Issue 01

Enhanced Frequency Control Capability (EFCC)

Progress Report January – June 2015

ALSTOM BELECTRIC centrica flexitricity MANCHESTER 1824 The University of Manchester University of Strathclyde Glasgow

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Executive summary

One of the key changes resulting from the move towards decarbonisation of the electricity sector is the increase in the level of new technologies such as wind and solar photovoltaic (PV) on the system, and decommissioning of thermal power plants. This change brings a number of challenges for power systems as presented in National Grid's System Operability Framework (SOF). Amongst those challenges, system inertia will be reduced because of fewer thermal power stations running on the system.

To mitigate this challenge, the Enhanced Frequency Control Capability (EFCC) project was awarded as part of the 2014 Network Innovation Competition (NIC). The EFCC project aims to carry out a range of technical and commercial innovations to ensure there are innovative solutions in place to control the system frequency in the future, as controlling the system frequency will become more challenging with reduced system inertia. The EFCC focuses primarily on innovation in the system operation domain, and given the number of parties involved in facilitating, and providing the services to the system operator, it was desirable to design the project in such a way that is collaborative, and therefore a number of different partners are involved in this project.

Ultimately, the EFCC will provide greater clarity to the industry on the new ways of controlling the system frequency, necessary commercial incentives and products, and how new technologies such as solar PV, Demand Side Response (DSR), wind, battery storage, HVDC Interconnectors, and different modes of operation of Combined Cycle Gas Turbines (CCGT) can provide the solutions to operate the grid in the most economic and efficient way.

Summary of Progress (January 2015 – June 2015)

In this reporting period, the focus has been on the mobilisation of the team and appointing a dedicated project team, finalising the contracts with all partners, designing the new control system algorithm for the fast detection of the frequency events, and also evaluating various options in terms of the use of battery storage for the project. In summary:

- Mobilisation of the resource for all work packages is complete. Within National Grid: dedicated Technical Project Manager Charlotte Grant, and an Implementation Project Manager Lisa Cressy are the resources for the EFCC project
- The Project Implementation Document (PID) which sets out the appropriate governance and control processes for successful management of the project is in place
- All project partners have also appointed their dedicated team and project managers to liaise with the project team and attend project steering committee meetings
- All partners have agreed to contractual term
- Across the work packages, the project has made significant progress against the objectives of work package 1. The event detection algorithm which was due for delivery and forms an important part of this project was developed in April 2015. The performance of the model must be tested and verified
- The project website which is one of the key means of knowledge dissemination was developed in March 2015 and the information regarding the project partners, and the scope of the project, is uploaded and disseminated. **http://www.nationalgridconnecting.com/The_balance_of_power/**
- The project team has been to a number of events and presented the scope of the project. Amongst those:
  – The System Operability Framework (SOF) Industrial Workshop in April 2015
  – The Institution of Engineering and Technology (IET) Event on Synthetic Inertia in May 2015.

The project team is looking forward to the next phase of the project, and to test and trial the capability of the tools and models developed to detect system events.

Project background and business case

In order to meet carbon reduction targets, the UK needs to significantly increase the volume of low carbon energy technologies that are connected to the GB transmission system. The overall impact of increasing these types of technologies will be a reduction in system inertia.

System inertia is a characteristic of an electrical transmission that provides system robustness against any frequency disturbances and is a result of the energy stored in the rotating mass of electrical machines i.e. generators and motors.

As more renewable energy technologies such as wind, solar PV and other convertor-based technologies (e.g. interconnectors) are connected to the transmission system, there will be a corresponding reduction in inertia since these technologies do not contribute to natural mechanical inertia.

In the UK the transmission system frequency is nominally 50Hz and the System Operator caters for various imbalances caused by changes in demand or generation to maintain the frequency in accordance with the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS). However, the lower the system inertia, the more susceptible a transmission system is to a higher rate of change of frequency (RoCoF) in the event of the loss of a significant volume of generation or demand and requires an increase in the speed and volume of frequency response.

The EFCC Project full submission provided cost–benefit analysis (CBA) to show that under existing mechanisms to control frequency response used by National Grid, the future increase in response requirement to control frequency is anticipated to be £200m–£250m per annum by 2020. This cost is based on the Gone Green Future Energy Scenario as published by National Grid in 2014, giving rise to an increase in RoCoF of 0.3Hz/s.

The objective of this project is to develop and demonstrate an innovative new monitoring and control system which will obtain accurate frequency data at a regional level, calculate the required rate and volume of very fast response and then enable the initiation of this required response. This system will then be used to demonstrate the viability of obtaining rapid response from new technologies such as solar PV, battery storage and wind farms. The new system will demonstrate the coordination of fast response from demand side response (DSR), and fast ramp up from thermal power plants.

Using the output of this trial, a fully optimised and coordinated model will be developed which ensures the appropriate mix of response is developed. This will support the development of an appropriate commercial framework prior to project completion in March 2018.

The outcome of EFCC will demonstrate that the GB transmission system will remain operable by reducing the overall level of frequency response held, with the successful development and implementation of this project resulting in a predicted saving to the end consumer of £150m–£200m per annum.

The reduction in system inertia is already a problem experienced by many Network Licensees. Even a moderate future uptake of renewables will see the effects on, and costs of, managing the system increase significantly.

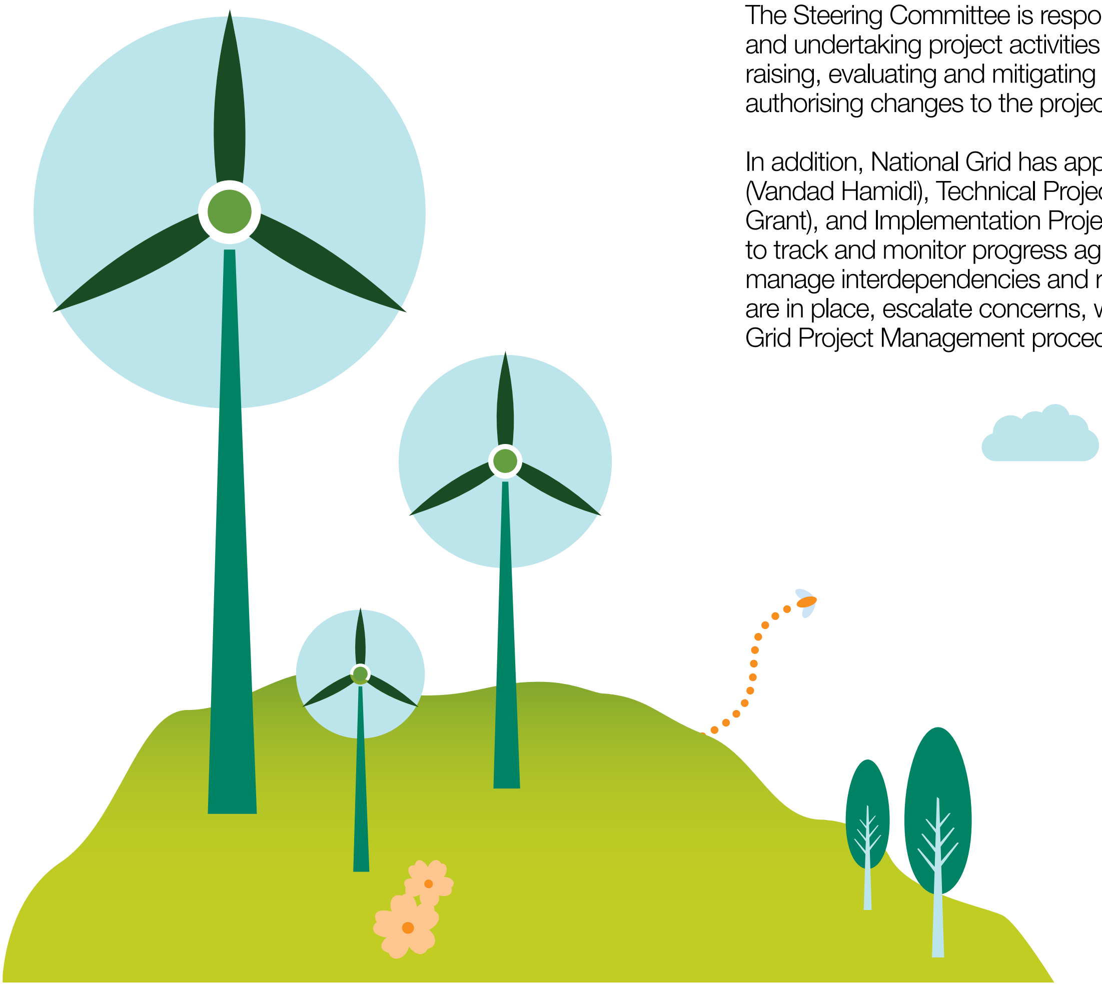
Project manager's report

The project received formal approval and the Project Direction in December 2014. This first project progress report covers the period from January 2015 to June 2015.

In the first six months of the project, the main activities undertaken have been the agreement to contractual terms with all EFCC partners, the establishment of the project hierarchy and structure, the control and event detection algorithm specifications and the investigation of existing battery storage facilities for participation in the project.

All project partners have now agreed to sign a formal contract although there have been challenges with achieving this deliverable. Working with a number of partners on a multi-party contract has resulted in a delay to agreement of the contract against the successful delivery reward criterion milestone. Despite the delay, there has not been an impact on the progression of the project with the event detection algorithm development and control platform development specifications still achieving the Successful Delivery Reward Criteria (SDRC) target of April 2015.

Further detail on this and the other project highlights are detailed in the Project Manager's report.



Project hierarchy

In order to provide a project structure for the effective direction, management, and control of the project, with clear responsibilities and accountabilities, a delivery structure was established.

The structure and hierarchy is shown in Figure 1 and comprises the following elements with an outline of main responsibilities:

- **System Operator (SO) Innovation Board**
  Governance, oversight, business alignment, approval of strategic decisions, conflict resolution
- **Project Sponsor** – *Richard Smith, Head of Network Strategy, National Grid*
  Provide project direction and alignment with strategic business objectives, ensure business issues are resolved in a timely manner and provide an escalation route for key risks
- **Project Steering Committee**
  Each project partner has provided a dedicated lead representative (as named in Figure 1) and employed appropriate additional resource support to ensure successful delivery of project objectives. The project has benefited from the continuity of resource within the partner organisations that had been involved with the project proposal submission.

  The Steering Committee is responsible for developing and undertaking project activities, completing deliverables, raising, evaluating and mitigating identified risks and authorising changes to the project plan.

  In addition, National Grid has appointed Project Director (Vandad Hamidi), Technical Project Manager (Charlotte Grant), and Implementation Project Manager (Lisa Cressy) to track and monitor progress against the project plan, manage interdependencies and risks, ensuring interventions are in place, escalate concerns, whilst ensuring National Grid Project Management procedures are adhered to.

Project manager's report cont.

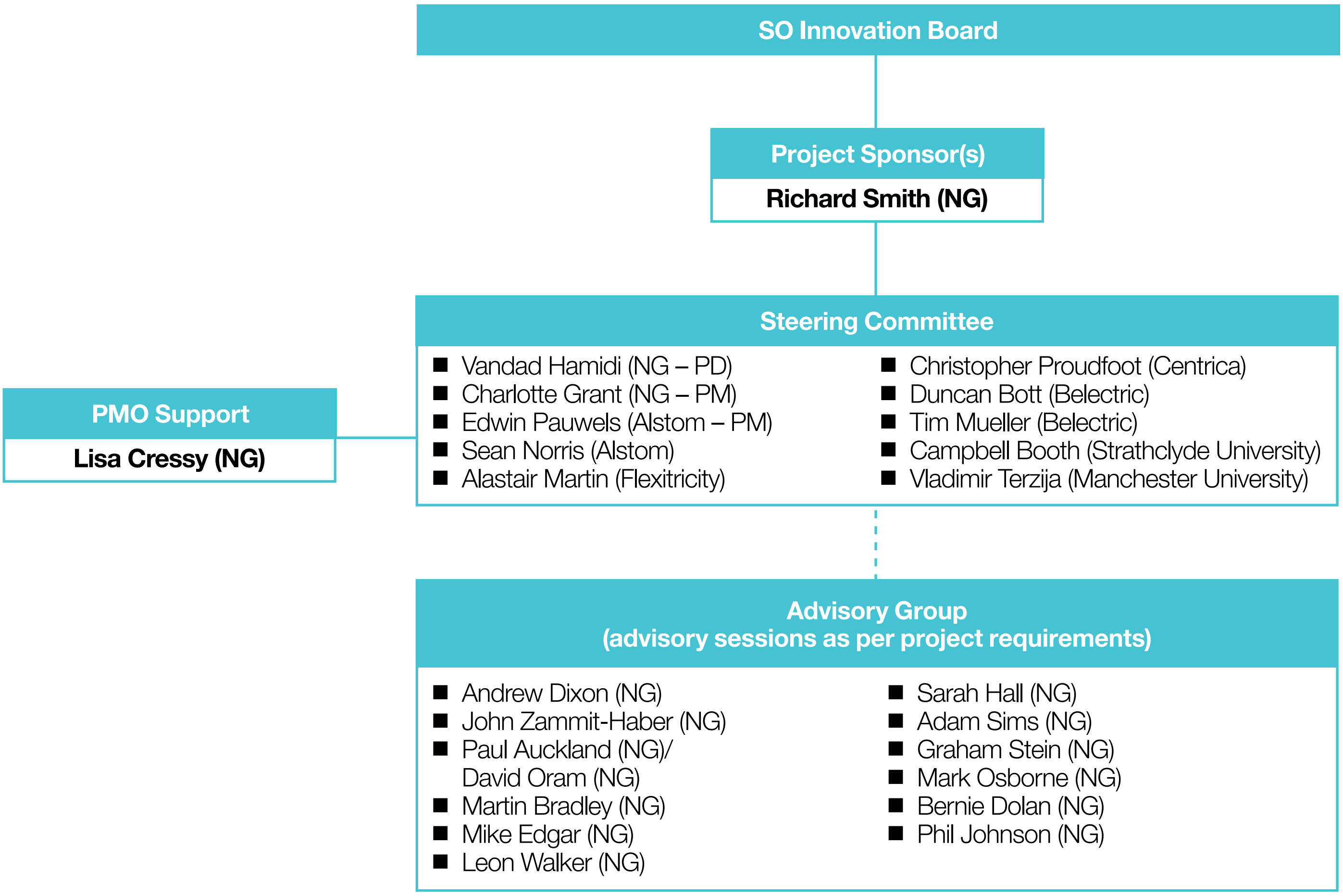


Figure 1
Project hierarchy

- **Project Advisory Group**
  The people nominated within this group are specialists from across National Grid's business that will provide specific input to work packages during various stages of the project. There is representation from RIIO Delivery Team, Strategy & Innovation, Commercial Services, Technical Policy and Energy Balancing Delivery that will be involved during the project as necessary.

Project steering committee meetings

After the project was awarded an initial kick-off meeting was held on 9 December 2014 in Warwick with all project partners. This was beneficial in engaging all parties with the various aspects of the project ahead of the commencement date.

Since the start of the project in January 2015, the Committee has held monthly teleconference meetings during this reporting period and will continue to do so in order to discuss progress updates, enable risks to be highlighted and mitigated and agree actions. The focus of the initial progress meetings was to discuss the project contractual agreement, the governance structure, and format of these meetings.

A quarterly face-to-face meeting was held on 29 April at National Grid House in Warwick to discuss the outcomes of key project tasks during the reporting period and agree the coordination and development of work streams between all parties. The location of future regular face-to-face meetings will be rotated amongst the various partner sites to facilitate wide engagement.

Project progress

Project progress is shown in Table 1 below against milestone SDRC activities for this period.

Further comment is provided below against activities that started during this period.

Description	Due Date	Status
Formal contract signed by all partners	31/03/2015	Agreement to contract in principle achieved April 2015
Launch of knowledge-sharing e-hub	31/03/2015	Achieved 27/03/2015
Completion of event detection algorithm	30/04/2015	Achieved 30/04/2015
Completion of control specification	30/04/2015	Achieved 30/04/2015

Table 1
SDRC milestones January to June 2015

Forecast for next reporting period

The project activities to be undertaken during the next reporting period are shown in Table 2 below.

Work Package	Description	Partner	Comments	Timescale
1	Monitoring & Control Scheme	Alstom	Development of resource allocation concepts and algorithm to allocate the appropriate frequency response from the various providers	May – Aug 2015
1	Monitoring & Control Scheme	Alstom	Ongoing development of control platform	Jan 2015 – Aug 2016
2.1	Demand Side Response	Flexitricity	Finalisation of list of specific customers for participation in EFCC. Commence site visits to outline technical modifications required for trials	July 2015 – Apr 2016
2.2 & 2.5	Large scale generation and wind	Centrica	Review of performance criteria against each existing operational management system and impact assessment on the wind turbine power convertors	Oct 2015 – Jan 2016
2.3	Solar PV power plant	Belectric	Site preparation for inverter installation to trial the provision of reactive power	Oct 2015 – Mar 2016
3 & 4	Optimisation & Validation	Universities of Manchester & Strathclyde	System studies on representative GB transmission network to assess proportionate responses from service providers using Alstom's event detection algorithm	June 2015 – Sept 2017
6	Commercial	National Grid	Commence assessment of economic value of new rapid frequency service	Jul 2015 – Mar 2018
7	Communications	National Grid	Continue review of VISOR project and monitor progress of data gathered from existing phasor measurement units. Commence outline of compliance process for service providers	Jan 2015 – Dec 2017

Table 2
Work Package activities for June to December 2015

Further to the activities shown above, the Steering Committee is continuing to develop a full set of study scenarios that will enable the project to validate the Alstom control models and demonstrate rapid frequency response. The scenarios will progress from offline simulation studies to using actual hardware and electrical equipment to more accurately replicate transmission system conditions. These studies will be carried out using system analysis software (DIgSilent Powerfactory), Real Time Digital Simulator (RTDS, Manchester University) and the Power Networks Demonstration Centre (PNDC) at Strathclyde University.

The Low Carbon Network Innovation Conference will be held on 24–26 November in Liverpool at the ACC. This will be an opportunity to disseminate knowledge as National Grid will be exhibiting and also presenting on the EFCC project during a break-out session.

The Steering Committee will continue to seek opportunities to share learning outcomes with the wider industry.

Project manager's report cont.

Business case update

Lincs wind farm was proposed in the EFCC full submission for rapid frequency response trials. In order to finalise the test schedule, National Grid is in discussions with Centrica and the other joint venture partners for Lincs wind farm.

Bank account

Bank statements can be found 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

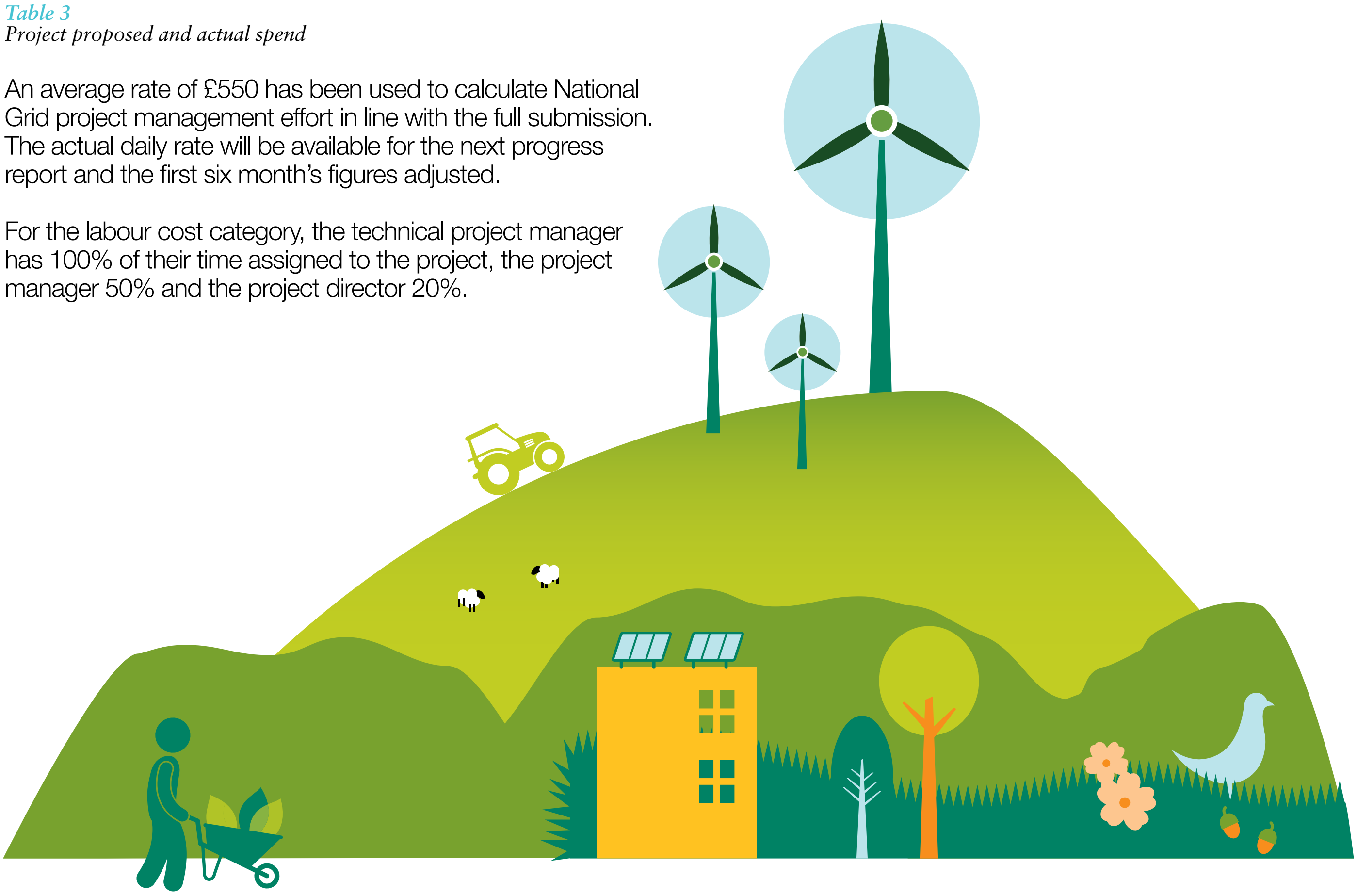
Cost Category	Proposed	Actual	Variance
Labour	£261,189	£123,520	£137,669
Equipment			
Contractors	£48,231	£48,231	£0
IPR Costs			
Travel & Expenses			
Payments to users			
Contingency			
Decommissioning			
Other			
Total	**£309,420**	**£171,751**	**£137,669**

Table 3
Project proposed and actual spend

An average rate of £550 has been used to calculate National Grid project management effort in line with the full submission. The actual daily rate will be available for the next progress report and the first six month's figures adjusted.

For the labour cost category, the technical project manager has 100% of their time assigned to the project, the project manager 50% and the project director 20%.

Over the first six months, savings have been made on National Grid project management costs explaining the variance between the proposed and actual project spend. The project continues to be managed effectively utilising the current resource levels. Additional project management or technical resource may be needed as the project develops in line with the proposed costs.



Successful Delivery Reward Criteria (SDRC)

Formal contract signed by all partners

The target date for all partners to sign a joint contract was 31 March. However, due to protracted challenges with finalising the terms of the contract, an agreement to these terms has been reached by all partners and Ofgem informed of contractual progress. Arrangements have been made for all partners to sign the contract throughout June.

During the contract negotiations with the project partners, several learning points arose and are summarised in the Learning Outcomes section of this report.

Launch of knowledge-sharing e-hub

The original due date as outlined in the full project submission was 31 March 2015. The EFCC knowledge-sharing website was successfully launched on 27 March 2015 via National Grid's Connecting Extra website which showcases news articles across the European Energy Industry. This website provides detailed information on the business case, project objectives, collaboration partners and details of each work package to be delivered. The website will be updated regularly throughout the lifetime of the project to disseminate learning outcomes and publicise events.

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

Event detection algorithm

This work has been led by Alstom. The event detection algorithm will be used within the monitoring and control system to analyse input signals and decide whether an event on the transmission system requires a response from wind farms, DSR, gas turbines, solar PV and battery storage. Alstom successfully delivered a specification as scheduled within the full submission document on 30 April 2015 and this will be reviewed and agreed by the Steering Committee. The specification describes the principles of the event detection, algorithm functionality and simulation tests that were carried out.

This document is covered by Alstom's background intellectual property rights, and as such not all information can be published via the knowledge-sharing e-hub.

Control platform specification

The control platform specification was successfully delivered by Alstom as outlined in the full submission document on 30 April 2015 and will be reviewed and agreed by the Steering Committee. The platform will facilitate communication between the main control system under EFCC and control systems of the various response providers.

This document is covered by Alstom's background intellectual property rights, and as such not all information can be published via the knowledge-sharing e-hub.

Successful Delivery Reward Criteria (SDRC) cont.

Battery storage justification report

During this reporting period, National Grid and Belectric have undertaken investigations of existing battery storage sites throughout the UK to ascertain if they can be used to test rapid frequency response during the project. As part of the project direction letter, Ofgem requested that an analysis be carried out of available battery storage facilities and a justification report prepared in advance of committing to funding an additional battery unit within the EFCC project. This report will be submitted on 30 June 2015.

Using published data such as the Energy Storage Operators' Forum (ESOF)[1], each site was initially evalutated on its size and potential capability to provide rapid frequency response on the GB transmission system. In addition, a general enquiry was sent to Distribution Network Operators (DNOs) that currently have demonstration battery storage facilities. The enquiry outlined the objectives of EFCC, the reasons for the enquiry and the possibility of an existing storage facility being available for the EFCC project. DNOs were also invited to complete a questionnaire to confirm the technical capability of their sites. The outcome of these enquires has resulted in three sites as potential candidates for the EFCC project. Table 5 below summaries these sites.

Battery Site	DNO	Power, Capacity	Battery Technology	Comments
Leighton Buzzard	UK Power Networks	6MW, 10MWh	Li-NMC	LCNF-funded project; commissioned November 2014. Investigating battery storage capabilities for ancilliary services provision completing December 2016.
Darlington (Rise Carr)	Northen Power Grid	2.5MW, 5MWh	Li-Ion	Commissioned November 2013. Currently evalutating options for future research and/or trials for ancilliary services provision
Willenhall	Western Power Distribution	2MW, 1MWh	Li-Ti	Commissioning to complete May 2015. EPSRC-funded project to explore advantages of energy storage. End of demonstration phase of project due March 2017

Table 4
Existing Battery Storage Project Status Summary

Further enquires were made to respective DNOs regarding any planned projects or activities throughout 2017 (when rapid frequency response trials are scheduled to commence) and cost implications if they participate in this project.

A site visit to Leighton Buzzard was undertaken by National Grid and Belectric on 28 April 2015 to further understand the site, its control and operating regime, future operational timescales plus challenges faced during the project.

An evaluation of these sites is being carried out to assess the financial impact and timescales of using existing battery storage units and the outcome will be published in a separate justification report that will be published on 30 June.

If an existing battery storage unit is chosen to participate in the EFCC project, it will be possible to gain learning for rapid frequency response and coordinating this response across a variety of response providers as outlined in the project submission. However EFCC requests funding to generate knowledge in combining solar PV with battery storage to explore the benefits of a combined service that could increase with the anticipated rapid and significant growth of renewables that will be connected to the system. Trialling combined solar PV and battery storage will not only demonstrate capability in delivering rapid frequency response for low inertia systems, but also go some way to validate and establish the full potential of combining technologies.

1: http://www.eatechnology.com/products-and-services/create-smarter-grids/electrical-energy-storage/energy-storage-operators-forum/esof-good-practice-guide

Future SDRCs

There are two SDRCs due within the next reporting period.

Description	Due Date	Status	Comments
Analysis of existing battery storage costs and benefits for inclusion within EFCC	30/06/2015	Green	
Complete resource allocation algorithm	31/08/2015	Amber	Dependency on outcome of interface discussions with partners. Variety of technologies and associated deployment use cases as well as existence of legacy systems imply complex end-to-end solution.

Table 5
SDRCs for the next reporting period

Key

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

Battery storage justification report

As previously mentioned, the analysis of existing battery storage facilities will be presented as a separate justification report written by National Grid with contribution from Belectric. Analysis will summarise the technical capability of whether existing battery facilities can contribute to rapid frequency response, along with the financial and commercial impact upon the EFCC project.

Completion of resource allocation algorithm

Alstom will develop the algorithms for the resource allocation to be deployed on the monitoring and control system platform. The controllable resources for the provision of rapid response are wind farms, demand side response, gas turbines, solar PV and battery storage. Technologies have different response characteristics where optimisation algorithms will need to be developed to function with the resource algorithms to allocate and coordinate the responses to deliver a targeted, controlled and proportionate response to alleviate frequency deviations. Therefore, the resource algorithms together with the development of optimisation work will form the completed solution, where the development of the resource algorithms will identify the requirements and objectives of the optimisation functions.

The development of the optimisation algorithms will be a collaborative effort between Manchester University and Alstom which is due to begin after completion of resource algorithms, if not earlier. The resource algorithm work will be carried out with the collaboration of all project partners to ascertain specific response characteristics in addition to the output from network study analysis.

A report will be produced containing a description of the principle of the application, the algorithm functionality and a description of simulation tests undertaken.

Learning outcomes

Partner contractual agreement

All project partners have now agreed to a formal contract although there have been challenges with achieving this deliverable. Working with a number of partners on a multi-party contract has resulted in a delay to agreement of the contract against the successful delivery reward criterion milestone. Although the formal contract is not yet signed by all partners, the project has progressed as planned without any delays.

Contract management – As multi-party contracts can take a significant amount of time to agree, early engagement with partners on discussing the headline clauses would be beneficial. For future similar projects, it would be useful to seek agreement in principle with partners on the contract and include more all-partner discussions in an effort to reduce the negotiation period.

Control platform protocol communications

In collaboration with project partners, Alstom has reviewed protocol requirements for proposed EFCC deployment use cases. Alstom's Statement of Work proposes international standard protocols IEEE C37.118, IEC 60870-5-104 and IEC 61850 (GOOSE). Investigations have shown that few of the sites nominated as response providers by the project partners use these protocols. Alstom are currently collating options to resolve how interfaces can be achieved between the Alstom control system and the response providers, resources or resource control systems.

Intellectual property rights

No intellectual property has been created during this reporting period.

Current risks

Through the project structure and governance process, any potential issues or significant changes that affect project delivery can be identified and mitigation actions put in place for resolution of any identified issues. To ensure effective risk management, risks are at regular intervals.

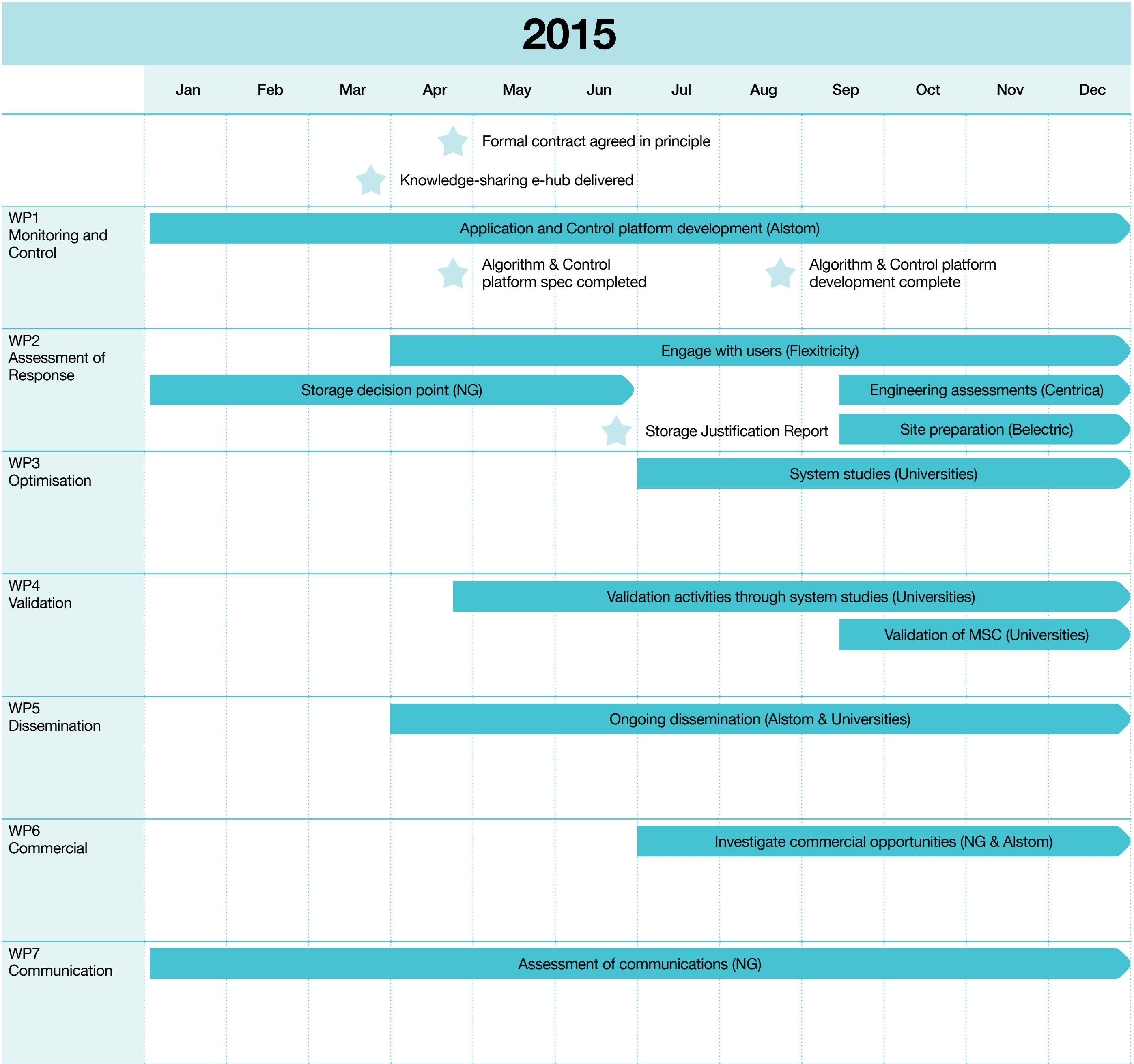
The table contained in the appendices provides an updated view of the Project Risk Register.

Assurance statement

This report has been produced in accordance with the overall 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 the EFCC (NIC) Project Director (Vandad Hamidi) .

Every effort has been made to ensure all information contained within this report is accurate.

Appendix A: EFCC Project Plan – 2015



Appendix B: Bank statement

Date	Type	Receipts	Payments	Customer Ref	Detail Information	Balance
5-Mar-15	MSC	15.00		REFUND CHGS 23JA	N LSC10XT	15.00
15-Apr-15	MSC	575,990.00		0000	NO 3 PAYMENTS CHARITY UC FEE	576,005.00
15-May-15	MSC	575,990.00		0000	NO 3 PAYMENTS LICENCES FEES	1,151,995.00
22-May-15	TRF	823,870.00		NATIONAL GRID EL	NGRDGB2LSSC /REMI//ROC/4754 PETS35338142 /ORDP/NATIONAL GRID ELECTRICITY TRANSMISSJO COOK // BANKING SERVICES SHARED SERVICES F /BENM/NGET PLC NIC FREQ CONTROLGB	1,975,865.00

Total		Receipts	Payments
		1,975,865.00	0.00

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

Risk No.	WorkStreams/ Area	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	3	2	3	9	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 due to 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	1	3	4	4	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	3	6	Steering Group	Knowledge of, and responsibility for, project to not rely on one person. Ensure documentation and guidance exists to assist anyone joining project team. Thorough handover processes to be in place	Effective
7	General	Quality of technology is insufficient – the monitoring and control system and/or equipment installed at response sites	Least cost option 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	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 CBA 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	3	3	3	9	Project Manager	Academics have a large internal candidate-base of experienced PDRAs. Reputation and facilities of partners will attract high-calibre candidates. Process for advertising for suitable candidates is progressing	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	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

Risk No.	WorkStreams/ Area	Risk Description	Cause	Consequence	Risk Owner	Likelihood (1–5)	Financial Impact (1–5)	Reputational Impact (1–5)	RAG	Escalate To	Action Plan	Control Opinion
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 degradation in the event of a loss of telecommunications	Effective
15	General	Inefficient operation of MCS	MCS not configured correctly which results in spurious tripping or excessive amounts of control initation commands	Over-response from resources reducing stability, excessive set-point changes in generators reducing asset lifetime	National Grid	3	3	4	12	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	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 available time for reports, tuning dissemination	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
19	General	Outage required for commissioning.	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	2	1	3	6	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 & Environmental	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

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23	WP1 – Control System	Technology partner fails to deliver suitable product on time	Problems with design and build	Project is delayed.	Alstom	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	Effective
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	Alstom	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 have been issued for partner review. Consolidated review comments (comments response sheet) will be assessed/discussed during project meetings and/or design review meeting Resource Allocation will be split into two parts, i.e. Requirements and Specification. We will seek partner feedback on requirements before embarking on specification for resource allocation	Effective
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	Alstom	2	1	2	4	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	Effective
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	Alstom	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 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

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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	Alstom	4	2	2	8	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 and Control Platform have been issued for partner review. ALSTOM will engage with project partners to discuss requirements and concepts for Resource Allocation	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	Alstom	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	Alstom	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	Alstom	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	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	Alstom	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

Appendices cont.

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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	Alstom	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	Alstom	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
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	4	3	3	12	Project Manager	Flexitricity to identify and start negotiations with potential participants as a matter of priority 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, comprehension of the proposition, duration of trials, uncertainty of long-term commercial service, opportunity cost	Ability of DSR to deliver EFCC not proven	Flexitricity	3	2	4	12	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 generation	CCGT operators struggle to get relevant technical input from OEM	Lack of communication or timely response from OEM	The project is delayed	Centrica	3	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 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	Careful and detailed up-front planning; project plan not too tight	Effective
43	WP2.5 – Wind	Wind farm operators struggle to get relevant technical input from OEM	Lack of communication or timely response from OEM	The project is delayed	Centrica	3	2	2	6	Project Manager	Draw up "heads of terms" with OEM. Pay OEM (from funding) for relevant technical input	Effective

Appendices cont.

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44	WP3 – Optimisation	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	Universities	2	2	3	6	Project Manager	Establish communication channels. Specify data requirements early. Closely manage process and follow up on any delays Options for receiving appropriate network models have been discussed. Important that academic partners and Psymetrix/Alstom use the same models for studies	Effective
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 rollout may be severely impacted by issues not flagged during the validation phase	Universities	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 – Dissemination	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	Universities	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 – Commercial	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
48	WP1 – Control System	Demonstration partner fails to install and configure demonstration set-up on time for SAT	Challenges encountered during installation and configuration or lack of understanding/training	Demonstration is delayed with likely impact on other activities	Alstom	3	1	1	3	Project Manager	ALSTOM – Psymetrix will 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	Alstom	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	Alstom	4	2	2	8	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: - IEEE C37.118 - IEC-60870-5-104 - IEC-61850 (GOOSE) - Modbus - DNP3 - 4-20mA - Relay 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	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	3	4	4	12	Project Manager	Prepare justification for battery storage to Ofgem	Effective

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52	WP2.5 Wind	Centrica struggle to get agreement of JV partners to proceed with technical changes	Concerns about risk to production or risk of technical damage	The project is delayed OR we move from using LINCS to Lynn or Inner Dowsing	Centrica	2	2	2	4	Project Manager	OEM support will help (see risk 43). Have full support of Lincs Wind Farm Limited General Manager which should also help	Partially Effective
53	General	Contract not being signed by all partners impacting project deliverables	Extended contract negotiations due to requirement for multi-party agreement	Project deliverables being impacted and project delayed	National Grid	3	2	4	12	Steering Group	Continued negotiation with project partners on the contract terms	Effective
54	General	Contract not being signed by all partners impacting trials	Extended contract negotiations due to requirement for multi-party agreement	Unable to trial all resource providers	National Grid	2	4	4	8	Steering Group	Continued negotiation with project partners on the contract terms. Separation of Schedule 2.5 from the contract to progress with gaining signatures	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	Alstom	3	2	2	6	Project Manager	ALSTOM-Psymetrix will further develop Controller concepts & schemes. ALSTOM will work with project partners to establish suitable demonstration set-ups. Impact assessment will be conducted to assess potential extra requirements in terms of hardware and/or effort	Effective
56	WP2.3 – PV power plant	Contractual difficulties with current owners of PV power plants	Loss of generation during trials needs to be compensated. Appropriate contracts need to be signed	Insufficient testing	Belectric	3	1	1	3	Project Manager	Talks to owners have started already	Effective
57	WP2.3 – PV power plant	Technical difficulties	PV-Inverter behaviour does not match the needs of Psymetrix's control concept (speed of response)	Modification of control concept or partly compensation by storage	Belectric	3	2	2	6	Project Manager	Evaluation has started already	Effective
58	WP2.4 – Storage	Technical difficulties if OFGEM declines usage of BELECTRIC storage	Interface protocols, reaction speed, level of access and available testing time may be different than what has been planned, based on BELECTRIC storage	The project may be delayed or working package 2.4 might not be rolled out to full extend (limited response capability)	Belectric	4	3	4	16	Project Manager	Prepare justification for battery storage to Ofgem	Effective
59	WP2.4 – Storage	Distribution network constraints limiting speed of response	Due to the concept of fast frequency response, very quick power ramp rates need to be realised. This may cause (or raise fear of) oscillations and hard-to-control transients in the distribution network	Speed of response may need to be limited	Belectric	2	2	2	4	Project Manager	Start conversation with DNOs soon and together with NG	Effective

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

www.nationalgrid.com