*Electricity Network Innovation Competition Full Submission*

# *Supplementary Answer Form*

# Project: OSEAIT

Tick if this answer has been provided verbally: ☐

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| Project code | NGET_OSEAIT | Question Number | 36 |
| Question date | 16 October 2015 | Answer date | 21 October 2015 |
| Submission section question relates to | Projects | | |
| Topic | Costs | | |
| Question | Please provide the following for each identified 'NIC funded projects':<br>(a) A description of the project<br>(b) An assessment of how each project meets NIC evaluation criteria (a) and (d) | | |
| Notes on question | The evaluation criteria this question refers to are:<br>(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.<br>(d) Is innovative and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness. | | |
| Answer | The 'NIC funded projects' are suggested projects to be agreed by the Technical Advisory Board and are discussed in Section 6.9 of the first submission document. They are individually discussed from a financial perspective in answer JA_06 of the document developed to answer the questions raised at the first bilateral meeting.<br><br>It might nevertheless be the case that, following the updated prioritisation process, other projects with a different ratio of environmental/financial benefits is developed.<br><br>It is important to note that the cost for the delivery of these projects or a portfolio equal to this effort, is already included | | |

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| | within the bid. The bid also has approximately 30% headroom in labour to deliver further projects not included here.<br><br>**1. Evaluation of New Conductor Systems / New Inspection & Condition Assessment Techniques**<br><br>A detailed description can be found as part of the answer to Nick Jenkins following the first bilateral meeting. These two projects aim to deal with the new and the old overhead line systems. In the last few years there has been a rise in new materials being developed. This has led to a surge in new conductor technologies offereing lower losses and increased capacity for the same dimension. Some of our life trials have led to the discovery that these improved capabilities sometimes came alongside challenging installation issues and unwanted operational performances such as increased noise levels or vibrations. This work aims to trial the latest conductor technologies, including fittings, to understand their performance and capabilities.<br><br>For installed equipment, we need to improve our understanding of their degradation mechanisms. With these assets being located in remote areas and at height, it is important to develop technologies that allow us to inspect and monitor these assets easily, with confidence and ideally, non-intrusively. This project aims to develop the understanding of overhead lines and fittings as well as how technologies like non-contact x-ray or hyperspectral analysis can be of use.<br><br>(a) Uprating of conductors without impacting visual amenity would reduce environmental impact and allow lines to be upgraded to accommodate increased flows due to renewables. Furthermore, evaluation criteria to allow life extension of conductors and fittings would reduce the environmental impact of unnecessary decommissioning ahead of the assets' end of life.<br><br>(d) The work proposed here has never been conducted in the UK to this level of precision and understanting.<br><br>The conductors proposed by new entrants or old entrants with new materials and designs to reduce the cross-section of the conductor whilst maximising their operational |

specifications, have never been tried in the UK.

Whilst new sensor/monitoring technologies are consistently introduced to the market, the challenge of developing an understanding of the output means that, in many cases, it is very difficult to identify a resulting action following the inspection. Furthermore, laboratory trials of many of these technologies cannot take into account the challenges faced when taking the measurements on a stringed conductor, several hundred meters above ground.

**2. Circuit Breaker Monitoring**

To date there is no cost effective monitoring system available for circuit breakers with functionality that indicates a range of possible faults during normal switching operations. Conventional monitoring systems have many expensive sensors to measure specific aspects of the circuit breaker operation (e.g. contact travel, gas and hydraulic pressures, etc.) but there are constraints associated with the need to reduce the requirement for outages necessitated by the sensors and to find solutions which offer enhancements above current practices.

This project aims to use both healthy and defective circuit breakers to evaluate conventional and novel monitoring techniques to identify defects earlier to optimise maintenance, predict asset life and avoid preventable failures.

(a) Life extension of switchgear delivers benefits due to delayed decommissioning and reduced operational costs.
(b) There is currently no condition monitoring system whose output can be used to enable the enhanced planning, management and maintenance of these critical assets.

**3. Low and medium voltage switchgear panel monitoring**

There is presently no method available to successfully monitorin low and medium voltage switchgear panels without opening them. This project builds upon the previous project, Circuit Breaker Monitoring, to develop this capability.

The project will remove existing in service switchboardsand bring them to the facility. They will then be monitored until failure occurs.  Apart from an increase in knowledge of their failure mechanisms, we will understand whether the same

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| | technology can be used to monitor lover voltage / different technology equipment.<br><br>(a) Life extension of switchgear delivers benefits due to delayed decommissioning and reduced operational costs.<br>(d) There is currently no cost-effective, online system to deliver actionable outputs upon confident decisions can be made.<br><br>**4. Insulation defect monitoring in gas insulated switchgear filled with $SF_6$**<br><br>Present condition monitoring technology in this area can efficiently detect certain types of defects as long as each gas section is monitored. Nevertheless, irrespective of this detection, the impact the failure has on the asset's end of life is not very well understood. Confident actions to maximise investment are hence difficult to make. This project will apply tools and techniques to improve the ability to detect insulation defects in substations of this nature by running the assets through to failure under various environmental and loading conditions.<br><br>(a) Life extension of switchgear delivers benefits due to delayed decommissioning and reduced operational costs.<br>(d) There is currently no cost-effective, online system to deliver actionable outputs upon confident decisions can be made.<br><br>**5. HV Harmonic Impact on Transformers**<br><br>This project aims to understand the impact of harmonics over the lifetime of transformers as a result of the connection of renewable generation on to the network, with the intention of understanding the potential impacts to asset lives and what options are available for mitigation.<br><br>Renewable energy systems such as wind farms and solar photovoltaic (PV) installations are being considered as a promising generation source. With the incoming high penetration of distributed generation and direct feeds from wind farms it is it is not fully known what the effects are on a large asset such as a transformer.<br><br>The use of power inverters used in the generation of renewable energy causes high frequencies or distorted sine waves to be transmitted into the network. These can have |

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| | adverse effects on assets that were not designed with this in mind. Harmonics can cause increased hysteresis losses within a transformer, and in the case of a transformer that is heavily loaded can cause :-<br><br>• Increase the operating temperature of a transformer<br>• Cause insulation damage through localise heating<br>• De-rate a transformer<br>• Cause irreversible damage<br>• Reduce asset life<br><br>There are 2 key drivers for this project are; to increase the understanding the effects of harmonics on a Supergrid transformer (stray Eddie currents, heating, losses, etc) through measurement and to evaluate any mitigation options.<br><br>**6. Tap Changer Monitoring**<br><br>Degradation of tap changers in transformers can lead to the catastrophic failures of the transformers themselves. Nevertheless, very little is known about their degradation mechanisms. Similar to the other projects described in this answer, the aim of this work is to develop our understanding of the failure mechanisms which would allow us to develop more detailed and dynamic degradation curves and allowing us to replace faulty equipment before failure.<br><br>(a) This work can potentially yield high financial benefits as the monitoring of smaller assets can prevent the catastrophic failure of SGTs. The financial and environmental benefits relate to the life extension of these assets and their failure prevention.<br><br>(d) There is presently not cost-effective way to monitor tap changers.<br><br>**7. SF6 Leak Management and Repair Techniques**<br><br>Please refer to the answer to Nick Jenkins following the first bilateral meeting.<br><br>**8. Asset Thermal Model for Remote Operations**<br><br>Please refer to the answer to Nick Jenkins following the first bilateral meeting. |

## 9. RFI Sensitivity and Characterisation

An early indicator of defects in the high voltage insulation is tiny electrical arcs anywhere between the conductor and earth. These 'arcs' can be detected in various ways, with one method is to look at the radiometric or small transient signals emitted from these defects. Due to the various ways of a signal being generated or transmitted from within or external to the asset, it is can lead to mis-interpretation or lack of confidence in the technique. The aim of this project is the enhance our understanding of the non-intrusive measurement made from RFI and pd (Partial Discharge) to define better limits to enable better asset management decisions while managing risk associated risks, including failures, operational, and the surveying in a high voltage environment. The project will enhance the correlation between the non-intrusive measurement and conventional measurements such as impedance and bridge measurements from known sources in known locations.

RFI in air insulated substations have been used for many years as a general surveying tool to assess whether an asset is showing 'abnormal' stress, critically relaying on the operators experience with the phenomenon and knowledge of the asset. This has generally been used in addition to the maintenance program to look for defects while the asset is in service. The benefit of RFI surveying is that it can detect many partial discharge sources, it weakness is that many of these sources can be man-made (mobile phones, digital tv, etc.) or benign from an asset integrity viewpoint.

As part of the move to condition based maintenance, in order to improve availability, reduce cost and avoid failures, has moved the dependency of this type of data from additional information on an assets performance, to being part of the critical path for its ability to perform and remain in service.

The combination of increased capability in the technology, need to remove avoidable false positives from interpretation reducing cost, and the dependency on being able to assess the condition of an asset while keeping in service needs a better methodology to normalise the data a provide quantitative data into analytical models that will enable change.

(a) Reduced operational costs and improving our knowledge of assets allowing us to maintain or refurbish them before replacement is the only viable option. It will also provide further capability to run assets closer to their end of life.

(d) There is presently not sufficient understanding to correlate the measurements to their cause. This leads to

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| | actions which are not optimised.<br>**10. Digital Data and Visualisation**<br>This project looks at merging all the outputs from all the systems which are being delivered as part of this bid and investigates ways to display them so that an operator can make confident and quick decisions. A lot of sources of information and a lot of information itself is needed to take asset management decisions. At present this requires various systems or the movement between different windows in the compuer to try and understand it all.<br>This project brings this work together from an asset management perspective and investigates new multi-vector visualisation techniques and improved methods of information organisation and display.<br>**11. Degradation Curve of a hot Joint**<br>This project aims to non-intrusively detect defects that would demonstrate themselves with an abnormal thermal signature, without the need to reconfigure the network, while avoiding false negatives. This will be achieved by developing a 'hot joint model' that is able to normalise the predicted temperature using measurements captures during a survey. These will include temperatures, load and ambient conditions. The initial objective is to have some generic models for load carrying components, non-load carrying and indoor/outdoor.<br>a) Life extension of switchgear delivers benefits due to delayed decommissioning and reduced operational costs.<br>d) There is currently no cost-effective, online system to deliver actionable outputs upon confident decisions can be made.<br>**12. Conductor Audible Noise**<br>Some overhead lines occur close to built up areas and their corona impact local consumers. This project does not directly yield significant financial benefit, it provides a better environment to consumers and helps us deliver solutions to reduce the impact the network has on their lives.<br>**13. Architecture for substation secondary systems**<br>This project will develop and field trial the future protection and control solutions for National Grid Transmission substations. It will produce an efficient implementation |

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| | methodology for IEC 61850 which addresses the system access limitations and asset management challenges currently being faced.<br><br>The project will investigate benefits in the following areas:<br><br>1. The design and development potentially can be standardised at all levels (station, bay and interfaces) within a substation. This will allow proven solutions be used repeatedly for different projects/sites, thus the project risks and resources will be minimised saving time and money<br><br>2. The installation and commissioning will be much safer and quicker than traditional approaches. The "plug and play" will be possible for the installation and replacement due to use of IEC61850 based fibre optical bus and standardised interfaces. Therefore the required outages of primary system will be significantly reduced ensuring availability is maintained. Safety, health and environment are improved by reducing the need for cross site secondary circuit cabling migrating associated risks<br><br>3. The operation and maintenance could greatly benefit from the new approach. Full deployment of digital technology and removal of copper wirings should make the operation of the secondary system more reliable as faults can be more easily recognised and replaced. This would also challenge the traditional concept/requirements for maintenance. The new technology will enhance functions such as condition monitoring and remote access, which should further improve the operation and maintenance by providing real time information to enable the operator to take the best informed action. This process will be safer as the new secondary systems transmit data of CT and VT analogue signals via bay process bus. This poses no safety risks of opening CT circuits, and hence improving the safety when the protection replacement is carried out with primary circuit in service<br><br>4. The replacement and de-commissioning can be achieved in a quick plug and play manner. Components used will no longer be limited to a specific manufacturer due to Inter-operability/Inter-changeability facilitated by the IEC61850 protocol. This will significantly reduce the requirements and costs for the Post Delivery Support Agreement (PDSA). By enabling any unit to be replaced by any other IEC61850 machine therefore not tying NG into uncompetitive PDSA's. The new technology using IEC 61850 communication protocol will enable vendor interoperability and easier modification and extension of the secondary schemes, particularly allowing reconfiguration and feature enhancement by software means, rather than the modification of hardwiring as would have been the case in the past. |

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| | This work can only be peformed at a facility as the one proposed due to the following reasons:<br>1. Working in an operational substation will require very long commissioning programmes to enable a different solution to be accepted onto the system. This facility provides a unique opportunity to develop the solution and also optimise the implementation procedure off-line rather than having to work in the confines of an operational substation.<br>2. Does not require the constant supervision of a Senior Authorised Person (SAP) during any work which could trip a circuit. This is a scares resource and required to deliver the capital plan and ongoing work on site. This makes the engineering and commissioning cheaper and faster.<br>3. Affords the opportunity to get it wrong without affecting customer's security of supply. Protection and control replacement requires knitting in between new and legacy systems.<br>4. Trial evaluation<br>a. Easier to supervise and monitor performance<br>b. Can impose onerous operating conditions to test the solution in situ (this can't be replicated in a lab)<br>5. Cost viability due to economy of scale via ability to do multiple projects in parallel and utilisation of test equipment and resources over a long period of time.<br>a. Deeside is typical of transmission substations and will present most of the challenges<br>b. The site has a range of bay types on site that represent the functionality on most sites<br>c. Presents the ability to repair, test, modify, and repeat without impacting customers or the network<br><br>**14. Backfilling of current gas insulated switchgear with alternative gases**<br>Please refer to the answer to Nick Jenkins following the first bilateral meeting. |

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| Attachments | |