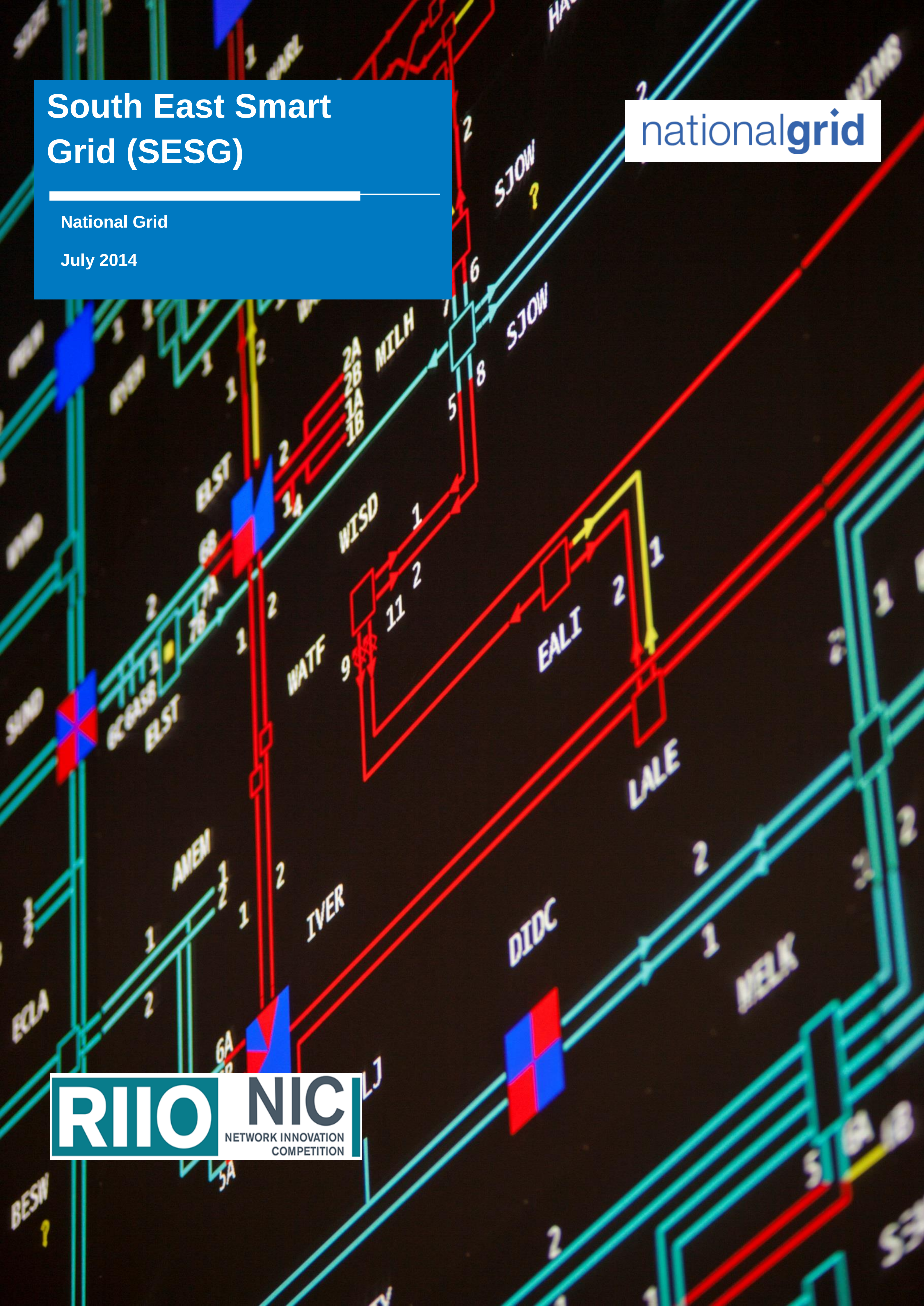
South East Smart Grid (SESG)

National Grid

July 2014



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RIIO NIC NETWORK INNOVATION COMPETITION

Electricity Network Innovation Competition Full Submission Pro-forma

Contents

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Section 1: Project Summary

1.1 Project Title:

South East Smart Grid (SESG)

1.2 Funding Licensee:

National Grid Electricity Transmission Plc

1.3 Project Summary:

Doubling the size of interconnection capacity between GB and continent could result in £1bn per annum savings on GB consumers' electricity bill through the import of low cost, low carbon energy from Europe along with reduced generation constraint costs. More than half of this potential saving is associated with the interconnectors connecting to the South East region of the network. In addition, National Grid's Future Energy Scenario (FES) has forecast a large volume of Solar PV, onshore and offshore wind farms to connect in this region.

The existing transmission network capability will not allow unrestricted flows across these new interconnectors, further a conventional approach will require major network reinforcement in the form of a new transmission line at an estimated cost of over £500m and a completion date no earlier than 2025. Without a 'smart' approach this will result in delays and constraint costs affecting the benefit to the UK consumer.

The SESG project will seek to develop a new suite of technical and commercial services and/or changes in operational practice through a co-ordinated approach with the distribution network operator to address the network capacity issues. A range of trials will be undertaken to demonstrate the benefits of a coordinated planning between transmission and distribution system, and utilisation of distributed resources (i.e. solar, wind, storage and demand side response) and transmission resources in a coordinated manner.

SESG will provide a pioneering "whole system" method to manage power flows which enable additional capability in the network. SESG will deliver learning and techniques that will be rolled out to other areas of the network and recommendations on how to integrate these with the market.

The project is expected to **start in January 2015 and finish by March 2018**.

1.4 Funding

1.4.1 NIC Funding Request (£k): 9,707.14

1.4.2 Network Licensee Compulsory Contribution(£k): 1,103.52

1.4.3 Network Licensee Extra Contribution (£k): N/A

1.4.4 External Funding - excluding from NICs/LCNF (£k): 795.38

1.4.5 Total Project cost (£k): 11,820.38

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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 Projects which are interlinked with one Project requesting funding from the Electricity Network Innovation Competition (NIC) and the other Project(s) applying for funding from the Gas NIC and/or Low Carbon Networks (LCN) Fund.

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

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

Siemens	(£481.5k contribution)
Imperial College	(£178k contribution)
UK Power Networks	(£97.58k contribution)
Elexon	(£38.3k contribution)

Project Supporters

SP Energy Networks, Western Power Distribution, EDF Energy

All Letters of Support are available in Appendix 8.

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
January 2015	March 2018

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title:	**1.8.3 Contact Address:**
Dr. Vandad Hamidi SMARTer System Performance Manager	B3 – Network Strategy – Transmission Network Services National Grid House – WarwickTechnologyPark – Gallows Hill Warwick – CV346DA
1.8.2 Email & Telephone Number: Vandad.Hamidi@Nationalgrid.com +44-(0)7962-827267	

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Section 2: Project Description

This section should be between 8 and10 pages.

The SESG project, combines a combination of technical, and commercial innovation activities, and by considering a whole system approach, develops a new system to enable the coordinated use of both the transmission and distribution system and all Users connected to these systems. This will be the key enabler in providing nearly £500m per annum savings for the GB electricity consumers and avoid/defer major investment on the transmission system.

2.1 Aims and Objectives

According to recent analysis, meeting the European Commission's target of having at least 10% of the capacity through cross border interconnection could save the GB consumer up to **£1 billion per year** by 2020 [1]. In order to accomplish this, an additional 4-5GW of European interconnectors would need to connect by 2020. Half of this required European interconnection (2GW) will connect in the South East area of the network.

The South East network is a congested area of the network both in demand and generation, with demand concentrated in the London area and generation in the Thames Estuary. The main interconnectors with Europe, which are located in the region, have a significant impact on power flows in the area. With the imminent increase in volume of interconnection to Europe (Nemo Link and Eleclink), and also increase in intermittent renewable generation such as wind and solar, the resulting operational impact will be the need to constrain the interconnectors in the area to maintain system stability with an increase in constraint costs.

By the time the new interconnectors are expected to connect, the transmission network would not accommodate unrestricted flow across the interconnectors. There will be need for major network reinforcement in the form of building a new transmission line at an estimated cost of over £500m and an expected completion date of no earlier than 2025. Otherwise, to operate the system securely, it is required to either delay the connection date of interconnectors, or limit the power flow across them, both reducing the benefit they bring for the GB consumers.

SESG aims to use an innovative method that brings together knowledge and resources between the distribution and transmission systems in order to better manage power flows and reduce the requirement for constraining generation (in particular interconnection). The proposed method is an application of an innovative smart grid concept, which allows more efficient management of constraints by estimating the system state in real-time, collecting signals from available distributed and transmission resources and taking appropriate and timely action based on system behaviour.

2.1.1 The problems which need to be resolved

The existing South East network has been operating under severe conditions, mainly caused by the fact that the whole south cost is connected by a single overhead line route (double circuit) stretching more than 200km, as shown in Figure 2-1. Sellindge and Dungeness substations have experienced most of the operational issues in the region. Historical data and studies carried out by National Grid indicate the need for de-loading the interconnection to France during periods of low demand to mitigate operational risks.

Further contributing to the problem, there is only one major synchronous generation source in the area (Dungeness Nuclear Power Station) to support regional inertia and voltage. This unit may not be running during low demand conditions in the future, further weakening the region.

[1] Getting more connected, March 2014 http://www2.nationalgrid.com/About-us/European-business-development/Interconnectors/

Project Description continued

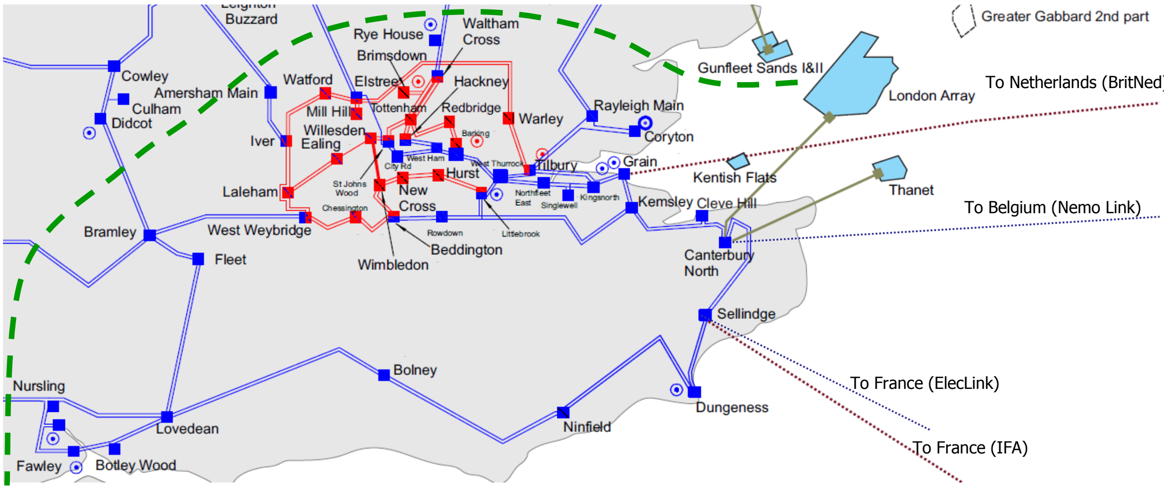

Figure 2-1 The South East Network. The dotted green line defines the area of interest. A more detailed map, which includes UKPN's network, is available in Appendix 10.

Moving forward, National Grid's Gone Green 2014 Future Energy Scenario estimates the following changes in the South East network in the next decade:

- Additional 2 GW of European interconnectors (Nemo Link and ElecLink)
- Approximately 1 GW increase in solar and wind capacity in next decade. Note: this includes distributed generation, i.e. generators connected to the distribution network, rather than the transmission network.

Figure 2-2 Changes in generation background: more renewables and European Interconnection

These changes in the generation mix will have an immediate impact on network operation, resulting in additional challenges in the South East. These challenges can be summarised in **two main categories**:

1) Power Flow Limitation in and out of the South East Area (as defined in Figure 2-1): The additional installed capacity will cause heavy circuit loading which will limit the amount of power that can flow through the transmission circuits that feed the area.

2) Voltage Management Limitation in the South Coast: As stated, the whole south coast is connected by a single 400kV overhead line route (double circuit) stretching more than 200km. The length of this line coupled with the fact that interconnectors in the area can change their output from exporting to importing has led to complex challenges related to voltage management in the area. Currently voltage is managed

through the use of existing reactive support infrastructure connected to the transmission system as well as scheduling response from generators. In the future, these voltage management issues in the area will be exacerbated due to the large amounts of European interconnectors and intermittent generation (wind and solar) that will connect.

2.1.2 The methods being trialled

Whilst there are a wide variety of technical challenges in the South East area, it is possible to summarise the effect of any disturbance arising from any of these conditions and the effect that SESG would have upon this situation in general terms. Figure 2-3 shows the four distinct operational network states (A, B, C & D) which occur before and after any disturbance. As shown in the figure, before a disturbance occurs (state A), the system remains in the 'normal' condition (green region). When the system suffers a disturbance (in state B), a rapid response is necessary in order to return the system to 'normal' (in state C) and further stabilised to reach state D.

Now, the actions taken to stabilise the system after a disturbance (in states B and C) will result in a reduction of the available resources that would respond to a second disturbance. This is depicted in the figure as a reduction of the 'normal' (green) region in state D. As the amount of European interconnection increases, the range of states the network may operate in grows and SESG will act to avoid operating in an unsafe condition.

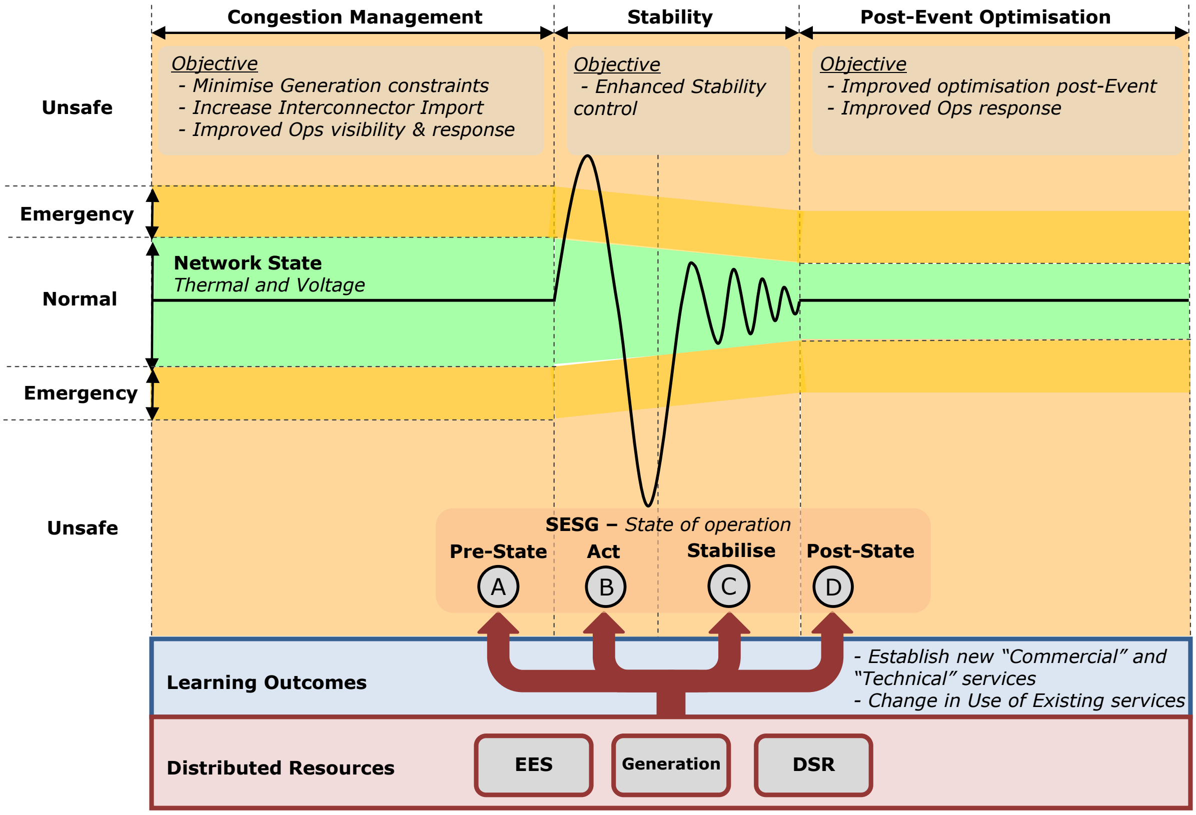

Figure 2-3 Network Operating States (Thermal and Voltage)

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Project Description continued

All these network states (A, B, C and D) are tackled in the SESG project through a series of work packages, as shown in Figure 2-4. Refer to Appendix 5 for detailed explanation on how SESG adds value to each network state.

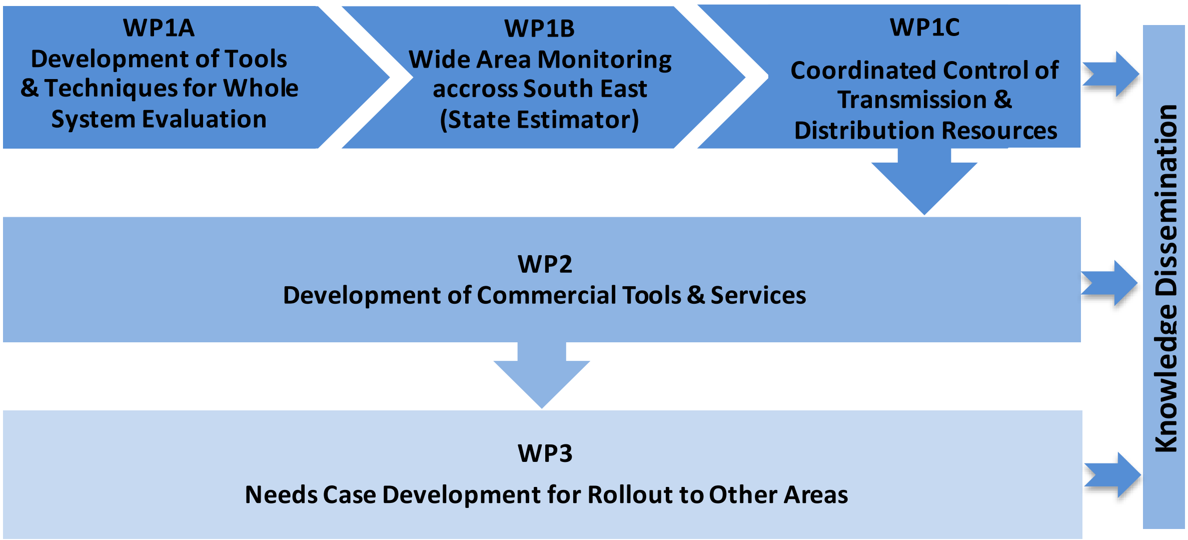

Figure 2-4 SESG Approach

2.1.3 The Development or Demonstration being undertaken

From these work packages, there are five stages considered for demonstration:

Stage 1: Demonstration of a whole system approach in modelling and development of need case for smart solution

- With our academic project partner; Imperial College of London, we will develop the necessary tools and techniques to enable application of wide area monitoring and control, and response from transmission and distribution resources to manage network constraints.

Stage 2: Demonstration of a Wide Area Monitoring and Control (WAMC) on transmission and distribution system

- With our project partners; Siemens and UKPN we will develop a pilot scheme of monitoring, command and control system in the south east to estimate system parameters in real time, and enable both open-loo and closed-loop decision making.

Stage 3: Demonstration of coordinated response from transmission and distribution connected resources

- With our project partners; Siemens and UKPN, we will test and evaluate responses from all available resources from both transmission and distribution system under different system conditions. The resources we expect to perform this demonstration on include demand side response, energy storage, embedded generation.

Stage 4: Demonstration of innovative commercial services to incentivise the service providers to participate in the new market

- With our project partners; Elexon and Imperial College of London, we will develop new commercial services required to ensure this can be commercially viable under a business as usual.

Stage 5: Development of a non-build solution using both commercial and technical knowledge of the project for immediate roll out

- With all the project partners, we will develop a non-build solution under the network development policy for roll out to other parts of the network.

2.2 Technical Description of Project

SESG will be delivered through a number of related work packages. These are described here with particular reference to their innovative nature. The technical description is included in Appendix 5 in more detail.

WP1A – Development of Tools and Techniques for Whole System Evaluation of Smart Solutions

The SESG project requires interaction between transmission and distribution resources. Due to the complexities of this interaction, models from the distribution system will need to be analysed in combination with those in the transmission system in order to understand the level of response that may be available at both transmission and distribution network level.

Imperial College will perform extensive analysis and computer simulation studies of the South-East network (at both transmission and distribution levels) to determine the appropriate monitoring locations, validate the effectiveness and benefits of coordinated control within both transmission and distribution networks. The key task will include

- T1.1: Development of computer simulation models of the South East network
- T1.2: Identification of optimal locations for installing monitoring devices
- T1.3: Development of Virtual Power Plant concepts to enable flexible resources in distribution networks to support control of the South East transmission network
- T1.4: Investigation of coordinated control strategies in collaboration with Siemens and validation of the control platform through computer simulation

Alongside computer simulations, real-time hardware-in-loop (HIL) simulations will be performed at the Maurice Hancock Smart Energy Laboratory at Imperial College. The dynamic behaviour of the South-East network will be emulated in real-time with a combined HIL scaled physical models of relevant elements of the South-East system, and in particular the VSC- HVDC converters (the technology envisaged to be used for new HVDC interconnectors). This will incorporate simulation models of the network running in a real-time power system simulation platform, Opal-RT interfaced to the physical platform using a power converter acting as a power amplifier. The real-time controller will be implemented in a rapid control prototyping (RCP) platform from Opal-RT. The control hardware will receive measurement signals from a real-time network simulation platform and issue control commands back to it the same manner as the SESG Central System Monitoring would do.

The main tasks to be undertaken are:

- T1.5: extend the existing real-time network simulation platform to simulate the behaviour of the South East network in real time
- T1.6: integrate the physical hardware (converters for interconnectors, aggregated storage etc.) with the real-time network simulator to create a hardware-in-loop simulation environment
- T1.7: validate coordinated control strategies with real-time hardware-in-loop simulation

The real-time hardware-in-loop simulation facility will enable Imperial College to validate and the monitoring and control algorithms to be trialled in this project (under WP1B and

WP1C) and investigate potential improvements and/or generalisation for wider roll out elsewhere (WP3).

The output of this work package will provide the information required for the next work package on the level of monitoring on the network (at transmission and distribution) such as which Grid Supply Points (GSPs) will require monitoring devices as well as the level of response required from the distribution network for each GSP.

Innovation: Development of the models, and control algorithms required for development of WAMC on transmission and distribution network, as well as regional response estimation (at different GSPs).

WP1B – Wide Area Monitoring across South East (T&D State Estimator)

Knowing the network status in real time prior to taking any operational actions will be crucial in order to make operational decisions. Conventionally, operational actions are planned based on historical data, engineering judgment or the generation/demand profile of the network. However, in a congested, weak network with considerable volumes of intermittent generation, the system operator needs to take actions in a more critical time scale, in order to ensure fully optimised, economic and efficient operation of the network.

To achieve this, the operator will need greater level of real-time visibility of the network. Hence, there is a requirement to develop system wide area monitoring and control (WAMC). In the first instance, existing measurement/control units will be examined to discover if they could be suitable for the purpose of smart grid deployment and where necessary, additional equipment will be installed for monitoring to the transmission and distribution network. The analysis and simulations carried out by Imperial College in WP1A will inform WP1B by identifying most appropriate sites for monitoring.

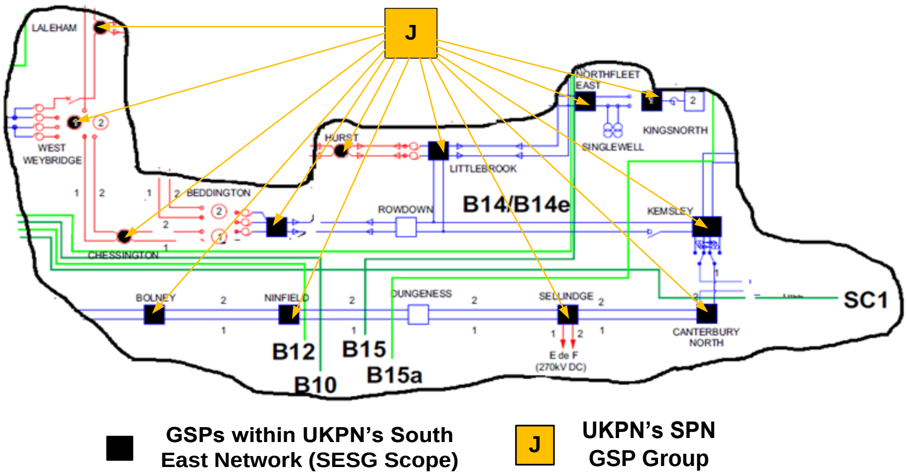

Figure 2-5 UKPN's SPN Grid Supply Points with Transmission Boundaries

Figure 2-5 shows the 13 GSPs that fall within UKPN's SPN region as well as the system boundaries that may directly affect this region. The WAMC enhances NG's visibility of which GSPs can help in managing the constraints and enable performing necessary control (either autonomously by the control system or with operator's instruction) at GSP level to instruct the response to be delivered at the GSP level. The analysis and simulations carried out in WP1A will inform WP1B by identifying most appropriate sites for monitoring. Through this approach, the aim is to transform the traditional, manual control system of the South East region into an automated, modern smart grid enabling the use of distributed resources such as DSR, storage and embedded generation to manage constraints.

Innovation: The existing system monitoring is limited to either transmission or distribution level. Therefore, there is a lack of a comprehensive real-time monitoring system to evaluate the whole network status in one picture. SESG utilises an innovative method for system monitoring using all available system monitoring devices to ensure measurement will be taken from the optimum location and with high resolution (time scale) for real-time applications.

WP1C – Coordinated Control of Transmission and Distribution Resources

The interaction between transmission system equipment and distributed resources shall be investigated. A smart co-ordination of distributed resources (such as DSR) with transmission resources may defer or even avoid the need for building of new infrastructures. The methods used makes the best use of transmission and distributed resources. For example, voltage depression resulting from south east interconnectors when they are on importing mode could be managed by appropriate demand side response.

Developing a suite of technical and commercial services by utilising both transmission and distribution resources in South East is the main deliverable of SESG. Devices such as solar PVs, DSR and storage units are available to assist the system operator in managing the operational challenges listed in section 2.1.1. This work package will demonstrate how these units can be controlled and managed by the WAMC tools developed in WP1B. An important innovation of SESG is that the DNO should be able to monitor/command the distribution resources in real time based on transmission system requirements. WP1C trials innovative control methods which will be replicable in other areas within the network to manage the network constraints (as listed in Section 2.1.1) using a whole system approach.

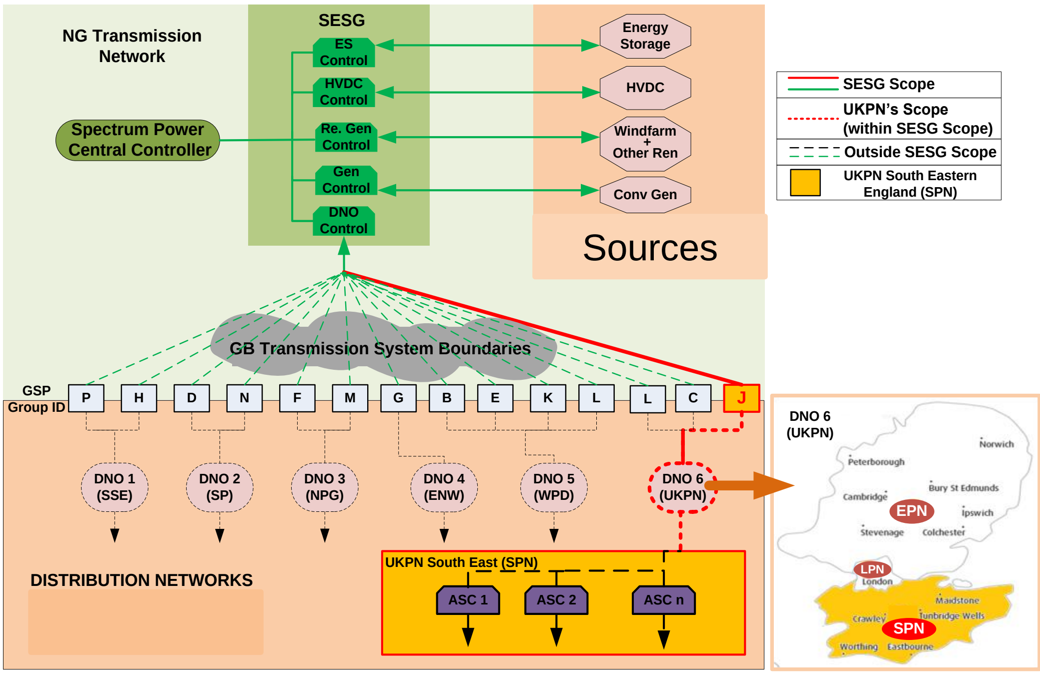

Figure 2-6 Proposed overall system architecture.

The diagram in Figure 2-6 is an overview of Siemens' proposed solution architecture that will meet all of the objectives of the SESG project. The proposed solution uses a central intelligence to deliver flexible, scalable and expandable intelligence through an active interface with the transmission actors. The proposed spectrum power tool also has an important capability of optimal dispatch to balance active demand with dynamic generations. The tool centrally monitors and controls all of the Energy Storage (ES), HVDC, Renewable Generations (Re. Gen), Conventional Generators and relevant DNO equipment that are connected to NG transmission network.

The Grid Supply Point (GSP) serves as an interface between National Grid Electricity Transmission (NGET) and DNO's network. These are grouped at a high level into specific regions and DNO's. Figure 2-6 shows all of the 14 high level GSP Groups relevant to SESG project and are part of UKPN's SPN network. Hence all control actions that will be performed by the SESG central control will directly and only affect these 13 GSPs. All other GSP's are outside the scope of the SESG project.

Our academic partner will support validation of the coordinated control schemes using the real-time test facility (described under WP1A). For the interconnectors, offshore wind farms and aggregated storage, scaled-down physical hardware set-ups would be used in the validation exercise. Other resources would be included within the network model running on an Opal-RT simulator. The coordinated control strategies would be implemented within a rapid control prototyping control (RCP) platform from Opal-RT with an interface between the system emulation and RCP platforms.

Innovation: The demonstration of the control system capable of estimating the resource required at different GSPs, to coordinate the over level of response from transmission and distribution connected resources.

WP2 Development of Commercial Tools and Services

The roll out of the commercial tools and techniques developed as part of WP1 to other parts of the network under a business as usual requires both technical and commercial innovations. The technical aspects of the coordinated approach in managing the network constraints will be developed as part of WP1. The WP2 focuses on the type of commercial services which enable the use of such concept as an alternative to investment in building new transmission infrastructure. This activity will be carried out by Elexon and Imperial College and will result in developing proposals for new market signals (through new commercial services) for a range of service providers. These new commercial services will be valued based on the knowledge gained in WP1 and cost of network investment which will ensure an economic and efficient solution is developed.

The service providers which are capable of providing the response to the grid (at transmission or distribution level), require commercial incentives. There are currently gaps in the commercial services available in order to roll out the non-build solution concept relying on coordinated response from transmission and distribution resources. In this work package, we will develop such services which require a careful assessment in terms of comparison against conventional solutions, duration of the service contract, payment mechanism (availability + utilisation), avoidance of conflict/duplication of services, etc. To address this, Imperial College will carry out comprehensive analysis of the option value of such contracts for both Transmission and Distribution networks (T2-1). This will require coordination between Transmission and Distribution network operators to ensure that the DER offering services will be able to support transmission network whilst respecting the distribution network operating constraints and limits.

Innovation: The incentives to be provided to service providers require a detailed assessment of the long term benefit of such services, against constraint cost, and cost of the conventional solutions. These new commercial service will enable development of non-build solutions providing greater value for the consumers.

WP3 Need Case Development for Rollout to Other Areas

The amount of knowledge developed in the previous work packages will be captured in WP3 to develop a need case for rollout of the project to other areas of the network. This involves demonstration of potential value of the technical and commercial tools to become a business-as-usual tool under network development policy.

The roll of the concepts developed in the SESG to other parts of the network which without investment may impose constraint cost, or delay in connection of interconnectors, requires development of the concept as a non-build solution under the network development policy. This work package develops this solution (which will include identification of risks and opportunities), which will then be considered as part of future cost-benefit analysis carried out to justify network investment in conjunction with conventional solutions.

Innovation: The non-build solution within network development policy (based on least-regret approach) which enables the network development teams to consider as economic and efficient solutions. The activities as part of WP3 ensure the opportunities, and enabling measures for the successful roll out of the concept are developed so they can be implemented without delay.

2.3 Description of design of trials

The solutions developed in each individual work package of SESG will be validated through the following trials:

WP1A (Technical) - Development of tools and techniques for whole System evaluation

The joint models from transmission and distribution systems which allow the trials to be tested first, will be developed at this phase. The models enable studying the behaviour of transmission and distribution resources, to determine the potential for using distributed resources to manage transmission constraints in the South East region. This will keep feeding back to the model so that it is as robust as possible by the end of the project. Real time demonstration will also use the flexible test platforms available at the Maurice Hancock Smart Energy Laboratory at Imperial College. The lab has been developed around rapid-prototyping power converters for testing smart grid controllers and devices for low voltage applications with physical models of transmission lines and cables. That has been augmented with two scaled models of multi-modular VSC-HVDC converters, with a third model with embedded energy storage being commissioned. These converters use the same topologies applied by the major VSC-HVDC manufacturers and can effectively replicate the behaviour of these systems.

The system simulation platform will combine hardware-in-the-loop (HIL) scaled physical models of relevant elements of the South-East system, specifically the VSC-HVDC converters, with complex high order simulation models of the power system running in real-time power system simulation hardware such as Real Time Digital Simulator (RTDS) interfaced to the physical platform using a power converter acting as a power amplifier. Please refer to Appendix 5 for more details on the work Imperial College would carry out.

WP1B (Technical) - Wide Area Monitoring across South East (State Estimator)

The first implementation stage of the SESG will involve the creation of a monitoring and control centre for the South East area, as well as the installation of system monitoring devices in the South East area. This centre will collect the signals from the monitoring devices, the control units and the distributed resources. System monitoring devices will provide real-time measurements of system variables on key nodes of the network to the central monitoring system (some of these devices have been used in Humber Smart Zone).

Once the devices are installed, appropriate tests such as latency of data signals will be carried out.

The accuracy and reliability of the state estimation algorithm will also be validated. The number of system monitoring devices installed is expected to be sufficient to provide redundancy to estimate the most relevant states of the system. Thus, a selection of the available signals could be used for the estimation algorithm, whereas the remainder of the available signals could be used to compare the estimated values against the actual values measured in the system. This scheme would be allowed to run for an extended period of time to capture valuable data to assess the adequacy of the model under a range of system conditions.

The level of redundancy provided by the installed measurement devices will also be evaluated based on comparing the accuracy of the estimated voltage stability margins obtained using different sets of real measurements as opposed to using simulated measurement data. This analysis will provide valuable information about the effectiveness of the installed PMUs and provide insight on the areas of the grid that may require additional measurement deployment.

WP1C (Technical) - Coordinated Control of Transmission and Distribution Resources

One of the key innovations of SESG is the coordination of large-scale actuators in the transmission grid (HVDC converters, SVCs, etc) with the different resources in the distribution network (demand side response, embedded generation, and energy storage).

A series of tests will be performed at different levels to showcase the ability of these resources to provide the desired in response to instructions sent by the state estimator. Tests will be carried out at different levels of aggregation. To conduct such tests, the control centre will issue commands to produce different types of responses (active power absorption reduction, reactive power injection, etc.) under different scenarios (peak demand, low demand, high wind, high solar PV production etc.). The information obtained from these tests will play an important role in WP2 as it will be used to adjust and to validate the resource models developed.

WP2 (Commercial Innovation) - Development of Commercial Tools and Services

The new commercial services which will be developed enable providing right level of incentives for the services required for the SESG. The trial at this stage will mainly be focusing on the interaction of such new services with existing commercial services.

WP3 (Commercial / Technical) Needs Case Development for Rollout to Other Areas

In WP3 the new non-build solution as part of network development policy will be trialled and the roll out mechanism, and approach for such concept across the system will be evaluated.

2.4 Changes since Initial Screening Process (ISP)

The scope of the SESG project in this document is consistent with the submission for the Initial Screening Process (ISP). However, the following changes have occurred:

- Given the level of preliminary work carried out so far, we intend to **start the project in January 2015**.
- The total cost of the project has been modified to **£11,820.38k**

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

The SESG project will enable a saving of up to £500m per annum to GB consumers by enabling the unconstrained operation of interconnectors in the area.

3.1 Context

As described in section 2.1, doubling the size of interconnection capacity between GB and Europe could **save the GB consumer up to £1 billion per year in their electricity bill** [2]. In order to accomplish this, an additional 4-5GW of European interconnectors would need to be built and connected by 2020 and it is National Grid's responsibility to ensure that these interconnectors can transfer power without constraint, while ensuring the most economic and efficient solution to achieve this. Any restriction in the power flow capability of the interconnectors undermines the financial savings they can bring for the GB consumers.

A significant proportion of these European interconnectors (2GW) will be connecting in the South East in the next decade (ElecLink and Nemo Link). However, the South East network is a heavily congested electricity network with high levels of both generation and demand making it a complex area to manage operationally. With additional interconnection to Europe as well as an expected increase in intermittent renewable generation in the area, the network will be impossible or hugely expensive to manage under current operational arrangements when all projected interconnectors are at their maximum output. The two "business as usual" methods would be to either constrain generation or reinforcing the network.

SESG aims to enhance network capability without the immediate need to build new infrastructure. This will facilitate the integration of European interconnection and renewables without the need for significant reinforcement. The utilisation of smart grid technologies will lead to lower costs, reduced transmission and distribution losses, efficient power production and optimal asset utilisation. These benefits, along with eliminating the requirement for building new assets, will reduce the carbon footprint of the transmission networks while keeping the cost down for the consumer.

In this section we compare the costs and benefits of continuing with a business-as-usual approach, and SESG by considering both short-term and long-term effects of each approach.

3.2 Business as usual

Identifying the future network reinforcement options involves a process as shown in Figure 3-1 and briefly discussed here:

Stage 1 - Input; Future Generation and Demand Background:

The process starts with studying the future generation and demand, which are scenario dependent, and their impact on the network depending on each scenario will be different.

[2] Getting more connected, March 2014 http://www2.nationalgrid.com/About-

us/European-business-development/Interconnectors/

Stage 2 - Requirements; studying network capability and required transfer:

Under each scenario, the network capability is compared against the future required power transfer. If the required transfer is higher than the network capability, this is an indication of potential constraint requirement.

Stage 3 - Solutions; and identifying the solutions:

A range of solutions are considered at this stage; starting from the solutions which maximise the use of existing assets, to major reinforcements (i.e. building new transmission line). The non-build solutions (i.e. smarter solutions) are also considered at this stage only if they have been trialled and tested before.

Stage 4 - Selection; deciding on what solutions, and when to implement them:

A cost benefits analysis will be carried out at this stage to compare the constraint costs against the lifetime cost of proposed solutions to ensure that timely investments are made to provide greater network efficiency and value for the consumers.

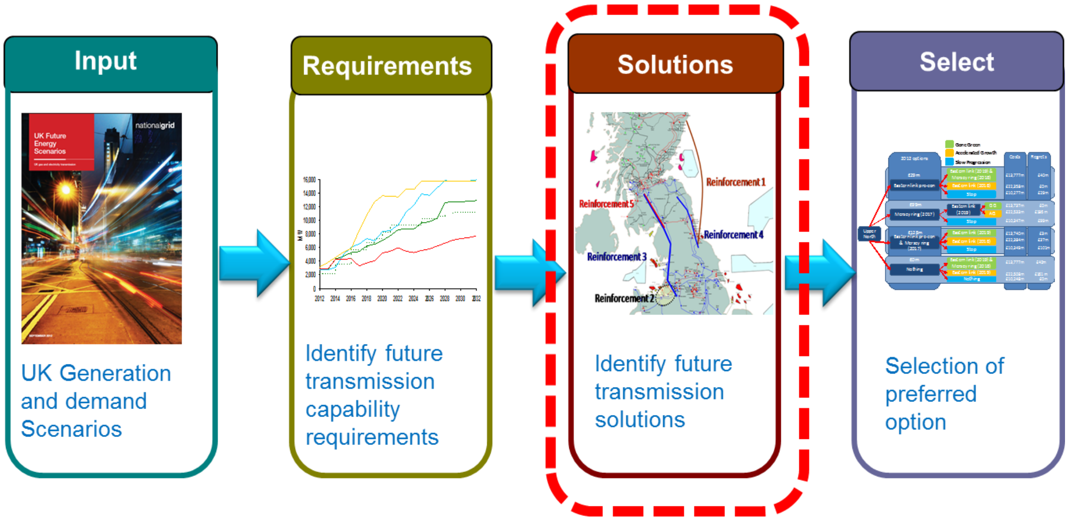

Figure 3-1 Network Development Process.

As it can be seen above the stage 3 (solutions) is an important aspect as depending on what solution is available to network planners, the selection list of a range of options can be developed. Under a business as usual, given some of the smarter technologies have never had any trials on the network, the options will be limited (and potentially expensive).

As explained in section 2, the operating cost resulting from constraint management in the South East area will make reinforcement an inevitable option. The number of times a year that the South East experiences constraint management due to the interconnector with France, thermal and Voltage Management (London area) is increasing.

Project Business Case continued

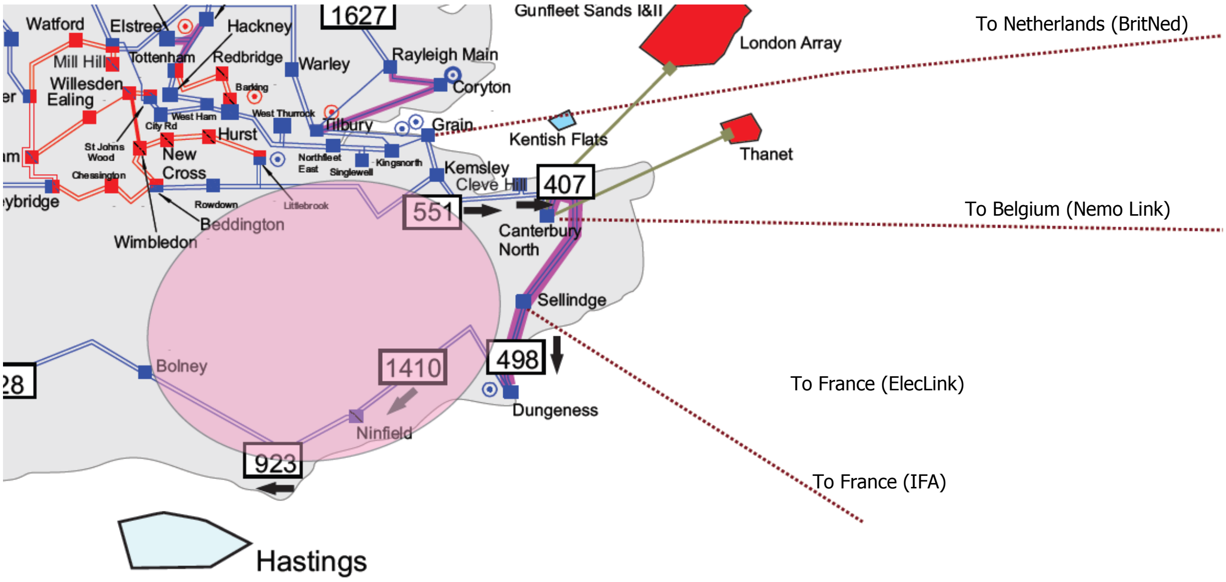

Figure 3-2 South East reinforcement requirements. Source: ETYS 2013 [3].

With more interconnection with Europe the required transfer for the south east increases considerably. The increased required boundary transfer will reach the point that violates the existing boundary capability.

With more renewables- especially solar PVs connections in the south coast the required boundary transfer may be higher and as a result the boundary capability may be violated even sooner than estimated.

The other technical challenge which the network will face in the region is "voltage instability" when the new interconnectors operate at their rated capacity. This is mainly due to lack of major dynamic compensation equipment in this area and a weak network.

Therefore, to manage the network constraints under a business and usual scenario the proposed solutions are:

- Constraining flow across interconnectors;

vs

- Installation of number of reactive power compensation units (i.e. SVC, STATCOM)
- Installation of new transmission line between Sellinge 400kV and 400kV ring around London (i.e. to a substation such as Beddington 400kV or Rowdown 400kV).

[3] Electricty Ten Year Statement 2013. Appendix C – Power Flow Diagrams. http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/Electricity-ten-year-statement/Current-statement/

Constraining the interconnectors in the long run will be economically inefficient and ultimately the new infrastructure will be required. This will be an extremely expensive option (i.e. costing around £500m) and with a very long lead time.

3.3 Need for Smart Grid

As mentioned in previous section, the disadvantages of a business as usual process to manage South East's issue are increase in cost for the consumers if conventional solutions are only considered for the network development. It was also mentioned that the new smarter technologies require demonstration first to be fully effective and used as a tool for network planning.

The driver for being economic and efficient, increasing the competition in the market to provide technologies which are unconventional, and maximising the use of resources at both transmission and distribution networks all create the need case for a smart grid.

Smart grid is a secure, economic and efficient and sustainable network planning tool, through advanced automation processes. A more advanced monitoring and control system will enable management of the network at full capacity.

Some of the key objectives of smart grid applications are:

- Utilisation of the existing network capability and enhance network capability through automated actions;
- Providing TSO and DNO effective interface to facilitate the use of resources and ensuring security of the whole system;
- Employing advanced monitoring and control systems to enable the operator to have control on power flow and how the network behaves in real time.

<u>A smart grid application ensures the right balance between operational complexity and asset investment</u>

The SESG provides the following benefits which are discussed later on in more detail:

- Enhancing the network capability and avoiding constraint cost;
- Increasing network resilience; and
- Creating a platform to use distribution network resources.

3.3.1 Enhancing network capability

The methods demonstrated in the SESG project will provide the extra transmission capability the network requires to accommodate the increasing level of European interconnection and renewables by removing the transmission constraints. These constraints include:

- Steady state voltage (managing high voltage conditions)

- Dynamic voltage stability
- Commutation of HVDCs
- Thermal overloading
- Rotor angle Stability

These topics, their consequence and financial cost to manage these issue, and how much savings which is envisaged by implementation of SESG is shown in Table 3-1. Further details on the calculation of this table can be found in Appendix 6.

Network Characteristic	How affected in the South East region	Consequence	Impact on Cost	How SESG Helps
Steady state Voltage	Low demand (when interconnectors are floating), long transmission lines (high charging gain)	Significant constraint cost to control voltage	In excess of **£14m** just in 2013 and will inevitably rise	No longer requires constraining generators => **£6m** savings per annum
Dynamic Voltage Stability	Long transmission lines, absence of voltage control plants (power station, FACTS) particularly at high transfer periods of interconnectors	With increasing the level of interconnectors the problem is exacerbated – Need for extra reactive power compensation	At least **£60m** extra investment once new interconnectors are connected (based on £20m unit cost for a 200MVar Statcom x3)	At least **£20m** savings by removing the need case at least one unit
Commutation of CSC-HVDC	Reduction in network strength (short circuit level) when large power stations are not running	Constraining the HVDC Interconnectors flow (**import capability**) and risk to **Security of Supply –** as a result of permanent shut down of the link	In excess of **£80m per annum** based on just 6% of time, and import restriction of 1000MW (500 MW on each bipole)	Allow unrestricted flow by providing a coordinated response (small disturbances will have less impact on commutation) – The savings are at least for half of that time (between **£35m-£45m per annum**)
Thermal overloading and Rotor Angle Stability	Following a transmission fault the loading level on the remaining circuits will be high and significant phase shift increase	Requirement for building a new transmission line	**circa £500m**	Defers/delays the need case

Table 3-1 Summary of network constraints mitigated by SESG and respective financial saving

3.3.2 Increasing network resilience

The SESG method provides greater visibility on how the network behaves and is able to estimate the consequences of potential faults. The state estimator tool can inform the system operator if at any point a fault could lead to a more serious incident (i.e. cascading fault). This will maximise the network resilience and benefits:

- GB Consumers who will not be at risk of blackouts due to large disturbances on the transmission level (i.e. avoiding a scenario similar to London Blackout in August 2003 resulting in severe interruptions in the capital). This are of the network in winter peak conditions has always been a major energy gateway to provide security of supply through power import on interconnectors. In the future with increasing the number of interconnectors, the resilience of the network becomes even more important given the reduction in generation margin (available at GB) and dependency of the secure energy supply to ability to trade power across interconnectors.

- Transmission and distribution network users (i.e. Generators). This area of the networks accommodates a nuclear power station, number of windfarms and solar PV farms, and HVDC interconnectors. The resilience of the network will improve which in turn reduces the risk of being disconnected due to network disturbances. The small disturbances on the transmission networks can be detected in real time and mitigating measures will be applied to avoid damaging the plants, or any disruptions in their operation.

3.3.3 Creating a platform to use distributed resources

Various resources such as demand side response, energy storage, and embedded generators within the distribution network, if aggregated (i.e. their collective effect), can be used to manage both transmission and distribution technical challenges with regard to providing capacity. There are however technical and commercial challenges which need to be addressed in order to create a platform to use such this ever increasing capability. The SESG project aims to demonstrate (both technically and commercially), by use of a combination of wide area monitoring and control (WAMPAC), and commercial innovation, the use of distributed resources can be feasible.

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Section 4: Evaluation Criteria

This section should be between 8 and10 pages.

The SESG project will support a low carbon future by enabling the unconstrained operation of interconnectors through an innovative method of managing the system.

a) Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers

The Department of Energy and Climate Change (DECC) set out the target of achieving emission reduction to 67% of 1990 levels by 2020 and 50% by 2027. SESG will play an important role in enabling the UK to meet its low carbon emission targets by enhancing network capability to accommodate the low carbon generation technologies in the south east.

Replacing fossil fuel power plants with renewable sources of generation is a decisive factor in the development of low carbon energy policies. In DECC's "Carbon Plan", more European Interconnection was identified as a key element to achieve these targets and the ideal location for interconnection with Europe is the South East. However, this area is a heavily congested area which will exacerbate with the introduction of new interconnectors (NEMO Link and Eleclink) as well as the extra renewable generation. The SESG project provides an innovative, quicker, cheaper, and environmentally friendly option to increase the network capability. The SESG facilitates the connections of low carbon technologies such as Solar PV and Wind, as well as unconstrained powerflow across the European interconnectors:

- The potential CO_2 savings which can be achieved from smooth connection of Wind and Solar alone in this area is shown below (assuming a 30% load factor for wind, and 10% for solar PV) is in excess of 3 million tonnes of CO_2 per year based on expected 2020 installation level (based on CO_2/kWh of 0.48kg/kWh)
- The 2GW European interconnection in the south East will result in further savings in excess of 6 million tonnes of CO_2 per annum.

The achievement of such potentially high levels of saving on carbon emissions will be facilitated by enhancing the transmission and distribution network capability in the south east region by the SESG. In section 3, the conventional transmission reinforcement options were discussed. The solutions such as transmission lines, large substation plants (i.e. SVC, STATCOM) all have environmental impacts during the installation, commissioning, and the lifetime of their asset.

For instance, in case of the overhead line required in the South East, quantification of the exact environmental impacts associated with it is difficult since it is largely dependent on location factors such as "disruption to community" etc. However, the following environmental issues are common when building new transmission infrastructures which by the SESG will be avoided:

- Land use;
- Noise;
- Public health and safety;
- Sensitive plants and animals;

- Soil erosion;
- Visual impact.

The carbon savings, and energy savings associated with the SESG are detailed in Appendix 1. The financial benefits are described in Section 3, and supported by the Cost-Benefit Analysis in Appendix 6.

b) Provides value for money to electricity transmission customers

The SESG project by developing alternative, and smart tools (both technical and commercial), provides more economic, efficient, and easy to implement means of network design and operation.

- National Grid as the transmission owner in England and Wales, will use the SESG to facilitate customer connections in a timely manner at an optimum cost. The application of the tools developed by SESG, is envisaged to be used in other parts of the network which face similar challenges such as:
    - South West of England (with increasing the penetration of embedded generation, and large infeeds such as the new nuclear power station);
    - North Wales (due to connection of offshore windfarms);
    - North East (due to connection of large offshore windfarms);
- The GBSO will benefit from SESG by diversifying the tools available for more economic and efficient operation of the grid, as well as creating additional tools to enhance system resilience;
- The SESG increases the network resilience, and the transmission network users (DNOs, Generators, Interconnectors, etc.) will not face the plant damage due to unexpected transmission faults.

As described in section 3 (Business Case), the SESG will have some inherent benefits which are not dependent on deployment of low carbon technologies. This has been calculated in our CBA to be in the region of £6m per annum (just for the South East Network). With the expected increase in the volume of low carbon technologies such as solar PV and wind, and European Interconnections, this project will provide savings up to £500m per annum for the GB consumers.

Identification and Selection process for Project Partners

National Grid sought project proposals for South East Smart Grid with a view to submitting a developed project to the NIC. The process which National Grid went through began in September 2013, when the priorities for innovation on design and operation of the transmission system was identified and subsequently published as part of Electricity Ten Year Statement (ETYS) in November 2013. We began the stakeholder engagement to gather ideas from our stakeholders, understand the solutions they can offer, and then sought agreement across the business on 2014 Network Innovation Competition projects.

Evaluation Criteria continued

We formally invited various stakeholders to submit their expression of interest, their proposals on the solutions they can offer, and level of engagement for the SESG project. The publicly available SESG briefing note entailed broad issues that National Grid wish to address and whether interested candidates are able to develop a project to the timeline required by the NIC.

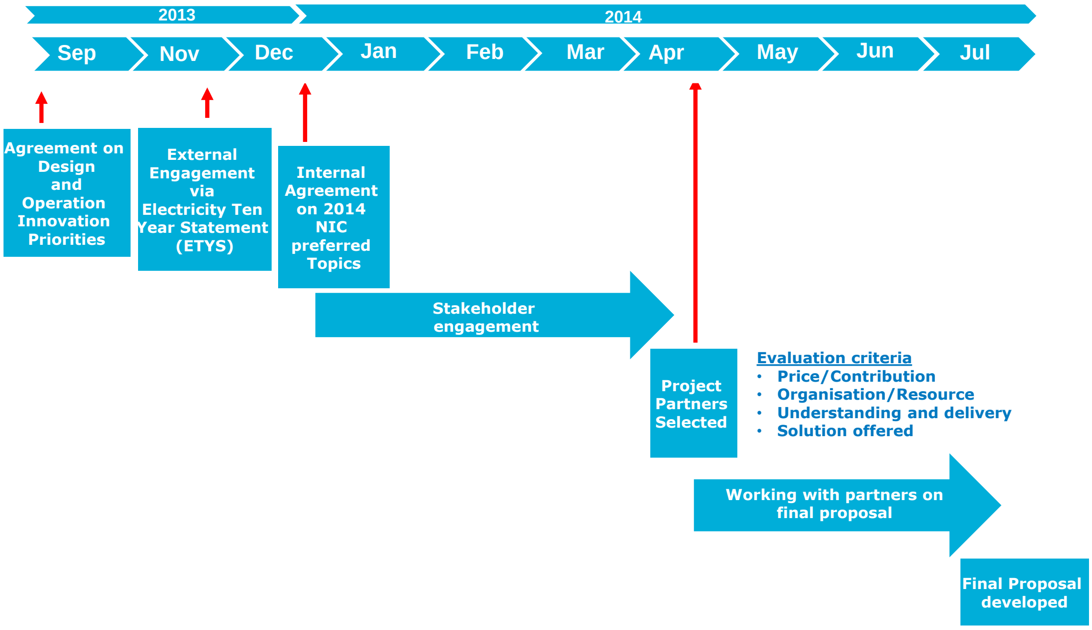

Figure 4-1 Partner Selection and Development of SESG Timeline.

Expression of interest alongside with qualifying information (proposals for solution description, relevant experience, project budget proposals, indication of external funding/contribution, compliance with NIC terms and conditions-Intellectual Property Rights etc.) were requested from all interested candidates within a specified time frame. National Grid's innovation team, procurement team, and the SMARTer System Performance Manager oversaw the process, and the selection criteria which were based on:

- Price/Contribution
- Organisation/resource
- Understanding and delivery
- Solution offered

Rationale for Partner selection

Selection of project partners was an important decision to make and a number of factors were considered around risk, capability, experience, contribution level as well as meeting the NIC governance criteria to qualify as a project partner. The partners that SESG envisaged for this project will bring extensive experience to this project which creates more value for the consumers and reduces the risk.

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Evaluation Criteria continued

Siemens have been identified and selected as the project partner (technology provider) for the SESG for the following reasons:

Siemens has extensive experience of LCNF (Tier 2) bid process, having worked as a project partner to various DNOs in each of first 4 years of the programme and participated in Expert Panel and Consultant Sessions, with 100% success record.

Siemens has proven delivery capability around large scale system integration and innovation projects; this includes its role as overall control architecture supply and integration for the largest smart grid project in the UK today, the Ofgem funded Customer Led Network Revolution.

Siemens is a technology and solution provider to National Grid and has delivered a broad range of type registered and innovative control solutions, such as Operational Tripping Systems. Siemens has also provided innovative ancillary services like active Frequency management (Fast/Slow response), active reactive power management and active load management to National Grid as part of the CLASS project delivered to one of the UK DNO.

Siemens's nature and level of contribution compared to other interested parties was higher and more beneficial for SESG.

The Imperial College of London's control and power department has world class reputation in research and development in the subject area proposed for SESG. The group provides the capability to perform number of laboratory testing and simulation for the applications proposed for this project. The group has also been active in previous IFI/NIA/LCNF projects. The previous IFI funded project focusing on the tools and techniques (feasibility studies) is the key project which has been completed successfully by this institute, and it allowed us to develop SESG project to demonstrate the tools and techniques which were identified as feasible for trial.

ELEXON has been selected as partner because of experience of running the balancing and settlement market. We envisage the ELEXON's role as advisor alongside the academic partner being vital for development of the commercial innovation aspects of the SESG (market arrangements, developing products, impact assessment).

UK Power Networks (UKPN) is the local Distribution Network Operator (DNO) for the south east of England. It is expected that significant volumes of embedded generation to be connected in this area which in turn requires transmission and distribution reinforcements. By working closely with UKPN, ensuring the transmission and distribution related issues are considered in parallel, as well as facilitating the access to the sites where monitoring devices need installation.

c) Generates knowledge that can be shared amongst all relevant Network Licensees

SESG generates a number of key areas of knowledge which can be shared amongst all relevant Network Licensees:

- Design of new smart and effective system monitoring tools. This includes new system monitoring devices in addition to the improvement of existing equipment;
- Validation of Smart Grid network under different system conditions. The different Smart Grid parameters are tested for specific distributed and transmission resources hence can be used for other Smart Grid applications;
- The coordination of equipment located in different voltage levels (Transmission and Distribution). The efficient method of communicating with distributed resources is explored;
- The optimal operational arrangement of DC links connecting to the onshore transmission system is determined. This knowledge can be handed over to the other Transmission Licensees for any offshore connection to the main transmission system.

The description of the approach to knowledge dissemination, is detailed in Section 5 of this document.

d) Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

Previous smart grid projects have mainly applied to small scale and specific applications. For example as described in Appendix 9, we have investigated the use of monitoring and control at the transmission level for managing some of the transmission constraints. Project VISOR (of which NGET is a partner) is developing advanced monitoring of the network to manage wide range of system related issues (such as sub-synchronous oscillations, inter-area oscillations). Number of projects led by DNOs under Low Carbon Network Fund (LCNF), have investigated the use of DSR, and storage to manage localised constraints.

We believe distributed resources have the potential to help with managing transmission constraints and provide significant benefits to the consumers. To enable this potential, whole system monitoring and control, resource estimation, and initiation, as well as new commercial measures are required. This application at such scale has not been demonstrated before, and given the potential, we have identified it as an area for immediate innovation.

SESG utilises all available resources connected to the distribution and transmission system for the first time, at such large scale. The South East is a very complex network; therefore, the modification of existing operating arrangements requires considerable investigation and effort. There are different parties at different voltage levels engaged in the project. This adds to the complexity of the project. The concept proposed in SESG, cannot proceed as be business as usual due to the following risks:

Technical Risks

- System Monitoring –The monitoring and control system are extended to different distributed and transmission resources. Conventionally, the monitoring devices have been assigned for specific applications. SESG develops comprehensive system monitoring involving devices attached into different voltage levels with different specifications.
- Coordination of Distributed and Transmission Resources –The coordinated response of distributed and transmission resources will be tested and validated in SESG. For the first time all available resources will be used to mitigate a system or network issue.
- Distributed Response Identification –Qualifying and quantifying the response from distributed resources are challenging processes. Doing this requires the involvement of different partners and is not a common practice. A range of distribution resources, including generation, compensation equipment and demand, shall be tested under different network/system conditions.

Operational risks

- Management of Distribution and Transmission systems - The real-time management of Distribution and Transmission networks is a complex procedure require specific tools and control schemes
- Failure of main system monitoring - Building a backup /support centre when the main monitoring system fails is essential. It requires detailed investigation of the network and investment if necessary

Commercial risks

- New response market requirement – The existing market arrangement is not able to accommodate response from the various Smart Grid devices. A new market regime is required to incorporate coordinated response from transmission and distributed resources.

Regulatory risks

- The existing business standards such as The National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS), Grid Code, and Distribution Codes may not be aligned with future network development project such as SESG. Whilst there are well defined processes around required modifications to these codes and standards, the knowledge and evidence for such changes can only be obtained via demonstration projects such as SESG.

(e) Involvement of other partners and external funding

National Grid engaged with external stakeholders once the NIC 2014 project was identified. A briefing note indicating SESG candidates was available on the company's website. There have been discussions with relevant customers, suppliers and partners to elaborate the project's aim and objectives in further detail. A considerable number of candidates, ranging from technology providers, the south eastern network licence area, UKPN to demand side aggregator and universities, have shown interest in SESG.

NGET has discussed the need for external funding, and all of our partners are contributing (both in-kind, and financially) to this project. The external funding made available to this project is mentioned in Section 1, and detailed in Appendix 2. The details of our partners can be found in Appendix 7. In addition, their letters of support are included in Appendix 8.

Imperial College London

Imperial College of London is the academic partner of the project, and provides academic expertise, as well as data evaluation, validation, quality control, testing, and knowledge dissemination.

Siemens

Siemens was among the candidates that expressed interest in the SESG project and it submitted a Technical Proposal as part of the Initial Screening Process (ISP) stage. Siemens was selected as a partner to the project using key evaluation criteria like contribution level, relevant experience and capability.

Siemens will be the key technology provider with a substantial involvement (technology development) to deliver WP1B (State Estimation), support National Grid and UKPN in 1C (Response Evaluation) of the project, as well as being involved in other stages.

Siemens has allocated resources to support the SESG project and has confirmed availability to support full bid submission and subsequent assistance as part of future Expert/Consultant Panels. This support would be provided by Siemens as part of its 'in-kind' contribution as role of partner.

UK Power Networks (UKPN)

UKPN recognises the importance of the project and have agreed to partner with us and contribute to the project. The technical description of the project was shared, discussed and agreed in a number of bilateral discussions with UKPN. UKPN as a project partner allow the development of the state estimator on transmission and distribution system, allowing the access to the distributed resources within the DNO's network.

Elexon

Given the nature of trials proposed as part of the SESG, and need for development of commercial services to enable the roll out of the concept to other parts of the network, Elexon will provide expertise in designing new commercial services. Elexon in conjunction with our academic partner support the immediate roll out of the SESG to other parts of the network, and help in developing the non-build solutions.

(f) Relevance and timing

Interconnection with Europe is a major operational and environmental challenge facing the UK over the next two decades. The South East in particular has the operational challenge of being a very congested area and has had several system incidents in the past two years. There will be two interconnectors connecting in this area in the next decade: Nemo Link and Eleclink.

National Grid will need to better understand the specific dynamics of the area in order to determine the most cost effective option of reinforcement. Future reinforcements will include a large amount of static and dynamic compensation in order to ensure sufficient reactive support but there is a requirement to understand how quickly these pieces of equipment would need to respond to a system event. Also, there is the need for synchronising the control of all the devices in the area. The SESG project will provide a Wide Area Monitoring System (WAMS) that allows this to be accomplished.

In addition to interconnection, under severe network conditions (for example, high demand, low demand, and high wind high solar production) the operator may need constrain the output of renewables to manage the network. SESG ensures smooth operation of renewables under severe network conditions.

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Section 5: Knowledge dissemination

This section should be between 3 and5 pages.

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

The SESG project will develop invaluable learning for other network licensees as well as for the electricity industry in general. Knowlegde will be disseminated continuously throughout the duration of the project.

The SESG project will be the first of its kind to demonstrate the effectiveness of a whole system approach in providing the capability the network requires. The concept will be extended across the system (as a non-build solution) and therefore knowledge dissemination will be an important part of this project. The knowledge dissemination will have some specific objectives:

- To introduce the concept of a whole system transmission and distribution planning, and build confidence amongst the stakeholders with regard to operability of the concept; and
- To send market signals to develop the tools and solutions in large scale and help in commercialisation and roll out of the concept to other parts of the network.

To achieve above objectives, it will be required to the create necessary forums to share the learnings as part of SESG with various stakeholders; ranging from members of the public in the South East region, to technology providers, and DNOs. This section will describe the approach SESG project will take in knowledge dissemination.

5.1 Knowledge dissemination

The successful implementation of SESG, and roll-out of the concept across the system requires a systematic knowledge sharing at all stages of the project. SESG will share the knowledge of project equitably amongst all stakeholder groups as identified in Figure 5-1.

Figure 5-1 Knowledge Dissemination Audience.

Knowledge dissemination continued

5.1.1 Development phase

During the development phase of the SESG's state estimator, various elements and areas will generate new knowledge which will be disseminated:

- **SESG State Estimator (a Whole System Approach):** The development of control systems monitoring the system parameters (i.e. voltage, phase angle etc.) and identify system integrity limit for the south coast under normal, and various contingencies. The state estimator will consider both transmission and distribution network's behaviour ensuring a fully optimised control system for the SESG. The target audience of this work include TOs, DNOs, technology providers and academia.
- **Resource Estimation:** The SESG will develop an innovative tool which enables estimation of required response from distributed resources to manage the identified constraints on the transmission network. Such resources are embedded within the DNO's network and communication capability, availability of such resources, and impact estimation are the learnings which will be disseminated. The target audience at this stage are TOs, DNOs, technology providers, academia, demand side aggregators, and embedded generators.
- **Commercial optimisation:** The optimisation in the use of transmission and distribution resources and development of commercial services to enhance the network capability (as appose to capital investment) are some of the important areas which SESG's knowledge dissemination will expedite the roll-out of the concept. The target audience are TOs, DNOs, academia, generator companies, and interconnectors.
- **Innovative Network Development:** SESG will help in building confidence amongst the consumers with regard to innovative measure taken to develop a safe, sustainable and economic electricity network. The SESG creates the opportunity for the local communities to be more engaged with the electricity sector by:
    - Developing the understanding of the complex measures taken by the network companies to be more economic and efficient through innovation;
    - Understanding of the value which the SESG bring for them (i.e. savings on electricity bill, and less environmental impact);
    - Encouraging more involvement of younger population in development of future networks by showcasing innovative and exciting projects such as SESG and creating a new image of what the 21st century electricity industry looks like.

5.1.2 Post-project completion

The SESG's developed tool:

- **Constraint management:** The ability to dynamically evaluate the state of the system in the South East, and avoid unnecessary constraints in real time.
- **Real time data access:** It is envisaged the future grid development activities (i.e.

generation and demand connection), and research projects require greater access to data and in such a way to allow comparing system behaviour between different parts. The SESG tool will provide access to such data on the network which enable more economic and efficient transmission and distribution planning in the south east, as well as more effective research and developments in this area.

- **Smart Grid Training Centre:** The system operator, transmission and distribution planners, OFTOs, and academic institutes will have the opportunity in the future to be trained on smart grid platforms developed for SESG. The training centre based at Warwick in collaboration with Transmission National Control Centre (TNCC) using the new developed monitoring and control platform will be a vital centre for developing the capability within the industry in such areas.

5.1.3 Knowledge dissemination approach

The SESG project has a range of stakeholder groups which inevitably have differing levels of expertise and interests. The knowledge dissemination methods envisaged for SESG ensures the stakeholders receive the required knowledge that are relevant to their own business and needs via targeted dissemination activities. National Grid's customer and stakeholder engagement team will oversee the methods to ensure a clear, targeted approach in knowledge dissemination and receive feedback from our stakeholders at various stages.

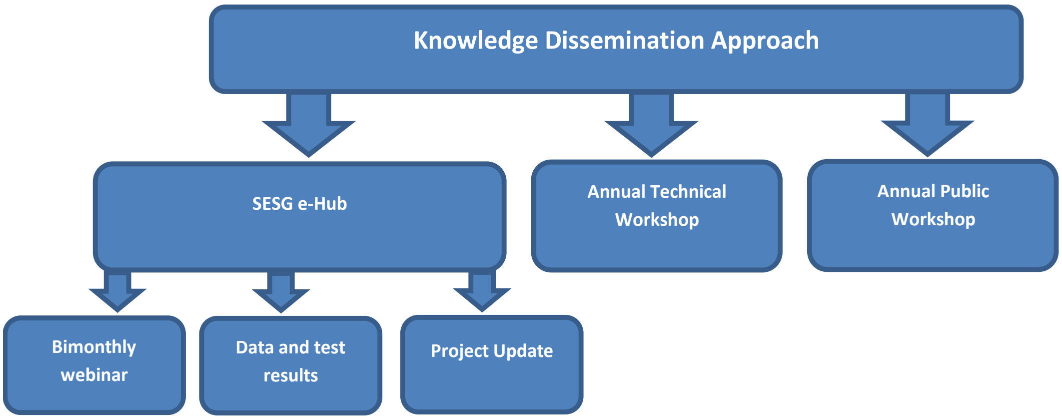

Figure 5-2 Knowledge Dissemination Approach

The **academic partners will assist significantly** in the knowledge dissemination. A project e-hub will be created in order to provide regular update to the stakeholders, share the available knowledge and data, and announces the significant learnings at different stages of the project. We will be hosting bi-monthly webinars inviting the key partners to present the developments and demonstrations carried out to the stakeholders. We will also hold physical knowledge sharing sessions with presence of key stakeholders of the project.

We believe the transformation of grid into a SMARTer grid, benefits from more consumers' support. We therefore propose to hold annual knowledge sharing event for the member of the public geographically reside in the areas we are developing this innovative solutions. This is to show the benefits, savings, and future opportunities which will be created as part of this project to the end-use electricity consumers.

Knowledge dissemination continued

5.2 IPR

It is not anticipated that SESG will fall outside the default Intellectual Property Rights (IPR) arrangements defined by NIC governance document. In addition to the steps described above in knowledge dissemination, this section will make specific reference to the work carried out to ensure full compliance with default IPR. A full review of the section 9 of the NIC governance document has been carried out with SESG partners, and as well as the agreement on the learnings of each work package (as described in section 2). The following steps will be taken to ensure a full compliance with default IPR:

- National Grid has detailed the expected learnings of each work package. This has been agreed with the partners and all relevant data, models, simulation results, and control system developed as part of SESG will be publicly available on SESG e-hub

- It is expected that the technology provider of the project may wish to contribute to development of some of the Solutions (control hard ware and software development, and monitoring hardware) in order to retain the IPR. This will fall under "Foreground IPR" as described in section 9 of the NIC governance document. Any product developed on such basis, will be made available for purchase on fair and reasonable terms. In the collaboration agreement between National Grid and the partners the "Foreground IPR" will be specifically described to ensure the compliance with section 9 of the NIC governance document.

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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 (%): 50

The SESG project has done all work necessary and is on the road to success.

6.1 Background

The success of the South East Smart Grid (SESG) project is dependent on several factors outlined in Figure 6-1. All of these factors have been considered and we are confident that all these areas have received sufficient level of attention for the project to commence without delay:

- **Previous Projects:** We have identified a number of projects related to SESG which have provided valuable learning points to both National Grid and our partners.
- **Technology readiness**: Our partner Siemens has had previous experience with the solution platform "Spectrum Power" and we are confident that the platform will provide the most appropriate solution for SESG.
- **Project Governance:** A strong governance framework has been put in place to ensure the success of the project.
- **Quality Control:** Steps have been taken to ensure accuracy of all information.
- **Inherent Benefits:** The project will deliver valuable knowledge irrespective of the success of the low carbon benefit.
- **Contingency Planning:** Risk assessments are in place to ensure any risks have a sufficient level of mitigation.

Figure 6-1 Factors in the success of SESG. .

6.2 Previous Experience

We have identified several related projects which will provide learning to the delivery of SESG. The learning points from these projects are outlined in Table 6-1 and further detail can be found in Appendix 9.

Project	Learning Points for SESG
National Grid Humber SmartZone	✓ Installing Phasor Measurement Units ✓ Installing Random Access Memory Units ✓ Upgrading Communication Systems ✓ Intelligent operational inter-trip scheme ✓ Overhead lines dynamic thermal rating ✓ Congestion Management ✓ Alarm and protection setting optimisation
ENW Customer Led Ancillary Services Support (CLASS)	✓ Local distribution control scheme ✓ Frequency Management ✓ Load Management ✓ Voltage Optimization ✓ Distribution Automation
Northern PowerGrid Grand Unified Scheme (GUS)	✓ Central and Local distribution control scheme ✓ Constraint Management ✓ Experience with Spectrum Power
Low Carbon London	✓ Decentralised energy trial which is investigating new Active Network Management (ANM) automation and control techniques. ✓ Demand response from industrial and commercial customers
Flexible Plug and Play	✓ New commercial arrangement allowing the DNO to manage the output of the distributed generator to ensure the network constraints. ✓ High-speed telecommunications platform for advanced control and monitoring. ✓ Trial smart technologies including active network management (ANM), automatic voltage control, dynamic line rating, novel protection scheme for reverse flows and RTUs interfaced with ANM
Project VISOR	✓ Wide Area Monitoring ✓ Detection of Sub-Synchronous Oscillation ✓ Detection of Inter-Area Oscillations
America OG&E's Smart Grid	✓ Advanced metering infrastructure ✓ Dynamic pricing programs
America Ruston Smart Grid	✓ Meter data management system (MDMS)

Table 6-1 Learning from other Projects related to SESG.

Project Readiness continued

In particular, SESG builds on the Humber SmartZone project, a project undertaken by National Grid which was funded through the Network Innovation Allowance (NIA). This project was developed as an alternative solution to reinforcement. The project involved the development of a proof of concept that provided flexible enhanced circuit ratings through a combination of wide area monitoring, predictive ratings and dynamic security analysis. Through this project, National Grid gained invaluable experience that will ensure the success of SESG. We have also carried out a detailed feasibility study with Imperial College of London, on the reliability evaluation of smart solutions which will be demonstrated as part of SESG.

However, SESG will still need to fill in the following gaps:

- Comprehensive system monitoring combining both Transmission and Distribution Level (whole-system approach)
- Enabling the use of distributed resources to manage transmission constraints (tackling communication, cyber security risks, etc.)
- Development of market signals to enable the roll out of the concept

These three points demonstrate the ground-breaking nature of SESG.

6.3 Technology Readiness

Our partner Siemens is the technology provider for the SESG project. Siemens has extensive experience in providing solutions to the energy industry. *Spectrum Power*, the solution platform suggested by Siemens to deliver the SESG project, has been previously used in many projects around the world. As shown in Figure 6-2, Siemens's tool is used by over 1600 control centres worldwide (Transmission & Distribution) with over 200 in the UK and Continental Europe. Amongst these control centres, 34 of them are Transmission Control Systems including ENTSO-E Belgium, BritNed UK, Dong Energy Denmark and TransnetBW GmbH Germany.

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Project Readiness continued

Figure 6-2 Control Centres that use Siemens Spectrum Power

In particular, Siemens has used this platform in the project titled 'Northern PowerGrid Grand Unified Scheme (GUS)' shown in Table 6-1. This project was part of the Customer Led Network Revolution (CLNR) and a major component of this is the implementation of a Grand Unified Scheme (GUS) made up of a combination of existing and novel network devices. The aim of the GUS was to demonstrate increased network flexibility and capability by coordinated action (control and monitoring) of enhanced network devices. Siemens will be able to apply many of the learning points from this project to SESG.

From the GUS project and all the other projects existing worldwide, Siemens has gained extensive experience in using the *Spectrum Power* platform for the delivery of complex data systems to automatically manage the operation of power networks and they are confident that it can use it to develop an appropriate solution for the SESG project.

6.4 Project Governance

A project team will be formed to run the SESG project. The team will be led by National Grid and will provide regular feedback and updates to senior management. Dr. Vandad Hamidi will be acting as the key point of contact with Ofgem, project delivery team, and the steering committee. Appendix 7 provides more detail on the project team that will be formed to deliver the SESG project.

Project Readiness continued

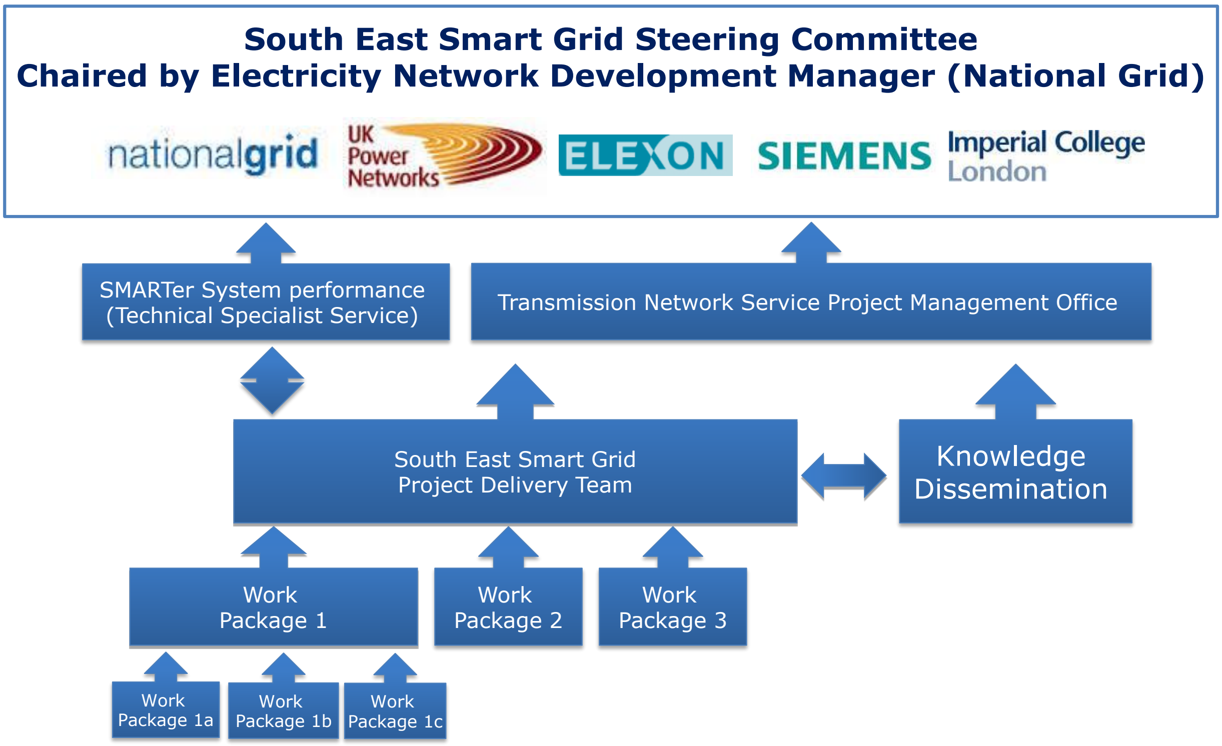

Figure 6-3 Project Management Structure

SESG will start in a timely manner. The partners have been engaged with SESG since initial stage of the project and have valuable experience about smart grid and south east network. They are fully aware of project milestones, their role and contribution, and have confirmed that the project objectives are achievable. A high level project plan has been developed for this purpose and a summary of the timings of the project plan is shown in Figure 6-4 with more detail available in Appendix 3.

As well as the project plan, due to our partner selection, there would be no requirement to perform a tender process to find the supplier for the technology, thus ensuring no delay to commencement of the project. We are also confident that the solution platform provided by our partner Siemens (*Spectrum Power*) is fit for purpose and, due to their previous experience, we are confident that this technology would be deployed without delay.

Project Readiness continued

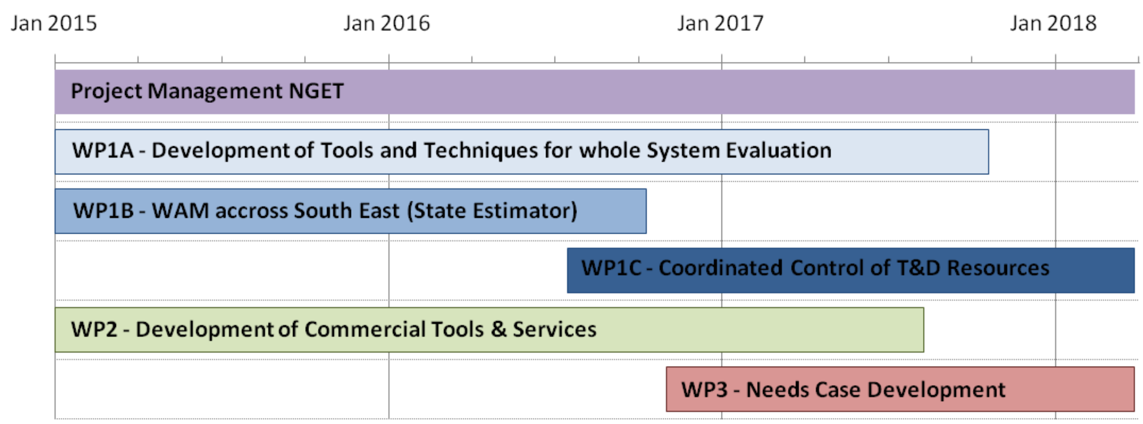

Figure 6-4 High Level Programme (See Appendix 3 for more detail)

We have taken a number of steps to accurately estimate the costs and benefits of the project. The project partners assisted NGET to estimate the cost and benefit of the SESG project. The detailed cost evaluation was used to build up the project costs and this is detailed in the full submission spreadsheet found in Appendix 2. Partners have a considerable stake in the project cost estimation and he similar projects have been assessed by NGET and key partners in the past. The list of these projects is provided in this section. Therefore SESG costs and benefits can be benchmarked considering the previous successful projects.

We will employ a number of measures to minimise the possibility of cost overruns or shortfalls in Direct Benefits. NGET detailed project plan and KPIs ensures the risks associated to SESG are being captured and handled. We have contingency plans in place to ensure any risks are appropriately mitigated. The risk register, and the contingency plans are set in a way to capture risks in different sections of the project.

6.5 Quality Control

We have verified all information included in the proposal. There is a procedure to verify information provided to SESG before implementation to ensure the quality of the data being used. A combination of past system events, and simulation exercise will be used for verification of the initial data used for the SESG. The data gathered as part of trials and demonstrations, will go through a separate validation exercise using post-event simulations which helps in validation of the proposed control system for SESG.

6.6 Inherent Benefits

SESG will deliver learning irrespective of the take up of low-carbon technologies and renewables. Irrespective of the delivery of the carbon benefits described in section 4, the learning points from this project will be invaluable for the efficient development of the transmission system. The learning from this project will allow to make better decisions on investment in the future and the knowledge gained from the transmission system will be used to determine the best option.

6.7 Contingency Planning

Processes are in place to identify circumstances which could affect successful delivery of the project. We are confident that given the significant volume of preliminary work carried out so far, combined with the experience of the project partners SESG is on the road to success.

However, as part of developing the proposal for SESG, we have engaged our partners in identifying the potential areas which require careful risk assessment, to as the success of the SESG project is dependent on managing the risks appropriately. We have identified these potential risks to the project and have put mitigation actions in place to ensure the success of the project. A full risk assessment is included in Appendix 4.

The project steering group with representations of all partners will oversee the project and an update on the project risks will be provided to the steering committee every month. The National Grid's Global Risk Management System (GRMS) which has been used to manage number of processes and project across National Grid, will be used for SESG. Given the innovative nature of the SESG project, there may be exceptional circumstances which the project will have to be suspended. The steering committee will be provided with a detailed report on the causes, and risks which has led to not being able to deliver the agreed tasks within SESG. The steering committee will then provide a detailed report, including the completed milestones, and what has not been delivered to the authority with proposed recommendations (i.e. delay the project, or suspension in line with NIC governance document sections 8.30-8.42).

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Section 7: Regulatory issues

This section should be between 1 and3 pages.

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

It is not expected that the SESG project will require any derogations, consents or changes to the regulatory arrangements in order to implement the project.

7.1 Data Confidentiality

The data required for the SESG project are the data currently shared between National Grid, and UKPN under grid code (i.e. provision of data from DNOs as part of Week 24 data submission, and between National Grid and DNOs as part of Week 48 data submission), and as part of the trial of SESG, there is no requirement for any derogations or license exemptions.

The work package 2 (commercial service development) however will explore the potential areas where the share of the data such as the availability of demand side aggregators, under the existing regulatory regimes may not be possible, and therefore require modifications.

7.2 Balancing and Settlement Code

As part of work package 2, the services developed will be assessed in conjunction with existing services (i.e. Balancing Services, Short Term Operating Service) to ensure any areas which may conflict with the existing arrangements are identified and modification of the service, or the codes will be proposed.

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Section 8: Customer impacts

This section should be between 2 and 4 pages.

8.1 Impact on Transmission Network Customers

The existing transmission network users in the area where SESG will be implemented include:

- IFA Interconnector (2GW Cross Channel HVDC Link)
- Dungeness Nuclear Power Station
- UKPN at grid supply points

And in the future:

- Eleclink (Cross Channel HVDC Link)
- Nemo Link (Cross Channel HVDC Link)

The implementation of the SESG does not require interruption of generation or supply capability of the existing or future transmission network customers. Therefore, it is not expected that the SESG project will have any adverse impact on the transmission network customers.

8.2 Impact on Distribution Network Customers

The SESG will be coordinating the response from transmission and distribution resources. In the work package 1b and work package 1c the monitoring devices necessary at the distribution level will also be implemented without any adverse effect such as interruption of supply, or quality of supply issues for the distribution network customers. We expect to recruit number of service providers within the distribution network which can respond to network constraints and this will be done via performing invitation to tender to prospective service providers with full coordination with UKPN.

8.3 Benefits to Transmission and Distribution Network Customers

The existing and future customers within the South East network (at both transmission and distribution level) will benefit significantly from having access to the SESG platform, and the data and knowledge shared amongst them.

The SESG provides greater resilience by implementing an enhanced monitoring of the transmission and distribution network. Such increase in resilience, will benefit the customers such as the nuclear generator (Dungeness Power Station) in this area, by being an additional measure for ensuring the long term safety of a nuclear site.

With regard to HVDC interconnectors, the enhanced monitoring of the network provided by SESG, in addition to the resilience, will help in reducing the design and upgrade cost of these network users by providing more accurate data regarding network behaviour. Given the expected start/completion date of this project, the new interconnectors expected to connect to the network will have the opportunity to use the data from SESG platform to optimise their designs.

At the grid interface points between National Grid and UKPN, the coordinated monitoring

Customer impacts continued

and state estimation allow both NGET, and UKPN to consider a range of network issues in a much more coordinated way. Topics such as outage coordination, change in network characteristics and managing challenges such as high volts, etc. in long term can all be managed and any solution proposed will be based on the new capabilities provided by SESG.

Similar to transmission connected customers, the distribution network customers such as generators will see greater network resilience. The key benefit of SESG for them is enabling the distribution connected customers to provide new services to the grid.

Section 9: Successful Delivery Reward Criteria

This section should be between 2 and5 pages.

Criteria 9.1

Formal Memorandum of Understanding and Agreement in Place with Project Partners

In order to achieve the project objectives, it is crucial that all project partners are committed to deliver allocated tasks. At the early stages, establishing this agreement with the project partner is the first measure of success for SESG.

Evidence

- Formal memorandum of understanding, and agreement signed by all project partners by the end of April 2015.

Criteria 9.2

Whole System Evaluation Models Developed

One of the key deliverables of the project is to enhance system state estimation when transmission and distribution network topological changes. It is important that validated models are developed to allow the assessment of benefits of whole system estate estimation.

Evidence

The following components should be delivered for success at this stage:

- Development of validated models enabling real time testing. The model developed must allow the simulation of WP1b components (at transmission and distribution level)
- Development of Virtual Power Plant concepts to enable flexible resources in distribution networks to be trialled at WP1c
- Report detailing the description of real-time controller as implemented in a rapid control prototyping (RCP) platform from Opal-RT.

Criteria 9.3

SESG State Estimator Developed Successfully

The state estimator enabling the monitoring of the South East network at both transmission and distribution level and determining the level of response required at different GSPs.

Evidence

- The state estimator developed and demonstrated in *Spectrum Power*

- The state estimator has incorporated both transmission and distribution system

Successful Delivery Reward Criteria continued

- The state estimation enables the assessment of system behaviour against the following criteria
  - Steady State Voltage
  - Dynamic Voltage Stability
  - Rotor-Angle stability
- The state estimator communicates in real time with monitoring devices and indicating the level of response at the GSP level

Criteria 9.4

Response evaluation from Distributed Resources

The SESG is demonstrating how the use of distributed and transmission resources can have the potential to manage transmission constraints. The trial on distributed resources and understanding the capability of the resources to respond to signals sent by the state estimator will enable the key technical objective of the project.

Evidence

- The procurement process is established with list of potential service providers
- Contracts signed between SESG and Service providers
- Agreement with UKPN and response providers to respond to WP1b state estimator's signal
- Trial carried out at system states indicated by WP1a
- Response recorded and validated

Successful Delivery Reward Criteria continued

Criteria 9.5

Successful development of new Commercial Services to enable the use of Distributed Resources

To enable the roll out of the SESG concept, the new commercial services which incentivise the service providers (distributed resources) to provide response to the transmission system will be developed.

Evidence

- New commercial service with detailed description of the service type, duration, and payment methodology developed

Criteria 9.6

Successful Roll Out Plan Developed

The immediate areas for deployment of SESG concept identified, and the Network Development Policy (NDP) is enabled to perform the assessment of SESG concept as a non-build solution.

Evidence

- Developing non-build solution under NDP; enabling least regret assessment alongside transmission solutions
- The roll out plan including the sites, degree of benefit and dates identified

Criteria 9.7

Successful Knowledge Dissemination of SESG

Successful dissemination of knowledge generated by SESG within National Grid, to other transmission owner, DNOs, and industry stakeholders will be carried out to ensure the learnings are communicated at different stages of the project to enable timely roll out of the non-build solution concept.

Evidence

- Knowledge sharing e-hub developed
- All non-confidential data, and models developed as part of SESG to be shared on the e-hub
- Work package reports delivered at the end of each work package and made available on the e-hub
- Smart Grid Training Programme based on SESG developed for transmission planners using SESG facilities

Successful Delivery Reward Criteria continued

- Annual knowledge dissemination event (at least one per year) organised

Criteria 9.8

Project close and knowledge dissemination

The project is planned from January 2015 until March 2018. The project is well organised to satisfy all pre-set objectives and deadlines. Eventually the optimal management of South East network is demonstrated and the relevant commercial services are developed. The Smart Grid application used in South East can be trialled for other parts of network.

Evidence

- The project is assessed against its initial goal and objectives.
- All reports and findings are disseminated as appropriate and the final report is sent to authority.
- Project close down by March 2018.

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Section 10: List of Appendices

Appendix	Item and Short Summary
1	**Benefit Tables** *Fully populated according to template & guidance*
2	**Full Submission Spreadsheet (Confidential)** *Fully populated according to template & guidance*
3	**Project Plan** *A high level Project Plan of the main deliverables of each Work Package*
4	**Project Risk Register, Risk Management and Contingency Plans** *Detailed Risk Register with contingency plans and mitigation actions*
5	**Technical Description of the Project** *A detailed description of the project*
6	**Cost Benefit Analysis** *Analysis of the benefit of the SESG project*
7	**Organogram of the Project and Description of Partners** *More detail on the organisation of the project and the partners.*
8	**Letters of Support** *Letter of commitment from NGET and project partners as well as letters of support from project supporters*
9	**List of Previous Projects** *A list and high level summary of previous projects together with the learning that they bring to SESG*
10	**Detailed South East Map from UKPN** *A detailed map of the distribution and transmission assets in the South East area*