SP TRANSMISSION

Transmission Innovation Strategy Review 2014-2020

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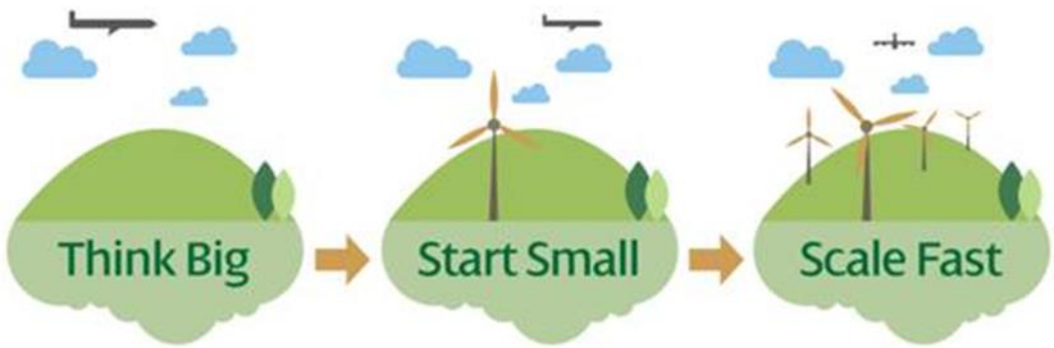

1 Introduction

SP Energy Networks (SPEN) presented the Transmission Innovation Strategy (SPT Innovation Strategy, Dec 2011) as part of their RIIO-T1 (2013-2021) submission, which was subsequently fast-tracked in 2012. This strategy paper presented the strong innovation needs in transforming the transmission network to enable a low carbon economy while maintaining high standards of supply security and reliability. The document further outlined the five clear innovation objectives within SPT:

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 pursued which includes commercial, process and technology innovation. Our activity has a relevant focus on developments at different technology and commercial readiness levels 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.

Detailed studies and considerations fed into the SPT Innovation Strategy, the underlying principles of which are still deemed to be valid judged by the then and current policy framework. DECC (Department of Energy and Climate Change) and Ofgem (Office of Gas and Electricity Markets,) have subsequently published a number of documents that have provided greater clarity on the direction and future of our electricity system. Those documents include:

- Electricity System Assessment of Future Challenges (2012)
- Electricity Market Reform Delivery Plan (Dec, 2013)
- Smart Grid Vision and Route map (Feb, 2014)

In addition, SPEN presented its corresponding Smart Grid Strategy and Innovation Strategy under the RIIO-ED1 regime in 2014. The experiences and lessons learned from the first year delivery of RIIO-T1 provide knowledge and experiences to ensure that transmission innovation is carried out in a coordinated and collaborative manner. All of which provide an optimum opportunity to review the existing transmission innovation strategy and bring it up to date.

This review document presents how SPT Innovation Strategy is being amended to reflect our latest analysis of the views and new evidence gathered during stakeholder engagement and learning arising during the first year of RIIO-T1 delivery. This review serves the purpose of redefining and detailing the delivery, so that innovation strategies are broadly comparable to the levels of support available under RIIO-T1, adjusted to account for a more transparent, tangible and successful delivery.

Reviews of SPT Innovation Strategy will be carried out on a regular basis with a balanced approach to provide certainty from the policy making dimension, to take into account the nature of innovation, the latest technology advancements, and evolving customer and stakeholder requirements.

2 Stronger Requirements to Innovate

Policy and recommendations published by various government and professional bodies shape the current trend in energy systems and can help identify any potential innovation areas SPT could explore.

DECC and Ofgem have proposed the Energy Markets Reform (EMR) and set out a detailed delivery plan. While many of the changes in markets will be handled through National Grid as the System Operator, the effects of a different market scheme on generation should be understood and managed by transmission network stakeholders. The two components within the EMR framework are: Strike Price for Contracts for Difference (CfD), and the Capacity Market. With the CfD scheme, new technologies are being incentivised, with higher prices paid for emerging technologies. While new technologies can pose further risk to the system, the aim is to counteract this risk with the introduction of the capacity market. The Capacity Market will provide a regular retainer payment to reliable forms of capacity (both demand and supply side), in return for such capacity being available when the electricity supply is squeezed. This should reduce the threat of blackouts due to insufficient capacity on the system.

The effects from the new reforms and policies, however, remain to be seen. The pace of renewable development, large scale onshore/offshore wind in particular, will have significant impact on transmission networking planning and operation. The uncertainties regarding renewable energy development have been recognised and resulted in three scenarios in the Ten Year Statement: Slow Progress, Gone Green and Accelerated Growth. Therefore, the future of onshore and offshore wind projects connected directly to the GB transmission network is associated with uncertainty in the commercial and regulatory framework and long-term stability for investment. For ScottishPower, this means a stronger need for a transmission network that is as flexible as possible to cater for as many future scenarios as possible.

Along with the market reforms, there is a significant push towards smart grids and the additional control and visibility that they offer to all stakeholders in the network. Not only does it facilitate the deployment of renewables, but also allows operators to better manage and control systems and react to problems much faster. This is particularly important as system inertia reduces, requiring different operation and control practices.

Smart grid development requires increased and coordinated control and observability at both distribution and transmission levels. With accurate and real-time supply and demand information, and options for balancing supply locally (e.g. Demand Side Response, storage), Distribution Network Operators (DNOs) will be able to free up existing capacity and make better use of existing assets. This can help deliver faster and cheaper connections for businesses and generators and helps to defer or avoid the need for costly reinforcement of the wider network. This would be highly relevant to Transmission Owners (TOs) as it can be used to offset the transmission reinforcement directly. Increased visibility with the means to control and manage the network will improve stability and reliability of the network. For the smart grid, much of the focus has been placed on DNOs and their potential roles as Distribution System Operators (DSOs), however it is equally important to fully understand the effects and requirements of the future system and that TOs will also need to migrate to a smarter system along with different operating procedures and possible infrastructure.

While Smart Grid technology has a very valuable contribution to the GB energy system, the further uncertainty associated with this development should be recognised regarding the use of the transmission system and the performance of the power system as a whole. If, for example, Smart Grid technology enables more renewable generation connections in the north of Scotland and the price signals on a high wind / low load period lead to a demand response (increase) in the south of England, there may be some difficulties in transmission power flow management. There is therefore a responsibility for a transmission owner to observe and characterise the increasingly complex usage of the transmission assets and address emerging risks at an early stage to facilitate the low-carbon economy.

3 Our Future Network Vision

SPEN presented our vision for Future Networks in our Smart Grid Strategy, which Transmission Innovation is a part of. A smart grid integrates communications, innovative network technologies and services as well as monitoring and control technologies. These techniques provide cost-effective ways of making the network more flexible and reliable. To achieve a smarter grid, we describe it as having five dimensions:

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 aspect 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.

The diagram below 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 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: NIC VISOR Preparation	✓	✓	✓		
	✓		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		✓			
	✓		NIA 1310: Shunt Reactor Switching Innovation Study				✓	

4 Identified Area

Alongside the current innovation strategy key points stated in the RIIO-T1 Transmission Innovation Strategy, some new points may be added based on the internal and external stakeholder engagement. It is important that the existing strategies are also developed as much of the current key points are still very relevant.

The position of SPT in innovation is built upon wide stakeholder consultation, thorough analysis and in-depth understanding. It has to be recognised that a short-term future with vast renewable deployment is not certain under the current situation. This may have a significant bearing on SPTs evolving innovation strategy.

Key points to focus on from existing strategy

1. Improving SPT asset performance and utilisation. This area covers initiatives such as increasing capacity of the network, or life extending assets through new techniques to assess risk.
2. Meeting customer service expectations; including responding to customer enquiries as well as new approaches for connecting customers
3. Becoming more cost efficient; looking at alternative systems and technologies which will allow the overall unit cost of delivery to be reduced, this may include new procurement approaches as well as alternative technology.
4. Reducing SPT environmental impact; this will include areas such as visual mitigation and alternative materials for insulation amongst others.
5. Facilitating new generation; to allow for the transmission system to accommodate larger volumes of different types of generation as well as some of the challenges this will present like greater intermittency, variation in power flows and fault level, and quality of supply.
6. Preparing for future uses of electricity; understanding the impact on the network of new measures such as demand side management, the impact of electric vehicles and greater volumes of distributed generation on the transmission network.

SPT is already developing the platform for visualisation which will serve as a vital tool for addressing much of the issues outlined. However, without the ability to take any action based on the visualisation, operators may be left at a disadvantage. With the problems of both reducing system inertia and short circuit levels said to become more regional, it may well become both a TO and SO problem. While the control over generation may lie with the SO due to the market implications, other options of control may be available. These could include network level control of devices such as storage, Static VAR Compensators (SVCs), dynamic line ratings or adaptive network based protection.

There is also the opportunity to create a mechanism by which to encourage new generators to provide additional services. This may include intertripping, adjustment of outputs in exchange for lower transmission usage charges. This may need agreement with the SO on how to integrate these with market mechanisms. With the addition of HVDC converters to the networks, control through this path may be easier to implement.

Particular attention should be based on innovative schemes which would address the main issues of localised lower inertia and also the operation with lower short circuit levels and considering what assets in the system and being deployed could be shaped to enhance these concerns. Therefore, there is an opportunity for two levels of control, TO level control and SO level control. The TO level control would be owned and operated by the TO and would be based on network solutions, while the SO based solutions would be owned by the TO but operated by the SO. The advantage of such schemes is that they may add vital additional capacity to the system without reducing the quality of supply and make better real time use of the transmission system. The benefits of the schemes would be the cost compared with traditional reinforcement while retaining the similar outputs of transferring more power through the network. The other advantage is that such schemes should be faster to build than traditional reinforcement and so the TO can earn more from the increased transmission usage sooner.

There are also other issues which should be considered based on the following:

- The Western HVDC link is new to the GB grid, and the control strategy to optimise the AC and DC routes merits further investigation.
- With new Offshore Transmission Owners (OFTOs) connecting to the transmission system, there is the potential for very large wind connections to be connected at a single point. The risk of high wind cut out and the resulting power swings then become a major concern. The effects of such a large loss of power on stability and voltage control should be addressed and methods to counteract these effects should be sought.
- With the addition of the series compensation on the B6 boundary to release addition capacity, there is the opportunity for any new HVDC installations to interact with the control modes from the series compensators. This is something which may cause issues with day to day operation and the planning must be done to ensure that this is either avoided or controlled. This may require the necessity for any new HVDC connection to provide the additional capability to damp modes of oscillation, or the possibility of additional damping to the system must be considered. This is an area which may also benefit from further research.
- With the deployment of integrated power quality monitoring device on the GB transmission network, the information required to facilitate connection requests and the design for supply quality standards compliance can be time and effort consuming. How to make the relevant network information including power quality background available in an efficient and practical manner can be of great support to our customers.

While there is a necessity to increase the innovation on future network investment and also in the operation of the systems, the potential for research in achieving these aims should also be realised. The following should be considered as possible areas in which to invest in research.

Particular focus on Research

1. New Monitoring and Control approaches for low inertia systems
2. Liaise and Study the effects of increased numbers of OFTOs along the lines of interactions with existing transmission system, loss of infeed etc.
3. Novel approaches to offsetting investment in reinforcement but yielding additional capacity
4. Stability of future systems and consideration of potential problems
5. Interactions of control modes between B6 series compensators and HVDC converters
6. New applications with increased visualisation from Phase Measurement Units (PMUs)/Synchrophasors (North American Synchrophasor Initiatives, NASPI)
7. New Control Techniques to deal with high-speed cut out event
8. Power quality and its data mining at transmission network level
9. Research and demonstration to uplift Technology Readiness Levels (TRL) of new technologies which benefit the transmission network in long term

5 Developing Leadership Roles in Transmission Innovation

One of the disadvantages of the new energy system will be a very different profile of system inertia, and this is not entirely dependent upon the Governments' effect on renewable investment. With the Large Combustion Plant Directive (LCPD) going to shut down over 11 GW of conventional plant by 2015, the future inertia is guaranteed to be different. This will introduce very different system conditions and will require a new approach to control and operation. The current topics of the innovation strategy from SPT are very similar to the current innovation plans from SHE-Transmission, where SHE-Transmission currently have many projects ongoing in similar areas.

In the 2011 SPT innovation strategy, three main areas were described, *Wide Area Monitoring, Smart Transmission Zone* and *Dynamic Rating of overhead lines*. The latter is also the subject of SPEN and SHE- Transmission innovation plans. However, the concepts of wide area monitoring and control (smart transmission zone), where SPT is acknowledged to be the industry leader, put SPT in a very strong position in the future of low inertia systems.

There will be a need for new innovation in managing systems with low inertia, and with the problem of low inertia likely to affect SPT more so than National Grid (as GBSO) it provides an ideal opportunity to lead the way. Coupled with the fact that SPT are industry leaders in wide area monitoring, SPT are well placed to step forward and become leaders in low inertia system visibility and management. Not only is the low inertia likely to be a problem, but the effects of reduced damping and low short circuit levels are also important.

With the success of the VISOR application being led by SPT and the experience gained from the Smart Transmission Zone project (under the NIA regime), much of the groundwork towards developing a smart transmission zone is underway.

With the problems posed by local inertia variation, it is likely that local control measures will also become necessary and so innovative control strategies will be required. The smart transmission zone project highlighted the benefits of innovative control measures and was said to have greater potential than existing intertripping methods. A complete smart grid will require co-operation from the SO, TOs and DNOs, to create solutions that will lead to a strong reliable grid. With any additional renewables that are deployed, transmission systems may be required to carry more power. If any additional power deployed on the SHE- Transmission system must flow through SPTs system then designing for additional capacity is unavoidable.

The investment and timeframes must be considered for how to best achieve this additional capacity. SPT need to be prepared for different scenarios as every scenario will have their effects on the SPT system. Either way, a smarter, more adaptable grid may provide many innovative solutions to provide additional capacity more quickly while offsetting the costs of new infrastructure.

There is also a great opportunity in the creation of the new OFTOs. Developing relations with new operators, developing new methods to operate in conjunction with a new type of customer and to provide a resilient point of access for these new sources offers SPT the chance to explore this new interaction. It could allow SPT to develop the precedent that future TOs could adopt. The opportunity is not only applicable to OFTOs but indeed any future connections with HVDC convertors. This has particular impact on SPT as the operation of HVDC could introduce problems with the new installation of series compensators on the boundary. There is the potential for interaction between the control modes of these devices and this deserves attention from a TO operation point of view on how to control these interactions. This could be achieved by requiring new HVDC connections to provide additional damping, TO operated control or other methods to tackle interactions such as power oscillations damping.

Indeed the effects of OFTOs and the smart grid should not be ignored. With a large source of power being connected via an independent transmission operator, the effects of losing such a large infeed should be considered. If a large supply was lost, the boundaries such as B6 will see a large angle swing coupled with a possible reverse of power flows with power flowing from England to Scotland. Coupled with the low inertia, new control schemes will need to be used in order to handle these new types of contingencies.

The latest technology requires recognition, underpins the development and offers valid alternatives to the conventional reinforcement or connection methodology. SPT should continue the pro-active approach to improve the awareness and identify the innovation opportunity. A typical example can be found from its leadership in initialising the Low Frequency AC Technology under NIA regime.

The following is a list of areas and key innovation opportunities which SPT is in a strong position to take a leadership role in for the near future given their current experience.

Establishing leadership for transmission innovation

- Leaders in Wide Area Monitoring
  Including HVDC/AC Transmission Network interaction

- Leaders in localised inertia system management
  Additional damping resources
  Dealing with low short circuit levels

- Leaders in innovative control strategies/solutions
  For large infeed loss
  For low inertia system
  Voltage management

- Leaders in TO/DSO integrated innovation

- Leaders in new standards, new technology demonstration

  IEC 61850, LFAC