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Enhanced Frequency Control Capability (EFCC)

Progress report January – June 2016

GE BELECTRIC centrica Flexitricity MANCHESTER 1824 The University of Manchester University of Strathclyde Glasgow

Contents

Executive summary

As Britain's electricity sector becomes increasingly decarbonised, traditional thermal power stations are closing and the amount of new generation technologies, such as wind and solar photovoltaic (PV), on the network is rising. This creates a number of challenges, which are laid out in National Grid's System Operability Framework (SOF). Among these is the fact that thermal power stations have traditionally provided inertia, which acts as a natural aid to maintaining system frequency. New generation technologies don't typically provide this inertia, which increases the risk of rapid changes in frequency.

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 systems. It aims to explore how new technologies, such as battery storage, solar PV, demand side response (DSR), wind, and different modes of operation of combined cycle gas turbines (CCGTs) can help keep the transmission system stable in the most cost-effective and efficient way. Commercial incentives and products will also be developed to encourage the widest participation in a new market for fast frequency response.

Summary of Progress (January 2016-June 2016)

In this reporting period, the focus has been on the further development of the monitoring and control system (MCS). In summary:

- Significant progress was made against the objectives of Work Package 1. The completion of the resource optimisation algorithm, which is central to the co-ordination of the scheme, means the MCS now has the capability to coordinate a diverse range of response resources and maintain a stable system in an optimum way.
- Further progress has also been made against the objectives of Work Package 2, which measures the response potential of different providers (such as wind and solar PV). National Grid has continued working with DONG Energy and Siemens to develop an agreed approach to demonstrate a wind farm's ability to provide fast, initiated frequency response. Flexitricity have also learned that Combined Heat and Power's (CHP) participation in spinning inertia appears to be feasible and continues to populate their customer portfolio for participation in EFCC trials. Centrica have also successfully simulated faster response on their CCGTs.
- Progress has also been made on Work Package 6. Grid Solutions produced a discussion paper proposing a market approach for EFCC that also incorporates feedback from industry stakeholders. Commercialisation of concepts around speed of response, geographical location of response and real inertia have been put forward for further discussion within the project.
- The project team continued to share its ongoing learnings. A highlight was the project's first knowledge-sharing event, held in Birmingham on 25th February. More than 140 people from a broad range of stakeholders attended and provided valuable feedback, which is likely to influence our thinking moving forward.

The biggest change we faced in this reporting period was Ofgem's decision to decline funding for a new battery storage unit. In summary:

- We strongly believe that battery storage has an important role to play in providing rapid frequency response and the team is now exploring new ways of keeping battery storage within the scope of the project.

The project team is looking forward to the next phase of the project, which will see the software applications being added to the control system hardware and partner training and site acceptance testing being carried out. Once that's complete the MCS will be ready to share with our partners and we'll begin the validation and demonstration of rapid frequency control.

Project background and business case

The pioneering Enhanced Frequency Control Capability (EFCC) project proposes an inspiring solution to a complex conundrum and promises to save National Grid and its customers up to £200m a year. At the heart of the issue lies something called system inertia – the resistance of an object to any change in motion. Today's large, rotating power generators provide lots of inertia, which can be released into the system to keep the transmission network stable. Inertia also provides a natural aid to achieving frequency stability – the vital balance between power supply and demand which National Grid has a licence obligation to control.

However, meeting future carbon reduction targets means increasing our use of renewables, which do not provide inertia. The resulting reduction in system inertia is known to increase the risk of rapid changes to frequency and the threat of severe faults or blackout. As a result, a greater volume and speed of frequency response will be needed to keep the transmission network stable. Using only existing mechanisms to control frequency response could potentially cost an additional £200m-£250m a year by 2020.

The EFCC project proposes a more sustainable and cost-effective way of doing things by investigating how newer technologies, such as wind farms, solar PV, energy storage and demand side response can play a larger role in maintaining system frequency. Through the development of an innovative wide-area monitoring and control frequency response system, the EFCC project will open the door to more response being provided by newer, more sustainable energy solutions. An appropriate new balancing service will then be developed and rolled out after the project finishes in March 2018.

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 will not be unique to National Grid and will be felt by all system operators. So the results of the trials, and the solutions offered, will be of particular interest to global Transmission System Operators (TSOs). Visit our project microsite to find out more:

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

Project manager's report

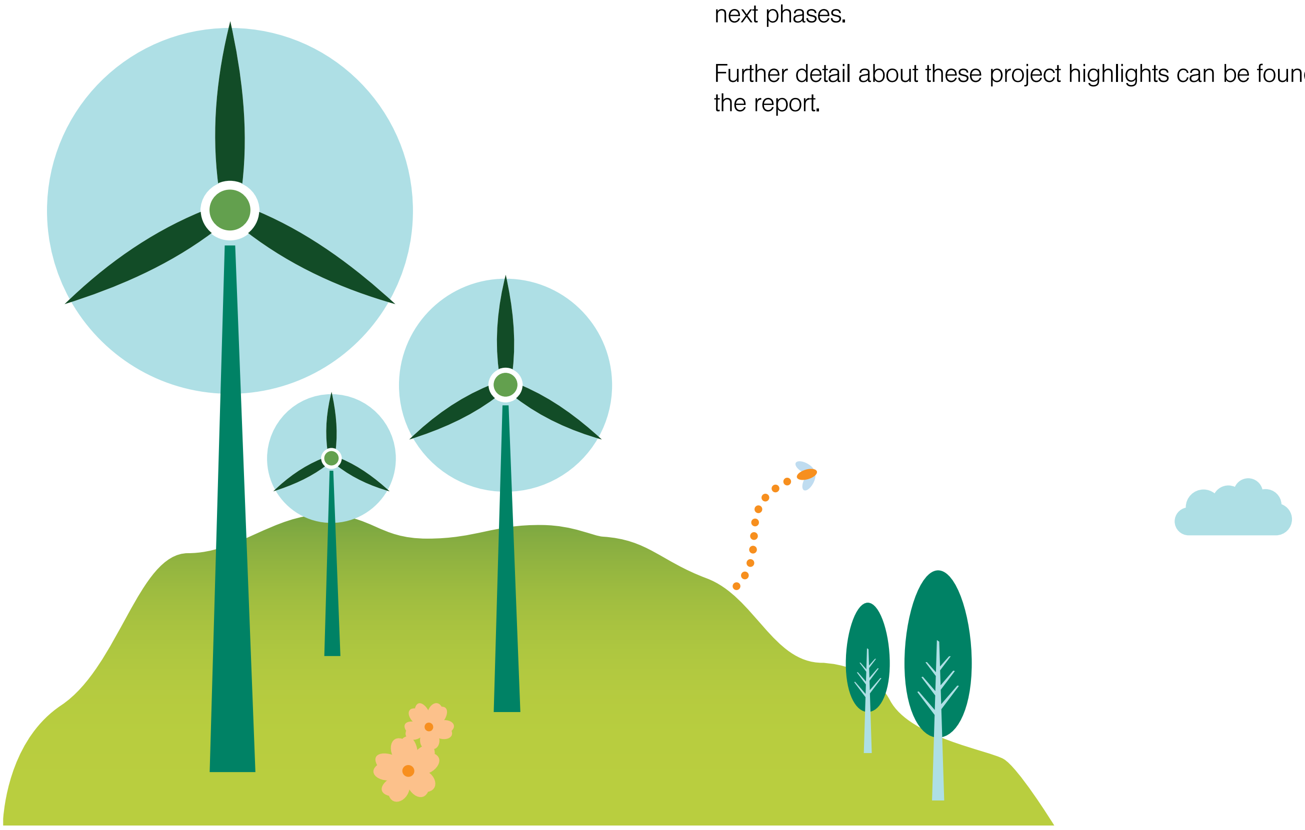
The project received formal approval and the Project Direction in December 2014. This is the third progress report and covers January to June 2016.

During this time, the main activity has been the further development of the monitoring and control system and its functional applications. Grid Solutions (a GE and Alstom joint venture) has met successful delivery reward criteria (SDRC) milestones for the following:

- Resource optimisation algorithm
- Complete testing of developed control system applications
- Complete control platform development

This marks the end of a key stage of development in this work package (Work Package 1, see page 9). The next step will be hardware testing, before the control units are sent out to project partners towards the end of the next reporting period. Validation and demonstrations of rapid frequency response will then begin.

At the start of this period, the project received Ofgem's decision to decline requested funding for a new battery storage unit for combined solar PV and battery storage trials. In our response, we expressed our belief that battery storage can still play an important role in ensuring system reliability. As a result, the team has been investigating new ways of keeping battery storage in the project. Further details are included in the report's business case update section.



In the previous report, we explained that the participation of Lincs wind farm in the project hadn't been confirmed. In this reporting period, we have made progress. DONG Energy and Siemens have been working together and an outline test schedule to demonstrate the capability of wind to provide rapid frequency response has been agreed, along with associated costs. It has been confirmed that the test will not be carried out at Lincs wind farm. Instead, tests are proposed to take place at two separate wind farms using different wind turbine technologies. This will greatly increase our opportunities to learn what can be achieved with wind. Contract discussions have progressed for a three-party agreement between National Grid, DONG and Siemens. As previously reported, it hasn't been possible for Grid Solutions to develop a control system hardware communications interface with the wind turbine. Instead, the project is exploring how rate of change of frequency (RoCoF) values could be used to demonstrate rapid frequency response.

The previous report also highlighted that a significant delay in signing a formal multi-party contract had left the University of Manchester unable to recruit a PhD student and Research Assistant for the project. Both have now been appointed and their activities are being reviewed to ensure they balance the full scope of the project with its required outcomes. At this stage, there is no impact to the SDRC due on 1st November 2017.

The project held its first knowledge-sharing event on 25th February in Birmingham. It was a big success, with more than 140 people from a broad range of stakeholders attending. The entire project team and external partners took part, sharing everything they'd learned so far. The team also used the opportunity to gather valuable feedback from the industry experts who attended. This will be fed back into the project and could influence our thinking and methodology in the project's next phases.

Further detail about these project highlights can be found later in the report.

Project steering committee

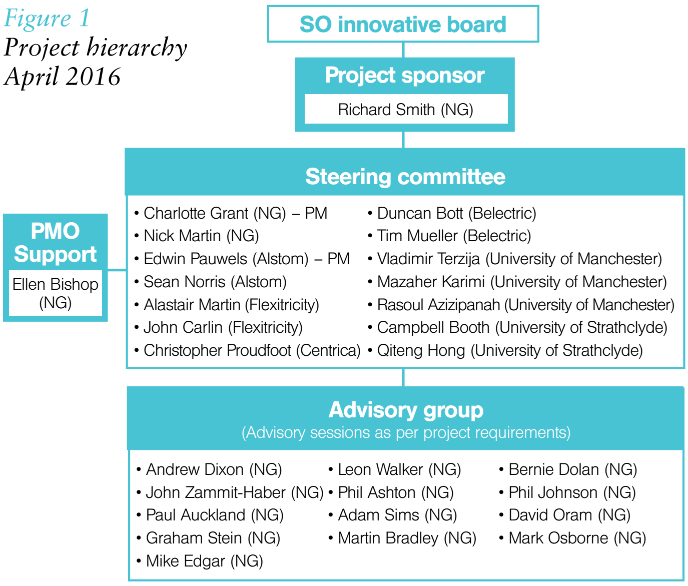
The Steering Committee is responsible for developing and agreeing project activities, project results, raising, testing and reducing identified risks, and authorising changes to the project plan.

During this reporting period Vandad Hamidi left National Grid. As Project Director, it was Vandad's responsibility to progress the project and communicate key activities to senior stakeholders in National Grid. Following his departure, the business carried out an internal process review and as a result Technical Project Manager Charlotte Grant has taken responsibility for these areas.

National Grid has appointed Ellen Bishop to provide project management support to the Technical Project Manager. Ellen replaces Lisa Cressy.

There have been further changes in the Steering Committee, such as the appointment of a Research Assistant at the University of Manchester, and an updated project hierarchy is shown in Figure 1, below. All existing responsibilities and knowledge have been carefully handed over to the new personnel to ensure there's no impact on the project.

Figure 1
Project hierarchy April 2016



Project steering committee meetings

The Steering Committee continues to hold monthly teleconference meetings to discuss progress, allow risks to be highlighted and managed, and agree actions. A quarterly face-to-face meeting was held on 25th May 2016 at the University of Strathclyde. The team discussed key outcomes from the reporting period and agreed on the coordination and development of work between all parties. These meetings will continue to be rotated between different sites to encourage the widest engagement.

Contract signing and impact to the project

As mentioned earlier, agreeing the terms of a multi-party agreement at the start of the project took longer than expected. As a result, the University of Manchester couldn't begin recruiting for a dedicated Research Assistant and PhD student for the project until after July 2015. These appointments were made in January and February 2016, which is shown in the project hierarchy, above. Progress has continued on Work Package 3 (Optimisation), with our partners carrying out analysis to show the risks of not having coordinated frequency response. Progress is also being made on Work Package 4 (Validation), with the development of scenarios that will be used to test the accuracy of the monitoring and control system. The project team is continuing to monitor and develop targeted analysis scenarios to fulfil the requirements of these work packages. All activities are being reviewed to ensure both the scope and required outcomes of the project are delivered. We believe enough time has been allowed within these work packages to meet our objectives, and at this stage there is no impact to the associated SDRC for Work Package 4. It's worth noting that there is no SDRC requirement for Work Package 3.

Project progress against SDRC milestones

Progress against our SDRC milestones during this reporting period is shown in Table 1, below. Further detail is provided in the SDRC section.

Table 1
SDRC summary for January – June 2016

Description	Due date	Status
Resource optimisation algorithm	31st January 2016	Achieved 29/01/2016
EFCC knowledge dissemination event	31st March 2016	Achieved 25/02/2016
Complete testing of developed control system applications	30th April 2016	Achieved 29/04/2016
Complete control platform development	30th April 2016	Achieved 29/04/2016

Grid Solutions has produced reports following the completion of application testing and the development of the control platform. These documents mark a critical milestone in the evolution of the monitoring and control system. The applications will now be taken forward and implemented into the hardware before the control units are issued to the project partners. This will begin during the next reporting period.

Due to intellectual property restrictions, we can't make all the information regarding the control platform and developed algorithms public. However, versions of both these reports will be published on the EFCC project website.

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.

The table in the appendices 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

We will continue to record and share all the lessons learned throughout the life of the project. Through ongoing reviews and project meetings all learning points are discussed and assessed by our project team and partners. Outcomes and breakthroughs are also shared at conferences, workshops and university demonstration events.

We hosted a hugely successful knowledge-sharing event in Birmingham on 25th February. More than 140 stakeholders from across the industry attended and the whole project team, along with our project partners, delivered a day of interactive sessions sharing their knowledge and insights. Among the stakeholders in the audience were generators, financiers, developers and consultants. With so much expertise under one roof, we were keen to unlock all that value so we encouraged feedback throughout the day. This will be fed back into the project to see how it could influence our thinking and plans going forward.

Project partner Flexitricity has presented the EFFC project to a variety of audiences spanning retail, CHP, industrial generation, energy management and renewable generation, with further knowledge-sharing events planned. The objectives of these are:

- To raise awareness of the project among industrial and commercial energy users and small generation operators
- To recruit businesses to participate in DSR as well as any emerging service that is developed during the project

Flexitricity has also engaged directly with a selection of hand-picked organisations from its base of around 45 contracted customers, as well as with a number of other prospects.

Project reports, such as Grid Solutions' application and control platform documents, which describe the development stage of the control system, are part of the intellectual property developed in the project and will be uploaded onto the project website.

During this reporting period, the following events were attended and publications submitted.

Table 2
Knowledge sharing events January – June 2016

Event/ publication	Date	Organisation	Contribution
EFCC knowledge dissemination event	February 2016	Belectric, Centrica, Flexitricity, GE Grid Solutions, National Grid, University of Manchester, University of Strathclyde	Presentations from all project partners to share project outcomes so far
Industrial power association	March 2016	Flexitricity	Potential for CHP to deliver spinning inertia
Scottish renewables	March 2016	Flexitricity	Renewables and inertia response
Energy management exhibition	March 2016	Flexitricity	Static RoCoF, dynamic RoCoF and spinning inertia opportunities in industrial energy consumption
Retail energy forum	March 2016	Flexitricity	Static RoCoF, dynamic RoCoF and spinning inertia opportunities in retail energy management
Utility week future networks conference	March 2016	National Grid	National Grid presentation on future operability challenges and the role of innovation. Discussion about project objectives and outcomes with representatives from generation and distribution, and technology specialists and consultants

Forecast for next reporting period

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

Table 3
Work package activities for July – December 2016

Work package	Description	Partner	Comments	Status	Timescale
1	Monitoring & control scheme	Grid Solutions	Perform extensive testing on the controller and software infrastructure; design and complete FAT (Factory Acceptance Test)	Green	April 2016 - Aug 2016
1	Monitoring & control scheme	Grid Solutions	Demonstration Phase 1 – specification design including installation diagrams. In parallel, carry out equipment training for all partners (Sept/Oct 2016)	Green	Aug 2016 – Oct 2016
1	Monitoring & control scheme	Grid Solutions/ University of Manchester	Demonstration Phase 2 – installation and configuration of PMUs and control hardware for HiL (Hardware-in-the-Loop) testing	Green	Oct 2016 – Dec 2016
1	Monitoring & control scheme	Grid Solutions/ University of Strathclyde	Demonstration Phase 3 – installation and configuration of PMUs and control hardware for PNDC (Power Networks Demonstration Centre) testing	Green	Dec 2016 – Feb 2017
2.1	Demand side response	Flextricity	Finalisation of list of customers for participation in EFCC. Carry out design modifications to incorporate the control scheme and agree site specific requirements	Red *1	Jun 2016 – Dec 2016
2.2	Large scale generation	Centrica	Finalise specification, engineering and operational design changes and send for technical approval. Start planning and scheduling of demonstration	Green	Jun 2016 – Dec 2016
2.3	PV power plant	Belectric	Ongoing site preparation and installation of switching equipment. Further work required to modify software and control systems to emulate ramp characteristics for frequency response	Amber	Sept 2016
3	Opitimisation	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*2	Amber	Jun 2016 - March 2017
4	Validation	Universities of Manchester & Strathclyde	Implementation of monitoring and control system for HiL and PNDC testing. Begin validation of Grid Solutions' developed system	Green	June 2015 – Sept 2017
6	Commercial	National Grid	Begin assessment of economic value of new rapid frequency service	Green	Jul 2015 – Mar 2018
7	IS communications	National Grid	Continue review of VISOR project and monitor progress of data gathered from existing phasor measurement units. 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

*1 Information as to why this activity has been considered red is provided on Page 10 in Section: Successful delivery reward criteria for the next reporting period.

*2 This activity has been considered amber due to the delay in recruiting Research Assistants. The work package continues to be reviewed to ensure the necessary study analysis is carried out.

Business case update

Battery storage – Work Package 2.4

In our EFCC submission, National Grid requested £1.2m of funding to invest in a new battery storage unit. The aim of this was to explore how a service which combined solar PV and battery storage could benefit the transmission system. Ofgem asked for further cost-benefit analysis to justify the investment.

At the start of this reporting period (January 2016), Ofgem decided not to fund this element of the project and asked that all associated funds be returned to consumers. However, Ofgem said that it believed battery storage could still play a key role in ensuring future system reliability.

The project was disappointed that Work Package 2.4 was not funded. We're now exploring how this part of the project can be taken forward as we strongly believe that combining storage with solar PV has significant potential to help reduce the future cost of operating the system.

The project team has been looking at a number of existing and new battery storage projects, with the intention of seeking NIA funding to carry out EFCC-related trials.

Our existing project partner, BELECTRIC has put forward a proposal to provide access to a battery on a rental basis in order to retain the scope of the project. A combined response from PV and Battery would still be possible and the associated operational advantages (like a combined, more efficient frequency response) would still be achieved. In addition, these operational trials would influence the development of the commercial service (work package 6). Separate NIA funding for this proposal is currently being discussed that would align with EFCC timescales and could also enable the following areas to be investigated.

- Distributed fault ride through of PV and battery
- Extra reactive power support to manage voltage
- Black start capability via solar PV, enabled by the battery unit

Lincs wind farm trials – Work Package 2.5

The previous report explained that National Grid had begun discussions with DONG Energy and Siemens about possible options for wind farm trials and an agreement in principle had been reached.

During this reporting period, National Grid has continued working with both organisations to develop an agreed approach to potential wind turbine tests. The aim of these will be to demonstrate a wind farm'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.

After DONG Energy put together a shortlist of potential sites, Siemens has now completed an initial impact assessment on the turbine technologies available at these sites. This assessment includes the possibility of testing turbines at two different sites. It has also been confirmed that Lincs wind farm will not be selected.

A detailed asset-risk assessment has been included in the schedule of activities that will form part of the contract, as this needs to be completed before tests can begin.

As explained in the previous report, delays in confirming the wind farm site had made it difficult to include the control system in this part of the project. It has now been decided that the use of a control unit during these wind farm tests is not within the scope of the project. Learning will still be obtained from the tests to understanding wind turbine response characteristics.

One of the main outstanding challenges in finalising the contract surrounds the sharing of liabilities for the duration of the work activities. Final proposals are being reviewed and it is anticipated that an agreement will be in place by the end of June.

As a result of these negotiations, activity dates for this work package will change and that will impact on the SDRC detailed in the Project Direction.

National Grid will formally request an amendment to the Project Direction to change this SDRC.

Enhanced frequency response – National Grid issue Invitation to Tender

On 22nd September 2015, our Commercial Services team issued an Invitation for Expressions of Interest from businesses capable of providing an enhanced frequency response (EFR) service. This requires them to deliver active power within 500 milliseconds (ms) and achieve full output in one second from the detection of either a pre- or post-system fault that causes a change in frequency.

Following this, pre-qualified parties were selected and on 15th April 2016 National Grid published an Invitation to Tender for the EFR service. Following feedback from potential providers, the capability characteristics for the service have been changed and full details can be found here **http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx.** The service continues to be based on an absolute value of system frequency and will provide dynamic – continuous – frequency response.

There is an overlap with the speed of provision of this service and the objectives of the EFCC project. However, EFCC is aiming to provide a faster coordinated response time (i.e. quicker than 500ms) from newer inverter-based technologies in low inertia systems. In addition, the EFCC project will develop a Britain-wide control system that will detect RoCoF and reliably coordinate a proportionate response from providers on a targeted regional level. By setting in motion a response based on RoCoF, system frequency will be contained more quickly than before.

The project is keen to encourage wide participation in an enhanced service and we're working closely with the Commercial Services Team to achieve that. We're sharing learnings about the technical capabilities required to deliver the service and also looking at market intelligence to assess the potential economic value of an enhanced frequency product (Work Package 6). This work will ensure that once a new service is developed through EFCC, it will be well defined and able to achieve rapid uptake at the end of the project.

Bank account

Bank statements have been provided to Ofgem. Due to the confidential nature of the project bank statements, they have been included in the 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 for January 2015 - June 2016

Cost category	Actual	Proposed / budget	Variance
Labour	£432,895.00	£886,325.00	£453,430.00
Equipment	£32,000.00	£47,000.00	£15,000.00
Contractors	£587,931.96	£1,004,159.00	£416,227.04
IT			
IPR Costs			
Travel and expenses	£0.00	£16,000.00	£16,000.00
Payments to users			
Contingency	£0.00	£204,232.00	£0.00
Decommissioning			
Other			

During the first half of 2016 National Grid has maintained the resource levels assigned during the latter half of 2015, resulting in a closer alignment to the proposed costs. These costs over the full lifecycle of the project remain under budget. The variance between the budget and the actual expenditure on labour reflects the National Grid savings made over the first year of the project, particularly in the first six months. The project continues to be managed effectively utilising the current resource levels.

The variance between the contractor proposed and actual costs is related to timing rather than underspend. The project is awaiting confirmation of all contractor costs allocated for this reporting period; once these are confirmed the variance will be significantly reduced.

In January 2016 a decision was taken by Ofgem not to agree funding for work package 2.4 on battery storage. This has resulted in the proposed allocated amount for work package 2.4 being removed from the budget displayed here and will be returned to Ofgem prior to the closing of the project in 2018.

The variance on equipment costs for this period is due the timing of project requirements rather than underspend.

There remains no use of the contingency budget.

Successful delivery reward criteria (SDRC)

The following work, related to SDRCs, was led by Grid Solutions in this reporting period. The documents detailed here are covered by Grid Solutions' background intellectual property rights, so not all information can be published on the project's knowledge-sharing website.

Resource optimisation algorithm: Work Package 1

This document explains how various types of frequency response technologies can be coordinated to provide the optimal, or best, response to maintain a stable system. It was successfully delivered on 29th January 2016 and has been reviewed by the Steering Committee.

The proposed solution caters for both long-term and short-term optimisations. The longer-term optimisation will rely on market and contractual arrangements with prospective EFCC participants, which will allow National Grid to make decisions based on resource availability in real time. The short-term optimisation, which is the main focus of the report, is the function that will calculate the amount of response required once a system disturbance has been detected.

Further detail is provided in the Learning Outcomes section of this report.

Control platform development: Work Package 1

As explained in the first progress report, the control platform will provide the means for the main control system under EFCC to communicate with the control systems of response providers.

This document describes the controller design in detail, including the specific communications protocols that will be put in place for demonstration trials with each project partner. It was successfully delivered on 29th April 2016 in line with the agreed project milestone.

Further detail is provided in the Learning Outcomes section.

Application development & testing: Work Package 1

This document summarises the testing and validation that has been carried out on the application functional blocks (AFBs). These are the various functional algorithms that make up the developed control system (e.g. event detection and regional aggregation). It describes the types of tests carried out and gives results. It was successfully delivered on 29th April 2016 in line with the agreed milestone.

Further detail is provided in the Learning Outcomes section.

Successful delivery reward criteria (SDRC)

Successful delivery reward criteria for the next reporting period

There are two SDRCs due in the next reporting period: June 2016 – December 2016.

Table 5
SDRCs for next reporting period

Description	Due date	Status	Comments
Agreements in place with DSR customers for participation in EFCC	30/06/2016	Red	
Complete controller testing (Work Package 1)	31/08/2016	Green	

It is unlikely that all agreements will be in place with DSR customers for participation in the EFCC project by the end of June. Flexitricity has continued to engage with their customers to discuss the project objectives, their operating regimes and outline proposals for trials. They have succeeded in securing customer interest in all three DSR categories that are targeted in this project (static RoCoF response, spinning inertia and dynamic response) and it is anticipated that contracts will be in place across all three categories. Further discussion is required to confirm the technical requirements for trials with the short-listed participants, in advance of contracts being confirmed.

Future successful delivery reward criteria

As mentioned earlier in the report, National Grid may request a change to the SDRC associated with Work Package 2.5 following the concluding discussions with DONG and Siemens.

Learning outcomes

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

Work Package 1: Monitoring and control system

The development of the Monitoring and Control System (MCS) met three key milestones:

- Optimisation development report
- Applications testing report
- Control platform development report

Optimisation development report

Project partner GE Grid Solutions finished developing the final application – Optimisation – for the MCS. This will be used to manage the range of available response resources in the system. The aim of the algorithms – or set of rules - behind this application is to arrange resources in an order that will provide the best response to an event in terms of speed and duration. This is important for the MCS due to the variety of resources, each with different characteristics, that are available to provide frequency response.

The application will receive data, such as available power, and response and delay times, from each of the available providers. It will use this to compare the resources and work out the best way of coordinating and deploying them. For example, during a frequency event, certain resources should act first to bring the system under control as quickly as possible, so the optimisation process will consider the response times, ramp rates and duration of response for each of the resources. The application will then produce a series of tables containing the optimised information and these will be used to work out the best response. The application is central to the coordination of the scheme.

The journey for this application began when an initial specification was produced, explaining its intended purpose. From there, the application has been successfully developed and a completed development report was issued in January.

The control system's Resource Allocation application, which was completed and reported in August 2015, had certain components that relied on the completion of the Optimisation application. For that reason, parts of its development were reported as being possible approaches, but subject to changes. With the Optimisation application now complete, these components have been fully developed and implemented, so the Resource Allocation application is also now complete. These changes are explained in more detail in the Applications Testing report.

Application Testing report

With all applications now complete, a formal test process of the software was carried out and the test report was delivered in April. The software will now be put to use on the control hardware. The test report included a brief description of each of the applications and the results of detailed testing on their functionality, input data, and behaviour of user settings. These results showed that each of the applications performed as expected, based on the delivered and agreed functional design specifications reviewed by partners during the development stages.

Control platform development report

Finally, a report has been completed for the control system's hardware platform. This describes the PhasorController architecture and development process. A version of the controller is now available for use in the EFCC project. It meets the needs of each of the project partners, which were captured in initial meetings. In the project, three types of controller are required; region aggregator, local controller and central supervisor. These differ, in terms of the applications they contain and the communication paths between them. The current version of the hardware platform is ready for the software applications to be added. Following this, formal testing will begin, with the hardware being used to perform individual control and system control testing. This will be carried out in the next reporting period.

The applications testing and control platform development reports are covered by GE's background intellectual property rights. As a result, not all information can be published on the project's knowledge-sharing website.

Work Package 2.1: Demand side response

Project partner Flexitricity has learned:

- Combined Heat and Power (CHP) participation in spinning inertia appears to be feasible, but can't be entirely separated from forces in the energy market. For example, CHP operators are reluctant to operate below 65% output, which means that switching from one prime mover – CHP's mechanical core - to two would cause total electricity output to rise by 30% and heat by slightly more. At the same time, the total inertia provided doubles. There is therefore a net gain in inertia against power output, but it is around 70% of the theoretical maximum value.
- CHP operators would prefer to extend existing scheduled runs (earlier starts and later finishes) than include additional starts in their daily schedule. The economic impact of extended runs appears to be reasonable.
- The chemical and banking industries would consider participating in a static RoCoF service, while the water industry would contemplate dynamic RoCoF services. Technical challenges are significant in the latter.

Work Package 2.2: Large scale generation

Centrica has made the following progress:

- Successfully simulated faster response on its CCGTs. This work shows that conventional primary response could be achieved in 2-3 seconds less than the 10-second threshold laid out in the Grid Code.
- The next step for Centrica is to make the necessary logic changes – in other words, the way its systems respond - to its plant at South Humber Bank. It will leave these in service, but inactive, so it can see how the plant would respond to changes in system frequency. If the plant responds as expected, the revised logic will then be made active. It could either be put into direct service and allowed to respond to actual system frequency and/or frequency simulations could be run at the plant to test its response.
- Centrica is working on the engineering changes needed to put the revised logic in place and has the full support of internal stakeholders. Assuming the above steps are all successful, the next stage would be to connect the plant to the project's Monitoring and Control System.

Work Package 2.3: Solar PV

BELECTRIC has carried out the following activities during this reporting period associated with the PV power plant at Rainbows.

- Planning for the installation of control components in the PV plant. This also involved close coordination with Grid Solutions with respect to PMU and MCS local control installation.
- Production of new switching cabinet for new control components has started with an expected completion date of 15th July. Afterwards, testing, shipping and commissioning will take place.
- The software development with respect to control of solar PV and potentially battery storage has continued. This has included the completion of the software framework components (e.g. database, error handling and communication). The development for IEC61850/GOOSE for communication with the local controller has continued as well as modifications for the control algorithms for the PV power plant.

Installation and communications testing was originally forecast to complete in June 2016 and is now expected to be September 2016. Sufficient contingency has been allowed for within the project timescales, so there is no impact on subsequent activities.

Work Packages 3 & 4: Optimisation and validation

The University of Strathclyde has been working on preparing the tests that will thoroughly validate the EFCC scheme. These will be carried out at the Power Networks Demonstration Centre (PNDC). A model of the GB transmission network, which was produced in PowerFactory by National Grid, has been used to simulate a wide variety of scenarios to improve understanding of the system's behaviour under different frequency events. From these studies, credible scenarios will be defined and selected to test the performance of the EFCC scheme. A test proposal, which describes the activities for validating the scheme, has been developed with the project partners and the test programme is being finalised. The Strathclyde team is also working on putting the proposed tests into effect at PNDC and a test implementation document is being developed.

At PNDC, details of the communication between the load banks and EFCC hardware using Modbus have been developed and agreed with GE Grid Solutions. A physical phasor measurement unit (PMU) has been installed and an accurate voltage measurement and recording device has also been put in place. An RTDS transmission network model for five regions has been developed and is being refined. This model will be used to simulate, in real time, the behaviour of network regions with different levels of 'local' inertia during frequency and fault events. The RTDS model will also be merged with the PNDC physical network to create a test-bed for the EFCC scheme. An initial set of tests to show the motor-generator (MG) set's response to various commands and events has been carried out. This work improved the understanding of the MG set's capability and will help define the scenarios for the tests. Communication links that will be used for joining together the EFCC hardware and the RTDS models using IEEE C37.118.2 and IEC 61850 GOOSE messaging have been established.

To summarise, work at the University of Strathclyde during the reporting period has been progressing well as it prepares for the deployment and testing of the EFCC scheme, which is scheduled for the beginning of 2017.

The University of Manchester is contributing to system studies and RTDS Hardware in Loop (HiL) testing. The following work has been completed in this reporting period:

- Elementary system studies and simulations for system frequency response are ongoing, without coordinated supervisory control i.e. no MCS.
- The hardware that is required for the HiL testing by the University of Manchester has been approved with GE and National Grid (two regional aggregators, four local controllers and one central supervisory).
- A two-area test system has been modelled in RTDS for HiL testing to allow initial simulations of the MCS to be carried out.
- Conversion of the 36-zone National Grid model from PowerFactory software into RTDS is ongoing. This will be used for high-level testing and demonstration of the MCS, coordination of response and further understanding of the regional inertia concept.

Work Package 6: Commercial

As explained in the Business Case section, National Grid is running a tender for businesses to provide an enhanced frequency response service. Those providers that have met the initial criteria have given us an insight into the types of technologies that are capable of delivering enhanced frequency response. In turn, this tells us who could participate in a future EFCC service product.

The full development of the EFCC, RoCoF based new commercial service is due to start in January 2017, and work will be undertaken by the University of Manchester and National Grid. We'll also be collaborating with Grid Solutions, as implementing the new service into the optimisation algorithm – in other words, establishing a response providers place in the overall coordination of response technologies – could have cost implications.

Grid Solutions has produced a discussion paper proposing a market approach for EFCC. This focuses on making sure that the capabilities of the various new technologies can be coordinated with existing response services. It also explores the creation of an incentive to encourage potential future participants that could be based on the speed of response as well as geographical location.

This is being reviewed by the commercial team within National Grid as well as the project partners. This document will form the basis for further discussion with technology providers to gather their feedback and potentially shape the ongoing work being done by the Commercial Services teams.

Work Package 7: IS communications

The project continues to consider the requirements for the communications infrastructure that will support 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 VISOR (Visualisation of Real Time System Dynamics using Enhanced Monitoring), is a critical input into the EFCC project that provides infrastructure and system parameter data. However, since VISOR is for monitoring purposes only, a key challenge is ensuring the necessary communications reliability and robustness for EFCC to facilitate the control of response providers and prevent system instability. Options for EFCC interoperability with VISOR communication platforms have been initially outlined and discussed between the respective project teams.

One option is to have parallel phasor data concentrators specifically for EFCC purposes to ensure rapid response times can be achieved. The 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.

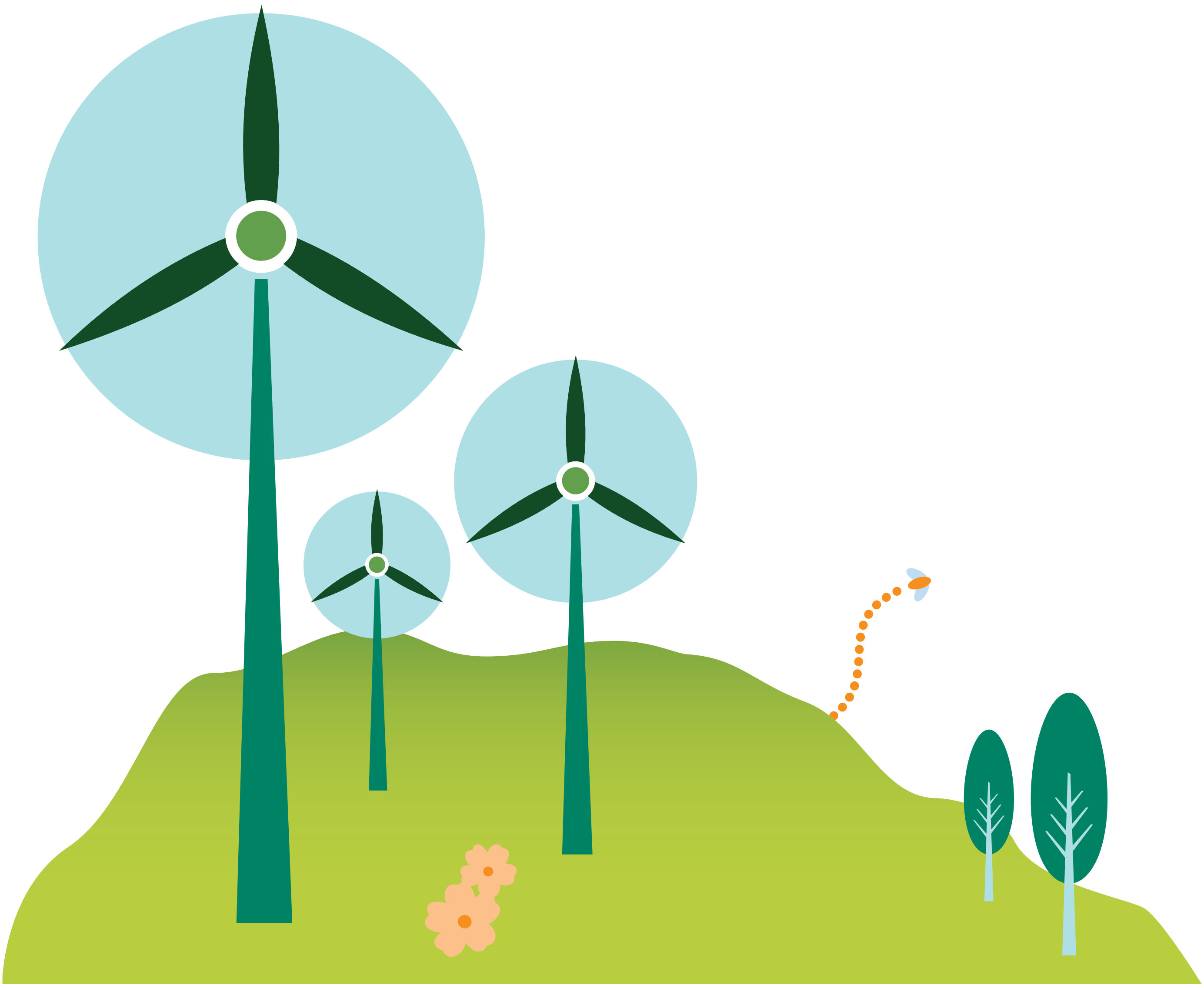
National Grid will also carry out a demonstration of the MCS utilising the central supervisor, regional aggregator and local controller units being developed by Grid Solutions. The aim of this demonstration is to utilise real data from VISOR with a view to integrating with other control systems.

In parallel, National Grid has considered potential substations at which new PMUs can be installed to increase the visibility of real-time system information on the transmission network. The short list of sites is being coordinated with the VISOR team to optimise outcomes and ensure there is no duplication. Further system access for the installation and commissioning of the equipment is being considered and detailed engineering is to be undertaken.

Intellectual property rights

To meet the requirements to publish intellectual property (IP) developed in this project, Grid Solutions will make versions of the optimisation algorithm, applications testing and control platform development documents available on the project website. Full versions of these documents were made available to all project partners as part of the multi-party contract that was signed. Publically available versions will also be uploaded to our knowledge-sharing website.

This approach to the review and publication of background and foreground IP will be repeated on all documents produced during the project.



Current risks

Project risks are being monitored and reviewed on a regular basis by the project partners. Key risks for this reporting period with an amber or red status have been included below and a full risk register can be found in the appendices of this report.

Table 6
Current risks

Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Rick 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	4	20	Steering Group	We have fully considered future developments and scenarios and made sure that the solution matches what is planned for the system.	Effective
34	WP2.1 – DSR	Flexitricity is unable to provide participants for planned trials.	Timing, risk and commercial terms make 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	5	3	3	15	Project Manager	When project begins, and as a matter of priority, work with Flexitricity to identify and begin negotiations with potential participants. Appendix 5, Detailed Project Description, describes the incentives offered.	Effective
35	WP2.1 – DSR	DSR recruitment: industrial and commercial electricity customers unwilling to participate.	I&C energy managers' workloads, confusion over the proposition, length of trials, uncertainty of service in the long term, costs involved.	Ability of DSR to deliver EFCC not proven.	Flexitricity	4	2	4	16	Project Manager	Use Flexitricity's large customer base and contracting process for recruitment.	Effective
56	WP 2.5 – 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	3	12	Project Manager	Contractual discussions taking place early in process.	Effective

Risk management cont.

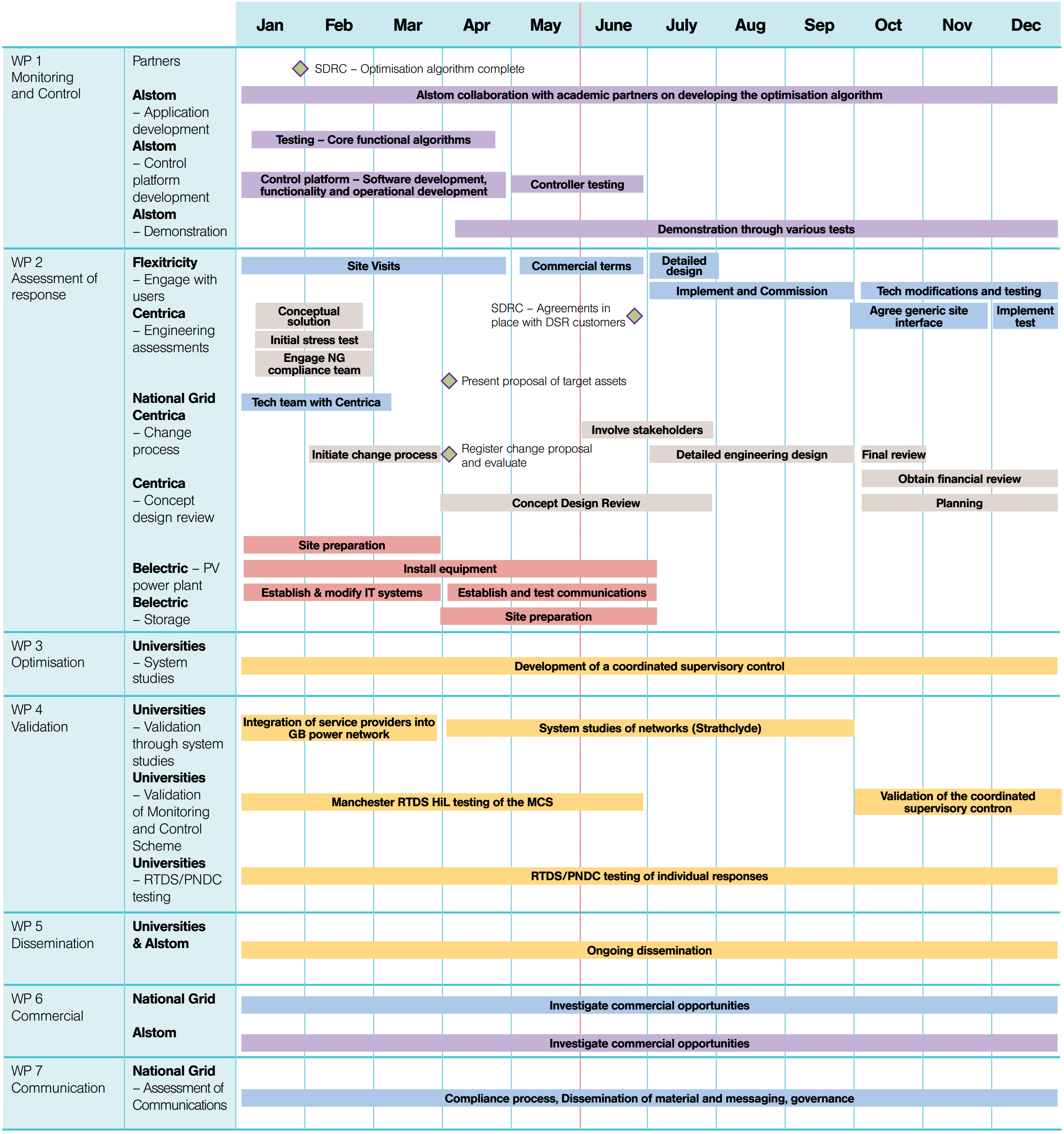
Risk No.	Work-streams / areas	Risk description	Cause	Consequence	Rick owner	Likelihood (1-5)	Financial Impact (1-5)	Reputational Impact (1-5)	RAG	Escalate to	Action plan	Control opinion
58	WP1 – Control System	4-20mA Interface.	4-20mA currently not part of TPSA Product Roadmap due to other priorities.	Full 4-20mA interface not ready for demonstration testing.	Grid Solutions	4	3	2	12	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to 4-20mA. Implementation of the same.	Effective
59	WP1 – Control System	Digital Interface.	Capabilities of Digital Interface are limited. Alternative hardware solution needed if more than six digitals are required. Improvement of product is required within TPSA Product Roadmap.	Full Digital interface not ready for demonstration testing if more than six digitals required.	Grid Solutions	4	3	2	12	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to Digital for set-ups requiring more than six digitals. Implementation of the same.	Effective
60	WP2.4 – Storage	Technical difficulties if OFGEM declines use of BELECTRIC storage.	Interface protocols, reaction speed, level of access and available testing time may be different to what has been planned, based on BELECTRIC storage.	The project may be delayed or working package 2.4 might not be rolled out to its full extent (limited response capability).	Belectric	3	3	4	12	Project Manager	Confirm regulatory risk with Ofgem and prepare justification for NIA funding for renting a battery to carry out trials.	Effective

Assurance statement

This report has been produced in agreement with the entire project hierarchy. The report has been written by the EFCC (NIC) Technical Project Manager Charlotte Grant, reviewed by the EFCC (NIC) Project Steering Group and approved by Graham Stein, Electricity Policy and Performance Manager, on behalf of the Project Sponsor Richard Smith.

Every effort has been made to ensure all information in the report is accurate.

Appendix A: EFCC (NIC) project year ahead 2016



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 results of project is reduced or project is delayed.	Project Manager	2	2	3	6	Steering Group	Ensure thorough contracts in place. Procurement processes have considered ongoing size and reliability of partners. Replacement partners have been considered and could be approached if required.	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.	Potential project funding gap. Alternative funding is required or the project scope is reduced.	Project Manager	1	3	2	3	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.	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	Define cost risk owner.	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	4	20	Steering Group	We have fully considered future developments and scenarios. We have ensured usefulness of solution matches planning of system.	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	2	2	4	6	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.	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
7	General	Quality of technology - ie, the monitoring and control system and/ or equipment installed at response sites - is insufficient.	The least-cost option is taken ahead of quality and reliability; quality control insufficient at suppliers.	The solution offered is not reliable and commercial opportunities will be reduced. Costs are incurred through delays and replacements.	Suppliers	4	2	3	12	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.	Effective
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.	Suppliers	4	2	3	12	Project Manager	Future requirements considered and built into specification. Flexibility has been built in.	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.	Effective
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

Appendices cont.

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
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.	Suppliers	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.	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	2	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.	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.	Effective
14	General	Loss of telecom-munications.	Technical fault leads to loss of telecommunications between systems.	Reduced availability and performance.	National Grid	3	3	3	9	Project Manager	Design scheme for continued operation or graceful degredation in the event of a loss of telecommunications.	Effective

Appendices cont.

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 needless tripping or an excessive amount of control initiation commands.	Over-response from resources reduces stability and excessive set-point changes in generators reduce asset lifetime.	National Grid	3	3	4	12	Project Manager	The scheme will be extensively tested in a laboratory before being put to use on the network. The system will also be evaluated using recorded measurements from the GB systems, allowing for tuning and configuration in a safe environment. Academic partners will also provide suitable facilities to test response on generators, reducing risk to assets after deployment.	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	Effective
17	General	Installation.	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 reducing the avilable time for reports, tuning dissemenation.	National Grid	3	1	3	9	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 3 partners in IT requirements of WAMS project.	Effective
18	General	Communications.	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	2	1	2	4	Project Manager	Work closely with National Grid and partners to ensure that new comms links not critical to project success. Ensure that the communications infrastructure is well understood and the chosen control scheme can best work with available infrastructure.	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
19	General	Outage required for commission-ing	Inability to obtain the relevant outages for commissioning.	Possible delays to commissioning programme, or cost of outage.	National Grid	2	1	3	6	Project Manager	Outages identified and incorporated in Scheme Requirement Document	Effective
20	General	Commissioning.	Commissioning procedures encounter problems.	Delays in commissioning the project.	National Grid	3	1	3	9	Project Manager	Identify and agree all the commissioning procedures with the supplier for the new technology, and the problems that might be encountered	Effective
21	General	Capital costs.	Costs higher than anticipated.	Project budget exceeded.	National Grid	2	1	2	4	Project Manager	FIDIC contract, Contractor takes risk. Commodity price to be hedged	Effective
22	Health, Safety & Environ-mental	New equipment.	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. Controller to go through rigorous testing.	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
23	WP1 - Control System	Technology partner fails to deliver suitable product on time.	Problems with design and build.	Project is delayed.	Grid Solutions	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 ALSTOM unit in Massy/France. Product commercially available by summer 2015. Assessment of technical suitability completed with positive result. ALSTOM management support secured during project approval and project review meetings. A formal collaboration framework with ALSTOM 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 6 digitals). Suitability for 4-20mA and Digital captured separately in Risk Register.	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.	Grid Solutions	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 Alstom 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.	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 commercially 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	Grid Solutions	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. 2 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 NMSProject. 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.	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 developed.	Extension required for the development period which adds delays to all consecutive elements of the project.	Grid Solutions	2	1	2	4	Project Manager	Staged approach to application development with simple initial target in first year. Allow sufficent 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 aims for early/staged end-to-end testing/ demonstration for phasor data concentrator, regional aggregator, system aggregator and event detection. This agile approach will validate/confirm system architecture, development strategies and design concepts at early stages and allow for fine-tuning, if required. Project partners will be provided with regular progress updates and confidence level.	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
27	WP1 - Control System	Resource Interoperability	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.	Grid Solutions	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 project partner meeting 30th April. Specifications Event Detection, Control Platform and Resource Allocation were issued for partner review and comments have been addressed. ALSTOM 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 sperately.	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
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.	Grid Solutions	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 Alstom and Academic Partners on Optimisation.	Effective
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.	Grid Solutions	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. Roll-out on a larger scale may, therefore, result in the controller's reduced performance due to increased amounts of measurement and resource data. An additional risk stems from exceeding the technical capacity of the controller with complex algorithms and increased inputs, e.g. more resources to optimise.	Timely roll-out could be put at risk, delaying our ability to put what we've learned from the project into action. The risk for this stage of the project is minimal.	Grid Solutions	3	4	2	12	Project Manager	Laboratory testing will include scalability. This will test the control platform with a greater number of inputs than will be used in trials. This will allow the limits of the control platform to be found and define new methods to overcome them. From this, we'll learn how to deploy the control system for larger roll-out, minimising the risk of delays. The controller development path enables easy porting between hardware platforms. If greater performance is required, other hardware solutions will be considered.	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
31	WP1 - Control System	Additional testing and tuning.	The controller may require additional tests and fine tuning based on real system measurements ifrom the UK network to ensure robust operation. Data will need to be gathered over a sufficient period to determine the control scheme performent.	The selected control scheme will be unable to effectively deploy resources to arrest a frequency excursion.	Grid Solutions	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
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.	Grid Solutions	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.	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 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.	Grid Solutions	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.	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
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	5	3	3	15	Project Manager	Work with Flexitricity to identify, and begin negotiations with, potential participants as a matter of priority once project commences. Appendix 5, Detailed Project Description, describes the incentives offered.	Effective
35	WP2.1 - DSR	DSR recruitment: industrial and commercial electriciy customers unwilling to participate.	I&C energy managers' workloads, comprehension of the proposition, duration of trials, uncertainty of long-term commercial service, 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.	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	Effective
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.	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).	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	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 ot terms" with OEM. Pay OEM (from funding) for relevent technical input.	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
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 in summer.	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	Academic team contains expert knowledge. All data to be provided in timely manner. Problems to be escalated to Project Manager.	Effective
44	WP3 - Optimi-sation	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.	Univer-sities	2	2	3	6	Project Manager	Discussion with GE (WP1) has started.	Effective
45	WP4 - Valid-ation	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 rollout may be severely impacted by issues not flagged during the validation phase.	Univer-sities	2	3	3	6	Project Manager	Academic team contains expert knowledge. All data to be provided in timely manner. Problems to be escalated to Project Manager.	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.	Univer-sities	1	2	3	3	Project Manager	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.	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	2	4	4	8	Steering Group	Ensure that knowledge is shared. Establish clear communication channels with interested parties. Develop commercial terms thoroughly prior to roll out.	Effective

Appendices cont.

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
48	WP1 - Control System	Demonstration partner fails to install and configure demonstration setup on time for SAT.	Challenges encountered during installation and configuration or lack of understanding/training.	Demonstration is delayed with likely impact on other activities.	Grid Solutions	3	1	1	3	Project Manager	ALSTOM - Psymetrix wil provide PMU/ MCS training during Demonstration 1 timeframe (combined with FAT). Psymetrix 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.	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.	Grid Solutions	2	1	1	2	Project Manager	Ensure early engagement with suppliers and project stakeholders to ensure delivery and installation as per project schedule.	Effective
50	WP1 - Control System	Number of interface protocols impacts development 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.	Grid Solutions	2	1	2	4	Project Manager	ALSTOM - Psymetrix will act as Design Lead/Technical Authority and aim for early stakeholder engagement. Define clear objectives in terms of minimising number of interfaces, protocols and messages at the outset of the project. The following interface protocols have been identified to date (ref. interface discussions): - IEEE C37.118 (as per contract) - IEC 60870-5-104 (as per contract) - IEC 61850 (GOOSE) (as per contract) - IEC 61850 (MMS) (innovation proposal) - Modbus (as per legacy)	Effective

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50						2	1	2	4		- DNP3 (as per legacy) - 4-20mA (as per legacy) - Digital/Relay (as per legacy) The following interface protocols are currently being proposed as part of a revised scope: - IEEE C37.118 - IEC 61850 (GOOSE) - LAN/WAN - Modbus - Digital (<= 6 digitals) - Convertor - Modbus to 4-20mA - Convertor - Modbus to Digital The following are considered out of scope: - IEC 60870-5-104 (Wind not confirmed) - IEC 61850 (MMS) - replaced with GOOSE LAN/WAN - DNP3 4-20mA and Digital covered through ADAM 6024 Advantech Convertor. Additional interface discussions with project partners to discuss interface details and messaging. Perform impact assessment and quantify implications in terms of effort, cost, schedule and risk related to development of additional interfaces.	

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51	WP2.4 - Storage	OFGEM needing to accept storage in "Smarter Frequency Control".	Insufficient evidence 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
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. CLOSED. DESCRIPTION MOVED AND INCORPORATED INTO RISK 56.	Effective
55	WP1 - Control System	Number of PhasorController applications.	Concept design frequency control has identified potential for the following controller applications: - Local PhasorController 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.	Grid Solutions	3	2	2	6	Project Manager	ALSTOM-Psymetrix will further develop Controller concepts & schemes. ALSTOM will lwork 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.	Effective
56	WP 2.5 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	3	12	Project Manager	Contractual discussions taking place early in process.	Effective

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57	WP1 - Control System	Number of PhasorController applications	Concept design frequency control has identified potential for the following controller applications: - Local PhasorController 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.	Grid Solutions	3	2	2	6	Project Manager	ALSTOM-Psymetrix will further develop Controller concepts & schemes. ALSTOM 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. Alstom-Psymetrix to plan procurement internally.	Effective
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.	Grid Solutions	4	3	2	12	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to 4-20mA. Implementation of the same.	Effective
59	WP1 - Control System	Digital Interface	Capabilities of Digital Interface limited. Alternative hardware solution needed if more than six digitals required. Product improvement is required within TPSA Product Roadmap.	Full Digital interface not ready for demonstration testing if more than 6 digitals required.	Grid Solutions	4	3	2	12	Project Manager	Communicate proposal for inclusion of Advantech ADAM 6024 Convertor Modbus to digital for set-ups requiring more than six digitals. Implementation of the same.	Effective
60	WP2.4 – Storage	Technical difficulties if OFGEM declines use of BELECTRIC storage.	Interface protocols, reaction speed, level of access and available testing time may be different to what has been planned, based on BELECTRIC storage.	The project may be delayed or working package 2.4 might not be rolled out to its full extent (limited response capability).	Belectric	3	3	4	12	Project Manager	Confirm regulatory risk with Ofgem and prepare justification for NIA funding for renting a battery to carry out trials.	Effective

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

www.nationalgrid.com