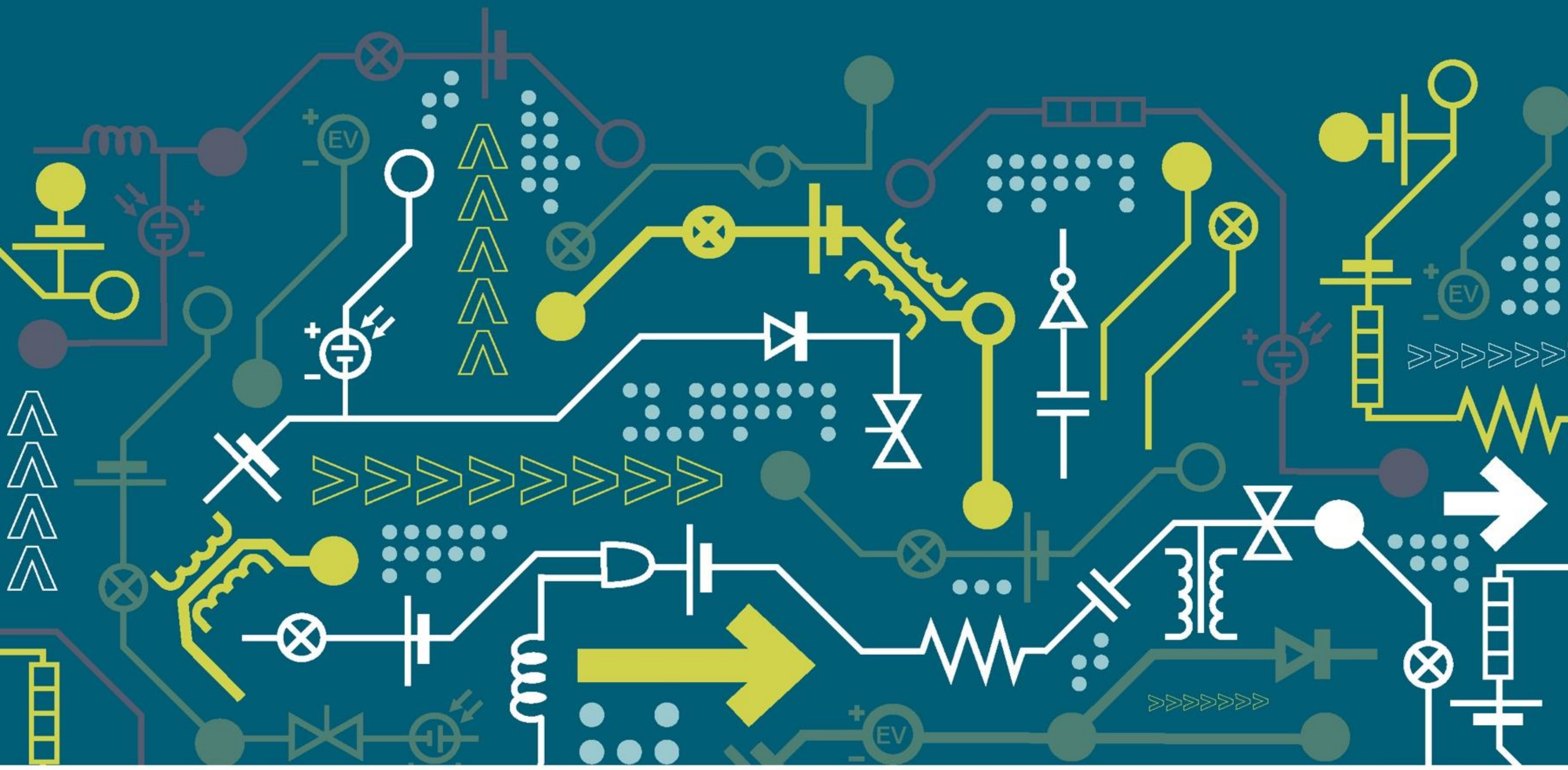
WPD INNOVATION

Virtual Statcom

Project Closedown Report



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1 Executive Summary

Political and social forces in the UK are driving the change towards the use of low carbon technologies (LCTs) such as renewable generation, electric vehicles (EVs) and the electrification of domestic heating. As LCTs are becoming integrated into existing electricity networks, technical constraints arise that can limit the total amount of generation or load a network can host. The Virtual Statcom project as an innovation project has investigated the technical feasibility of increasing network hosting capacity, for both generation and load, by optimising the reactive power dispatch of distributed generators (DGs). The project scope, objectives and success criteria set out in the projects NIA Project Registration and PEA document have been successfully delivered.

To enable the investigation two algorithms were developed. The first is an algorithm to determine the generation or load hosting capacity of a network. The second is an algorithm to optimise the reactive power output of existing generators with the aim of increasing hosting capacity. These two algorithms make up the Virtual Statcom algorithms.

Extensive analysis was undertaken using the Virtual Statcom algorithms with 3000 studies being undertaken covering extreme operating conditions and historic time series load / generation scenarios requiring circa 6 million power flow calculations. The following Western Power Distribution (WPD) networks, selected for different network characteristics, were used in the analysis; Barnstable 33 kV Bulk Supply Point (BSP), Pyworthy and North Tawton 33 kV BSP, Tiverton 33 kV BSP and Tiverton Moorhayes 11 kV Primary.

The key technical outcomes from the Virtual Statcom Project are:

- The Virtual Statcom algorithms released a small level of generation hosting capacity which depended on the network topology and assets. Therefore, the Virtual Statcom solution would need to be combined with other network interventions to increase the generation capacity benefits provided.
- The Virtual Statcom algorithms released significant load hosting capacity, with an average load hosting capacity increase of between 8-31 MW for each 33 kV BSP network assessed. This is equivalent to an extra 10,000 domestically connected EV's across the three BSP networks. The method to increase the load hosting capacity of a network also reduces overall electrical losses in a network.
- The Virtual Statcom optimisation algorithm demonstrated the ability to resolve or reduce constraints in networks through optimised reactive power dispatch, this has the potential to reduce the amount of active power curtailment required to manage network constraints.

The key technical outcomes from the project have been used to develop high level specifications for a trial of how the Virtual Statcom optimisation algorithm can be applied. This included options for both a real time reactive power control system and a system planning tool to manage network constraints.

This project has shown that the Virtual Statcom can enable DNOs to increase the capacity of their networks to host more low carbon technologies, the next steps required before the Virtual Statcom outcomes delivered in this project can become business as usual are to:

- Quantify the expected commercial benefit of the Virtual Statcom for market participants.
- Design the technical solution required to implement a Virtual Statcom system.
- Select a suitable network(s) for testing a Virtual Statcom system and carry out a trial.
- Design the commercial, regulatory and legal mechanisms to incentivise owners of reactive power assets to offer reactive capability to the Virtual Statcom system.

2 Project Background

As an increasing number of low carbon technologies (LCTs) connect to distribution networks, technical constraints arise that can limit the total amount of generation or load a network can host. To overcome the technical constraints associated with LCTs and continue to operate a safe, secure and reliable network, Distribution Network Owners (DNOs) can undertake traditional network reinforcements or develop innovative solutions. A key focus of innovative solutions is to increase the utilisation of existing assets to defer network reinforcements, the Virtual Statcom project fits in this category of project.

The existing DGs connected to Distribution Networks' BSPs and Primary networks operate with a fixed power factor between unity and 0.95 leading (importing reactive power). The power factor is fixed based on traditional distribution network design and operation assumptions and may not be appropriate for all network conditions. This is the fundamental area that the Virtual Statcom project has investigated. The concept of the Virtual Statcom assumes that instead of DGs operating with a fixed power factor, the DGs can operate across a power factor range.

The objective of the Virtual Statcom project was to determine the technical feasibility of increasing the network hosting capacity, for both generation and load, through implementing an algorithm to control and coordinate the reactive power output of existing generators in the distribution network. The hypothesis was that by optimising the reactive power output of DGs in a network for different conditions, through perhaps a new flexibility service, there was potential to increase the hosting capacity for both load and generation LCTs.

3 Objectives and Scope

The main objective of the Virtual Statcom project was to determine the technical feasibility of implementing an algorithm in power system analysis software, which can control and coordinate the power factor of existing generators in order to increase network hosting capacity for load or generation. In addition, if the project determined it was technically feasible to increase hosting capacity a determination would be made as to whether the implementation of such a technology in a trial project is recommended.

The scope ranged from undertaking an initial literature review through to the implementation of the Virtual Statcom algorithms and graphical user interface to allow users to undertake studies. Table 3.1 provides a breakdown of the project scope used to achieve the project objective and the scope status following the completion of the project.

Table 3.1 Summary of project scope

Scope	Status
Validation of the network models that will be used in the studies, the selection of the study areas and the initial specification of the algorithm (Virtual Statcom) that will optimise the reactive power output of generators.	✓
Carry out power system studies that will show the operation of the network and its existing constraints will be performed (base case studies). Implement the optimisation algorithm and compare the amount of additional capacity it releases against base case studies.	✓
Produce a Graphical User Interface which will enable the user to run the Virtual Statcom Algorithm on a network of their choice and evaluate the calculated capacity released with the usage of the Virtual Statcom.	✓
Perform time series studies to evaluate the network capacity that could be released by the Virtual Statcom in a number of months.	✓
Create a detailed specification of the Virtual Statcom and make recommendations for the potential implementation and trial of such a technology in WPD's network.	✓

It can be seen from Table 3.1 that the scope for the Virtual Statcom project was completed successfully.

4 Success Criteria

The project successfully met the criteria specified in the original "NIA Project Registration and PEA document" for the Virtual Statcom project, dated January 2019. The success criteria for the project are summarised in Table 4.1.

Table 4.1 Project success criteria

Success Criteria	Status
An algorithm is designed and successfully implemented in power system analysis software, that coordinates the power factor of existing generators in order to release network capacity. The design and operation of the algorithm is documented. **Complete – The design and operation of the Virtual Statcom Optimisation algorithm is captured in Work Package 2 report dated November 2019 and Work Package 4 report dated May 2020.**	✓
An algorithm is designed and successfully implemented in power system analysis software, that evaluates the network capacity using a consistent methodology. The design and operation of the algorithm is documented. **Complete – The design and operation of the Virtual Statcom Hosting Capacity algorithm is captured in the Work Package 2 report dated November 2019.**	✓
The capacity released using the Virtual Statcom in various scenarios is evaluated and documented. **Complete – Virtual Statcom studies evaluated the capacity released in various edge case and historical load and generation scenarios. The results are captured in Work Package 2 report dated November 2019 and Work Package 4 report dated May 2020.**	✓
Recommendations are made on whether a Virtual Statcom should be trialled on the network. **Complete – Recommendations on how the Virtual Statcom concept can be trialled on the network are provided in Work Package 5 report dated August 2020.**	✓
A specification is produced for the Virtual Statcom which will describe the required functions of the system and its technical specifications. **Complete – A specification for the Virtual Statcom software and a functional speciation for trial operation of the Virtual Statcom concept is provided in Work Package 5 report dated August 2020.**	✓

5 Details of the Work Carried Out

5.1 Introduction

The delivery of the Virtual Statcom project was structured into five Work Packages (WP) shown in Table 5.1 and detailed within the following sections of the report.

Table 5.1 - Project Work Packages

Work Package	Title
WP1	Virtual Statcom design, study zone selection and data validation
WP2	Power flow simulations and Virtual Statcom algorithms implementation
WP3	Graphical User Interface
WP4	Time series comparison studies
WP5	Virtual Statcom feasibility study reporting

5.2 WP1 - Virtual Statcom design, study zone selection and data validation

Work Package 1 involved all the necessary preparation work required prior to commencing the implementation of algorithms and performing power system studies this included:

- **Study Network Selection** - The project focused on WPD's Southwest region and selected three 33 kV Bulk Supply Point (BSPs) network and one 11 kV Primary networks. Networks were selected with different characteristics.

- **Data Validation** - Historic supervisory control and data acquisition (SCADA) load and generation data was obtained and validated for each study network to enable time series studies to be undertaken in Work Package 4.

- **Developing the Virtual Statcom Design Methodology** - A literature review was undertaken to guide the design methodology for the Virtual Statcom project. The literature review captured the existing academic and industry knowledge from journal papers and other innovation projects. The literature review identified the need for two distinct algorithms to be developed; A hosting capacity algorithm and an optimisation algorithm. These two algorithms together make up the Virtual Statcom algorithms.

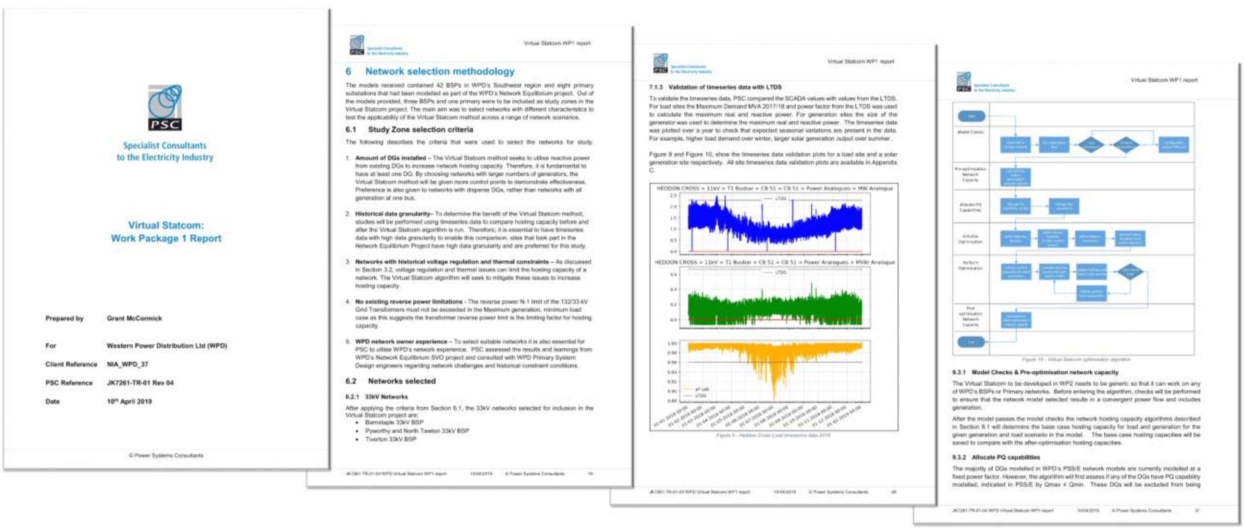

Figure 5.1 - Extracts from Work Package 1 Report

5.3 WP2 - Power flow simulations and Virtual Statcom algorithms implementation

Work Package 2 represented the most significant work package in the Virtual Statcom project. The work package included:

- **Power system analysis of the selected networks –** Power system analysis of each study zone network was undertaken using Siemens PSS/E software to identify any network constraints present in the networks for given load / generation scenarios and network contingency configurations.

- **Implementation of the Virtual Statcom Hosting Capacity algorithm –** The hosting capacity algorithm designed in WP1 was implemented using Python programming language and Siemens PSS/E software. The hosting capacity algorithm calculates the additional load or generation that a network can accommodate.

- **Implementation of the Virtual Statcom Optimisation algorithm –** The optimisation algorithm designed in WP1 was implemented using Python programming language and Siemens PSS/E software. The optimisation algorithm optimises the reactive power output of distributed generators (DGs).

- **Virtual Statcom simulation studies –** The Virtual Statcom algorithms developed were used to quantify the amount of additional load or generation hosting capacity was released by the Virtual Statcom approach in the study zones in edge case generation and load scenarios.

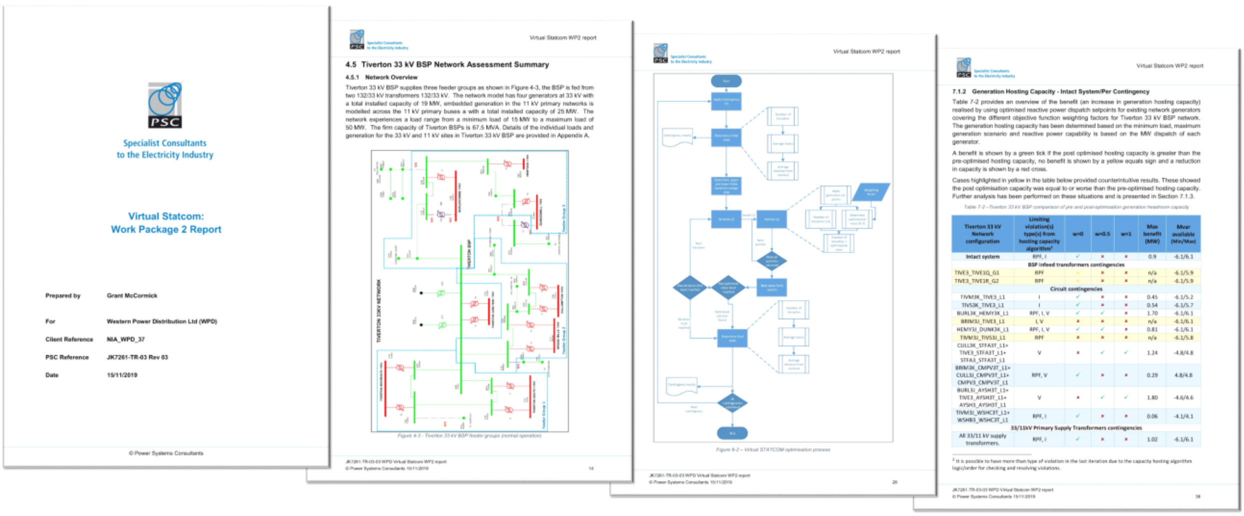

Figure 5.2 - Extracts from Work Package 2 Report

5.4 WP3 - Graphical User Interface

Work Package 3 developed a Graphical User Interface (GUI) to allow users to run the Virtual Statcom algorithms. The development of the GUI involved:

- **Functional requirements/initial design –** High level functional requirements for the GUI were developed to guide the initial design of the Virtual Statcom GUI.

- **Development and user testing** – The GUI was implemented using Python programming language to integrate the Virtual Statcom hosting capacity and optimisation algorithms into a GUI so that the algorithms could be run from the GUI. The GUI was developed and tested using an agile approach to successfully deliver the final GUI with required functionality.

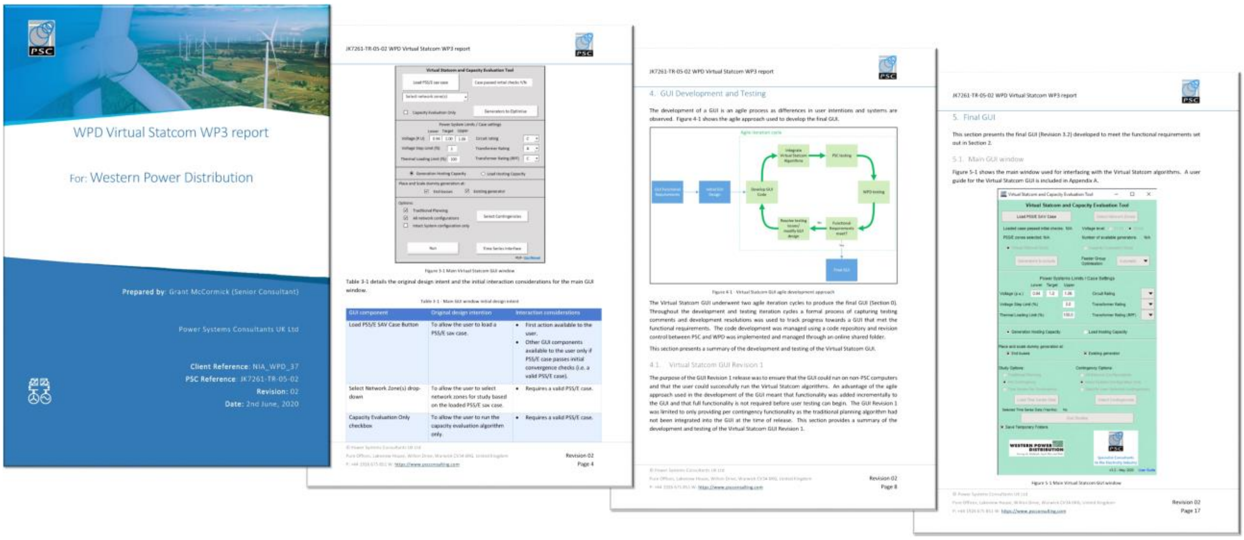

Figure 5.3 - Extracts from Work Package 3 Report

5.5 WP4 - Time series comparison studies

Work Package 4 included running studies using Virtual Statcom algorithms developed in Work Package 2 on historical load and generation scenarios. The following work was carried out in Work Package 4.

- **Revision of Virtual Statcom algorithms –** The algorithms were revised to include a feeder group approach when determining the hosting capacity and optimised reactive power set points for distributed generators.

- **Time series functionality** – Functionality was implemented using Python programming language to enable scenarios to be created from historical load and generation data and the Virtual Statcom algorithms to run on these scenarios in an automated way.

- **Time series studies –** Four weeklong periods from different seasons were selected for the time series studies. The studies were run using a high-performance computer to reduce the computation time.

Figure 5.4 - Extracts from Work Package 4 Report

5.6 WP5 - Virtual Statcom feasibility study reporting

Work Package 5 included summarising and drawing conclusions regarding the technical feasibility of the Virtual Statcom. The following work was carried out in Work Package 4.

- **Project Conclusions –** Conclusions were made on the technical feasibility of the Virtual Statcom to increase load and generation hosting capacity.

- **Evaluation of the Virtual Statcom concept for trial projects –** Two potential trial approaches for the Virtual Statcom were detailed; A real time control system and a planning time tool.

- **Development of functional specifications –** For both trial projects identified functional specifications were developed.

Figure 5.5 - Extracts from Work Package 5 Report

6 Performance Compared to Original Aims, Objectives and Success Criteria

6.1 Overview

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

The project found that the Virtual Statcom through optimised reactive power dispatch it is possible to significantly increase load hosting capacity, manage networks constraints and reduce systems losses. However, the Virtual Statcom only released small increases in generation hosting capacity. The details contained within the various Work Package reports and material generated through this project provide valuable learnings that should be used to develop the Virtual Statcom concept for use in a network trial project.

6.2 Project Scope

The project successfully delivered the original project scope as detailed in Table 6.1.

Table 6.1 Project scope performance

Scope	Status	Performance
Validation of the network models that will be used in the studies, the selection of the study areas and the initial specification of the algorithm (Virtual Statcom) that will optimise the reactive power output of generators.	✓	Two edge cases were created to validate all network models. From the network models three 33 kV Bulk Supply Point (BSP) networks and one 11 kV Primary network were selected as study zones for the project. A literature review was used to guide the development of the initial specification of the Virtual Statcom algorithms.
Carry out power system studies that will show the operation of the network and its existing constraints will be performed (base case studies). Implement the optimisation algorithm and compare the amount of additional capacity it releases against base case studies.	✓	Power system studies on the project study zone networks identified existing load and generation constraints in each of the networks. The Virtual Statcom algorithms were implemented using Python programming language and Siemens PSS/E software and determined the extra load or generation hosting capacity released in edge case scenarios.
Produce a Graphical User Interface which will enable the user to run the Virtual Statcom Algorithm on a network of their choice and evaluate the calculated capacity released with the usage of the Virtual Statcom.	✓	A GUI was developed that allowed the user to run the Virtual Statcom Algorithm on a network of their choice and evaluate the calculated load or generation capacity released by the Virtual Statcom optimisation algorithm.
Perform time series studies to evaluate the network capacity that could be released by the Virtual Statcom in a number of months.	✓	Time series studies were undertaken to determine the generation and load hosting capacity released for historical load and generation scenarios.
Create a detailed specification of the Virtual Statcom and make recommendations for the potential implementation and trial of such a technology in WPD's network.	✓	The project identified the potential for two trial projects using the Virtual Statcom concept. Functional Specifications were developed for a real time control system and a planning time tool.

6.3 Project Objectives

The project successfully delivered against the project objectives as detailed in Table 6.2.

Table 6.2 Project objectives performance

Project Objectives	Status	Performance
Implementation of an algorithm in power system analysis software, which can control and coordinate the power factor of existing generators in order to increase network capacity.	✓	The Virtual Statcom algorithms were implemented using Python programming language and Siemens PSS/E software and determine the extra load or generation hosting capacity released by optimising the reactive power output of existing network generators for a given load and generation scenario.
Provide recommendations on whether the implementation of such a technology in a trial project is recommended.	✓	The project identified and recommended the two potential trial projects using the Virtual Statcom concept. Functional specifications were developed for a real time control system and a planning time tool.

6.4 Success Criteria

The project delivered against the success criteria as detailed in Table 6.3.

Table 6.3 Project success criteria performance

Success Criteria	Status	Performance
An algorithm is designed and successfully implemented in power system analysis software, that coordinates the power factor of existing generators in order to release network capacity. The design and operation of the algorithm is documented.	✓	The Virtual Statcom Optimisation algorithm was implemented using Python programming language and Siemens PSS/E software. The algorithm optimises the reactive power set points of distributed generators to increase the load or generation hosting capacity of the network. The design and operation of the optimisation algorithm is documented in Work Package 2 and Work Package 4 reports.
An algorithm is designed and successfully implemented in power system analysis software, that evaluates the network capacity using a consistent methodology. The design and operation of the algorithm is documented.	✓	The Virtual Statcom Hosting Capacity algorithm was implemented using Python programming language and Siemens PSS/E software. The algorithm determines the load or generation hosting capacity released for a given load and generation scenario. The design and operation of the hosting capacity algorithm is documented in Work Package 2 and Work Package 4 reports.
The capacity released using the Virtual Statcom in various scenarios is evaluated and documented.	✓	The Virtual Statcom studies evaluated the capacity released in various edge case and historical load and generation scenarios. The Virtual Statcom released significant load hosting capacity but only small levels of generation hosting capacity. The results are detailed in Work Package 2 and Work Package 4 reports.

Recommendations are made on whether a Virtual Statcom should be trialled on the network.	✓	The project identified and recommended the two potential trial projects using the Virtual Statcom concept; A real time control system and a planning time tool.
A specification is produced for the Virtual Statcom which will describe the required functions of the system and its technical specifications.	✓	The project identified the potential for two trial projects using the Virtual Statcom concept. Functional Specifications were developed for a real time control system and a planning time tool. These are included in the Work Package 5 report.

7 Required Modifications to the Planned Approach during the course of the project

The planned approach was followed during the project and no significant modifications were made.

8 Project Costs

Activity	Budget	Actual
WPD Project Management	£ 21,525	£20,271
PSC contract	£ 245,030	£ 245,030
Total	£ 266,555	£265,301

WPD costs were slightly less than anticipated and the project was completed under budget.

9 Lessons Learnt for Future Projects

The project team ensured that lessons from the project were captured on a monthly basis. Table 9.1 details the key learnings that were generated from the project.

Table 9.1 Project learnings

Item	Description
1.	During the course of the initial literature review the papers reviewed provided the learnings that the majority of papers aim to optimise reactive power sources including DGs applying various Evolutionary/Genetic optimisation solvers. A particle swarm optimisation (PSO) solver is often used as the benchmark to test new/novel solvers against. The literature review also identified three approach to calculate a network load or generation hosting capacity; per node non-concurrent, WPD’s method used in the Equilibrium project, and per node concurrent to maximise installed capacity.
2.	The historical load and generation data extracted from the SCADA systems was not in a suitable format to allow time series studies to be undertaken in PSS/E. An approach was developed to transform the data into a suitable format for validating and time series analysis. This approach could benefit future projects when extracting historical data from SCADA systems. Details of the approach are provided in the Work Package 1 report.
3.	The location of the placement of additional generators to be scaled up in the network can affect the calculated generation hosting capacity of a network. Three approaches of placing generators in the networks were assessed with the placement of generators at the ends of feeders and existing generator locations providing the highest generation hosting capacity. Details of the generator placements approach are included in the Work Package 2 report.
4.	Significant time was spent developing an algorithm to automatically identify the circuits to include in a contingency, this relied on naming conventions as the models being used were ‘branch-node’ models rather than ‘node-breaker’ models. Future projects of a similar nature should aim to use ‘node-breaker’ models to help automate contingency identification and analysis.
5.	Optimisation to increase generation hosting in a network is complex task. This is due to a trade of when optimising to increasing voltage headroom for generation the thermal headroom for generation is reduced and vice versa.
6.	Future projects should aim to defined standard technical terminology as early as possible to remove confusion and ambiguity.
7.	The agile approach used when developing the GUI successfully allowed a GUI to be developed to meet a set of functional requirements. Future projects of a similar nature should make use of agile testing and development cycles when developing a GUI. When undertaking an agile approach for the delivery of a GUI, consideration prior to onset of the GUI development should be taken to; understand end user systems, define detailed functional requirements and define user acceptance criteria.

10 Outcomes of the project

10.1 Introduction

The Virtual Statcom project was delivered in five work packages (WP), with the findings from each WP presented in a report:

- **WP1 "Virtual Statcom design, study zone selection and data validation" Report**– This deliverable presented; the findings from the literature review, the networks selected as study zones for the project, and data validation results for the selected study zones. The deliverable also presented the initial design for the Virtual Statcom hosting capacity and optimisation algorithms.

- **WP2 "Power flow simulations and Virtual Statcom algorithms implementation" Report**– This deliverable presented; the initial power system analysis of the study zones, the implementation of the Virtual Statcom algorithms and the results of the Virtual Statcom studies for edge case generation and load scenarios.

- **WP3 "Graphical User Interface" Report** – This deliverable presented the development of the GUI, the final GUI implemented as well as lessons learnt from the development of the GUI. The deliverable also provided a user guide for the Virtual Statcom GUI.

- **WP4 "Time series comparison studies" Report** – This deliverable presented; the updates made to the Virtual Statcom algorithms and the results from time series studies using the Virtual Statcom algorithms.

- **WP5 "Virtual Statcom feasibility study reporting" Report** – This deliverable presented a summary of all work packages and conclusions from the project regarding the technical feasibility of the Virtual Statcom concept. The deliverable also provided functional specifications for a real time control system and planning time tool to utilise the Virtual Statcom concept.

10.2 Technical Outcomes

The Virtual Statcom project delivered the following outputs:

- **The Virtual Statcom hosting capacity algorithm -** to determine the available generation or load hosting capacity for a given network.

- **The Virtual Statcom optimisation algorithm –** to resolve or reduce network constraints and optimise the reactive dispatch for existing generators.

- **The Virtual Statcom GUI** - to run the Virtual Statcom Algorithms

The Virtual Statcom algorithms were used to investigate the feasibility of increasing generation and load hosting capacity for the following three 33 kV BSP networks and one 11 kV Primary network, shown geographically in Figure 10.1.

- Barnstable 33 kV BSP

- Pyworthy and North Tawton 33 kV BSP

- Tiverton 33 kV BSP

- Tiverton Moorhayes 11 kV Primary

Figure 10.1 - Location of study networks

The following subsections detail the technical outcomes from the investigation of the feasibility of increasing generation and load hosting capacity for the study networks.

10.2.1 Virtual Statcom Hosting Capacity Algorithm

The Virtual Statcom hosting capacity algorithm delivered can be used to determine the available generation or load hosting capacity for a given network in each contingency configuration. The algorithm is also able to be used to determine the contingency configuration with the lowest hosting capacity, termed the traditional planning hosting capacity.

10.2.2 Virtual Statcom Optimisation Algorithm

The Virtual Statcom optimisation algorithm has demonstrated the ability to resolve or reduce constraints in networks through optimised reactive power dispatch, this can reduce the amount of active power curtailment required to manage network constraints. There is the potential for a real time tool to use the Virtual Statcom optimisation algorithm to dispatch reactive power to resolve network constraints.

In networks with no network constraints the optimisation algorithm is able to minimise an objective function based on network power flows and bus voltages. The structure of the optimisation algorithm also allows different objective functions to be easily incorporated.

10.2.3 Feasibility of Optimisation to Increase Generation Hosting

The Virtual Statcom algorithm has shown that little generation capacity can be released by optimising the reactive power output of existing generators. A trade-off exists when optimising to increase thermal headroom and optimising to increase voltage headroom for generation. Due to this trade-off, network complexities and interactions between different feeder groups, minimising objective functions developed in the project does not always provide an increase in generation hosting capacity for all network configurations, system generation and load profiles.

10.2.4 Feasibility of Optimisation to Increase Load Hosting

The Virtual Statcom has shown that load hosting capacity can be released by optimising the reactive power output of existing generators. The trade-off that exists when increasing generation in a network is not present when increasing load. More specifically, optimising to increase thermal headroom and optimising to increase voltage headroom for load have the same outcome of higher system voltages and lower network losses.

Figure 10.2 shows the additional load hosting capacity released by the Virtual Statcom for the networks assessed and shows that on average the load hosting capacity increase was between 8-31 MW for each 33 kV Bulk Supply Point (BSP) network. Figure 10.3 shows the equivalent electrical vehicles enable in each network, which equates to approximately 10,000 domestically connected EV chargers across the three BSP networks.

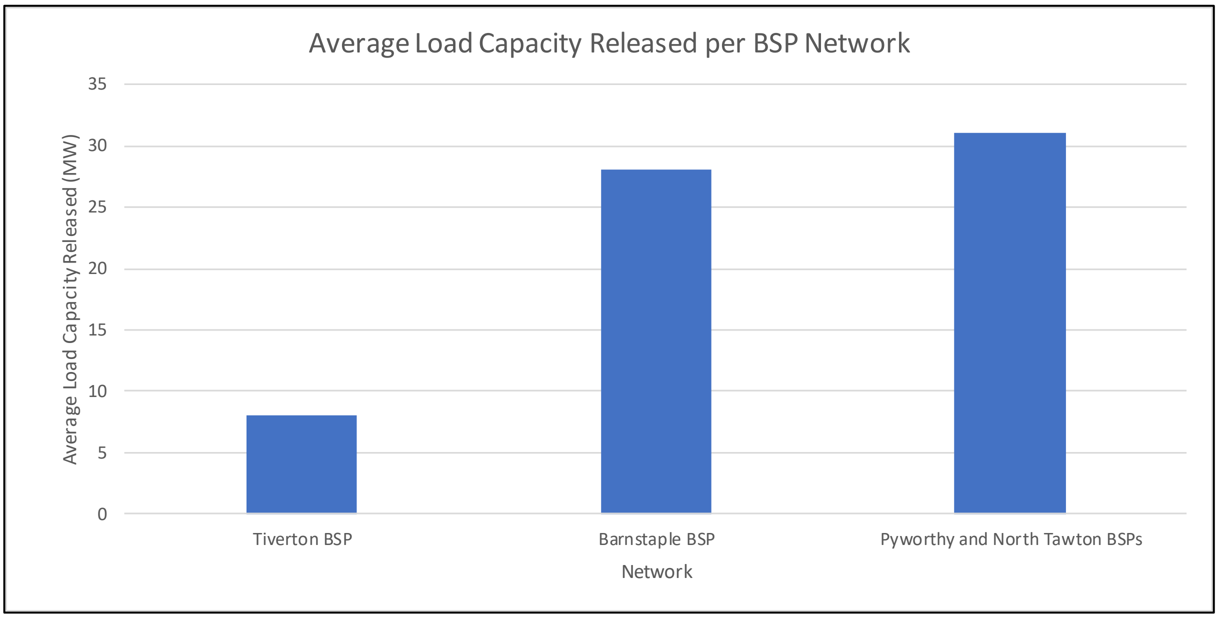

Figure 10.2- Average load capacity released by Virtual Statcom (MW)

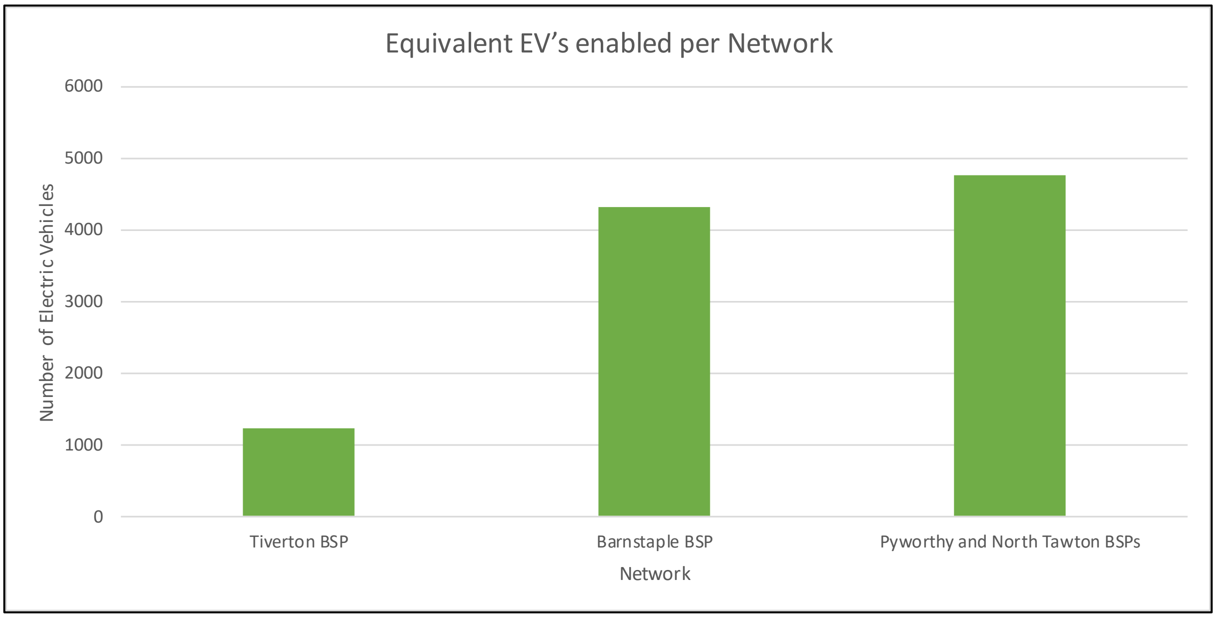

Figure 10.3 - Average load capacity released by Virtual Statcom as equivalent number of electric vehicles

There is the potential for a real time Virtual Statcom tool to use optimised reactive power dispatch to reduce losses and improve the load hosting capacity of a network to serve the expected increases in load from LCTs. Reduced losses in power system networks also reduces the environmental impact of supplying electricity and lowers costs to the end customer.

10.3 Legal and Regulatory Outcomes

Legal and regulatory outcomes were not assessed as part of this project.

10.4 Commercial Outcomes

This project was focused on technical outcomes. However, the trial considerations developed in Work Package 5 identified that a commercial mechanism would be needed for how reactive power providers would be compensated for the export or import of reactive power. This commercial requirement would need to be developed as part of a network trial project.

11 Data Access Details

The deliverables and associated information for the Virtual Statcom project have been published on our innovation website.

Table 11.1 provides links to the deliverables that have been published.

Table 11.1 Links to project deliverables

Deliverable
WP1 “Virtual Statcom design, study zone selection and data validation” report Link: https://www.westernpower.co.uk/downloads-view-reciteme/34105
WP2 “Power flow simulations and Virtual Statcom algorithms implementation” report Link: https://www.westernpower.co.uk/downloads-view-reciteme/109138
WP3 “Graphical User Interface” report Link: https://www.westernpower.co.uk/downloads-view-reciteme/125377
WP4 “Time series comparison studies” report Link: https://www.westernpower.co.uk/downloads-view-reciteme/125389
WP5 “Virtual Statcom feasibility study reporting” report Link: https://www.westernpower.co.uk/downloads-view/162589

Table 11.2 Links to associated conference papers

Paper
Conference: Cired 2020 Berlin: Title: Utilising distributed reactive power to increase network connection capacity Link: **https://www.cired-repository.org/**

12 Foreground IPR

Work upon this project created the Intellectual Property (IP) summarised in Table 12.1. This IP is considered as foreground.

Table 12.1 Foreground Intellectual Property

Item	Description
1.	**Virtual Statcom Hosting Capacity algorithm –** This project designed a hosting capacity algorithm. This algorithm is implemented using Python programming language within Siemens PSS/E software. The hosting capacity algorithm calculates the additional load or generation that a network can accommodate.
2.	**Virtual Statcom Optimisation algorithm –** This project designed an optimisation algorithm. This algorithm was implemented using Python programming language within Siemens PSS/E software. The optimisation algorithm optimises the reactive power output of distributed generators (DGs).
3.	**Graphical User Interface (GUI)** – This interface allows users to run the Virtual Statcom algorithms.

13 Planned Implementation

Based on the conclusions of the project and feedback gathered from stakeholders, the Virtual Statcom concept has shown the potential to be used as a real time reactive power dispatch system to enable the connection of more LCTs to networks, manage network constraints and reduce network losses.

The steps required before the Virtual Statcom real time system concept delivered in this project can become business as usual are:

1. Carry out further work to quantify the expected commercial benefit of the Virtual Statcom for market participants in a WPD's South West region, both to ensure that the approach is justified and to generate interest from potential participants.
2. Design the technical solution required to implement a Virtual Statcom real time control system either by adapting existing control and communication systems or developing new systems.
3. Select a suitable network(s) for testing a Virtual Statcom real time control system and carry out a trial.
4. Design the commercial, regulatory and legal mechanisms to incentivise owners of reactive power assets to offer reactive capability to the Virtual Statcom real time control system.

14 Other Comments

Not Applicable

15 Contact

Further details on the project can be made available through the contact information below:

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Glossary

Acronym	Term
BSP	Bulk Supply Point
DG	Distributed Generator
DNO	Distribution Network Operator
LCT	Low Carbon Technology
MW	Megawatts, unit for real power
Mvar	Mega volt-amperes reactive, unit for reactive power
NIA	Network Innovation Allowance
p.u.	Per unit
pf	Power Factor
PSC	Power Systems Consultants UK Ltd
PSS/E	Power System Simulator for Engineering
Python	A high-level, general-purpose programming language
SCADA	Supervisory Control and Data Acquisition
WP	Work Package
WPD	Western Power Distribution

Western Power Distribution (East Midlands) plc, No2366923
Western Power Distribution (West Midlands) plc, No3600574
Western Power Distribution (South West) plc, No2366894
Western Power Distribution (South Wales) plc, No2366985
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