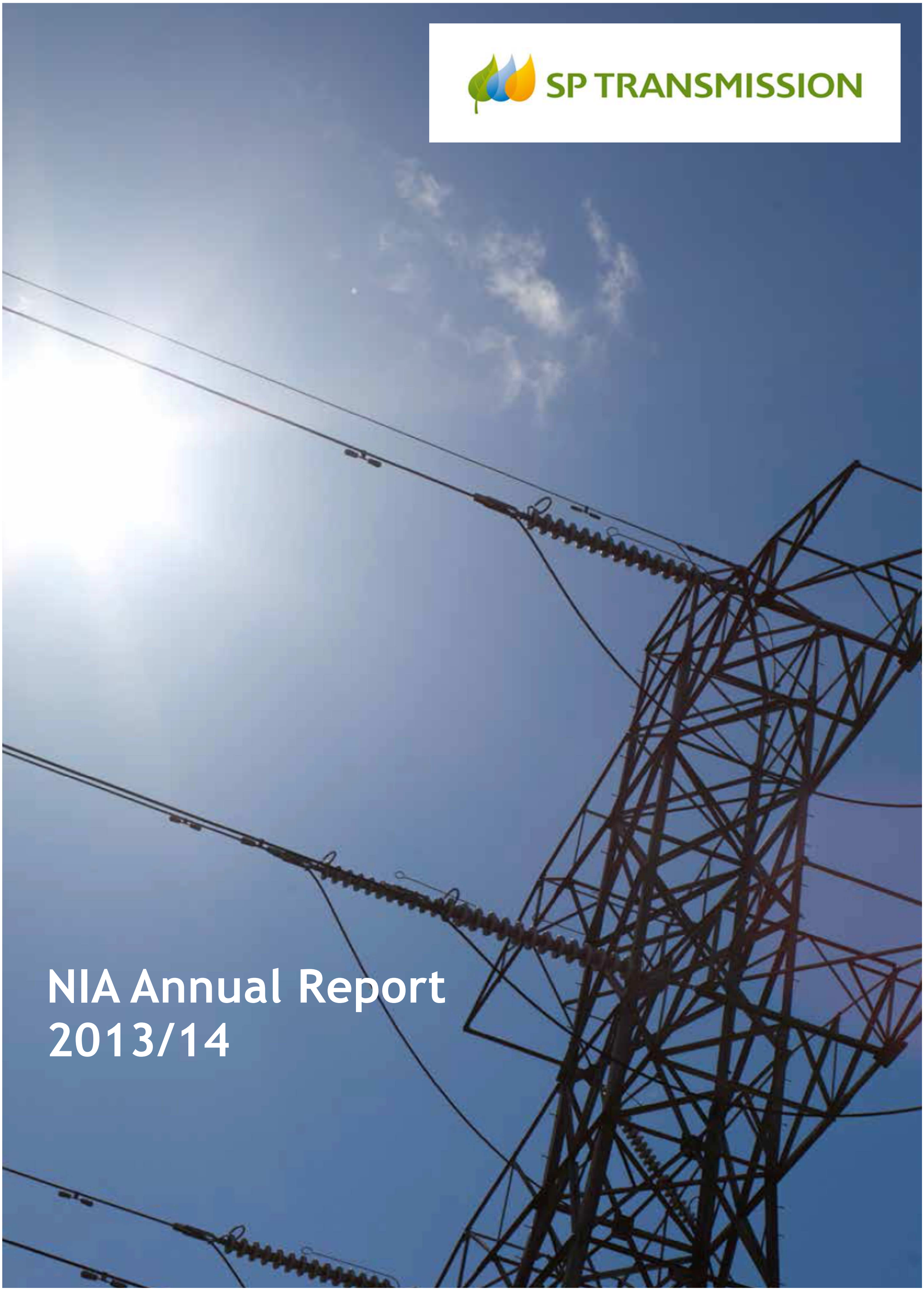
SP TRANSMISSION



NIA Annual Report 2013/14

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Foreword

ScottishPower Energy Networks (SPEN) is committed to delivering the Transmission Grid of the future through our licensed business ScottishPower Transmission. This is our first Network Innovation Allowance (NIA) Annual Report, and given that this is the first year for NIA funding represents a snapshot of the projects we have initialised during the regulatory year 2013/2014.

Today the transmission system faces many challenges from the growth in renewable generation and the decline in the more traditional thermal generation. These challenges are driving our project selection choices to ensure that we meet the needs of the transmission system stakeholders. A stable, resilient transmission system has and must continue to provide the backbone of the UK's electricity networks. As the generation mix and the location of that generation changes so must the transmission grid change. SPEN must make the right investment choices for our transmission system while balancing cost efficiency, resilience and stability and it is the insights gained through delivering NIA projects that will give us that knowledge and ability.

Our portfolio of Transmission NIA projects will continue to grow as it meets these challenges head on and we look forward to 2015/16 when we will be reporting on our combined Transmission and Distribution NIA successes.

George Spowart

Engineering Director

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Executive Summary

Our first Network Innovation Allowance (NIA) Annual Report has been compiled in accordance with Ofgem's Electricity Network Innovation Allowance Governance Document which sets out the regulation, governance and administration of the Electricity NIA. This first NIA Annual Statement presents a snapshot of the projects we have initialised during the regulatory year 2013/2014.

The progress of each project aligns with the five innovation objectives set out in our Transmission Innovation Statement:

- Innovation meeting the needs of stakeholders;
- Innovation opportunities are identified in a timely manner, which will benefit these stakeholders;
- Innovation is managed in an efficient and proactive manner;
- A balanced portfolio of innovation is pursed which includes commercial, process and technology innovation; and
- The outcome of innovation activity is adopted by the wider business to ensure that customers benefit at the earliest opportunity whilst minimising the risk to the integrity of the network.

Our NIA innovation project portfolio will continue to be shaped by on-going stakeholder engagement, both internal and external, with a view to maintaining a balanced portfolio that will address not just the near/medium term transmission issues, during the current price control period, but also those anticipated as longer term requirements.

In addition to funding smaller projects, we have successfully utilised the NIA funding to prepare for the Network Innovation Competition (NIC) submission. One of the direct outcomes is the application of VISOR (Visualisation of Real Time System Dynamic Performance) under the NIC regime in 2013, where SPT leads a consortium of transmission licensees to challenge the existing technologies on wide area monitoring and generate the innovative approach to carry out real time assessments.

We will continue our strong commitments in innovation and to ensure that our innovation at SPT is:

- Meaningful, tangible and adaptable for business;
- Is carried out in an efficient, coordinated and collaborative manner; and
- Represents value for money for customers in the long term.

At the outset of any NIA project development consideration will be given to the road map to adoption of relevant innovative techniques, technologies and processes with the ambition to expedite the transition to Business and Usual status.

We trust that you will find this report informative and will continue to proactively learn from other licensees or learn by doing while sharing knowledge gained in order that the transmission business plays its part in achieving the UK low carbon aspirations.

1 Introduction

Scottish Power Transmission has obligations to meet the Special Condition 3H (The Network Innovation Allowance) of the Electricity Transmission Licence, which was introduced as one of the key innovation proposals for the RIIO-T1 (Revenue = Incentives + Innovation + Outputs, 2013-2021) model for price control. The purpose of the NIA is to encourage Network Licensees to innovate to address issues associated with the development of their networks.

NIA is to provide a consistent level of funding to Network Licensees to allow them to carry out smaller innovative projects for two purposes:

- To fund smaller projects which meet the criteria set out in this Governance Document; and
- To fund the preparation of submissions to the Network Innovation Competition (NIC) which meet the criteria set out in the NIC Governance Document.

From that point of view, NIA plays an important and integrated role in uplifting the technology readiness levels (TRL), preparing for flagship demonstrations at national level and knowledge sharing.

It is acknowledged that the transmission network will experience unprecedented change in response to realising the low carbon ambitions for the UK. In order to meet the associated challenges innovative techniques, technologies and processes will be required to develop the transmission network. This is recognised by the fact that Innovation is a key element of the new RIIO - T1 model for price controls with the introduction of the NIA.

This report presents SPT's NIA activities during the first year of its introduction, summarises progress made against objectives and highlights areas of significant new learning.

Developments in our transmission network over recent years have fundamentally been driven by an ongoing process of stakeholder engagement. SPT has identified a number of key themes as a result of our ongoing stakeholder engagement which are the principal drivers behind our innovation strategy.

Following a comprehensive stakeholder mapping activity, which formed part of our Transmission Innovation Strategy published in 2011, the key outputs from subsequent stakeholder engagement to date have been:

- Communicating with stakeholders to understand their needs and expectations more effectively;
- The connection of customers (demand and generation) onto the network to deliver sustainable low carbon energy through fair, clear and accessible processes;
- Maintain security of supplies and maximise long term value for end-users through improved network availability and reliability processes; and
- Minimise the environmental impact of our operations.

SPT recognise that consideration needs to be given to not only the RIIO-T1 period and stakeholder's immediate needs, but also how we address the longer term issues which the transmission network may face. This is being addressed through a balanced portfolio of innovation projects where we are considering some of the longer term issues which may involve technology and techniques at a lower technology readiness level as well as immediate challenges to be faced over the next decade. This consideration is detailed within the report along with details of how our NIA activities link to SPT's innovation strategy.

2 Progress Summary

During the reporting year 1st April 13 to 31st March 14 ScottishPower Transmission registered a total of ten NIA projects. Of these, the following four projects had been initiated under the Innovative Funding Incentive (IFI):

NIA SPT 1301 Electrical Power Research Institute (EPRI) Programme Engagement

NIA SPT 1302 Enhanced Weather Modelling for Dynamic Line Ratings

NIA SPT 1303 IEC 61850 Integration of Substation Protection and Control - Test Facility

NIA SPT 1305 Nanocomp

The following sections provide a short overview of each project and summarises the progress that SPT has made on them. Further details can be found on ScottishPower's website and on the ENA Learning Portal . Key learning associated with these projects is summarised in Section 4.

2.1 NIA SPT 1300 VISOR Proposal Development

The VISOR project has been selected by SPT as it offers the opportunity to increase boundary capacity and detect specific instabilities such as Sub Synchronous Oscillation. It provides innovation to complement and underpin the technology integration challenge. VISOR will realise the full potential of real time data captured by Phase Monitoring Unit (PMU) which in turn will promote the acceleration of a low carbon energy sector and create knowledge that will benefit all Transmission Owners (TOs), Offshore Transmission Owners (OFTOs) and Distribution Networks Owners (DNOs) investing in new technologies.

In order to meet government energy policy, TOs are investing heavily in system upgrades, some of which deploy new technologies, i.e. embedded HVDC links and Series Compensation etc. The commissioning of these technologies on the GB transmission system leads to a finite risk of unforeseen and potentially damaging oscillatory (e.g. sub-synchronous oscillation, SSO) interaction between transmission and generation plant and this may also impact on security of supply, if not appropriately managed.

The transmission boundary between Scotland and England is heavily constrained by voltage and stability limits. Stability limits are normally assessed by off-line study with the application of appropriate operational margins. There is currently no facility to use the real time system data to establish operational limits.

The existing planning and operation of the transmission system is based heavily on off-line deterministic studies and there are few opportunities to validate the results of the model against the real system performance. The provision of Phase Measurement Units (PMU) data enables the network impedance to be accurately measured and the performance of dynamic models to be validated.

ScottishPower and National Grid have previously installed PMU that monitor system dynamic behaviour but this system has significant shortfalls in capability, i.e. it can only see oscillatory behaviours up to about 10Hz whereas new technologies may exhibit behaviours at higher frequencies up to the nominal system frequency i.e. 50Hz. The current installed system provides no means of identifying the location or source of a disturbance.

The objective of this project was to develop a full research and demonstration proposal under the NIC mechanism for Ofgem and the Expert Panel to evaluate.

The project was successful in that it provided sufficient details, scientific evidences and clear business benefits to enable a positive recommendation from the Expert Panel for the VISOR project.

2.1.1 NIA SPT 1300 Project Progress

This project started in June, 2013 and was completed in December, 2013 following the formal approval from the regulator. The approval provided an opportunity to bring this project to the next level.

From the dimension of the NIA, this development project met the original objectives and success criteria.

The NIC VISOR project is now scheduled for delivery within 40 months from January 2014.

2.2 NIA SPT 1301 Electrical Power Research Institute (EPRI) Programme Engagement

EPRI's Grid Operations research programme delivers value using the shared experiences and understanding of its utility and independent system operator (ISO) members in conjunction with the expertise of EPRI's staff and network of top-level contractors.

The programme collects network experiences and learning at international level, conducts research projects that lead to prototype methods and tools that can be utilised by system operators, and supports members in their research needs. EPRI also engages with external industry standards, regulatory, and research efforts to ensure that the EPRI research programme is taking advantage of broader industry efforts and advancing the state of the art technologies.

This research programme also strives to provide members near-term, mid-term, and long-term value. For example, the 2013 Grid Operations research programme will finalise the development of prototype tools for supporting identification and mitigation of potential voltage stability concerns and deliver prototype tools and guidelines for identifying the optimal black start capability needed to restore the system after an outage during a time when many system are re-evaluating black start/restoration plans given the evolving generation mix. At the same time, EPRI will continue development/evaluations of advanced data processing, computing technologies, and solution algorithms to improve the performance of all operational analytics and decision making. The outcome of this research programme will allow transmission licensees to capitalise on the latest technology advancement and lead to a more effective network development and operation. This project will facilitate the awareness and application of new technologies on the transmission network and benefit both customers and stakeholders by accelerating cost effective renewable generation connections.

A key objective is for ScottishPower Transmission engineers to continue to engage fully with the EPRI research programme and apply relevant outcomes to business activities and innovation projects.

2.2.1 NIA SPT 1301 Project Progress

Our programme engagement was initiated from January 2013, and will continue for three years.

In order to help realise the aforementioned objective two dedicated meetings between SPT internal stakeholders and EPRI project engineers were arranged to ensure that the knowledge generated from the engagement programme could be fully appreciated. In addition, EPRI arranged a HVDC project workshop at Wokingham to present their study results. SPT has also been actively involved in the scope definition and staged reporting via teleconference. Consequently, this project is considered to be on track to realise business benefits.

2.3 NIA SPT 1302 Enhanced Weather Modelling for Dynamic Line Ratings

Dynamic Line Rating (DLR) schemes have the potential to release significant network headroom on circuits supplying renewable generation that can be controlled by Active Network Management (ANM) schemes. Whilst the same DLR uplifts are present on the network's main interconnector circuits, the headroom cannot be as readily exploited as there is less correlation between the required power transfer capacity and the ambient conditions under which significant uplifts can be achieved; nor is there a single controllable load to be coupled with an ANM scheme to avoid excursions on the network. As a result of this, the exploitation of DLRs on the main interconnector circuits will be reliant on Control Engineers to manage the network loads and keep them in line with the available DLR uplift. However, to effectively do this without risking excursions on the network the Control Engineers will need to have confidence that the DLR will be available for a prolonged period of time, and this depends on accurate forecasting of dynamic ratings. At present the main focus of DLR schemes developed has been on the generation of an instantaneous value as opposed to a forecasted value several hours into the future.

This project makes use of an advanced spatial/temporal model developed within the Electronic and Electrical Engineering Department at Strathclyde University, and supported by SPT, over the last five years. In the enhancement of the methods for forecasting of dynamic ratings, Strathclyde University will use the available weather data from existing meteorological stations and hourly meteorological data from other sites across the UK to which Strathclyde University has access. The forecasting will be applied to the estimation of wind speed and directions in the vicinity of key overhead line spans for the purpose of calculating dynamic overhead line ratings. The model will also be applied to air temperature forecasting as it is the combination of wind speed and air temperature that determines overhead line cooling and subsequent maximum current carrying capacity.

The success criteria is the application of spatial interpolation techniques to determine forecasts at regular intervals along an overhead line and the use of wind speed, wind direction and air temperature forecasting to determine local overhead line cooling rates.

Other success criteria will be the provision of an estimate of uncertainty associated with the forecast so that the system operator can make appropriate judgements with respect to management of risk and the necessity for preventive actions.

2.3.1 NIA SPT 1302 Project Progress

This project has been registered as a joint project by National Grid, and therefore they will provide a progress summary in their NIA Annual Report 13/14 consequently; no project progress has been included in this report. However, we, as an active partner of the project, will outline our New Learning for this project under Section 4.

2.4 NIA SPT 1303 IEC 61850 Integration of Substation Protection and Control - Test Facility

The IEC 61850 standard is intended to provide a standardised framework for the implementation of communication-based Substation Automation Systems (SAS). The principal benefits of employing the IEC 61850 approach are to achieve:

- Reduced engineering through re-usable designs
- Reduced time and cost for assembly and wiring
- Reduced site wiring and installation
- Increased off-line testing resulting in faster commissioning and reduced outage durations

Early experiences of attempting to engineer an IEC61850 compliant multi-vendor substation using the various files and software tools from each vendor led to unsatisfactory conclusions:

- It was difficult to achieve interoperability between devices from different vendors as each vendor has implemented the IEC 61850 standard according to its own designs. No two vendors implement the same functions to the same extent.
- The engineering process was complex and time consuming. It required extensive work to create the Intelligent Engineering Device (IED) configuration files and an expert knowledge of the underlying format of IEC 61850 configurations.

To further our knowledge experience and understanding of a GB compliant IEC 61850 process and related compliant IED’s, we intend to create an IEC 61850 test facility in Cambuslang that would not only create a "station bus" simulation substation but also allow the pilot of the new IEC 60870-101 communication protocol to our Operational Control Centre (OCC). This facility would provide the following benefits:

- Allow the testing of multiple IEC 61850 IED's from different vendors, remote terminal units (RTU’s) and fault recorders for compatibility and operational adequacy.
- Enable the risk free trial of the new IEC 60870-5-101 communication protocol and its support tools (the replacement of the existing Mk2A protocol).
- Allow the testing and programming of IED's before installation reducing outage time and streamlining work on site.
- Future proofing: if the IEC 61850 standard ever changes/progresses, this centre will be able to prove compatibility with future versions.
- Reduced support costs as SPEN would provide first line support for this system (i.e. reduced costly third party support).

The main project objectives area as follows:

- Prove the interoperability of all the IEDs and their performance in the SAS architecture proposed by ScottishPower.
- Prove communication between the test facility and the OCC using IEC 60870-5-101 (create a substation "Cambuslang") and prove all required functionality from the OCC (including support tools).
- Thoroughly test compatibility of any new IED to be installed onto the network.
- Understand and document any issues faced and resolved from the above activities.
- Share all knowledge gained.

2.4.1 NIA SPT 1303 Project Progress

The Project started in April, 2013, and has a two year duration. Progress against our objectives for the project to date is as follows:

- Multi-vendor IED interoperability has been proven and we are currently evaluating the performance in the SAS architecture.
- Remote communications for the test substation at Cambuslang have been established and we are in the process of establishing communications with the OCC.
- We are presently evaluating IEDs
- As we encounter issues we have recorded what they are and how we resolved them.
- It is planned to roll out training which will address knowledge and skills.

We are on schedule to address the issues highlighted in the previous section and realise the principle benefits of using IEC 61850 approach.

2.5 NIA SPT 1304 Smart Transmission Zone

There is an increasing quantity of onshore and offshore wind generation and as a result the power flows across the transmission system are becoming increasing variable and unpredictable. In time this will compromise the security of the network as control engineers will lose the ability to ensure the system is operating economically.

In addition as the system becomes more complex previous security systems, such as inter-trip systems which are designed to automatically trip generation or carry out automatic system reconfiguration, will require redesign to optimise operational responses. The system modelling effort required to manage special protection systems will increase and the duration and opportunity to engage special protection systems may reduce significantly.

The determination of the power system 'state' pre and post fault is a key requirement in determining the post fault control action. The connection of generation to transmission boundary circuits leads to a very complex set of variables since the amount of generation to be tripped to restore security/stability will vary with the fault point, pre-fault transfers, generation background, parallel HVDC flows and other pre-fault network contingencies.

This proposal included a generic feasibility study that would identify the performance requirements and functionality of a Smart Zone control system detailing technology limitation i.e. state measurement, system modelling and communications etc. The benefits of employing PMUs in the determination of network states to inform post fault control would also be evaluated.

The objectives set for the work were as follows:

- Carry out a generic feasibility study on the performance requirements and functionality of a Smart Zone control system.
- Increase security and stability of the transmission system.
- Understand the performance and how reliable the IT communication system is along with any changes which may be necessary to withstand the future needs of the system.

By exploring various smart control technologies, including the information from Phase Measurement Units (PMU), this project will provide valuable information and guidance regarding the future applications of VISOR.

2.5.1 NIA SPT 1304 Project Progress

The project started in October 2013 with maximum 18 months duration.

To date, an extensive literature review has been carried out and simulation studies undertaken to confirm the smart transmission zone design. The first draft report was produced, and a presentation from Alstom Grid on the outcomes was given in February 2014 to SPT internal stakeholders.

The initial studies demonstrated significant potential for large renewable generators (onshore windfarm) to be part of a smart transmission zone algorithm.

The study is now under review and it is planned to set out a clear route map for potential implementation.

2.6 NIA SPT 1305 Nanocomp

Transmission network operators are currently planning development of the next generation of high efficiency and reliable HVDC transmission systems to connect large offshore wind farms to load centres and provide network reinforcement. The operational voltage stresses for these HVDC systems are, however, extreme and difficult to control. Establishment of higher performance and more reliable insulation material solutions, which are still affordable, is one of the major challenges that the electricity transmission industry faces.

Successful insulation technology demonstration and its subsequent implementation is seen as vital to supporting timely expansion of renewable generation and its integration in the UK power grid.

In laboratory R&D, nanocomposite electrical insulation materials have been shown to significantly out-perform conventional micro composite insulating materials but results have been inconsistent and scaling to manufacturing processes has been problematic.

The planned work includes mastering the different facets of nanophase processing of cost effective materials for repeatable and scale independent manufacturing of preproduction materials for optioneering and optimisation as well as for demonstrator HVDC components that test scalability. The development will use state of the art processing and measurement methods to establish design and processing rules and to support the design of components with highly optimised electrical and physical properties that can withstand the multi-stress environments found in HVDC systems.

The design and processing rules will then be trialled by manufacturing a demonstration component and undertaking suitable electrical and mechanical testing of the component.

The work will assess whether nanocomposites can be dispersed in polymeric insulation material in a reproducible fashion and whether a new improved insulation material can be created and used to construct full size products such as bushings. The project will evaluate the potential of the new material to offer the reduction in size of insulation, which in turn could represent significant cost savings for the industry.

2.6.1 NIA SPT 1305 Project Progress

This project has been registered as a joint project by Scottish and Southern Energy, and therefore they will provide a progress summary in their NIA Annual Report 13/14 consequently; no project progress has been included in this report. However, we, as an active partner of the project, will outline our New Learning for this project under Section 4.

2.7 NIA SPT 1306 HVDC Cable Conditioning Monitoring Project

In response to the 'market need' for improved maintenance information, HVPD Ltd is developing an integrated high voltage network management system (OLPD-HVDC) that will address the emerging industry demand for the 'holistic' condition monitoring of HVDC cable networks. The system will provide early warning of faults and therefore allow direct preventative maintenance to help improve operating efficiency through the use of 'holistic' condition monitoring technology solutions and a corresponding, robust condition based management approach to managing these assets. The monitoring technology will be able to indicate insulation defects along with cable faults ahead of failure to allow for preventative maintenance interventions. This will prevent the need for unplanned outages and downtime which as a result improves the security of supply and reduces operation and maintenance costs.

The objective of the work is as follows:

- Improve accuracy and detail of information available on the condition of the HVDC networks.
- Increase ability to carry out preventative maintenance.
- Reduce the number of cable and insulation failures and as a result the outages and downtime.
- Allow more accurate determination of where the faults in the cables have occurred and thus reduce costs of repairs.

2.7.1 NIA SPT 1306 Project Progress

The project started in October 2013 and was originally scheduled to be carried out in two, 9-month phases. This has now been extended to two, 12-month phases. The project partners have successfully completed the first milestones detailed below and are on schedule to achieve original projects aims, objectives and success criteria.

There were two deliverables the first is a consultation questionnaire report which has been prepared which includes the questions proposed and responses from industry. The consultation questionnaire report presents results from a survey collected from worldwide stakeholders involved and/or interested in HVDC systems and also a face to face meeting with HVDC operators (National Grid EBD and TenneT). The second was the development of an alpha system specification report which has been prepared to address the system design including equipment, data processing tools, testing procedures and overviews of HVDC systems with regards to on-line partial discharge detection.

2.8 NIA SPT 1307 MVDC

Today's power systems use alternating current (AC) for transmission of electrical energy but historically the first grids were based on direct current (DC). As a result of considerable technical progress in the field of high-power semiconductor devices and cable technology, high-voltage point-to-point direct current (HVDC) transmission has been incorporated into grid networks.

Due to the high cost of HVDC power electronics (which is likely to continue in the foreseeable future), the physical demonstration, testing and development using high voltage levels can be prohibitive. Lower voltage level research and testing could, in certain instances, help understand the technology at higher voltages, by extrapolating the results based on the modular concept of the HVDC equipment.

This type of research and testing facility provides additional societal benefits such as the facilitation of more competition in the DC suppliers sector, de-risk the manufacturing constraints and help SME companies to develop technologies in this space. Such a facility could also support the development of supply chain companies.

The scope of the project is to understand what MVDC research and development initiatives are being conducted worldwide and to understand from an industrial perspective, the future direction of MVDC in the electricity transmission and distribution systems.

2.8.1 NIA SPT 1307 Project Progress

The project started in July, 2013 and was scheduled for 12 months. A report has been produced by Strathclyde University that carried out a comprehensive literature review, and provides details of MVDC research facilities in other parts of the world. This learning to date will be used to inform the future direction of this project.

2.9 NIA SPT 1308 Synthetic Inertia

There is concern over the future stability of power systems as they incorporate reducing amounts of conventional synchronous machines and increasing quantities of wind farms. As a result there is an increased interest in the provision of synthetic inertia from wind power plants to introduce more stability to the system.

There are two main situations where the stability of the system could be improved by synthetic inertia:

- Firstly, during a major loss of generation or interconnection capacity.
- Secondly, during a short-circuit fault on the system. In this case the fault results in an acceleration, usually limited by the inertia of a rotating plant, due to the reduced active power demand on generators in the vicinity of the fault.

The conventional thermal generation assets can provide strong system inertia due to their long and heavy shafts to hold the system frequency. Operation of wind generation on the power system, on the other hand, will be linked with the network via power electronic device which decouple the generation from the network frequency. Hence the high level of penetration of wind generation in a transmission network will impact on the first swing stability of conventional synchronous machines following a network short circuit fault. However, the timescales for response to allow effective action to be taken in time to affect the first swing stability are challenging, with detection of a fault event within 10/20 ms, followed by initiation of response from the wind capacity within 60-80ms.

In the two cases outlined in the section above, synthetic inertia could improve the system as following:

- In the first case an inertial response from a converter-interfaced energy source, in the form of a temporarily increased real power contribution, would be desirable following the detection of a significant drop in the system frequency and/or increase the rate of change of frequency.
- In the second case some form of response from wind farms (either through reducing/ceasing to supply power, or ideally, even by absorbing power from the accelerating system) is desirable.

In addition careful modelling of the power system, turbines, inverters and their control, could provide a good guide as to what can be expected from the wind plant, but the more difficult engineering challenge is the provision of a robust and reliably fast fault detection system.

This project will be deemed successful if the system stability is increased with the use of synthetic inertia, and as a result remains reliable.

2.9.1 NIA SPT 1308 Project Progress

This project is at an early stage of development and consequently it is the intent to provide further details in subsequent annual reports.

2.10 NIA SPT 1309 Low Frequency Electricity Transmission Technology Evaluation

This project will be a comprehensive and objective appraisal of the concept of Low Frequency Alternating Current (LFAC) transmission as an alternative to High Voltage Direct Current (HVDC) transmission.

High Voltage Alternating Current (HVAC) cabling is the current standard being used for offshore power transmission; however, as distances offshore increase the charging reactive power associated with the cable can prohibit its use. This project will assess the implications of reducing the operating frequency (e.g. in the range of 0.5 to 5Hz, or 1/3 of the nominal frequency) in order to reduce the charging reactive power and increase transmission capability, such that HVAC could, potentially, be used in far offshore applications. However, the reduction of the frequency would have an adverse impact on the size/weight of the power plants. Hence the size implication for the associated low frequency transformers will require to be addressed. In addition, the assessment will consider the following:

- Quantification of the benefits and the limitations of the LFAC concept, giving a comparative evaluation against favoured voltage sources converter (VSC) HVDC technology. Differences in converters, cables and circuit breakers are to be evaluated based on their predicted stresses during operation.

- Operations (control and protection) of the LFAC transmission concept, under different windfarm scenarios and transients, satisfying all the grid code requirements.

- Criteria under which LFAC transmission would be a more attractive design option, with respect to variables such as transmission distance and voltage level.

2.10.1 NIA SPT 1309 Project Progress

The project started in December 2013, and scheduled for 18 months. SPT has initiated research work with Warwick and Newcastle University. The collaboration agreement was signed off with the project partners and appropriate resources have been put in place.

The project is on track of delivering the project objectives which includes a comprehensive literature review (to help inform the project direction) plus modelling of low frequency ac transmission technology and evaluation of its potential impact on the transmission business.

The project is aiming to clarify the existing status of this technology, to map the important stakeholders of this technology, to identify potential business applications and to present simulation studies to inform the industry.

3 NIA Activities Linked to SPT Innovation Strategy

It is recognised that innovation cannot be a prescribed by rigid process but must stimulate creativity and new ideas. However, to ensure good governance, SPT has applied an over-arching framework to ensure that it is managed efficiently and delivers the benefits without constraining creativity.

The five innovation objectives within SPT are:

1. Innovation meeting the needs of stakeholders;
2. Innovation opportunities are identified in a timely manner, which will benefit these stakeholders;
3. Innovation is managed in an efficient and proactive manner;
4. A balanced portfolio of innovation is pursed which includes commercial, process and technology innovation. Our activity has a relevant focus on developments at different technology and commercial readiness levels to which balances radical with incremental innovation; and
5. The outcome of innovation activity is adopted by the wider business to ensure that customers benefit at the earliest opportunity whilst minimising the risk to the integrity of the network.

Figure 1 outlines the general R&D management structure within SPT.

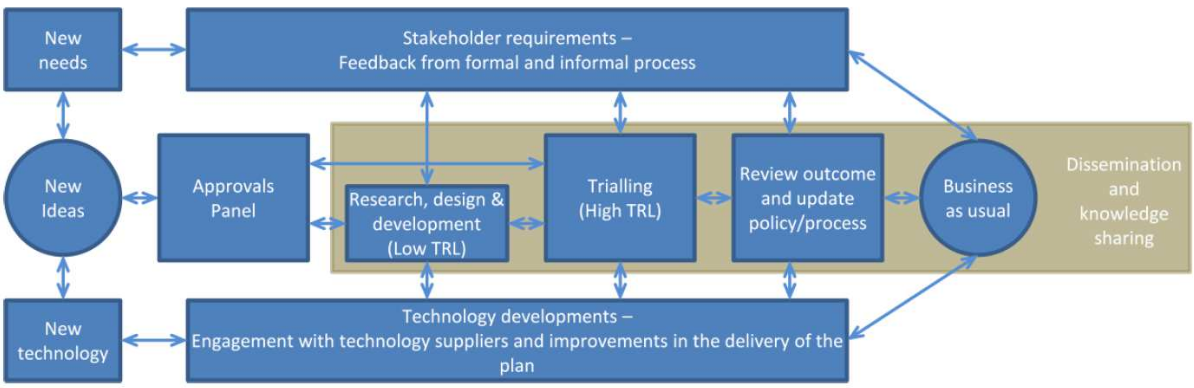

Figure 1 SPT Innovation Management Procedure

As part of our long term innovation strategy, stakeholder engagement will be central to ensuring that our innovation plans are meeting customer's expectations. The involvement of stakeholders is also a vital source of ideas for innovation – particularly the academic community, equipment suppliers and other network operators (DNOs and TOs).

Figure 2 illustrates the NIA development process at SPT.

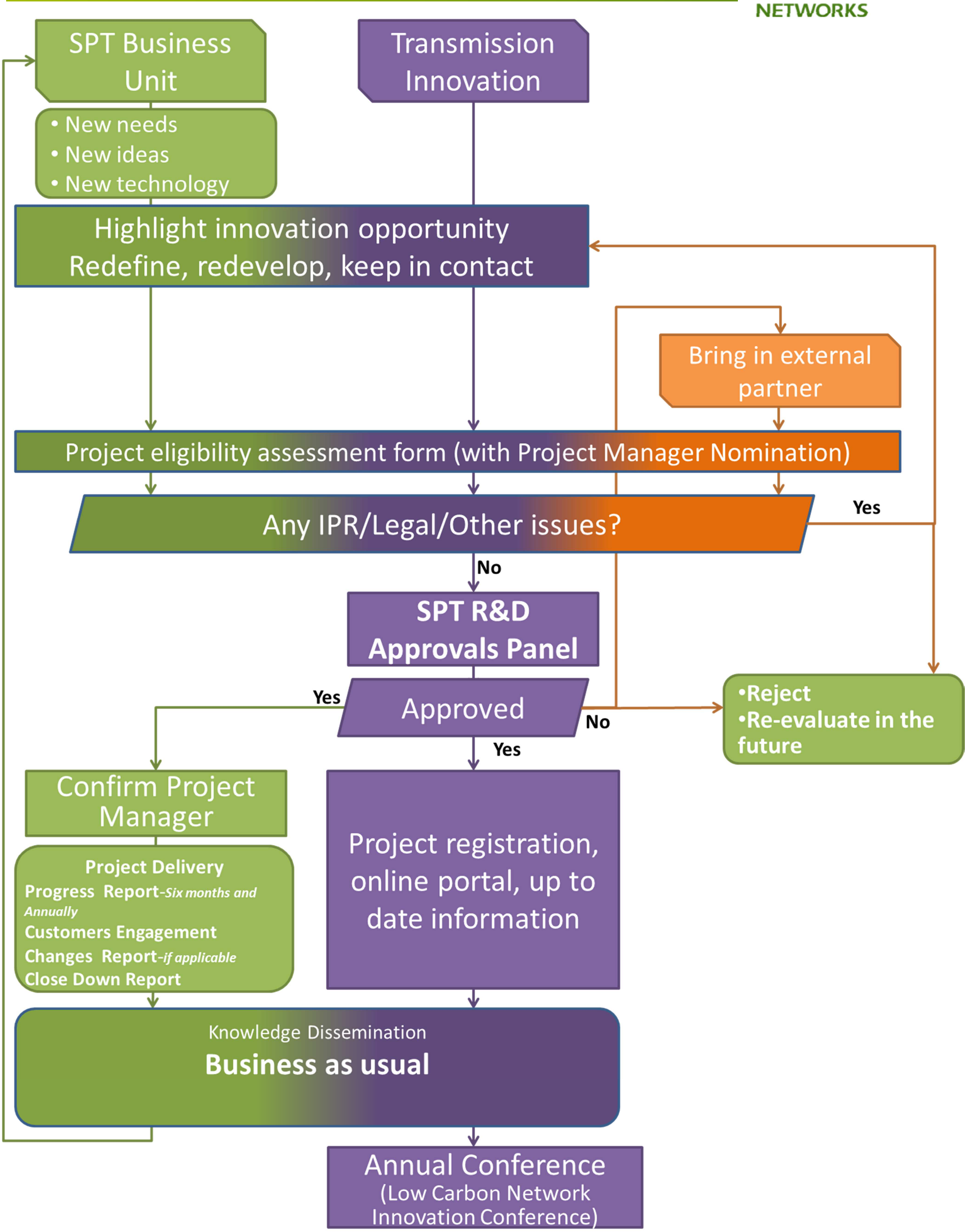

Figure 2 SPT NIA development process

Our approach to innovation development is summarised in figure 3 below which contains five steps:

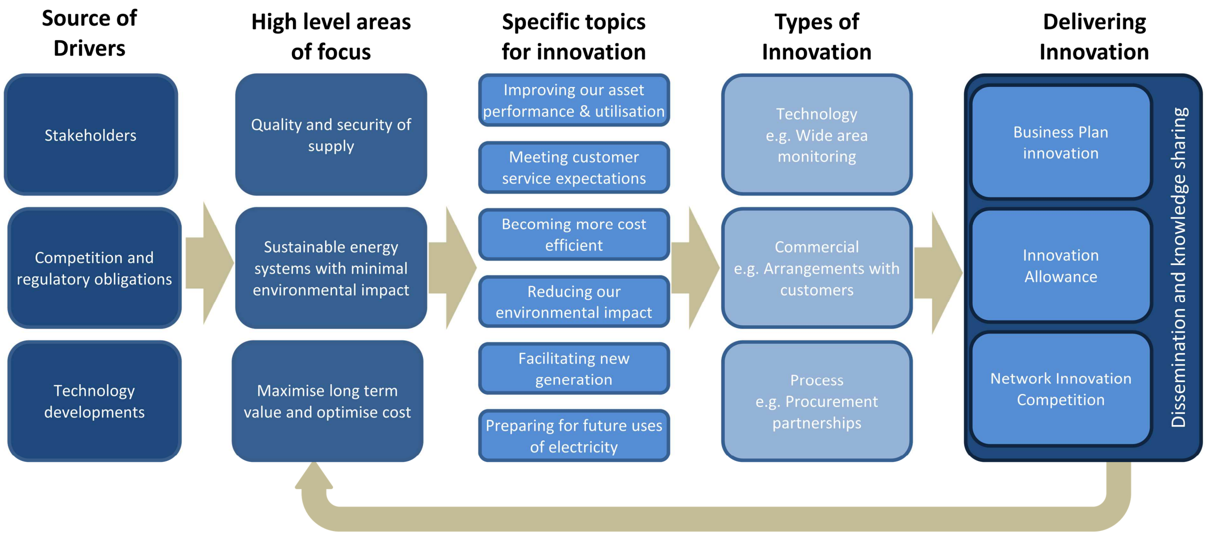

Figure 3 SPT Approach to Innovation Development

In order to realise our future network vision we have identified the following five dimensions that require to be addressed:

1. **Visibility**: the combination of monitoring devices, computing process and communications infrastructure provides an effective means to present the real time information for wide area monitoring. This visibility can cover almost all the aspects regarding transmission network performance, ranging from steady state thermal limitation of critical boundaries to sub-synchronous oscillation behaviour in the local area. This visibility provides a new dimension and reference for system operation and protection.

2. **Controllability:** the visibility of transmission network at the GB level requires review of some control algorithms which had been designed based on a centralised approach. Smart grid control involves many more controlled elements than in the conventional design, together with greater uncertainty in generation. The increasing complexity requires new approaches to observing, modelling and controlling the interactions between generation, transmission, distribution, and load. How to react to the information available requires a defined and coordinated approach to ensure that the existing supply quality and reliability standards are not compromised, and that customers can realise maximum benefit from the latest technology.

3. **Intelligence:** As a result of the improved visibility and control of the network, active management of generation output around network constraints will improve the time required to connect new demand and generation. Wide area monitoring combined with real time asset ratings, will ensure that maximum capacity is utilised before reinforcement is required. Processing of network data will also inform designers of when reinforcement is required and inform the deployment of appropriate, cost effective, solutions.

4. **Interoperability:** The variety of new technologies deployed on the network will require to be interoperable such that new solutions can be readily integrated, for example through the application of technology standards such as IEC61850. We will work with the wider industry nationally and internationally to develop open-access standards. Reliable and secure communication systems will also be required to transfer data across the network combined with IT systems that can effectively manage the new data that is generated. This will require a significant extension of our communications systems using internal and external services to achieve the necessary coverage.

5. **Commercial Mechanisms:** Our network will be reliant on commercial arrangements with network users as there are close linkages with many of the technology solutions.

To achieve these five dimensions, we consider three different ways in which we invest in the network. These investments can be described as follows:

Enablers: This includes smart-ready asset replacement and other investments which create a robust foundation and enabler for the smart grid applications. These are considered as "no regrets" investments which can be deployed in a top-down manner and are an essential component of the network. Having the enabling technology in place will allow us to flex between different future scenarios. Typical enablers are Remote Terminal Units for SCADA with expansion capability and the installation of additional network monitoring.

Applications: This is the implementation of a solution which has an immediate application to directly address an output within RIIO-T1 such as meeting load growth, facilitating new customer connections or improving quality of service. Where we have proposed a smart application, a cost benefit analysis (CBA) will be undertaken as in most cases a comparison with a traditional solution can be made. Typical applications are real time thermal ratings, intelligent voltage control or active network management.

Future Proofing: Where a positive business case exists, we will identify where additional enabling technologies are considered to be of long term benefit to customers, although not necessarily required in the short term. This category is also regarded as top-down investment as it is required to further enable other applications in the longer term. Future proofing investments are also subject to a CBA to ensure that they are efficient investments for the customer. Typical future proofing includes oversizing conductors for future load requirements and switchgear being pre-wired for sensors and automation.

The variety of new technology and commercial arrangements deployed on the network are vital to meeting the future requirements of our customers in a responsive and cost-effective way. However, it will be through the effective management and stewardship of the existing asset base that we will ensure value for money and that a sustainable network solution is delivered.

3.1.1 SPT NIA Project Mapping with Innovation Strategy

Figure 4 illustrates the mapping of the first year NIA projects against the aforementioned dimensions and network investment.

Network Investment			NIA Innovation Projects	Specific Dimension				
Enabler	Application	Future Proofing		Visibility	Controllability	Intelligence	Interoperability	Commercial Mechanism
✓		✓	NIA 1300: NIC VISOR Preparation	✓	✓	✓		
	✓		NIA 1301: Electrical Power Research Institute (EPRI) Engagement					
	✓		NIA 1302: Enhanced Weather Modelling for Dynamic Line Rating					✓
		✓	NIA 1303: IEC61850 Integration of Substation Protection and Control – Test Facility				✓	
✓			NIA 1304: Smart Transmission Zones			✓		
✓	✓		NIA 1305: Nanocomp		✓			
	✓		NIA 1306: HVDC Cable Conditioning Monitoring Zone	✓		✓		
		✓	NIA 1307: MV-DC and Feasibility Studies		✓		✓	
✓		✓	NIA 1308: TIC (Strathclyde university) Synthetic Inertia	✓	✓			
		✓	NIA 1309: Low Frequency AC Transmission Technology Evaluations		✓			

Figure 4 NIA Project Mapping with SPT Innovation Strategy

4 Areas of Significant New Learning

The following identifies area of learning on a project by project basis:

NEW LEARNING:

NIA SPT 1300 VISOR Proposal Development

NIA has proven to provide an important role in facilitating and preparing NIC proposal where flagship innovation is expected. SPT identified an opportunity to develop a national wide area monitoring demonstration based on a previous IFI Tier 1 (the precedent of NIA) project. Learning from this project included:

- To ensure that the benefits that can be realised from existing and previous NIA projects are capitalised upon.
- The need to engage with other transmission network stakeholders at both national and international levels to realise maximum value.
- To ensure resources are available to deliver the project in an efficient and timely manner and that a professional team with strong sense of responsibility is in place.

NIA SPT 1301 Electrical Power Research Institute (EPRI)

EPRI's annual report on the transmission operations work packages that SPT has engaged in has been received and commented on. The report presented the work undertaken thus far and included the sub-modules on transmission security.

In addition, SPT has received feedback to help inform the two specific projects: one is the HVDC control and simulation, and the other is VISOR. The feedback enhanced our existing understanding of the technical nature of those projects and help shape the proposal to meet the industry needs.

The report also reflected the feedback from SPT regarding the HVDC work stream and Wide Area Monitoring Technology.

NIA SPT 1302 Enhanced Weather Modelling for Dynamic Line Ratings

Please refer to National Grid's NIA Annual Report 13/14 for details of areas of any significant new learning on this collaboration project.

The University of Strathclyde has produced a detailed review of Dynamic Line Rating (DLR) techniques, including a comparison of direct monitoring vs. indirect interface techniques. Research has also begun on the performance of several spatial interpolation methods for meteorological conditions.

NIA SPT 1303 IEC 61850 Integration of Substation Protection and Control - Test Facility

This project will be deemed successful if the test centre, under development, becomes fully functional and the learning from the centre has been used to enable novel protection system deployment in transmission substations.

During the course of the project we have proven multi-vendor Intelligent Engineering Device (IED) interoperability and were we have encountered an issue we have recorded details and what was done to resolve them.

As this project is for evaluation purposes only we have yet to come across genuine difficulties. Any lessons learned with the test build will be passed on when we do our first build. There will be full knowledge transfer between ScottishPower/ Iberdrola, manufacturers, TSO's and DNO's and it is envisaged that external parties may use this Centre.

NIA SPT 1304 Smart Transmission Zone

The smart transmission zone design study initial results are currently subject to review. There are, however, some technical and commercial questions to be addressed before the study findings can be accepted. Following this a route map for potential implementation will be set out.

The project has successfully improved the technology readiness level and provided valuable design knowledge.

NIA SPT 1305 NIC Nanocomp

Please refer to Scottish and Southern Energy's NIA Annual Report 13/14 for any details of areas of significant new learning on this collaboration project.

The understanding gained by this project and the materials design rules developed will feed into HV equipment design to achieve new high performance equipment with significantly improved voltage and power ratings and potentially much smaller size for the same rating. Electrical measurements have confirmed excellent space charge charging and dissipation behaviour and very good current-voltage behaviour for the Nanomaterials under consideration.

NIA SPT 1306 HVDC Cable Conditioning Monitoring Project

Based on the responses provided from the consultation questionnaire, it was found that the use of Voltage Source Converter (VSC) technology in HVDC system was comparable to the use of Line Commutate Converter (LCC) technology. This result reflects the emergence of VSC technology due to the attractiveness of its operation. It should also be noted that some respondents were involved in the use of both technologies. Additionally, collected data showed that academic respondents indicated familiarities in understanding of the use of HVDC technology in HV laboratories.

NIA SPT 1307 MVDC

The concept of MVDC systems remains to be proven as feasible (control schemes, protection systems, DC circuit breaker etc.) even though technology for other industries is commercially available. It is important to understand the future challenges being faced and the technologies.

A review has been undertaken and a report compiled on MVDC research and development facilities worldwide. This will help identified requirements for a UK MVDC research facility. This work could be used to inform a future Network Innovation Competition (NIC) funding application to support the development of such a research facility.

NIA SPT 1308 Synthetic Inertia

It has been recognised via the initial stakeholder engagement that Synthetic Inertia problem is of wide concern by the transmission operators worldwide. This project will help to address the adverse impacts on system inertia associated with renewable generation, and benefit both transmission licensees and renewable developers.

This project is at an early stage of development and new learning is expected in due course.

NIA SPT 1309 Low Frequency Electricity Transmission Technology Evaluation

This project did not formally start until 1st April 14 but has the potential to offer up valuable research in a valid alternative transmission technology with higher technology readiness. The project will lay a solid foundation for SPT and other transmission licensees to lead and carry out potential demonstration projects in the near future.