Electricity Network Innovation Competition

Report and Recommendations 2014

Prepared for

The Gas & Electricity Markets Authority

By

The Electricity Network Innovation Competition Expert Panel

October 2014

1 Introduction

1.1 This report prepared by the Electricity Network Innovation Competition Expert Panel (the Panel) sets out the Panel's recommendations to the Gas and Electricity Markets Authority on the portfolio of projects to be funded in the 2014 NIC funding round. Members of the Expert Panel are as follows:

- Dr Robin Bidwell (Chair)
- Sharon Darcy
- Prof Nicholas Jenkins
- Prof David Newbery
- Alan Bryce

1.2 We received four submissions. The total funding requested from the ENIC was £28.47m and the fund available this year is £27m. Full details of each submission will be available on the Ofgem website. The names of the Funding Licensee, titles of the submissions and the amount requested from the ENIC Fund are as follows (the values in brackets indicate the total cost of the projects).

- **Enhanced Frequency Control Capability (EFCC) - National Grid Electricity Transmission - £6.911m requested (£9.344m in total)**
- **Modular Approach to Substation Construction (MASC) - SHE Transmission - £2.835m requested (£3.263m in total)**
- **Offshore Cable Repair Vessel and Universal Joint - TC Ormonde OFTO Limited - £9.016 requested (£10.329m in total)**
- **South East Smart Grid (SESG) - National Grid Electricity Transmission - £9.707m requested (£11.820m in total)**

1.3 The Expert Panel followed the evaluation process set out in the Electricity Network Innovation Competition Governance Document (1 Feb 2013). Initial submissions were received by Ofgem and were screened by Ofgem staff for compliance with the requirements set out for the Initial Screening Process. Consultants were appointed by Ofgem to review the submissions (the Consultants' reports will be published in full). The Panel met the Funding Licensees early in the evaluation process to allow the project teams to present their submissions. The Panel and the Consultants met the Funding Licensees a second time to allow them to clarify points and address matters of concern to the Panel. During the period up to the completion of the Consultants' reports and prior to the second meeting with the Funding Licensees, the Consultants and the Panel sent each of the Funding Licensees a number of questions with the purpose of clarifying the submissions and highlighting areas of concern.

Following these meetings, the Panel met to review each of the submissions in the context of the criteria set out in the Governance Document. In evaluating the submissions, the Panel took into account all of the documents that had been made available: the submissions, their appendices, the Consultants' reports as well as any additional information that had been submitted via Ofgem or the Consultants from the Funding Licensees; they also took account of information from meetings that were held with the Funding Licensees and any material provided during those meetings. Based on this evaluation, the Panel reviewed the projects against the criteria.

1.4 This report should be read together with the Consultants' reports, the Funding Licensees' submissions and the other information that is published concurrently with these on the Ofgem website. This report sets out the results of the Panel's deliberations and its recommendations for the Authority. As such it is primarily concerned with the views of the Panel; all the details of the projects and the technical evaluations undertaken by the Consultants are contained in the other published documents.

2 Evaluation Criteria

2.1 The criteria that the Panel are required to take into account in the evaluation process are set out in the Electricity Network Innovation Competition Governance Document (1 Feb 2013).

In this section we list the evaluation criteria and briefly discuss a number of points that arose during the evaluation process and that provide some context to the evaluation of the projects described in the following section. A full description of the criteria is set out in the Governance Document.

2.2 (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.

A successful project must have the potential to accelerate the development of a low carbon energy sector, or deliver wider environmental benefits, or deliver a combination of both. In addition, it will have the potential to deliver net financial benefits to existing and/or future customers.

An important role that the transmission networks play in accelerating the development of a low carbon energy sector is ensuring that renewables and other low carbon technologies are integrated into the network and system operation as quickly and at as low a cost as possible. Over the next 20 years, major investment in the GB power system is planned in order to connect new forms of generation at new locations and transport the power to load centres. There is a growing recognition of the costs of operating a low carbon power system and the opportunities for economies offered by Demand Side Management.

Two of the projects addressed the operation of the transmission system and the costs and opportunities arising from the increasing use of low

carbon generation and international interconnectors. Low carbon generators often exhibit different electrical and mechanical characteristics, compared to the more conventional thermal generators that they are displacing, making it necessary to develop a number of new approaches to system operation. As low carbon generation increases its share of GB electricity these emerging operational challenges will require innovative solutions if financial and environmental costs are to be contained.

There is an increasing blurring of the distinction between transmission and distribution networks in particular through the growing interaction between networks and the consequences this has for the design and operation of both systems. Thus one project proposed to develop a 132 kV/33 kV substation that could simplify and accelerate connections to the transmission system in Scotland or to the distribution systems in England and Wales. Other proposals were to use distributed resources connected at distribution voltages to help manage the transmission system. The Panel was concerned that during the preparation of the proposals there had perhaps not been the close interaction with the DNOs that would be desirable in order to ensure a co-ordinated and optimised response and it was not clear that sufficient recognition had been taken of the extensive work on Demand Side Management in previous LCN Fund projects.

The aim of each of the four proposals was, through innovation, to make more effective use of the GB transmission networks. This aim was consistent with the objective of the competition and successful projects should lead to a reduced environmental footprint and lower costs to customers.

From some Proposals it was difficult to quantify with confidence the benefits that are anticipated when the intervention proposed would be rolled out. Greater clarity of the anticipated benefits and clear comparisons with the cheapest established alternative approach to achieving the same result would have helped the Panel.

2.3 (b) Provides value for money to electricity customers.

Again this year, the Panel found it difficult to identify the key objectives of some projects and how the various packages of work would be integrated into a final solution. It was also sometimes difficult to determine from the information provided whether or not the costs of all aspects of a project were proportionate to the work proposed and whether the project would be implemented in such a way as offered best value for money.

The Panel recognises that this is an innovation fund and that there is a considerable amount of uncertainty associated with the work necessary to deliver some of the outcomes but greater clarity about the costs and activities of each work stream and by each project partner would have been useful. The Panel wish to encourage strongly the use of the Network Innovation Allowance and other funding sources to undertake preliminary work and develop future project ideas in more detail before submission to the ENIC.

The Panel would have liked to see clearer evidence that all appropriate steps had been taken to drive down costs through tendering and other measures to encourage competition. Improved processes for identifying and selecting consultants, universities and other expertise partners are also needed. The Panel would have liked to see a greater diversity of university groups and contractors and encourage the Funding Licensees to make further efforts to broaden the field of partners and collaborators.

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

The ENIC Fund is intended to support innovation and create new learning that is of value to all Transmission Network Licensees (NETSO, TOs and OFTOs) – and there needs to be a sound plan to disseminate

this knowledge. All the proposed projects had the potential to generate significant and valuable new knowledge. With the increasing blurring of the distinction between transmission and distribution it is important for Transmission Licensees to engage with the DNOs.

The need to develop the transmission system to accommodate renewable generation and replace ageing assets is common throughout Europe and the Panel would have liked to see more evidence of active attempts to gain learning from international transmission companies and other industrial sectors.

Submarine cable transmission and offshore systems are becoming more extensive and although it was encouraging to see one proposal from an OFTO, the involvement of more Licensees in this emerging area is desirable.

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

The GB transmission system is being developed rapidly and the projects proposed use a combination of technical and commercial innovation to control the costs of these developments.

All the projects were innovative and went beyond business as usual. One project used an innovative commercial approach while others will reassess long established operating practices. In all cases the risks had been assessed and effective risk management plans proposed in the submissions.

2.6 (e) Involvement of other partners and external funding.

Each of the four proposed projects was led by a TO or an OFTO as the Funding Licensee. The extent of the financial contributions of the Funding Licensees varied across the proposed projects. The Panel would have liked to see greater clarity of how the learning from the projects would be translated into Business as Usual and the commercial mechanisms that would facilitate this. Several of the projects focussed almost exclusively on technical issues and paid insufficient attention to both customer engagement and the intended commercial operation. It is particularly important that when proposing to access distributed resources the mechanism of engagement with customers is spelt out clearly.

The collaboration of a number of universities was welcomed but on one occasion the final selection of a university partner appeared to have come about through a rather ad-hoc process. The Panel considered that evidence of a more structured method of soliciting expressions of interest from different expertise partners including universities would be valuable in increasing the engagement of outside groups as well as increasing the pool of collaborators including academic partners.

2.7 (f) Relevance and timing.

All the proposed projects addressed making better use of the GB power system to connect and operate low carbon generation at minimum cost. This is a relevant and urgent issue. The proposed projects would contribute directly to the development of a low carbon power system at reasonable cost and were both relevant and timely.

The Panel was encouraged by one submission from an OFTO and given the extent and cost of offshore networks that are planned would like to encourage future submissions addressing issues of offshore transmission.

2.8 (g) Demonstration of a robust methodology and that the project is ready to implement.

The project plan must be sound and the project ready to implement. In particular the anticipated role of project partners and suppliers needs to be both well-defined and a clear route map designed showing how accountability is to be assigned and the co-operation of partners secured. In two of the projects, the Panel considered that further work could have been undertaken in the preparation of the proposal particularly to increase the certainty that the project partners would contribute as anticipated. It was disappointing that there appeared to have been little use made of Innovation Funding Incentive or Network Innovation Allowance projects to prepare for these larger proposals.

For a number of the projects the Panel was still not entirely satisfied with the Successful Delivery Reward Criteria – it would like to see more emphasis on outcomes as milestones rather than process.

2.9 Comments on process.

The Panel meets the Funding Licensees twice during the evaluation process. Prior to the second meeting the Panel sends a list of questions they would like to see answered at the second presentation. This process worked fairly well although those proposals that were not fully developed found some difficulties in providing clear, quantified and consistent answers to some questions. It is of concern to the Panel if the objectives of a proposed project, and particularly its projected benefits, appear to change significantly during the evaluation process.

For the size of budget requested, the Panel considered that more preparatory work could have been undertaken for some projects. This would have resulted in clearer objectives that remained stable during the evaluation process. The Panel would like to encourage greater diversity in the teams from the Licensees who presented their proposals. One of the aims of the competition is to encourage innovation throughout the companies and so a wide involvement in the bid preparation and presentation is desirable. The Panel was concerned that

occasionally some members of the presentation team did not appear to have detailed knowledge of the proposal.

3 Evaluation of submissions

3.1 Enhanced Frequency Control Capability (EFCC) - National Grid Electricity Transmission - £6.911m requested (£9.344m in total)

The GB power system frequency is maintained at 50 Hz by balancing generation and demand. Excess demand results in a frequency drop and excess generation in a frequency rise. The imbalance between generation and demand drives a change in frequency, and the speed with which this occurs is determined by the size of the imbalance moderated by the inertia, provided by the spinning generators and loads connected to the system. Many low carbon generation sources e.g. solar PV, variable speed wind turbines and DC interconnectors are connected through static power electronics and do not contribute to this beneficial system inertia. These static generation sources are increasingly displacing conventional spinning generators so reducing the inertia of the power system. Hence the GB power system is becoming "lighter" as it is de-carbonised, resulting in more rapid frequency excursions when, for example, a large generator trips. Uncontrolled frequency excursions cannot be tolerated, as they would lead to generators and customers being disconnected from the system and in extreme cases could challenge the integrity of the system and lead to the whole GB electricity system shutting down. The conventional ways to manage changes in frequency rely on operating additional thermal generation part-loaded but fully contributing their potential inertia. As much of this is fossil-fired, it has a high environmental and financial cost.

The project proposes to develop and demonstrate a novel frequency measurement and control method to address this reduction in inertia. A control system will be developed to demonstrate the viability of obtaining rapid frequency response services from a portfolio of sources such as solar PV, storage, demand side response (DSR) and wind farms. A new approach will be taken to measuring system frequency (and rate

of change of frequency) using Phasor Measurement Units (PMUs) in different parts of GB and, through the control system, used to instruct fast frequency response from generation and load. The method will demonstrate the coordination of fast response from DSR, wind, solar PV and storage and fast start up from thermal power plants. A commercial framework enabling a variety of sources to participate in the provision of inertia services will also be developed.

Low carbon/environmental and financial benefits. The conventional approaches to limit the frequency excursions in a low inertia power system are to

- Limit the size of the sudden load/generation imbalance
- Constrain on spinning generators that are not otherwise needed to supply energy, in order to provide inertia
- Constrain off some generators that are not contributing inertia and replace them with fossil plant that provides inertia
- Increase the amount of frequency responsive generation operating by part-loading fossil generators.

All of these potentially incur carbon penalties or forego potential carbon savings, and so the carbon benefits of this project would be considerable if successful. National Grid states that using these established techniques will increase the annual cost of controlling frequency excursions by £200m-£250m/year by 2020. The project calculates significant financial benefits ranging from £131m to £600m per annum, depending on which of the three Business As Usual approaches the proposed solution is compared to namely: 1) limiting the maximum sudden imbalance; 2) constraining on generation; or 3) increasing the volume of conventional response. The details of the calculations of anticipated benefits were challenged during the bilateral discussions. However, the Panel consider the likely environmental and financial benefits of a successful project to be sufficiently large to easily justify the project cost. The delivery of these benefits is clearly dependent on the success of the proposed commercial methods in providing fast response.

The proposal represents good value to customers as the bulk of the potential benefits of the project will accrue to NGET's customers. Cost savings will flow through to customers via reductions in the Balancing Services Use of System (BSUoS) charge.

Value for Money. The proposal represents good value for money. Partners were selected after a publicly available formal invitation for expressions of interest. We understand 20 proposals were received and these were evaluated against four criteria, including price / contribution.

The Panel was pleased to see that its concern over the high cost of the battery had been recognised and that before proceeding with procurement of the battery and inverters an evaluation would be undertaken to investigate the lowest cost way to gain the necessary learning. The Panel emphasised that several innovation projects had installed battery and inverter systems that might be suitable for the testing proposed (e.g. Smarter Network Storage, 6MW, 10 MWh). A formal gate would be introduced into the project plan to identify the lowest cost way of achieving the learning of Work Package 2.3 and Work Package 2.4 before any primary equipment was purchased.

The Panel was also pleased to see the introduction of Work Package 7 to investigate the capability (and hence cost) of the communications system required.

The Panel probed the bid team about the respective roles provided by the two universities and received assurance that these were distinctly different enough to justify their joint inclusion. The Panel was concerned that the scope of the inputs from the two universities were not well defined, especially since they are playing an important role at a significant cost to the project.

The Panel was pleased to see the Project was making good use of the PMUs installed under the VISOR project.

Generates knowledge that can be shared amongst all relevant Network Licensees. Low inertia and the need for additional frequency response is an issue primarily of interest to the GB SO (National Grid) but the increased visibility of frequency across the transmission network will also be valuable for TOs. The market based approach being developed in this project will allow multiple generators and loads to offer frequency response services and will provide important learning for potential suppliers of this service. The project will also provide potentially useful learning on geographic frequency issues in GB.

Is innovative (i.e. not business as usual). The concept of obtaining a portfolio of response service from diverse sources connected at locations across the transmission and distribution networks, taking account of the variation of rates of change of frequency across GB, is innovative. Measuring frequency and taking control decisions, using real-time data from geographically dispersed PMU's is also an important part of the innovation in this project. The Panel was initially concerned that NGET appeared not to have studied the lessons that could be drawn from other small, high intermittent generation systems such as the islands of Ireland and Iceland, as well as other stressed systems such as California and Texas. NGET was able to reassure the Panel that they were both aware of and in active communication with many of these system operators and ENTSO-E, and that the project would add to rather than duplicate studies elsewhere.

Partners and funding. Partners are Alstom Psymetrix (PMU technology and control system provider), Belectric (battery storage and PV plant response), Centrica (wind and large scale thermal response from a CCGT), and Flexitricity (DSR provider).

There are also two University partners: The University of Manchester (testing hardware in the loop); and the University of Strathclyde (Power Networks Demonstration Centre testing the physical infrastructure and demonstrating full monitoring, control, communications and response - with a greater role in validation and dissemination).

The project partners make up a strong team. All project partners are making financial contributions through discounted rates totalling £1.412k.

Relevance and timing. The project is relevant and timely. By 2018/19, under the National Grid "Gone Green" scenario, it is estimated that system inertia will be reduced by 37% and that the time for frequency to drop to 49.2 Hz (the threshold when customer load is disconnected) following a major incident will be less than half the time it takes today. A conventional response to this lack of inertia will be very expensive.

Methodology. The increasing cost of providing frequency response as the inertia of the system reduces is of major concern and requires urgent attention. The proposal describes the problem well and offers an innovative solution. However, the methodology of the project is not as well developed as the Panel would have wished. A number of independent activities are proposed that will deliver useful learning, but these are not integrated well into a single whole either technically or commercially. The proposed technique relies on rapid communication of the frequency measurements and the instructions to the controllable generation and loads but in the original submission this was not to be comprehensively tested. Even after re-submission, the project plan does not include a comprehensive overall end-to-end test of the system and the Panel remains concerned that considerable further work would be required before the technique could be implemented. In questioning, NGET told the Panel that, if the proposed solutions worked, they envisaged moving relatively easily into day-to-day operations. An additional work package was included in the final submission to ensure that technical issues associated with roll-out are identified on the same timescales as the commercial framework is designed, and by implication should therefore not pose a hindrance to implementation.

Risks that have been identified include the speed at which the communications system can operate and whether there is an adequate

supply of responsive plant and demand for the service. On the latter point, the Panel had some concerns that a co-ordinated approach was needed in the sector so that providers of response, especially smaller players, would know what the most beneficial options were for them to pursue.

Panel Conclusions. The Panel concluded this is an innovative proposal addressing a most important problem that will have increasingly costly implications, both financially and for emissions, unless a solution is found. There is no doubt that the cost of business as usual is extremely high and the potential to reduce this therefore is also high. Hence the Panel considered the Project suitable for funding but with a stage gate to ensure Work Packages 2.3 and 2.4 are undertaken at minimum cost.

The Panel remains concerned over the clarity of the proposal and the lack of a clear route map to a final implementation (both technically and commercially). The project will acquire much useful information in a very important area but the transition to a workable solution remains opaque. It is recommended that during the early stages of the project a clear plan is developed for how the outcomes of the project might be integrated into Business as Usual.

3.2 Modular Approach to Substation Construction (MASC) - SHE Transmission - £2.835m requested (£3.363m in total)

Transmission substations are usually unique with each being designed individually. This leads to considerable bespoke design, particularly of civil works, as well as significant on-site activity.

The project will demonstrate the design, construction and operation of a modular substation, much of which will be constructed in the factory. Various standardized modules of the substation will be fabricated and tested in the factory, brought to site and assembled on simple foundations. Advantages claimed for the proposed modular construction include reduced:

- Physical footprint and hence environmental impact
- On-site work and construction time
- Costs of around 20% over the life of the substation

A demonstrator unit of a 132/33kV substation for the connection of a renewable energy generator will be installed although the modular approach being trialled is widely applicable to substations supplying load at similar voltages. ENIC funding is requested only for the additional costs of using the modular construction technique on the demonstrator unit, and the costs that would be incurred of a conventional substation of similar rating will be recovered through established commercial mechanisms.

The more compact arrangement of equipment within the modular substation will require careful reassessment and codification of safe operating practices. An important part of the project is to investigate and demonstrate how such equipment can be procured, installed and safely operated.

Low carbon/environmental and financial benefits. The low carbon/environmental benefits are reduced footprint, environmental impact and civil works, and possibly, through faster construction, earlier connection of low carbon technologies. Financial benefits are estimated to be up to 20% cost saving compared to a conventional Air Insulated design over the life of the substation. Therefore, provided the 20% cost saving can be achieved, SHE Transmission estimate that the MASC project will deliver benefits up to £655m by 2050 across GB, the majority of which will be passed directly to transmission customers. Even if the cost reduction is only half that the benefits are very large compared to the project cost.

Value for money. This is a well-constructed project offering good value for money. Tenders for the development and manufacture of the modular substation will be invited from a wide field including

[redacted] suppliers of substation equipment [redacted] who have already expressed interest.

Funding from the ENIC is sought only for the development of the methodology of designing, installing and operating modular substations and any additional costs of the demonstrator unit above those of a conventional substation. The costs of a conventional substation of equivalent rating to the demonstrator will be recovered in the usual way.

Generates knowledge. The project will generate considerable knowledge. Modular substations are already used in other countries where space is constrained or operating conditions are difficult. However the careful assessment of the technical design of the modular substation with the possible simplifications, reduction in footprint and novel civil works will be important learning to ensure that those functions that are required of a substation are retained and it can be operated safely and satisfactorily.

A MASC decision tool will be developed to provide a cost-benefit analysis of a modular substation in comparison to a conventional build one for a given set of parameters.

It is also planned to develop a MASC 3-D virtual simulation tool so that a user can "walk" around the substation and be provided with information about the plant within it. This is intended for both training and dissemination which given the nature of the project will be important.

Is innovative (i.e. not business as usual). The company recognized that the individual components within the modular substation are not innovative. The key knowledge gained would be through integrating the different parts into one unit and the safety case that will allow such compact equipment to be operated. A permanent, modular substation has not been implemented at this scale on the GB electricity network.

The increasing number of substations required for the connection of low carbon generation (wind and solar PV), and for the replacement of end-of-life plant on GB's electricity networks, offers the opportunity to deploy simple modular substations extensively.

The reduced size of the substation, accompanied by more integration of separate components into a single installation, requires the development of safety practices, understanding of maintenance regimes and operating best practice. These vital aspects of the project would be innovative.

Partners and funding. SHE Transmission has made a deliberate decision not to recruit project partners and there is no external funding. Instead it is proposed to incorporate in-depth stakeholder engagement within Phase 1 of the project. The design and fabrication of the demonstrator will then be procured through open tender. It was argued that involvement of the DNOs and other TOs would be premature at this stage.

The Panel was concerned that the widespread adoption of the modular substation into Business As Usual requires changes in operating practices by other TOs and the DNOs and that the strategy for engaging them, and achieving the necessary change, had not been adequately described in the proposal. It is particularly important to ensure any modular design will be accepted and adopted by the DNOs and other TOs, not least to develop a size of market of commercial interest to manufacturers.

Relevance and timing. The design philosophy and procurement practice of transmission substations has not changed radically since methodologies developed in the 1960's. SHE Transmission has commissioned a market survey, which indicates that some 1,330 new transmission substations will be required by 2050. A significant number will be of the simple single bay type proposed for the demonstrator. Thus the project and demonstrator are timely.

Methodology. The methodology proposed for the procurement of the demonstrator is robust. [redacted] suppliers of substation equipment have expressed enthusiasm for the project.

However, the use of a modular approach to transmission substation design and construction will require new operational practices and procedures in order to realise the potential benefits. The Panel was concerned that the considerable work needed to obtain the support of the other TOs and DNOs for the changes in operating practices that would be required had been under-estimated. The possible role of the ENA in enabling these discussions was not discussed in the submission

Panel conclusions. The Panel considered this to be a well-constructed project that would demonstrate a novel approach to the construction and operation of substations at modest cost in the UK. The forecast increase in the number of substations required for the connection of Low Carbon generation as well as the requirement to reinforce and renew existing 132/33 kV substations gives confidence that if the project is successful the modular approach should be adopted widely.

The Panel had two key concerns. The project offers the opportunity for a constructive re-examination and challenge of well-established operating practices. During the bilateral meetings, the Panel expressed concern that the mechanism by which the other TOs and DNOs would be engaged in this was not adequately addressed.

Secondly there was a concern that the modular approach could give the purchaser less flexibility to procure individual items of equipment for the substation from different vendors. Hence there is a need to engage a number of potential suppliers of the modular substation in order to ensure competition.

However, the submission team in discussion was conscious of the need to engage the other TOs and DNOs in the project and solicit bids from the maximum possible number of vendors. Therefore overall the Panel

considered that given the size of potential benefits, the novelty of the approach and the relatively modest cost that the project should be supported.

3.3 Offshore Cable Repair Vessel and Universal Joint - TC Ormonde OFTO Limited - £9.016 requested (£10.329m in total)

There is presently 3.9 GW of offshore wind generation capacity off the coast of GB. The power is exported to shore at a voltage of less than 150 kV through approximately 30 submarine AC cable circuits of total length 920 km. By 2030 it is expected the offshore wind farm capacity could increase to around 30 GW with a total circuit length of 8,000 km (although some of these circuits are likely to use DC cables). The transmission circuits are owned and operated by Offshore Transmission Owners (OFTOs).

The aim of the project is to reduce the cost and time taken for the repair of offshore power export transmission submarine power cables operated by the OFTOs. Two complementary approaches are proposed within the project:

(1) The conversion of an existing telecommunications submarine cable repair vessel to also include facilities for the repair of power cables. The vessel would be made available to all OFTOs through the ACMA (Atlantic Cable Maintenance & Repair Agreement). The converted vessel would be suitable for repair of AC and DC submarine power cables.

(2) The development of a universal submarine cable joint suitable for all OFTO power export transmission cables in service at present. (i.e. AC 3 core, 132-150 kV).

At present faults on the submarine transmission cables operated by OFTOs can be repaired either by using a cable laying ship or by converting a general-purpose ship or barge for the duration of the repair. Both options are expensive and likely to be time consuming. A cable laying ship may not be available when needed and the conversion of a

general-purpose vessel is time consuming and expensive. The availability of a submarine power cable repair ship will significantly reduce the time and cost of a repair. During the bilateral discussions it was confirmed that the cable repair ship would also be suitable for the repair of the DC cables that are used for the bootstraps (i.e. long subsea cables being deployed by the GB Transmission Operators to connect two onshore substations) and interconnectors. There is a clear benefit to consumers by reducing the likelihood and costs of long outages of submarine cables.

Cable manufacturers do not encourage jointing of their cables by others and the development of a general-purpose joint suitable for the offshore wind farm power export cables will increase competition in the repair of these cables.

The Funding Licensee is TC Ormonde OFTO Ltd, one of the three GB OFTOs at present. The main contractor is Global Marine Systems Ltd (GMSL), the owner of the telecommunications repair ship that will be modified for power cable repairs in this project.

Low carbon/environmental and financial benefits. The environmental benefit of the project arises from the reduced cable outage times of the OFTO power export transmission cables. This has been estimated as ranging from 7,220 (present) – 26,689 (2030) tonnes of CO_2 per annum. The annual financial benefits that were estimated by the Funding Licensee are £2.4m (present) and £6.2m (2030) to offshore wind generators through additional revenue and £1.7m (present) and £10.5m (2030) to OFTOs through reduced repair costs.

A considerable part of the benefits, particularly in the short term, accrues to the OFTOs and wind generators and this gave the Panel concern. However, there are some benefits that flow through to final consumers, although partly at the expense of lower profits for generators. The value of this improved delivery from offshore wind farms arising from more rapid repairs is estimated at £0.7 million per year and this accrues entirely to consumers. As interconnectors and the bootstraps are significantly

larger (typically 1 GW capacity) their improved availability would have a material impact on the wholesale price of electricity and hence to final consumers. The Panel was told that the additional benefit from the reduction in repair costs and more rapid repair of faults on interconnectors and bootstraps was estimated to be £28m/year. The panel was assured that the vessel would be able to handle such cables.

GMSL also stands to benefit from owning the modified vessel but a number of measures have been put in place to ensure that it does not profit unreasonably from this.

Offshore transmission circuits are constructed with varying degrees of redundancy depending on estimates of the reliability of the cables. The proposal claims large savings in capital costs as wind farm developers gain confidence that the transmission cables can be repaired quickly and so will reduce or eliminate any redundancy in the future design of offshore wind farm power export transmission circuits. The proposal also argues that the future costs of offshore transmission tenders would reduce as the tenderers would have more certainty that repairs could be carried out at lower cost than at present. However the Panel recognized that as it is usual for the OFTOs to insure against the failure of offshore cables, the benefits that accrue to the transmission system will depend on the insurance market reducing its rates.

Value for money. The modification of an existing telecommunications cable repair ship to include the capability to repair transmission power cables represents good value for money. The operation of the ship through the ACMA will allow the fixed cost of the vessel, that would only be required for repairing occasional faults on OFTO power cables, to be shared with the more common telecommunication cable faults.

The membership fee to the ACMA is charged on a per-km of cable basis, [redacted], with daily vessel fees charged for use of the vessel. There is an

expectation that power companies will be able to join the Alliance on the same terms as telecoms companies.

The profit of GMSL, the main contractor and owner of the cable repair ship, will be limited to 5%. The ship conversion and cable joint repair sub-contractors will be selected by tender.

The project has a Preliminary Phase (in which the costs will not exceed 4% of the project cost [redacted]) to allow for finalising of the specification and the fixed price contract with GMSL for the vessel conversion and joint development. GMSL has committed to supplying the vessel on the terms agreed for a period of 7 years.

Generates knowledge. The outcomes from this project are in two forms:

1 The knowledge from the project in the development and design of the universal subsea joint and modified repair vessel; and

2 The capability to repair submarine power cables that will be delivered by the project and will be available immediately to all interested parties through membership of ACMA.

There will also be knowledge creation in terms of a model for cable repairs, which could be replicated for other circumstances (e.g. shallow waters, other cable types).

The knowledge generated through the project will be shared with all OFTOs who will need to commit to engage with this scheme for the proposed benefits to be realised. A comprehensive close down report will record the learning of the project on both technical and commercial matters.

Is innovative (i.e. not business as usual). Ships have previously been converted for carrying out power cable repairs. However, the use of the modified telecom / power cable repair vessel through the ACMA is

commercially innovative, as is the adaptation of the vessel to move the power cable handling equipment into position rapidly.

A universal joint for offshore power transmission cables would be technically innovative, although universal joints are used for offshore telecommunications cables and terrestrial power cables.

Partners and funding. A key party in the project is the main contractor, GMSL, who will undertake, or be responsible for, the majority of the project [redacted] including the preliminary design phase; vessel modification; and development of the universal cable joint (via subcontractors). GMSL was chosen as the main contractor during the development of the project. There are only two vessel owners contracted to ACMA and only GMSL was prepared to accept the risks of any cost over-run of the fixed price contract.

Global Marine Systems Limited (GMSL):

- owns the world's largest fleet of cable ships, with a particular strength in telecommunication repairs;
- owns the *Wave Sentinel*, which is the vessel that is proposed to be modified for this project. The *Wave Sentinel* operates under the ACMA, and is the only British-based ship to operate under the ACMA; and
- has agreed to the commercial conditions required by the ENIC fund, and have expressed a high level of interest in the concept.

The Panel had some concerns about the level of engagement and commitment from other OFTOs and the limited discussions that have been held so far with other offshore cable owners and operators (including National Grid).

There is no external funding.

Relevance and timing. The maintenance and repair of an increasingly large and critical network of offshore cables is a key challenge associated

with the move to a low carbon economy. These offshore cables facilitate offshore wind connections, interconnectors (which can be used to facilitate renewable generation import and export) and bootstraps (also used to facilitate bulk transfer of renewable generation across the GB national transmission system). Offshore cable repairs are currently expensive and slow. OFTOs have struggled to get a solution to this problem in place due to their difficulties in investing ahead of need given their project based financial structures and the free rider problem, with future benefits being competed away in an OFTO selection competition.

This project seeks to improve the availability of offshore cables for offshore wind generation through using the modified vessel in tandem with the universal cable joint, where applicable to the type of cable, and with existing specialist cable joints for all other types of cable.

Methodology. TC Ormonde has undertaken a considerable body of preparatory work that gave the Panel confidence in the methodology of the project. The equipment required to modify the vessel is off-the-shelf, and the universal joint would be based on proven onshore jointing technologies. In addition, basic design for the modified vessel has been undertaken, and independently reviewed, and the universal cable joint concept has been reviewed. The review of the modified vessel concluded that the work required is significant but achievable, as well as supporting the concept of the initial phase of work. The review of the universal cable joint development also concluded that the work is technically feasible, subject to identification of a suitable organisation to develop the joint and adherence to test regimes and carrying out sea trials.

The Panel had some concerns that the existing telecoms members of the ACMA may not be willing to admit power companies on the existing membership terms or may change these terms for power companies if the solution had any negative impacts on their own services. The Chair of the ACMA who attended one of the meetings with the Panel thought

that given the stability and long standing nature of the arrangement (it has existed for nearly 50 years) and the fact that its rules cannot be changed without agreement of 60+ of its members, this was unlikely. This same reluctance to change rules also precludes a "beneficiary pays" principle in which the OFTOs would pay a higher annual membership fee that would recover the cost of converting the vessel.

Panel Conclusions. The Panel considered this to be an important and innovative project.

The development of a universal 150 kV AC joint and training of jointers will lead to quicker and cheaper repairs of the power export cables from the present generation of offshore wind farms.

The converted repair vessel is flexible and able to be used to repair wind farm power export cables and larger DC cables of the kind used for the bootstraps and interconnectors, although jointing staff from the cable manufacturers would then still be required.

The project is well structured with a preliminary phase (accounting for less than 4% of the budget) during which the main contract with GMSL will be finalised.

The Panel did, however, have some concerns; specifically

- That benefits would potentially accrue to OFTOs that had previously tendered for these contracts knowing the high cost of cable repair – although this benefit would depend on whether the insurance markets reduced their rates given the potential reduction in the costs of repair
- That financial benefits would potentially accrue to renewable generator operators from the faster repair times
- Customers would benefit through lower prices by avoiding a lengthy repair outage, however the savings to the OFTOs and generators could be significant (although OFTO losses through disruption are capped at 10% and the risk is insured)

- And the Fund (paid for by customers' money) would be purchasing an asset for the private sector.

The Panel was also concerned that the agreement with GMSL for use of the modified ship lapses after 7 years, although if the project is successful there would be a clear incentive to extend the agreement.

However the Panel believed that this project had significant benefits for GB customers as a whole in facilitating the more rapid repair of wind farm export cables, interconnectors and bootstraps. Thus, provided that clear and robust safeguards were provided on the following points, the project should be supported.

Before proceeding beyond the Preliminary Phase the following should be addressed:

1 Agreement is obtained from ACMA members to accept OFTOs on existing membership terms.
2 Discussions should be held with all GB OFTOs to ensure they will sign up to the design of the project and examine the potential for making use of the service. This should also be a requirement in future OFTO tenders.
3 Discussions should be held with onshore TOs and other interested parties to make sure the converted vessel will be suitable for the repair of bootstraps and interconnectors and a commitment secured that they will examine the potential for joining the scheme.
4 A mechanism should be agreed with Ofgem whereby savings to the OFTOs that result from the project should be shared with all transmission customers, on a similar basis as for onshore projects.

3.4 South East Smart Grid (SESG) - National Grid Electricity Transmission - £9.707m requested (£11.820m in total)

The transmission network in the South East of England is relatively weak with one 400kV double-circuit along the south coast and limited synchronous generation. The network in the area is increasingly constrained by thermal limits, short-circuit levels, and voltage stability and this will be exacerbated by the two additional 1GW interconnectors expected to connect to the South East before 2020. The business as usual approach to facilitate the connection of these additional interconnectors would require a new 400kV transmission route and reactive power compensation. The planned route would cross the South Downs and would probably give rise to considerable opposition and delays.

This project is to provide an alternative "non-build" or "deferred build" option through the development of a more informed means of managing the system, including adjusting demand and supply on the distribution network. This will be achieved through a combined effort between the System Operator, Distribution Network Operator and Aggregators, by utilising advanced monitoring, Low Carbon Technologies (LCTs) and associated commercial frameworks.

The project will take an integrated approach to monitoring the combined transmission and distribution networks in the region, and managing the transmission system, by controlling load and generation on the distribution network through commercial services. It addresses an important problem in the South East of England but the project has wider relevance where traditional circuit reinforcement is difficult and time consuming.

Low carbon/environmental and financial benefits. It is expected that an additional 2 GW of interconnector capacity will be connected in the South East before 2020. This, together with changes in the mix of regional generation and demand are the key drivers for this project. NGET claims that SESG, in facilitating this increase, and by extending a similar regional management approach to other parts of GB would provide up to £500m/annum of savings for the GB customers through reduced investment requirements, constraint costs, and lower wholesale electricity

prices. In a reply to a question, NG stated that the main benefit of SESG would be to reduce constraints due to possible commutation failure on the existing 2 GW CSC HVDC link at Sellindge when importing power, caused by low short circuit levels. This was valued at £35-45m/annum.

The Panel was concerned by the lack of clarity over which of the many potential issues were really the key ones affecting the power system in the South East, including whether the focus was on real or reactive power. They also noted the limited insight into the nature and potential of techniques that SESG would employ to manage the network, to what extent these would be able to provide a firm and sustainable response, and the consequent financial benefits. Although the cost benefit analysis provided in the revised version in Appendix 6 identifies very large potential benefits, there is a lack of clarity over many of them and the extent to which they are additive or substitutes. This is particularly true of some of the investment savings – e.g. the new transmission line valued at £500 m and the 675 MVar of dynamic reactive power support valued at £60 m. In both cases it is unclear whether they can be avoided or merely deferred, and it may be that the lack of visibility of the capacity of the existing system makes this hard to determine. It is also unclear whether they will be required shortly in any case and whether if they are required they reduce the value of the contribution of this project.

Nevertheless, the amounts of potential savings are so large that even if a small fraction can be realised the project would deliver substantial net benefits to consumers in the South East, and if successful, potentially even greater benefits when more widely deployed.

Value for money. Given the lack of clarity over the objectives of the project and the methodology to be used, it is hard to determine if it offers value for money. There is significant expenditure on Imperial College (£1.5m) and Siemens (£2.6m) and it was not clear that a robust competitive process against a defined scope of work and clear published criteria had been undertaken before they were selected. The Panel noted that around half of the total project cost would be incurred in developing

the monitoring, modelling and data-sets for the combined networks, and felt that the success of this half of the project would be critical to the success of the project overall. It was not clear that committing customers' money to the project, given its level of definition and the way the project plan had been structured, would represent a good value/risk balance.

Generates knowledge. The project is innovative and rather open ended. Thus it will generate very considerable knowledge. The approach of applying wide area management on a regional basis, and also making use of resources on both the transmission and distribution networks, could be expected to advance the industry's knowledge significantly.

Is innovative (i.e. not business as usual). The project is extremely innovative in using generation and load on the distribution network to support the operation of the transmission system, and in applying wide area management in a specific region and across both transmission and distribution. The distributed resources used to support the transmission system will be engaged through a set of commercial mechanisms. There was no Supplier or Aggregator in the project team and it was not clear to the Panel what preparatory work had been undertaken to provide reasonable confidence that there would be adequate firm distributed resources available for the purposes of the project that was not already committed to other projects.

Partners and funding. The project relies heavily on Imperial College, Siemens and Elexon. These Partners have a strong record but it was not clear to the Panel that their anticipated work had been sufficiently well defined. It was also of concern to the Panel that the method by which distributed resources would be procured was not well described. It was also unclear, given the defining role of the distribution network in this project, whether the local DNO was as engaged in the project as might be required.

Relevance and timing. The project is timely and relevant. The transmission network in the South East has a particular set of pressing

problems that need urgent attention. It is an excellent test bed for integrating transmission and distribution networks into a smart grid. The project would yield much timely learning as transmission networks become congested with new interconnectors and increased low carbon generation.

Methodology. The proposed method by which the transmission system is managed by utilising distributed resources is very innovative but not well defined. Hence it is difficult to be confident about the implementation of the project. There is a lack of clarity as to what distributed resources will actually be called upon to do and their anticipated function in the power system.

An important element of the project is the engagement of distribution customers to deliver the services needed to support the transmission system. It was unclear how this would be achieved.

There was limited recognition of previous LCNF projects that addressed the commercial aspects of Demand Side Management or of the current LCNF KASM project proposal, which addresses constraints on the 132 kV network in the South East.

Panel Conclusions. The Panel considered that this was a most interesting and innovative proposal addressing a pressing problem in the South East using an approach that has wider potential applications. However, the Panel was disappointed that the proposal was not developed to the stage where it could be recommended for funding. It is a relatively expensive project and there remains too much uncertainty over the precise objectives and methodology whereby the transmission system could be managed through smart interventions on the distribution system. The Panel was concerned that the detailed objectives and claimed benefits of the project did not remain stable during the discussions and questioning and considered that insufficient preparatory work had been undertaken, particularly over the potential engagement of suppliers of demand side services. There were also

concerns over the value for money associated with the procurement of Imperial College and Siemens.

The Panel was entirely supportive of the ambition to understand better the interaction between transmission and distribution networks and to address transmission constraints through non-build solutions. It recognised the increasing difficulties that the transmission system in the South East will experience with the imminent connection of interconnectors and retirement of synchronous generators. However, it was difficult to obtain a clear picture of the anticipated scope and path of the project. The Panel would strongly encourage the Funding Licensee to use NIA or other funding to address urgently the important issues that have been identified in the proposal and through these funding streams to undertake preliminary work that clarifies the precise nature of the problem(s) causing constraints on the network, their possible solutions and to develop a well-structured plan to undertake the necessary work.

4 Recommendations to the Authority

4.1 We set out below our recommendations to the Authority on the funding of the 2014 Network Innovation Competition projects.

4.2 The Expert Panel recommends that the following project is funded without any conditions.

- **Modular Approach to Substation Construction (MASC) - SHE Transmission**

4.3 The Expert Panel recommends that the following projects are funded but subject to the conditions listed below.

- **Enhanced Frequency Control Capability (EFCC) - National Grid Electricity Transmission**

The Panel recommends that the funding for Work Packages 2.3 and 2.4 of this project is made contingent upon the Licensee demonstrating to the satisfaction of Ofgem that Work Packages 2.3 and 2.4 are being undertaken at minimum practical cost. In particular no battery or inverter equipment should be purchased until the Licensee has taken all reasonable steps to make sure that no other battery and inverter equipment bought on previous innovation projects funded by Ofgem can be used to obtain the required learning.

- **Offshore Cable Repair Vessel and Universal Joint - TC Ormonde OFTO Limited**

The Panel recommends that funding for this project beyond the preliminary phase (which will not exceed 4% of the project budget) is made contingent upon the Licensee:

1. Securing agreement from ACMA members to accept OFTOs on existing membership terms.
2. Holding discussions with all the GB OFTOs to ensure they will sign up to the design of the project and examine the potential for making use of the service.
3. Holding discussions with the onshore TOs and other interested parties to make sure the converted vessel will be suitable for the repair of bootstraps and interconnectors and secure a commitment that they will examine the potential for joining the scheme.
4. Agreeing a mechanism with Ofgem whereby savings to the OFTOs that result from the project should be shared with all transmission customers, on a similar basis as for onshore projects.

4.4 The Panel recommends that the Authority does NOT fund the following project.

- **South East Smart Grid (SESG) - National Grid Electricity Transmission**

The Panel agrees that the transmission system in the South East of England requires urgent attention with the imminent connection of two new interconnectors and increasing distributed generation. The traditional solution of a new 400 kV circuit and reactive power compensation would be expensive and very time consuming to build. The proposed alternative solution of using additional monitoring in the area and distributed resources on the distribution system to manage the transmission network was innovative and with wide potential applications elsewhere.

However, the Panel was left with no clear understanding of the cause and extent of the constraints that would be addressed, the mechanism by which they would be resolved and whether the team had a well thought through plan that would deliver the project efficiently. Thus the Panel was unable to recommend the project for funding at this time.

Recognising both the importance of addressing the situation in the South East and the innovative nature of the solution proposed the Panel would encourage further work using NIA or other funding to clarify the problem and method of solution prior to a possible fresh submission.

4.5 Overall, the Panel was pleased to see a number of relevant and innovative proposals that offered significant potential benefits to customers through supporting the connection and integration of low carbon generation. It would be useful to remind the Funding Licensees of those aspects of the evaluations that caused the Panel difficulty so that these can be addressed in future submissions.

- It is important that the Panel is provided with a clear, consistent and quantified understanding of the problem that is being addressed together with the technical and commercial innovations being proposed for its solution. It is of concern, particularly as bid development costs have already been paid, that some proposals required considerable time by the Panel and consultants before a

clear understanding of the problem and method of solution was obtained.

- It is similarly important that the Panel is provided with a clear, consistent and quantified understanding of the benefits of a proposed project (where appropriate by method). Every effort needs to be made to state and explain the underlying assumptions in the submission.

- A number of the Panel Members also serve on the LCNF Panel. The LCNF competition has been running for several years and it is noticeable that the clarity and accessibility of the submissions has increased over time. Specifically, the LCNF submissions have now greater clarity on the individual tasks to be undertaken, how and by whom these will be carried out and the expected outcomes.

- It appeared to the Panel that there was also a considerable difference in the maturity of the content of the proposals and their readiness for implementation. The use of IFI, NIA and other funding for preparatory work is strongly encouraged.

- There is a tension between engaging partners at an early stage of the development of a project and subsequently carrying out a competitive procurement exercise on a well-defined scope of work. The Panel would encourage Funding Licensees to consider how best to manage these two, often distinct, phases of work to achieve best value for customers.

- The Panel noted that some steps had been taken to extend and formalise the identification and selection of universities and would encourage the Funding Licensees to continue with this in order to widen the pool of potential partners and ensure value for money. It is essential that the scope of work to be undertaken is properly specified and that there is some evidence of a competitive process.

- The Panel was particularly pleased to receive a well-prepared bid from an OFTO and would encourage future submissions addressing offshore networks.

- The Panel noted an emerging theme in the proposals of a closer integration of transmission and distribution systems. However, there was limited evidence of close interaction between TOs and DNOs in the preparation of the bids and this needs to be improved.

- Several of the projects focussed almost exclusively on technical issues and paid insufficient attention to customer engagement and the intended transition into business as usual. Experience from LCNF projects has shown the considerable difficulty of engaging customers in Demand Side Response but this learning was not acknowledged in some proposals. Similarly the transition phase from the completion of a successful project to the Method being adopted as Business as Usual needs to be spelled out.

- The Panel would like to reiterate its concerns about Successful Delivery Reward Criteria: these should be tied to outcomes and not just stages in the process.

- The Panel are always reassured by the presence of senior management at the evaluation meetings to demonstrate the commitment of the organisation to the project and a preparedness to take the results of the project into business-as-usual. In order to encourage greater diversity in project teams, it is possible to bring different project members to different bilateral meetings.

4.6 The Panel would like to thank the project teams for their hard work and for their engagement during the evaluation process; we would also like to thank the external consultants and the Ofgem team for all of the support and assistance that was provided.