Issue 04

Enhanced Frequency Control Capability (EFCC)

Progress report July – December 2016

Contents

Executive summary

Great Britain's electricity sector is becoming increasingly decarbonised. Many traditional thermal power stations have closed and will continue to close. In addition, the amount of renewable generation such as solar PV and wind on the electricity network is increasing.

This changing landscape leads to system challenges that are explained further in National Grid's System Operability Framework (SOF)[1]. Among these is the fact that traditional thermal power stations provide inertia, which acts as a natural aid in maintaining system frequency. Renewable generation technologies do not typically provide inertia. Reducing system inertia is known to increase the risk of rapid changes to system frequency and the threat of faults on the network.

The Enhanced Frequency Control Capability (EFCC) project sees National Grid working with industry and academia to provide greater clarity on innovative ways of controlling frequency in low inertia transmission systems. It aims to explore how technologies such as solar PV, demand side response (DSR) and different ways of operating combined cycle gas turbines (CCGTs) can help to keep the transmission system stable in the most cost-effective and efficient way.

[1] http://www.nationalgrid.com/SOF

Summary of Progress: July – December 2016

The main activity during this reporting period has been the further development of the monitoring and control system (MCS) and its functional applications. Control platform testing has been completed and culminated in a successful factory acceptance test (FAT). The completion of the testing within planned timescales proved challenging and the corresponding Successful Delivery Reward Criteria (SDRC) was delayed by one month.

GE Grid Solutions and the remainder of the project team are confident that this small delay in the fulfilment of this SDRC requirement will have no negative impact on the overall progression of the rest of the project or any part of it. Subsequently, Phasor Measurement Unit (PMU) and controller hardware has been delivered to GE Grid Solutions' Edinburgh site for configuration prior to shipment to partner trial sites. Comprehensive training on the use of these has also been provided.

National Grid has continued to work with both DONG Energy and Siemens to develop an agreed approach to potential wind turbine trials. The aim will be to demonstrate a windfarm's ability to provide fast, initiated frequency response. A stage-one contract was signed in October 2016 for trials to occur on test turbines and work on this is already under way. A stage-two contract for trials to take place on a fully operational, commercial windfarm is still being discussed. The main outstanding issue in finalising the stage-two contract surrounds the sharing of liabilities for the duration of the work.

Ofgem confirmed in January 2016 that funding would not be approved for a new battery storage unit to facilitate trials of hybrid battery storage and solar PV within the original EFCC proposal. Since then a review of shortlisted options of third-party providers to maintain battery storage participation within the project has taken place. Separately, Belectric has also reviewed its business case and decided to fund its own battery storage unit with a view to providing ancillary services in the future.

National Grid has subsequently approved the use of Network Innovation Allowance (NIA) funding to cover the costs of leasing the Belectric battery storage unit for the duration of the EFCC trials. This is because the proposal has been significantly de-risked for consumers due to changes in approach and the energy landscape. This proposal maintains the overall EFCC objective. It also maximises the potential learning of investigating hybrid battery storage and solar PV over and above battery storage-only options.

Flexitricity has continued to make significant progress in securing customer interest in all three DSR categories targeted in the project: static Rate of Change of Frequency (RoCoF), real inertia and simulated inertia / dynamic RoCoF. Three customers are now contracted across two of the trial types. Flexitricity continues to pursue customer participation in the dynamic RoCoF element of the project and remains positive about securing contracts for this. A formal change request seeking an extension to the SDRC completion date has been submitted to Ofgem for approval.

The project team continued to share what it has learned throughout this reporting period. A highlight was the Low Carbon Networks and Innovation (LCNI) Conference in Manchester. The project had a dedicated stand in the exhibition hall that provided insight about the project and that also demonstrated the GE Grid Solutions' PhasorController platform. The project also ran its own dedicated presentation session during the conference. Presentation responsibilities were shared between National Grid and GE Grid Solutions. The session attracted a broad range of stakeholders and generated a lot of interest.

The project team is now focused on the next phase of the project. This will see the installation, configuration and site acceptance testing (SAT) of PMUs and controller hardware for academic and commercial partner field trials. This will begin the validation and demonstration of rapid frequency control.

Project background and business case

Meeting future UK government carbon reduction targets will mean increasing the use of renewable generation, which typically does not provide inertia – the resistance of an object to any change in motion.

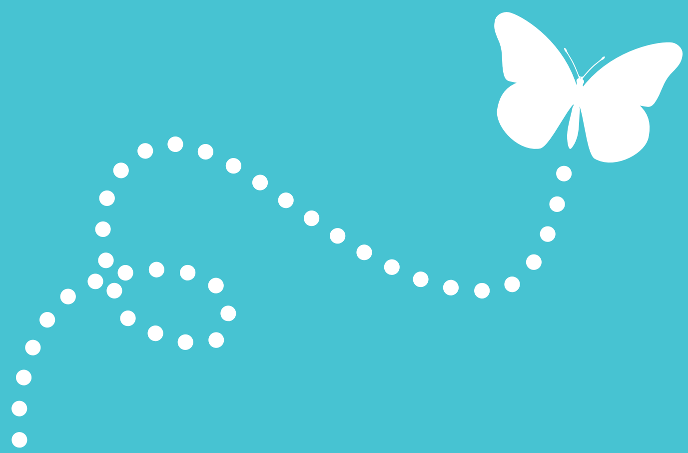
Reduced system inertia is known to increase the risk of rapid changes to system frequency and the consequent threat of faults on the network. As a result, a greater volume and speed of frequency response will be needed to keep the transmission network stable.

Through the Enhanced Frequency Control Capability (EFCC) project, National Grid is working with industry and academia to clarify innovative ways of controlling frequency in low inertia transmission systems. It aims to explore how technologies such as solar PV, demand side response (DSR) and different modes of operation of combined cycle gas turbines (CCGTs) can help to keep the transmission system stable in the most cost-effective and efficient way.

By developing an innovative wide-area monitoring and control frequency response system, the EFCC project aims to open the door to more frequency response being provided by newer, more sustainable energy solutions. Commercial incentives and products will also be developed to encourage the widest participation in a new market for fast frequency response.

The EFCC project will also generate important knowledge that can be shared with relevant network licensees and service providers. The challenge of managing low system inertia is not unique to National Grid. The results of trials, and the solutions offered, will also be of particular interest to global Transmission System Operators (TSOs). You can find out more by visiting our project microsite:

http://www.nationalgridconnecting.com/The_balance_of_power/index.html



Project manager's report

The project received formal approval and the Project Direction in December, 2014. This is the fourth progress report and covers the period of July to December, 2016.

Work Package 1: Monitoring and control system

The focus of this reporting period has been to develop further the monitoring and control system and its functional applications. Control platform testing was completed and resulted in a successful factory acceptance test (FAT). PMU and controller hardware has been delivered to GE Grid Solutions' Edinburgh site for configuration prior to shipment to partner trial sites. A comprehensive training course has also been delivered to provide all project partners with sufficient knowledge of PMU equipment, PhasorController equipment, PhasorPoint monitoring software, EFCC applications, PLC Workbench and PLC scheme configuration. Validation and demonstrations of rapid frequency response will now commence at the beginning of 2017.

Work Package 2.4: Battery storage

It has previously been reported that the project would not be rewarded the requested funding for a new battery storage unit for combined solar PV and battery storage trials. The project team believes that battery storage can still play a significant role in ensuring system reliability. As a result, the team has been investigating new ways of keeping battery storage within the project scope. National Grid has subsequently approved the use of NIA funding to cover the costs of leasing the Belectric battery storage facility for the duration of the EFCC trials.

Work Package 2.5: Wind

National Grid has continued to engage with DONG Energy and Siemens to determine an outline test schedule to demonstrate the capability of windfarms to provide rapid frequency response and the associated costs of doing so. Contract discussions have progressed for a three-party agreement between National Grid, DONG Energy and Siemens. All three parties recently signed an initial contract for frequency response tests on trial turbines and this work is now under way. Discussions are still ongoing regarding a second contract for tests on a commercially operating windfarm. All three parties are working hard to achieve this.

Project knowledge sharing and dissemination

Project representatives recently attended the LCNI Conference in Manchester. The project had a dedicated stand in the exhibition hall giving an overview of the project and demonstrated the GE Grid Solutions PhasorController platform. This generated a lot of interest and the project team was kept busy demonstrating the EFCC system and fielding a diverse range of questions.

The project had its own dedicated presentation session during the conference, with presentation responsibilities shared between National Grid and GE Grid Solutions. The session attracted a broad range of stakeholders and again generated plenty of interest.

Further detail on all of these project highlights can be found later in this report.

Project steering committee

The steering committee is responsible for developing and agreeing project activities; approving project results; raising, testing and reducing identified risks to the project, and authorising changes to the project plan.

During this reporting period, Project Manager Charlotte Grant has left the project to undertake a fresh challenge within National Grid. The project team would like to recognise and acknowledge all the hard work and effort Charlotte committed to the project during her tenure and wishes her well in her future ventures. Lilian Macleod has been appointed as Charlotte's replacement and joined the project full-time from 1st September, 2016.

National Grid has also appointed Nigel McClenaghan to provide additional project management support. Nigel replaces Ellen Bishop. All existing responsibilities and knowledge have been carefully handed over to the new personnel to ensure that there is no impact on the project's progress. There have been no further changes to the steering committee hierarchy.

The project steering committee continues to hold regular teleconference meetings to discuss project progress, allow risks to be identified and managed, and to agree actions. Following the personnel changes reported above, the format and frequency of these meetings are being reviewed. More individual project partner engagement meetings with National Grid are also being scheduled.

A quarterly face-to-face meeting was held on 1st November, 2016 in Warwick, where the project team discussed key outcomes from the reporting period and agreed on the coordination and development of work between all parties for the weeks and months ahead. These quarterly face-to-face meetings will continue to be rotated between different locations to encourage the widest engagement.

Project progress against SDRC milestones

Progress against our SDRC milestones during this reporting period is shown in Table 1 below. Further detail is given in the SDRC chapter later in this report.

Table 1
SDRC Summary: July – December 2016

Description	Due date	Status
Agreements in place with DSR customers for participation in EFCC trials	30th June, 2016	Ongoing
Complete control platform development controller testing	31st August, 2016	Achieved 30th September, 2016

Agreements in place with DSR customers for participation in EFCC trials

In a letter dated 23rd June, 2016 the project team forewarned Ofgem that it expected to miss the SDRC requirement to have agreements in place with DSR customers by the end of June 2016, as set out in the project direction. This was later confirmed to Ofgem in a second letter dated 5th August, 2016. As explained at the time, while this is disappointing, the project team does not envisage this delay will have a detrimental impact on the overall programme to demonstrate DSR within the project nor on any other SDRC.

It was identified at the start of the project that there could be insufficient appetite among DSR customers to get involved in a time-limited project with no certainty of long-term revenue. However, despite this, significant progress has been made in securing customer interest in all three targeted DSR categories (static RoCoF, real inertia and simulated inertia / dynamic RoCoF). Three customers are now contracted across two of the trial types. Flexitricity continues to pursue customer participation in the dynamic RoCoF element of the project and remains positive about securing contracts for this. A formal change request seeking an extension to the SDRC completion date has been submitted to Ofgem for approval.

Complete control platform development controller testing

In a letter dated 15th September, 2016 the project team submitted to Ofgem an interim EFCC Control Platform Development Controller Testing Report. However, it was acknowledged that the full complement of controller testing, as determined by GE Grid Solutions, had not been completed within the allocated timescales. A detailed overview of all successfully completed and outstanding test cases was available within the interim test report.

It was acknowledged that completing testing within the original timescales had been challenging for a number of reasons, including the increased technical scope, with three types of controllers and an additional number of interfaces; plus a higher level of complexity, including end-to-end integration, performance and technical challenges.

In addition, testing completed to date had also highlighted areas that required resolving and further testing. This is not unusual given the innovative and untried nature of the technology being developed.

The project team believes that testing performance and operational stability is very important, especially considering the limited timeframes the project is aiming for in terms of fast frequency response. It is therefore important to gather proper evidence and prove operational readiness before deployment in the field. A further, final test report was completed and submitted to Ofgem by 30th September, 2016. GE Grid Solutions and the remainder of the project team are confident that this small delay in the fulfilment of this SDRC requirement will not adversely affect the overall progress of the remainder of the project or any part thereof.

Project risks

A robust project structure and governance process means that any potential issues or changes that could affect project delivery are identified quickly and actions are put in place to resolve them. Appendix C provides an update of the project risk register. Key risks for this reporting period can be found later in this report.

Project knowledge sharing and dissemination

The project team will continue to record and share all the lessons learned throughout the project. All learning points are discussed and assessed via ongoing reviews and project meetings. Outcomes and breakthroughs are also shared at conferences, workshops and university demonstration events.

Events that were attended and publications that were submitted during this reporting period by all project partners are listed in Table 2 below.

Table 2
Knowledge Sharing Events: July – December 2016

Event / publication	Date	Organisation	Contribution
BDO	July 2016	Flexitricity	Energy storage and frequency response.
General Meeting IEEE PES	July 2016	University of Manchester	A new inertia emulator and fuzzy-based LFC to support inertial and governor responses using Jaya algorithm.
IEEE Transactions on Power Delivery IEEE PES	July 2016	University of Manchester	A new centralised adaptive under frequency load shedding controller for micro-grids based on a distribution state estimator.
CIGRE Conference Paris	21st-26th August 2016	GE Grid Solutions	EFCC and VISOR joint presentation: 'Great Britain's Power System Applies GE's Innovative WAMS and Control Solutions to Increase Renewable Penetration': A GE industry focus event presented by P. Ashton (NG), P. Mohapatra (SPEN) and D. Wilson (GE). A presentation on the emerging need for and benefits of fast-acting frequency response and a demonstration of the GE monitoring and control system (MCS) incorporating the PhasorController control platform.

Project manager’s report cont.

Event / publication	Date	Organisation	Contribution
CIGRE Paper Paris	August 2016	GE Grid Solutions	Paper: ‘Advances in Wide Area Monitoring and Control to Address Emerging Requirements Related to Inertia, Stability and Power Transfer in the GB Power System’: A published paper, poster presentation and contributions to study committee SC C2: Operations and Control.
Innovative Smart Grid Technologies (ISGT) IEEE PES	September 2016	University of Manchester	Smart frequency control for the future GB power system.
LCNI Conference Manchester	11th-13th October 2016	National Grid/ GE Grid Solutions/ Flexitricity/ University of Manchester/ University of Strathclyde	Presentation and panel discussion about the project to a variety of audiences and demonstration of EFCC capabilities on PhasorController control platform on the National Grid exhibition stand. The University of Manchester also provided a presentation and demonstration of Hardware in the Loop (HiL) testing.
Advantage Royal Society Event	October 2016	Flexitricity	Inertia services in the context of frequency response. Internet of things and smart grid communications.
Conference of the Electric Power Supply Industry (CEPSI) Paper Bangkok	October 2016	GE Grid Solutions	Paper: ‘Advances in Wide Area Monitoring and Control in the GB Grid’: Won the best paper award. Authors: D. Wilson, S. Clark, S. Norris, F. Young (GE), P. Mohapatra (SPEN), P. Ashton (NG) and P. Wall, V. Terzija (UoM).
Energy Source and Distribution Magazine Article Australia	November / December 2016	GE Grid Solutions	Australian magazine article accepted for publication in November / December 2016.
Elsevier Book Chapter UK	2016	GE Grid Solutions	Book: ‘Phasor Measurement Units and Wide Area Monitoring Systems: From Sensors to the System’. D. Wilson (GE) contribution: ‘Chapter 9: Real Life Examples of Wide Area Measurement Systems’.
RTDS European User’s Group Meeting	2016	University of Strathclyde	Dr Ibrahim Abdulhadi presented the EFCC project and the proposed tests to be conducted at PNDC at this three-day seminar.

GE Grid Solutions

In August 2016, GE Grid Solutions presented the EFCC project and demonstrated PhasorController capabilities at CIGRE in Paris.

GE Grid Solutions conducted control platform testing between May and August 2016. Due to the increased technical scope and complexity level, control platform testing was extended until the end of September 2016. Project partners received intermediate and final control platform test reports towards the end of August and the end of September 2016 respectively. The test reports aimed to provide project partners with technical insight and confidence levels that they needed before moving into the project’s demonstration phase.

GE Grid Solutions has provided training to project partners:

- Days 1-3: GE Reason PMU equipment training
- Days 4-5: EFCC applications training (regional / system aggregator, event detection, resource allocation)
- Day 5: PLC Workbench and PLC scheme configuration training (setup deployment scheme)
- Day 6: PhasorController equipment training
- Day 7: PhasorPoint software training.

Towards the end of the training schedule, a FAT was successfully conducted to demonstrate EFCC capabilities to project partners.

Flexitricity

Flexitricity has presented the EFCC project to several audiences. These include CHP, retail, energy management, industrial generation and renewable generation. The objectives are two-fold: firstly, to raise awareness of the project among industrial and commercial energy users and small generation operators. Secondly, to recruit businesses to participate in DSR as well as any emerging service developed during the project.

Flexitricity has also discussed the EFCC project in numerous one-to-one engagements with industrial, commercial and public service electricity users, community energy and other CHP operators and energy storage developers.

LCNI Conference

National Grid and GE Grid Solutions demonstrated the new PhasorController control platform for the EFCC system at the three-day LCNI Conference in Manchester between 11th and 13th October 2016. National Grid and GE Grid Solutions also jointly presented the EFCC concept and project status during a dedicated timeslot on the second day of the event.

Forecast for next reporting period

The project activities for the next reporting period are shown in Table 3, below.

Table 3
Work Package Activities: January – June 2017

Work package	Description	Partner	Comments	Status	Timescale
1	Monitoring control scheme	GE Grid Solutions/ University of Manchester	Demonstration Phase 2: installation, configuration and SAT of PMUs and control hardware for RTDS testing.	Amber*[2]	Jan 2017 – Feb 2017
1	Monitoring control scheme	GE Grid Solutions/ University of Strathclyde	Demonstration Phase 3: installation, configuration and SAT of PMUs and control hardware for PNDC testing.	Green	Jan 2017 – Feb 2017
1	Monitoring control scheme	GE Grid Solutions/ Flexitricity	Demonstration Phase 4: installation, configuration and SAT of PMUs and control hardware for DSR field trials.	Green	Mar 2017 – Jun 2017
1	Monitoring control scheme	GE Grid Solutions/ Centrica	Demonstration Phase 4: installation, configuration and SAT of PMUs and control hardware for thermal plant field trials.	Green	Mar 2017 – Jun 2017
1	Monitoring control scheme	GE Grid Solutions/ Belectric	Demonstration Phase 4: installation, configuration and SAT of PMUs and control hardware for solar PV field trials.	Green	Mar 2017 – Jun 2017
1	Monitoring control scheme	GE Grid Solutions/ National Grid	Demonstration Phase 4: installation, configuration and SAT of PMUs and control hardware for National Grid testing.	Green	Mar 2017 – Jun 2017
1	Monitoring control scheme	GE Grid Solutions	Control scheme data and performance review.	Green	Jan 2017 – Mar 2018
1	Monitoring control scheme	GE Grid Solutions	Revision of applications.	Green	Sep 2016 – Mar 2017
1	Monitoring control scheme	GE Grid Solutions	Revision of control platform.	Green	Sep 2016 – Jul 2017
2.1	Demand side response	Flexitricity	Prepare for and begin DSR field trials.	Amber*[3]	Jan 2017 – Nov 2017
2.2	Large scale generation	Centrica	Prepare for and begin thermal plant field trials.	Green	Jan 2017 – Jul 2017
2.3	Solar PV power plant	Belectric	Prepare for and begin solar PV field trials.	Green	Jan 2017 – Oct 2017
3	Optimisation	University of Manchester	System studies on representative GB transmission network to assess proportionate responses from service providers and development of an optimal supervisory control strategy.	Amber*[4]	Jun 2016 – Mar 2017
4	Validation	Universities of Manchester and Strathclyde	Implementation of monitoring and control system for HiL and PNDC testing and begin validation of GE Grid Solutions' developed system.	Amber*[2]	Jun 2015 – Sep 2017
6	Commercial	National Grid	Begin assessment of economic value of new rapid frequency service.	Green	Jul 2015 – Mar 2018
7	Communications	National Grid	Begin evaluation of the communication infrastructure requirements and assess the current technical capabilities of the system. Coordinate installation of additional PMUs at National Grid substations to increase WAMS capability.	Green	Jan 2015 – Dec 2017

Status	Description
Red	Unlikely to complete by due date
Amber	Minor issues but expected to complete by due date
Green	On track to complete by due date

[2] This activity is amber due to delays in the procurement of necessary hardware for the RTDS testing.

[3] This activity has amber status because Flexitricity is still contracting customers to participate in EFCC field trials. Nevertheless, Flexitricity is confident that participation will be secured in all three DSR categories targeted within this project and that field trials will still be completed within planned timescales.

[4] This activity is amber due to the delay in recruiting Research Assistants at the University of Manchester as previously reported. The work package continues to be reviewed to ensure that the necessary study analysis is completed.

Business case update

Work Package 2.4: Battery Storage

In the original EFCC submission, the project requested £1.12 million of funding to invest in a new battery storage unit. The aim was to explore how a service that combined solar PV and battery storage could benefit the transmission system. This represented a significant proportion of the total project costs. Ofgem therefore requested additional cost benefit analysis to justify this investment.

Ofgem decided in January 2016 not to fund this element of the project and that all associated project costs for Work Package 2.4: Battery Storage should be returned to consumers. However, Ofgem confirmed that it still believed battery storage could play a key role in ensuring future system reliability.

Following confirmation that funding would not be approved for a new battery storage unit to facilitate trials of hybrid battery storage and solar PV within the original EFCC proposal, a review has taken place of shortlisted options of third-party providers to maintain battery storage participation within EFCC trials. Separately, Belectric has also reviewed its business case and decided to fund its own battery storage unit with a view to providing ancillary services in the future.

Our proposal is to use NIA funding to cover the costs of leasing the Belectric battery storage unit for the duration of the EFCC trials. This proposal maintains the overall EFCC objective. It also maximises the potential learning of investigating hybrid battery storage and solar PV over and above battery storage only options. NIA funding has subsequently been approved by National Grid and funds allocated. This is primarily because the proposal has been significantly de-risked for consumers due to changes in approach and the energy landscape, as:

- Leasing the Belectric battery storage unit significantly reduces funding sought
- Recent changes in the energy landscape have identified an increased requirement for flexible generation. New storage technologies, particularly batteries, are emerging into the market with active industry discussion taking place about their role and the options they could bring to the electricity sector.

Work Package 2.5: Wind

National Grid is in discussion with DONG Energy and Siemens about possible options for windfarm trials.

During this reporting period, National Grid has continued to work with both organisations to develop an agreed approach to potential wind turbine tests. The aim of the tests will be to demonstrate a windfarm's ability to provide fast, initiated frequency response.

The tests will also give us an understanding of the power recovery period of wind turbines. This is essential to maintain the balance of generation and demand and ensure effective coordination with other frequency response providers.

It has been decided that the use of a GE Grid Solutions' control unit during these windfarm tests is no longer within the project scope. The park pilot in the windfarm has both the capability of measuring the system frequency and instructing the windfarm to provide the required frequency response in the specified form. Hence the use of a third party asset is not necessary in this instance. These tests will therefore provide insight to wind turbine response characteristics. It has also been confirmed that Lincs windfarm will not be selected for trials.

A stage-one contract has recently been signed for trials to take place on test turbines and work on this is already under way. A beta version of the turbine software as well as test equipment to perform a turbine level test has been set up in the first test turbine. Results from this first stage and the use of kinetic energy for supporting system under frequency conditions are promising concerning response time and magnitude. Stage-one works will also include an assessment by DONG Energy in terms of the overall volume of response that can be achieved from the proposed scheme on their portfolio of wind and the commercial implications of doing so.

A stage-two contract for trials on a fully operational, commercial windfarm is still being discussed. One of the main outstanding challenges in finalising the stage-two contract surrounds the sharing of liabilities for the duration of the work.

Due to these extended negotiations, activity dates for this work package may need to change and this may affect the corresponding SDRC. National Grid may therefore formally request an amendment to the project direction to change the completion date of this SDRC in due course.

Enhanced frequency response (EFR)

Enhanced frequency response (EFR) is defined by National Grid as a service that achieves 100% active power output at one second or less of registering a frequency deviation. This is a new service being developed to improve management of the transmission system frequency pre-fault.

National Grid has procured 200MW of EFR through the tendering exercise held in July 2016. Bids were received from numerous providers, the majority of which were battery storage units. Results were published on 26 August 2016. Contracts have been awarded on a four-year term, giving providers the certainty they need to develop technologies. Further details can be found at http://www2.nationalgrid.com/enhanced-frequency-response.aspx.

There are common features between the speed of provision of the EFR service and the objectives of the EFCC project. However, EFCC has several advantages over EFR in terms of speed, stability, predictability and flexibility to incorporate diverse resources.

However, the more sophisticated monitoring and control system and the more generalised service market are longer-term developments. The simpler, local control approach of EFR allows earlier deployment to meet immediate needs and gain practical experience.

At the end of the four-year EFR contract period, the need for fast frequency response services is expected to be even greater than today. EFR assets will therefore continue to be of great value. In view of the learning gained from both the EFR and EFCC projects, it is likely that the controlling mechanisms may change and the reward mechanism may become more generalised.

Bank account

Bank statements have been provided to Ofgem. Due to the confidential nature of the project bank statements, these have been included within the redacted appendices of this report.

Progress against budget

Project expenditure is within the budget defined in the Project Direction. The table below details the project expenditure to date and highlights any variances against the budget.

Project budget

Table 4
Proposed and Actual Spend: January 2015 – December 2016 (£000's)

Cost category	Actual	Budget	Variance
Labour	594.0	1,246.6	(652.5)
Equipment	353.7	477.0	(123.3)
Contractors	931.7	1,132.3	(200.6)
IT	30.0	30.0	0.0
IPR costs			
Travel and expenses	45.5	49.0	(3.5)
Payments to users	0.0	650.0	(650.0)
Contingency	62.2	336.3	(274.2)
Decommissioning			
Other			
Totals	**2,017.1**	**3,921.2**	**(1,904.1)**

The information in Table 4 excludes the funding for Work Package 2.4: Storage in accordance with the Project Direction Letter[5]. In addition, the financial profile for Work Package 2.5: Wind has been reallocated in line with the revised timescale. The key financial changes during this reporting period are as follows.

National Grid labour needs are monitored regularly to ensure the right resources are allocated to the project. These costs remain under budget over the full lifecycle of the project.

The difference between the budget and the actual expenditure on labour reflects the National Grid savings made over the first year of the project. Travel and expenses include spend from the start of the project to the end of the reporting period.

Actual spend on payments to users is consistent with the schedule of the project trials. It includes the adjustments made to the timeline of Work Package 2.1: Demand Side Response. The equipment costs are due to receipt of PMU and controller hardware, with the procurement of additional equipment accounting for the contingency spend.

[5] https://www.ofgem.gov.uk/sites/default/files/docs/2015/01/enic_project_direction_efcc_final_0.pdf

Successful delivery reward criteria (SDRC)

GE Grid Solutions

The following work, related to SDRCs, was led by GE Grid Solutions in this reporting period. The document detailed below is covered by GE Grid Solutions' background intellectual property rights, so cannot be published onto the project's knowledge sharing microsite.

Work Package 1: Control Platform Development

This document summarises the testing and validation carried out on the PhasorController control platform. Controller units were set up and tested as follows:

- **System Testing:** Controller units configured and tested individually as isolated units (i.e. local controller, regional aggregator or central supervisor). Inputs, functionality, behaviour and outputs validated against specification details and Simulink test results from applications testing phase.
- **Integration Testing:** Controller units configured and tested as part of end-to-end integration test environment (i.e. local controllers, regional aggregators and central supervisor connected). Inputs, functionality, behaviour and outputs validated against specification details and Simulink test results from applications testing phase.
- **Performance and Operations Testing:** Controller units were tested under stress conditions and operational behaviour was recorded.

The document describes the types of tests carried out and gives detailed results.

An interim test report was delivered on 31st August 2016 in line with the agreed SDRC milestone. However, completion of control platform testing within the original timelines was challenging due to significantly increased technical scope and complexity level. For example, the technical scope included three types of controllers and an additional number of interfaces, while there was greater complexity from end-to-end integration, system performance and technical challenges. GE Grid Solutions therefore continued control platform testing beyond the SDRC milestone. A final test report was delivered on 30th September 2016. The extended control platform testing phase had no impact on the overall project schedule.

Flexitricity

The other SDRC within this reporting period related to the need for Flexitricity to have agreements in place with DSR customers by the end of June 2016. As explained earlier in this report, the project team notified Ofgem of its expectation to miss this SDRC requirement.

However, three customers are now contracted across two of the trial types. Flexitricity continues to pursue customer participation in the dynamic RoCoF element of the project and remains positive about securing customer participation for this. A formal change request seeking an extension to the SDRC completion date has been submitted to Ofgem for approval.

Successful delivery reward criteria (SDRC) cont.

Successful delivery reward criteria for the next reporting period

There is only one SDRC due in the next reporting period of January – June 2017, as shown below in Table 5.

Table 5
SDRCs For Next Reporting Period: January – June 2017

Description	Due date	Status	Comments
Monitoring and control system developed successfully: Application development: Revision completed	31st March 2017	Green	–

Future successful delivery reward criteria

As reported previously and mentioned again earlier in this report, National Grid may request a change to the SDRC associated with Work Package 2.5: Wind, following the conclusion of discussions with DONG Energy and Siemens.

Learning outcomes

This section describes what has been learned in the project during this reporting period.

Work Package 1: Monitoring and control system

The development of the monitoring and control system (MCS) met the following key milestones:

- Delivery of PMU hardware to project partners
- Delivery of controller hardware
- Control platform testing report
- Provision of training to project partners
- Completion of demonstration #1 (FAT at GE Grid Solutions).

Delivery of PMU hardware to project partners

GE Reason PMU hardware has been successfully delivered to project partners.

Delivery of controller hardware

GE PhasorController hardware has been delivered locally to the GE project team in Edinburgh. The GE project team will pre-configure controller units as per deployment scheme details agreed with project partners prior to shipping, installation, integration and site acceptance testing (SAT).

Control platform testing report

A formal test process of the control platform was carried out. Completion of control platform testing within the original timelines was challenging due to increased technical scope and complexity level. For example, the technical scope included three types of controllers and an additional number of interfaces, while there was greater complexity from end-to-end integration, performance and technical challenges. The following was agreed upon:

- Delivery of Interim Report: Control Platform Testing by 31st August 2016 as per the SDRC milestone
- Continue controller testing beyond the SDRC milestone and perform extended control platform testing during September 2016
- Delivery of Final Report: Control Platform Testing by 30th September 2016.

The test report included a description of each of the controller types and the embedded applications as well as the results of detailed testing on their functionality, input data and behaviour.

Dedicated sections described the level of integration testing, performance testing and operations testing performed. The results in the final report showed that the control platform performed as expected, based on the delivered and agreed functional design specification reviewed by partners during the development stages. Defects identified during the testing phase were addressed by GE Grid Solutions.

The current version of the hardware platform is ready for the demonstration phase. Following this, formal demonstrations will begin, with the hardware being used to support the various simulation and technical field trials. The technical field trials will be carried out in the next reporting period.

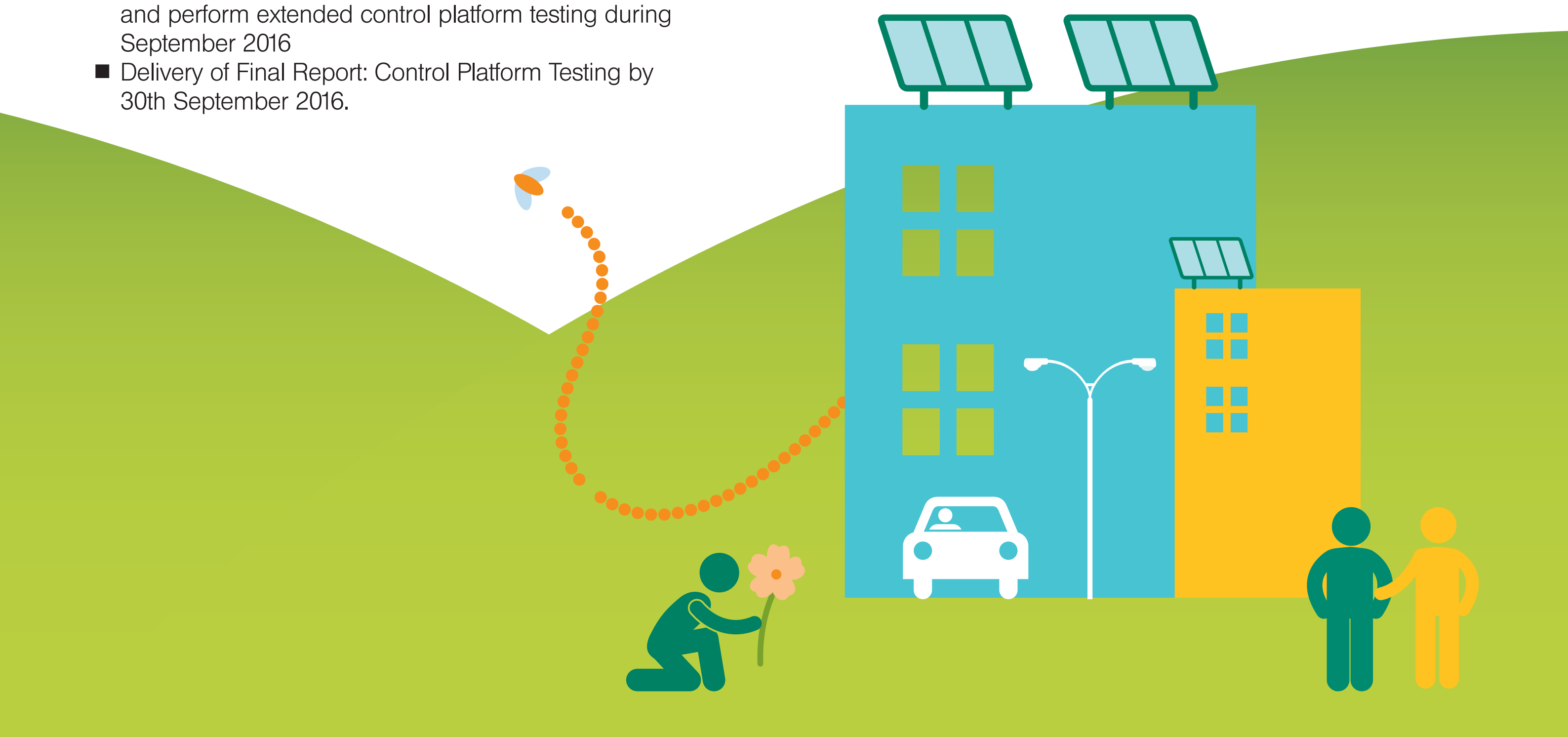
The control platform testing report is covered by GE Grid Solutions' background intellectual property rights. As a result, not all information can be published on the project's knowledge sharing microsite.

Provision of training to project partners

GE Grid Solutions has provided a seven-day training course from 19th to 27th October 2016 to give project partners sufficient knowledge on PMU equipment, PhasorController equipment, PhasorPoint monitoring software, EFCC applications, PLC Workbench and PLC scheme configuration.

Completion of demonstration #1 (FAT at GE Grid Solutions)

On 28th October 2016, a FAT was conducted at GE Grid Solutions' offices in Edinburgh. EFCC capabilities were successfully demonstrated to project partners. The demonstration setup included five controller units: two local controllers, two regional aggregators and one central supervisor.



Work Package 2.1: Demand side response

Following extensive discussions with potential demand side participants, Flexitricity has now secured contracts for trials with three separate organisations:

1. A major chemicals producer that will participate in the static RoCoF trial with one large site of 6.1MW

2. A district heating scheme with two 3MW gas-fired reciprocating CHP engines that will participate in the spinning inertia trial

3. A horticultural company with two 1.5MW gas-fired reciprocating CHP engines that will participate in the spinning inertia trial.

Flexitricity would like to add one or two more static RoCoF participants and talks are under way with two potential customers. If additional participation is secured, the project will be able to test lower-cost methods of detecting RoCoF on site.

Flexitricity has also conducted site visits with two potential partners for the dynamic RoCoF element of the project. This is the part of the project considered the most challenging because it involves relatively deep intervention in site control systems.

Nevertheless, there is a reasonable chance of securing participation. Both sites surveyed are waste-water treatment works. Furthermore, Flexitricity will shortly survey a cold store which also has dynamic RoCoF potential.

All the sites contracted or attempting to be contracted for the EFCC trials are existing Flexitricity customers. Flexitricity has discussed the project with numerous other industrial, commercial and public service electricity users, community energy and other CHP operators and energy storage developers. The emphasis on existing customers is pragmatic, based on meeting project timescales. Other customers are more likely to become involved in later, business-as-usual applications of EFCC.

Work Package 2.2: Large scale generation

Centrica is making steady progress implementing revised frequency control logic on its CCGT at South Humber Bank. Staff at South Humber Bank power station are now fully involved in the project. Previously, Centrica's input was largely confined to two members of staff leading on the project working remotely.

Two members of staff attended the GE Grid Solutions training for the PMU. The PMU has since been received at South Humber Bank. Centrica is finalising details with GE Grid Solutions on the best way to install the monitoring unit and link the GE Grid Solutions equipment to the power station Distributed Control Systems (DCS).

Centrica and GE Grid Solutions are considering whether media converters can be used to connect the RA332 via twisted pair. There is some distance between the measurement CTs and VTs where the RA332 would be housed and the electronics room where the RPV311 Unit, RT430 Clock and DCS are located. Currently there is no optical fibre infrastructure between the two locations.

The engineering change process is progressing ahead of implementation of the revised frequency control logic and PMU connection. Discussions have taken place between Centrica and National Grid about testing the revised frequency control logic.

This will clarify National Grid's test requirements and the best way to implement the test without compromising existing Grid Code compliant frequency response at the power station. The discussions will help to define the objectives and to develop a test programme. This will provide useful information about possible future modes of operation.

More recently, following discussion at a full project steering meeting, Centrica is considering implementing the test logic so that it will respond more quickly to high frequency events, in addition to low frequency events. This provision will be included in the design as an option within the test logic.

Centrica remains on course to implement the changes by the end of the year. The plant will be tested in early 2017, initially in isolation, then together with the GE Grid Solutions local controller soon afterwards.

Work Package 2.3: Solar PV

Belectric has undertaken the following activities during this reporting period for the solar PV power plant at Rainbows. Site preparation has continued and a new communication configuration designed. Hardware manufacturing and the delivery of new controller components on site are now complete.

Software development for the Belectric hybrid controller with framework and new control algorithms has also taken place. Communications between the Belectric hybrid controller and the GE Grid Solutions local controller have also been developed in close collaboration with GE Grid Solutions.

A cloud movement camera and a PV model have been integrated into the Belectric hybrid controller. The equipment has been clarified, designed and manufactured to integrate the GE Grid Solutions PMU into the existing collecting station on site.

The decision for distributed data stream management of PMU log data, split between internal and externally transferred data is available. The concept for outside communication setup for large scale PMU log data is still in progress.

The following learning outcomes have been achieved during this reporting period:

- A higher accuracy of resource capabilities has been achieved by integrating a cloud movement camera and a PV model into the Belectric hybrid controller.

- Belectric can provide a positive and a negative frequency response with solar PV by shifting down the working point of the solar PV plant. However, this is cost intensive and can only be applied for short periods of time.

- The new communication standard, IEC 61850 GOOSE, has been implemented for communication between the Belectric hybrid controller and the GE Grid Solutions local controller.

In addition and as explained earlier in this report, the concept of a Belectric hybrid solar PV and battery storage resource is still being pursued. Therefore, Belectric continues to work towards this and the following learning outcomes have been achieved:

- The combination of solar PV and battery storage can provide a positive and a negative frequency response with more regulating power and at lower costs than with solar PV only.

Work Packages 3 and 4: Optimisation and validation

The University of Manchester

The University of Manchester has been working on simulation-based system studies on DIgSILENT PowerFactory and Real Time Digital Simulator (RTDS) Hardware in the Loop (HiL) testing to test and validate the performance of the GE Grid Solutions monitoring and control system (MCS).

Simulation-based system studies

System studies focused on system frequency response without supervisory control and modelling of service providers in DIgSILENT PowerFactory:

- **Frequency Response of a System without Supervisory Control: System Frequency Response (SFR) Model:** This looked at the frequency behaviour of a large scale power system deploying its simple and reduced order system frequency response under sudden load disturbances. The effects of different parameters like reheat time constant, inertia constant, damping factor, fraction of total power generated by the turbine, governor regulation and mechanical power gain factor on system frequency using a typical SFR model are investigated by time-domain simulation studies.

- **Frequency Response of a System without Supervisory Control: Small Signal Analysis:** Small signal analysis and time-domain dynamic simulation techniques to test and study the system frequency response of a power system network under generator trip disturbances have been investigated. A two area, four generator test system is chosen to determine the fundamental nature of inter-area modes of oscillation. In this study the small signal formulation of a linear system is provided and investigated and their relevance to the frequency response of the system analysed. Then the effects of disparate devices like the Power System Stabiliser (PSS), Automatic Voltage Regulator (AVR) and governor, as well as different parameters like reheat time constant, inertia time constant, load damping coefficient, fraction of total power generated by the turbine and governor speed regulation are investigated by small signal analysis and time-domain simulation studies respectively. Additionally, the effects of these factors on minimum post-contingency frequency, rate of change of frequency and settling frequency are evaluated to determine their importance.

- **Service Providers Modelled in DIgSILENT PowerFactory:** The Doubly Fed Induction Generator (DFIG)-based wind turbine is modelled in DIgSILENT PowerFactory to assess the system frequency response. The control structure of a DFIG-based wind turbine, including the back-to-back converters (the grid side converter and rotor side converter of a DFIG), is simulated.

RTDS Hardware in the Loop (HiL) testing

The University of Manchester is focussed on system and component modelling in RSCAD, which is the simulation environment used by the RTDS. The team is also studying real-time hardware in the loop simulation of EFCC using the RTDS to validate the performance of the GE Grid Solutions MCS using HiL facilities.

The expected test scenario is that the RTDS will use virtual PMUs to provide IEEE C37.118 streams to the EFCC hardware and receive a suitable control output from the EFCC controllers (IEC 61850 GOOSE) as an input back into the real-time simulation. This will 'close the loop' between the simulation and the hardware, allowing the real-time simulation to incorporate the response of the control hardware.

In this regard, the power system test networks have been developed in RTDS and the communication links between RTDS and the MCS have been studied and configured. Two power system test models are ready for testing and validation of the MCS:

1. **Two Area Test System Model:** In this model there are two power system zones linked by a long parallel AC transmission line. In each zone the topology is identical. However, the parameters and set-point of generators and loads are different. To fulfil the testing requirement of the EFCC project, virtual and actual PMUs are installed in this model. Furthermore, a dynamic inertia control loop, disturbance control function and a load shedding controller have been developed to enhance the flexibility of the test system.

2. **Adapted 36-Zone GB Model:** 'Adapted' implies that this is now a 26-Zone GB Model as Scotland has been modelled as a single zone. At each zone of this model there is a synchronous generator, load and a controllable current source model. The total generation and demand data at each zone is acquired from the National Grid 36-Zone GB Model in DIgSILENT PowerFactory software and can be modified based on different penetration scenarios. The current source is modelled to mimic different renewable energy behaviour. The capacity, ramping rate and other responses can also be changed.

The University of Strathclyde

The University of Strathclyde team has been working continuously on preparing the tests of the EFCC scheme using facilities at the Power Networks Demonstration Centre (PNDC).

A five-region reduced Great Britain (GB) transmission network model in RTDS, developed at Strathclyde, has been refined and tuned using historical data from incidents on the GB network recorded using PMUs. This model has been used, together with a new version of the 36-Zone GB network model in DIgSILENT PowerFactory developed by National Grid, to conduct various studies of events that impact on system frequency. The simulation results have been used to create credible test scenarios presented in the academic test proposal. This specifies the test activities that will be carried out at the University of Strathclyde and the University of Manchester and the test proposal has now been finalised.

Another main focus of the University of Strathclyde team in the past six months has been to set up a Power-Hardware in the Loop (P-HiL) testbed at PNDC as shown in Figure 1. The team has learned a lot from this, in terms of how the power system responds to disturbances, how P-HiL can be set up to reflect dynamic events accurately and how it can be used to test EFCC and other similar schemes. This learning is detailed in a paper that has been submitted to the IEEE for the General Meeting of the Power and Energy Society in 2017 – http://pes-gm.org/2017/.

The P-HiL configuration interfaces and synchronises the RTDS network model with the PNDC 11kV network through the motor generator set. Various frequency events can be simulated in the RTDS network model and the load banks at PNDC will be used as the controllable resources that are controlled by the EFCC scheme. The EFCC scheme will receive real time measurement signals from both the RTDS model and the local PMU interfaced to the actual network at the PNDC using the IEEE C37.118.2 protocol. This is an extremely realistic environment.

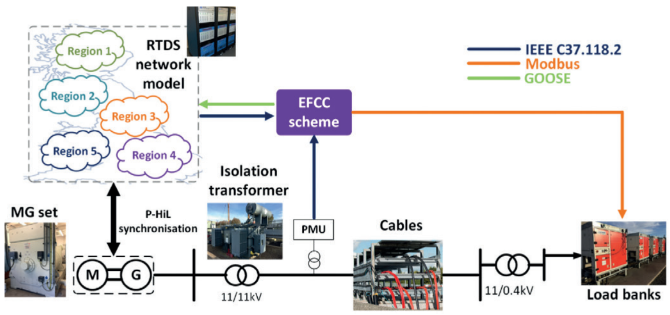
When an event is detected, the EFCC scheme, via the local controller, will send control commands to the resources modelled in RTDS using IEC 61850 GOOSE messaging and to the actual PNDC load banks using Modbus. The P-HiL configuration allows testing of the EFCC system's capability to detect the events in a timely way; to verify that the EFCC scheme instructs the correct amount of resource at the correct time and allows the team to assess how effective controls are in helping to manage frequency in a highly flexible and realistic environment.

Lessons learned from the test programme will be significant and will be reported via EFCC project reports, at EFCC dissemination and stakeholder engagement events, at international conferences and in peer-reviewed journal publications.

A core element of activity and learning in creating the P-HiL configuration centres on the control of the motor generator set for synchronising the RTDS model and the PNDC network. The University of Strathclyde team has developed a dedicated control algorithm to do this and it has been tested in simulation and through actual preliminary tests using the hardware.

With the communication links using the various illustrated protocols established and measurement and data recording devices in place, presently the team is working to validate the algorithm in hardware for full implementation of the testbed. The next phase of the work will also include the installation and commissioning of the EFCC devices when they are delivered and conducting tests of the EFCC scheme using the P-HiL testbed.

Figure 1
Proposed P-HiL testbed at PNDC



Finally, the University of Strathclyde is supervising a final-year undergraduate project to simulate and evaluate the impact of EFCC type schemes in several power system scenarios. Any useful reports and information from this project will be circulated to the EFCC project team.

Work Package 6: Commercial

The full development of the EFCC commercial service is due to formally start in January 2017 and work will be undertaken by National Grid and the University of Manchester. The work package will also require close collaboration with GE Grid Solutions given the potential impact on the optimisation algorithm.

The work package will focus on how the commercial service could be developed and offered to the industry. It will also draw on recent EFR experience where appropriate.

Work Package 7: Communications

The project continues to consider the requirements for the communications infrastructure to support the GE Grid Solutions' monitoring and control system. This will be developed throughout the next reporting period and the remainder of the project.

The wide area monitoring system (WAMS) being developed by the NIC VISOR[6] project, which is considering the visualisation of real-time system dynamics using enhanced monitoring, is an input into the EFCC project. It provides infrastructure and system parameter data.

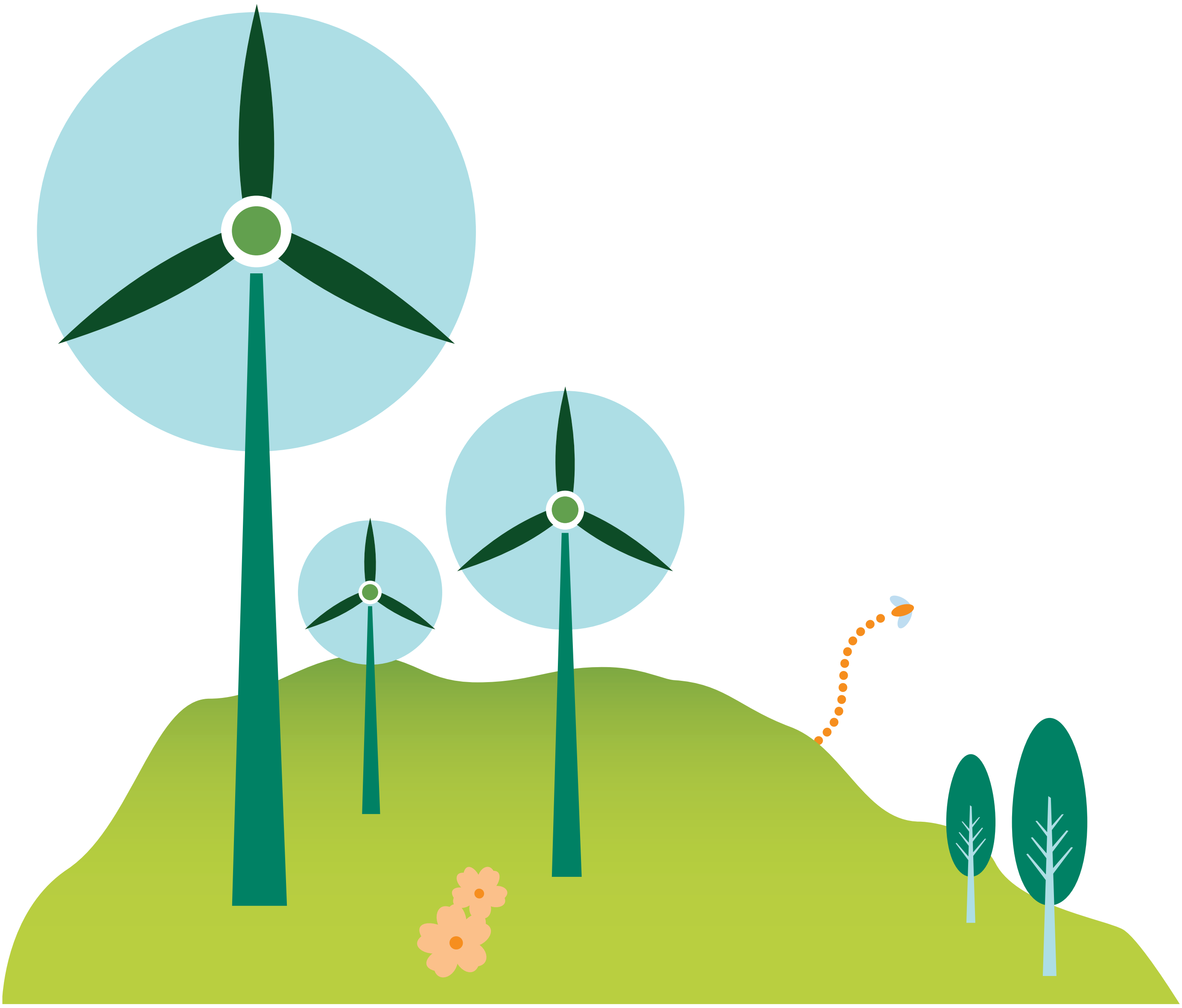
[6] http://www.spenergynetworks.co.uk/pages/visor.asp

However, VISOR is for monitoring purposes only. This means a key challenge is ensuring the necessary communications reliability and robustness for EFCC to facilitate the control of response providers and prevent system instability.

Demonstrations at the University of Manchester and the University of Strathclyde's Power Networks Demonstration Centre (PNDC), which form part of Work Package 4: Validation, will investigate communications latency and the capabilities of fast round-trip control of the scheme.

National Grid will also carry out a demonstration of GE Grid Solutions' monitoring and control system utilising the central supervisor, regional aggregator and local controller units.

In parallel, National Grid has identified substations where new PMUs can be installed to increase the visibility of real-time system information on the transmission network. Further system access for equipment installation and commissioning is being considered and detailed engineering is being undertaken.



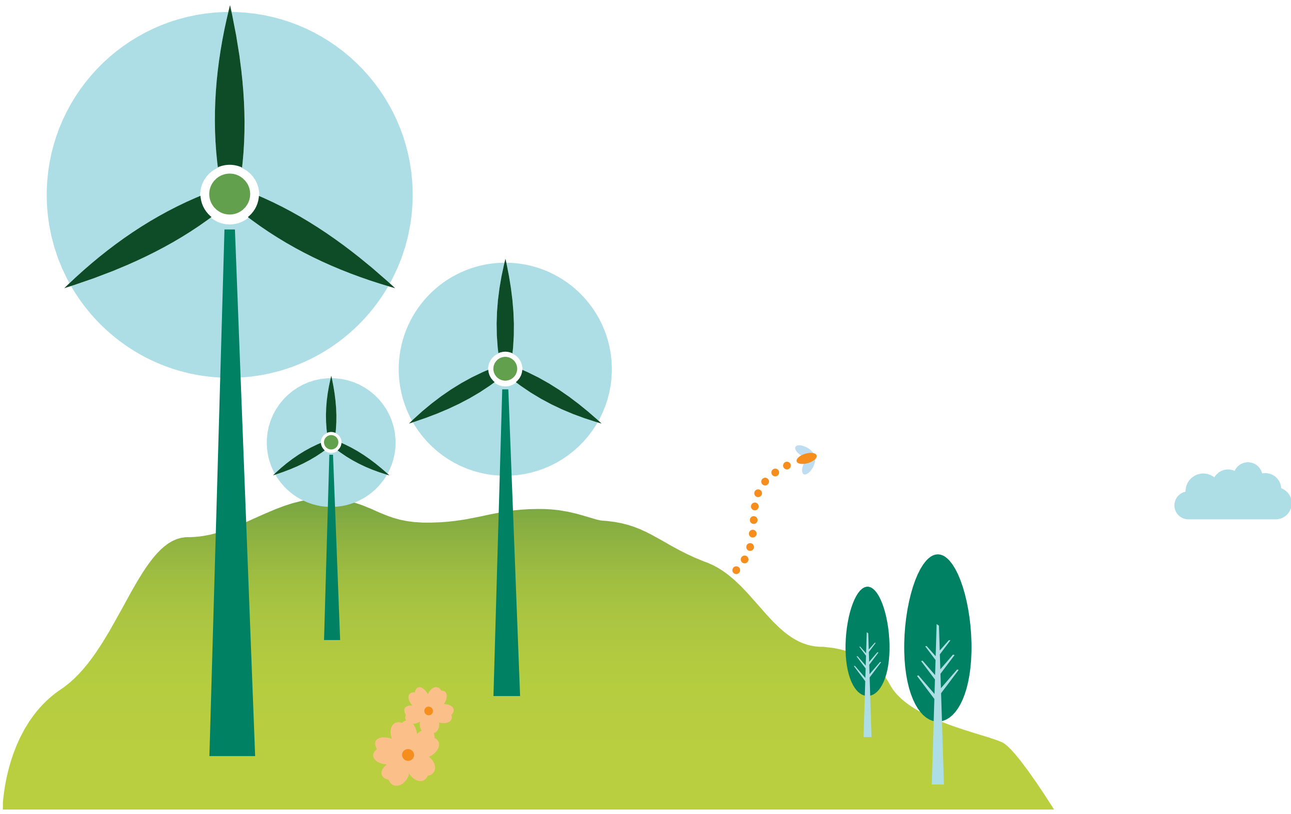
Intellectual property rights

To meet the requirements to publish intellectual property (IP) developed within this project, GE Grid Solutions will make versions of their reports and documents available on the project microsite where possible. Full versions of these will be shared with all project partners as part of the multi-party contract that was signed. This approach to the review and publication of background and foreground IP will be repeated on all documents produced during the project.

Risk management

Current risks

Project risks are being monitored and reviewed on a regular basis by all project partners. Key risks for this reporting period have been included below and a full risk register can be found in Appendix C of this report.



Risk management cont.

Table 6
Current risks

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
5	General	Significant changes to the GB electricity system during the life of the project.	Priorities or strategies for planning and managing the GB system may change.	Solution may no longer be suitable. Assumptions may no longer be accurate or appropriate.	Project Manager	5	3	5	25	Steering Group	We have fully considered future developments and scenarios. We have ensured usefulness of solution matches planning of system.	Partially Effective
6	General	Critical staff leave National Grid or our project partners during project lifecycle.	Usual and unavoidable staff turnover results in key staff leaving National Grid or our project partners.	Progress of the project is delayed. The expertise to deliver the project is no longer within the project team.	Project Manager	5	2	3	15	Steering Group	Knowledge of, and responsibility for, project to not rely with one person. Ensure documentation and guidance exists to assist anyone joining project team. Thorough handover processes to be in place.	Partially Effective
34	WP 2.1 – DSR	Flexitricity is unable to provide participants for planned trials.	Timing, risk and commercial terms makes it difficult to recruit DSR participants.	Trials are limited or unable to take place. The suitability and performance of the technology is not established.	Flexitricity	3	3	3	9	Project Manager	Participants provided for planned trials. Residual risk is that sites withdraw or unable to find company to sign up for dynamic RoCoF trials.	Partially Effective
56	WP 2.5 – Wind	EFCC project needs to agree with DONG and Siemens and associated Joint Venture partners for the use of a windfarm.	Delay in agreeing use of windfarm.	Delays to work package and overall project outcomes.	National Grid	4	3	5	20	Project Manager	Agree schedule of tests and activities early in the negotiation process and commence contractual discussions in parallel. Contractual discussions taking place and approaching completion.	Partially Effective
58	WP 1 – Control System	4-20mA interface.	4-20mA currently not part of TPSA Product Roadmap due to other priorities.	Full 4-20mA interface not ready for demonstration testing.	GE Grid Solutions	2	3	2	6	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to 4-20mA. Successfully tested.	Effective
59	WP 1 – Control System	Digital interface not ready for testing.	Capabilities digital interface limited. Alternative hardware solution required if more than six digitals required. Product enhancement required within TPSA Product Roadmap.	Full digital interface not ready for demonstration testing if more than six digitals required.	GE Grid Solutions	2	3	2	6	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to digital for setups requiring more than six digitals. Successfully tested.	Effective
62	WP3 – Optim-isation	Revised timeline for University of Manchester affects work deliverables of the project.	The University of Manchester's deliverables slipping due to delays in project recruitment and acquiring the appropriate tools for the systems studies.	Timeline for work deliverables compromised.	Project Manager	4	3	4	16	Steering Group	Revised project timeline agreed with the University of Manchester with associated project dependencies identified and managed.	Partially Effective

Assurance statement

This EFCC progress report has been produced in agreement with the entire project hierarchy. The report has been written and reviewed by all project partners. The report has been approved by the EFCC Steering Committee and by Graham Stein, Electricity Policy and Performance Manager on behalf of Richard Smith, the project sponsor. Every effort has been made to ensure all information in the report is true and accurate.

Appendix A: EFCC project plan

		July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
WP 1 Monitoring and Control	**GE** – Control Platform Development	Controller testing											
	GE – Demonstrations	Deliver hardware to partners						Demonstration 2 – RTDS					
			Demonstration 1 – GE							Demonstration 3 – PNDC			
										Demonstration 4 – System tests			
	GE – Application Development							Application revision					
	Manchester University – Academic Testing	System studies of the MCS using an appropriate GB network											
WP 2 Assessment of response	**Flexitricity** – DSR	Engage with users						Test MCS communication and response capability					
	Centrica – Large Scale Generation	Engineering design			Implement engineering changes								
	Belectric – PV power plant	Install equipment			Test communications			Test and demonstrate response capability					
	Dong / Siemens – Wind	Contract negotiations				Asset integrity impact assessment							
WP 3 Optimisation	**University of Manchester** – System studies	Development of a co-ordinated supervisory control strategy, system studies of the co-ordinated supervisory control strategy											
WP 4 Validation	**Universities** – Validation of Monitoring and Control Scheme	HiL validation of the MCS											
	Universities – RTDS/PNDC Testing	RTDS / PNDC testing of the individual responses of various EFCC-enabled sources / loads											
	Universities – Validate Supervisory Control				Validation of the co-ordinated supervisory control								
WP 5 Dissemination	**All Partners**	Ongoing dissemination											
WP 6 Commercial	**National Grid / GE**	Investigate commercial opportunities											
	National Grid / University of Manchester							Valuation of new balancing service, develop commercial balancing service					
WP 7 Communication	**National Grid**	Compliance process, balancing system evaluation, contingency plan evaluation, communications evaluation											

Appendix C: Project risk register, risk management and contingency plans

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
2	General	Partners leave project before completion.	Decision is taken by partner to leave the project. Reason could be commercial, operational, etc.	Work is lost or unable to commence and the usefulness of the project's results is reduced or project is delayed.	Project Manager	3	2	4	12	Steering Group	Ensure thorough contracts in place. Procurement processes have considered ongoing size and reliability of partners. Project management is engaging with partners to resolve issues.	Partially Effective
3	General	Estimated costs are substantially different to actual costs.	Full scope of work is not understood. Cost estimates are not validated. Project is not managed closely.	Overspend requiring Ofgem change request approval.	Project Manager	4	3	2	12	Steering Group	Ensure cost estimates are thorough and realistic and reflect full scope of work. Estimates validated based on tenders and market knowledge. Contingency included.	Partially Effective
4	General	Material costs increase.	The cost of materials rises for unforeseen circumstances.	Potential project funding gap. Alternative funding is required or the project scope is reduced.	Project Manager	3	2	3	9	Steering Group	Each partner to assess cost of equipment for ongoing basis and provide change requests for additional spend.	Partially Effective
5	General	Significant changes to the GB electricity system during the life of the project.	Priorities or strategies for planning and managing the GB system may change.	Solution may no longer be suitable. Assumptions may no longer be accurate or appropriate.	Project Manager	5	3	5	25	Steering Group	We have fully considered future developments and scenarios. We have ensured usefulness of solution matches planning of system.	Partially Effective
6	General	Critical staff leave National Grid or our project partners during project lifecycle.	Usual and unavoidable staff turnover results in key staff leaving National Grid or our project partners.	Progress of the project is delayed. The expertise to deliver the project is no longer within the project team.	Project Manager	5	2	3	15	Steering Group	Knowledge of, and responsibility for, project to not rely with one person. Ensure documentation and guidance exists to assist anyone joining project team. Thorough handover processes to be in place.	Partially Effective
7	General	Quality of technology is insufficient – i.e. the monitoring and control system and/or equipment installed at response sites.	The least-cost option is taken ahead of quality and reliability considerations; quality control insufficient at suppliers.	The solution offered is not reliable and commercial opportunities will be reduced. Costs are incurred through delays and replacements.	All Partners	3	3	3	9	Project Manager	All partners have been assessed based on reputation, track record and responses to NG tender. Ensure that price is not the prioritised criteria. Ensure quality control procedures are in place and followed throughout project.	Partially Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
8	General	Technology cannot be easily upgraded.	Monitoring and control technology and/or response equipment is designed without full consideration for future developments.	Technology is less useful in the future as the electricity system continues to develop. Required upgrades are costly or not possible.	GE	4	2	3	12	Project Manager	Future requirements considered and built into specification. Flexibility has been built in.	Partially Effective
9	General	Costs of solution over lifetime are high.	Full cost of solution is not considered and/or understood.	Future usefulness and commercial opportunities of solution are restricted.	Project Manager	3	3	3	9	Steering Group	Full long-term costs of solution have been considered as part of detailed Cost Benefit Analysis calculations.	Partially Effective
11	General	Component failure during project.	Equipment will be run in new ways and therefore may experience problems or failures.	The equipment may require repair or replacement. The tests may be delayed.	Belectric, Centrica, GE, Flexitricity	3	3	3	9	Project Manager	Thorough checks before tests. Clear understanding of equipment capabilities. Particular stress points identified. Spare parts and repairs lined up.	Partially Effective
12	General	Strategic Spares Policy.	Spares Policy for new technology may not be suitable when taking all risks into account.	If suitable spares are not identified and available, the risks of losing the PMU/Controller in the network may reduce effectiveness of project.	National Grid	3	3	3	9	Project Manager	Contingency plans will be drawn up to include potential alternative monitoring locations which could be used in the event of equipment and/or communications failure for continued operation. Off-the shelf products that are readily replaceable are used. The proposed structure will contain a number of PMUs in each zone which should allow continued supervisory actions with the loss of a device. For the controller, redundancy will be planned for to ensure the loss of the controller is suitably backed-up.	Not Effective
13	General	Maintenance requirements.	Manufacturer recommends intensive and regular maintenance activities which do not fit with project owner's expectations.	Regular intensive maintenance requires additional resource of field staff and potentially affecting the network operation thus reduce power transfer levels and potential constraint costs.	National Grid	3	3	3	9	Project Manager	Seek to work with the manufacturers to understand maintenance requirements and the impact on the design or selection of components. Remote VPN access to controller for remote logging and maintenance, especially for beta release stages.	Not Effective
14	General	Loss of telecommunications.	Technical fault leads to loss of telecommunications between systems.	Reduced availability and performance.	National Grid	3	3	4	12	Project Manager	Design scheme for continued operation or graceful degradation in the event of a loss of telecommunications.	Partially Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
15	General	Inefficient operation of MCS.	MCS not configured correctly which results in spurious tripping or excessive amounts of control initiation commands.	Over-response from resources reducing stability, excessive set-point changes in generators reducing asset lifetime.	National Grid	2	3	4	8	Project Manager	The scheme will be extensively tested in a laboratory environment before any network deployment. The system will also be evaluated using recorded measurements from the GB systems allowing tuning and configuration in a safe environment. Academic partners will also provide suitable facilities to test response on generators to reduce risk to assets after deployment.	Partially Effective
16	General	High operation and maintenance costs.	Cost for inspection, maintenance, repairs, spares, etc. are higher than expected.	Excessive OPEX costs compared to current alternatives.	National Grid	2	1	1	2	Project Manager	Maintenance requirements and spares etc. identified during Tender evaluation. Further work to be carried out to fully determine OPEX requirements.	Partially Effective
17	General	Delays in installing key control scheme components.	Supplier of TO/ TSO delay on Base Install. Delays in implementing control scheme platforms and comms routes to PMUs/ Controllers/ controllable resources. Co-ordination of National Grid and supplier staff availability.	Delays in key control scheme component will push back the trialling period and thus reduce the available time for reports, tuning dissemination.	National Grid	4	1	3	12	Project Manager	Select vendor with track record of commercial WAMS installations. Supplier must have experience of deploying in utility environment. Direct support by supplier via VPN for diagnosis. Comprehensive training by supplier for IT personnel in all three partners in IT requirements of WAMS project.	Partially Effective
18	General	Commun-ications between devices under-performs.	Communication Infrastructure is not fit for purpose.	The existing communication infrastructure may inhibit the speed of response of a control reducing scheme effectiveness.	National Grid	4	5	4	20	Project Manager	Work closely with National Grid and partners to ensure that new comms links are not critical to the project's success. Ensure that the communications infrastructure is well understood and the chosen control scheme can best work with available infrastructure.	Partially Effective
19	General	Outage required for commiss-ioning.	Inability to obtain the relevant outages for commissioning.	Possible delays to commissioning programme, or cost of outage.	National Grid	3	1	3	9	Project Manager	Outages identified and incorporated in Scheme Requirement Document.	Partially Effective
20	General	Commiss-ioning procedures encounter problems.	Commissioning procedures are unclear or untested, being difficult to complete in practice.	Delays in commissioning the project.	National Grid	4	3	4	16	Project Manager	Identify and agree all the commissioning procedures with the supplier for the new technology, and the problems that might be encountered.	Partially Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
21	General	Capital costs.	Costs higher than anticipated.	Project budget exceeded.	National Grid	2	1	2	4	Project Manager	Proactively managing the finance budget to ensure that it stays within original project budget.	Partially Effective
22	Health, Safety & Environ-mental	Use of new equipment causes a safety incident.	Lack of experience and knowledge regarding new pieces of equipment.	Health and safety risks present as a result of lack of experience. Inefficient working could result. Note that controller is low voltage equipment, and actions are taken through existing standard protection and control equipment.	Project Manager	2	1	4	8	Steering Group	Specialist tools and training required for maintenance activity. Procedures to be developed and reviewed by all partners SHES consultants. Controller to go through rigorous testing.	Partially Effective
23	WP1 – Control System	Technology partner fails to deliver suitable product on time.	Problems with design and build.	Project is delayed.	GE	1	2	2	2	Project Manager	Contracts to be put in place to penalise delays. Clear specification requirements in place. Development of technology to be closely managed to identify and resolve potential problems. Hardware platform delivered by GE unit in Massy/France. Product commercially available by summer 2015. Assessment of technical suitability completed with positive result. GE management support secured during project approval and project review meetings. A formal collaboration framework with GE internal supplier currently being established/put in place. Product considered suitable for C37.118, IEC 61850, IEC 60780-5-104, Modbus and digitals (up to six digitals). Suitability for 4-20mA and digital captured separately in Risk Register. GE demonstrations of hardware functionality successful demonstrated during Training and Demonstration #1 FAT (Oct 2016).	Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
24	WP1 – Control System	Technical specification lacks the clarity required to deliver the technology, or contains errors.	Requirements not fully understood. Quality control processes insufficient.	The technology developed may not match requirements or be suitable.	GE	2	2	2	4	Project Manager	Care to be taken over technical specification, with input from all relevant partners. Review process in place and then regular communication with GE and other partners to identify and resolve issues quickly. Specifications Event Detection and Control Platform were issued for partner review. Review comments assessed/ discussed during project meetings. Resource Allocation and Optimisation split into two parts, i.e. Functional Specification and Design Report. Formal QA with project partners done. Presentations concepts Event Detection and Resource Allocation during face-to-face Steering Committee meeting. Dedicated workshops for Optimisation with NG and UoM. GE demonstrations of application functionality successfully demonstrated during Training and Demonstration #1 FAT (October 2016).	Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
25	WP1 – Control System	Flexible embedded real-time controller not commer-cially available.	A controller with the flexibility to employ the required algorithm is not currently available and will require significant development effort. Resources must be in place for a timely start to the platform development.	Delays in sourcing suitable resources may extend the development period and delay deployment and trialling of the project.	GE	1	1	2	2	Project Manager	Source suitable development resources in advance of project start date to ensure that timely start can be made to project. Two embedded software developers have been working on the project since January 2015. Hardware platform commercially available from summer 2015 onwards. The project team has two units available for development and test purposes. Bi-weekly meetings with TPSA Massy team to ensure timely delivery of new TPSA boards, BSP upgrades, knowledge transfer and documentation. Tasks, deliverables and issues recorded/tracked in MS Project. 4-20mA currently not in TPSA Product Roadmap. Digital capabilities limited in terms of Board hardware setup and number of digitals available. Proposal to implement Modbus to 4-20mA/ digital convertors and to discuss option product development TPSA in terms of 4-20mA and digital interfaces. GE demonstrations of flexible real-time controller functionality successful during Training and Demonstration#1 FAT (October 2016).	Partially Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
26	WP1 – Control System	Event detection and response algorithms not available on embedded real-time controller.	The controller will use custom functions which are not currently available on the embedded control platform for determining of appropriate reaction. These functions will require development and testing before deployment. New control approaches need to be developed.	Extension required for the development period which adds delays to all consecutive elements of the project.	GE	2	1	2	4	Project Manager	Staged approach to application development with simple initial target in first year. Allow sufficient resources for all stages of algorithm development to ensure that sufficient effort is dedicated to the project at an early stage to avoid any delays and allow for sufficient resource for modification based on the outcomes of the early testing. The project has aimed for early/staged end-to-end testing/demonstration for phasor data concentrator, regional aggregator, system aggregator and event detection. This agile approach has validated/ confirmed system architecture, development strategies and design concepts at early stages and allowed for fine-tuning, when required. Project partners have been provided with regular progress updates and confidence level. Event detection and response algorithms have been successfully tested and demonstrated. Applications will be handed over to academic and commercial partners for simulation testing and technology field trials. Control Platform and Applications are taken into the next phase of the project, i.e. demonstration phase.	Effective

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27	WP1 – Control System	Resource Interop-erability.	Using distributed resources for frequency response is untested in the UK and the availability of resources when called upon is critical. There must exist a sufficient information exchange between the controller and the individual resources so that resources can be called upon in a timely manner.	Lack of comms path or interoperability issues between the controller and the resources may lead to delayed initiation of response and reduced ability of the central control scheme to halt frequency excursions.	GE	2	2	2	4	Project Manager	Agree common standards and offer a simple IO for all controllable components through standard interface protocols which will be agreed upon by all controllable resources. Plan demonstration without critical requirement for communication path to all response providers. Evaluate local control and assess the added benefit that central control brings if made available. Need for different interface protocols to communicate with distributed resources. The concepts of Local Control Units and Central Supervisor have been highlighted during a project partner meeting on 30th April. Specifications Event Detection, Control Platform and Resource Allocation were issued for partner review and comments have been addressed. GE will continue engagement with project partners to discuss requirements and concepts for different WP1 applications. Interface discussions with project partners are ongoing. Interfaces supporting 4-20mA and digital addressed separately.	Effective
28	WP1 – Control System	Resource flexibility.	Resources do not offer enough flexibility for control under proposed control scheme, either offering response which is difficult to quantify or response which is difficult to tune.	May require redesign of the control scheme adding delays to deployment.	GE	3	2	2	6	Project Manager	Collaborate closely with project partners through all stages to ensure that control scheme is designed according to limits of operation of various resource types. Especially, collaboration between GE and academic partners and WP 3 – Optimisation.	Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
29	WP1 – Control System	Control Scheme trial outcome.	Due to the innovative nature of the project, the selected control scheme when trialled may yield negative results, or introduce additional problems.	The selected control scheme will be unable to effectively deploy resources to arrest a frequency excursion.	GE	3	2	2	6	Project Manager	The risk is mitigated by using a number of candidate solutions which will be based on wide-area control, local-control and a hybrid-approach using both. If any problems arise from one candidate solution, other solutions will be readily available.	Effective
30	WP1 – Control System	Controller scalability for roll-out.	The controller will be developed for trial locations using a limited number of sites and corresponding PMU measurements. The control platform may see reduced performance due to increased amounts of measurement and resource data with larger-scale roll-out. An additional risk stems from exceeding the computational capacity of the controller with complex algorithms and increased inputs, e.g. more resources to optimise.	Timely roll-out of the scheme could be put at risk adding significant delays to full effectiveness of the scheme and putting the learning from the project into action. The risk for this stage of the project is minimal.	GE	3	4	2	12	Project Manager	Laboratory testing will allow scalability testing which can be used to test the control platform with a greater number of inputs than will be utilised in trialling. This will both allow the limits of the control platform to be found and define new methods by which to overcome these limits. How to deploy the control system for larger roll-out will then be a learning outcome of the project, minimising the risk of delayed roll-out. Controller development path enables easy porting between hardware platforms – if greater performance required, other hardware solutions will be considered. GE will continue performance testing/ monitoring at different stages throughout the project life-cycle and look into areas for further improvement.	Partially Effective
31	WP1 – Control System	Additional testing and tuning.	The controller may require additional tests and fine tuning based on real system measurements from the UK network to ensure robust operation. Data will need to be gathered over a sufficient period to determine the control scheme performance.	The selected control scheme will be unable to effectively deploy resources to arrest a frequency excursion.	National Grid	2	2	1	4	Project Manager	Information gathered from VISOR can provide an extended period of system measurements. This data can be replayed in the laboratory environment to test the control scheme with real measurements from the UK system to validate the behaviour while also allowing a longer capture period for sufficient disturbances.	Effective

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
32	WP1 – Control System	Data quality.	Inadequate data quality from PMUs due to problems with communications infrastructure, incompatible PMUs or from existing PMUs where experience has shown poor quality data.	Controller Application value and performance reduced.	GE	4	1	1	4	Project Manager	Require proof of prior installations with good data availability. Use PMUs that have evidence of acceptable practical performance, and standards compliance where possible. Applications to be robust to data packet loss. Review of data quality issues and resolution/improvement to be carried out. EFCC algorithms have been designed/developed to deal with data quality issues. Concepts such as confidence level and weighting have been introduced to include additional meta-data and logic to deal with data quality issues.	Effective
33	WP1 – Control System	RoCoF trip risk.	Controllable resources which are called upon to arrest frequency excursion may be conflicted by own Loss of Mains (LoM) RoCoF settings and trip. Also, risk of fast response rolling off at df/dt=0 when it should be sustained.	Loss of effectiveness of resources – unavailable for frequency support or prematurely returned to normal service.	GE	2	1	2	4	Project Manager	For trial purposes, RoCoF should be sufficiently low to avoid conflicts of LoM detection, however studies will be carried out to assess the problem for future roll-out. Project will provide learning outcome which can be used to inform future grid codes. Also, co-ordination of control to ensure smooth transitions between stages of response.	Partially Effective
34	WP2.1 – DSR	Flexitricity is unable to provide participants for planned trials.	Timing, risk and commercial terms makes it difficult to recruit DSR participants.	Trials are limited or unable to take place. The suitability and performance of the technology is not established.	Flexitricity	3	3	3	9	Project Manager	Participants provided for planned trials. Residual risk is that sites withdrawing or unable to find company to sign up for dynamic RoCoF trials.	Partially Effective
36	WP2.1 – DSR	DSR trials prove infeasible.	Complex technical interaction with existing commercial site processes.	Ability of DSR to deliver EFCC not proven.	Flexitricity	2	4	4	8	Project Manager	Pursue three separate technical approaches to spread risk (RoCoF, real inertia, simulated inertia). Investigate technical feasibility for higher risk technical approaches (especially simulated inertia) prior to trials.	Partially Effective

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37	WP2.1 – DSR	Total delay between detection and action too long for distributed resources including DSR.	Long signalling chain including communicating with remote sites.	Cannot dispatch certain resources fast enough.	Flexitricity	2	3	3	6	Project Manager	Include at least one fast-acting technical approach (RoCoF) for DSR, to compensate for other possible signalling delays.	Partially Effective
38	WP2.1 – DSR	Cost of DSR too high for large-scale roll-out.	Controls modifications (especially RoCoF and simulated inertia), spark spread (especially real inertia).	Project does not result in economic source of EFCC from DSR.	Flexitricity	2	3	4	8	Project Manager	Pursue three separate technical approaches to spread risk (RoCoF, real inertia, simulated inertia).	Partially Effective
39	WP2.1 – DSR	DSR deployment lead time too long.	Normal delays in dealing with industrial and commercial energy users.	Unable to operate trial for sufficient time; some customers are ready too late for trial.	Flexitricity	3	3	3	9	Project Manager	Commence EP recruitment during phase 1; show flexibility on trial dates and durations.	Partially Effective
40	WP2.2 – Large-Scale Gener-ation	CCGT operators struggle to get relevant technical input from OEM.	Lack of communication or timely response from OEM.	The project is delayed.	Centrica	2	2	2	6	Project Manager	Draw up 'heads of terms' with OEM. Pay OEM (from funding) for relevant technical input.	Partially Effective
41	WP2.3 – PV Power Plant	Bad weather (low irradiation).	Poor weather conditions will mean that trials cannot take place.	Insufficient test conditions will lead to delays in testing.	Belectric	3	1	1	3	Project Manager	Plan tests accordingly.	Partially Effective
44	WP3 – Optim-isation	Detailed models of the various technology types are not made available to academic partners for system studies.	Poor communication and project management. Possible restrictions on data.	Without detailed technology models, any optimised control scheme will be based on generic assumptions about technology capabilities which may not be accurate. As such, true performance will not align with simulated performance.	Univers-ities	2	2	3	6	Project Manager	Detailed model of Doubly Fed Induction Generator (DFIG) is created in PowerFactory for system studies. Service providers modelling is on-going.	Partially Effective

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45	WP4 – Validation	Unable to model the UK network with sufficient detail using the RTDS facilities in order to thoroughly validate proposed control solutions.	Lack of required data. Lack of expertise on project.	Wide scale roll-out may be severely impacted by issues not flagged during the validation phase.	Univer-sities	2	3	3	6	Project Manager	Reduced substation model of GB system has been simulated and modelled in RTDS. The required data are extracted from PowerFactory model and then RTDS model has been built.	Partially Effective
46	WP5 – Dissem-ination	Knowledge gained from project is not adequately shared with industry and other interested parties.	Lack of resources dedicated to dissemination. Failure to deliver events, website, etc.	A major benefit of, and reason for, the project is lost. Performance of solution and lessons learned are not shared.	Project Manager	1	1	5	5	Steering Group	Ensure knowledge sharing is a priority of project. Establish formal processes to disseminate results, reports, etc. Use working group, internet, academic partners to facilitate sharing.	Partially Effective
47	WP6 – Comm-ercial	Market for EFCC not taken up by possible resource providers.	Knowledge not disseminated, meaning providers unable to prepare. Commercial arrangements not attractive.	The successful roll out of the solution will be delayed.	Project Manager	3	4	4	12	Steering Group	Ensure that knowledge is shared. Establish clear communication channels with interested parties. Develop commercial terms thoroughly prior to roll out.	Partially Effective
48	WP1 – Control System	Demon-stration partner fails to install and configure demon-stration setup in time for SAT.	Challenges encountered during installation and configuration or lack of understanding/ training.	Demonstration is delayed with likely impact on other activities.	GE	3	1	1	3	Project Manager	GE will provide PMU/ MCS training during Demonstration 1 timeframe (combined with FAT). GE support effort during installation has been quantified for the different demonstration phases. Scope of works, functional design specification and system design specification will be produced as input to partner installation activities. Demonstration #1 has been successfully completed.	Partially Effective
49	WP1 – Control System	PMU/MCS Hardware Delivery.	Late delivery of PMUs and/or MCS controllers.	Demonstration is delayed with likely impact on other activities.	GE	2	1	1	2	Project Manager	Ensure early engagement with suppliers and project stakeholders to ensure delivery and installation as per project schedule. PMU hardware delivered to site. Controller hardware available for configuration in Edinburgh.	Partially Effective

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50	WP1 – Control System	Number of interface protocols impacts develop-ment and testing effort.	Project partners decide on multiple interfaces and/or different messaging protocols.	Extra design, development and testing effort required with impact on project delivery timelines.	GE	2	1	2	4	Project Manager	Interfaces developed and tested. Development and testing has been impacted due to extra scope and complexity. Milestone Testing Control Platform missed. Interim report issued and control platform testing extended by one month. Final report issued to project partners end of Sept 2016. Overall timelines respected and Demonstration Phase as planned.	Effective
55	WP1 – Control System	Number of Phasor-Controller applications	Concept design frequency control has identified potential for the following controller applications: - Local Phasor-Controller for system aggregation, fault detection, event detection and resource allocation - Regional Controller for regional aggregation and fault detection - Central PhasorController for management and distribution of configuration data (settings, thresholds, parameters).	Dependent on demonstration schemes envisioned, extra hardware may be required. Extra effort may be required for development, configuration and testing of extra Controller units.	GE	3	2	3	6	Project Manager	Number of applications and control platform capabilities have been defined and verified. Demonstration #1 has proven working concept.	Effective
56	WP2.5 – Wind	EFCC project needs to agree with DONG and Siemens and associated Joint Venture partners for the use of wind farm.	Delay in agreeing use of wind farm.	Delays to work package and overall project outcomes.	National Grid	4	3	5	20	Project Manager	Agree schedule of tests and activities early in the negotiation process and commence contractual discussions in parallel. Contractual discussions taking place and approaching completion.	Partially Effective

Appendices cont.

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58	WP1 – Control System	4-20mA interface.	4-20mA currently not part of TPSA Product Roadmap due to other priorities.	Full 4-20mA interface not ready for demonstration testing.	GE	2	3	2	6	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to 4-20mA. Successfully tested.	Effective
59	WP1 – Control System	Digital Interface not ready for testing.	Capabilities digital interface limited. Alternative hardware solution required if more than six digitals required. Product enhancement required within TPSA Product Roadmap.	Full digital interface not ready for demonstration testing if more than six digitals required.	GE	2	3	2	6	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to digital for setups requiring more than six digitals. Successfully tested.	Effective
61	WP2.5 – Wind	Revised timeline for wind workpack does not coordinate with the other workpacks.	Delays caused by the length of time to sign new partner contracts and unforeseen model data validation issues.	Wind test findings not being available in time for meaningful inclusion in the project conclusions & recommendations.	Project Manager	4	3	4	16	Steering Group	Work with partners to identify and resolve contractual issues and escalate modelling issues as appropriate.	Partially Effective
62	WP3 – Optim-isation	Revised timeline for University of Manchester affects work deliverables of the project.	The University of Manchester's deliverables slipping due to delays in project recruitment and acquiring the appropriate tools for the systems studies.	Timeline for work deliverables compromised.	Project Manager	4	3	4	16	Steering Group	Revised project timeline agreed with the University of Manchester with associated project dependencies identified and managed.	Partially Effective
63	General	General back loading of deliverables in the project.	Slippage against baseline for deliverables.	Comprising of scope of deliverables and quality of deliverables.	Project Manager	4	3	4	16	Steering Group	NGET and partners monthly review of planned deliverables, identifying any issues with delivery, investigating alternatives and escalating to Steering Group.	Partially Effective
64	General	Handoffs between partners are delayed.	Handoffs are not clear in the plan or not proactively managed to ensure the planned timeline is kept.	Delays compromising other work deliverables.	Project Manager	4	3	3	12	Steering Group	Dependency management planning included as standing agenda item at Steering Group meetings, where handoffs with dates are confirmed or issues managed around delivery are discussed and solutions identified.	Partially Effective
65	WP4 – Validation	System testing is delayed.	Additional trial equipment requirements identified, which are not immediately available to source.	Delay in testing phase, knocking on to delaying the general project timeline.	University of Manch-ester	4	3	3	12	Steering Group	Escalation to Steering Group for discussion and resolution.	Partially Effective

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66	WP2 – All	Test programme and schedule not clearly defined.	Test programme format not clearly defined, impacting scheduling of commercial trials.	Delays in test plan starting and quality of test outputs.	Project Manager	3	3	3	9	Steering Group	Escalation to Steering Group for discussion and resolution.	Partially Effective
67	WP2.2 – Large-Scale Generation	Trial timeline delayed due to potentially volatile market prices.	Recent high market prices creates reluctance to carry out non-essential work on plant.	Centrica delays testing programme.	Centrica	3	3	3	9	Project Manager	Centrica mitigation is that work is low risk and may be delayed a week or two if prices are exceptionally high at the time of planned works.	Partially Effective

Closed risks

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Risk owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
10	General	Academic service providers are unable to recruit appropriate staff to work on the project.	Lack of suitable candidates or interest in the project.	Trials are limited or unable to take place. The suitability and performance of the technology is not established.	Academic Project Manager	1	1	1	1	Project Manager	Academics have a large internal candidate-base of experienced Post Doctoral Research Assistants. Reputation and facilities of partners will attract high-calibre candidates. Process for advertising for suitable candidates is progressing. For UoM, a PhD student has been assigned. The expected RA is due to start in January, subject to visa approval. Student already recruited for UoS. Closed May 16. As relevant recruitment has taken place and staff are in situ.	Effective
35	WP2.1 – DSR	DSR recruitment: industrial and commercial electricity customers unwilling to participate.	I&C energy managers' workloads, comprehension of the proposition, duration of trials, uncertainty of long-term commercial service, and opportunity cost.	Ability of DSR to deliver EFCC not proven.	Flexitricity	4	2	4	16	Project Manager	Use Flexitricity's extensive existing customer base and contracting process for recruitment. Risk Closed merged with risk 34.	Effective
42	WP2.4 – Storage	Delayed installation and commissioning due to local problems.	Issues around grid connection and accessibility cause delays.	The project is delayed.	Belectric	3	2	3	9	Project Manager	Careful and detailed up-front planning; project plan not too tight. Closed as workpack 2.4 is descoped.	Effective
51	WP2.4 – Storage	OFGEM needing to accept storage in 'Smarter Frequency Control'.	Insufficient argumentation in front of Ofgem.	Storage combined with PV not part of 'Smart Frequency Control'.	NG/ Belectric	2	3	3	12	Project Manager	Prepare justification for battery storage to Ofgem. JAN 16 OFGEM NOT AGREED TO FUND THEREFORE ALTERNATIVE SOLUTIONS ARE BEING SOUGHT including a NIA proposal.	Effective

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52	WP2.5 – Wind	EFCC project needs to agree with all Joint Venture partners for use of Lincs, Lynn or Inner Dowsing.	Delay in agreeing use of wind farm.	Delays to project.	Project Manager	1	1	1	1	Steering Group	Communication taking place with Dong and Siemens. Risk Closed merged with risk 56.	Effective
57	WP1 – Control System	Number of Phasor-Controller applications	Concept design frequency control has identified potential for the following controller applications: - Local Phasor-Controller for system aggregation, fault detection, event detection and resource allocation - Regional Controller for regional aggregation and fault detection - Central Phasor-Controller for management and distribution of configuration data (settings, thresholds, parameters).	Dependent on demonstration schemes envisioned, extra hardware may be required. Extra effort may be required for development, configuration and testing of extra controller units.	GE	3	2	2	6	Project Manager	GE will further develop Controller concepts and schemes. GE will work with project partners to establish suitable demonstration setups. Impact assessment will be conducted to assess potential extra requirements in terms of hardware and/ or effort. Project partners to confirm/ justify number of controller with National Grid. GE to plan procurement internally. Closed partners confirmed number of controllers.	Effective

nationalgrid

National Grid
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

www.nationalgrid.com