Date of Submission

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Network Innovation Allowance Closedown Report

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

Project Closedown

Project Title		Project Reference
Alternative Bus Bar Protection Solution		NIA_NGET0064
Project Licensee(s)	**Project Start Date**	**Project Duration**
National Grid Electricity Transmission	Mar 2011	3 Years

Nominated Project Contact(s)

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Scope

A policy for single Digital Bus Bar Protection has been employed on the National Grid UK Transmission network since 2002 either as a replacement system (for duplicated high impedance schemes) or for all new build double bus bar substations. These systems have a distributed architecture with remote bay units (interfacing to the plant) for each protected circuit with ruggedized cross site fibre connections to a central processing unit. Where a substation has a centralised relay room (e.g. GIS) layout, the bay units are co-located in a suite of cubicles and connected with a network of fibre patch cords.

Objective(s)

This R&D Project aims to deliver an evaluation and desk top design solution of an alternative digital bus bar solution architecture. This will help formulate a future technical and procurement strategy for bus bar protection, potentially leading to a pilot installation, evaluation and deployment as a replacement (or new) bus bar protection system.

Success Criteria

This project will be successful when it reviews designs and products used by other utilities for adoption on the UK Transmission system. Further success is an option to install a viable digital bus bar protection system.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

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A number of different Busbar systems and versions have been supplied and installed from National Grid's preferred protection suppliers and Alliances over the past 20 years and these have required additional support through contracted Post Delivery Support Agreements (PDSAs) to provide field staff with the resources to manage faults and defects. A recent protection policy change also requires a second (hot standby) central processing unit to be deployed (with it own dedicated fibre connections) to better manage contingency issues for central processing unit failures.

The systems installed to date have proven to be generally reliable; however each system is bespoke to each supplier with a limited technical life, leading to issues with future substation extensions and potentially the need to consider equipment upgrades and early asset replacement of the complete system. This will have major issues on future system access to carry out this work across a complete substation.

Through work with CIGRE, contacts have been found with other utilities and National Grid US, it has been found that an alternative centralised bus bar protection system may offer greater asset management benefits in the longer term, especially when managed and supported by well trained internal staff.

The project consisted of three phases, with progress reported against each phase below.

1. For the initial appraisal a set of application interface designs and layouts for the busbar protection were produced. The designs were completed in 2013/14 and a prototype was successfully developed. Initial testing identified a requirement for further investigation to better understand the functionality and software to ensure complete confidence in this innovative protection equipment.
2. Stakeholder review. This was carried out in 2013 and a finalised set of application interface designs and layouts were produced. During 2014/15 the prototype was delivered to site. Some redesign work was undertaken to ensure the equipment was configured for use on the UK transmission system. The unit was built and a testing methodology was developed to undertake comprehensive analysis for evaluation of the phase segregated system.
3. Evaluation. The site work has now completed and the project is now undergoing a completion process. The outcomes will be evaluated and documented in a full completion report available on request.

The knowledge gained has resulted in changes to the relevant National Grid Technical Specification (TS 3.34.24) to incorporate a phase segregated busbar protection system.

Required Modifications to the Planned Approach During the Course of the Project

Project time scales were extended by 12 months due to resource availability and additional work required to configure the prototype for the UK transmission system.

Following an initial review of systems in use by other utilities, the scope was expanded and focussed on an investigation of a phase-segregated Centralised Busbar-Protection system as an "in-house build" for use on the UK Transmission System. Additional criteria to address the extended scope included the following:

- Assess the product capability and capacity based on a per phase application, i.e. one relay per phase.
- Assess the feasibility for National Grid to design, build and maintain a system completely in house.
- National Grid Technical Specification TS 3.24.34 has been modified to allow for phase segregated Centralised Busbar Protection.

The following list highlights the individual successes gained through the undertaking of this project:

- The experience and learning has provided input into existing National Grid technical specifications and policy statements for busbar protection solutions.
- The project has provided National Grid with an insight into the alternative cost effective busbar protection solutions available within the supply chain.
- The project has raised an awareness of the steps and process required to develop and implement a pilot project for a phase segregated busbar protection solution.
- The working test rig for a phase segregated busbar protection solution has been successfully developed.

This project completed within budget. Budget was £145,000 final costs were £142,000.

Lessons Learnt for Future Projects

The trial has proved the concept of a phase segregated busbar protection system and highlighted the key requirements for UK transmission system applications.

- The inter-operability between the relays using DNP3 has been proven and further modification to IEC61850 communication protocol will help the next stage of development for integrated protection systems. Once this phase has been completed the compatibility of the IEC61850 communication protocol will allow the integration of other protection components/products into the new busbar protection solution.
- Learning from this trial can be used to complete minor modifications to the tested system to bring it into line with the developed TS for future applications. Such modifications will help improve the functionality and performance of the overall solution. Through this learning the technical specification will be developed in a manner which allows future modifications and improvements to be made with minimal resource and time commitments.
- The knowledge gained on the 487B relays can be used for the further development of future National Grid Technical Specifications. This knowledge will help to make the management and production of future technical specifications more efficient and will feed into other busbar protection documents/projects ongoing within National Grid.
- A trial project can be developed for National Grid to further understand and gain experience for the application of a phase segregated busbar protection to the transmission system. The busbar protection solution could be trialled at a National Grid substation and interfaced to the transmission system in a secure and safe test environment. This would allow a full assessment of how the busbar protection solution would perform and interface with other plant/equipment on the real transmission system to be made.
- For future projects of a similar nature a more accurate forecast of the components needed at the very start of the project would save on time and resource commitments as the work progressed.
- By up and interfacing the solution with the real substation environment at the very start of future projects will help save on transport and labour costs as the project progresses.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

Since adopting numerical BBP systesm, National Grid has experienced significant operational advantages when compared with tranditional, high-impedance schemes;

- The numerical BBP systems allow for reduced maintenance activities and the in-built monitoring functionalities provide more effective supervision. Traditional high impedance schemes have limited supervision facilities, which may result in hidden defects going undetected.
- The installation and commissioning process for numerical BBP systems is vastly more efficient. This is mainly due to the ability to carry out pre commissioning testing in the factory environment where site configuration can be easily replicated in central units.
- Substation extension has proved onerous in the past for high impedance BBP schemes. The modifications required to cater for increased fault levels has resulted in design and commissioning issues. Numerical BBP schemes facilitate the ease of substation extension. Pre site commissioning testing can be conducted through a factory acceptance test. Physical modifications are minimal and are generally limited to the connection of a bay unit to the CU using fibre optic. National Grid has learned to cater for the issues of compatibility associated with the addition of new bay units to older CU's.

In the event of a bay unit failure, following switching out the affected primary bay, it is felt that an alternative method allowing for a more efficient return to service of the remainder of the BBP system could be provided.

National Grid's experiences have shown that a contingency plan or provision of a second standby central unit is essential to cater for central unit failures.

National Grid's experiences to date with numerical BBP systems have highlighted the absolute necessity for spares holding and the role of post commissioning support from the suppliers. Without the correct spares to deal with failures and compatibility issues, resultant operational restraints would be unmanageable.

The BBP systems installed on National Grid's networks operated correctly for an in–zone power system fault. There have been no BBP mal-operations coincident with an external power system fault. The estimated availability of the installed BBP systems is better

than 99.9%.

The completion of the project has produced the following outcomes:

- The knowledge gained on the 487B relays has been used in the development of the Technical Specification (TS 3.34.24) modifications.
- Analysis of the input/output (IO) capability identified the limitation of the relay for compliance against National Grid standards. In conjunction with Schweitzer Engineering Laboratories (SEL) an additional IO module 2240 was implemented and proven to be functionally acceptable.This uses DNP3 communication protocol over Ethernet to communicate with the three 487B relays.
- The limited I/O capacity identified has subsequently been recognised in Centralised Busbar Protection systems offered by other suppliers. It is probable that additional add-on I/O modules will be required to work with these relays and the knowledge gained in this trial gives National Grid the confidence to accept this design method without undue delay.
- A software modification is required to enable IEC61850 communications between the 2240 I/O module and the 487B relays. This will allow interoperability testing using the defined NG IEC61850 format between IEDs from different suppliers. For example, a GE B60 relay could be integrated and a SCS bay unit integrated for alarm reporting over Ethernet.
- An additional 487B relay is required to complete a configuration change and complete full functional testing to the modified NG TS 3.24.34. This will then allow a trial application of a phase segregated system at a National Grid substation.

Dissemination

The findings and learning from the work undertaken will be disseminated through meetings with external stakeholders, including manufacturers and other Transmission System Operators (TSOs). Internal workshops within National Grid can be held to review the findings and scope up further work.

The following dissemination plan has undertaken:

- Through modifications to the TS the knowledge and experience will be disseminated through National Grid.
- All the relevant documentation (Notes/Meeting minutes etc.) will be stored in a central location where authorised personnel with be able to access the information from the project.
- Meetings will be held within National Grid to further progress the trial application and devise a suitable strategy for delivering such a solution.
- Attendance at conferences or seminars on low impedance busbar protection which are relevant to the trial project in National Grid.

A paper “Modern Techniques for Protecting Busbars in HV Networks” was published in October 2010 to the Working Group (B5.16)

The Technology Readiness Level for this project started at a level 6 and completed the project on a level 8.

Planned Implementation

The next phase is a full assessment of the panel design, minor build and configuration modifications to comply with Technical Specification (TS) 3.24.34 and system testing before implementing on a Substation. Once the required modifications have been applied to the TS and this has been approved internally within National Grid the planning and commencement of a pilot project to extend the existing scope of work can begin.

In order for a pilot project to commence the following actions will need to be completed:

- A detailed plan to take into account the time period for each phase of the trial project.
- A robust resource plan to ensure each phase of the project can be successfully delivered on time and to budget.
- A materials projection list to ensure all components can be sourced externally or internally early on to avoid any undue delays.
- A work procedure put in place to ensure all wiring and terminations comply with the relevant National Grid Policy and Technical specifications.
- A detailed plan highlighting possible transmission outage/access dates for installation, testing and commissioning.
- Assess the requirements of type registration for delivering a successful prototype.

Other Comments

The trial has proven the concept of a phase segregated busbar protection system and the key requirements for National Grid and UK Transmission applications. Technical issues have been identified (and overcome) and the knowledge gained will be used to implement future Centralised systems.

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