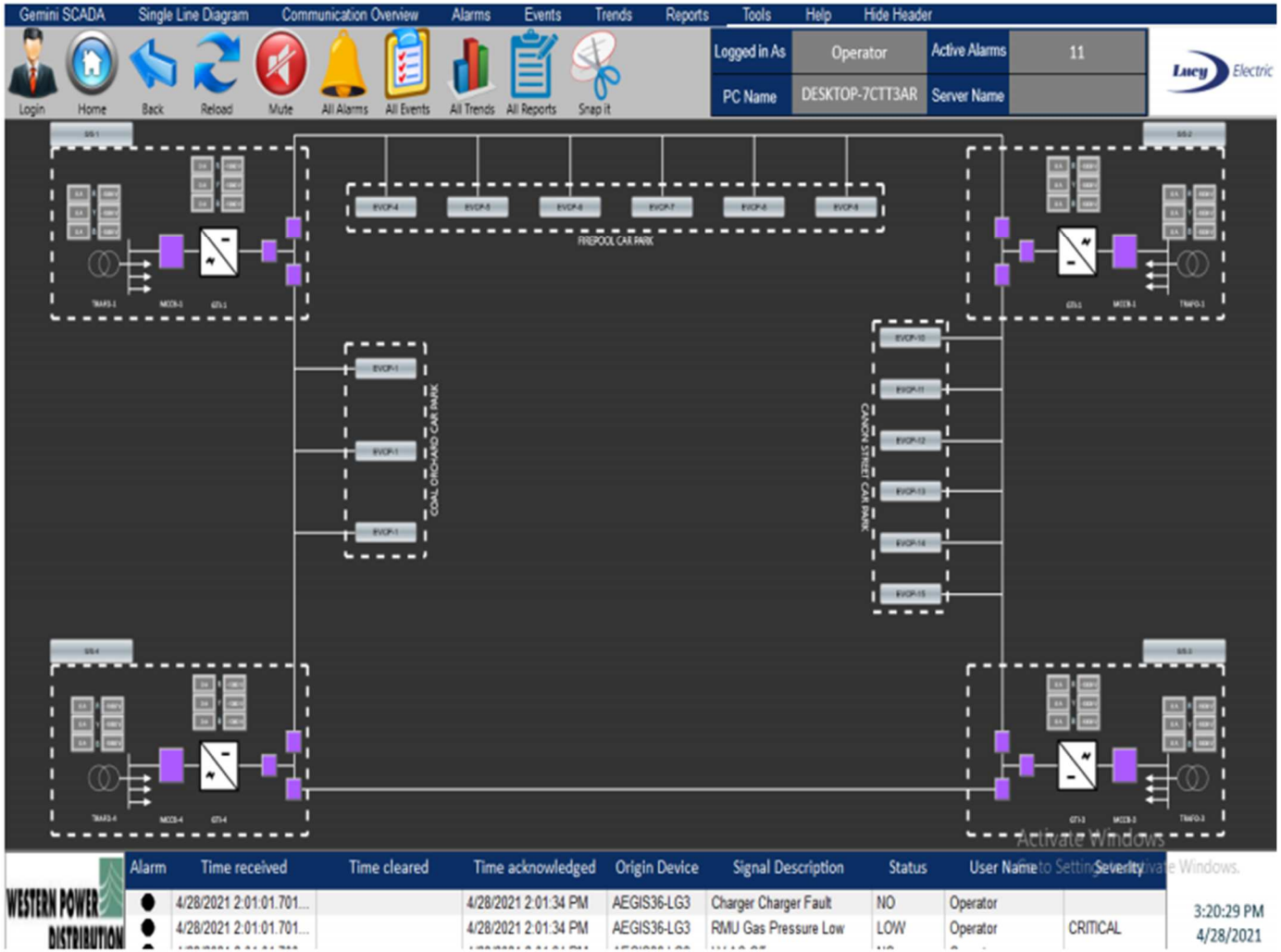


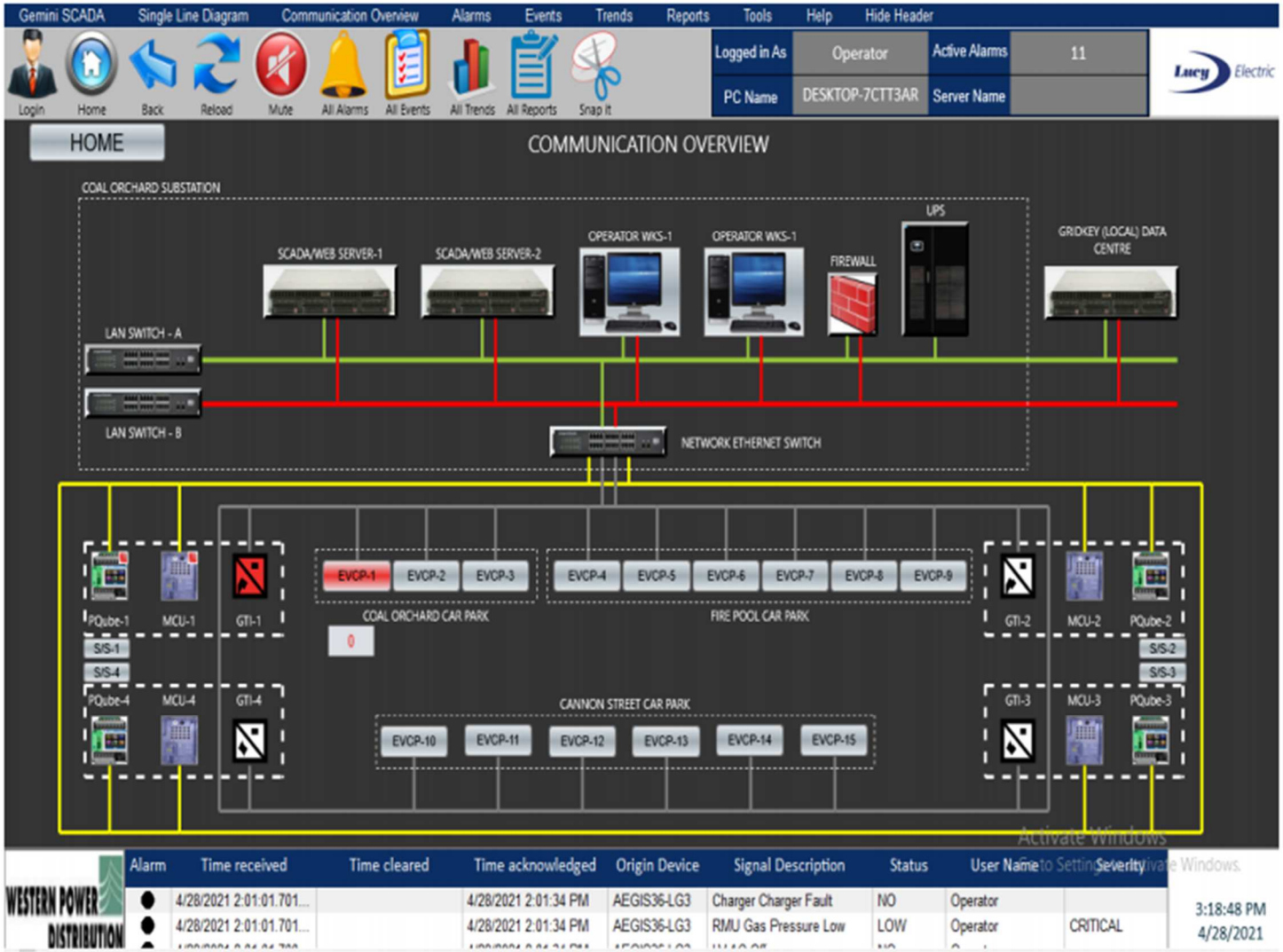


Charging Control Module Context



A.4 Supervisory Controller – Examples of HMI Design




Gemini SCADA
Single Line Diagram
Communication Overview
Alarms
Events
Trends
Reports
Tools
Help
Hide Header
Login
Home
Back
Reload
Mute
All Alarms
All Events
All Trends
All Reports
Snap it
Logged in As
Operator
Active Alarms
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Server Name
Lucy Electric
HOME
COMMUNICATION OVERVIEW
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SCADA/WEB SERVER-1
SCADA/WEB SERVER-2
OPERATOR WKS-1
OPERATOR WKS-1
FIREWALL
UPS
GRIDKEY (LOCAL) DATA CENTRE
LAN SWITCH - A
LAN SWITCH - B
NETWORK ETHERNET SWITCH
PQube-1
MCU-1
GTI-1
EVCP-1
EVCP-2
EVCP-3
EVCP-4
EVCP-5
EVCP-6
EVCP-7
EVCP-8
EVCP-9
COAL ORCHARD CAR PARK
FIRE POOL CAR PARK
GTI-2
MCU-2
PQube-2
S/S-1
S/S-4
S/S-2
S/S-3
PQube-4
MCU-4
GTI-4
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GTI-3
MCU-3
PQube-3
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Time cleared
Time acknowledged
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Status
User Name
Severity
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Operator
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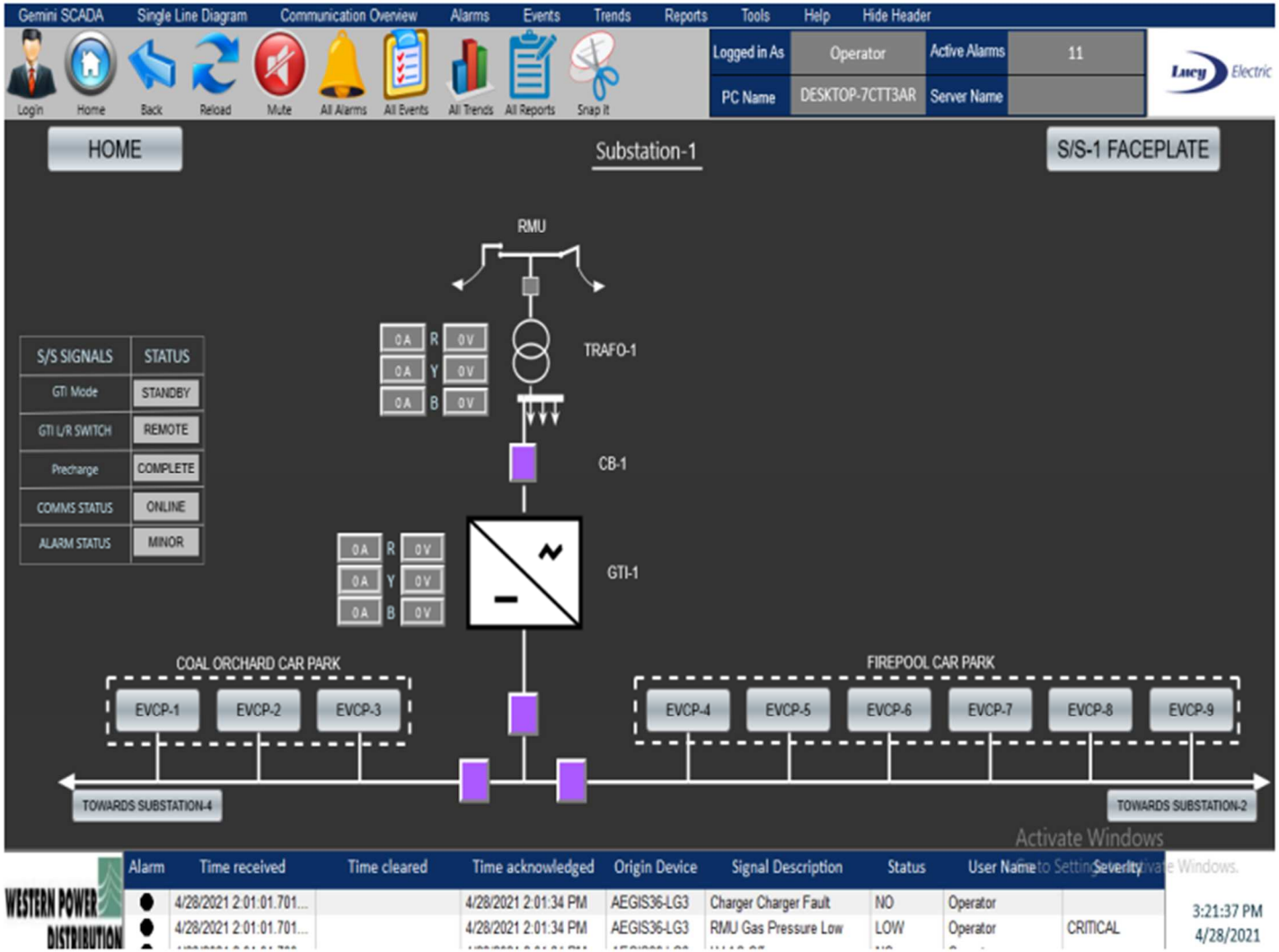
Gemini SCADA
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All Alarms
All Events
All Trends
All Reports
Snap it
Logged in As
Operator
Active Alarms
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PC Name
DESKTOP-7CTT3AR
Server Name
Lucy Electric
HOME
Substation-1
S/S-1 FACEPLATE
RMU
TRAFO-1
CB-1
GTI-1
S/S SIGNALS
STATUS
GTI Mode
STANDBY
GTI L/R SWITCH
REMOTE
Precharge
COMPLETE
COMMS STATUS
ONLINE
ALARM STATUS
MINOR
0A R 0V
0A Y 0V
0A B 0V
COAL ORCHARD CAR PARK
EVCP-1
EVCP-2
EVCP-3
FIREPOOL CAR PARK
EVCP-4
EVCP-5
EVCP-6
EVCP-7
EVCP-8
EVCP-9
TOWARDS SUBSTATION-4
TOWARDS SUBSTATION-2
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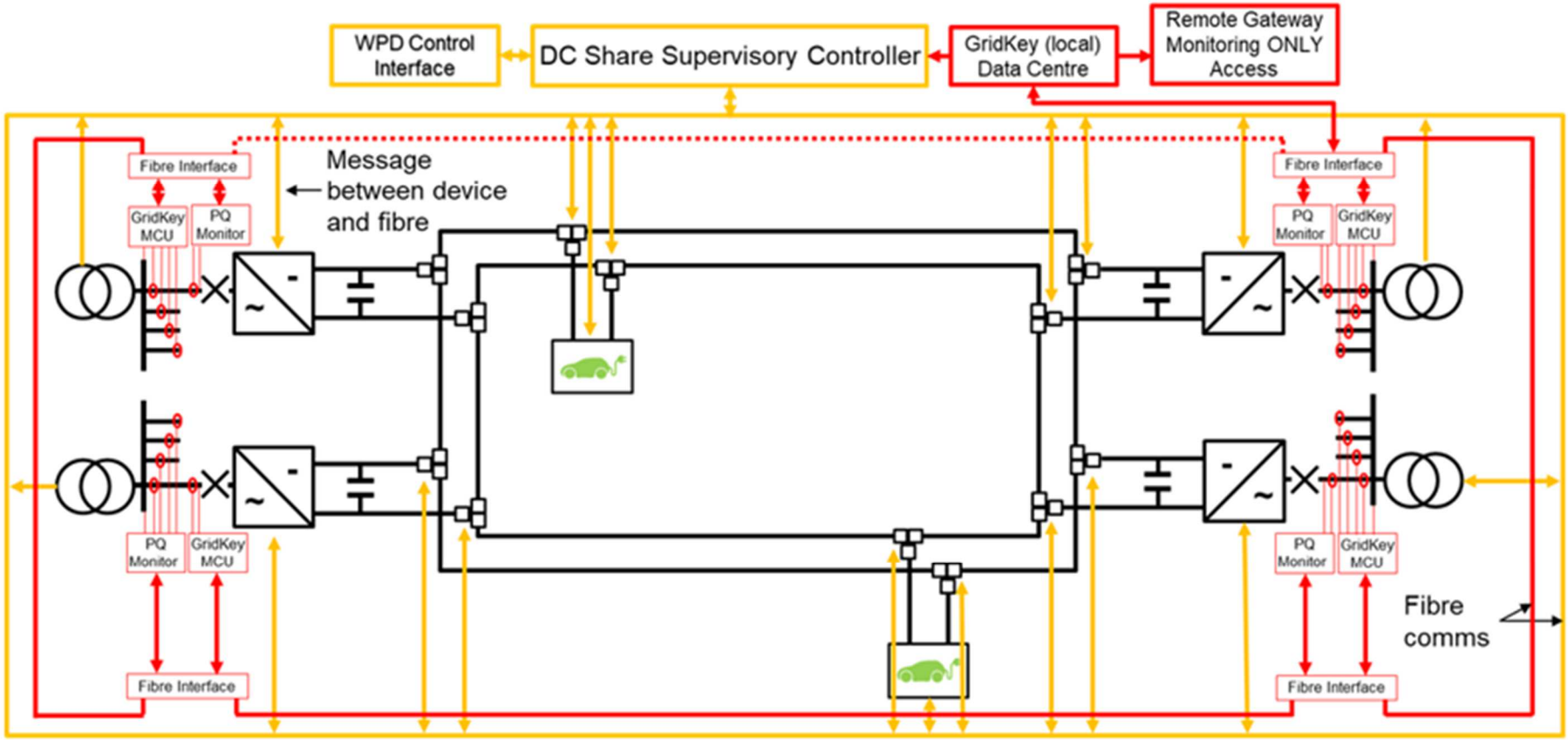
A.5 System Architecture



A.6 AC Measurand System - Summary of Connection Arrangements