LCN Fund
Low Carbon Networks

Project Code/Version No: UKPNT206

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Section 1: Project Summary

1.1 Project Title:

Kent Active System Management (KASM)

1.2 Funding DNO:

South Eastern Power Networks Plc (SPN) - UK Power Networks

1.3 Project Summary:

The last few years have seen a number of Grid Supply Points come under pressure from the level of generation on the distribution networks exporting their power. This is the most extreme form of the electricity network operating in the opposite way to which it was originally designed, where sections of the network are not only supplying their own demand but also exporting the surplus onto the transmission system.

The area of Kent being considered in this project contains only two GSPs of the >350 nationwide, and a third is being established in the area. Nevertheless, it currently requires 34 contingency scenarios to be analysed in order to understand it fully.

The introduction of wind, solar, and the presence of interconnectors increases the number of extremes that need to be analysed - there is no longer a simple 'day of highest winter demand' and 'day of lowest summer demand'. There are therefore more extremes; a greater requirement to monitor all contingencies; and a growth in the number of GSPs being affected.

Contingency analysis is a valuable tool to predict the effect of outages like failures of overhead lines and to take actions to keep the distribution network secure and reliable. UK Power Networks will trial for the first time the use of contingency analysis in the GB electricity distribution network. It will also be the first trial of the implementation on a coordinated and interfaced basis with the electricity transmission network.

The KASM project will tackle and demonstrate the value of contingency analysis software in operational timeframes on the network in East Kent, delivering conservatively estimated net benefits of £0.6m. Once proven successful, replication of this method across GB could conservatively provide net benefits of over £65m over the lifetime of the investment, when compared to business-as-usual approaches.

1.4 Funding

1.4.1 Second Tier Funding Request (£k): 3,345

1.4.2 DNO Compulsory Contribution (£k): 378

1.4.3 DNO Extra Contribution (£k): 72

1.4.4 External Funding - excluding from NICs (£k): 45

1.4.5 Total Project cost (£k): 3,898

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Section 1: Project Summary continued

1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more interlinked Projects with one Project requesting funding from the Low Carbon Networks (LCN) Fund and the other Project(s) applying for funding from the Electricity Network Innovation Competition (NIC) and/or Gas NIC.

1.5.1 Funding requested from the Electricity NIC or Gas NIC (£k, please state which other competition): N/A

1.5.2 Please confirm if the LCN Fund Project could proceed in absence of funding being awarded for the Electricity NIC or Gas NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☐ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

Project Partners: National Grid; Navigant Consulting (Europe) Ltd.

Project Suppliers: Following a competitive procurement process, UK Power Networks has selected Bigwood Systems, Inc. as the preferred supplier of the real-time contingency analysis software. UK Power Networks has selected Schneider Electric as a reserve supplier.

Project Supporters: N/A

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
01/01/2015	31/12/2017

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title: Matthieu Michel, LCNF Tier 2 Project Lead	**1.8.3 Contact Address:** Energy House Carrier Business Park Hazelwick Avenue Three Bridges Crawley, West Sussex RH10 1EX
1.8.2 Email & Telephone Number: Matthieu.Michel@ukpowernetworks.co.uk 07875 117278	

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Section 2: Project Description

This section should be between 8 and 10 pages.

2.1 Aims and Objectives

Context

Distribution networks are designed to security standards that ensure redundancy in components and supply points. Distributed generation such as on-shore wind and solar photovoltaic (PV) relies on an up-stream connection to export its power, and can therefore be affected by both maintenance and construction outages and outages caused by faults unless there is a redundant or alternate route for its power.

As such, there is a strong focus within Distribution Network Operators (DNOs) to find contingency plans to avoid or shorten maintenance outages; to restore demand customers; and to maintain routes for generation in event of a fault.

This role within DNOs, starts with the network planners who design the network at the desk, and respond to new connection requests by identifying points of connection to the network. The role continues with outage planners, who specialise in maintaining and optimising the programme of outages to best serve customers. Finally, control engineers who monitor the network in real-time, issue and manage safety permits to staff working on the network, and respond to faults by reconfiguring the network.

The set of activities described above is generally referred to as 'outage planning' and 'contingency analysis' and has been carried out by the GB DNOs for many years. However, these are now being carried out in a significantly different context, in particular taking the effects of distributed generation into account.

The UK Renewable Energy Roadmap set out a comprehensive target for 15% of the electricity generated in the UK to come from renewable energy sources by 2020. [1] The targets established in 2011, were reaffirmed in 2013. [2] A significant number of these new renewable energy sources will connect directly to the distribution network. The UK's policy is part of the overall European Union (EU) target of achieving 20% penetration by renewable energy sources in total energy consumption by 2020. [5] UK Power Networks' South Eastern licence area has, for example, 100 large-scale solar photovoltaic plants with a combined capacity of 1140 MW awaiting connection to the network, which will more than double the amount of distributed generation in the area.

Increasing the number and magnitude of generation facilities connected to the distribution network materially changes the operational requirements of these assets and the operators that manage them. Assets and operator capabilities that were traditionally designed around one direction of power flow (i.e., down from the transmission network to customers) must be able to effectively handle power flows that change direction, based on prevailing conditions. For example, during periods of low demand and high generator output, power can flow back up through bulk or grid supply points to satisfy load requirements in other parts of the network.

Furthermore, the intermittency of renewable energy sources like solar and wind introduces additional volatility and requires enhanced visibility and greater flexibility on the part of assets and operators in order to maintain the high levels of reliability that customers have come to expect.

The traditional distribution network was relatively simple to run and required a low level of monitoring and real-time analysis, since the operation of the loads and assets was

Project Description continued

predictable. With increasing volatility, arising primarily because of the increased penetration of distributed renewable generation, there is a need to modernise the distribution network in a way that allows interaction between planning and operation, and provides real-time flexibility without sacrificing reliability.

The Problem
The operating area of East Kent in the South Eastern Power Networks license area provides a perfect example of the operational and planning challenges that arise when large amounts of intermittent wind and solar generation are connected to a distribution network with limited local demand. These challenges have ultimately led to delays before renewable generators can join the network, and significant connection costs.

The operating area of East Kent, includes the 400/132 kV GSPs at Sellindge and Canterbury North. The firm capacity for Canterbury North, which has two super grid transformers (SGTs), is 276.5 MW in the winter and 244.2 MW in the summer. The Sellindge substation operates as a split double bus, with a pair of SGTs with a firm capacity of 276.5 MW in the winter and 244.2 MW in the summer dedicated to the Eurotunnel demand. The remaining two SGTs, with the same firm capacity, supply local demand. All of the six SGTs at both sites have a rating of 240 MVA. [4]

A large portion of the 132 kV network in East Kent operates in parallel with National Grid's 400 kV network. As a result, the networks are interdependent, and through flows on either can lead to post fault overloading. Exacerbating this condition are two high voltage direct current (HVDC) interconnections with continental Europe, over which market forces almost exclusively determine the flows. The first is a 2,000 MW interconnection with France that connects to the 400kV network at Sellindge. The second is a 1,000 MW interconnection with the Netherlands that connects to the 400kV network slightly north of Canterbury North at Grain. A third, 2,000 MW interconnector between Belgium and a new National Grid 400kV substation and GSP at Richborough is planned for 2018/2019 (NEMO). As part of the NEMO work, National Grid would reroute and uprate the 132 kV circuit between Richborough and Canterbury South to a 400 kV circuit between Richborough and Canterbury North. During the summer maintenance season, UK Power Networks anticipates that the construction work and planned outages associated with the NEMO works will place added pressure on outage planners and existing distributed generation connections.

The East Kent operating area currently contains approximately 510 MW of largely intermittent wind and solar PV generation connected to the 132 kV, EHV and HV networks. This includes the Thanet and Kentish Flats offshore wind farms, 315 MW and 90 MW respectively. Connection offers for a significant amount of additional generation (~450 MW), largely solar PV, were accepted and as such these facilities are due to connect in the short term.

Given the current demand growth expectations and the existing GSP capacity, UK Power Networks is not able to provide new connection offers in the area until 2020. Furthermore, the new National Grid funded GSP at Richborough, planned as part of the NEMO project, is not expected to increase the capacity of the East Kent network to accommodate additional generation on the 132 kV, EHV, and HV systems. As such, even once these works are complete there will be a continued need to add further capacity at the Richborough or Canterbury exit points to support a continued growth of renewable generation, and potentially a need for upgrades to UK Power Networks' overhead lines. As such, generators

Project Description continued

are not only seeing delays in joining the network but will also continue to experience high grid connection costs based on the GB DNOs' current ability to analyse and predict SGT utilisation.

Managing power flows on this complex, interconnected network are also set to become increasingly challenging since 34 contingency scenarios need to be analysed in order to understand it fully under single fault conditions. Generation output across the network will vary considerably by type, location and prevailing weather patterns, resulting in rapidly changing power flows, with the potential of reverse power flows to approach or exceed thermal constraints under a limited number of very specific post-fault conditions. Contingency scenarios need to be repeatedly re-analysed in the context of a growing and changing queue of distributed generators with offers to connect to the network.

Furthermore, a lack of real-time detailed information on the performance of the network contributes to conservative operating and planning practices, and as such, the network may not be utilised to its fullest potential.

UK Power Network recognises that in order to maintain the reliability of the network and achieve an optimal utilisation in the face of a rapidly changing landscape, requires the development of technical and analytical capabilities that do not currently exist within DNOs in the UK.

The Method
The Kent Active System Management (KASM) project will trial an innovative application of a software tool, real-time contingency analysis, in a DNO control room. Transmission system operators currently use a variant of this tool to actively manage the reliability of complex transmission networks.

The method brings together a number of technical and commercial components:
1. the development of the business processes and functional requirements to enable enhanced sharing of real-time operational data between DNOs and TNOs;
2. the implementation of a sophisticated suite of software tools that enables analysis of power flows for the current (intact) and post-fault (N-1, N-X) network states in operational timeframes and automatically quantifies operating shortfalls; and
3. the development of sophisticated near term unit-specific and bus-specific load and generation forecasting capabilities to enable accurate modelling of corrective and preventative control actions.

Together, this method will enable DNO control room engineers to more effectively monitor the network and to take preventative or corrective actions that limit the effects of a potential fault. The method will also enable advanced offline analysis using forecast data to allow outage and network planners to plan for the optimal operation and configuration of the network.

Finally, the collected data and the results of the contingency analysis will be stored in a database developed as part of the project. Overtime, this database will provide insight into the performance of the network under a wide variety of operating conditions, thus providing invaluable data that can help inform future operating and planning decisions, including future "smart" interventions.

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The Trials

The operating area in East Kent, as shown in Appendix B, is the ideal test bed to trial the proposed method. As discussed in Section 2.3 below, we have designed a series of trials that demonstrate the impact and benefit of contingency analysis modelling capabilities on reliability management, outage management, and long-term network planning.

The project will establish the necessary business processes and functional requirements to allow the exchange of real-time data between the UK Power Networks and National Grid control rooms. Additionally, UK Power Networks will procure an interactive software solution that will analyse power flows on the 400 kV and 132 kV networks in the East Kent area and prepare contingency analysis studies within operational timeframes. The software solution will display the results of the analysis to control room engineers and will store the results in an accessible database for future offline studies.

The deployment of the solution in East Kent will allow the control room engineers to manage the reliability of the network as new distributed generation comes online. It will also enhance the capability of outage planners to minimise constraints placed on the output from distributed generators during the summer maintenance season and during the major construction and reconfiguration activities required to complete the NEMO interconnection.

The knowledge and learning generated from the trials will enable a robust assessment of the full potential value of the modelling and analysis capability on reliability management, outage management, and long-term network planning business processes. We expect that the conclusions from the project will help other DNOs to implement similar solutions, thus taking an important step in modernising GB distribution networks.

The Solution(s)

The KASM project will deliver enhanced visibility and analysis capabilities regarding the power flows and stability of the 132 kV network to control room engineers and outage and network planners.

These capabilities will enable UK Power Networks to:

- manage the network in real-time in order to improve reliability;
- reduce congestion and better manage planned and unplanned network outages; and
- improve long-term planning capabilities to anticipate network capacity issues thus improving the reliability and capacity of the network.

2.2 Technical description of project

KASM involves the deployment of tools and capabilities that are integral to the active management of the distribution network and support the transition from a distribution network operator to a distribution system operator (DSO). The ability to model power flows and analyse possible post-fault conditions (N-1, N-X) in operational timeframes ensures the integrity of a network with increasingly variable power flows and enhances the value of flexible demand, dispatchable resources, and smart/controllable infrastructure (e.g., quad boosters, tap changing transformers, series reactance, etc.) by supporting active power flow management.

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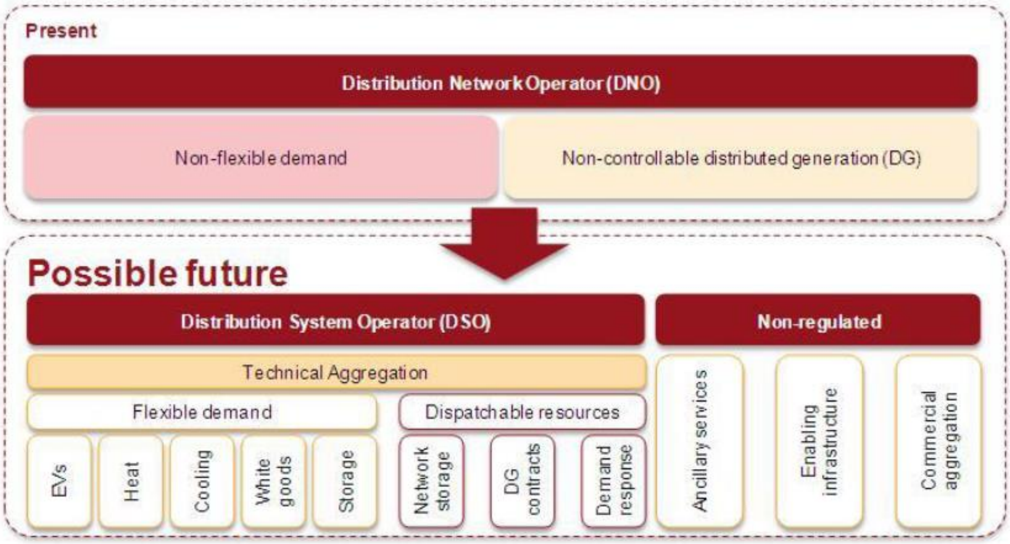
Figure 1: Transition from DNO to DSO [3]



The KASM project is innovative in its use of a contingency analysis platform, which is previously untested on a distribution network in GB, as the management of these networks was not sufficiently complex to warrant it. We have spoken to the Scottish DNOs, which operate joint control rooms with their transmission assets, and their capabilities are summarised in the evaluation criteria section. Furthermore, the establishment of a data interface between the DNO-TSO control rooms would trial for the first time in GB the use of enhanced coordination and integration across the GB network.

In order to deliver this innovation, we have arranged the KASM project into the following five work streams:

- WS1 – Information Sharing, Data Integration and Setup;
- WS2 – Contingency Analysis Tool Development and Integration;
- WS3 – Load and Generation Forecasting and Network Modelling;
- WS4 – Value Streams and Business Process Impacts; and
- WS5 – Knowledge Dissemination and Stakeholder Engagement.

WS1 – Information Sharing, Data Integration and Setup
This work stream will be responsible for reviewing existing business processes for data retrieval and usage. Modifications will be made to current processes and new business processes will be developed for obtaining the data required for contingency analysis activities. In this work stream the process and expectations to receive and provide data will be defined.

This work stream is also responsible for implementing the IT infrastructure that is required to achieve data transfer to and from National Grid in compliance with the data, security and performance requirements. Staff will be trained and assigned to monitor and ensure data transfer is maintained at the required service level.

WS2 – Contingency Analysis Tool Development and Integration
This work stream will be responsible for all activities related to getting the contingency analysis tool operational. In this work stream, activities related to functional design development and documentation will be conducted with input from the vendor and UK

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Power Networks operational teams. The developed design will be reviewed by UK Power Networks staff and potential changes to functionality, performance and output mechanisms will be documented.

Once the functional design is complete, data preparation to populate the contingency analysis tool is a key task in this work stream. UK Power Networks staff will be required to provide the contingency cases used within the tool and data dumps of the network model at periodic predetermined intervals will be made available to the vendor.

Design and data preparation are followed by the vendor software development and loading of the data provided by UK Power Networks. The provided data are loaded on to development hardware where the contingency analysis software operation and design verification is performed. Post development factory testing, site testing and demonstration is performed by the vendor and UK Power Networks staff. Successful test and demonstration leads to production implementation of the contingency analysis tool.

WS3 – Load and Generation Forecasting and Network Modelling
In this work stream, systems that will be used in conjunction with the contingency analysis tool will be developed. Uncertainties in forecasting intermittent resources such as wind, solar and system loads that do not fit the traditional load and generation pattern will need to be considered. In this work stream load and generation modules to accurately depict the nature of resources on the network will be developed. A forecasting model architecture that incorporates the following attributes will be developed:

- generator and load modules;
- forecasting engine;
- historical generation and load patterns;
- historical weather patterns; and
- optimisation and normalisation modules.

The metrics that will be derived from the developed forecasting modules will be the output curves for distributed generation in the area based on forecasted weather, and the load curves based on historical data and forecasted weather. We will also use forecasting error curves to assess the accuracy of the forecasts.

The overall structure of the forecasting modules has not yet been defined in detail, but our preferred solution is Bigwood Systems' Elite Multi Time-Scale Load and Generation Forecaster. UK Power Networks will work with the planning team and the software vendor to assist in designing the architecture. The design will include averaging or 'poll of polls' mechanisms to incorporate uncertainties of intermittent generation and load and achieve traditional type forecasts for the look-ahead horizon. We will actively seek to avoid duplication of any existing forecasting work and we will incorporate existent forecasts as inputs in order to minimise error (e.g., National Grid's wind forecasts for large wind generators).

WS4 – Value Streams and Business Process Impacts
Load and generation forecasting combined with accurate contingency analysis has the potential to provide a range of benefits with respect to network management. Accurate real-time, short and long term planning is valuable in effectively managing the distributed resources resulting in optimum use of the available network resources. The purpose of this work stream is to explore the objectives, design and methodology to conduct real-world trials with installed applications. The outcome of these trials will be used to support network

management functions across the different time horizons.

WS5 – Knowledge Dissemination and Stakeholder Engagement
The KASM project incorporates the use of software, hardware and soft measures that will produce various streams of knowledge and lessons learned. We envision that the project conclusions will have the most impact with DNOs, the TNOs, and distributed generation developers. Other parties that would potentially benefit from the knowledge generated by KASM are academic institutions, HM Department of Energy and Climate Change (DECC), Ofgem, the Electricity Network Association and various smart grid stakeholders and groups. Stakeholder engagement is a vital way of communicating project activities to interested parties; the information transfer process will be bi-directional so that information feeds back to the UK Power Networks' project team. Engagement activities will include periodic project workshops and internal dissemination events.

A dedicated work stream will focus solely on the capture and dissemination of knowledge and learning from the project to other DNOs and stakeholders for use in their projects and business activities.

2.3 Description of Design of Trials

Accurate real-time, short and long term planning is valuable in effectively managing the distributed resources resulting in optimum use of the available network resources. Work stream 4 will allow UK Power Networks to explore the objectives, design and methodology to conduct real-world trials with installed applications. The trials will cover:

- **real-time reliability management** - to manage network reliability in real-time with network model and network status data;
- **outage management** - short term load and generation forecasting models that use weather data in conjunction with the contingency analysis tool will be used to study network congestion in standalone systems
- **network capacity management** - long term planning of the network in the timeframe of one to five years ahead is performed.

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	What is it?	How we do it today	How KASM will deliver
Reliability Management	Real-time monitoring of the network operation and mitigation of the effects of faults	Restorative Alarms indicate to the control room engineers when asset loading exceeds established limits. Engineers make decisions on corrective actions.	Preventative Constantly analysing potential contingencies before they occur, alerting control room engineers, and recommending preventative actions
Outage Management	Assessing short-term operating conditions for the network based on planned maintenance and forecasted generation and demand	Manual Outage planners manually analyse all possible contingencies, to ensure that outage plan is consistent with n-1 reliability requirements	Automated Automate the analysis of all possible contingencies. Forecasting capability will allow outage planners to use hourly (or sub-hourly) estimates of demand and generation
Network Capacity Management	Assessing network capacity, and determining timely reinforcement to ensure reliable operation	Worst case Infrastructure planners design the system to withstand worst case planning assumptions	Actual Archiving capability will enable infrastructure planners to incorporate actual diversity of generation and coincidence with demand

The purpose of the **Reliability Management trials** will be to determine the operational framework and to assess the benefits of using the software suite in real-time in the network control room. Control room engineers will be trained to use the software suite and their feedback on its use will be used to customise the solution to their requirements.

We expect that the trial will involve the concurrent use of the solution with the existing operation framework for small periods of time throughout a year (to capture seasonal variances) in order to be able to compare ex-post the decisions made in each case (existing framework vs. framework based on software suite) and understand the difference in the results.

Furthermore, we will use at different times during the trial process questionnaires to capture the user experience from the use of the solution in order to tailor the software suite to the needs of the control room staff.

This benchmarking exercise will allow the generation of data that will in turn allow the project team to understand and quantify the benefit associated with the use of the solution in terms of reduced generation curtailment.

Project Description continued

Similar to the above, the **Outage Management trials** will involve the comparison of the use of the current methodology for forward planning (a few days ahead) with the proposed methodology that will involve the use of historical and forecasted data for generation, demand, HVDC interconnector operation, and power flows from the transmission network.
The results of the benchmarking exercise between the existing and new outage planning methodology will generate data that will allow the project team to quantify the benefit of the use of the proposed solution in terms of reduced generation curtailment.

All generators will continue to be given their outages based on current practice; but the Outage Planners during the trial will be able, at their discretion, to issue individual generators reduced outages or smaller curtailments, as their confidence in the software increases.

The data generated from the use of the software suite in Reliability Management and Outage Management will allow the development of a database that will in turn be used to develop a deterministic model for the **Network Capacity Management trials**.

Specifically, capacity planners will be asked as part of the KASM trial for Network Capacity Management to assess connection requests based on the existing framework. These connection requests will be re-assessed at a latter point using data around the coincidence of maximum generation and minimum load, transmission network power flows, and HVDC interconnector operation.

We expect that the use of the data from the proposed solution will allow capacity planners and connection designers to issue more connection offers that are not linked to network reinforcement. Using the data from this benchmarking exercise, the project team will be in a position to assess the level of additional network capacity that can be released through the use of the proposed solution.

The outcomes of these trials will be used to support network management functions across the different time horizons.

2.3 Changes since the ISP

The project no longer includes the trial of Smart Wire technology as an operational solution. Additionally, work streams have been added for the development of an inter-control room communication business framework (with National Grid being a partner) and for the development of load and generation forecasting modules.

References

[1] Department of Energy & Climate Change, "UK Energy Roadmap," London, 2011.
[2] Department of Energy & Climate Change, "UK Renewable Energy Roadmap Update 2013," London, 2013.
[3] UK Power Networks, "Business plan (2015 to 2023), Annex 9: Smart Grid Strategy," London, 2014.
[4] UK Power Networks, "Canterbury \ Sellindge, SPN Regional Development Plan," London, 2014.
[5] European Commission, "Directive of the European Parliament and of the Council amending ... Directive 2009/28/EC on the promotion and use of energy from renewable sources," Brussels, 2012.

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

UK Power Networks recognises a clear need to enhance its ability to actively analyse and manage the status of its 132 kV network. We recognise that the existing approach of investment and passive monitoring may result in sub-optimal utilisation of existing assets and places constraints on the penetration and operation of distributed generation resources. The KASM project will deliver benefits to our existing and future customers and all GB DNOs, by integrating and applying innovative real-time analysis tools with the ability to model power flows and analyse possible post-fault conditions (N-1, N-X) in operational as well as planning timeframes. The project will demonstrate how this capability can enhance reliability management, outage planning, and network (or infrastructure) planning practices.

3.1 Business case context

The UK government targets to achieve 15% of electricity from renewable sources by 2020 while at the same time, it is expected that installed solar capacity will exceed 19 GW by 2030 and wind capacity will exceed 12 GW (*Source:* Transform Model: Low Carbon Technology trajectories, central scenario, April 2014). This growth in installed renewable generation poses a significant challenge that will transform the way in which we generate and distribute electricity.

Over the last decade, we have seen a transition in the operation of the distribution network: from being primarily demand or load orientated, to a more integrated network containing far greater levels of embedded generation. This started with large-scale offshore and onshore wind and waste to energy. However, in the last five years, there has been an increase in the number of solar PV facilities connected to the EHV, HV, and LV networks. The first of these projects were generally small-scale domestic or commercial installations.

While the small-scale solar PV facilities continue to connect, in the last 12 to 18 months, we have also seen a major increase in enquiries and accepted connection offers for large-scale solar PV installations. These facilities are anywhere from 1 to 50 MW and are generally connecting to the EHV and 132 kV networks.

Figure 2 below shows the level of distributed generation connected or with accepted connection offers in SPN. Figure 3 shows the pace at which large-scale solar PV facilities have received and accepted connection offers over the 12-month period ending April 2014.

Figure 2: Distributed generation connections - SPN

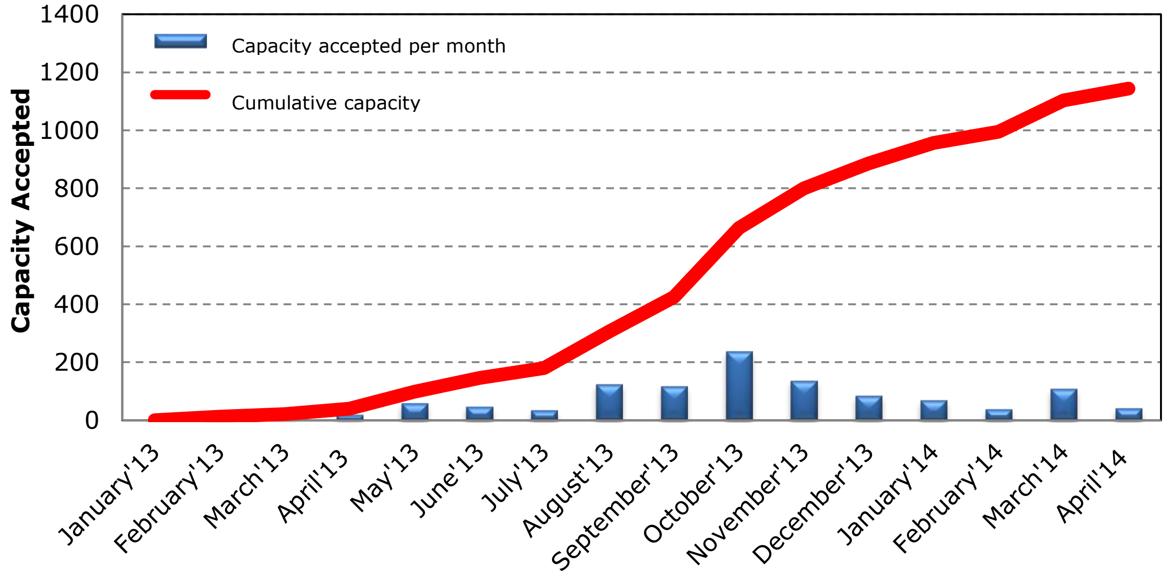
	Connected		Awaiting Connection	
	Number	**Capacity**	**Number**	**Capacity**
Large Scale Offshore Wind	2	450MW	0	0 MW
Large Scale Onshore Wind	3	100MW	0	0 MW
Large Scale Waste to Energy	3	100MW	0	0 MW
Large Scale PV	8	50MW	100	1140 MW

Note: The values above do not include small-scale household or commercial systems

To give an idea of the magnitude of this capacity, the London Olympic Park had a demand of approximately 45 MW during the games. The amount of generation capacity that accepted an offer to connect in SPN is approximately 25 times greater.

Project Business Case continued

Figure 3: SPN connection offers accepted



The situation in East Kent presents a perfect example of the issues and challenges associated with this evolution.

The East Kent operating area interconnects to the 400 kV transmission network at the GSPs at Canterbury North and Sellindge. The network covers a significant geographic area incorporating Canterbury, Richborough, Betteshanger, Sellindge, Ashford and Ruckinge. This configuration has operated well for many years, meeting and exceeding the demand requirement for the area.

The East Kent operating area currently contains approximately 510 MW of largely intermittent wind and solar PV generation connected to the 132 kV, EHV and HV networks. Connection offers for a significant amount of additional generation, (approximately 450 MW), largely solar PV were accepted and as such these facilities are due to connect in the short term.

Given the current demand growth expectations and the existing GSP capacity, UK Power Networks is not able to provide new connection offers until 2020. Furthermore, the new National Grid funded two-transformer GSP at Richborough, planned in connection with the NEMO project, is not expected to increase the capacity of the network to accommodate additional generation connections, but instead is designed to allow a new interconnector to be landed. As such, new incremental connection offers in the area are conditional on the customer paying for a third transformer at Richborough. The estimated cost of this third transformer and the associated switchgear and civil works is £11 million.

The large amount of incremental generation connecting to the East Kent network has eroded the capacity margin that existed in the region. As a result, the work done by outage planners to schedule and coordinate maintenance activities on the network has become increasingly difficult. In some instances in the last few years, this has resulted in the curtailment of distributed generation in order for UK Power Networks to carry out maintenance. We anticipate that further pressure will be placed on outage planners and existing distributed generation customers as new distributed generation connects and the

Project Business Case continued

construction work and planned outages associated with the NEMO project commence.

Finally, managing the power flows on this complex, interconnected network is becoming increasingly challenging. Generation output across the network varies considerably by type, location and prevailing weather patterns, resulting in rapidly changing power flows, with the potential for reverse power flows under an increasing number of conditions. Extensive network modelling conducted as part of the bid development process also demonstrated that the direction and magnitude of power flows over the interconnectors with France and the Netherlands significantly affects the power flows on the 132 kV network in East Kent. This places considerable added pressure on control room engineers to maintain the reliability and safety of the network.

3.2 Nature of benefits

KASM seeks to explore how a distribution network operator can use real-time power flow modelling and potential post-fault analysis capabilities, combined with enhanced generation and load forecasting, to:

- operate the network closer to its limit and hence as an alternative to traditional reinforcement;
- reduce constraints placed on generators during maintenance and other planned outages; and
- improve operational processes to reduce time-constraints on outage planners and reduce the overall risk on the network.

Contingency analysis is an advanced form of power flow modelling that evaluates the potential for adverse conditions (e.g., thermal overloads, voltage stability, etc.) on a network under an intact system state as well as under the universe of single (N-1) and multiple (N-X) contingencies. While not considered “contingencies” in a traditional sense, this could also include sudden increases or decreases in generation output from wind and or solar PV facilities.

The illustrative example below shows the indicative results of a contingency analysis for a simple network under an intact system state (left) and a state where one of the lines is on outage (right). For the intact system state, the analysis reveals that there are no potential thermal overloads under a single contingency event. For the outage condition state, the analysis reveals that there are certain events that could result in an overload. There are a number of factors that contribute to this potential condition, including the real-time demand at each of the nodes. Without access to this real-time capability, control room engineers, and outage and network planners generally use “worst-case” assumptions such as minimum or maximum demand.

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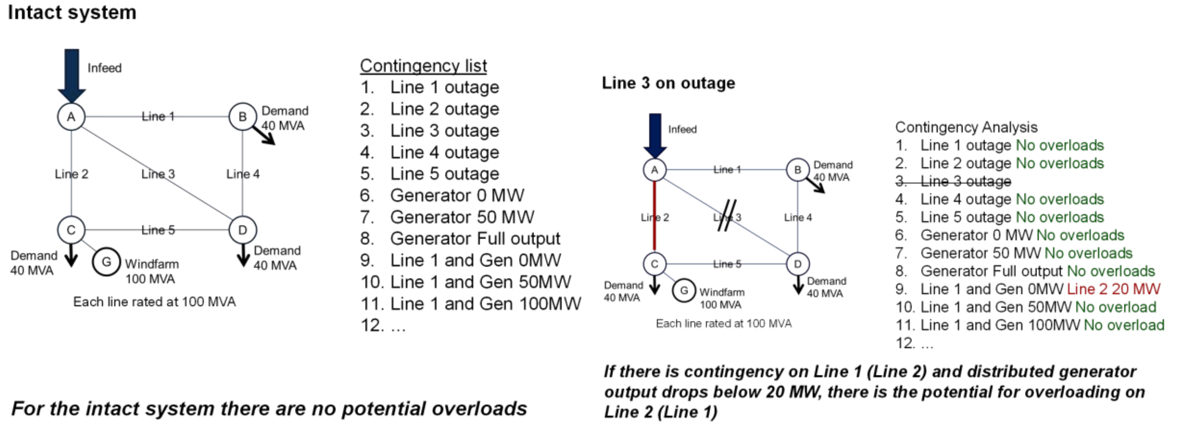
Project Business Case continued

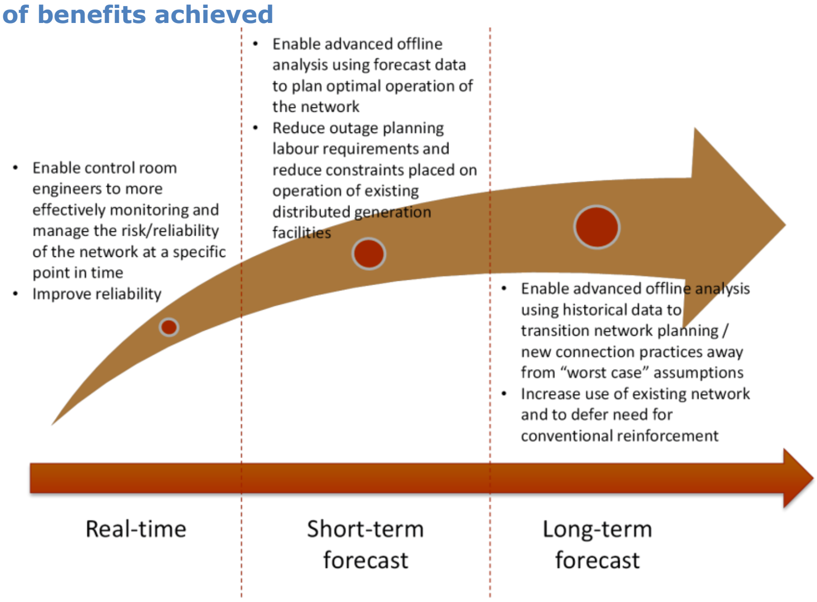
Figure 4: Illustrative example of contingency analysis output



This approach generally results in the underutilisation of the network when the "worst-case" conditions do not materialise. Furthermore, control room engineers are not able to prepare for and take preventative actions to eliminate or reduce the impact of potential contingencies.

The use of "worst-case" planning assumptions has a direct impact on the need for network reinforcement and the magnitude of the constraints placed on distributed generators during planned and unplanned outage conditions. Enhancing outage and network planners' modelling and analysis capabilities by introducing a real-time contingency analysis tool, with advanced load and intermittent generation forecasting capabilities and extensive archiving of past system states will enable the network to be operated closer to its limit and reduce constraints placed on generators during outages.

Figure 5: Types of benefits achieved



One benefit that we anticipate, but have not considered in the business case for this project is the impact on reliability. The reliability of the 132 kV network is already very high. The enhanced analysis and forecasting capabilities that will be deployed for this project will enable control room engineers to better plan for and mitigate high impact but low probability outage events.

3.3 Overall financial benefit

Overall, the KASM method is estimated to provide a **net benefit of £0.6 million in present (2014) terms over the business as usual approach**, as described below.

Net benefits were calculated using the following methodology:

- Quantification of the projected costs of the base case, or business as usual;
- Quantification of the projected costs of the KASM method;
- Quantification of the benefits which are unlocked through its deployment; and
- Quantification of the net benefit.

The base case scenario to resolve the constraints in the East Kent network involves the installation of a third SGT in Richborough right after the completion of the NEMO interconnector. This reinforcement will ease some of the constraints in the area concerning line overloads and reverse power flows on transformers. The base case cost for this type of traditional reinforcement is £9.7 million in present value (2014) terms.

Once demonstrated, the capital and operational cost element of replicating the KASM solution at an equivalent scale is estimated to be £2.3 million in present value (2014) terms. This assumes savings on project management, system integration, trial development and implementation, learning and knowledge dissemination, and contingency allowances.

Enabled by the learning and methods developed within the project and leveraging the enhanced capabilities the tool provides is conservatively estimated to give rise to the following benefits, which serve to offset the capital and operational costs of the system.

- Deferral of third SGT at Richborough: Advanced real-time modelling and analysis capabilities will enable the network to be utilised closer to its limit, thus enabling the deferral of the traditional reinforcement and installation of a third SGT at Richborough by two years, reducing the present value of this investment by £0.7 million to £9.0 million in present value (2014) terms.
- Higher utilisation of wind and solar capacity: Advanced real-time modelling and analysis capabilities, combined with more sophisticated near-term load and generation forecasting, will enable a reduction in the constraints placed on distribution connected wind and solar PV resources during maintenance and other planned outages. This additional production will displace higher carbon emitting resources and reduce lost revenue worth an estimated £2.1 million in present value (2014) terms.
  It is expected that the higher utilisation of wind and solar capacity will also have a positive effect on electricity bills for customers, as zero marginal cost generation will displace conventional generation from the grid. This added benefit has not been examined in the context of the KASM business case.
- Maintaining existing outage planning labour: Automating the forecasting and contingency analysis that is normally conducted manually by outage planners will obviate the need to add additional resources that would otherwise be required to manage the more sophisticated network in East Kent and the significant works planned around the NEMO project, an estimated benefit of £0.2 million in present value (2014) terms.

The overall net costs of replicating the KASM solution are estimated to be £9.1 million in present value (2014) terms. This cost is the result of combining the method cost, net of first-of-a-kind costs, with the benefits of the deferred reinforcement and the side benefits of

Project Business Case continued

the avoided generation curtailment and labour costs.

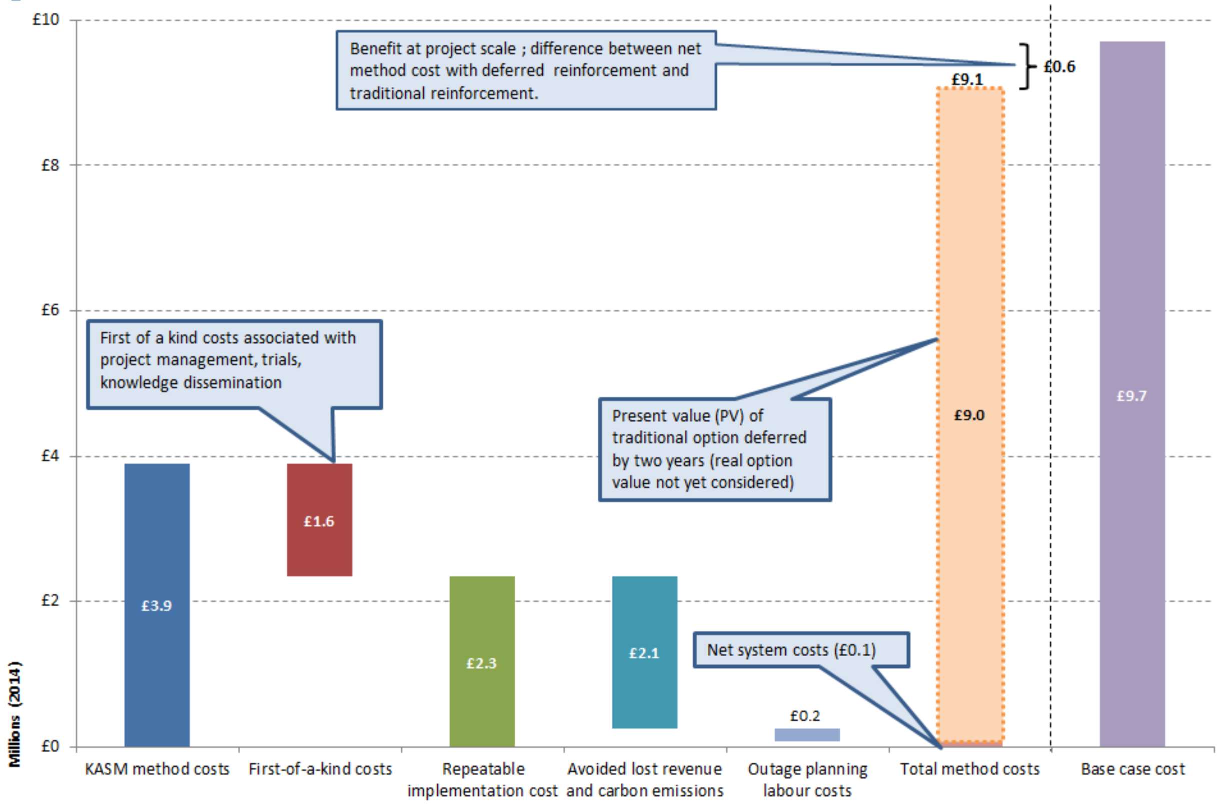
The deferral of the investment in the third SGT in Richborough presents a benefit in terms of the reduced net present value of the investment that is deferred by two years. At the same time, the deferral will provide the added benefit of flexibility, since the added time to the installation of the SGT will allow the collection of additional information around the behaviour of the network that can aid in determining the optimal timing and sizing of the reinforcement. This added benefit (known as *real options value*) hasn't been examined in the context of the business case.

Figure 6, below illustrates the calculation of net benefit. Appendix G contains additional detail on these calculations.

All figures have been calculated using UK Power Networks' proposed cost of capital of 3.5%, a capitalisation rate of 70% and a depreciation term of 45 years. As such, this is fully compliant with both Ofgem's Cost-Benefit Analysis requirements and typical HM Treasury principles.

Net benefits to customers in the early years, or much shorter time windows than the 45-year view are significantly higher.

Figure 6: Overall financial benefit



We believe that there are benefits in addition to the ones outlined above. Specifically, modelling of the East Kent network identified other network assets that could require generator-funded reinforcement in the near future (e.g., overhead lines). We expect that the use of the proposed solution will defer the need to reinforce these assets, similarly to the deferral of the third SGT at Richborough.

Furthermore, by creating the option to defer the investment in the third SGT at Richborough the method creates additional value. Using a real options valuation approach, we estimated that the stated benefit of £0.7m due to reinforcement deferral could be as high as £1.1m. This reflects the potential for further deferrals of the investment in the third SGT at Richborough as new information about supply or demand becomes available and the potential for a lower cost alternative to materialise.

3.4 Benefits of a wider rollout

Analysis conducted on the number of export constrained GSPs in the GB today and under alternate supply and demand scenarios identifies that there are between five to eight credible sites per year that could benefit from the deployment of the KASM method.
The application of the KASM method at these sites is estimated to defer the need for traditional network reinforcement, increase the capabilities of outage planners, and reduce the impact of planned outages on existing generation customers.

Using a conservative estimate of three sites per year for ten years starting in 2018, the estimated net benefit of a wider rollout across the GB is in excess of £65m in present value (2014) over the lifetime of the investment.

This level of benefit is achieved through a full rollout of contingency analysis and enhanced outage planning and management processes across all GB DNOs, and by achieving the performance improvements as assumed in the analysis presented above. The nature of the proposed solutions means that incremental or partial benefits can still be achieved with a more limited rollout.

Additional detail is provided in Appendix G.

3.5 Carbon benefits

The adoption of active system management techniques through the rollout of the KASM method will translate into environmental benefits through the higher utilisation of wind and solar capacity, avoiding the need to curtail zero-carbon generation.

As described previously, we estimate that there are at least 30 export constrained GSPs in the UK that could benefit from the deployment of a real-time contingency analysis solution by 2030. Linear extrapolation of the benefits estimated for the East Kent region, results in an estimated carbon emissions savings of approximately 275,000 tonnes of CO_2. This equates to an associated financial savings of £7.6 million in present value (2014) terms.

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Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

4.1 Accelerates the development of a low carbon energy sector and has the potential to deliver net financial benefits to future and/or existing customers

The Carbon Plan describes the Government's strategy to maintain security of supply whilst tackling climate change in a way that minimises costs and maximises economic benefit. This project strongly supports the principles that underpin this strategy.

Facilitate Low Carbon Generation: Within the East Kent area, high solar irradiance and favourable wind conditions support a timeline of renewables projects that contribute to the Carbon Plan's low carbon generation objective. The KASM method and real-time contingency analysis platform will give us deeper insight into the behaviour of this part of the network and provide us with more flexibility in terms of how it is managed. Ultimately, this improved capability will be reflected in a greater range of options to expedite future renewable generation connections that is attractive for renewables projects.

Building a stronger and smarter grid*:* We expect that power flows will become increasingly unpredictable, both intra- and inter-day, particularly in areas such as East Kent. This is due to new intermittent sources of generation such as wind and solar, and increasing interconnection within distribution networks and between distribution and transmission networks. The Carbon Plan implicitly recognises the complexity of power flows and calls for stronger and smarter grids to accommodate them. Real-time analysis and modelling capabilities are critical to actively managing this evolving landscape.

The contingency analysis platform is a key enabler of smarter networks*:* It provides insight into alternative network configurations and provides opportunities for new technologies. Ultimately, the CA tool will allow the network to operate closer to its design parameters whilst maintaining the integrity of the power system. Were this is to be adopted across other (increasingly interconnected) distribution networks, we might see a wider and more rapid adoption of smarter alternatives to traditional network investment.

Minimising cost and maximising economic benefit: As the Carbon Plan describes, all renewables generation projects are assessed against wider environmental factors before consent is granted. This inevitably drives uncertainty into the project lifecycle and timing of new generation connections. Our Method works towards a solution that maximises the volume of generation that connected to the network and minimises recourse to incremental investment until the investment signals are clear. By postponing traditional investment, and highlighting opportunities for alternatives, this project contributes towards reducing the cost of meeting the Carbon Plan.

We believe that in response to the network issues in East Kent the current 'business as usual' practice would require further capital investment. Early thinking would put the cost of this range of options in the low millions of pounds. This is comparable with the cost of learning from CA deployment in the network serving East Kent. However, the techniques will be relevant to our other operating areas and other DNOs' networks. Consequently, we expect the benefits of the CA platform to scale with a wider implementation.

Rollout to the GB Network*:* The KASM project will tackle and demonstrate the value of contingency analysis software in operational timeframes on the East Kent network, delivering conservatively estimated net benefits of £0.6m. Once proven successful, replication of this method across GB could conservatively provide savings of over £65m over the lifetime of the investment in present value (2014) terms, when compared to business-

Evaluation Criteria continued

as-usual approaches.

(b) Provides value for money to distribution customers

As previously stated, the KASM project will deliver estimated net benefits of £0.6m even at the scale of the East Kent network alone. Further details can be found in the Cost Benefit Analysis section in Appendix G. We believe the project also provides value for money in the way it was originally identified and procured.

We developed a list of 11 project concepts; and separately became aware of two requests for partners within Network Innovation Competition (NIC) projects. The list of 11 ideas comprised of four brought forward from within the UK Power Networks business, and seven from external partners including three SMEs. These were evaluated and three lead concepts developed further in the weeks leading up to the ISP submission (again, led by one SME, one major vendor and the other by internal business respectively), before final selection of this preferred proposal.

The rationale employed in selecting the shortlist incorporated a structured evaluation of several aspects with consensus agreement during a selection workshop. For instance, it was important that the proposal:

- addresses a substantial challenge that the business is already going to face,
- is clearly articulated,
- provides a sufficiently novel solution beyond business as usual,
- adds breadth to our project portfolio without duplication,
- is cost-effective when compared to traditional network options, and
- demonstrates clear benefits to distribution customers.

Project KASM is highly innovative: The project will demonstrate the use of contingency analysis in the control room of a GB DNO for the first time; control rooms do not currently have real-time data handling capacity. The conclusions and learning achieved from the project will be instrumental in helping other DNOs implement similar solutions, thus taking a first step in modernising the GB distribution network.

It will also bring together for first time DNO and TSO real-time data in the control room and that is significant difference when compared to the existing transmission network deployments of contingency analysis software.

A competitive procurement process was undertaken: UK Power Networks initiated a competitive procurement process to select the Contingency Analysis software supplier. This process enabled UK Power Networks to select the best contractor to deliver the solution, whilst ensuring value for money.

UK Power Networks followed its established procurement process by which an invitation to express interest (ITEI) in respect of contingency analysis software was advertised using the ENA Smarter Networks Portal. By using the trade press, Achilles UVDB category searches and chance meetings at conferences, fifteen companies expressed an interest. Subsequently invitations to tender (ITT) were issued to those who responded to the expression of interest and eight ITT responses were received. These bids were evaluated and suitable suppliers were subsequently shortlisted down to four; the preferred bidder has been identified as Bigwood Systems, Inc.

The selection was based on a scored technical evaluation and a commercial evaluation, and

Evaluation Criteria continued

the two then combined. The selected vendor represents a savings of approximately £1 million compared to the most expensive of the four shortlisted candidates.

External funding has been agreed: UK Power Networks is making an extra contribution of £72k (in excess of the 10% DNO compulsory contribution); the project will receive further contributions from its project partners Navigant Consulting (Europe) Ltd and National Grid (~£40k).

Day rates of project partners include discounted rates:

Partner name	Person Days	Initial blended day rate	Discounted blended day rate
UK Power Networks	3,464	Redacted	Redacted
National Grid	272	Redacted	Redacted
Navigant	24	Redacted	Redacted

(c) Generates knowledge that can be shared amongst all DNOs
Contingency analysis platforms are previously untested on GB distribution networks as DNO network management has not been sufficiently complex to warrant it. The two companies most likely to have used Contingency Analysis platforms are Scottish Power and Scottish and Southern Energy, both of whom effectively run their 132kV transmission network alongside their distribution network, and share a number of processes and tools between the two. We have spoken to Scottish Power and Scottish and Southern Energy and have confirmed that they have not yet implemented the use of Contingency Analysis in their control rooms for the distribution network.

Furthermore, during the bid development stage, we have received input from Bigwood, which has significant experience delivering contingency analysis solutions to utilities globally. We have been advised that state estimation may be required for our proposed solution, based on the amount of data we will have available from the network. Bigwood has confirmed our assessments that the number of DNOs globally that use a solution such as the proposed is very limited.

However, in the east Kent area, both current and forecast network interconnectivity and operational complexity now support such a trial. The trial is appropriately sized to provide meaningful results whilst limiting the scale to the manageable area of East Kent. We expect the project to generate significant learning opportunities that will assist other DNOs implement similar solutions, thus taking a first step in modernising the GB distribution networks.

At the same time, it will be the first time that a framework for communication and data exchange between distribution and transmission system operators will be put in place. This benefit has a the potential to deliver operational gains in the wider GB network thought the enhanced cooperation with National Grid and we expect all DNOs to gain from the learnings of this aspect of the project.

We will learn from and comprehensively report on the implementation of the Contingency Analysis platform. Specifically:

- Procurement through to implementation - Subject to procurement confidentiality, we will capture the learning from all stages of the implementation lifecycle from specification to development and control system integration to aid the deployment of the technology into another DNOs; and

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Evaluation Criteria continued

- Operation and Impact - The operation of the system once installed will provide the major opportunity for learning. Operating procedures will be changed to incorporate the use of the Contingency Analysis platform, which will enable the formal reporting of how frequently and effectively it is utilised. In addition, we will include any 'softer' learning associated with how frequently and effectively the package is used by staff from both the operational and outage planning team.

The dissemination of learning from the project: The project will generate a continual stream of knowledge; all learning will be managed by a Knowledge Dissemination lead. The lead will have the responsibility of arranging activities to spread the learning from the project to stakeholders including the DNO community. The Knowledge Dissemination lead will use a Knowledge Dissemination roadmap to plan and guide these activities; this "live" document will be based on best practices from other LCN Fund projects. The UK Power Networks Future Networks Team will be consulted on all activities in order to maintain alignment with any other dissemination activities being undertaken for other LCN Fund projects.

The knowledge products generated will include project website pages; press releases and articles; videos; training materials; newsletters and project brochures. Social media shall also be used for project related tweets and blogs and newer forms shall be explored for posting video sound bites and photos. Various dissemination channels will be used to share project learning such as: UK Power Networks specific training and workshops; project stakeholder meetings; conferences, workshops and events; newsletters; reports, technical data and analysis; industry groups and forums; UK Power Networks' Innovation website; partner websites; press releases and articles; social media. The channels will be selected to best suit the type of knowledge and format.

The project's treatment of intellectual property rights: The project will conform to standard LCN Fund intellectual property rights requirements.

(d) Involvement of other partners and external funding

Based on previous years' experiences, we have now delivered continuous improvement in our project selection and formulation processes.

We are regularly in contact with our current and potential new partners and suppliers. This engagement is important for us, not just for the Low Carbon Network Fund process but also to keep abreast with the latest developments, new upcoming solutions and to 'test' draft documents before final publication. We engage with them in a structured way via our 'Critical Friends Panels', representing academia, manufacturers and other stakeholders. In a more ad-hoc fashion, we also engage with them via conferences and other power sector functions.

Relevant project partners and suppliers were leveraged via existing relationships, whilst new approaches were encouraged from third parties.

Partners have been engaged through the project selection phase: We developed a list of 11 project concepts; and separately became aware of two requests for partners within Network Innovation Competition (NIC) projects. The list of 11 ideas comprised of four brought forward from within the UK Power Networks business, and seven from external partners including the SMEs. These were evaluated and three lead concepts developed further in the weeks leading up to the ISP submission (again, led by one SME, one major

Evaluation Criteria continued

vendor and the other by the internal business respectively), before final selection of this preferred proposal. This list of projects was consulted on with a wide range of stakeholders within UK Power Networks representing operational, IT, asset management and connections viewpoints.

When the final projects were selected we assessed each partner involved in the selection process relevant to the projects on their own merits of what knowledge, skills, experience and delivery capability they could contribute to the project.

Project KASM has developed key project partners: UK Power Networks has selected partners who have the experience and capability to successfully deliver this project.

National Grid will provide real-time information on power flows across 400kV SGTs; the configuration of the network, including switching; the output of generators connected to the transmission network; and the output of the HVDC interconnectors in the area. The project will initiate and enable frequent discourse between UK Power Networks and National Grid that will facilitate better communication and more opportunities for collaboration. National Grid were approached due to key data they hold. We are engaged with National Grid and are developing the terms of a Memorandum of Understanding.

We have provided an initial estimate of the data link to National Grid in the detailed project costs (Appendix A2). UK Power Networks will hold discussions with National Grid to explore the reduction of the stated cost of the proposed data link. If we achieve a reduction, we will modify the expected project cost accordingly.

Bigwood Systems is the preferred supplier of the Contingency Analysis software solution. Bigwood Systems will also be a valuable project partner; their contribution will not be limited to software supply but also training opportunities and continued software support. Bigwood Systems were engaged though UK Power Networks' established procurement process. A formal contract will be signed once all terms have been agreed and the decision to award project funding has been made.

UK Power Networks have nominated a project lead, Matthieu Michel, with overall responsibility for project delivery. UK Power Networks will appoint a specialist IT project manager (the Work stream 2 lead) reporting to Mathieu to manage time and budget. The project Design Authority will in turn report to Matthieu and represent the solution's users and ensure that the solution is utilising best practice. The Design Authority will draw upon Navigant's experience for advice during project implementation, as part of a wider group of experts. Navigant will provide assistance on the development and integration of the contingency analysis software and will also support business processes.

Navigant has considerable experience assisting international utilities to develop and implement smart grid projects. Navigant has been engaged with UK Power Networks throughout the bid selection and development process and a formal contractual arrangement has been agreed between both parties.

The CV of the Navigant expert that will be providing support to KASM is provided in Appendix J.

Alternative funding arrangements
UK Power Networks is making a contribution of £72k in excess of the DNO compulsory

Evaluation Criteria continued

contribution. The project will receive further contributions for its project partners Navigant Consulting (Europe) Ltd and National Grid (~£40k).

(e) Relevance and timing
Project KASM addresses problems that exist today: UK Power Networks recognise that additional network visibility and control within operational timeframes is required in order to release additional generation capacity in the distribution network while avoiding or deferring conventional reinforcement schemes.

Traditionally, the DNO was a largely passive network operator that builds in response to demand growth and has limited capability to take on an active role in managing power flow and participation on its network in real (or operational) timeframes. As DNOs transition to active system operators, additional real-time tools and data analysis capabilities are required. One such tool and capability, that this project will demonstrate for the first time in the control room of a UK DNO, is contingency analysis.

The East Kent operating area currently contains approximately 510 MW of largely intermittent wind and solar photovoltaic (PV) generation connected to the 132 kV, EHV and HV networks. This includes the Thanet and Kentish Flats offshore wind farms, 315 MW and 90 MW respectively. Connection offers for a significant (~450 MW) amount of additional generation, largely solar PV and wind, were accepted and as such these facilities are due to connect in the short term. Project KASM addresses these areas of need and conducts trials in an exceptionally well-suited network that is due to see a significant increase in distributed generation.

By targeting a "real" issue in an area such as East Kent, the likelihood of positive results is greatly increased. If successful, the results from the project will form part of business as usual network management practices.

(f) Demonstration of a robust methodology and that the project is ready to implement

Detailed project plan: A KASM project plan has been developed and has been presented in Appendix C. The project plan lists all tasks to be completed, details milestones; SDRC and events such as conferences and knowledge dissemination workshops. The plan maps the timescales and duration of each of these activities so that the project manager can track the progress of each task and the status of the project throughout its lifecycle.

Resources: A project organogram has also been included in Appendix E. The organogram shows the project sponsor, senior responsible officer and project manager. It lays out the structure and roles of the project management office; identifies the Work Stream leads for all five Work Streams and lays out the structure of the design authority. The KASM project partners are Bigwood Systems (software supplier), National Grid (System Operator and data provider) and Navigant Consulting (Europe) Ltd (technical consultants). The project will also utilise contractors for software integration with the OSI Soft PI platform and for additional network modelling. For further details of Project KASM's partners please see Appendix F.

Demonstrate timely implementation: By initiating and completing a number of key activities during the preparation of the full submission, the project is ready to commence at the beginning of January 2015:

Evaluation Criteria continued

- The project has progressed through UK Power Networks' business as usual internal business change and IT/IS architecture governance processes, the Project Governance and Control (PG&C) and Design Authority Board, respectively. This ensures that all the relevant internal stakeholders are fully engaged and formally committed to the project.
- In-depth analysis of the project objectives and requirements has been undertaken, resulting in the development of a well-defined scope and description for each work stream. This is summarised in the diagrams following (Section 6) and included in detail in Appendix H, outlining the trials to be completed with clear learning objectives and outcomes.
- In order to demonstrate value for money and optimum preparation for a timely project start, we have worked closely with IT specialists and the IT procurement team to specify our IT requirements and complete a procurement process with contingency analysis software and integration services suppliers in accordance with UK Power Networks' IT procurement approach. During the course of the preparation of the full bid submission, we have issued a request for qualifications, received and evaluated initial supplier responses, issued a full request for proposals, received and evaluated full submissions, and down-selected to a preferred vendor. By the start of the project, we will have will have finalised the specifications and negotiated a full implementation contract, meaning that the project delivery team will make an impact from day one on a typically long lead-time element of the project.
- Continual engagement with the project directors and project managers of UK Power Networks' existing portfolio of LCN Fund projects ensures a detailed understanding of lessons learnt on these projects can be applied to this project.
- Significantly, the project governance and management processes developed and implemented on the Flexible Plug and Play project, and subsequently on the Smarter Network Storage and Future Urban Networks projects, will be used as the basis for the project handbook that will define governance and management arrangements from project kick-off.
- A detailed project plan identifying the key activities, milestones and dependencies has been produced in consultation with our partners in Appendix C. This plan will be continually reviewed and refined during the submission evaluation period to ensure that it is maintained as a fully comprehensive, accurate and up-to-date plan for project delivery starting at the beginning of January 2015.

Customer impact: We do not envisage any negative direct customer impacts resulting from the deployment of the Contingency Analysis software. Although traditional load customers will be unaffected by the project, existing Distributed Generation customers are expected to experience positive impacts as results of the trial. Benefits may include fewer constraints on power outages and improved congestion management. Customer Impacts have been discussed in greater detail in Section 8.

Cost and Benefit: To ensure robust and realistic costs, they have been calculated with a bottom-up approach across each of the project Work Streams. The Method costs have been carefully prepared with detailed procurement costs identified during the submission preparation phase, including using costs determined from the competitive tendering process for the contingency analysis software and integration support.

Benefits have been determined for the project method described, along with customer benefits and the benefits of wider rollout to GB. More detail is provided in Appendix G – Cost Benefit Analysis.

Evaluation Criteria continued

Successful Delivery Reward Criteria (SDRC): Linking to work streams, the SDRC define key successes and milestones throughout the project. Six SDRC have been defined for this project.

1. Development of the strategy for inter-control room communication protocol for the purposes of KASM
2. Completion of the system integration of Contingency Analysis (CA) software into UK Power Networks systems, excluding a real-time link to National Grid
3. Completion of installation of forecasting modules that will link the DNO control room with other data sources
4. Demonstration of use of real-time contingency analysis in the control room
5. Completion of trials and implementation of reliability management, outage management and network capacity management
6. Development of business design to incorporate contingency analysis as business-as-usual

The SDRC are described in further detail in Section 9.

Risk register, risk management and mitigation: A risk register including mitigation actions has been developed for this project. The risk register will be reviewed regularly as part of project management process procedures. Please see Appendix D for full details.

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Section 5: Knowledge dissemination

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☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

5.1 Learning Dissemination

The transition from DNO to DSO through the use of enhanced network visibility and data analysis is a key priority for distribution operators in the UK and the EU. UK Power Networks will conduct trials in a small area of its network that will attempt to demonstrate and quantify the impact of such initiatives, while maintaining a set of attributes that can be replicated in other areas and networks.

While the project will only trial a specific set of solutions, the broader creation of an analytical framework based on data collections and utilisation will provide the capability to incorporate in the future a variety of smart assets that will serve to enhance the overall network flexibility.

The project has been divided into five project work streams:

- WS1 – Information Sharing, Data Integration and Setup;
- WS2 – Contingency Analysis Tool Development and Integration;
- WS3 – Load and Generation Forecasting Modelling;
- WS4 – Value Streams and Business Process Impacts; and
- WS5 – Knowledge Dissemination and Stakeholder Engagement.

UK Power Networks envisage that the project conclusions will have the most impact with DNOs, TSOs, and distributed generation developers. Other parties that would potentially benefit from the knowledge generated by KASM are academic institutions, DECC, Ofgem, the ENA and various smart grid stakeholders and groups.

In order to ensure that knowledge dissemination activities are managed effectively and provide the desired impact, a separate work stream has been created (WS5) that would also involve all the relevant stakeholder engagement activities that are part of the KASM trials.

A knowledge dissemination roadmap will be developed at the start of the project in order to produce a clear and effective dissemination plan. The goal of this dissemination plan is to ensure accessibility to, and dissemination of, the KASM project results and methods.

Dissemination objectives and scope

The Knowledge Dissemination work stream will aim to:

- Identify appropriate persons and organisations with interest in the project and its outcomes;
- Ensure that all knowledge acquired by UK Power Networks and any partners throughout the project lifecycle is available to any interested parties; and
- Using the most appropriate channels, share the acquired knowledge.

Dissemination activities roles and responsibilities

- A dedicated knowledge dissemination lead will be deployed to the project and their role will include the planning of knowledge dissemination activities;
- A knowledge dissemination roadmap will be developed at the start of the project based on best practices from previous Low Carbon Network Fund projects such as Flexible Plug and Play (FPP) and Flexible Urban Network – Low Voltage (FUN-LV), to produce a clear

Knowledge dissemination continued

plan for effective dissemination activities;

- The UK Power Networks' Future Networks team will be consulted on the development and implementation of all dissemination activities to ensure synergy with dissemination activities carried out by other Low Carbon Network Fund projects and to avoid conflict and duplication. Where possible, the activities will be coordinated with other DNOs undertaking similar knowledge dissemination activities;
- As outlined in the memorandum of understanding; project partners will fully support and where appropriate participate in dissemination activities throughout the lifecycle of the project;
- Where knowledge from the project has been identified as having the potential to make a material and positive difference to the operation of UK Power Networks networks and those of other DNOs, the knowledge is presented in a way that can be transferred into business as usual solutions; and
- The project's knowledge dissemination lead will be responsible, with support and involvement internally as well as from any project partners, for identifying the most relevant stakeholders and defining the most appropriate channels for knowledge and learning dissemination.

Methods and areas for knowledge capture

The KASM project incorporates the use of software, hardware and soft measures, such as business processes, therefore there will be various knowledge streams created by the project.

The project team, supported by the knowledge dissemination lead, will ensure that information and outputs are captured throughout the project lifecycle to ensure that all relevant and appropriate knowledge and learning can be made available to stakeholders. We expect knowledge to be generated from the following activities:

- UK Power Networks expects that the implementation of a data aggregating module that will link the DNO control room with various data sources will create valuable technical knowledge for other DNOs;
- Furthermore, the integration of a data analysis software solution that will operate in real-time will also add to the generated technical knowledge;
- The use of the analysis results in real-time or offline will provide additional network knowledge to control room engineers and network planners; and
- The use of network monitoring in the control room that has only been used at the TSO level before is expected to generate additional knowledge around network modernisation and the transition from DNO to DSO.

Planning for knowledge dissemination

As a result of the various Low Carbon Network Fund projects undertaken by UK Power Networks, knowledge dissemination techniques and channels are well established. One of the products that utilises this past and current project experience is the knowledge dissemination roadmap. The roadmap will be developed at the start of the project and will ensure that a well-structured approach is taken and communicated to the whole project team, including project partners. The roadmap will be a "live" document that is regularly reviewed throughout the project's lifecycle.

The roadmap will also enable UK Power Networks to coordinate knowledge dissemination activities across all their Low Carbon Network Fund projects, and wherever possible the projects of other DNOs. This coordination helps ensure the maximum impact and effectiveness of the knowledge dissemination.

Knowledge dissemination continued

The following sections on Target Audience, Dissemination Products and Dissemination Channels will be expanded and combined to create the roadmap.

Target audience

The target audience for dissemination activities is anticipated to include but not be limited to:

- UK Power Networks staff;
- All DNOs (from GB and beyond);
- Ofgem;
- DECC;
- The Energy Networks Association (ENA);
- Industry and Government led working groups such as those overseen by the Smart Grid Forum and Smart Grids GB;
- Industrial and commercial organisations operating in the low carbon sector such as PV installers;
- Academic institutions involved with renewable energy and smart grids; and
- Manufacturers and vendors of relevant utility-scale software; and
- Organisations with an interest in renewable energy.

Dissemination products

The knowledge dissemination roadmap will be the first dissemination product to be produced; it will outline the type and content of the material to be shared and define and describe the processes, methods and timescales for any learning and knowledge dissemination.

Throughout the project, the project manager will compile logs of lessons learned to support the constant capture and transfer of knowledge to partners and stakeholders. The knowledge and learning captured throughout the project will be disseminated through a range of products including, but not limited to:

- Reports and documents developed by the project and defined in the Section 9: Successful Delivery Reward Criteria; Workshops and learning events;
- Project website pages on the dedicated UK Power Networks Innovation microsite and other social media deliverables;
- Press releases and articles;
- Videos for information and familiarisation purposes;
- Training materials;
- Newsletters; and
- Project brochures and other printed material about the project.

In addition to traditional social media such as tweets and blogs, the use of other innovative social media platforms will also be explored for video sound bites and posting photos. We will also use these short videos for project news flashes on the UK Power Networks' Innovation microsite (www.ukpowernetworks.co.uk/innovation) and as mini tutorials delivered in meetings or over the internet.

All relevant information will also be made available through the ENA Smarter Networks Portal.

Dissemination channels

Due to the range of stakeholders in the KASM project the style of dissemination should be tailored to suit each audience type based on their requirements. The stakeholder should be

Knowledge dissemination continued

central to any knowledge dissemination activity; by adopting a bi-directional information transfer process, learning opportunities will be maximised and stakeholders will be able to provide feedback on the project to the project manager and team. This type of process will also allow project partners to input any potentially useful external views which will ultimately increase the value of the project.

The knowledge obtained through the project will be disseminated using a variety of methods and communications media, including:

- Specific training and familiarisation material and workshops for UK Power Networks staff and other DNOs;
- Regular project stakeholder meetings;
- Conferences and workshops;
- Speaking opportunities at externally organised conferences and events;
- Newsletters;
- Reports, technical data and analysis;
- Industry working groups and forums;
- Dedicated project pages on UK Power Networks’ Innovation website as well as project specific content on partner websites;
- Videos;
- Press releases and articles, particularly in trade press; and
- Blogs and other social media, such as Twitter.

5.2 Intellectual Property Rights Arrangements

The project will conform to standard LCN Fund intellectual property rights requirements. The Request for Quotation (RFQ) for the contingency analysis software included a model contract agreement containing terms and conditions required by the LCN Fund. Whilst a full contractual negotiation has not been completed at this stage, all short-listed proponents accepted these without material modifications.

Under the standard intellectual property rights rules for the LCN Fund, Bigwood Systems Inc. is committed to providing the contingency analysis solution at an equivalent price to all other DNOs. Any source code developed to support the integration of the contingency analysis software into the IS/IT architecture at UK Power Networks will be made available to other DNOs at no additional cost, provided it is directly compatible (i.e. the data historian, distribution management system, SCADA systems, etc., are the same version).

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Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%): 5

Requested level of protection against Direct Benefits that they wish to apply for (%): N/A

6.1 Evidence of why the project can start in a timely manner

A number of key activities have been initiated/completed during the preparation of the full submission which ensures that the project is ready to fully start at the beginning of January 2015:

- The project has progressed through UK Power Networks' business as usual internal business change and IT/IS architecture governance processes, the Project Governance and Control (PG&C) and Design Authority Board, respectively. This ensures that all the relevant internal stakeholders are fully engaged and formally committed to the project.
- In-depth analysis of the project objectives and requirements has been undertaken, resulting in the development of a well-defined scope and description for each work stream. This is summarised in the diagrams following and included in detail in Appendix H, outlining the trials to be completed with clear learning objectives and outcomes.
- In order to demonstrate value for money and optimum preparation for a timely project start, we have worked closely with our IT specialists and IT procurement team to specify our IT requirements and complete a procurement process with contingency analysis software and integration services suppliers in accordance with UK Power Networks' IT procurement approach. During the course of the preparation of the full bid submission, we have issued a request for qualifications, received and evaluated initial supplier responses, issued a full request for proposals, received and evaluated full submissions, and down-selected to a preferred vendor. By the start of the project, we will have will have finalised the specifications, meaning that the project delivery team will make an impact from day one on a typically long lead-time element of the project.
- Continual engagement with the project directors and project managers of UK Power Networks' existing portfolio of Low Carbon Network Fund projects ensures a detailed understanding of lessons learnt on other projects can be applied to this project.
- Significantly, the project governance and management processes developed and implemented on the Flexible Plug and Play project, and subsequently on the Smarter Network Storage and Future Urban Networks projects, will be used as the basis for the project handbook that will define governance and management arrangements from project kick-off.
- A detailed project plan identifying the key activities, milestones and dependencies has been produced in consultation with our partners in Appendix C. This plan will be continually reviewed and refined during the submission evaluation period to ensure that it is maintained as a fully comprehensive, accurate and up-to-date plan for project delivery starting at the beginning of January 2015.
- A risk register has been prepared, detailing key risks potentially affecting the project delivery, along with mitigation plans in Appendix D. As with the project plan, this will be continually reviewed and refined during the submission evaluation period to ensure that it is maintained as a fully comprehensive, accurate and up-to-date reflection of project risks and mitigations in place for project delivery starting at the beginning of January 2015.
- A clearly defined project organisation chart has been developed in Appendix E which reflects the governance and management arrangements that will be defined in the

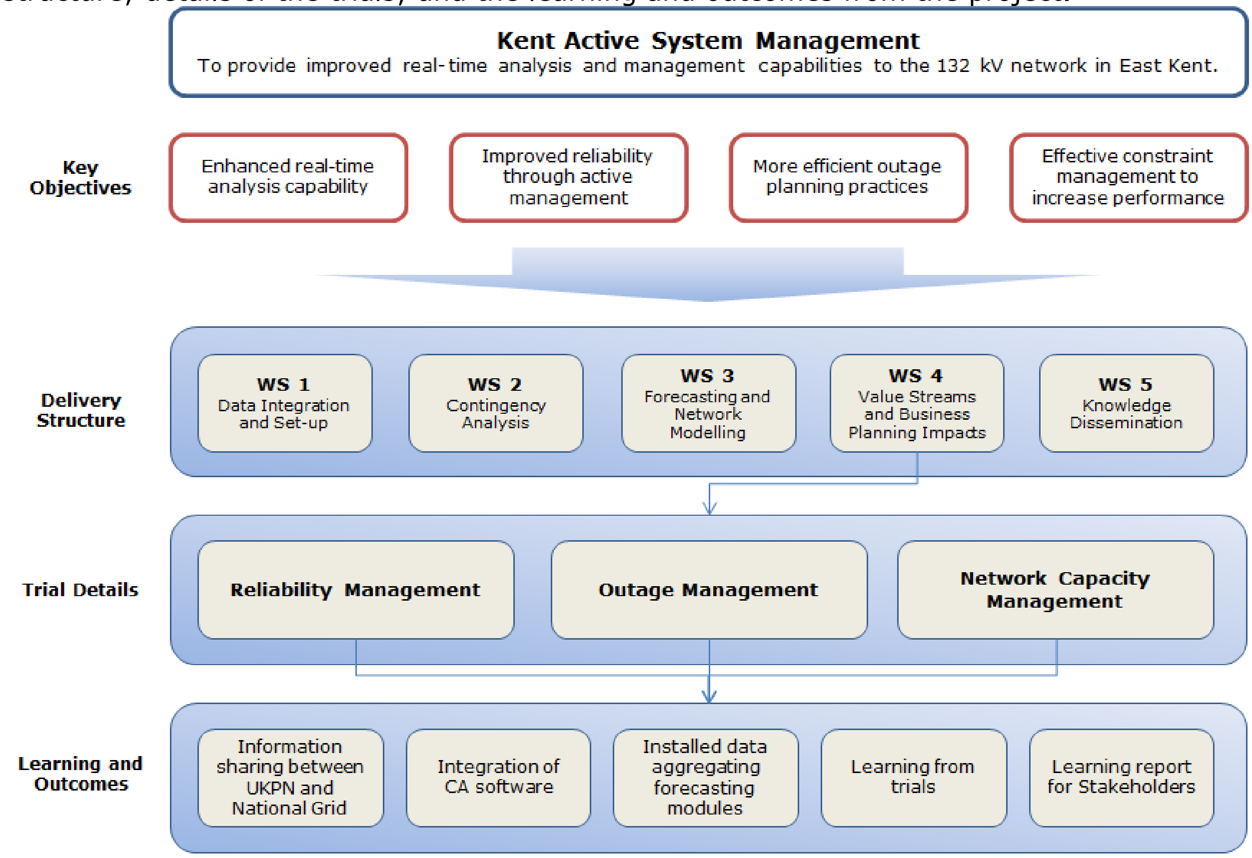
Project Readiness continued

project handbook. This demonstrates that we have the people in place that have the authority, responsibility and knowledge to make the key decisions in an effective and timely manner. Through the submission evaluation period we will transition from the bid team to the enduring project team. A number of the bid team will be part of the enduring project team; the enduring project team is in place to commence at the beginning of January 2015.

- UK Power Networks has significant capability both in its Future Networks team and its Information Systems (IS) team. The Future Networks team alone includes an ex-network planner for the area being considered, and an ex-outage planner. The IS team has already deployed two staff, an architect and an IT project manager, on existing Low Carbon Network Fund projects who both have prior experience working at National Grid on their business-critical systems.

Project Overview

The diagram below illustrates the key elements of the project: objectives; delivery structure; details of the trials; and the learning and outcomes from the project.



6.2 Senior management commitment

The project has been developed in conjunction with UK Power Networks' senior management who have demonstrated management commitment and ensured the availability of input and support from in-house specialists. Management commitment has been achieved through regular presentation of the project at Executive Management Team meetings and also at Senior Management team meetings within relevant directorates, which complies with UK Power Networks' Project Governance & Control process. Support from in-

Project Readiness continued

house specialists has been achieved through regular project meetings with senior managers and other senior discipline leaders with expertise in a number of areas including IT systems and outage planning. UK Power Networks has a developing portfolio of existing Low Carbon Network Fund projects and this experience is also being brought to bear through engagement with the relevant project directors and project managers.

We have engaged with our own senior management and with our partners' senior management, each of whom have provided inputs on the project scope, delivery phases and success criteria. The experiences and guidance in their areas of expertise has enabled a robust project to be prepared.

Partner roles and areas of expertise are detailed fully in Appendix F, with examples of experience and capability below:

- **Bigwood Systems, Inc**. has implemented similar Contingency Analysis software solutions for a number of large power sector customers including Tokyo Electric Power Company (TEPCO) (utility), PJM and California ISO (both regional transmission organisations).
- As transmission network operator in England, **National Grid** will provide real-time information on power flows across 400kV SGTs; the configuration of the network, including switching; the output of generators that are connected to the transmission network; and the output of the HVDC interconnectors in the area.
- **Navigant Consulting (Europe) Ltd.** has considerable experience assisting international utilities to develop and implement smart grid projects. Navigant will provide assistance on the development and integration of the contingency analysis software and supporting business processes.

6.3 Evidence of how the costs and benefits have been estimated

To ensure robust and realistic costs, these have been calculated with a bottom-up approach across each of the project Work Streams. The UK Power Networks' costs estimates are based on:

- Inputs from a number of UK Power Networks' experts for labour requirements, including for procurement, legal and dissemination activities;
- Inputs from UK Power Networks' technical specialists including labour elements for IT system integration activity and equipment installation for the trials;
- Quotations received from the Partners and suppliers, benchmarking where possible and utilising procurement expertise in specific areas to challenge costs and leverage existing commercial arrangements with suppliers (particularly for IT costs). This approach has led to significant downward refinement of IT costs through the submission preparation;
- Previous experience of delivering similar projects, particularly other Low Carbon Network Fund tier 2 projects; and
- A rigorous full cost and scope review to ensure that costs are accurate and provide value for money.

The method costs have been carefully prepared with detailed procurement costs identified during the submission preparation phase, including using costs determined from the competitive tendering process for the contingency analysis software and integration support.

Benefits have been determined for the project method described, along with the benefits of a wider rollout to GB. Careful consideration has been given to the calculation of potential benefits that are based on:

Project Readiness continued

- professional / engineering judgement;
- verifiable and credible sources for unit costs; and
- extensive modelling of the Kent network.

In all instances, we err on the conservative side. More detail is provided in Appendix G.

Additionally, should there be a reduction in the costs incurred for the work in implementing a link between National Grid and UKPN's control room, this will be returned in its entirety to customers as an under-run.

6.4 Evidence of the measures a DNO will employ to minimise the possibility of cost overruns or shortfalls in direct benefits

To support the delivery of a quality project both to budget and timely delivery, project management will be based on industry leading and proven UK Power Networks' delivery methodologies, based on PRINCE 2, and established governance processes. The project has a procurement component and establishing suitable suppliers and identifying competitive costs has been a key focus during the full submission preparation. In addition, a risk register has been prepared which details the identified risks and mitigation strategies in Appendix D.

Project delivery and governance controls will be defined fully in the project handbook, based on the approach used on the Flexible Plug and Play, Smarter Network Storage, and Future Urban Networks – Low Voltage. These include:

- A Project Steering Group comprising the key stakeholders and decision makers within UK Power Networks, including the Project Sponsor Ben Wilson and chaired by Senior Responsible Owner Martin Wilcox. This group is ultimately responsible for the project and will make decisions that have an overall impact on the benefits and outputs that the project will deliver. They will assess major change requests, review the impact on the project business case, and identify and review risks and issues associated with major change requests;
- Monthly reporting to the Steering Group and to the UK Power Networks' Executive Management Team by the Project Sponsor to provide regular review points and allow full financial and project control;
- A Project Board comprising the Project Manager, Work Stream Managers and Programme Management Officer, will meet fortnightly. The Board is responsible for the operational management of the project, focused on reviewing progress against plan, and resolving risks and issues. They will also approve change requests within a defined tolerance and prepare change requests for submission to the Steering Group for major changes;
- Regular risk reviews undertaken by the Project Manager with results reported to the Project Sponsor and Project Steering Group;
- A Design Authority who will review and approve all key project deliverables, with ultimate responsibility for the overall solutions being delivered by the project. Change requests may be initiated by the Design Authority directly or by the Work Streams. Change requests initiated by the Work Streams will be reviewed by the Design Authority prior to submission;
- Management of work streams in accordance with milestone plans supported by detailed project plans and a clearly defined list of deliverables from each work stream. Each of these will be produced in consultation with our project partners to ensure a strong foundation for clarity of scope, objectives, approach and deliverables;
- A robust change management procedure to ensure that change request impacts are fully

Project Readiness continued

analysed at the appropriate level of authority depending on the scale of the change;
- Quarterly project partner/supplier reviews will track and discuss progress and risks to project delivery.

6.5 Accuracy of information

UK Power Networks has endeavoured to ensure all of the information included within this full submission is accurate. Information included within the proposal has been gathered from within UK Power Networks, the project partners, suppliers and other subject matter experts. All of this information has been reviewed to confirm and refine understanding, whilst evaluating the validity and integrity of the information. Detailed equipment cost information has been collated during the full submission preparation and this is detailed within the Evaluation Criteria.

A bid team, incorporating a full time bid lead and design authority, has worked with partners to prepare and review the bid. Project partners have also ensured information provided by them has been through a thorough internal review and approval process before being provided to UK Power Networks.

6.6 Risks to project learning

KASM involves the deployment of tools and capabilities that are integral to the active management of the distribution network and support the transition from a distribution network operator to a distribution system operator. The ability to model power flows and analyse possible post-fault conditions (N-1, N-X) in operational timeframes ensures the integrity of a network with increasingly variable power flows and enhances the value of flexible demand, dispatchable resources, and smart/controllable infrastructure (e.g., quad boosters, tap changing transformers, series reactance, etc.) by supporting active power flow management.

The East Kent operating area currently contains approximately 510 MW of largely intermittent wind and solar photovoltaic (PV) generation connected to the 132 kV, EHV and HV networks. Connection offers for a significant (~450 MW) amount of additional generation, largely solar PV and wind, were accepted and as such these facilities are due to connect in the short term. As such the East Kent area provides a perfect example of the operational and planning challenges that arise when large amounts of intermittent wind and solar generation are connected to a distribution network with limited local demand and will provide excellent learning opportunities.

The learning outcomes of the project will be delivered without dependence on the speed of take up of distributed generation in the trial area. Throughout the project, the Project Manager, supporting the continual capture and transfer of knowledge to partners and internal / external stakeholders, will maintain details of the lessons learned. This will build upon the experiences and best practice emerging from current UK Power Networks' Low Carbon Network Fund projects, namely Low Carbon London, Flexible Plug and Play, Smarter Network Storage, and Future Urban Networks – Low Voltage.

6.7 The processes in place to identify circumstances where the most appropriate course of action will be to suspend the project, pending permission from Ofgem that it can be halted

As part of the UK Power Networks internal governance there are number of processes in place to identify, assess and manage any issues that may affect the project. These processes help to maintain the smooth running of the project, whilst also aiding identifying

Project Readiness continued

the most appropriate course of action at any point.

The internal UK Power Networks' Project Governance and Control process, is based upon the PRINCE2 methodology, with a gate approval process which reviews the project at critical stages throughout its life-cycle. The project must meet the mandatory entry/exit criteria for any particular gate (which takes into account risks, issues, benefits realisation and financial position), which the Project Manager will need to provide evidence. At a more detailed level, the project governance and management controls defined in the project handbook provide further assurances that the appropriate processes are in place.

A risk management and contingency plan is used to identify, analyse, control and review all of the risks, whilst calculating the potential cost impact. The Project Manager is responsible for ensuring all risks and issues are effectively managed and those above the agreed tolerance are escalated to the Project Steering Group. The Project Steering Group has overall responsibility to determine whether the most appropriate course of action would be to suspend the Project.

We have identified the highest risk issue to the project to be around the costs associated with establishing a real-time communication link between UK Power Networks and National Grid. Failure to establish this link could lead to a delay in the project. Because of this, we have initiated communication with National Grid at an early stage in the bid development and we have already agreed on the basic terms of cooperation.

We have worked to mitigate this risk through proactive engagement and understanding of risks from an early stage and the consideration of alternate ways the data could be obtained to enable the trials in East Kent.

Specifically, we have explored the use of near-real time data as an alternative to the data link with National Grid that could help setup the processes for the proposed solution in the interim and while overcoming any potential difficulties in establishing said link.

The development of the load and generation forecasting modules could also provide additional data that can be used in the development of the solution.

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Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

We do not foresee any derogations or changes to the regulatory regime in support of these trials.

Confidentiality of Data

Our conversations with National Grid during the bid development phase have identified that there are licence requirements that restrict the sharing of certain confidential information. We believe that this restriction pertains primarily to future state information that could be used to manipulate the market. Work Stream 1 contains specific tasks to further explore, understand and resolve the implications of these requirements and ensure that safeguards are put in place.

Section 8: Customer impacts

This section should be between 2 and 4 pages.

We do not envisage any negative direct customer impacts resulting from the deployment of the Contingency Analysis software.

Although traditional load customers will be unaffected by the project, existing Distributed Generation customers are expected to experience positive impacts as results of the trial. Benefits may include fewer constraints on power outages and improved congestion management.

Any necessary network outages or liaison with customers during the implementation of these methods will be managed in accordance with our standard business practices to ensure continuity of supplies to our customers.

In the event that contingency analysis implementation manifests new options for pre-emptive or corrective actions to address network constraints we will use these to better inform the longer term planning analysis. We will then engage with customers to explore any new options using best practices developed through experience with our other Low Carbon Networks Fund tier 2 projects and our business teams that work specifically with a particular market segment.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

Criterion (9.1)
Development of the strategy for inter-control room communication protocol for the purposes of KASM by end of December 2015

Evidence (9.1)
- Published report on key technical and commercial challenges relevant to inter-control room link and the KASM project, whether proposed by the KASM team or raised by stakeholders, including other DNOs;
- Implementation guidelines for the inter-control room communication link in consultation with National Grid for use by the project.

Criterion (9.2)
Completion of the system integration of Contingency Analysis (CA) software into UK Power Networks systems, excluding a real-time link to National Grid, by end of March 2016

Evidence (9.2)
- Sign-off on set up of CA software;
- Sign-off on successful demonstration and testing of CA software; and
- Published report on CA software integration that includes the control room IT architecture, lessons learned, engagement with other DNOs, and identified risks.

Criterion (9.3)
Completion of installation of forecasting modules that will link the DNO control room with other data sources by end of March 2016

Evidence (9.3)
- Sign-off on installation of forecasting modules;
- Forecast data, benchmarked for accuracy against historical data;
- Published report demonstrating forecasts including each of solar, on-shore wind and off-shore wind;
- Forecast error curves plotted at primary substation, 132kV circuit, and GSP levels;
- Description of integration architecture with the overall solution;
- Published report on data aggregating forecasting modules that includes lessons learned and identified risks.

Criterion (9.4)
Demonstration of use of real-time contingency analysis in the control room by end of December 2016

Evidence (9.4)
- Demonstration of contingency results from live SCADA readings, supplied within 15 minutes of them being collected;
- Completion of user survey identifying the most critical forecast time periods perceived by control room users (e.g. next 15 mins; tomorrow; next shift);
- Published report with description of the solution, the user interface, and the capabilities.

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Successful Delivery Reward Criteria continued

Criterion (9.5)
Completion of trials and implementation of reliability management, outage management and network capacity management by end of December 2017

Evidence (9.5)
- Published results from functional trials and the achieved benefits in reduced distributed generation curtailment;
- Published report demonstrating data collection from Grain, Kemsley, Cleve Hill, Canterbury North, Sellindge, Dungeness and Ninfield 400kV network and sensitivity of the contingency analysis results to this data;
- List of connection offers that have been linked to reinforcement when assessed using conventional processes, and identification of those that have been revised to remove the reinforcement requirement after being assessed using the trialled methodology; quantification of the released network capacity based on the comparison of the above list;
- Published report on considerations for selecting, designing and installing CA software for each use case.

Criterion (9.6)
Development of business design to incorporate contingency analysis as business-as-usual by end of December 2017

Evidence (9.6)
- Identification of business areas impacted by the introduction of contingency analysis in a Distribution Network Operator
- Outline of proposed changes to systems, policies and processes required in the DNO operating model in order to incorporate contingency analysis as part the business as usual operation

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Section 10: List of Appendices

List of Appendices

Appendix A1	–	Benefits tables
Appendix A2	–	Full submission spreadsheet: Separate Excel file in Ofgem template
Appendix B	–	Maps and network diagrams: Maps and diagrams presenting trial areas
Appendix C	–	Project plan: Outlining detail activity of project deliverables
Appendix D	–	Risk register and mitigation plan: Table of identified risks, mitigation methods and contingency plans
Appendix E	–	Organogram: Structure of project team including partners and contractors
Appendix F	–	Project partners: Introduction to project partners, working arrangements and roles and responsibilities on the project
Appendix G	–	Cost benefit analysis: Detailed cost benefit analysis
Appendix H	–	Work stream descriptions: Detailed breakdown of work streams
Appendix I	–	Letter of support from National Grid
Appendix J	–	CV of Navigant Expert
Addendum	–	List of Changes for Re-Submission

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Appendix A1 – Benefits tables

KEY

Method	Method name
Method 1	Use of contingency analysis software in the control room to achieve reliability management, outage management and network capacity management benefits
Method 2	N/A
Method 3	N/A

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LCN Fund – financial benefits

Financial benefit (£m)								
Scale	**Method**	**Method Cost**	**Base Case Cost**	**Benefit**			**Notes**	**Cross-references**
				2020	**2030**	**2050**		
Post-trial solution *(individual deployment)*	Method 1	9.1	9.7	0.8	0.7	0.6	*Method cost and base cost is based on one individual deployment.* *Benefit is based on the benefits described in the Business Case, discounted in 2014 money using the Ofgem CBA sheet.*	Section 3: Project Business Case Appendix G
	Method 2	-	-	-	-	-		
	Method 3	-	-	-	-	-		
Licensee scale *If applicable, indicate the number of relevant sites on the Licensees' network.*	Method 1	14.7	18.0	0.8	3.6	3.4	*Method cost and base cost is based on two individual deployments within a single license area.* *Benefit is based on the benefits described in the Business Case, discounted in 2014 money using the Ofgem CBA sheet.*	Section 3: Project Business Case Appendix G
	Method 2	-	-	-	-	-		
	Method 3	-	-	-	-	-		
GB rollout scale *If applicable, indicate the number of relevant sites on the GB network.*	Method 1	185	251	13.7	70.8	67.7	*Method cost and base cost is based on 30 deployments across multiple license areas.* *Benefit is based on the costs and benefits described in the Business Case, discounted in 2014 money using the Ofgem CBA sheet.*	Section 3: Project Business Case Appendix G
	Method 2	-	-	-	-	-		
	Method 3	-	-	-	-	-		

LCN Fund - carbon benefits

Capacity released (kWh)								
Scale	**Method**	**Method Cost**	**Base Case Cost**	**Benefit**			**Notes**	**Cross-references**
				2020	**2030**	**2050**		
Post-trial solution *(individual deployment)*	Method 1	9.1m	9.7m	24,303,000	24,303,000	24,303,000	*Method cost and base cost is based on one individual deployment.*	Section 3: Project Business Case Appendix G
	Method 2	-	-	-	-	-		
	Method 3	-	-	-	-	-		
Licensee scale *If applicable, indicate the number of relevant sites on the Licensees' network.*	Method 1	14.7m	18.0m	24,303,000	48,606,000	48,606,000	*Method cost and base cost is based on two individual deployments within a single license area.*	Section 3: Project Business Case Appendix G
	Method 2	-	-	-	-	-		
	Method 3	-	-	-	-	-		
GB rollout scale *If applicable, indicate the number of relevant sites on the GB network.*	Method 1	185m	251m	72,909,000	729,086,000	729,086,000	*Method cost and base cost is based on 30 deployments across multiple license areas.*	Section 3: Project Business Case Appendix G
	Method 2	-	-	-	-	-		
	Method 3	-	-	-	-	-		

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Appendix A2 – Full Submission Spreadsheet

This document has been submitted as a separate file.

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Appendix B – Maps and Network Diagrams

List of Figures

Figure B1 – Google map of SPN licence area

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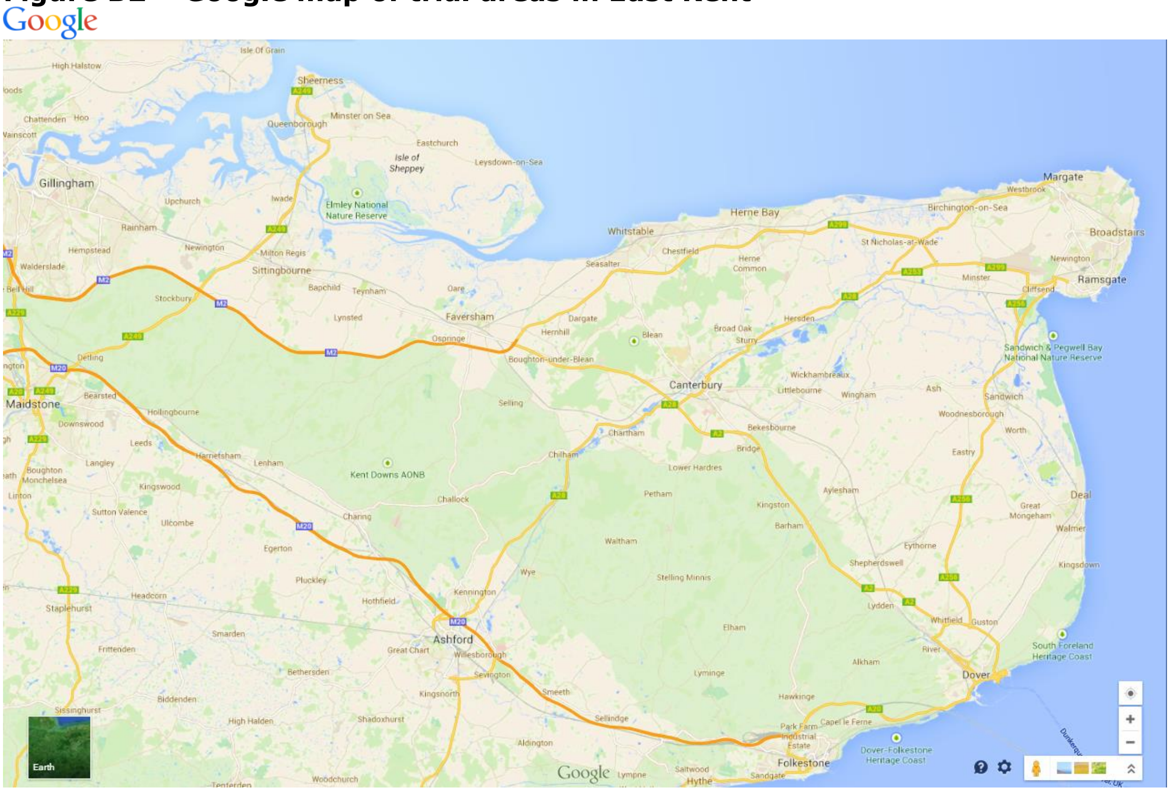
Figure B2 – Google map of trial areas in East Kent



LCN Fund
Low Carbon Networks

Project Code/Version No: UKPNT206

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Figure B3 – East Kent Schematic System Map

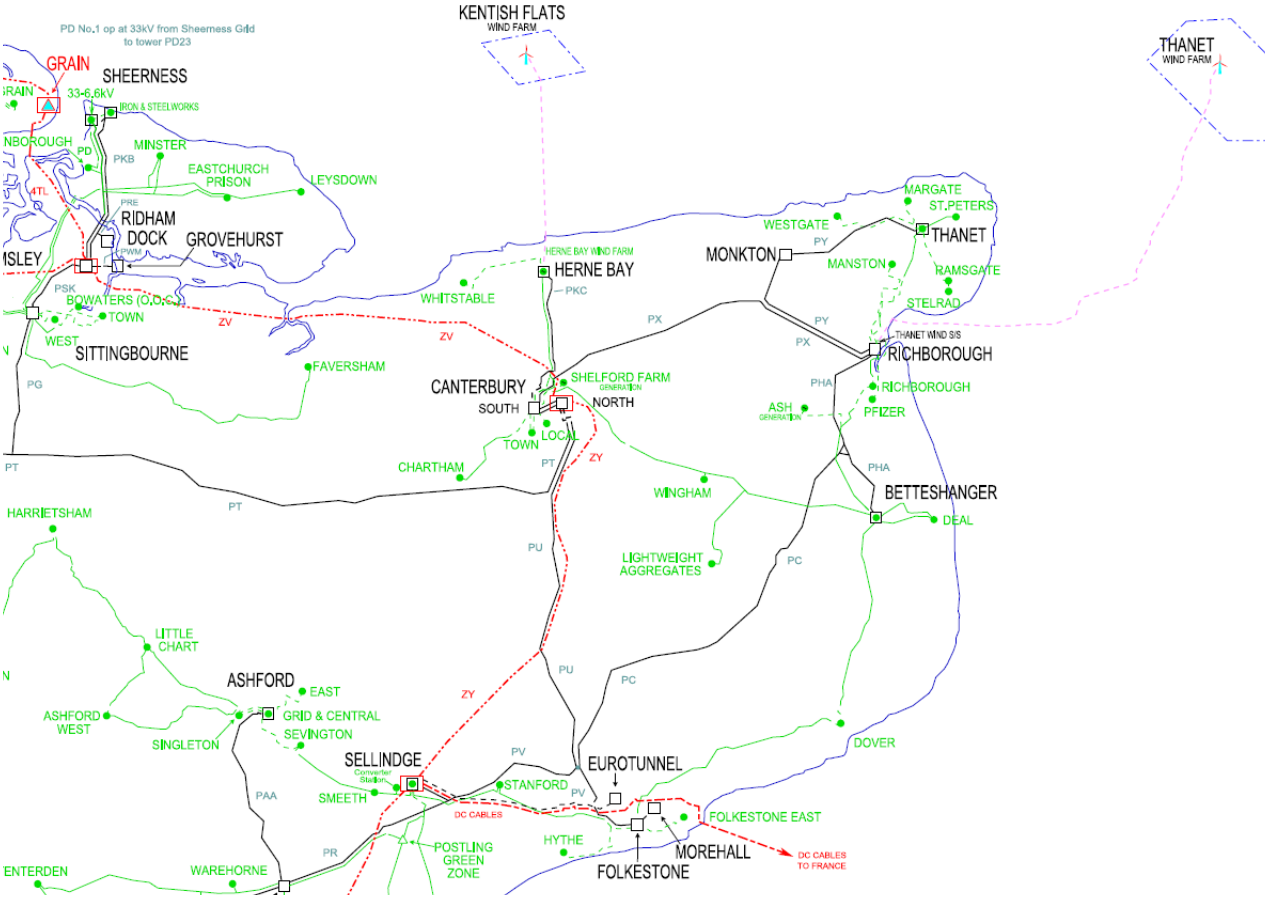


Figure B4 – Network diagram, 400kV

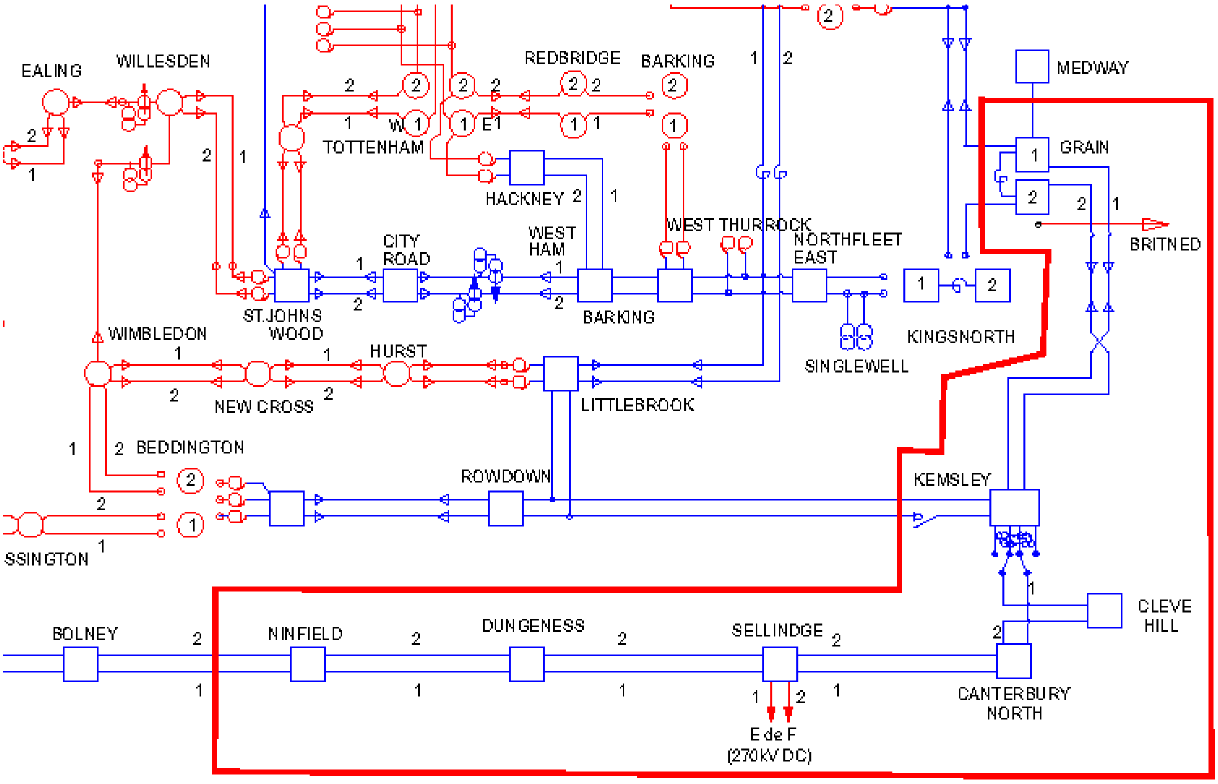
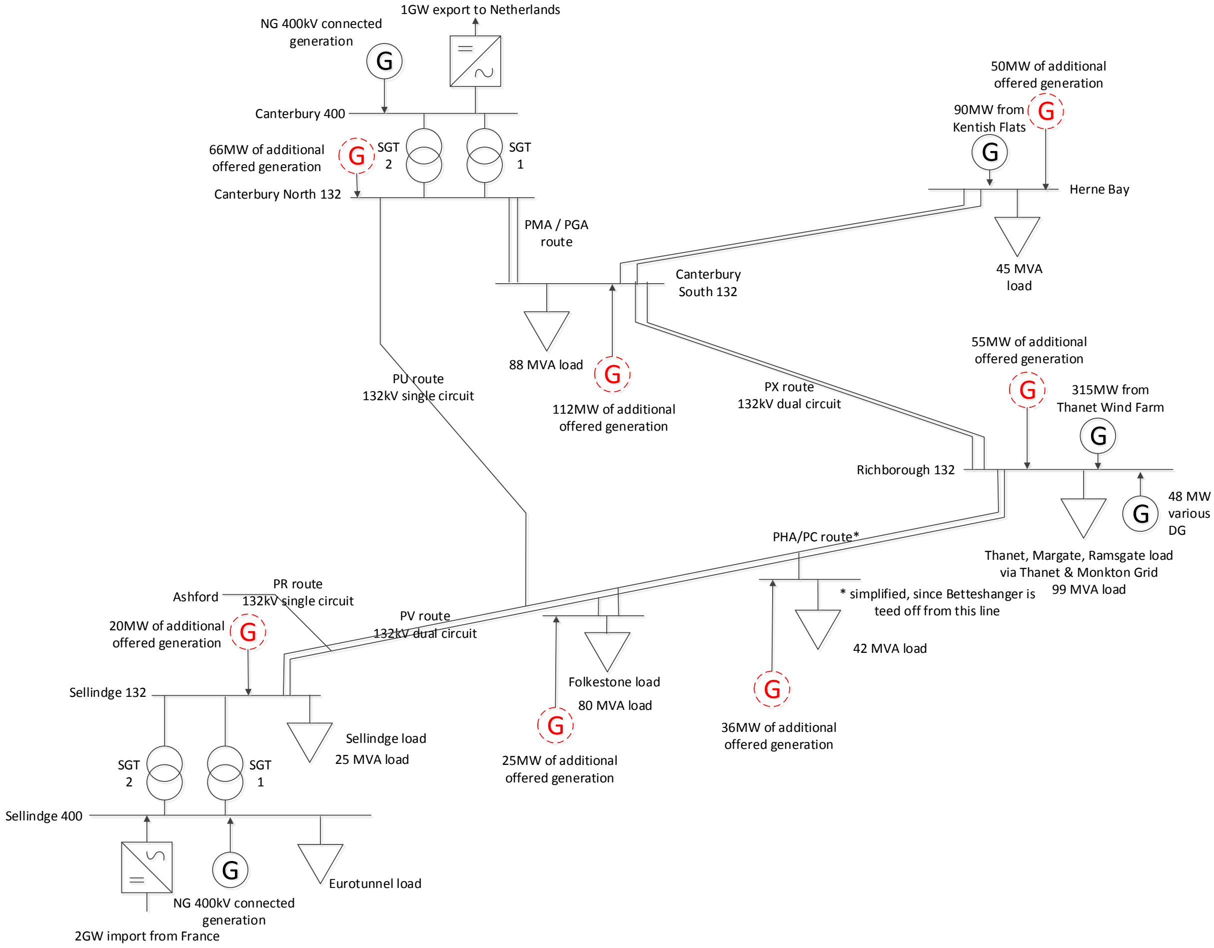
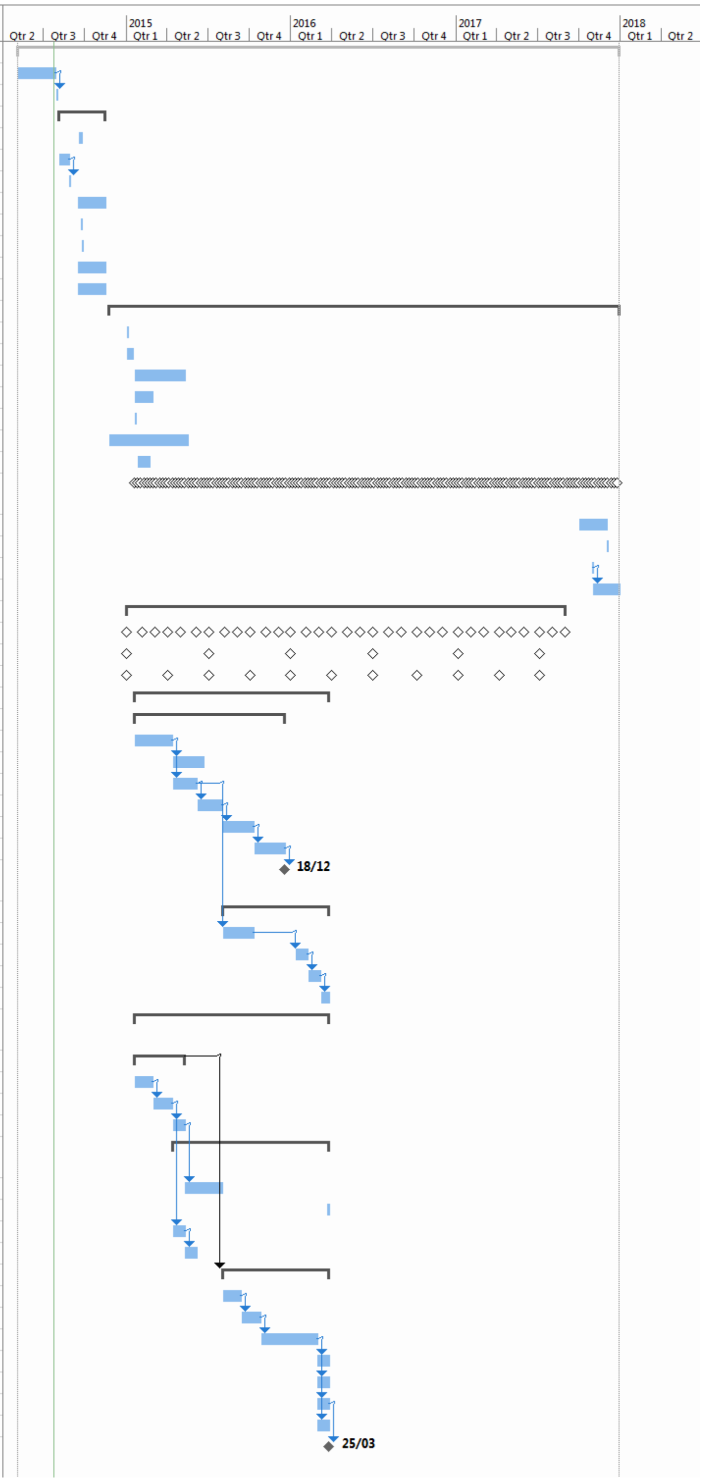


Figure B5 – Network diagram, 132kV



Appendix C – Project Plan

ID	Task Name	Duration	Start	Finish
0	**KASM**	**955 days?**	**Mon 05/05/14**	**Fri 29/12/17**
1	Project KASM bid submission	60 days	Mon 05/05/14	Fri 25/07/14
2	Post submission	3 days	Mon 28/07/14	Wed 30/07/14
3	**Pre Award Activities**	**75 days**	**Mon 04/08/14**	**Fri 14/11/14**
4	Post submission review and lessons learnt	5 days	Wed 17/09/14	Tue 23/09/14
5	Early bilateral meeting preparation	17 days	Mon 04/08/14	Tue 26/08/14
6	Early bilateral meeting with Expert Panel	1 day	Wed 27/08/14	Wed 27/08/14
7	Investigate further external funding channels	45 days	Mon 15/09/14	Fri 14/11/14
8	Full bilateral meeting preparation	1 day	Mon 22/09/14	Mon 22/09/14
9	Full bilateral meeting with Expert Panel	1 day	Tue 23/09/14	Tue 23/09/14
10	Initiate drafting of delivery contracts	45 days	Mon 15/09/14	Fri 14/11/14
11	Confirm resource plan and create job descriptions	45 days	Mon 15/09/14	Fri 14/11/14
12	**Project Management**	**810 days**	**Mon 24/11/14**	**Fri 29/12/17**
13	Project kick-off	1 day	Thu 01/01/15	Thu 01/01/15
14	Project governance and controls in place	10 days	Thu 01/01/15	Wed 14/01/15
15	Project team mobilisation and resourcing	80 days	Mon 19/01/15	Fri 08/05/15
16	Create communications plan	30 days	Mon 19/01/15	Fri 27/02/15
17	Review of bid submission plan	3 days	Mon 19/01/15	Wed 21/01/15
18	Complete contracts with suppliers	125 days	Mon 24/11/14	Fri 15/05/15
19	Create project outline plan and Stage 1 detailed plan	20 days	Mon 26/01/15	Fri 20/02/15
20	**Project plan review, update and creation of further stages (weekly)**	**765 days**	**Mon 19/01/15**	**Mon 25/12/17**
175	Prepare final benefits report	44 days	Mon 02/10/17	Thu 30/11/17
176	Final benefits report	1 day	Thu 30/11/17	Thu 30/11/17
177	Decommissioning (as required)	1 day	Mon 30/10/17	Mon 30/10/17
178	Project closure	44 days	Tue 31/10/17	Fri 29/12/17
179	**Project Governance**	**695 days**	**Fri 02/01/15**	**Fri 01/09/17**
180	**Project Internal Steering Group (monthly)**	**695 days**	**Fri 02/01/15**	**Fri 01/09/17**
214	**Project Progress Report (6 months)**	**655 days**	**Fri 02/01/15**	**Fri 07/07/17**
221	**Project Forums (Quarterly)**	**655 days**	**Fri 02/01/15**	**Fri 07/07/17**
233	**WS1: Data Integration and Setup**	**310 days**	Mon 19/01/15	**Fri 25/03/16**
234	**Develop business process for real-time data transfer**	**240 days**	**Mon 19/01/15**	**Fri 18/12/15**
235	Review current processes	60 days	Mon 19/01/15	Fri 10/04/15
236	Future state data transfer mechanism	50 days	Mon 13/04/15	Fri 19/06/15
237	IT requirement gathering	40 days	Mon 13/04/15	Fri 05/06/15
238	Data retrieval and storage requirements	40 days	Mon 08/06/15	Fri 31/07/15
239	New Business process mapping	50 days	Mon 03/08/15	Fri 09/10/15
240	Stakeholder verification	50 days	Mon 12/10/15	Fri 18/12/15
241	**National Grid consultation for inter-control room communication framework SDRC 9.1**	0 days	Fri 18/12/15	Fri 18/12/15
242	**Data transfer infrastructure**	**170 days**	**Mon 03/08/15**	**Fri 25/03/16**
243	Review IT requirements	50 days	Mon 03/08/15	Fri 09/10/15
244	Procure IT hardware	20 days	Mon 11/01/16	Fri 05/02/16
245	Install and configure IT hardware	20 days	Mon 08/02/16	Fri 04/03/16
246	Data connection test and verification	15 days	Mon 07/03/16	Fri 25/03/16
247	**WS2: Contingency Analysis Tool Development and Integration**	**310 days**	**Mon 19/01/15**	**Fri 25/03/16**
248	**Functional design development and review**	**80 days**	Mon 19/01/15	**Fri 08/05/15**
249	Functional Design Review (Base Functionality)	30 days	**Mon 19/01/15**	Fri 27/02/15
250	Custom Functional Design	30 days	Mon 02/03/15	Fri 10/04/15
251	Custom Design Review	20 days	Mon 13/04/15	Fri 08/05/15
252	**Data extract, scenario creation and acceptance testing**	**250 days**	**Mon 13/04/15**	**Fri 25/03/16**
253	UKPN Data Extraction	60 days	Mon 11/05/15	Fri 31/07/15
254	National Grid data dump	5 days	Mon 21/03/16	Fri 25/03/16
255	Scenario data	20 days	Mon 13/04/15	Fri 08/05/15
256	Development Testing	20 days	Mon 11/05/15	Fri 05/06/15
257	**Software development and Testing**	**170 days**	**Mon 03/08/15**	**Fri 25/03/16**
258	Development Hardware procurement	30 days	Mon 03/08/15	Fri 11/09/15
259	Base software install and configuration	30 days	Mon 14/09/15	Fri 23/10/15
260	Standard and Custom functionality development	90 days	Mon 26/10/15	Fri 26/02/16
261	Performance testing	20 days	Mon 29/02/16	Fri 25/03/16
262	Factory Acceptance testing	20 days	Mon 29/02/16	Fri 25/03/16
263	Defect Resolution	20 days	Mon 29/02/16	Fri 25/03/16
264	Site Testing	20 days	Mon 29/02/16	Fri 25/03/16
265	**New Successful system integration of Contingency Analysis (CA) software SDRC 9.2**	0 days	Fri 25/03/16	Fri 25/03/16



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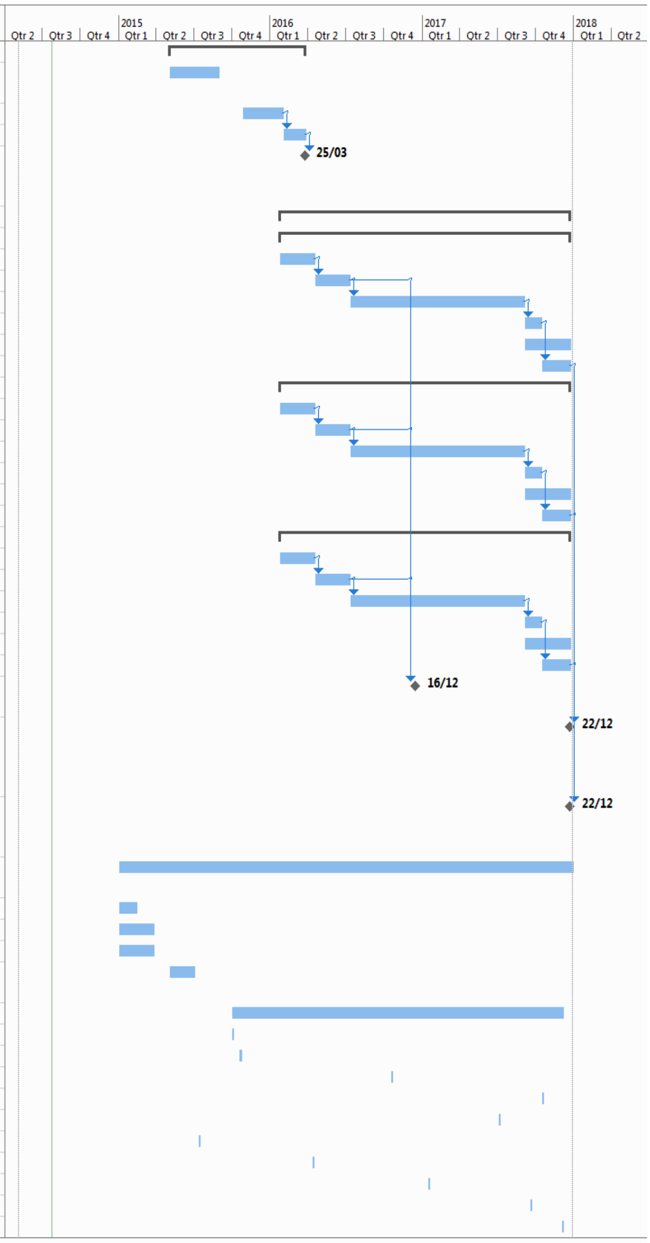
ID	Task Name	Duration	Start	Finish
266	**WS3: Load and Generation Forecasting and Modelling**	**235 days**	Mon 04/05/15	**Fri 25/03/16**
267	Design architecture and develop load and generation modules	85 days	Mon 04/05/15	Fri 28/08/15
268	Data collection and model development	70 days	Mon 26/10/15	Fri 29/01/16
269	Model test and reporting	40 days	Mon 01/02/16	Fri 25/03/16
270	Successful installation of data aggregating forecasting modules that will link the DNO control room with other data sources SDRC 9.3	0 days	Fri 25/03/16	Fri 25/03/16
271	**WS4: Value Streams and Business Process Impacts**	**500 days**	Mon 25/01/16	**Fri 22/12/17**
272	**Trial for reliability management**	**500 days**	Mon 25/01/16	**Fri 22/12/17**
273	Trial objectives and design	60 days	Mon 25/01/16	Fri 15/04/16
274	Trial methodology	60 days	Mon 18/04/16	Fri 08/07/16
275	Collect data	300 days	Mon 11/07/16	Fri 01/09/17
276	Validation of data	30 days	Mon 04/09/17	Fri 13/10/17
277	Analyse results	80 days	Mon 04/09/17	Fri 22/12/17
278	Produce report on results of trial	50 days	Mon 16/10/17	Fri 22/12/17
279	**Trial for outage management**	**500 days**	Mon 25/01/16	**Fri 22/12/17**
280	Trial objectives and design	60 days	Mon 25/01/16	Fri 15/04/16
281	Trial methodology	60 days	Mon 18/04/16	Fri 08/07/16
282	Collect data	300 days	Mon 11/07/16	Fri 01/09/17
283	Validation of data	30 days	Mon 04/09/17	Fri 13/10/17
284	Analyse results	80 days	Mon 04/09/17	Fri 22/12/17
285	Produce report on results of trial	50 days	Mon 16/10/17	Fri 22/12/17
286	**Trial for network capacity management**	**500 days**	Mon 25/01/16	**Fri 22/12/17**
287	Trial objectives and design	60 days	Mon 25/01/16	Fri 15/04/16
288	Trial methodology	60 days	Mon 18/04/16	Fri 08/07/16
289	Collect data	300 days	Mon 11/07/16	Fri 01/09/17
290	Validation of data	30 days	Mon 04/09/17	Fri 13/10/17
291	Analyse results	80 days	Mon 04/09/17	Fri 22/12/17
292	Produce report on results of trial	50 days	Mon 16/10/17	Fri 22/12/17
293	Successful use of real-time contingency analysis in the control room SDRC 9.4	0 days	Fri 16/12/16	Fri 16/12/16
294	Successful completion of trials and implementation of reliability management, outage management and network capacity management SDRC 9.5	0 days	Fri 22/12/17	Fri 22/12/17
295	Successful development of business design to incorporate contingency analysis as business-as-usual SDRC 9.6	0 days	Fri 22/12/17	Fri 22/12/17
296	**WS5: Knowledge Dissemination and Stakeholder Engagement**	782 days	Thu 01/01/15	Fri 29/12/17
297	Development of knowledge dissemination roadmap	30 days	Thu 01/01/15	Wed 11/02/15
298	Develop project webpage and dissemination tools	60 days	Thu 01/01/15	Wed 25/03/15
299	Seminars, workshops and conferences planning	60 days	Thu 01/01/15	Wed 25/03/15
300	Production of report showing key technical and commercial project challenges	42 days	Mon 04/05/15	Tue 30/06/15
301	**Events**	568 days?	Thu 01/10/15	Mon 04/12/17
302	Launch event and workshop for SDRC 9.1-9.3	1 day	Thu 01/10/15	Thu 01/10/15
303	LCNF annual conference, 2015	3 days	Mon 19/10/15	Wed 21/10/15
304	LCNF annual conference, 2016	3 days	Mon 17/10/16	Wed 19/10/16
305	LCNF annual conference, 2017	3 days	Mon 16/10/17	Wed 18/10/17
306	Workshop for SDRC 9.5-9.7	1 day	Mon 03/07/17	Mon 03/07/17
307	UKPN Internal dissemination events #1	1 day	Mon 13/07/15	Mon 13/07/15
308	UKPN Internal dissemination events #2	1 day	Mon 11/04/16	Mon 11/04/16
309	UKPN Internal dissemination events #3	1 day	Mon 16/01/17	Mon 16/01/17
310	UKPN Internal dissemination events #4	1 day	Mon 18/09/17	Mon 18/09/17
311	Project close down event	1 day	Mon 04/12/17	Mon 04/12/17



Appendix D – Risk Register and Mitigation Plan

Ref No.	Area	Overall Risk Status	Risk & Impact Description	Impact	Risk Owner	Probab-ility	Mitigating Actions
R0001	Bid	On track	Final funding not awarded and project unable to commence in 2014	High	UKPN	20%	Ensure high bid quality, regular reviews, clear differentiation and stakeholder engagement.
R0002	Design	On track	Project partner(s) withdraw their support at the start of the project	Medium	UKPN	5%	Regular contact maintained throughout bid preparation and up to project start date. Contracts outline LCNF requirements in advance. Reserve supplier has been nominated.
R0003	Project Delivery	On track	The software solution fails to perform to specification leading to system incompatibilities and unsatisfactory trial results	High	UKPN	10%	The software solution will be subject to performance testing using benchmarking or simulators under various operating conditions. Software requirements to be defined at design stage and suitable software chosen for the purpose of the trials. UK Power Networks to agree Service Level Agreements (SLAs) for software solution.
R0004	Learning Dissem-ination	On track	There is lost learning during Knowledge Dissemination and Stakeholder Engagement	High	UKPN	10%	Identify stakeholders early on. Dissemination WS is fully engaged with

Ref No.	Area	Overall Risk Status	Risk & Impact Description	Impact	Risk Owner	Probab-ility	Mitigating Actions
			activities due to differing interests and learning styles of stakeholders				technical WS at an early stage and lessons learnt are captured from the LCNF projects.
R0005	Project Delivery	On track	A lack of available technical and project resources cause a delay to the project	Medium	UKPN	10%	Resource plan completed with UK Power Networks resources. Several other projects closing which will release skilled resource.
R0006	Project Delivery	On track	The software partner goes out of business before the solution has been delivered	High	UKPN	10%	Full financial due diligence undertaken as part of UK Power Networks procurement procedure, identify alternative supplier.
R0007	Project Delivery	On track	The software partner goes out of business after the solution has been delivered resulting in lack of continuity/support	Medium	UKPN	10%	Full financial due diligence undertaken as part of UK Power Networks procurement procedure, arrange a software ESCROW and novation of liabilities to OEM.
R0008	Project Delivery	On track	The trials do not deliver the expected results	High	UKPN	5%	Expectations are managed due to thorough planning and frequent reporting. Lessons gathered throughout process.

Ref No.	Area	Overall Risk Status	Risk & Impact Description	Impact	Risk Owner	Probab-ility	Mitigating Actions
R0009	Project Delivery	On track	National Grid do not deliver data in the timescales required	High	UKPN	15%	Proactive engagement and understanding of risks from early stage. Static values and alternative data sources considered such as balancing mechanism reports.
R0010	Project Delivery	On track	National Grid data costs far exceed estimate resulting in data being too expensive to acquire	Medium	UKPN	10%	Static values and alternative data sources considered such as balancing mechanism reports.
R0011	IT	On track	Integration of software solution cannot be delivered in time resulting in delays	Medium	UKPN	10%	Progress reported weekly, project planning tools implemented.
R0012	Project Delivery	On track	UK Power Networks staff are not actively engaged or in a timely manner resulting in poor engagement and delays	Medium	UKPN	5%	Ensure early engagement activities and stakeholder events for UK Power Networks staff.
R0013	IT	On track	Visualisation of outputs from software tool not in line with operator expectations	Low	UKPN	5%	Engage with operators early in the process to help inform the design to mimic existing Distribution Management System. Limited contingency added into timescales to allow re-design if necessary.
R0014	External risk	On track	Connectees commit to pay for significant SGT upgrades at both Canterbury and Richborough, and overhead line upgrades adding	High	UKPN	10%	Monitor all new connection requests. Support any efforts by DG developers to form group connections or

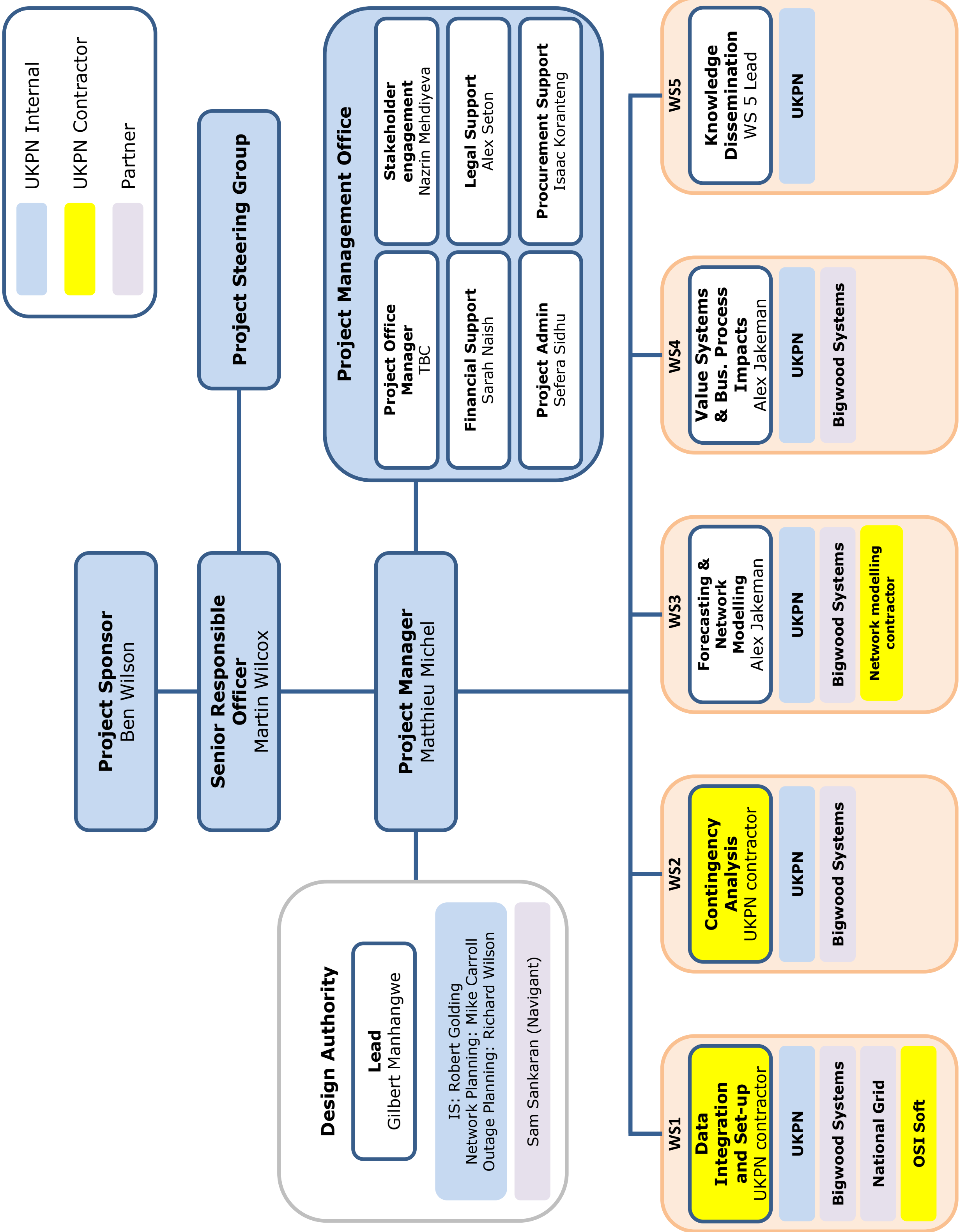
Ref No.	Area	Overall Risk Status	Risk & Impact Description	Impact	Risk Owner	Probab-ility	Mitigating Actions
			significant capacity to the network and removing the export constraints				joint connection requests
R0015	Project Delivery	On track	Exceeding the estimated budget for the project	High	UKPN	5%	We have conducted detailed project planning and cost reporting, based on our prior experience in delivering LCNF projects
R0016	Project Delivery	On track	Exceeding the estimated implementation timeline and underestimating required resources	High	UKPN	5%	We have conducted detailed project planning, allowing comfortable implementation margins and a multitude of resources. UKPN has significant experience internally in project management and IT project implementation.

LCN Fund
Low Carbon Networks

Project Code/Version No:
UKPNT206

Low Carbon Networks Fund Full Submission Pro-forma

Appendix E – Organogram



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Appendix F – Project Partners

Organisation	National Grid
Organisation type / description	System Operator
Relationship to DNO (if any)	UK Power Networks have many statutory and consultative interfaces; however there is no existing relationship between UK Power Networks and National Grid related to this project.
KASM role summary	National Grid will provide real-time information on: 1. Power flows across 400kV SGTs 2. The configuration of the network, including switching 3. The output of generators that are connected to the transmission network 4. The output of the HVDC interconnectors in the area
What does the partner bring to KASM?	National Grid is a key operational partner and the data they hold is important to the success for the project.
Funding	National Grid provided an initial estimate of the in-kind contribution that it will make to the project (~£40k)
Contractual relationship	Under negotiation: The parties intend to sign a Memorandum of Understanding and Participation Agreement, akin to prior contracts negotiated and agreed between the two companies.
External collaborator benefits from the project	The project will improve the flow of information between National Grid and UK Power Networks resulting in further collaboration opportunities and improving the reliability of the network.

Organisation	Bigwood Systems, Inc.
Organisation type / description	Software Supplier
Relationship to DNO (if any)	New relationship, selected through a competitive procurement process to provide the Contingency Analysis software solution.
KASM role summary	The supply and delivery of a contingency analysis and load and generation forecasting tool that will enable the prioritisation of the impact of actual and potential outage events on UK Power Networks 132kV electricity distribution network.
What does the partner bring to KASM?	Bigwood and its SecureSuite (VSA&E) Tool & Elite software was selected from a number of proposals because of its innovative approach, unique visualisation of results, and competitive price.
Funding	N/A
Contractual relationship	A contractual agreement will be signed once all terms have been agreed and the LCNF funding decision has been made.
External collaborator benefits from the project	Bigwood Systems will benefit from exposure to a new market. A high profile qualification in Europe will assist Bigwood Systems' marketing efforts in the UK and Europe.

Organisation	Navigant Consulting (Europe) Ltd.
Organisation type / description	Specialised management consultancy
Relationship to DNO (if any)	Provides management consultancy services to UK Power Networks. Navigant staff assisted in the selection of the preferred software vendor, scoping of the KASM project, and development of the Full Submission.
KASM role summary	To provide support in Work Stream 2 – Contingency Analysis Tool Development and Integration and 3 – Load and Generation Forecasting and Modelling and to support the development and integration of the Bigwood solution.
What does the partner bring to KASM?	Specialised technical knowledge and project management expertise. Navigant have worked with international utilities on many smart grid assignments involving unique software tools.
Funding	Navigant will provide an in-kind contribution equal to 10% of its professional fees.
Contractual relationship	Navigant is currently under a contractual agreement with UK Power Networks.
External collaborator benefits from the project	An excellent case study for business development purposes Best practice insights that can benefit other stakeholders and clients Relationship building with UK Power Networks

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Appendix G – Cost Benefit Analysis

Project benefits

KASM seeks to explore how a distribution network operator can use real-time power flow modelling and potential post-fault analysis capabilities, combined with enhanced generation and load forecasting, to:

- operate the network closer to its limit and hence as an alternative to traditional reinforcement;
- reduce constraints placed on generators during maintenance and other planned outages; and
- improve operational processes to reduce time-constraints on outage planners and reduce the overall risk on the network.

In the case of East Kent, UK Power Networks estimates that the proposed method may defer the installation of a new SGT in Richborough by two years. This is equivalent to a net benefit of £0.7m in present value (2014) terms over a 45-year capitalisation and depreciation term.

Figure 7: KASM benefit from deferred reinforcement

Description	Nominal cost (£m)	Present Value in 2014 (£m)
Installation of SGT at Richborough in 2018 (base case)	11.0	9.7
Deferred installation of SGT at Richborough in 2020	11.0	9.0
	Benefit	0.7

The benefit above will be realised through the transition of network capacity management from a passive, fit-and-forget approach to a probabilistic approach based on network data. Presently, capacity planning for most DNOs is based on the "worst-case scenario", and connection offers are oftentimes linked to expensive reinforcement works that might only be necessary for a few hours every year.

UK Power Networks has conducted an analysis of the historical hourly demand and generation data in SPN's East Kent network to determine the frequency of occurrence for the worst-case scenario. The results of the analysis showed that the network is presenting the worst operating condition for only a few hours each year, and that managing the network using "smart" interventions during those hours can allow the deferral of the investment in conventional reinforcement.

Our analysis showed that there is capacity of about 300 MW between 2014 and 2016 that can be gained in the network, which will be subject to unfavourable conditions for less than 20 hours per year. We believe that conservatively, the solution will be able to make enough capacity available to maintain the existing annual rate of increase in distributed generation connections in the East Kent network area for two years (10% or approximately 100 MW per year), which is less than the predicted margin of 300 MW. Based on this, we believe that our estimate for a two-year deferral in the installation of a third SGT in the network is realistic.

Additional benefits include: (i) a reduction in the number and magnitude of constraints placed on embedded generators, both wind and solar PV, (ii) the corresponding reduction in carbon emissions, and (iii) a reduction in labour requirements to effectively plan and manage outages.

Reduction in number and magnitude of constraints
We have assumed a reduction in constraints placed on existing embedded wind (Thanet only, 315 MW) and solar PV (385 MW) facilities, results in a corresponding increase in production equivalent to two days per annum at a 35% and 15% production factor. This is equivalent to an increase of approximately 5.3 GWh of wind and 2.8 GWh of solar PV production. To calculate the financial benefit, the lost revenue method proposed by Baringa and validated through recent work across the UK power sector and published in a recent report for Elexon was applied. The costs are based on the value of ROC subsidies and wholesale price for electricity.

Corresponding carbon emissions
The incremental production from embedded wind and solar PV displaces carbon emissions that would otherwise have been generated by upstream electricity resources. At a rate of approximately 0.45 tn/MWh (DEFRA – "2012 greenhouse gas conversion factors for company reporting"), the avoided carbon emissions are approximately 3,600 tonnes per annum.

Avoided outage planning labour costs
We have assumed that one full-time equivalent will be avoided due to the use of the software. The estimated cost for an outage planner is £70,000 per annum.

We have used the Ofgem CBA spreadsheet tool to calculate the net present value of the annual benefits of the project. The results are displayed in the table below.

Figure 8: Benefits of KASM project

Description		Duration (yrs)	Annual Benefit (£m)	Present Value of Benefit in 2014 (£m)
Reduction in number and magnitude of constraints	8,120 MWh	3	0.80	2.09
Carbon emissions reduction	3,600 tonnes	3	0.03	
Avoided outage planning labour	1 FTE	3	0.07	0.18

All figures are calculated based on UK Power Networks' proposed cost of capital of 3.5%, a capitalisation ratio of 70%, and a depreciation term of 45 years. As such, this is fully compliant with both Ofgem's Cost-Benefit Analysis requirements and typical HM Treasury principles.

Benefits to wider GB roll-out

A database of GSPs for all GB DNO license areas was created and some simple metrics assessed to determine the applicability of contingency analysis tools at each GSP. Information was obtained from the Long Term Development Statements (LTDS) for each of the GB DNOs and the National Grid Electricity Ten Year Statement (ETYS). Data collected is listed in Figure 9.

Figure 9: GSP Data Collected

Data Points	Units	Description	Source
GSP Name	text	Unique name/identifier	ETYS and LTDS
GSP Capacity	MVA	MVA capacity of the super grid transformers	ETYS
GSP N-1 Capacity	MVA	MVA capacity in N-1 conditions	ETYS
Maximum Demand	MVA	MVA maximum demand	LTDS
Minimum Demand	MVA	MVA minimum demand	Derived
Total Generation Capacity	MVA	MVA total generation	LTDS – where MW value given, assumed 0.9 PF
Maximum Net Import	MVA	MVA maximum import through the GSP	Derived
Maximum Net Export	MVA	MVA maximum export through the GSP	Derived

The analysis described below demonstrates the potential value of a full rollout of contingency analysis tools across all GB DNOs. Value is derived from deferring the cost of reinforcement at export constrained GSPs and from reducing the lost energy production of embedded generators during outages.

Derived Metrics

Some metrics were extracted directly from the available data while others were derived, as follows:

- **GSP N-1 Capacity:** The sum total of the capacities of all Super-Grid Transformers (SGTs) connected to the GSP was calculated, then the capacity of the largest SGT was subtracted from that, to give a worst-case N-1 capacity.
- **Minimum Demand:** The minimum demand is assumed to be 35% of maximum demand in all license areas for the purpose of this study.
- **Maximum Net Import and Export Levels:** Maximum Net Import was taken to be equal to the level of maximum demand (generation output assumed to be zero in this worst case). Maximum Net Export was taken to be equal to the difference between the total embedded generation capacity and minimum demand.

It should be noted that the Maximum Demand figure used is the sum of all peak loads at substations below the GSP. Minimum demand is then derived as a fixed percentage of that maximum.

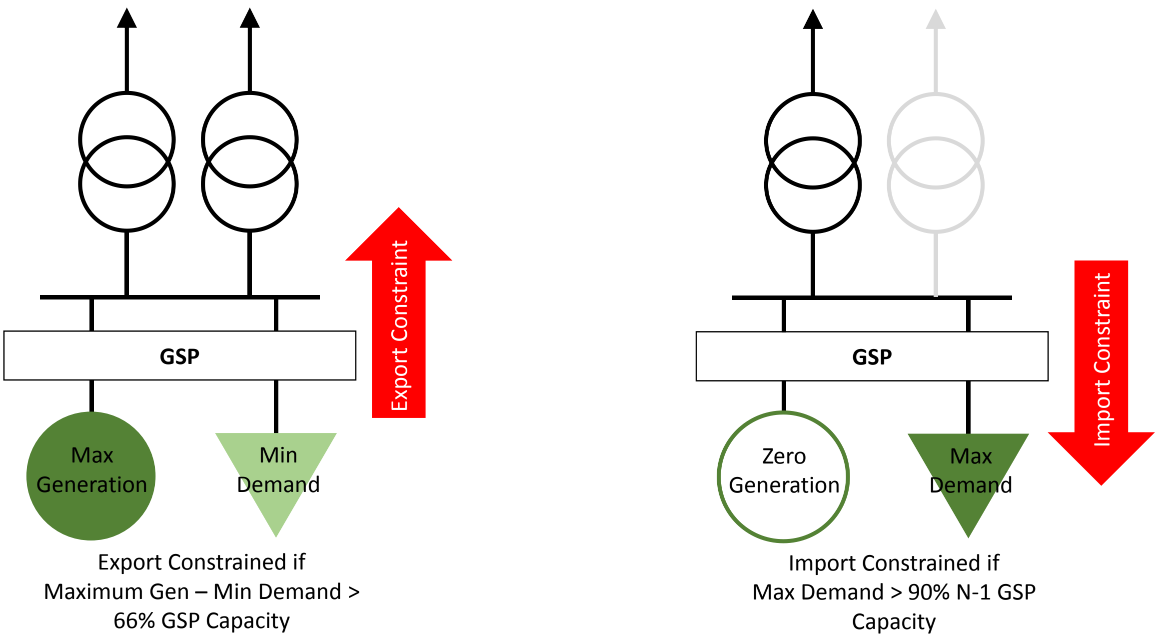
Applicability of Contingency Analysis

The analysis is based on identifying the constrained GSPs and postulating that contingency analysis tools could be used to defer the reinforcement associated with those constraints.

- **Constrained GSPs:** A GSP is considered to be 'constrained' if its Maximum Net Import exceeds 90% of its calculated N-1 capacity; or its Maximum Net Export exceeds 66% of its calculated intact capacity.
- **Export-Constrained GSPs:** A GSP is considered to be 'export-constrained' if its Maximum Net Export exceeds 66% of its calculated intact capacity – this empirical assumption is based on UK Power Networks' understanding and experience of export constraints at GSPs. This value is used in the analysis but it is acknowledged that the actual export limit will vary by location and possibly also by time.

The assumptions on identify constrained GSPs are illustrated in Figure 10.

Figure 10: Identification of Constrained GSPs



Benefits of Contingency Analysis
The potential benefits of the contingency tools are assessed in two ways.

- **Deferral of investments to relieve constraints:** The potential benefit of contingency analysis is inferred from the reduction in the number of export constrained GSPs that might be achieved. The initial identification of Constrained GSPs is based on worst case conditions, assuming minimum demand is 35% of the maximum demand. Contingency analysis, with associated smart solutions like Active Network Management, allows networks to be managed more closely based on actual conditions. This is reflected in the analysis by reassessing GSP constraints using an average demand level of 60% of peak demand, instead of the minimum demand. Where this changes a GSP from being export constrained, and therefore requiring reinforcement, to not being constrained, the deferral of investment is recognised as a benefit.
- **Reduced impact of outages:** The contingency analysis tools are also expected to aid in the planning for outages and the operation of networks under outage conditions. Outage planning is typically done far in advance and therefore leads to conservative approaches to outage times and the limits imposed on generators during those outages.

Base Case and Future Scenarios
A base case was created for each DNO license area from the latest LTDS and ETYS data. Future scenarios were created using high and low generation and demand growth multipliers based on values from the National Future Energy Scenarios report. This alters the GSP import and export levels and results in changes in constraints.

The low values are based on the 'No Progression' scenario, which represents a future where there is little to no innovation in the renewable energy sector, gas is the preferred choice of generator and all renewables targets are missed.

The high values are based on the 'Gone Green' scenario, which assumes a balanced approach to renewable growth, i.e. all generation technologies grow at a similar rate where the GB renewables target for 2020 and indicative targets for 2030 are met. The decrease in demand values reflects the increase in energy efficiency measures and the high uptake of electric vehicles and heat pumps.

The changes in demand and generation expected by 2019 and 2024 are represented by the percentage multiplier values in Figure 11. These years were selected to align approximately with UK Power Networks upgrade plans in the Kent network area (due 2019) and the end of the RIIO ED1 review period in 2023.

Figure 11: Demand and generation scenarios (% change over base case)

	2019		2024	
	HIGH	**LOW**	**HIGH**	**LOW**
Demand	-2%	0%	-3%	-1%
Embedded Generation	40%	30%	69%	48%

Results

The study identified 93 constrained GSPs for the base case across all licence areas from a total of 348 GSPs that were assessed, 40 of which are export-constrained. The analysis demonstrated that on average, each license area in the GB network presented two to three export-constrained GSPs.

Applying the future demand and generation scenarios for 2019 and 2024, the identified constrained GSPs are presented in below, where:

- HG = high generation, LG = low generation; and
- HD = high demand, LD = low demand.

Figure 12: Constrained and Export-constrained GSPs in 2019 and 2024

2019	HGHD	HGLD	LGHD	LGLD
Constrained GSPs	78	80	71	74
Export-constrained GSPs	37	37	37	37

2024	HGHD	HGLD	LGHD	LGLD
Constrained GSPs	83	83	77	77
Export-constrained GSPs	51	51	43	43

Deferral of Reinforcement

The impact of using contingency analysis tools is assessed for the base case and the 2019 and 2024 future scenarios. The results are shown in Figure 13. As outlined above, it is assumed that due to the use of contingency analysis the worst-case export limit calculation is modified. Contingency analysis will allow closer management of network constraints and allow more generation to connect without requiring reinforcement. To simulate this, with contingency analysis a GSP is defined as export constrained when Maximum Generation minus 60% of Maximum Demand exceeds 66% of the intact GSP transformer capacity.

Figure 13: Export Constrained GSPs with and without Contingency Analysis

	2019 HGHD	2019 HGLD	2019 LGHD	2019 LGLD	2024 HGHD	2024 HGLD	2024 LGHD	2024 LGLD
Without CA	37	37	37	37	51	51	43	43
With CA	32	32	29	29	44	44	38	38
Reduction	5	5	8	8	7	7	5	5

The results show that with contingency analysis tools, based on the assumptions set out previously, the number of export constrained GSPs can be reduced. Across the scenarios, the reduction in GSPs requiring reinforcement is estimated to be between five and eight per year.

The purpose of this analysis was to demonstrate the maximum potential of the method case, when implemented at all possible locations. We think of this analysis as the upper bound of the potential benefits that can be realised when implementing the proposed solution.

In order to capture the inherent uncertainty around the potential benefits of the method case when scaled up to the GB network, we considered that a realistic potential for the solution is the implementation of the solution at 30 sites through 2030, or at three sites per year over ten years for the entire GB network.

Impact of Outages

Based on available information, and using the 'Gone Green' scenario (representing a high growth of Renewables) in National Grid's Future Energy Scenarios, the installed capacity of embedded generation in each scenario is presented in Figure 14.

Figure 14: Future Installed Capacity of Embedded Generation

Fuel Type	2014 Installed Capacity (MW)	2019 Installed Capacity (MW)	2024 Installed Capacity (MW)
Onshore Wind	3,021	5,040	5,898
Offshore Wind	715	872	872
Hydro	428	488	528
CHP	3,267	3,632	3,739
Biomass	395	414	430
Solar PV	1,726	4,487	7,642

As outlined above, contingency analysis tools are also expected to reduce the average length of outages and allow generators to operate, on average, at a higher level of output during those outages. This provides potential gains to generators, who will suffer a lower reduction in lost energy.

For a given limit on power output, the lost energy depends on the pattern of production from the generator. Intermittent renewable sources like wind and PV produce most of their energy at relatively low power levels so a 10% reduction in their maximum power output will not reduce energy production by as much as 10%.

Assume that the typical length of outages suffered by an embedded generator each year is 14 days and that during that time its output will be limited to 33% of its rated capacity. For simplicity, if we postulate that improved contingency analysis methods will reduce outages on average by one day, and enhanced network operation means that the limit on output can be increased, on average to 66% of rated capacity, we can estimate a financial benefit.

To calculate the financial benefit, the lost revenue method proposed by Baringa and validated through recent work across the UK power sector and published in a recent report for Elexon is applied. The costs are based on the value of ROC subsidies and wholesale price for electricity. The average ROC value used is £45/MWh and £46/MWh used for wholesale electricity. In addition to these costs, embedded benefits, subsidies for carbon levy exemption certificates and relevant discounts associated with power purchase agreements are applied.

The results for the estimated annual benefits from a full rollout of Contingency Analysis across all of GB are shown in Figure 15.

Figure 15: Reduction in Energy and Revenue Losses with Contingency Analysis and Enhanced Outage Planning and Management Processes (all generation technologies)

	2014		2019		2024	
Generator Type	**Reduction in Lost Energy (GWh)**	**Annual Financial Benefit (£M)**	**Reduction in Lost Energy (GWh)**	**Annual Financial Benefit (£M)**	**Reduction in Lost Energy (GWh)**	**Annual Financial Benefit (£M)**
Onshore Wind	82.5	7.4	137.7	12.4	161.1	14.5
Offshore Wind	19.5	2.6	23.8	3.2	23.8	3.2
Hydro	13.6	1.1	15.5	1.3	16.8	1.4
CHP	333.0	31.2	370.2	34.7	381.1	35.8
Biomass	33.2	3.7	34.7	4.0	36.1	4.1
Solar PV	14.4	1.7	37.3	4.6	63.6	7.8
Total	**496.2**	**47.9**	**619.3**	**60.1**	**682.5**	**66.7**

Examining only solar and wind technologies in the table above, we calculate the results in

Figure 16 below, which are consistent with the calculated annual benefit in the East Kent area (approximately £0.8m per license area).

Figure 16: Reduction in Energy and Revenue Losses with Contingency Analysis and Enhanced Outage Planning and Management Processes (solar and wind only)

	2014		2019		2024	
Generator Type	**Reduction in Lost Energy (GWh)**	**Annual Financial Benefit (£M)**	**Reduction in Lost Energy (GWh)**	**Annual Financial Benefit (£M)**	**Reduction in Lost Energy (GWh)**	**Annual Financial Benefit (£M)**
Onshore Wind	82.5	7.4	137.7	12.4	161.1	14.5
Offshore Wind	19.5	2.6	23.8	3.2	23.8	3.2
Solar PV	14.4	1.7	37.3	4.6	63.6	7.8
Total	**116.4**	**11.7**	**198.8**	**20.2**	**248.5**	**25.5**
Average savings per distribution license area		**0.8**		**1.4**		**1.8**

Conclusions
The analysis described above demonstrates the potential value of a full rollout of contingency analysis tools across all GB DNOs. Value is derived from deferring the cost of reinforcement at export constrained GSPs and from reducing the lost energy production of embedded generators during outages.

Based on publicly available information, and widely accepted scenarios for future changes in demand and generation, the potential value of the contingency analysis tools now and in future years is assessed.

The analysis of networks from GSP level provides a top-down perspective on network constraints and a number of simplifications have been applied to the study. The assessment of outages is based on overall totals and assumed averages for outage duration and restrictions imposed on generators. The generation and demand scenarios are applied uniformly across all of GB network, with the exception of London where only demand scenarios are used. So, while there are a number of assumptions in the analysis, the approach still provides evidence that a smart solutions such as contingency analysis could deliver value both to network owners and operators and to their generation customers.

The analysis concludes that there are between five to eight credible sites per year that could benefit from the deployment of the KASM method. We used a conservative estimate of three sites per year for ten years starting in 2018 in order to capture potential uncertainty around the estimate number of sites, and the single site benefits calculated for East Kent. **Our estimate for the net benefit of a wider rollout across the GB is in excess of £65m in present value (2014) terms over the lifetime of the investment.**

This level of benefit is achieved through a full rollout of contingency analysis and enhanced outage planning and management processes across all GB DNOs, and by achieving the performance improvements as assumed in the analysis. The nature of the proposed solutions means that incremental or partial benefits can still be achieved with a more limited rollout.

Extrapolating to 2050

The GB wide benefits have been extrapolated to 2050 under the assumption that no new sites are added after 2030 (i.e. after 2027, that is after the solution has been applied to 30 sites). As a result, the net benefit in present value (2014) terms is higher in 2030 than it is in 2050.

We have assumed an initial, up-front cost to each of the six DNO groups equal to the proposed solution's cost, net of "first-of-a-kind costs". This would allow DNO groups to use the proposed solution across all their licence areas.

The lifetime of the investment is considered to be 45 years.

Figure 17: Net Benefits at 2020, 2030, 2050, and lifetime

	2020 (2014 £m)	**2030 (2014 £m)**	**2050 (2014 £m)**	**Lifetime (2014 £m)**
Project-level (one site)	0.8	0.7	0.6	0.6
License area-level (two sites)*	0.8	3.6	3.4	3.3
GB network-level (30 sites)**	13.7	70.8	67.7	65.6

* Dividing the 30 sites per DNO licence area yields 2.14 sites per DNO licence area, as such we assumed two sites per DNO licence area.
The investment in the second site is assumed to occur in 2019.

** It is assumed that DNO groups will integrate the solution (i.e., borne the up-front cost) in 2018, and that three implementations will occur each year between 2018 and 2027.

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Appendix H – Work Stream Descriptions

Work Stream 1: Information Sharing, Data Integration and Setup

Work Stream Summary:
This Work Stream will be responsible for reviewing existing business processes for data retrieval and usage. Modifications will be made to current processes and development of new business processes for obtaining the data required for contingency analysis activity. In this Work Stream the processes and expectations to receive and provide data will be defined.

This Work Stream is also responsible for implementing the IT infrastructure that is required to achieve data transfer to and from National Grid in compliance with the data, security and performance requirements. Staff will be trained and assigned to monitor and ensure data transfer is maintained at the required service level.

WS 1.1 Develop Business Process to enable data transfer
In this work area the current data retrieval and transfer process is reviewed with UK Power Networks staff mapping out the business process that is currently used. Any changes to this process from the documented process are identified. The data transfer mechanism in the "future state" is developed. This future state data transfer mechanism will yield IT requirements to enable data transfer.

This Work Stream is also responsible for designing the data retrieval format that is required by UK Power Networks systems to consume the incoming data for analysis. Data storage requirements will be identified and hardware requirements will be addressed by the infrastructure activities.

To develop the modified business process to enable data transfer, the electrical network area proposed for this project is defined. Previously mapped processes are used as a baseline and new process workshops will be conducted to make sure the stakeholders and associated personnel are in agreement with the process change.

Key Components:

- Review Business processes
- Business requirements from UK Power Networks operational staff
- Evaluate limitations and alternatives
- Business requirements from National Grid to support data transfer
- IT requirements from UK Power Networks internal operations to support data transfer
- Data storage process and retention requirements

Dependencies:

- Involvement of National Grid IT and regulatory staff.
- Regulatory approvals, should there be any need to clarify and confirm both National Grid's and UK Power Networks' ability to share and process data in compliance with existing regulations.

High level Roles and Responsibilities:

- UK Power Networks internal operations and IT staff will be responsible to review current processes and future state processes

- Potentially help from external consultants to provide support in developing business processes
- National Grid IT and operations will be responsible to provide IT and business requirements to support data transfer

Reports and Dissemination:
- Modified set of business processes
- Business requirements
- IT requirements

WS 1.2 Data transfer Infrastructure
In this Work Stream all the work related to infrastructure modifications to enable data transfer from National Grid will be undertaken. During the data transfer business process activities IT infrastructure requirements to enable successful data transfer will be identified. These requirements combined with UK Power Networks IT standards will help develop the IT architecture to support the data transfer. Input from National Grid's IT resources will be solicited to ensure compliant technologies are used. For example: if National Grid used Secure ICCP to transfer operational data to external entities, UK Power Networks should be compliant to receive and send data through Secure ICCP methods.

This Work Stream is also responsible to install the necessary hardware that is required to achieve data transfer between National Grid and UK Power Networks. Data storage requirements will be evaluated and additional hardware required to store the incoming data will be implemented. Testing of communication between National Grid for security, performance and data integrity will carried out in this Work Stream.

Key Components:
- IT requirement gathering
- IT Vendor/Product selection aligned with UK Power Networks IT standards
- Hardware implementation
- Testing of interfaces
- Data storage implementation

Dependencies:
- This Work Stream is dependent on UK Power Networks being successful in obtaining project funding
- IT requirements from data transfer business process activity

High Level Roles and Responsibilities:
- UK Power Networks IT staff are responsible for selection and implementation of hardware
- National Grid IT and operations staff is responsible for testing and confirming data transfer
- UK Power Networks IT security to ensure data security and compliance with policies
- UK Power Networks operations staff to ensure data quality and format
- IT hardware vendor to deliver and support installation

Reports and Dissemination:

- Training documents to support IT and operational requirements
- IT hardware tools and manuals

Work Stream 2: Contingency Analysis Tool Development and Integration

Work Stream Summary:
This Work Stream will be responsible for all activities related to getting the Contingency Analysis tool operational. In this Work Stream activities related to functional design development and documentation will be conducted with input from the vendor and UK Power Networks operational team. The developed design will be reviewed by UK Power Networks staff. Potential design changes to functionality, performance and output mechanisms will be documented.

Once the functional design is complete data preparation to populate the contingency analysis tool is a key task in this Work Stream. UK Power Networks staff will be required to provide the contingency cases that will be used with the tool and data dumps of the network model at periodic, predetermined intervals will be made available to the vendor.

Design and data preparation is followed by the vendor software development and loading of the data provided by UK Power Networks. The provided data is loaded on to development hardware where the contingency analysis software operation and design verification is performed. Post development factory testing, site testing and demonstration is performed by the vendor and UK Power Networks staff. Successful testing and demonstration leads to production implementation of the contingency analysis tool.

WS 2.1 Functional Design Development and Review
In this work area the vendor will share the functional design of the contingency analysis tool with UK Power Networks operations staff. The team will review the design of the standard product and suggest any modification that may be needed by UK Power Networks to conduct business as usual. Custom requirements will be discussed with the software vendor and functional design for custom functionality will be developed and reviewed. UK Power Networks operational staff will play a key role in reviewing the functionality as they will be required to operate the tool once put into production. Modifications to the design will be communicated and documented.

Design changes that are minor are likely to be accommodated by the vendor via configuration adjustment or minor changes to the software. Major changes to functionality will be negotiated between the vendor and UK Power Networks staff. Data requirements for custom and modified capabilities will be tracked and documented.

Key Components:
- Develop functional requirements
- Develop functional design
- Review functional design and provide feedback
- Custom requirements gathering and feature design
- Vendor will assist in custom data input definition

Dependencies:
- This Work Stream is dependent on vendor selection for Contingency Analysis tool.

High level Roles and Responsibilities:

- Vendor will provide standard and custom functionality design documents for review
- UK Power Networks internal operations is responsible to review the provided design from the vendor
- Correction and modifications to the design will be done by vendor and UK Power Networks staff
- Custom requirements will be provided to vendor by UK Power Networks staff

Reports and Dissemination:

- Standard and custom design documents
- Data format requirement document
- Functionality modification and custom feature document
- Signed Statement of Work from vendor

WS 2.2 Data Extract, Scenario Creation, and Acceptance Testing

In this Work Stream the vendor's base software system requires customer data to run the contingency analysis tool on UK Power Networks data. The vendor will provide data templates in which the tool accepts data and work with UK Power Networks to extract the desired data in the appropriate format and template. This process has to be repeated at predetermined intervals like development, testing and site acceptance phases of the project.

UK Power Networks operations staff will collect all the required scenarios that will be input into the contingency analysis tool and develop new cases if needed and work with the vendor to provide the cases in the required format. With the base model information and contingency scenarios provided to the vendor, the software development phases will begin. The vendor will provide test procedures for UK Power Networks to review and approve. UK Power Networks will identify additional steps that it may require to test the contingency analysis functionality.

Post development, UK Power Networks and the vendor team will test the functionalities identified in the functional requirements and statement of work. Test results will be documented with tracking of defects that may arise during testing. The vendor will provide periodic updates on the defect resolution and functionality will be retested for the defects. Similar testing mechanism will adopted for UK Power Networks site testing and production testing.

Key Components:

- Data format and template definition
- Extract and prepare data for consumption
- Contingency scenario development
- Develop and review test procedures
- Perform factory, site and production testing
- Defect resolution and retest

Dependencies:

- This Work Stream is dependent on the vendor selection for the Contingency Analysis tool
- Agreement on functionality and scope of work
- Server and client hardware procurement

High Level Roles and Responsibilities:

- Vendor has responsibility for the provision of the data format and template for data extraction
- Vendor and UK Power Networks staff jointly responsible for data extraction and preparation
- UK Power Networks, Vendor and hardware vendor responsible for procuring and assembling development system
- Vendor is responsible for the provision of test procedures
- UK Power Networks staff is responsible for provision of contingency scenarios and vendor is responsible for the input of cases into the application
- UK Power Networks is responsible for the review and approval of test procedures and to add any test steps required
- Vendor and UK Power Networks staff jointly responsible for software and performance testing
- Vendor responsible for fixing defects and working with UK Power Networks staff to retest and obtain sign off

Reports and Dissemination:

- Data template
- Contingency scenarios documentation
- Test procedures
- Test outcome report

WS 2.3 Software development

In this work area the vendor has full control of the activities. Once the scope, design and data have been provided, the vendor shall install the application on UK Power Networks hardware or development system and begin base functionality verification. Parallel activities to implement modifications and custom functionality will also be in progress. UK Power Networks will request periodic updates and bug reports from the vendor to ensure the project schedule does not slip and milestones are met. Vendor will develop standard and custom software functionalities with UK Power Networks data set and test the application internally. Once satisfactory operation and performance is achieved vendor will involve UK Power Networks to complete factory, site and performance testing.

Key Components:

- Software install on UK Power Networks development hardware
- Data load into development system
- Progress of product development
- Pre-factory acceptance tests

Dependencies:

- Data extraction and format
- Agreement on functionality and scope of work
- Server and client hardware procurement
- Functional and technical design

High Level Roles and Responsibilities:

- Vendor is responsible for loading UK Power Networks data
- Vendor is responsible for product development
- Vendor is responsible for providing periodic updates
- Vendor is responsible for internal testing

Reports and Dissemination:
- Periodic progress updates

<u>Work stream 3: Load and Generator Forecasting Modelling</u>

Work stream Summary:
In this Work Stream, systems that will be used in conjunction with the contingency analysis tool will be developed. Uncertainties in forecasting intermittent resources such as wind, solar and system loads that don't fit the traditional load and generation pattern will need to be considered. In this Work Stream load and generation modules to accurately depict the nature of resources on the network will be developed. A forecasting model architecture that incorporates the following attributes will be developed:
- Generator and load modules
- Forecasting engine
- Historical generation and load patterns
- Historical weather patterns
- Optimisation and normalisation modules

WS 3.1 Design Architecture and Develop Load and Generation Modules
In this Work Stream UK Power Networks will work with the vendor to provide generation and load information that is connected to the network. Additionally data gathering on the types of assets in service will help in developing the load and generator modules that can be used in the forecasting model. Depending on the types of distributed resources like solar, wind, size of the farm and grid connection details several modules that depict the variations in configuration will be developed.

The overall architecture that incorporates the generator and load modules combined with other factors like weather forecast, anticipated wind, historical generation and load will be developed. UK Power Networks will work with the planning team and the vendor to assist in designing the architecture. The design will include averaging or 'poll of polls' mechanisms to incorporate uncertainties of intermittent generation and load and achieve traditional type forecasts for the look-ahead horizon.

Key Components
- Generator and load modules
- Develop functional requirements
- Develop functional design
- Architecture development
- Integration of modules and external factors

Dependencies
- Historical, load, generation and weather data.

High level Roles and Responsibilities
- UK Power Networks is responsible for providing generation and load information

- Vendor and UK Power Networks staff are responsible for developing the architecture
- Vendor will develop modules and design interfaces to weather and other factors
- UK Power Networks is responsible for the review of the design and the provision of feedback

Reports and Dissemination:

- Module and architecture design documents
- Data format requirement document
- Interface requirements and integration plan

WS 3.2 Data Collection and Model development

In this Work Stream the vendor will work with UK Power Networks staff to get all the relevant data related to the assets. Historical generation and load data will be required to analyse their patterns and develop accurate modules. Historical weather data will also be collected from UK Power Networks or commercially available services to better understand weather patterns and correlate them with generation and load patterns.

The above historical load and generation data combined with historical and forecasted weather data will be integrated into the forecasting model by the vendor. The model development will leverage similar forecasting models used in the past at other utilities. The vendor has full responsibility for developing the models and interfaces. UK Power Networks will request periodic updates to ensure timely execution of development activities.

Key Components:

- Data format and template definition
- Extract data for consumption
- Obtain weather data
- Develop models and interfaces
- Develop and review test procedures

Dependencies:

- Historical, load, generation and weather data

High Level Roles and Responsibilities:

- Vendor is responsible for providing the data format and template for data extraction
- Vendor and UK Power Networks staff jointly responsible for data extraction and preparation
- Vendor is responsible for the provision of test procedures
- UK Power Networks is responsible for the review and approval of test procedures and the addition of any test steps required
- Vendor is responsible for loading UK Power Networks data
- Vendor is responsible for product development
- Vendor is responsible for the provision of periodic updates

Reports and Dissemination:

- Data template
- Model user manual
- Test procedures

- Test outcome report

WS 3.3 Model Test and Reporting
In this Work Stream the vendor and UK Power Networks staff will test the forecasting model. Test procedures developed by the vendor and additional tests by UK Power Network staff will be executed on the model. Historical data will be used on the forecasting model to generate reports. These reports will be compared against actual system conditions that have been collected to ensure model accuracy. Corrections to model algorithms will be made by the vendor to ensure validity of the forecasted data. WS 4 activities are largely dependent on the accuracy of the model and reporting capabilities. Report templates will be jointly developed by UK Power Networks and the vendor. Model testing will ensure that different types of generation and load modules integrate with the weather and historical data to produce the desired reports.

Key Components:
- Software testing on UK Power Networks hardware
- Report templates
- Archive of historical system conditions
- Pre-factory and factory acceptance tests

Dependencies:
- Accuracy of Work Stream 4 activities
- Generator and load modules and forecasting model design and development

High Level Roles and Responsibilities:
- UK Power Networks is responsible for providing the report template
- Vendor is responsible for producing the desired reports and data for other modelling functions
- UK Power Networks and vendor are responsible for adequately testing the models

Reports and Dissemination:
- Test procedures
- Model accuracy requirements
- Report templates

<u>Work stream 4: Value Streams and Business Impacts</u>

Work stream Summary:
Load and generation forecasting combined with accurate contingency analysis has the potential to provide a range of benefits with respect to network management. Accurate real-time, short and long term planning is valuable in effectively managing the distributed resources resulting in optimum use of the available generation. The purpose of this Work Stream is to explore the objectives, design and methodology to conduct real-world trials with installed applications. The outcome of these trials will be used to support network management functions at the different time horizons.

WS 4.1 Real time Reliability Management
In this work area the installed contingency analysis tool will be used to manage network reliability in real-time with network model and network status data that is obtained from National Grid via ICCP and UK Power Networks models. Given the state of the network predefined contingency scenarios will be run on the model. Violations will be evaluated

at various parts of the network and suggested remedial actions by the system or operator informed actions will be considered to effectively manage load and/or generation in real-time. This type of network management is supplemented by short term and long term studies that predict system conditions and enable operators to anticipate network issues.

Key Components:
- Contingency Analysis tool
- Real time data feed
- Network control mechanism
- Business processes defining operational procedures
- Reporting mechanism

Dependencies:
- This Work Stream is dependent on successful Contingency Analysis tool installation
- Availability of real-time network data feed from National Grid

High level Roles and Responsibilities:
UK Power Networks will be responsible for developing the materials and assessment for this work stream and could potentially avail services of an engineering firm to do the analysis work. Guidance and support will be provided by National Grid and contingency analysis tool vendor as needed.

Reports and Dissemination:
- A summary report will be produced, describing the range of network applications for real time network management
- Services and applications to be demonstrated within the operational phase of the project will be identified and indicative value estimates produced that shall be validated in the project.
- Detailed service trial plans will be produced to support the phased demonstration of the applications covering DNO service demonstrations signed statement of Work from vendor

WS 4.2 Congestion Management and Outage Planning
In this Work Stream short term load and generation forecasting models that use weather data in conjunction with the contingency analysis tool will be used to study network congestion in standalone systems. These study scenarios help in near term analysis of network congestion and outage scenarios with the time frame ranging from a day ahead to a few weeks before the expected network conditions. This type of analysis is valuable for UK Power Networks network operations to manage the network and reduce outage which increases reliability.

Key Components:
- Accurate generator and load modelling
- Contingency analysis tool accuracy
- Forecast data and modelling

Dependencies:
- This Work Stream is dependent on successful completion of Work Stream 1, Work Stream 2 and Work Stream 3
- It is dependent on the accuracy of the data available

High Level Roles and Responsibilities:
UK Power Networks will be responsible for designing and carrying out the tests, ensuring safety standards and operational procedures are adhered to.

Reports and Dissemination:
- Report summarising the trials carried out and results achieved
- Benefits incorporating the applications that future active DSOs may procure
- Contribution to learning and dissemination events for other DNOs

WS 4.3 Network Capacity Management
In this work stream long term planning of the network in the timeframe of one to six months ahead is performed. The main deciding factors that affect this long term planning are:

- Load and generation forecasting models
- Contingency analysis outputs
- New generation or load that is connected
- Seasonal weather changes

UK Power Networks will use the above factors with a modified topology to execute study scenarios to anticipate network capacity issues under take preventative measures to ensure network reliability and manage network capacity.

Key Components:
- Accurate generator and load modelling
- Contingency analysis tool accuracy
- Forecast data and modelling
- Network infrastructure changes
- Weather forecast

Dependencies:
- This work stream is dependent on successful completion of Work Stream 1, Work Stream 2 and Work Stream 3
- It is dependent on the accuracy of the data available
- Tracking of new projects to connect or disconnect new load and/or generation

High Level Roles and Responsibilities:
UK Power Networks will be responsible for designing and carrying out the tests, ensuring safety standards and operational procedures are adhered to.

Reports and Dissemination:
- Report summarising the trials carried out and results achieved
- Benefits of incorporating the applications that future active DSOs may procure
- Contribution to learning and dissemination events for other DNOs

Work Stream 5: Knowledge Dissemination and Stakeholder Engagement

Work Stream Summary
The KASM project incorporates the use of software, hardware and soft measures which will produce various streams of knowledge and lessons learned. We envision that the project conclusions will have the most impact with DNOs, TSOs and distributed generation developers. Other parties that would potentially benefit from the knowledge

generated by KASM are academic institutions, DECC, Ofgem, the ENA and various smart grid stakeholders and groups. Stakeholder engagement is a vital way of communicating project activities to interested parties; the information transfer process should be bi-directional so that information can be fed back to UK Power Networks' project team. Engagement activities will include periodic project workshops and internal dissemination events.

Project knowledge will be shared with the most appropriate audience and the knowledge product and most suitable dissemination channel will be selected for the audience type.

WS 5.1 Knowledge Dissemination Roadmap
A knowledge dissemination roadmap will be developed at the start of the project in order to produce a clear and effective dissemination plan. The goal of this dissemination plan is to ensure accessibility to, and dissemination of, the KASM project results and methods.
The roadmap will include a timetable for dissemination activities and events; and will present the project's stakeholders and audiences. The roadmap will define and describe the knowledge likely to be produced by Work Streams' 1 to 4, the associated timings and will begin to assign suitable channels for its dissemination.

Key Components:
- Outline the stakeholders and audiences.
- Map the knowledge; expected timings and most appropriate dissemination channel.
- A timetable of all dissemination activities throughout the project lifecycle.

Dependencies:
- Work Stream 1-4 output definition and timescales.
- Dates of external conferences such as the LCNF annual conference.
- Work Stream 1-4 technical learning.

High level roles and responsibilities:
Work Stream 5 lead. Other Work Stream leads.

Reports and dissemination:
- A Knowledge Dissemination Roadmap in report format.

WS 5.2 Website and Preparation of Dissemination Products
The Knowledge Dissemination Roadmap will help define the type and content of the material to be shared and define and describe the processes, methods and timescales for any learning and knowledge dissemination. A project website page will be created specifically for Project KASM and hosted on the dedicated UK Power Networks Innovation microsite. The content of this webpage will be written by the Work Stream 5 lead with input from the other Work Stream leads where necessary.

Key Components:
- Reports and documents developed by the project and defined in the Section 9: Successful Delivery Reward Criteria; Workshops and learning events;
- Project website pages on the dedicated UK Power Networks Innovation microsite and other social media deliverables;
- Press releases and articles;
- Videos for information and familiarisation purposes;

- Training materials;
- Newsletters; and
- Project brochures and other printed material about the project.

Dependencies:
- Work Stream 1-4 output deliverables.

High level roles and responsibilities:
Work Stream 5 lead. Other Work Stream leads.

Reports and dissemination:
A report outlining all dissemination products and tools.

WS 5.3 Seminars, Workshops and Conferences
A number of events will be organised to support knowledge dissemination and stakeholder engagement. These events will be organised at certain milestones throughout the project lifecycle. The annual LCNF conference will also offer an opportunity to discuss the knowledge and learning generated by the project with an appropriate audience.

Key Components:
- Launch event and workshop for SDRC 9.1-9.3 Q4 2015. Internal and external parties will be invited to the launch event where the project will be presented. The workshop will also be used to present the knowledge gained from SDRC 9.1-9.3.
- LCNF Annual Conference Q4 2015.
- Workshop for SDRC 9.4-9.6 Q3 2017. The workshop will present the knowledge gained from SDRC 9.4-9.6.
- Internal dissemination events (3-4 events) for UK Power Networks staff.
- Project close down event Q4 2017/Q1 2018. Wrap-up event.

Dependencies:
- Work Stream 1-4 output deliverables.
- Venue availability.

High level roles and responsibilities:
Work Stream 5 lead. Other Work Stream leads.

Reports and dissemination:
Report outlining successes of all events held.

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Appendix I – Letter of support from National Grid

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

To: Mr. Sotiris Georgiopoulos
Future Networks
UK Power Networks
237 Southwark Bridge Road
London, SE1 6NP

24th July 2014

Dear Sotiris,

I would like to confirm the support in principle of National Grid for the LCNF T2 – Kent Active System Management (KASM) for the Low Carbon Network Fund.

National Grid is the Electricity Transmission Owner of the England and Wales network, and the System Operator in Great Britain. We have number of grid supply points (GSP) with UK Power Networks across our network and therefore are interested in this project from the technical prospective, and the value it can bring for the consumers.

The technical challenges that the KASM is addressing are relevant to National Grid's business particularly the use of smarter technologies and state estimator enabling the connection of distributed generation and improvements to system reliability.

In conclusion, we are supportive of the proposal and recognise the benefits that will come from the methods which will be trialled and demonstrated as part of KASM. We are looking forward to continuing our engagement and are willing to provide the required support to this project.

Kind regards,

Dr. Vandad Hamidi

SMARTer System Performance Manager

[By email]

Appendix J – CV of Navigant Expert

NAVIGANT

Sundararaman (Sam) Sankaran

Sundararaman (Sam) Sankaran
Associate Director

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77 S. Bedford St
Suite 400

Tel: 781.270.8348
Cell: 508.330.2506
Fax: 781.270.0418

Sam.sankaran@navigant.com

Professional History

- Navigant Consulting, Inc | Associate Director
- Accenture | Manager
- National Grid USA | Lead Engineer
- GE Energy | Professional Engineer

Education

- Master of Science, Mississippi State University (Power Systems and Power Quality) - 1999
- Bachelor of Science in Electrical Engineering from Mangalore University - 1996

Professional Associations

- IEEE Power & Energy Society

Sam Sankaran is an Associate Director at Navigant in the Energy Practice's Emerging Technology and Business Strategy group. He has more than 14 years of utility experience. Mr. Sam has fulfilled several roles as a software vendor, real-time operations and consultant, all of which has a special focus on the electricity utility industry.

Sam's project work includes Smart Grid strategy for the DoD. Utility software design, development, testing and quality assurance using six sigma methodologies. Process improvement for business transformation, utility real-time operations and storm restoration. Redesigned support strategy to align with IT-OT convergence. Supporting Transmission and Distribution control operations managing systems support.

PROFESSIONAL EXPERIENCE

Software Development and Quality Assurance: Sam developed Energy Management System software at GE. He was involved in design and development of power application programmes. His experience consists of leading several national and international projects from design to implementation. Sam was trained in Six Sigma DMAIC phases and has obtained green belt certification for using these quality assurance methodologies to improve software development and maintenance. He was instrumental in developing database management techniques to streamline customer data migration and optimisation. These techniques have been repeatable with little error leading to significant cost savings on projects. Sam was also involved in developing new product initiatives by coordinating feedback through user group meeting to enhance the capabilities of the software. Sam conducted training sessions in-house and at customer locations. He has coached and mentored several new employees in Six Sigma methodologies adapted to software development and implementation.

NAVIGANT

Sundararaman (Sam) Sankaran

- Business Process Improvement: Sam has been involved with several business process mapping and improvement projects. His project experience includes business process mapping and identifying requirements to enable business transition to a different Regional Transmission Operator. The work involved conducting detailed workshops with the operations and IT groups to map the "as-is" business processes and associated tools, followed by "to-be" scenarios along with IT systems and process implications and generate updated business processes. Sam was also involved in leading a business process improvement project for large utility in the northeast. The work involved assessment of existing storm response documents, mapping these processes, identifying interactions with other related processes, comparison against industry best practices and identify areas for improvement. In the real-time operations support role, Sam has developed, refined and continuously improved transmission and distribution operations processes to manage day to day business support. In this capacity Sam was also responsible for managing business continuity processes and backup operations support.
- Business Strategy: Sam is currently working on a Smart Grid strategy for the DoD. Work involved assessment of collected data from the different defence facilities, presenting the current state and identifying areas for improvement and financial savings. Sam's work on other DOD projects include assessment of Electricity, Steam and Natural gas usage at a Navy Facility to determine ways to reduce cost, increase use of renewable sources and enhance energy security. He assisted in developing presented economic models to evaluate the different options. He was also involved in developing a network support strategy for a large utility in the Midwest that has plans for a converged IT-OT infrastructure. Sam conducted series of workshops and interviews to gather information about the existing support structure. He was instrumental in presenting the gaps and developing a transition plan from a people, process and technology perspective. The transition plan was presented by the utility at upcoming conferences.
- Real-time Operations: Sam participated as a key member of the utility working groups to develop plans that increased system reliability and visibility. He was involved with projects to expand network requiring network display and database updates to the EMS and DMS. Sam conducted targeted training sessions and helped stand up an effective training environment. Built and supported the database environment for inter-utility training simulators. Facilitated user group meetings as the chairman of the user group committee and organised discussions to enhance software products and services. Sam supported federal and local regulatory audits. He created specialised displays and custom workflows for state and federal regulatory compliance.

Project Code/Version No: UKPNT206

Low Carbon Networks Fund Full Submission Pro-forma

Addendum – List of Changes for Re-Submission

Pro-forma section and Topic	Expected amendment to submission	Reasons for amendment
Checked box in page 2, section 1.5.2	Un-check	It was checked by mistake in the original submission
Section 2: Project Description Topic 2.2: Technical description of the project	Details around the forecasting capabilities, and how they will relate with existing capabilities	Requested by Expert Panel, and discussed in second bilateral meeting
Section 2: Project Description Topic 2.3: Description of design of trials	Details around how the trials will be ran, and how their outputs will be associated with the project benefits	Suggested in the Consultant's Interrogation Report
Section 2: Project Description Topic 2.3: Description of design of trials	Details around how the users will be trained during the project trials stage to be able to use the solution at the end of the project	Requested by Expert Panel in email after second bilateral meeting
Section 3: Project Business Case Topic 3.3: Overall financial benefits	Additional benefits to the business case, regarding reinforcement of other assets and real options valuation	Revision was presented at the second bilateral meeting
Section 3: Project Business Case Topic 3.3: Overall financial benefits	Revision of expected net benefit at the GB network-scale	Revision of costing model at the GB-scale, as presented in the second bilateral meeting
Section 4: Evaluation Criteria Topic (c): Generates knowledge that can be shared amongst all DNOs	Details around engagement with other engagement with other DNOs, TNOs and Contingency Analysis software suppliers during the bid development stage and learnings that were gained	Requested by Expert Panel in email after second bilateral meeting

Section 4: Evaluation Criteria Topic (d): Involvement of other partners and external funding	Details around Navigant's role in the project	Requested by Expert Panel, and presented in second bilateral meeting
Section 5: Knowledge Dissemination Topic (d): Involvement of other partners and external funding	Include note that if the cost for the link with National Grid is lower than what was originally quoted, the remaining funds will be returned to the customers	Agreed by the business after discussion with National Grid, and presented at the second bilateral meeting
Section 5: Knowledge Dissemination Topic 5.2: Intellectual Property Rights Arrangements	Include note about software integration source code provided by Bigwood free to other DNOs	Requested by Expert Panel, and presented in the post-submission Q&A
Section 9: Successful Delivery Reward Criteria	Include criteria to demonstrate engagement with other DNOs throughout the project	Requested by Expert Panel in email after second bilateral meeting
Section 9: Successful Delivery Reward Criteria	Provide more specific wording and practical metrics to measure performance	Requested by Expert Panel, and presented at second bilateral meeting
Appendix A1: Benefits table	Revision of expected net benefit at the GB network-scale	Revision of costing model at the GB-scale, as presented in the second bilateral meeting
Appendix A2: Full Submission Spreadsheet	Include note that state estimation is not included in the software costs, but any added cost would only be marginal; project will still deliver net benefit	Requested by Expert Panel in email after second bilateral meeting

Appendix D: Risk Register and Mitigation Plan	Revise to include additional risks around cost and time overrun	Suggested in the Consultant's Interrogation Report
Appendix E: Organogram	Identify "Matthieu Michel" as the Project Manager	Has been appointed to the role after the Full Bid Submission
Appendix G: Cost Benefit Analysis	Revision of expected net benefit at the GB network-scale	Revision of costing model at the GB-scale, as presented in the second bilateral meeting
Appendix G: Cost Benefit Analysis	Further detail around how the deferral in the investment in the SGT is achieved	Suggested in the Consultant's Interrogation Report
Appendix J (new)	Add CV of the person who will offer support from Navigant	Requested by Expert Panel, and presented in the second bilateral meeting
Addendum	Outline changes from original submission	-
Whole	All	Spelling and formatting corrections as required