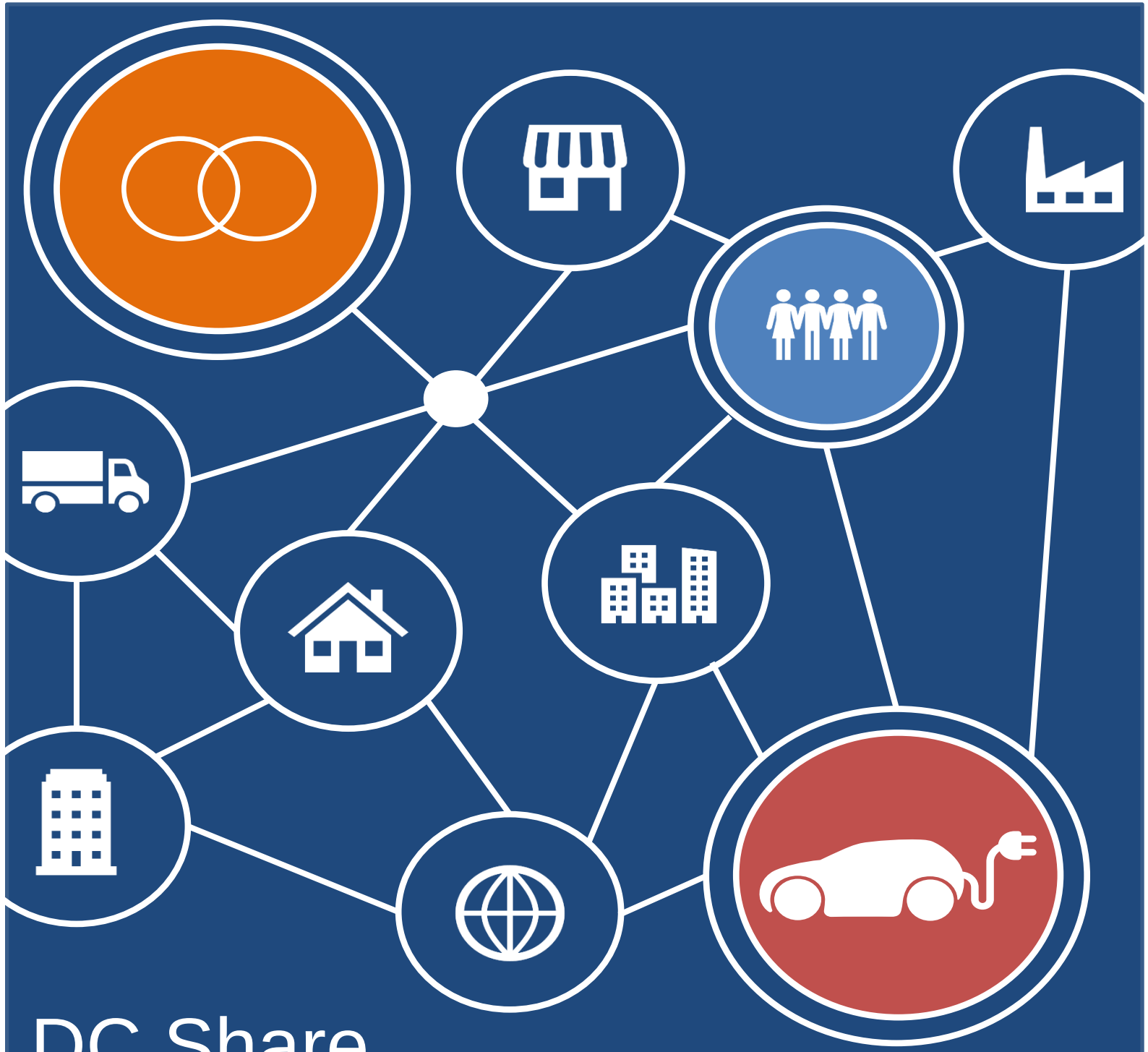

DC Share

Project Progress Report No.2

July – Dec 2020

ED 11196 | FINAL v2 | Date 23/12/2020

Customer:

Western Power Distribution

Customer reference:

Project Direction ref: WPD EMID / DC Share

Confidentiality, copyright & reproduction:

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Author:

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Approved By:

Sarah Carter

Date:

23 December 2020

Ricardo Energy & Environment reference:

Ref: ED11196- FINAL v2

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
FSP	Full Submission Pro-forma
GB	Great Britain
GTI	Grid Tied Inverter
LA	Local Authority
LV	Low Voltage
NDA	Non-Disclosure Agreement
NIC	Network Innovation Competition
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 en-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 second Project Progress Report (PPR) details the progress of the Project during the six month period July through December 2020.

Work in the last six months has mainly focussed around 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:

- Planning permission issues concluded with the Local Authority and the Ofgem Gateway Milestone date of 30th September 2020 achieved.
- Refinement of the site selection and DC ring design has been undertaken following Local Authority feedback on preferred location of available car park locations. All changes have been notified to Ofgem and accepted.
- Detailed technical design of the system which consisted of a series of technical meetings and workshops between all Parties to present, discuss and assess various issues associated with cabling, substation interfaces, earthing arrangements, stray currents, protection, control, communications and system architecture, GTI design and EVCP design continues to occur.
- Procurement for equipment has commenced, notably for the GTI & EVCP long-lead items, the control and communications system, the AC and DC cable and the DC meter.
- Support and services from a Charge Point Operator (CPO) have been secured.
- The project website has been developed, tested and placed online.
- Drafting and submission of the Final Design Report to Ofgem

During the course of this reporting period travel restrictions imposed during the first half of the year caused by the COVID-19 pandemic initially relaxed but then a second “lockdown” period was imposed, further restricting travel. The project team have adapted and continued to work remotely utilising tools such as ‘Teams’ for virtual meetings between project partners.

During the relaxation of the rules, the project team including engineers from WPD, Ricardo and Turbo Power Systems, met on-site at Taunton to fully survey the selected substations for access, room and electrical connection points, which was an activity that was suspended from the first national lockdown. Off the back of this meeting the team refined the trial sites that were selected with the new selection and layout sent and approved by Ofgem.

2.3 Business Case

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

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 seven (7) lessons learnt, with five (5) new ones introduced during the report 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 47 risks have been raised of which 9 are now closed and all risks previously classified as “Severe” or “Major” have either now ben closed or re-risked.

The “Severe” risks are all associated with the Covid-19 pandemic and it is expected that these will naturally disappear or become adequately mitigated.

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.

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 and progressed the design issues associated with the DC cabling.
2) Ricardo Energy & Environment (REE) has, apart from managing the entire project and coordinating all Parties and works, reviewed the main design documents, finalised a suite of bidding documents for the Supervisory Controller and floated the same.
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) Vectos (South) Ltd have provided support during the planning application process

In addition to the above, we have developed and concluded relationships with the following Parties during this reporting period:

6) Somerset West and Taunton Local Authority (SWT LA) who will provide necessary support throughout the entire project period and will ultimately benefit from the introduction of the rapid EVCP infrastructure post-project completion
7) Swarco, who will become the Charge Point Operator (CPO) and assume ownership of the EVCP infrastructure post-project completion.

3.2 Project Background (Overview)

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

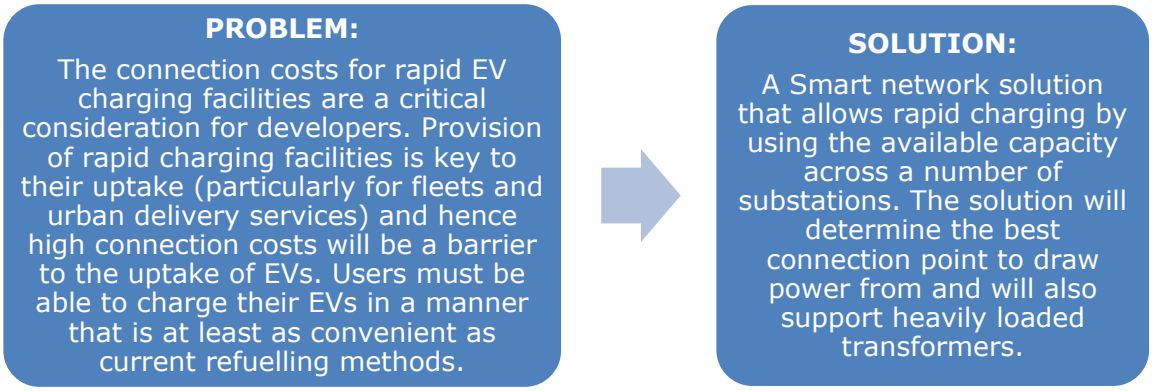
The aim is therefore to assist with rapid Electric Vehicle (EV) charging requirements by providing reliable facilities where they are needed, whilst making optimal use of the available network capacity without the need for immediate network reinforcement.

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.

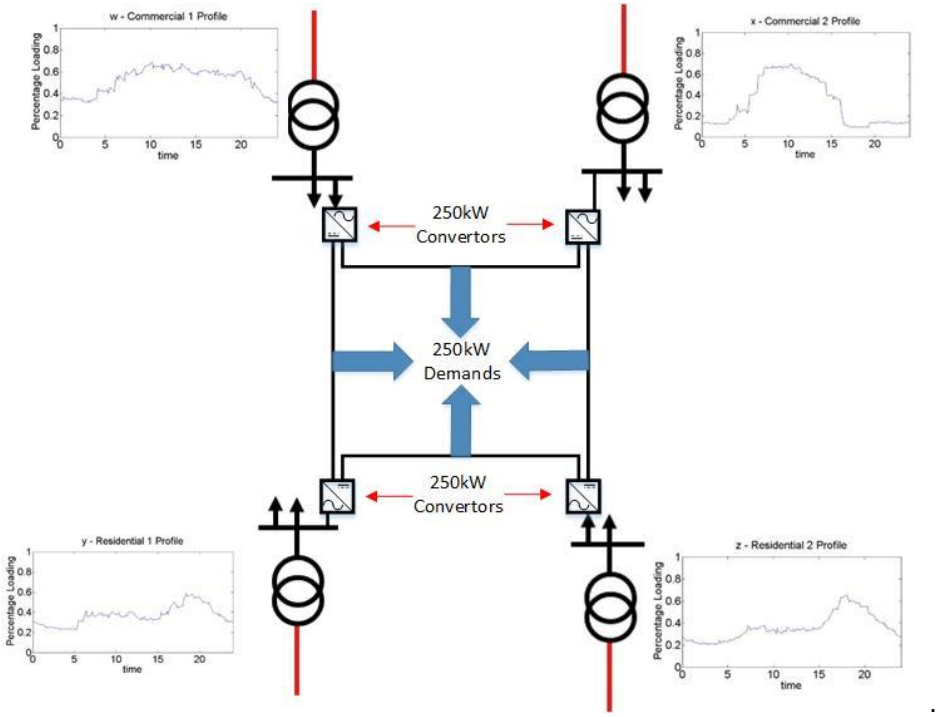
The Project will provide a means of sharing system capacity across AC secondary substations with different load profiles. Using a DC ring to provide the capacity for the rapid charging points leaves capacity on the existing LV AC cables for demand growth of the existing users.

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 will connect the DC bus to a cable circuit. The smaller unit means that siting devices within substations will be possible in more locations, which will reduce the visual and audible impact.
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.

During this reporting period, the long-lead equipment items have been ordered with delivery to TPS factory expected to be completed by July 2021.

In addition, the non-long-lead equipment items have started to be identified and ordered by TPS and at the current time this procurement is on track with deliveries expected throughout the course of 2021.

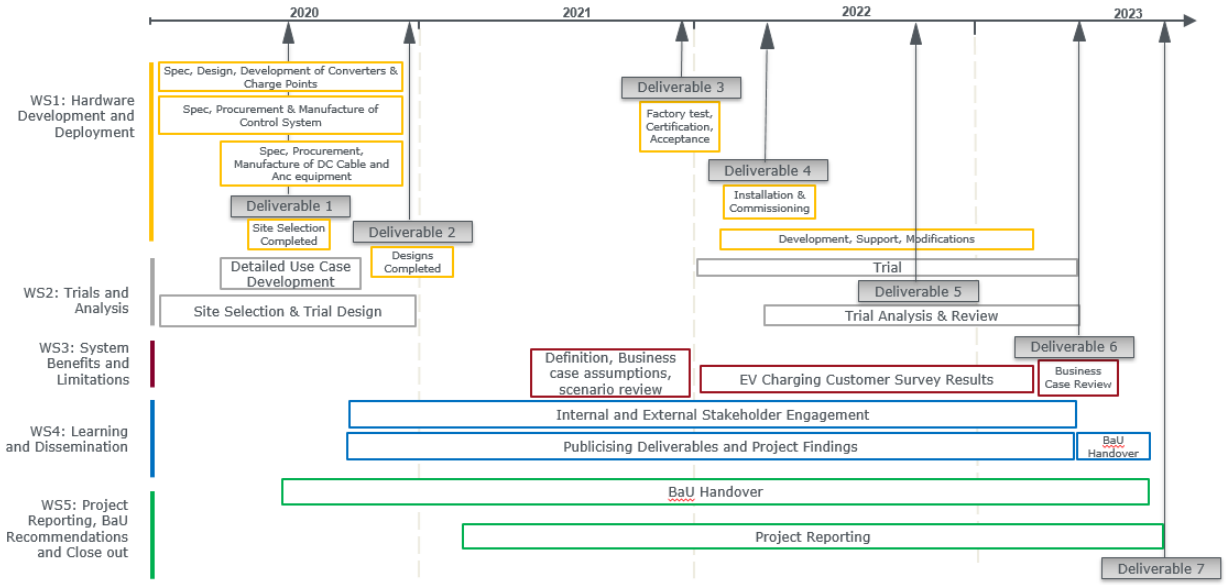
The FAT milestone date of 18 December 2021 remains a challenge but may still be achievable. The works scheduled to occur during 2021 will be closely monitored to identify and mitigate risks that may adversely affect the ongoing schedule.

Table 2: Original and Contingency Key Milestone Dates

Reference	Project Milestone	Original Key Milestone Dates	Contingency Key Milestone Dates (*Estimated at time of Contract Signature*)
WP 1	Site Selection Completed	31 May 2020	31 May 2020
WP 2	Final System Design Report	30 September 2020	18 December 2020
WP 3	Factory Acceptance	31 March 2021	18 December 2021
WP 4	Installation Completion	31 July 2021	30 April 2022
WP 5	Trial Interim Report	31 January 2022	30 September 2022
WP 6	Trial Results Report and EV Charging Customer Experience	30 November 2022	30 June 2023
WP 7	Close Down Report. Final Conclusions and BaU recommendation	31 March 2023	30 October 2023
N/A	Comply with knowledge transfer requirements of the Governance Document	End of Project	End of Project

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

Figure 3 – Project Plan and Key Milestones



All Parties will endeavour to accelerate the programme and regain some of the delays introduced by the COVID-19 pandemic. We intend to progress and complete all site ground works (eg cable trench dig, cable lay, reinstatement, coiled terminations at each substation site etc) throughout 2021 so that when the equipment is ready for shipment it can be installed and connected without any further undue delay. In this manner, we plan to accelerate the equipment installation and commissioning period and commence with the site trials on or before 30th April 2022.

3.4 Progress During Reporting Period

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

3.4.1 Contract Signature

With the successful conclusion of the WPD/ENW Contract signature occurring during this reporting period, all individual Contracts between Parties have now been signed.

3.4.2 Site Selection

The site selection report (Deliverable #1) was completed and formally issued for Ofgem review and approval on 29th May 2020.

Ofgem approval was provided on 4th June 2020.

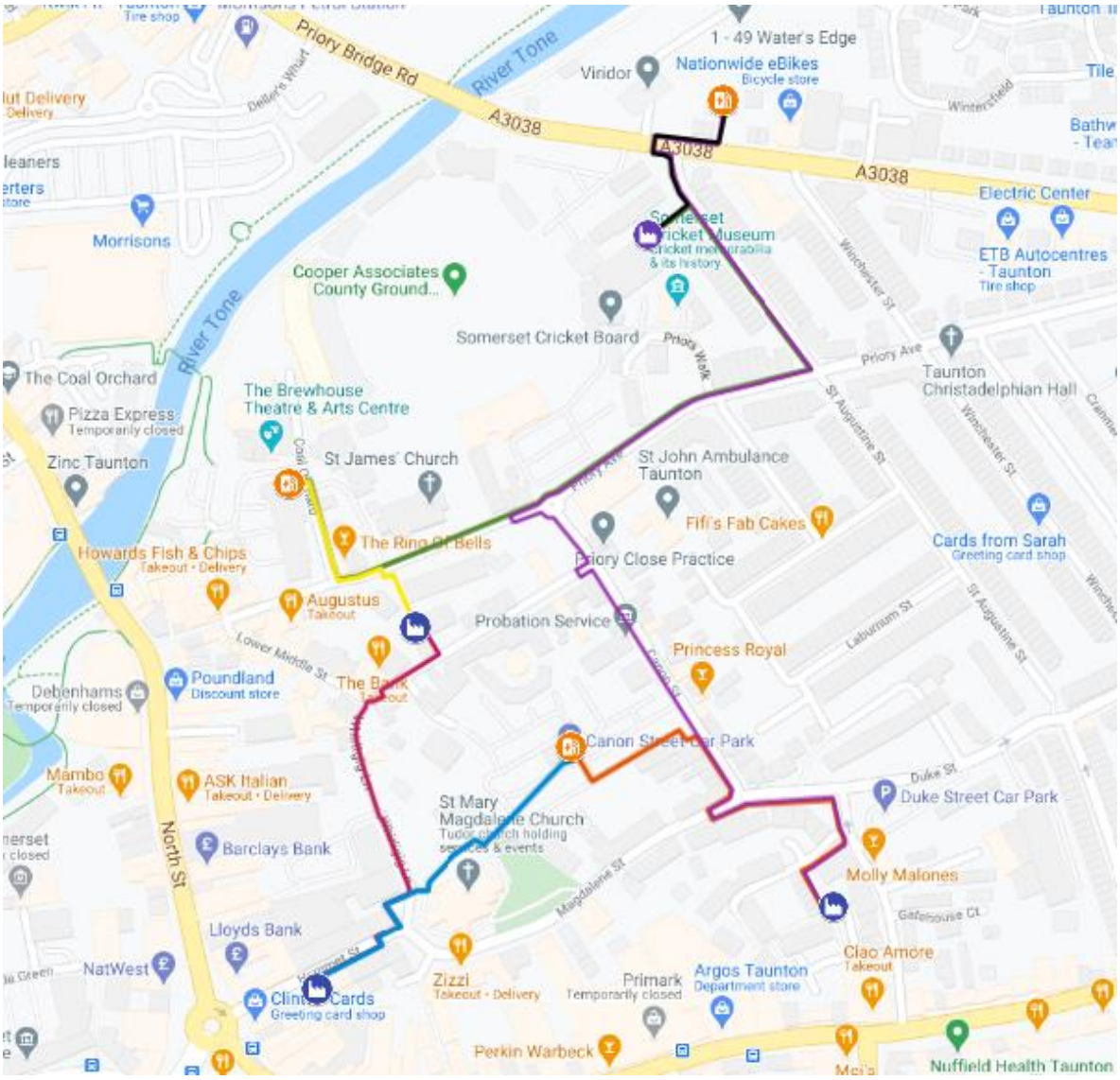
Since submission of this report and following on from further LA discussions, we have made the following changes ("***improvements***") to the DC ring design, as summarised below.

All such changes have been advised to Ofgem who have accepted the changes.

- Originally LA requested Firepool and Coal Orchard car parks be included in the design, with the Firepool car park being located north of the River Tone, hence a "river crossing" to connect all sites was required.
- LA has now advised that the Firepool development will straddle both sides of the River Tone and their preference is now to provide EVCP on the Firepool development located on the southern side of the River Tone. This has removed the need for a river crossing and also has meant the substation we originally planned to use north of the river (Canal Street SStn) is now inappropriate due to its location.
- LA has advised that only three (3) EVCP bays are available at Coal Orchard car park. Given that only 6 or 7 EVCP bays are available at Firepool car park we needed to incorporate a further LA car park into the design to maintain 15 rapid EVCP. After discussion with the LA they have requested we integrate Cannon Street car park.
- The final agreement with the LA on car parks, space availability for EVCP and the split of rapid charging types between car parks is therefore detailed upon the attached.
- With the Covid-19 travel restrictions gradually being lifted the project team has been able to visit Taunton and undertake further detailed site surveys, enabling us to assess suitability of a wider choice of substations, especially important now that the DC ring is required to route a different way through Taunton due to the change in LA car park locations.
- The final agreed design and choice of substations is therefore as shown on the attached. In summary, we shall now be using St Augustine Street, Eastgate Gardens, Hammet Street and Works substations to place the 4 x GTI equipment and form the DC ring.
- The four substations chosen are all suitable for the DC Share equipment installation in terms of space, availability of spare LV ways, varying load profiles, availability of latent capacity and closeness to the DC ring/cable route. They also avoid the need for any major road crossings, digging of any main commercial shopping streets and, of course, for any river crossing.
- In addition, we intend to place the main supervisory controller equipment within a brand new substation currently being constructed at Coal Orchard as there will be ample room here for the operator workstation and it will provide a more comfortable and secure environment for WPD staff to work from.

The current design for the DC ring is as shown in Figure 5 below.

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**

3.4.3 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 been concluded and detailed design documents for all the basic building blocks of the system submitted and reviewed.

Whilst full details relating to the system design can be found within the DC Share Final System Design report, submitted to Ofgem on the 18th December 2020, a summary of the main equipment designs as progressed during the reporting period is summarised below.

a) GTI Equipment

The documents submitted and reviewed are provided within Appendix A.2, which also provides a selection of graphics detailing how the GTI cubicles shall be constructed.

Full technical details relating to the GTI are provided with the GTI Technical Specification, Document No. 327-01-001.

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.

c) Supervisory Controller

The design for this system has concluded with a suite of procurement documents being finalised specifying the functional and performance requirements. The procurement for this system commenced during the reporting period.

Appendix A.4 provides a summary of the functionality provided by this Supervisory Controller.

d) Telecommunications Network

A direct buried fibre optic cable with 24 fibres will be installed by others in parallel with the DC ring. Each section of cable will be terminated in an associated fibre optic patch panel (wall boxes) at each of the eight locations where there are active project components i.e. GTIs, EVCPs and the System Controller location.

Each GTI and EVCP and the System Controller supplied by the Contractor will be configured to provide data communications in conformance with IEC 61850 standard for substation automation and communications. Dedicated fibres will be utilised to form an HSR ring that incorporates all the GTIs and EVCPs in conformance with the requirements of IEC 61850 and IEC 62439 3. Each GTI and EVCP will be delivered with two HSR nodes which will have RJ45 copper connectors and where they inter-connect with the optical fibre ring they will be fitted with suitable media converters, Each GTI and EVCP will be equipped with software required to support data interchanges in conformance with the requirements of IEC 61850.

The System Controller supplied by the Contractor shall include all necessary hardware and software as may be required to acquire data from and issue control signals to the GTIs and EVCPs via the HSR ring and associated IEC 61850 protocols for data interchange. There shall also be

provision for setting up time synchronisation messaging based on a time standard provided under this contract.

Appendix A.5 shows the system architecture.

e) AC Measurand Equipment

WPD will be providing their standard AC measurement system sourced directly from Lucy Gridkey. This equipment shall be integrated into the system architecture such that it operates on a dedicated fibre-optic network with the AC data being averaged and collected by the Lucy Local Data Control Centre and then made available to the Supervisory Controller.

WPD will dedicate fibres in the FO ring to establishing an Electrical Measurement WAN that links the Lucy GridKey Local Data Centre at Coal Orchard substations to the Lucy GridKey MCUs in each of the four substations where a GTI will be installed. The MCUs collect data from local sensors and will forward this to the GridKey Local Data Centre over the Electrical Measurement WAN. Data communications between the Lucy GridKey data store and the Supervisory Controller will be established on the basis of an API that supports transmission of data in JSON format.

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

A variety of other technical issues have also been progressed during this report period, such as those associated with the placement of equipment cubicles within each substation and the civil/ground works required for the EVCP's.

3.4.4 Procurement

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

a) GTI & EVCP Long-Lead Equipment

Procurement for this material was initiated immediately after Contract signature and current schedule indicates that 25% of this material should be delivered to TPS factory during March 2021 with the balance arriving in July 2021.

b) GTI & EVCP Non-Long-Lead Equipment

TPS have commenced with identifying all non-long-lead equipment and materials required to build the GTI's and EVCP's and initial orders for this material have been placed during the reporting period.

c) Supervisory Controller Equipment

The complete procurement activity for the Supervisory Controller commenced during the reporting period. Current deadline for bid submissions is 15th Jan 2021.

d) DC Cable

The DC cable has now been specified with involvement from the WPD Cable Engineer and DSO team. The project has now specified a 300mm2 duplex type cable to take the 800V around the DC ring. The next stage will be to issue the cable specification to industry cable manufacturers to gain estimates of cost for this bespoke cable, and then select a vendor to take forward to manufacturer.

e) DC Meter

A suitable supplier for a DC meter has been identified and an initial order for a single unit placed, with delivery made during November 2020. This unit will be tested by TPS in order to determine if the functionality and performance provided meets expectations and to assess best-build within the actual EVCP pillar.

3.4.5 Charge Point Operator (CPO) Issues

We have concluded discussions with a variety of UK CPO's and determined that Swarco are able to provide us with the most appropriate service, both during the project and post-project completion.

Discussions with Swarco have progressed through to securing an all-party signed Non-Disclosure Agreement (NDA) plus definition of respective roles and responsibilities during the project.

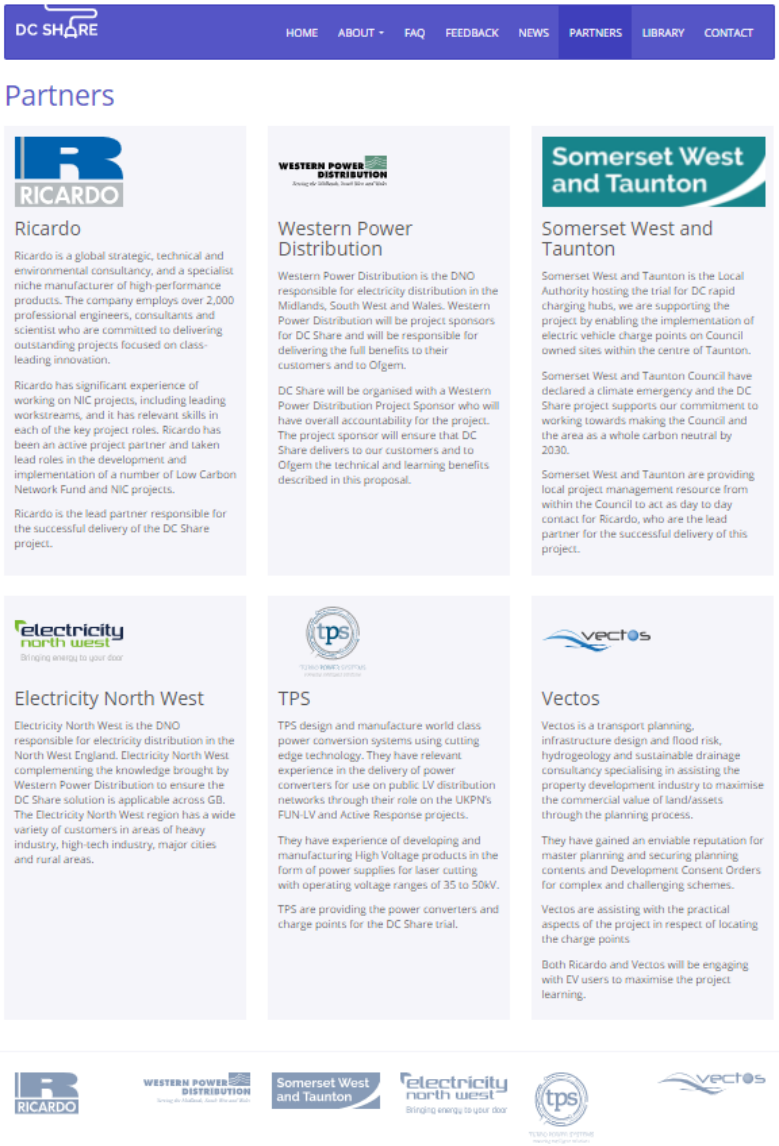
Technical conference calls have been held between all parties and, in particular, Swarco/TPS are in direct contact to discuss and resolve ongoing issues associated with designing and fabricating suitable EVCP's.

Swarco have also started discussions with the LA to discuss commercial arrangements post-project completion.

3.4.6 Project Website

The Project website has been revised during this reporting period to introduce the fact the Somerset West and Taunton Local Authority are working in collaboration with the DC Share project team and that the rial project will take place within their area.

Figure 6: Revised website pages



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

Error! Reference source not found. summarises the progress in this reporting period against the project plan. Key issues progressed during the reporting period are provided in Section **Error! Reference source not found.**.

Project Milestone #2 (Final System Design Report) was finalised and issued to Ofgem during this reporting period for their review by the Revised Key Milestone Due Date.

Table 3: Progress Against Plan

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

5.2 Next Reporting Period

As indicated in the previous PPR, due to the Covid-19 pandemic, there will be a delay in securing materials required to start GTI and EVCP fabrication. This, combined with the fact that the control/communications tendering package has not been able to be finalised until the GTI/EVCP designs are nearing completion, will mean that procurement for the control and communications systems and equipment may not complete until January 2021. However, we still anticipate being able to complete all the respective sub-system designs and fabrications throughout 2021 and complete the final integrated FAT by the revised key milestone due date of 18 December 2021, although this will be a challenging target to meet and, should any further delays be introduced either by COVID or during the remaining procurement processes, then this may introduce an additional negative impact on the schedule.

Regardless of the above, we shall strive to accelerate all activities during 2021 in order to make best efforts to complete the integrated FAT earlier and hence improve the overall schedule. Progress with such efforts shall be reported upon within the next PPR.

We shall also schedule to complete all site ground works (eg cable trench dig, cable lay, reinstatement, coiled terminations at each substation site etc) throughout 2021 so that when the equipment is ready for shipment it can be installed and connected 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 30th April 2022.

6. Progress Against Budget

Table 4: Progress Against Budget

	Total Budget	Expected Spend Dec 20	Actual Spend Dec 20	Variance £	Variance %
Labour	**490.94**	**38.92**	**35.65**	**-2.7**	**-1%**
WPD Project Management	98	30.22	35.46	5.81	1%
WPD Network Services	298.74	0	.19	.19	1%
ENW Costs	94.20	8.70	0	-8.7	-9%
Equipment	**1,189.06**	**119.20**	**120.23**	**1.03**	**0%**
Long Lead Hardware	119.20	119.20	119.20	0	0%
Converters & Charge Points	522.11	0	0	0	0%
Control System	395.88	0	0	0	0%
Misc Hardware	151.87	0	1.03	1.03	1%
Contractors	**2,693.37**	**1,532.28**	**1,406.59**	**-125.69**	**100%**
Site Selection	268.92	268.92	268.92	0	0%
Preliminary Design	786.78	786.78	786.78	0	0%
Final Design	183.29	183.29	57.60	-125.69	-68%
Procurement Activities	284.18	142.09	142.09	0	0%
Install & Commissioning	108.37	0	0	0	0%
Trial Design	189	151.20	151.20	0	0%
Trial Interim	260.09	0	0	0	0%
Trial Reporting & Analysis	159.81	0	0	0	0%
BaU Analysis	88.03	0	0	0	0%
Project Reporting	79	0	0	0	0%
Dig & Lay	286.09	0	0	0	0%
IPR Costs	**0**	**0**	**0**	**0**	**0%**
IT	**420.16**	**0**	**0**	**0**	**0%**
IT Costs (Fibre Ring)	420.16	0	0	0	0%
Travel & Expenses	**104.69**	**21.33**	**0**	**21.33**	**100%**
Travel & Expenses	104.69	21.33	0	-21.33	-100%
Contingency	**509.96**	**0**	**0**	**0**	**0%**
Contingency Costs	509.96	0	0	0	0%
Other	**220.38**	**0**	**0**	**0**	**0%**
WPD Cable costs	69	0	0	0	0%
Planning Application	5	5	5	0	0%
Other Costs	126.38	0	0	0	0%
TOTAL	**5,628.56**	**1,716.73**	**1,562.47**	**-146.83**	**-2.6%**

WPD project management has weighed heavy on the site selection and technical design elements of the project, it is anticipated that this will level out over the duration of the project.

Under Misc hardware, the project team have bought a DC meter to test for the project to ensure it will compatible and reliable with our network.

ENW and the outstanding Contractor costs are currently awaiting invoice post the submission of the Final Design report on the 18/12/2020. Underspend on travel and expenses is largely down to not travelling due to the coronavirus outbreak.

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
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

9. Learning Outcomes

9.1 This Reporting Period

During this reporting period, we have identified five (5) further “Lessons Learnt” as summarised below:

System Interfaces

Need to consider all interfaces between the various systems and ensure each "system" is assigned contractually to the Party who will ultimately be most suited to the work. For example, the telecommunication network interfaces to all other equipment plus supply of the main components has to comply with WPD approved procurement processes. Given WPD were scoped to undertake the site works associated with the telecommunications system it would have been more sensible to also assign the procurement of the actual materials to WPD and permit the specialist WPD telecoms team to develop the overall architecture/design. This re-assignment has now happened but is something that should be considered for future projects.

Equipment Assignments (DC Meters)

Ricardo were contractually tasked to purchase DC Meters which are required to reside within the EVCP's. This is the only component which TPS were not scoped to provide for their EVCP design. It would have been more sensible to make TPS responsible for the entire EVCP design and fabrication rather than have other Parties responsible for providing miscellaneous components.

DC Isolator Equipment

As a result of undertaking a Pre-Qualification Exercise, we have been able to determine that the market is not able to provide the DC share project with DC isolators which are small enough, within the project budget and/or able to be developed/provided within the project timescales.

In essence, the existing readily available solutions are DC circuit breakers designed for operation on DC traction networks. These DC circuit breakers exceed the space requirements inside the AC substations and at the EVCP locations.

DC Cable

We learnt from engaging with the DC cable vendor the importance of early engagement. Significant effort has been required to undertake the necessary protection calculations for designing a suitable cable. The DC cables may be near AC cable networks. Existing working practices have needed to be considered to ensure the DC cable looks significantly different from standard AC cables. This should prevent field engineers from mistaking the DC cable for an AC cable and minimise the risk of DC cables being mistaken for AC cables during maintenance of the AC network.

Not engaging early with the cable vendors may have delayed the procurement of the DC cable. No standard DC cable exists which is suitable for the DC share project and a specialist cable has been specified to meet the operational and safety requirements.

GTI Equipment

The GTIs are a significant size which are not suitable for installation in smaller substations, requiring careful considerations during site selection.

Additionally, the development of the GTI equipment required for DC Share has learnt from other innovation projects. The GTI is based on the 2T SOP architecture developed for the UK Power Networks NIC project Active Response. The development of the 2T SOP has experienced delays due to learning how to use silicon carbide (SiC) technology. SiC technology enables the devices to operate at a higher switching frequency reducing both the switching losses and the size of the AC inductors. However, operating at a higher frequency has presented challenges for selecting the material inside the core of the AC inductors and has increased the electrical noise with inside the cabinet. A specialist inductor core is required and every wire inside the cubical needs to be screened to prevent electrical noise issues.

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.
.

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					
2					
3					
4					
5					
6					

10.2 Current Reporting Period

There is no IPR generated or registered during this reporting period.

10.3 Overall IP Statement

It is not expected that we will register any IPR in the next reporting period.

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 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 forty-six (46) risks have been raised across both risk registers.

Since issue of the previous PPR, we have been able to close nine (9) risks, leaving thirty-seven (37) still active.

The risks closed were associated with activities that have now completed (eg ENW/WPD Contract is now signed) and/or associated with COVID-19 (annual leave advance bookings now completed)

No risks are now categorised as "severe" or "major".

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.

RISK	MITIGATION
Moderate Failed Procurements	Ensure procurement notices are well published and that the GCoC and PCoC are reasonable.
Moderate Costs for DC Isolators exceeds allocated budget.	Carry out thorough procurement exercise to ensure that all options have been considered and best value for money is chosen.
Moderate Cost for Control & Comms package exceeds budget.	Carry out thorough procurement exercise to ensure that all options have been considered and best value for money is chosen.
Moderate Additional structures (eg GRP) required at chosen substation Sites.	Raise change request to cover the cost of additional GRP housing.
Moderate Project Extends Beyond Original Completion date by up to 8 months (Contingency Milestone dates) and additional PM time is required to progress/conclude the project	Closely monitor the supply chain and raise change request to mitigate time and cost. Use Contingency Funds, Reserve £200k

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

Likelihood = Probability x Proximity						
	Certain/Imminent (21-25)	0	0	0	0	0
	More likely to occur than not/Likely to be near future	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	1	0	0	0
	Very unlikely to occur/Far in the future (1-5)	0	3	4	0	5
		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
		Impact				

	Minor	Moderate	Major	Severe	
Legend	8	5	0	0	No of instances
Total	13				No of live risks

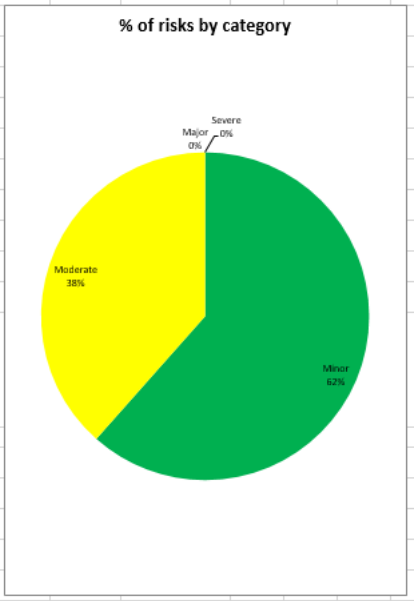
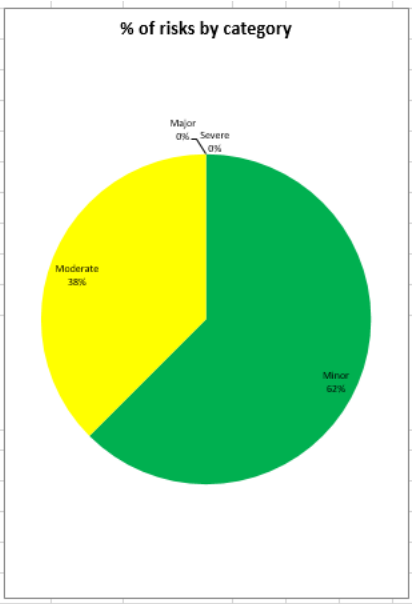


Figure 8: Risk Graphical Log (Project Issues)

Likelihood = Probability x Proximity						
	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	1	0	0	0
	Less likely to occur/Mid to long term (6-10)	0	2	4	0	0
	Very unlikely to occur/Far in the future (1-5)	0	7	6	3	1
		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
		Impact				

	Minor	Moderate	Major	Severe	
Legend	15	9	0	0	No of instances
Total	24				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 Project Manager (Ricky Duke).

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 Technical; Documents Submitted & Summary of Design Details

Critical Design Review Checklist

Project Information	
Project number:	327D
Project title:	DC Share - GTI
Part number:	TBC
Client:	WPD
Date of review:	15/09/2020

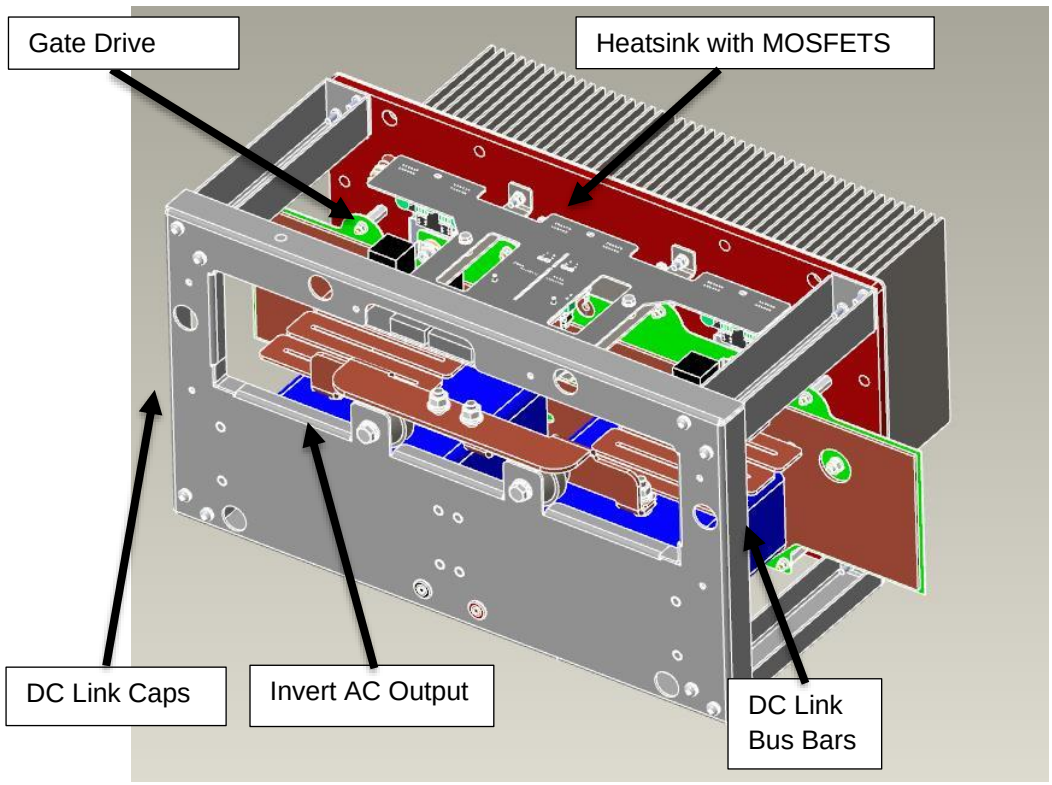
Ricardo		TPS	
Final Spec	=	PDR	Przemysla Lukasiak
Fianl Design	=	CDR	Steve Mitchel
			Daryl Jackson

Line Ref	Category	Descriptions	Document details & status: Document(s) required?	Type	Deadline: GTI	Actions / comments	Action assigned to	Status	Date action completed	Action(s) Open or Closed	Review required?
8	Requirements	Compliant with industry standard specifications	Yes	Final Design	18/11/2020	327-01-001 DC-Share Grid Tied Inverter _ System Specification	327-011-001 DC-Share Grid Tied Inverter _ System Specification	In PDR Folder	09/11/2020	Closed	Yes
9	Requirements	System functional description	Yes	Final Spec	04/11/2020	327-01-001 DC-Share Grid Tied Inverter _ System Specification	Przemyslaw Lukasiak	In PDR Folder	09/11/2020	Closed	
10	Requirements	Sub-system functional specification(s)	N/A	Final Spec	04/11/2020	No sub systems - N/A				N/A	N/A
11	Requirements	Requirements traceability matrix	Yes	Final Spec	04/11/2020	327-002 DC Share - Requirements Traceability Matrix	Przemyslaw Lukasiak	Live document / In CDR folder	25/11/2020	Closed	No
12	Requirements	Equipment safety approval checklist	Yes	Final Spec	04/11/2020	327-01-009 - GTI - Equipment Safety Approval Form	Przemyslaw Lukasiak	Doc open / In PDR Folder	11/11/2020	Closed	Yes
15	Requirements	Failure Mode Effect Analysis (FMEA)	Yes	Final Design	18/11/2020	327-01-010 - GTI DFMEA rev. 1, Live document	Przemyslaw Lukasiak Software Engineer	Live document / In CDR folder	25/11/2020	Closed	No
19	Interfaces	Electrical interfaces design complete and specification	Yes	Final Spec	04/11/2020	327-01-008 DC-Share GTI - Interfaces	Przemyslaw Lukasiak	In PDR Folder	11/11/2020	Closed	Yes
20	Interfaces	Mechanical interfaces design complete and specification	Yes	Final Spec	04/11/2020			In PDR Folder	11/11/2020	Closed	
21	Interfaces	Cooling interfaces designed	Yes	Final Spec	04/11/2020			In PDR Folder	11/11/2020	Closed	
22	Interfaces	Diagnostic software interfaces designed (PTE)	Yes	Final Spec	04/11/2020			In PDR Folder	11/11/2020	Closed	
24	Power & Control Circuit	Major component specifications released	Yes	Final Spec	04/11/2020	327-01-002 EDL - GTI	Przemyslaw Lukasiak	In PDR Folder	11/11/2020	Closed	No
25	Power & Control Circuit	Power circuit simulation model(s) and results	Yes	Final Design	18/11/2020	327-01-001 DC-Share Grid Tied Inverter _ System Specification	Przemyslaw Lukasiak	In PDR Folder	09/11/2020	Closed	Yes
26	Power & Control Circuit	Protection calculations and simulation model(s)	Yes	Final Design	18/11/2020	327-01-011 GTI - Protection calculations	Przemyslaw Lukasiak	In CDR folder		Closed	Yes
27	Power & Control Circuit	Thermal calculations and simulation model(s)	Yes	Final Design	18/11/2020	327-01-016 GTI Thermal budget	Przemyslaw Lukasiak	In CDR folder		Closed	No
28	Power & Control Circuit	Creepage, clearance and segregation has been reviewed?	Yes	Final Design	18/11/2020	327-01-006 - GTI creepage and clearence	Przemyslaw Lukasiak	Requires a review	11/12/2020	Closed	Yes
29	Power & Control Circuit	Overall schematic	Yes	Final Design	18/11/2020	327-01-003 GTI Schematic	Przemyslaw Lukasiak			Closed	Yes
32	Mechanical	ICD drawings complete	Yes	Final Spec	04/11/2020	327-01-008 DC-Share GTI - Interfaces (inside document)	Daryl Jackson	In PDR Folder	11/11/2020	Closed	Yes
33	Mechanical	3D detailed model	Yes	Final Design	18/11/2020	To be uploaded by the 10th Dec	Daryl Jackson	In PDR Folder	08/12/2020	Closed	No
36	Mechanical	Internal packaging	Yes	Final Design	18/11/2020	To be uploaded by the 10th Dec	Daryl Jackson	In PDR Folder	08/12/2020	Closed	No
38	Mechanical	Prototype weight estimate	Yes	Final Design	18/11/2020	To be confirmed later in Project	Daryl Jackson			Closed	No
42	Mechanical	Review external safety labels	Yes	Final Design	18/11/2020		Przemyslaw Lukasiak			Open	Yes
45	Software	Software Requirements Specification (SRS)	Yes	Final Spec	04/11/2020	327-01-015 GTI Software requirements Specification v1.0	Steve Mitchel	In PDR folder		Closed	No
50	Thermal	Pre-compliance testing	Yes	Final Design	18/11/2020	327-01-012 GTI Test Plan	Przemyslaw Lukasiak	Requires a review		Open	Yes
53	Thermal	Enclosure internal temperatures	Yes	Final Design	18/11/2020	327-01-012 GTI Test Plan	Przemyslaw Lukasiak	Requires a review		Open	
54	Thermal	Touch temperature limits	Yes	Final Design	18/11/2020	327-01-012 GTI Test Plan	Przemyslaw Lukasiak	Requires a review		Open	
57	EMC	EMC simulation/calculations completed indicating filter requirements	Yes	Final Design	18/11/2020	EMC filter chosen from catalogue (no simulation or calculations)	Przemyslaw Lukasiak			Closed	No
59	Audible Noise	All inductors, transformers and fans tested and within audible noise requirement	Yes	Final Design	18/11/2020	All components specified to meet the requirements	Przemyslaw Lukasiak			Closed	No
63	Environmental	Enclosure finishes specified	Yes	Final Spec	04/11/2020	Document updated from 2T	Daryl Jackson	In PDR Folder		Closed	Yes
64	Environmental	Storage/lifetime requirements understood and designed for	N/A	Final Design	18/11/2020	N/A	Przemyslaw Lukasiak	WiP		N/A	No
73	Materials / Safety	Safety review	Yes	Final Design	18/11/2020		Przemyslaw Lukasiak	WiP		Open	Yes
75	Materials / Safety	Grounding and bonding scheme meets safety requirements	Yes	Final Design	18/11/2020	327-01-011 GTI - Protection calculations	Przemyslaw Lukasiak	In CDR Folder		Closed	Yes
80	Test Readiness Review	All qualification test procedures identified and given Doc numbers	Yes	Final Design	18/11/2020	327-01-013 GTI - Type test specification	Przemyslaw Lukasiak	Dosument named		Closed	Yes
81	Test Readiness Review	Qualification test procedure test rigs / setups defined	Yes	Final Design	18/11/2020	327-01-012 GTI Test Plan	Przemyslaw Lukasiak	Requires a review		Open	Yes
83	Test Readiness Review	Routine test plan	Yes	Final Design	18/11/2020	327-01-012 GTI Test Plan	Przemyslaw Lukasiak	Requires a review		Open	Yes

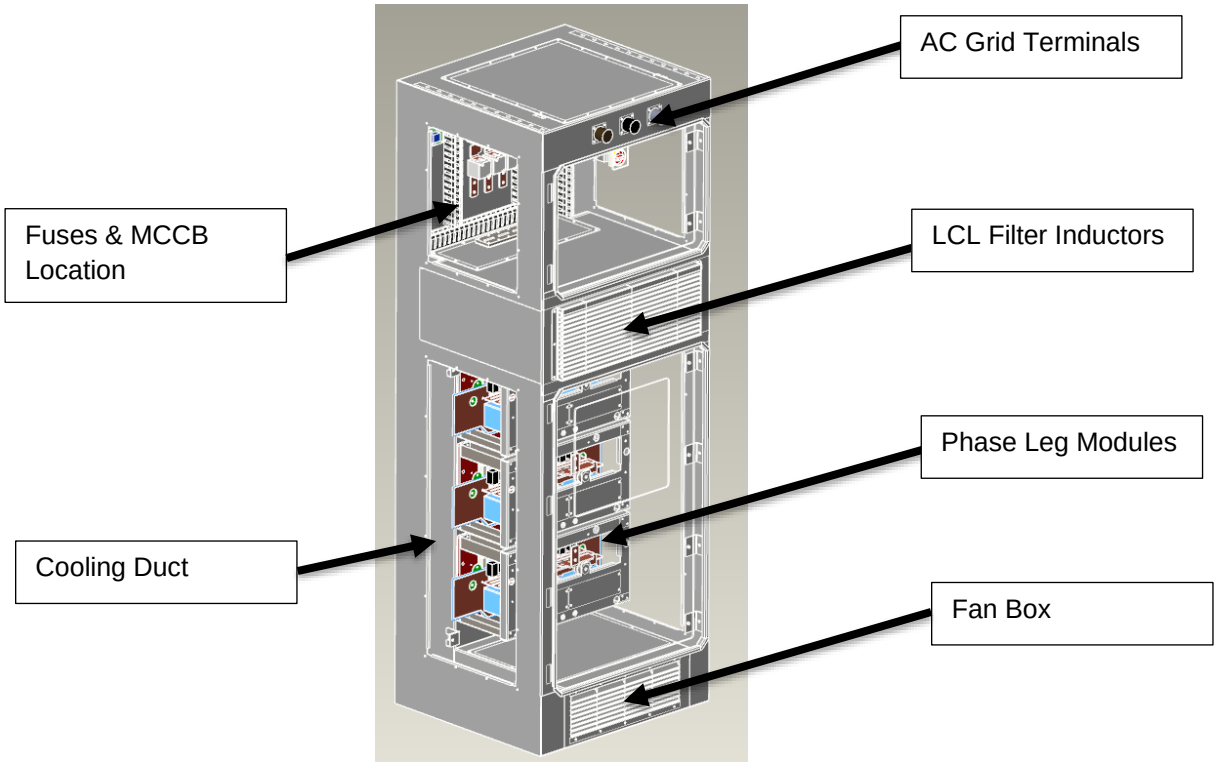
= Open
= In review or close to it
= Complete for this pahse

22 Final Design (CDR)
12 Final Spec (PDR)

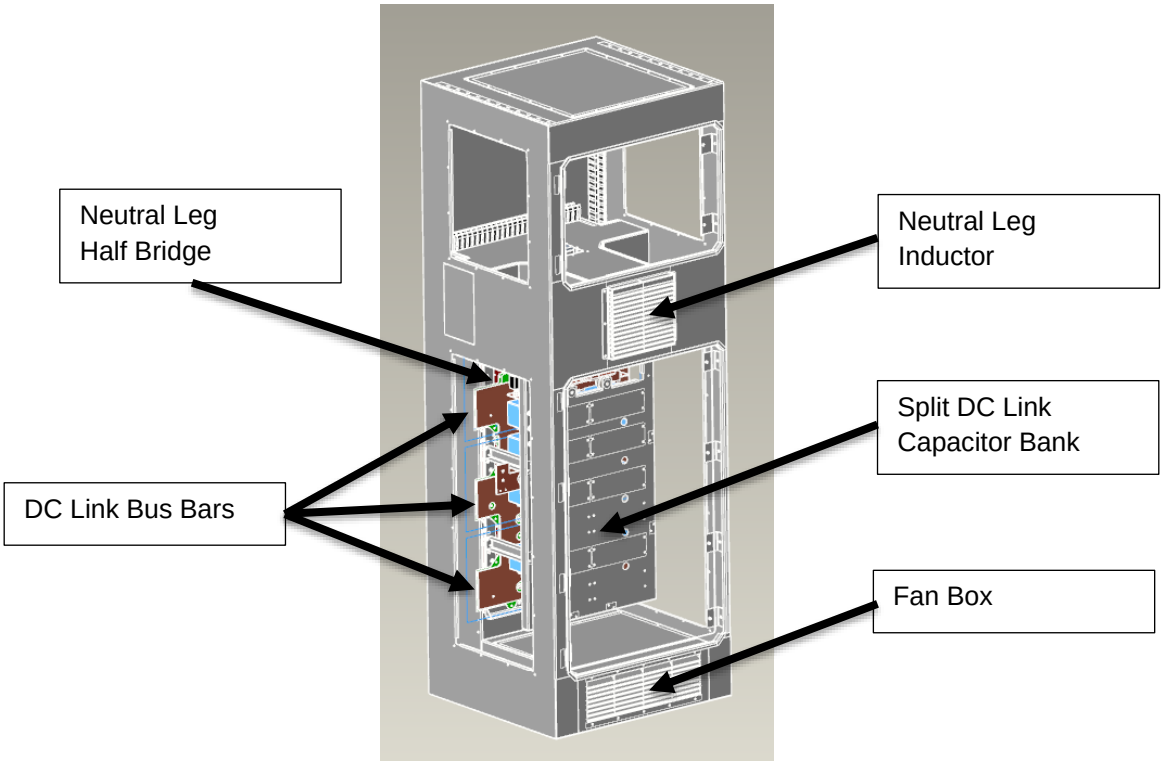
Inverter Leg Module



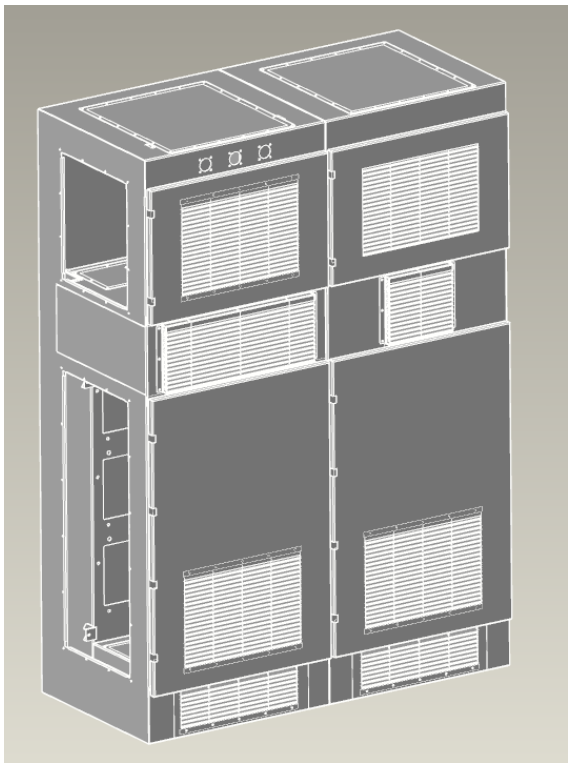
Inverter Enclosure Internal View



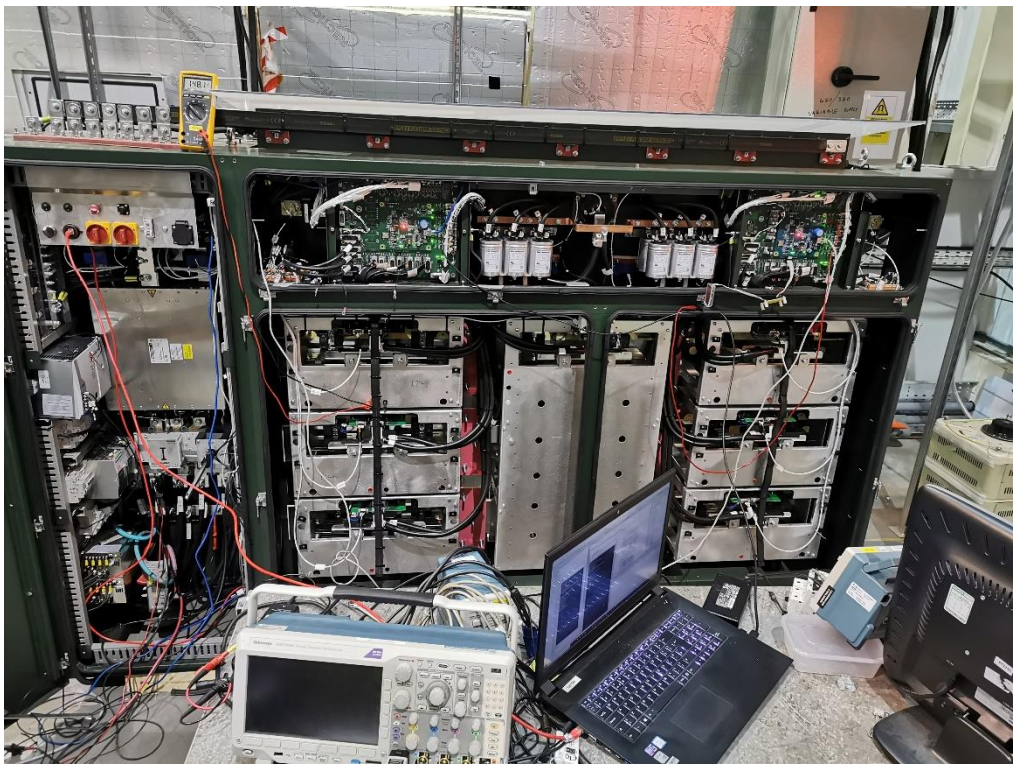
Neutral Leg Enclosure Internal View

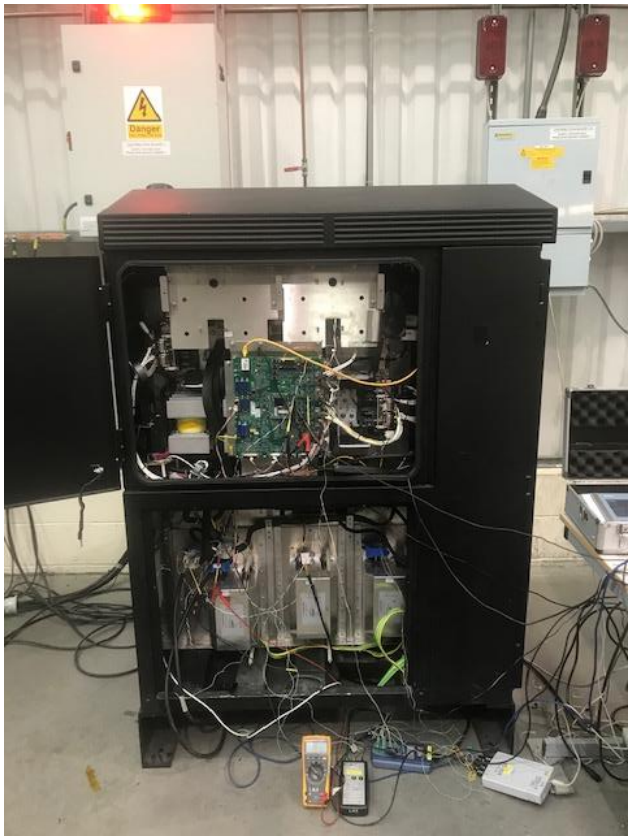


Complete GTI System View with Front Covers Fitted



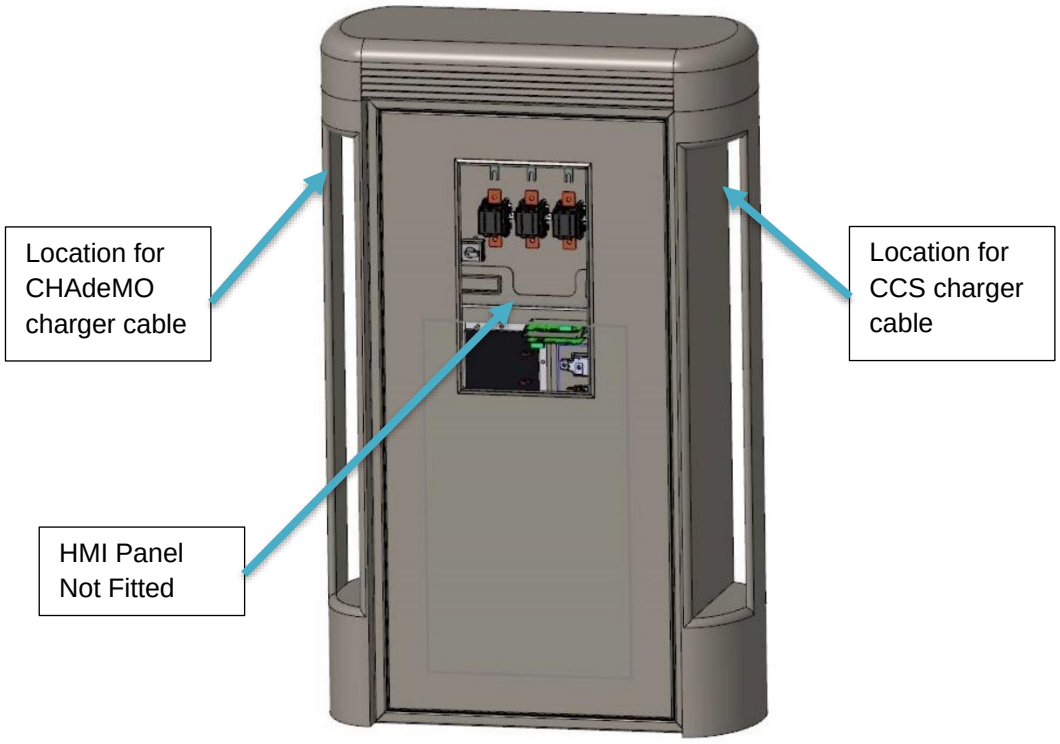
Example Equipment Undergoing Factory Testing (Previous Project)



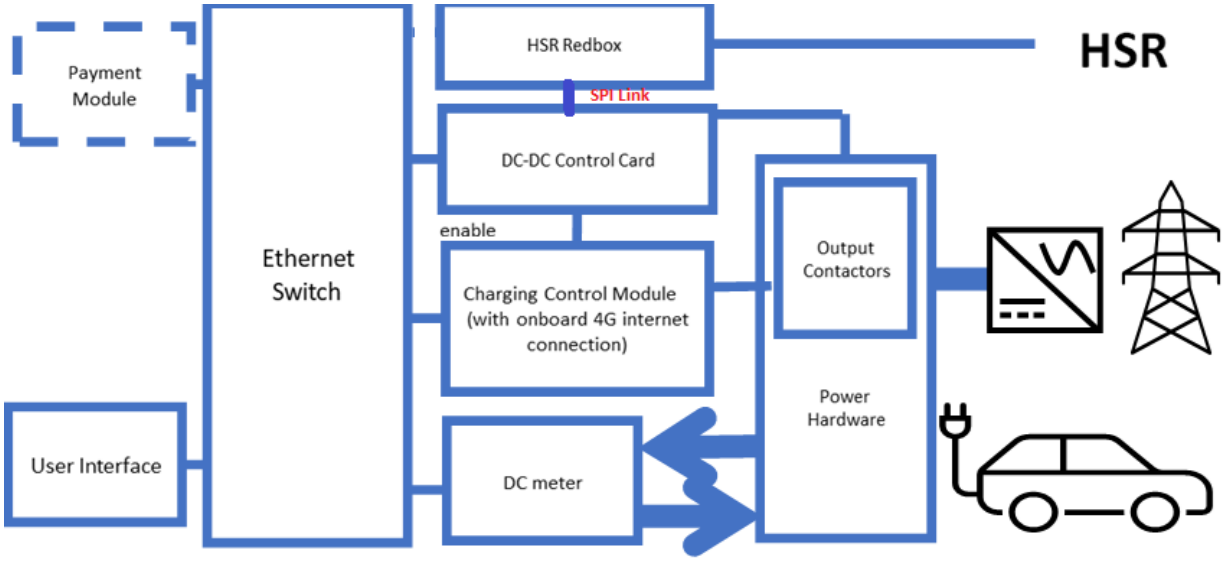


A.3 Electric Vehicle Charge Point Summary of Design Details

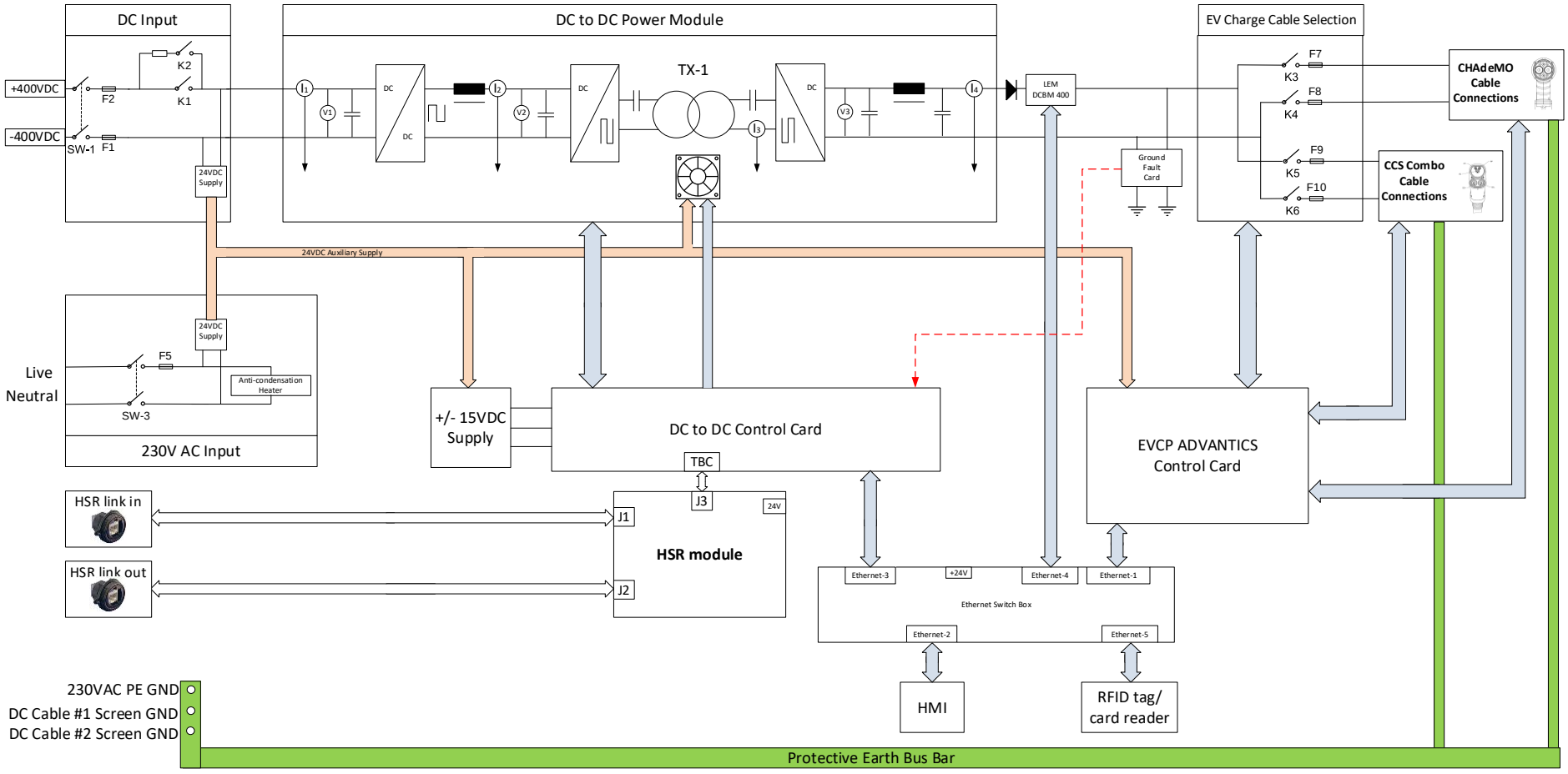
Front View of EVCP With HMI Panel Removed



Charging Control Module Context

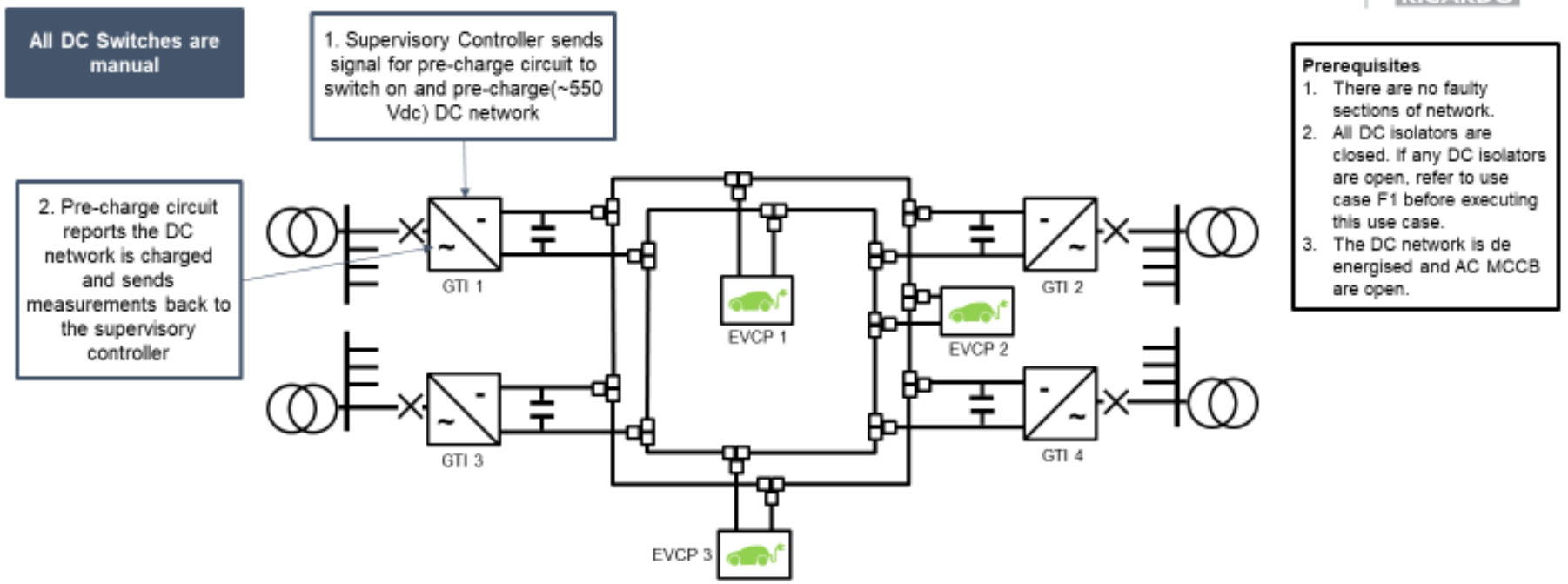


EV Charger Block Diagram



A.4 Supervisory Controller – Examples of Functionality

Use Case N1: Pre charge the DC cable in normal operation

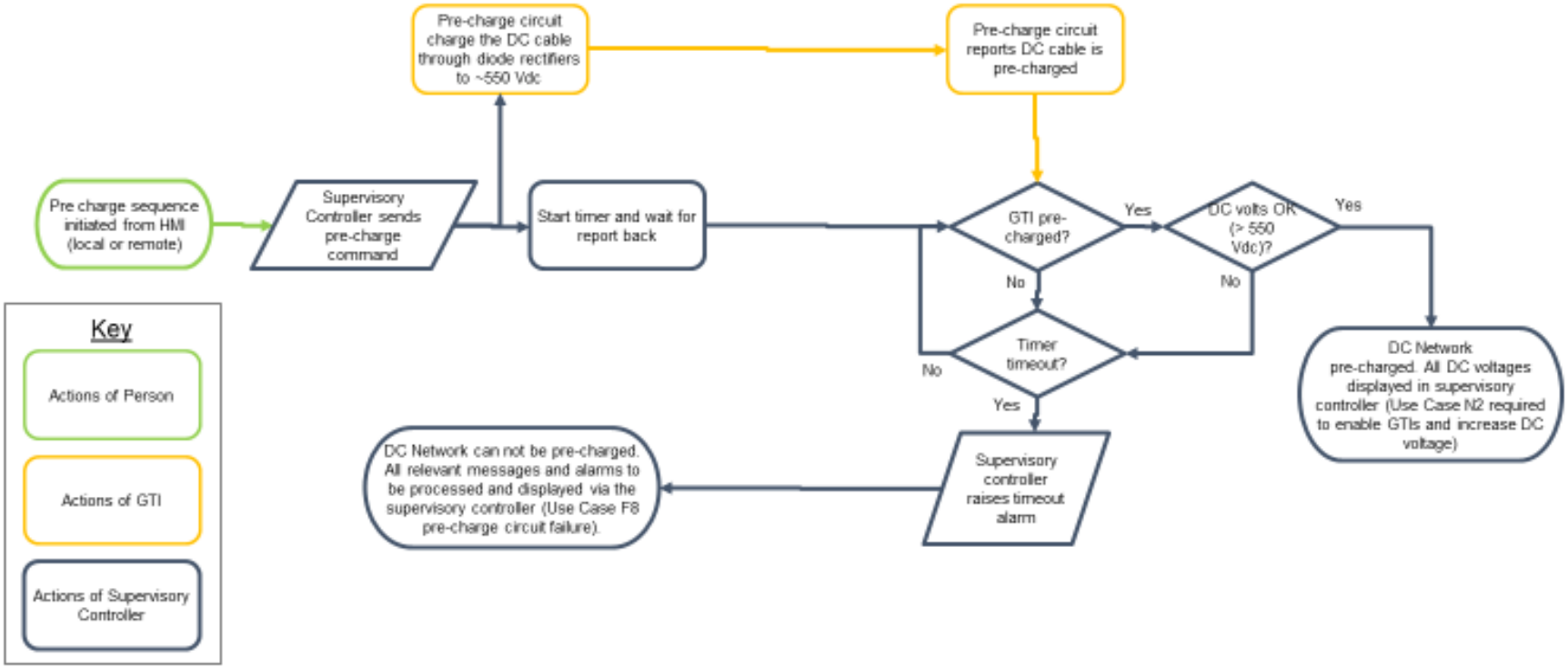


- Sequence starts with all GTIs disconnected from the AC supply and all DC isolators closed (from previous manual operation).
- It is currently planned that all GTIs have a pre-charge circuit which is instructed to charge the DC cable by sending a pre-charge signal. Failure to pre-charge the DC cable, or if one GTI experiences a fault during pre-charge, will result in all GTIs disconnecting (Use Case F8). Once the DC network is pre-charged, the GTIs can be enabled (Use Case N2).
- There may be the possibility of fewer pre-charge circuits being required to charge the DC cable.

7

Use Case N1: Pre charge the DC cable in normal operation flowchart

All DC Switches are manual and are all assumed closed



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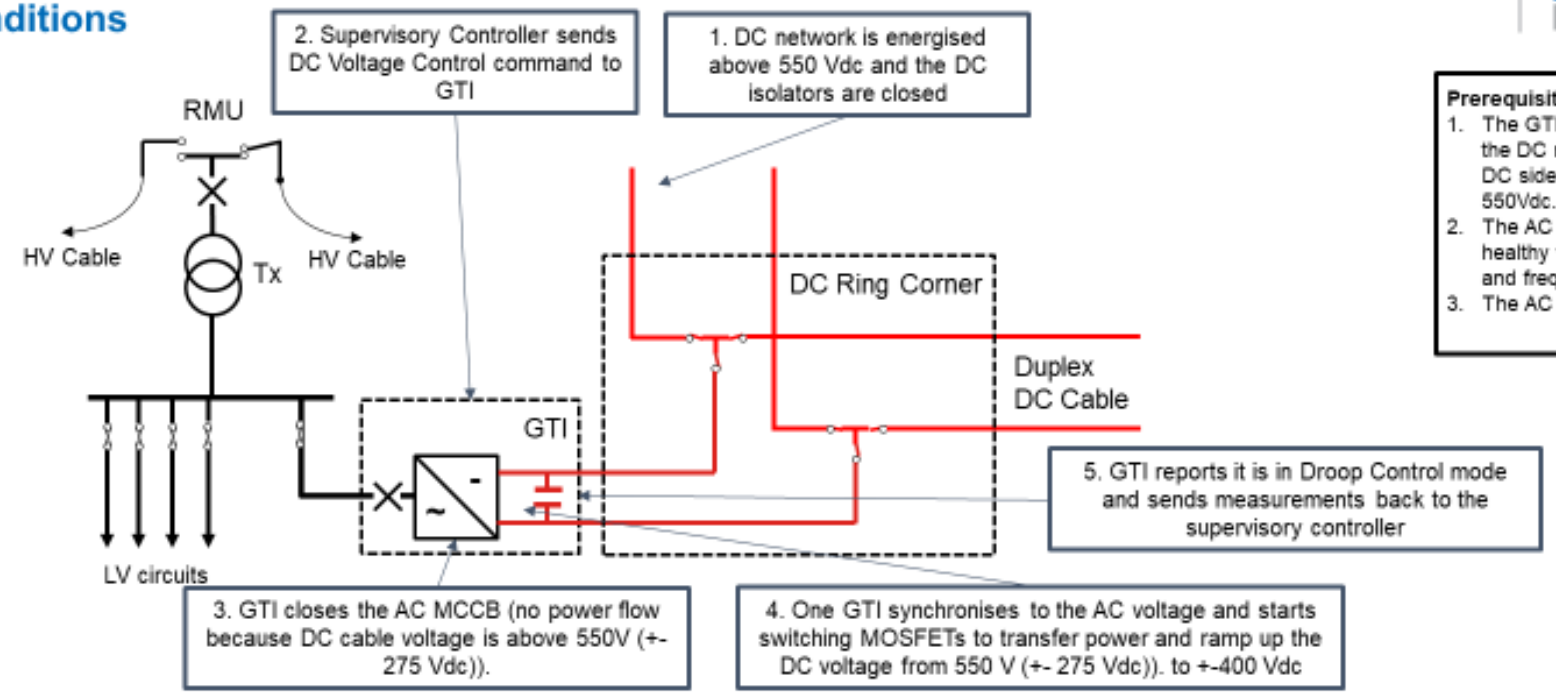
Use Case N2: Enabling a GTI when the DC cable is pre-charged in normal operating conditions

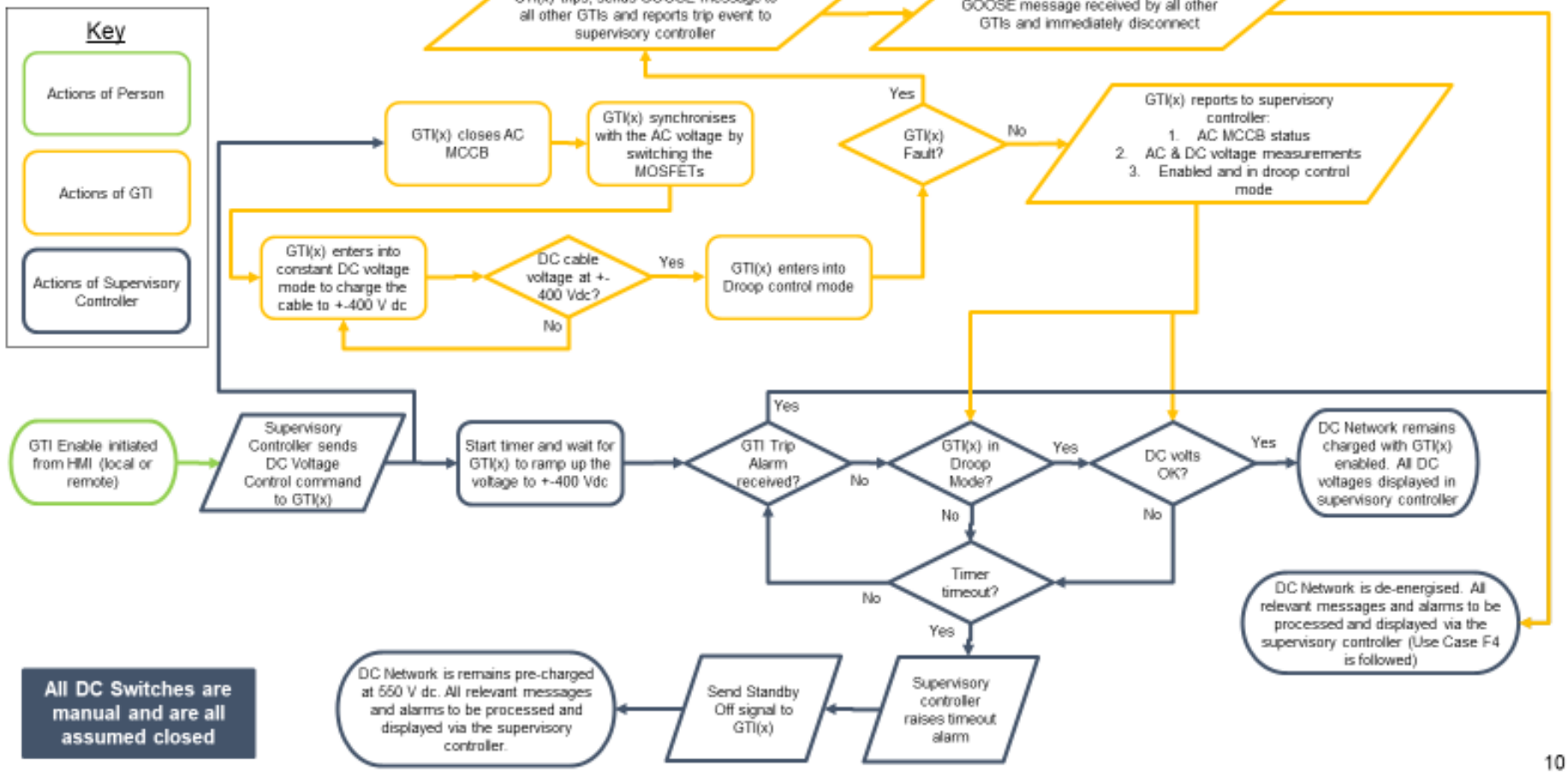


Prerequisites
1. The GTI is connected to the DC network and its DC side is pre-charged to 550Vdc.
2. The AC substation is healthy with normal volts and frequency.
3. The AC MCCB is open.

- Use case shows interaction between Supervisory Controller and GTI for starting a GTI when it is Standby Off mode and the DC cable is charged to about 550 Vdc (+- 275 Vdc).
- Only one of the GTIs is required to ramp up the pre-charged cable from 550 Vdc (+- 275 Vdc) to +- 400 Vdc. Once the cable voltage is at +-400 Vdc, the GTI will automatically change from Constant DC Voltage mode to Droop Control mode.

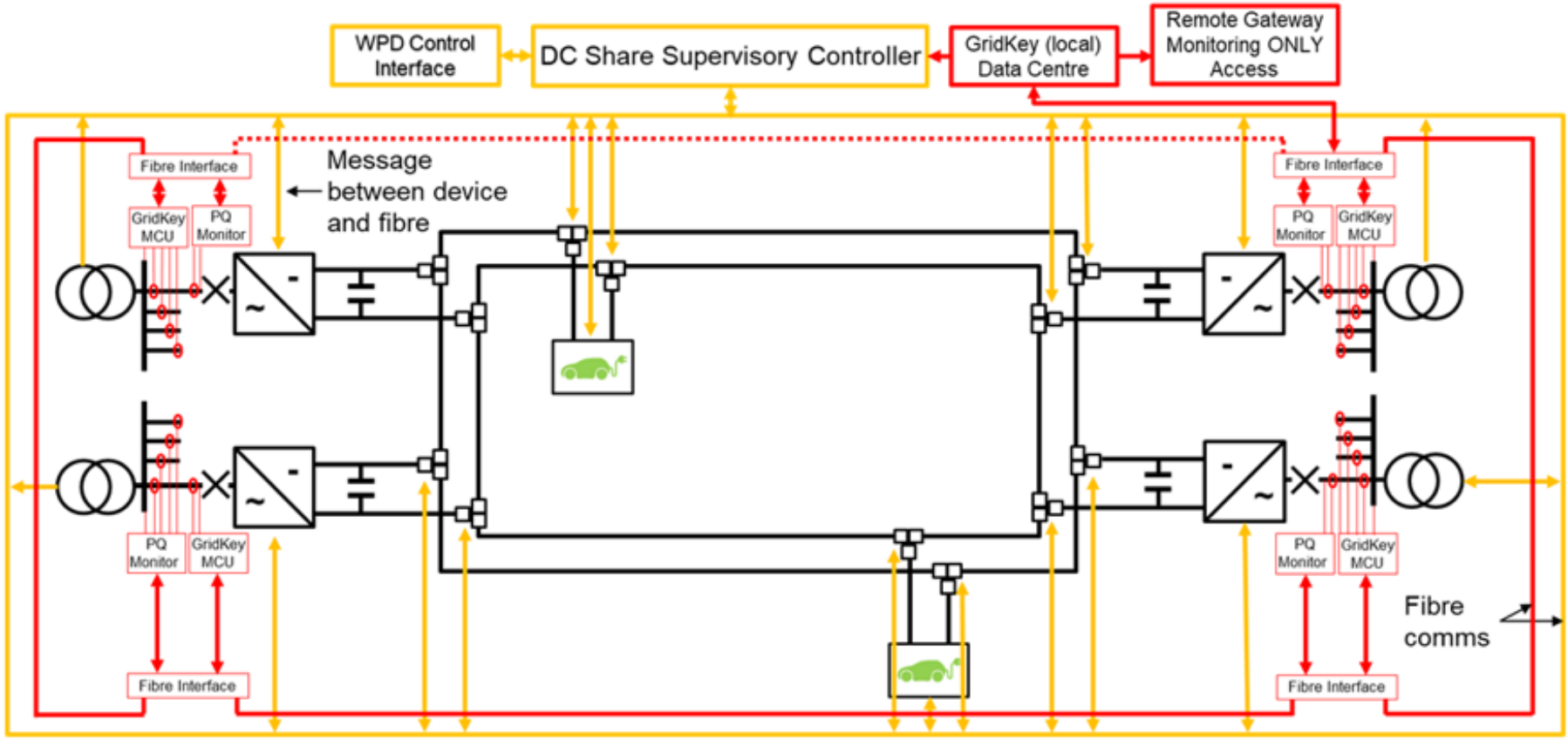
9

Use Case N2: Enabling a GTI when the DC cable is pre-charged in normal operating conditions



10

A.5 System Architecture



A.6 AC Measurand System - Summary of Connection Arrangements