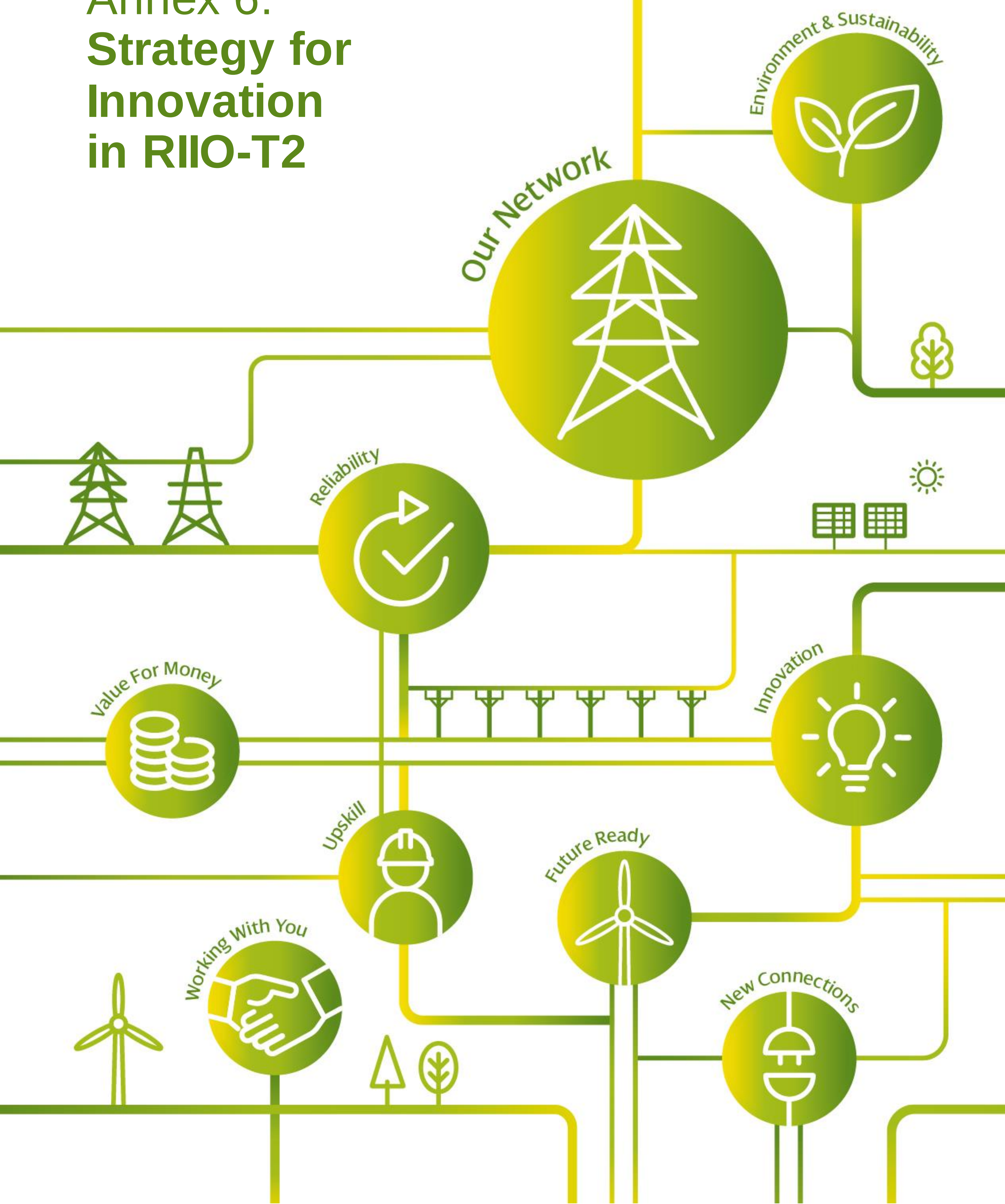
SP Energy Networks, RIIO-T2 Business Plan
December 2019 Submission

Annex 6:
Strategy for Innovation in RIIO-T2



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FOREWORD

1 Foreword

Over the past decade SP Transmission has led the way with its innovation activities, developing new technologies and solutions to address the challenges of the energy system transition. Our strategy is to use innovation as our core value to help deliver the needs of our consumers and wider stakeholders.

SP Energy Networks (**SPEN**) owns and operates three regulated electricity network businesses in the UK: SP Transmission plc (**SPT**), SP Distribution plc (**SPD**) and SP Manweb plc (**SPM**). Our transmission (**SPT**) and distribution (**SPD**) network in Scotland covers an area of almost 23,000km² in central and southern Scotland. In our licence areas we are the point of contact for all enquires relating to the electricity network. The safety and security of electricity supply is paramount to our day-to-day operations. We are dedicated to delivering a safe and reliable electricity supply to all of our consumers 24 hours a day, 365 days a year.

SPEN plays a significant role in the net zero transition in Great Britain (GB). In our licence areas 4.7 gigawatts (GW) of thermal plant has closed in recent years. Over a similar period, we have connected around 7GW of renewable generation; a significantly higher proportion compared to rest of the UK. In the UK we are a leading Transmission Network Owner (TO) in facilitating the connection of new renewable energy. SP Transmission owns and operates 154 substations and 4000km of overhead lines and cable network.

Over the last decade SP Transmission has led the way with its innovation activities, developing new technologies and solutions to address the challenges of the energy system transition. We believe an innovative mind-set and the culture of innovation promoted through our "**Culture of Innovation**" campaign within our organisation is the key to mitigating energy system transition challenges.

Ofgem has played a significant role in promoting innovation within the energy sector through the three innovation stimuli in the RIIO-1 price control: Network Innovation Allowance (**NIA**), Network Innovation Competition (**NIC**), Innovation Roll-out Mechanism (**IRM**). Ofgem is committed to continue supporting innovation in RIIO-2 through continuation of NIA fund, Innovation Roll-Out (**IR**) allowance through business plan justification and set up of a strategic innovation fund (**SIF**) to replace NIC.

Our plans will ensure that the benefits of innovation funded projects are fully realised in this and future price control periods as per our consumers and wider stakeholders' expectations. The costs and benefits provided in the strategy are our best estimates for RIIO-T2 based on our experience, assessment of benefits using a benefits model and careful assessment of past innovation projects.

Our innovation strategy provides an overview of the energy system transition challenges faced by TOs and the electricity system operator (ESO) in the coming decade and our plan to use our culture of innovation to mitigate these challenges in RIIO-T2. We also provide examples of innovation projects funded through the RIIO-1 innovation stimulus that we have successfully delivered, or are in the process of delivering, that we plan to roll-out in RIIO-T2 to generate benefits to our consumers and achieve GB's net zero targets.

Our commitment is to successfully deliver our innovation strategy in RIIO-T2 to achieve a "**Better Future, Quicker.**"

2 OUR INNOVATION PORTFOLIO

The RIIO-T2 innovation strategy for SP Energy Networks is divided into addressing six energy system transition challenges with each challenge addressed through four innovation clusters and sixteen innovation themes. The energy system transition challenges which our strategy focusses on addressing are as follows:

- **Improving the sustainability of our network and business processes and empowering our consumers**
- **Whole System Approach: overcoming boundary restrictions between electricity and gas transmission owners (TOs) and distribution network operators (DNOs), transport and telecommunications sector with increased customer engagement**
- **Integrating new technologies and enabling digitalisation, standardisation and cyber security**
- **Challenges related to black start**
- **Maintaining system security and stability: in light of reduced grid services, lower system strength, and increased grid dynamics and interactions**
- **Evolution of our transmission network and associated uncertainties: including new requirements for reinforcement and the replacement, operation and maintenance of aging assets**

2.1 Innovation Focus

The aim of our RIIO-T2 innovation strategy is to enable a future flexible network and to maintain its security and resilience in an uncertain future. We recognise the network of the future will need to facilitate the net zero economy, enable the connection of increasing levels renewable generation and ensure consumers and our workforce’s safety and security of supply. We also understand that achieving our ambition of the future energy system transition will have significant challenges.

We are in agreement with Ofgem that RIIO-2 innovation should be focussed on energy system challenges and creating longer term benefits for our consumers. We have mapped our six researched energy system transition (EST) challenges into innovation focus areas through our four main innovation clusters and themes based on ENTSOE's research and innovation (R&I) framework.[1]

C1 Network Modernisation

The network modernisation cluster aligns with the EST challenges of continuous evolution of our network and aging assets increasingly requiring innovative methods for operation and maintenance and condition based risk management. The themes in this cluster focus on optimal grid design based on the use of the most innovative and cost-effective technologies/ solutions that enable more flexibility.

Furthermore, the cluster also focuses on introduction of new materials and technologies that allow the development of our assets and associated infrastructure with high performance and/or lower costs. This includes methods to improve public acceptance and stakeholders' participation in transmission infrastructure to reduce environmental impact. Network modernisation cluster of innovation activities consists of four themes:

T1 Optimal Grid Design

T2 Smart Asset Management

T3 New Materials, Processes and Technologies

T4 Health & Safety Environment and Stakeholders

C2 System Security and Stability

We know that the changes to Scotland's energy mix and the closure of the country's last coal-powered power station means resilience and network stability is becoming our key priority EST challenge. Through our innovation projects we aim to focus on different aspects of network security.

We address the improvement of the dynamic observability of the transmission system. Furthermore, this cluster of our innovation aims to improve the black start plans using a common system approach including developing new procedures and strategy models for innovative ancillary services coming from different sources such as distributed energy resources (DER)s, storage and innovative methods for restorative action schemes.

The system security and stability cluster aligns with the EST challenges of reduced grid services, lower system strength, increasing grid dynamics and interactions and challenges with black start. Security and system stability cluster of innovation projects consist of four themes:

T5 Grid Observability

T6 Grid Controllability

T7 Network reliability and resilience

T8 Enhanced Ancillary Services

C3 Network Flexibility

Due to the decrease in the proportion of conventional flexible generation, new sources of network flexibility must be introduced to maintain the operability of our network. In future flexibility must be sourced from storage solutions, demand response, the integration of EVs and dynamic modelling of demand. In order to achieve this flexibility from DERs the TO-DNO interaction and visibility must be enabled through innovation that will support the T-D network operation while maintaining the quality and security of the supply.

The transmission network itself will become a source of flexibility though the increased use of our assets through use of real-time dynamic rating to increase power flow across power boundaries and through use of new methodologies that increase the use of transmission capacity in an economic manner. The network stability cluster aligns with the EST challenges related to black start and overcoming TO-DNO boundary restrictions. Network flexibility cluster consists of following four themes:

[1] Why we selected ENTSOE's framework for development of innovation clusters and themes?

- "From our day to day operation to our evolution into the utility of the future, stakeholders are at the heart of every decision we make." Ref Frank Mitchell CEO, SP Energy Networks. The R&I clusters and themes were developed using stakeholder feedback from a wide range of TOs and TSOs from ENTSOE framework which SP Energy Networks is a part of and has contributed to through various innovation projects.
- After careful review of our EST challenges we believe the clusters and themes defined in ENTSOE's framework are comprehensive and address all the EST challenges adequately
- The development of our RIIO-2 innovation strategy and selection innovation options for our RIIO-T2 business plan are based on a comprehensive innovation review process which was based on the R&I frameworks clusters and themes

T9 TO-DNO Interface

T10 Flexible Use of DERs

T11 Flexible Network Use

T12 Whole System Approach

C4 Digitalisation of Power Networks

Digitalisation of power networks will result in long term cost reduction and more efficient use of existing networks. It enables advanced asset management and system analysis and increases networks security.

This cluster of our innovations aims at considering the introduction of new digital technologies and enhanced data analytics through data-mining tools and development of standardised interfaces enabling data access to increase transparency in operation.

The cluster will also provide recommendations for standardisation activities and protocols for communications and data exchanges. This will ease the integration of new systems based on digital platforms. Increased digitalisation and complexity of interconnected information communication technology (ICT) systems in our network will also require updated cyber security policies, procedures and tools to mitigate cyber risks. The digitalisation of power networks cluster aligns with the EST challenges related to digitalisation, standardisation and cyber security.

Digitalisation of power networks cluster consists of four themes:

T13 New Digital Technologies

T14 Standardisation

T15 Enhance Data Analytics

T16 Cyber Security

Our innovation strategies detail our innovation activities in RIIO-T1, and the initiatives we will undertake in RIIO-T2 under these clusters and themes. In the following sections we will also discuss in detail:

Why we need innovation?

What are the challenges?

How we will address them?

We have marked each initiative as core, incremental or transformative innovation. We talk about our RIIO-T1 innovation, what we have learnt from others, how we will roll-out successful innovation projects, what benefits we have and will generate and most importantly our innovation ambition for RIIO-T2. This is our innovation portfolio for RIIO-T2.

- Core ()
- Incremental ()
- Transformative ()

3 INTRODUCTION

We have led the way in Great Britain's energy sector with our innovation activities. We have implemented new technologies and solutions on our network to address the challenges of the energy system transition.

Our innovation strategy builds on industry-wide innovation successes during RIIO-1. In RIIO-T2 we will be even bigger and better at innovation in going beyond the boundaries of our network, empowering consumers and accelerating our way towards achieving UK's net zero targets.

Innovation allows us to do more, for less, from making it easier to connect renewable generation, to improving the efficiency of our day-to-day operations and is crucial to achieving a "better future, quicker".

3.1 The Changing Energy Landscape

The UK played a central role in securing the 2015 Paris Agreement which builds upon existing UK legislation which targets a CO_2 reduction on 1990 levels by 50% ahead of 2030 and 80% by 2050.

Paris Agreement: "The Paris Agreement has the commitment of 195 countries to work collectively to combat climate change and adapt to its effects. From the international agreement there have been significant changes to carbon reduction targets."

The UK is expecting energy companies to play a leading role within the journey to a net zero economy. Ambitious targets have been set by UK and Scottish Governments to accelerate this journey.

Scotland's electricity supply today is largely decarbonised. In 2017, renewable electricity generation was equivalent to approximately 68% of Scotland's electricity consumption. New innovative approaches have enabled more renewable generation to be connected to the network, and facilitated the closure of larger thermal generations to be accelerated.

We are seeing changes in the generation, distribution and demand of electricity. Traditional power stations such as large coal power plants are being replaced with increasing numbers of small scale renewable generation such as wind, photovoltaics and biomass. This, coupled with the changing way we use energy for everyday activities such as heating and transport, means we need to look at innovative approaches to ensure the smart networks of the future are resilient, flexible and affordable for all.

3.1.1 Generation is changing……

"For the first time since the 1880s, coal, once the mainstay of our generation sector, was absent from GB's operating electricity generation mix on the 21st April 2017. A month later, on the 26th May, solar generation was meeting nearly a quarter of all electricity demand in GB." Electricity Network Innovation Strategy, ena March 2018.

SPT RIIO-T2 Electricity Scenarios, 2019, forecasts wind capacity increase in all projected future energy scenarios. Much of this growth is in offshore wind but a lot of onshore capacity growth is also projected primarily due favourable wind conditions and availability of land in Scotland. In 2017 there was for the first time renewable generation providing more than half of GB's electricity demand.

There is relatively low uncertainty relating to thermal plant on the SPT network, with only two large nuclear plants (Hunterston and Torness) currently connected. These plants are widely expected to close in the early and late 2020s respectively, and there is no new thermal capacity planned until 2030.

The changes in connected generation capacity mean that where the future for thermal and nuclear generation changes are clearer there are significant uncertainties associated with the scale of wind generation connected and this applies to the neighbouring transmission networks of SHETL and NGET as well.

The other aspect of uncertainty arises from "behind the meter" distribution connected generation which are projected to double by 2030 mainly in form of wind, solar, biomass and storage. The falling cost of solar technology and co-location with storage leads to significant growth in solar and is predicted to continue in coming years, especially in the community renewables scenario.

The growth in renewables and especially the distribution connected generation has resulted in change in power flows in the years 2017 and 2018. SP Transmission is now importing across the B6 boundary on days with low wind and many grid supply points (GSPs) see a reversal in power flow on days of high wind generation. The changes in power flow directions require us to develop innovative methods to contain fault level, and increase boundary transfer capability using existing assets which were designed for conventional generation while ensuring security of supply, especially during low wind periods.

3.1.2 So is demand…..

In addition to renewable sources of electricity, the electrification of heat and transport is essential to facilitate the UK meeting its climate change target. As a result, electricity demand has the potential to increase significantly and the shape of demand will also change (Ref SP Distribution Innovation Strategy). There is a wide spread of uncertainty around decarbonisation of heat by 2030. The Scottish Government Climate Change Plan aims for a share of low carbon heat by 2030 of around 35% (albeit not only from heat pumps) and the Committee on Climate Change's Scottish analysis assumes around 18%.

The number of electric vehicles – both plug-in hybrids and full electric – registered within SPT's area is currently very small; just over 4000 within a vehicle population of almost 3 million cars. However, momentum in support of electric vehicle adoption is building. According to RIIO-T2 Electricity Scenarios 2018, across the scenarios, the share of electric vehicles rises to between 4% and 20% by 2030, with deployment accelerating more rapidly shortly after this point. In SP Transmission area there will be more variations in net demand predicted in scenarios, while there will be a general increase in demand this could be largely offset by decentralised supply.

Although the technology advancement will drive up the demand for electricity, technology is also a potential enabler for reducing the demand at peak time by the use of smart applications. EVs and batteries can support the rollout of renewables by storing excess low carbon generation and by providing electricity back to the system when needed.

The RIIO-T2 Electricity Scenarios 2018 shows that although the increase in peak demand is expected to be significant it is likely that the majority of this increase can be offset by flexible loads. Therefore, careful consideration will be taken when planning network upgrades to ensure realistic levels of flexibility are incorporated. A greater variation is seen across each GSP. In some cases, increased supply may exceed a GSP's capacity for generation. Conversely, if new load is less flexible some GSPs may become rapidly demand constrained. The role of the SP Transmission network for manage the uncertainty will be to introduce flexibility and controllability to ensure that GSPs with higher generation and flexible demand can export power to areas of less flexible demand and lower connected generation. This will be achieved through careful system planning and also innovative solutions to actively manage demand conditions and use the flexibility further to provide essential grid services. New innovative approaches have enabled more sources of renewable generation to be connected to the network, and accelerated the closure of large thermal generators, thus aiding the journey towards our net zero future. This will also result in the rapid uptake of electric vehicles, electrification of heat, increased distributed and renewable generation, and the emergence of disruptive technologies. We're committed to making the most of this transition. We are also aware that change is happening faster than ever before. This pace is bringing new challenges which we're addressing by thinking differently and taking an innovative approach to our day-to-day business.

3.1.3 We Innovate….

Innovation is key to making sure the energy system transition is seen more as an opportunity than a challenge. We need to keep up with the changes and continue improving and modernising our ageing infrastructure and operations, while meeting our regulatory obligations. Our ultimate goals are to deliver benefits to GB consumers, while maintaining security and reliability of supply. We're innovating to drive progress and deliver across three areas:

1. Decarbonisation

- Increasing grid visibility and controllability to accommodate new renewable generation connections while maintaining reliability of our network
- Enabling decarbonisation of heat and transport
- Developing asset management tools to get the best value from our assets, and enhance network efficiency
- Collaborating with our supplier base and academia to leverage advancements in research and development worldwide; driving efficiencies and delivering a sustainable grid

2. Decentralisation

- Developing a more flexible and dynamic grid to be ready for an uncertain future
- Making more use of distributed energy resources
- Adopting a 'whole system' approach to work across our network boundaries and with other sectors

3. Digitalisation

- Using digitalisation, intelligence and data analytics to create meaningful information to optimise the operation of our network
- Enabling standardisation to deliver faster deployable solutions
- Deploying cyber security policies to protect our data and assets in the ever increasingly interconnected network

In RIIO-T2 we will continue to invest effectively in our network, and maintain and improve its reliability and resilience for the benefit of our consumers. We have embraced innovation, because we know that the challenges we face cannot be solved by doing things the same way we did a decade ago. We need to work even more collaboratively, and think outside the box to bring transformation in our business through innovation.

3.2 Development of our strategy

We successfully led and delivered innovation projects in RIIO-T1. This, together with our internal governance mechanism for managing our innovation portfolio, participation in industry-wide working groups and extensive engagement with 3rd parties, stakeholders and challenge groups, has provided us with the necessary foundation to build a strong and ambitious innovation strategy.

We identified that innovation is more than technology: it is also about our people, stakeholders, consumers, sustainable business processes and our regulator. Because of this, we believe our innovation strategy should cover both our 'innovation strategic focus' and 'culture of innovation'.

The innovation strategic focus section deals with the energy system transition challenges. It lays out a methodology, along with a detailed project portfolio to show how we address these challenges through innovation.

The culture of innovation section of our strategy addresses the wider aspects of innovation, such as our internal skillset, investment procedures and governance. This will make sure we get the best value out of our incentives and effectively collaborate with our stakeholders and the wider industry.

In order to develop the innovation capability section, we began by comprehensively reviewing innovation projects undertaken in RIIO-T1. This allowed us to identify projects with well-defined results that were also highly relevant to our business plan for RIIO-T2. As well as our own work, we carried out an extensive review of:

- Key areas of investment in our business and challenges faced by our network in RIIO-T1
- Innovation projects initiated and led by other UK transmission owners (TOs), distribution network operators (DNOs) and the energy system operator (ESO) and gas transmission and distribution network owners delivered through the RIIO-1 network innovation allowance (NIA), network innovation competition (NIC) and innovation roll-out mechanism (IRM) stimuli
- Innovation initiatives from across Europe and the rest of the world

The key energy system transition challenges and relevant projects identified through this review were developed into innovation options to be considered as part of our business plan development. These innovation options are identified throughout our business plan proposal and are also highlighted in detail in this innovation strategy annex. We also launched a wider RIIO-T2 innovation strategy stakeholder consultation and gathered feedback on our innovation ambition through webinars, presentations to the independent transmission user group, challenge group and site visits demonstrating innovation in action. Combined with our participation in various innovation stakeholder engagement activities in RIIO-1, this helped us develop a robust and ambitious innovation strategy which we present in the following sections.

4 Innovation Strategic Focus

Innovation strategic focus: we understand and are prepared for the energy system transition challenges

Renewables, new connections to Europe, the fast changing nature of demand – and the overall need to empower our consumers and provide them with a reliable, resilient service. This is innovation in action.

Scottish Government 2030 targets assume a considerably higher market penetration of renewable electricity than today – requiring in the region of 17 GW of installed capacity in 2030 (compared to 10.4 GW in June 2018) – with greater interconnection with parts of continental Europe providing an expanded market for our electricity. In this section, we have identified the main challenges that our transmission network is facing with the energy system transition. We will emphasise these challenges in our innovation projects to ensure a secure future for our consumers despite all the uncertainties involved.

4.1 Energy System Transition Challenges

4.1.1 *New requirements for reinforcement of our network in light of changing energy landscape*

Our network has a critical role to play in decarbonisation. As a TO it is our responsibility to unlock net zero economic growth by:

- Ensuring our investment plans align with the future network requirements
- Maintaining a resilient network in an uncertain future

Our license obligation as TO is to comply with the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS). The NETS SQSS sets out planning and operational criteria which determine the need for investment in our transmission equipment. We also have a license obligation to comply with the System Operator Transmission Owner Code (STC), which requires our assets to be made available to NG ESO, as National Electricity Transmission System Operator, for efficient operation of the network.

We are continuously developing an economic, efficient and co-ordinated system for the transmission of electricity within our licenced area to meet our license obligations and accommodate the Energy System Transition (EST) changes, especially over the past decade with accelerated growth of renewables connecting and with the ever-rising need to accommodate constantly changing power flows, meaning our network has seen significant reinforcements. The need for reinforcing our network comes with a cost to the customer. The changes in government policies and the drive to minimise costs to consumers require innovation to introduce more cost effective reinforcement options and, where possible, avoid reinforcement through innovative solutions to make more of our existing asset base such as dynamic ratings, active network management and wide area monitoring. Some of our key reinforcement schemes currently demonstrating our core innovation include (Ref: ensg document a vision for 2020):

- SPT/NGET Series compensation on the circuits connecting the Scottish and English Networks

- SPT – Western HVDC Link and associated works

Figure 1 Hunterston HVDC converter station

4.1.2 Replacement, operation and maintenance of assets for a resilient and sustainable network

Our network assets need to be replaced and/or upgraded when approaching the end of their expected life and to connect new generation. The volume of generation in the central and south of Scotland area is expected to increase over the coming years due to the growing capacity of onshore wind farms across the south of Scotland. In SP Transmission:

- Majority of 275kV network over 50 years' old
- Significant sections of 132kV network over 60 years' old
- We have connected over 7 GW of renewable generation in past 10 years

Along with reinforcing our network, more innovation is needed to have a more detailed view of how our assets are used and improve our asset management processes. This ensures we get the best value from our assets and maximise their remaining lives. In order to maximise the lives of our assets, we enable the evaluation of the current condition of the network assets where possible using non-intrusive methods, the reliability of the network assets, and the predicted rate of degradation in the condition of the network assets.

Asset management strategies have evolved from age-based interventions to condition and risk based approaches. However, for efficient and reliable condition based asset management, periodic and/or real-time asset condition data is vital. There is even more than ever a drive to use UAVs, LiDAR, sensors and monitoring systems to collect asset condition data. The vast diversity of our assets and their functions means we can effectively create volumes of condition data.

This has been a key area of our incremental/ adjacent innovation in RIIO-T1. We now own and operate various condition monitoring systems and we aim to further use innovation to develop a standardised method to create meaningful information and user friendly displays to provide real-time information to our operation and maintenance engineers, in the form of asset health maps, historical reports and predictive analysis for condition based risk management systems.

4.2 System Security and Stability Challenges

4.2.1 Reduced Grid Services

National System Operator (NG ESO), to ensure the stability and quality of electricity across the UK, uses ancillary market services such as frequency response, reserve services and reactive power and voltage management.

SP Transmission as a TO does not directly procure market services; it is our responsibility to provide different kinds of connections for market participants to enable the grid to have adequate reserve and emergency grid services. Traditionally, synchronous generators were the main source of ancillary services. The proportion of energy supplied by synchronous generators is decreasing in the decarbonised transmission system, the grid services provided by synchronous generators is rapidly declining and network operators face significant challenges.

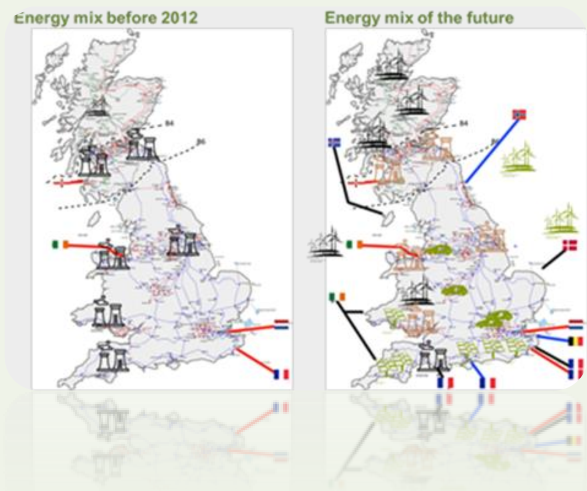


Figure 2 Change in GB Generation Profile

Frequency Response

Penetration of non-synchronous generation contributes to a shortage of dynamic and immediate responses to frequency changes. In periods of low demand and lower synchronous generation there is limited frequency response available. The lack of inertia leads to higher rate of change of frequency (RoCoF). The variations in system inertia are not uniform, with specific geographical regions being more affected due to their penetration of renewables, e.g. Scotland.

Reserve Services

As dispatchable generation connected to our network is constantly declining, the SO requires new options to carry out its role in managing system balance and operability. As a TO we play an important role enabling more distributed services to connect to our network at strategic points to allow the SO to backfill for the lost services from declining synchronous generation.

Reactive Power and Voltage Management

The ability to efficiently manage voltage on our network through reactive power control has drastically reduced. Reductions in reactive power demand at distribution level, and increased distributed energy sources create scenarios where the voltage at any given time of the day on the transmission network can be high and difficult to manage. The resulting challenge for our operational planners is to manage system voltages while also maintaining network availability.

4.3 Challenges related to Black Start and Grid Dynamics

Figure 3 Closure of coal-fired power stations

Black Start is the process in place to re-energise the system in case of the low probability event of a large discrepancy between generation and demand, and loss of power supply in large areas or the complete network, otherwise known blackout. There are black start service providers such as large thermal generators, aggregators and storage that can be immediately called into action in the event of a blackout.

The availability of conventional Black Start service providers will decrease as part of the shift away from conventional thermal generation. In Scotland 3.5GW of coal generation has recently closed. Extensive GB power system analysis by SPT shows black start and maintaining supply resilience will be more challenging and uneconomical from 2020 onwards unless other sources for critical services are generated through network flexibility.

Severe weather events are a regular feature of the climate in northern Britain. Past operational practice has been to dispatch generation in Scotland during severe weather to secure the system, prior to use of demand control measures. Due to a lack of thermal plants in the SPT area, sustained restoration of supplies in Central and Southern Scotland will rely on support being made available from both the NGET and SHE Transmission areas.

A repeat of the 2001 'Snow Blitz' today may be expected to disconnect Scotland from England and cause much more widespread loss of supply than in previous years.

Probabilistic assessment of restoration timescales to date clearly demonstrates:

- A significant extension to restoration time in Scotland
- A significant variation in regional restoration performance internal to Scotland
- Severe weather and/or major asset damage events could add several days to the predicted probabilistic recovery timelines

SPT is looking for alternative approaches to Black Start and new strategies to restore the system through significant and ongoing engagement with stakeholders and policy makers. We have studied the recent black start events around the world such as Australia and the USA. There are lessons to be learned and applied in the innovative planning and operation of the system in Scotland. We are exploring new and innovative avenues to prevent blackouts and efficiently manage black start through innovative measures such as:

- Real-time dynamic monitoring to accurately detect system stability issues
- Fast acting system integrity protection schemes to reduce demand and/or generation in case of a major transmission system fault and loss of generation
- Exploring distributed energy resources (DER) and developing innovative methodologies for black start from DERs. (Ref: Distributed ReStart project)

4.4 Increased Grid Dynamics and Interactions

The penetration of converter-based power generation and interconnectors continues to increase in our transmission network. The major challenge associated with converter-based technologies is lack of accurate modelling and experience in operating such systems over longer durations and under different network conditions in order to accurately predict its behaviour, performance and interactions with other network assets. More studies are required to understand how these new technologies can and should be represented in our dynamic simulations and to be able to effectively use and operate them on our network.

The converter-based technologies also contribute to the dynamic interactions in the network. Increased interactions in the grid drastically change power flow patterns and daily curves, leading to many boundaries of the GB transmission system becoming more frequently congested and dynamically managed, potentially resulting in increased constraint cost unless new network options are implemented. Increased interactions also require increased dynamic visibility of our network. Traditional SCADA and EMS systems are limited in providing such visibility and thus innovative solutions such as wide area monitoring using phasor measurement units need to be deployed and used in real-time. SPT's project VISOR in collaboration with other TOs and the ESO has successfully demonstrated that such dynamics can be visualised and resulting interactions can be managed. There still is a need for more innovation to enhance visualisation and analysis of grid dynamics and interactions to prevent low probability and extreme high risk events on our network. (Ref: VISOR report)

4.5 Whole System Approach

4.5.1 Overcoming TO-DNO boundary restrictions and our vision of DSO

SPEN as a transmission and distribution license owner is increasingly aware of the need to overcome the transmission and distribution network visibility boundaries and create more synergies between both networks. Traditionally the distribution network, as the name suggests, has been designed to meet local demand and distribute energy to end consumers. The rise in amounts of renewable, intermittent generation that are being incorporated into the transmission system have created a need for new, flexible operating capability, and – more importantly to the TO-DNO interface – the prolific or impending integration of energy resources connected to the distribution network. Integration of these DERs that include not only distributed generators, but also energy storage, EVs, demand response and energy efficiency, is changing the old paradigm under which the TOs and DNOs have operated and maintained their networks in the past. The way we define, or redefine, this interface is emerging as an important issue as the line blurs around roles and responsibilities.

In past 3 years we have increasingly seen large percentage of demand being met at the distribution level under favourable wind and solar conditions. On one hand while this poses a challenge for the transmission network owner and system operator to accurately predict demand over longer periods of time it also provides the transmission network with a new tool to generate essential power network flexibility by actively managing distribution connected resources. The focus of innovation in this area now and over the next decade will create more visibility of the distribution network for the system operator and develop solutions to create demand flexibility and harness essential grid services by interacting with the distribution network.

The key challenges in this area that require innovation are:

- Forecasting the short-term effects of DERs on demand – Dynamic modelling of demand
- Creating visibility, situational awareness, and control of DERs
- Harnessing DERs in distribution system for phase balancing and voltage regulation

4.6 Integrating new technologies and enabling digitalisation, standardisation and cyber security

4.6.1 Digitalisation and standardisation

"The cost, performance and deployment of many clean energy technologies have dramatically improved in recent years, accelerating transitions towards cleaner energy systems around the world. Digital technologies already play a vital role in accelerating decarbonisation efforts, but for digitalisation to reach its full decarbonisation potential, we need good policies informed by rigorous analysis." SETIS Magazine May 2018 - Digitalisation of the Energy sector

The developments brought by the information and communication technology (ICT) sector to the whole society and economy is also impacting the power system. The biggest gap in terms of technological advancement between other sectors and utilities is that of digital technologies, understanding of communication networks and data analysis. Network Owners have traditionally not been faced with such volumes of data, a large percentage of innovation initiatives in RIIO-1 required companies to be able to provide high speed and reliable communication networks.

RIIO-1 innovation projects brought in diverse forms of data, protocols for integration, types of data models and analysis platforms. This has, in a way, created awareness amongst NOs that without co-ordination and standardisation the diverse systems will be hard to manage and integrate with legacy systems, and moreover there is a skillset gap in managing and maintaining digital systems. These new developments should be considered in all innovation initiatives related to power system protection, monitoring, control, real-time applications and wide area applications. The need for innovation and/or inclusion of following factors for digitalisation in RIIO-T2 will stem from following key factors:

- Ensuring interoperability and standardisation of data formats, update of approvals procedures and technical requirements to better align with international standards for smart grids
- Upgrade of telecommunication infrastructure for future proofing against requirements for wide-area co-ordination of control and data exchange
- Definition of digital communication and application strategy with key learnings from telecoms sector
- Skill-set development to create digital workforce for the future

Figure 4 Digital Substation

Innovation is a key driver and solution to challenges and opportunities introduced through digitalisation. Innovation can help standardise and introduce a controlled approach to changes in ICT and digital technologies in power systems and for network owners.

4.6.2 Cyber Security

The energy infrastructure beyond the networks, generators and right to the prosumers (producers+consumers) is arguably one of the most complex and, at the same time, critical infrastructures relied upon by business to deliver essential services. Because of this reliance, any prolonged disruption could trigger a cascade of damaging effects across society. In the past, physical access to a substation was required in order to disrupt the energy flow and impact society; today the threat to supplies comes from more diverse sources and may not require physical access. The move from a traditional "copper-based power system" for communication to a system that more extensively integrates the information communication technology (ICT), digital technologies, data management and data hubs makes cyber-security of paramount importance. The increase in use of digital technologies and advanced communications also increase the cyber risk, however it needs to be understood that this risk in current development scenario is unavoidable and needs to be adequately addressed in our innovation and overall digital strategy.

"The 'Ukraine power grid attack' illustrates the impact of cyber-attacks on the electricity subsector. This attack resulted in 'several outages that caused approximately 225,000 consumers to lose power' across the country." (Source: SETIS Magazine May 2018 - Digitalisation of the Energy sector).

In such complex digital and interconnected ICT systems, network owners and especially TOs (as the impact of a cyber-attack on transmission infrastructure can have wide spread effects) must focus on the 'operational environment', to protect SCADA systems, protection and control equipment and detect potential attacks and respond to and recover from any incidents.

The increasingly evolving and changing nature of threats, response and recovery in case of a cyber-intrusion are of increasing importance. SP Transmission emphasises that cyber security cannot be addressed in silos; we have in RIIO-1 developed strong collaboration with other TOs, and wider industry initiatives to develop a strong cyber security strategy. The next challenge for us in RIIO-T2 is to maintain engineering efficiency and usability while applying the strategy and cyber security solutions to our day to day operations. We seek to innovate in the following areas for RIIO-T2 to make our operational network cyber secure beyond the implementation of firewalls and physical security:

- Developing intrusion detection systems at control centre and substation level to ensure secure real-time operation of our network
- Application of role based remote access control to our substations
- Application of international cyber security standards to our future intelligent electronic devices and communication network equipment

4.7 Improving the sustainability of our network and business processes and empowering our consumers

4.7.1 Achieving Sustainability

Sustainability is the key enabler for GB's net zero future; sustainability, though focussed on reducing longer term impacts on the environment, also determines the longer term viability of electricity transmission and distribution networks. SPEN is working to deliver the vision of our business becoming a sustainable networks business as set out in the sustainable business strategy, by embedding the principles of sustainability in our decision making. Actively selecting and taking forward innovation projects is a key area of opportunity. By collaborating with our stakeholders, manufacturers and other network companies we've identified opportunities to maximise sustainability outcomes where the initial innovative idea was motivated by other challenges.

We've also driven forward with projects that have sustainability goals at the heart of their business case, whether they are focussed on reducing our own environmental impacts, whether they are designed to reduce the cost to consumers, or whether they are required to help us adapt to a world in which the impacts of climate change are now being felt. SP Transmission is leading global efforts to identify a technical and commercially viable alternative to the use of Sulphur Hexafluoride (SF_6) as an insulating gas. SF_6 is the most carbon intensive greenhouse gas in the world and has been used extensively as an electrical insulator since the 1980s, when the industry moved away from using oil in mass quantities for health and safety reasons. We're also investigating opportunities to reduce energy losses from transmission substations by establishing, through audits and metering, the baseline level of energy usage of a number of trial substations in the SP Transmission licence area, and then use the collected data to model the performance of the substation buildings. These data models will allow opportunities for energy efficiency to be identified, then enable the development for a plan for substation energy efficiency. We're reviewing how we can support our supply chain to improve their whole environmental footprint. This action is driven following an innovative whole project life cycle assessment of our Kilgallioch wind farm connection that identified some 80-90% of the project's environmental impact was spent in the manufacturing and installation of the equipment.

Our strong belief is that sustainability and sustainable solutions should form a key part of the future vision of energy system transition and every future project and initiative should be subject to longer term sustainability checks. Any technical solution or initiative no matter how commercially favourable should also be sustainable to be deployed. The assets already on our network should have sustainable strategies defined for operation and maintenance. Our commitment is to further explore sustainable solutions, processes and methods in RIIO-T2 and we firmly believe innovation has a key role to play in this area to make our network and our business sustainable and create further socio-economic benefits for our consumers.

4.7.2 Empowering Our Consumers

Our regulator Ofgem has expressed their desire through the reforms placed for RIIO-2 innovation to place consumers, especially those in vulnerable situations, at the centre of future innovation incentives. This is in line with our business priorities of customer care, empowering our consumers and going beyond our duties to help consumers in need.

The position taken by Ofgem aligns with the drive to reduce costs for our consumers. We have a duty through our business and our innovation activities to stay “customer focussed”

There are various mechanisms that we can deploy to strengthen the position of our consumers by improving their rights to available information, enabling them to participate in the energy system transition and empowering them by giving them an active role in our future decisions through wider engagement and our wider DSO role.

Our consumers are already energy savvy: they better understand the energy issues and the need for energy efficiency, and the development of smart meters and connected smart appliances are enabling consumers to actively participate in residential energy management. In addition to meters, the penetration of renewable energy sources and storage technologies, smart appliances and EVs means more and more consumers are playing an active role in the power system and managing their own energy consumption. They are “our prosumers”.

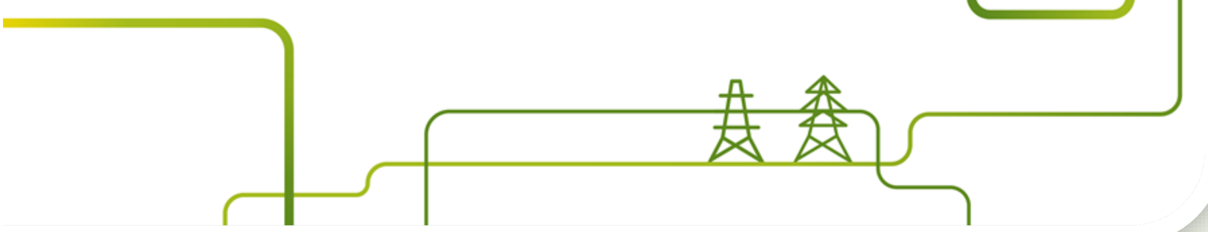
Our prosumers are more favouring localised energy production and trading. The DSO incentive is aimed at enabling more of these possibilities for our consumers and prosumers thus enabling more localised balancing services.

The important question for us as transmission owner is what role can we play in this increasingly changing energy landscape?

We are responsible to maintain a strong interconnected grid to enable the localised services to function efficiently reducing the risks for unplanned outages and/or large scale blackouts. In future, we will need our consumers’ participation in both our transmission and distribution network to create more flexibility and efficiency in our system. And innovation will play a key role in achieving this objective!

RIIO-T2 INNOVATION AMBITION

We plan to be even more transformative, and use innovation to achieve a 'Better Future, Quicker'.



5 RIIO-T2 Innovation Ambition

What really matters is fairly straightforward: how we trial and deliver industry-transformative innovation projects. Our business has evolved to foster an ever-growing culture of innovation, with a drive to build even more innovation capability and ability within our business.

We will see the benefits from roll-out of our ground-breaking innovation in RIIO-T1. Our innovation success from RIIO-T1 has provided us a solid foundation and understanding of the risks, challenges to be addressed, the level of engagement required with wider stakeholders, and the kind of skillset we need to build within our business to successfully drive innovation for a sustainable future.

5.1 Innovation funding

We are supportive of Ofgem's decision to maintain dedicated innovation funding in RIIO-T2 aligned to energy system transition challenges to support large scale innovation projects and ensure better alignment with public sector funding.

We believe Ofgem's decision to deploy governance including industry experts, network owners, system operator and 3rd parties in identification and setting of the focus for this reformed funding will provide us with the ability to utilise this funding for transformative projects collaboratively across the industry and deliver our net zero future quicker.

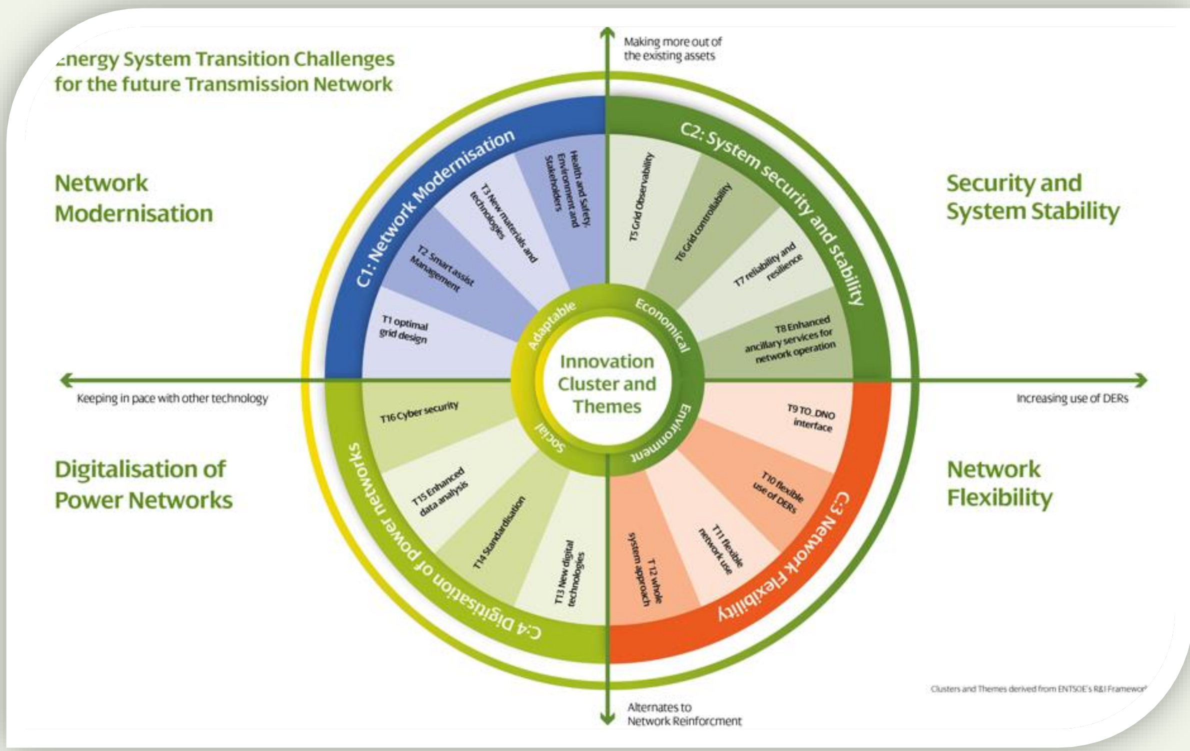
The proportion of funding allocated across the challenges may need to be regional as the issues faced by the transmission network in Scotland may be more pronounced than others. We will work with Ofgem on these key issues over the coming months to ensure the alignment of the large scale innovation funding with our and industry wide innovation strategies.

5.2 Using innovation to enable energy system transition

We will utilise this opportunity to develop innovation incentives using a whole system approach, accelerate digitalisation of our critical infrastructure, ensure stability and security of our network, and trial globally innovative technology solutions.

The continuity of NIA funding in RIIO-T2 will enable further research and development activities that are crucial to inform our future investment and network enhancement decisions, and trial of lower technology readiness level solutions on our network paving way to large scale deployment in future.

Our commitment for innovation is clear: "we will deliver on our innovation ambition to drive changes within our business. The benefits will be far-reaching: to accelerate decarbonisation and enhance digitalisation – but also to maintain a secure, reliable, efficient and sustainable network for future generations."



We are in complete agreement with Ofgem that we need to justify and show our plan to utilise NIA funding in RIIO-T2.

5.3 Enabling new and transformative innovation

We will focus on building our capability in grid modelling and enhanced capacity for large scale data analysis. This will require investment in new software as well as skills. Innovation is likely in the way we engage with others and try to access the most appropriate analysis capabilities, even if not in-house. We will utilise this ability to identify any threat to the security and stability of our network in light of the changing nature of generation and demand. We will be utilising our internal and external R&D capability and knowledge to pre-empt any scenario that might require significant investment in future controls and develop holistic approaches to manage the transition in an economic and efficient manner.

We also aim to explore the possibility of developing powerful visualisation tools which will combine 3-D modelling, artificial intelligence and advanced sensor technology to make best use of the technological advancements, which will make us early adopters within the industry to use state-of-the art digitisation and information technology to create more intelligence within our network. The technological solutions may be in their infant state, but through detailed case studies and gap analysis supported through innovation, we will enable the network digital twin of the future.

5.4 Enabling Whole System Approach

Our network has boundaries but innovation and the future solutions facilitating energy system challenges do not need to. We want to enable more holistic thinking through innovation to roll-out a true whole system approach. Can increasing visibility of our distribution network help address critical issues on the transmission network? Can we build in storage capability within our gas network? Can the telecommunication sector tell us more about accelerating digitalisation within the energy industry through shared services? These and many more important questions can only be answered through the whole system thinking and approach which we aim to enable through innovative incentives in RIIO-T2.

5.5 Empowering our consumers and addressing consumer vulnerability

Our consumers are at the heart of what we do. We consider that our job goes beyond keeping the lights on. We are known for our excellent customer care and we strive to serve our most vulnerable consumers by making them our priority. Can innovation play a role in it? Of course we need to play our part in tackling energy poverty, and empower our consumers to not only play a role but also benefit from energy system transition. We will make this one of our key priorities while defining our innovation projects in RIIO-T2.

The following sections detail our innovation activities under our four innovation clusters and sixteen innovation themes. Under each cluster and theme, we highlight what we did in RIIO-T1 under our innovation portfolio, the projects that we will be progressing as business as usual (BaU) in RIIO-T2 and the innovation areas we will explore in RIIO-T2.

We provide an estimate for cost of investment vs benefit generated for each cluster and theme, and estimated investment that will be required under NIA funding in RIIO-T2.

The Energy Networks Association (ENA) published the annual innovation strategy for electricity networks in 2018; in this strategy ENA published the innovation themes applicable for TOs, DNOs, ESO and OFTOs. We have mapped the themes of this strategy against ENA defined themes in the table below to highlight that our innovation strategy covers all themes identified by ENA in collaboration with industry stakeholders.

Innovation Themes	C1	C2	C3	C4
Network improvements and system operability	T2	T5, T7	T11	
Transition into a low carbon future	T1	T8	T9, T10 T11,T12	
New technologies and commercial evolution	T3		T9	T12,T16
Customer and stakeholder focus	T4		T10	
Safety, health and environment	T2,T4			T13

Table 1 Mapping of clusters and themes against ENA innovation themes

INNOVATION EXPENDITURE & BENEFITS

RIIO-T1: A track record to rely on
RIIO-T2: Delivering a balanced innovation portfolio

6 Innovation Expenditure & Benefits

In RIIO-T2 we will primarily innovate through business as usual using our TOTEX allowance. The innovation funding expenditure and funding request described in this section is for RIIO-T2 innovation roll-out and NIA projects.

Our innovation portfolio for RIIO-T2 represents a balanced ambition across our four clusters and sixteen themes of innovation building on the key learnings from RIIO-T1.

6.1 Our RIIO-T1 Innovation Portfolio, Investment and Benefits

One of the key learning from review of RIIO-1 innovation is as an asset owner our focus in innovation is more on network modernisation and topics related to system security and stability in collaboration with the ESO to mitigate the system risks associated with energy system transition as seen in Figure 5 and Figure 6. This is expected given our business is primarily responsible for asset and network management. Innovation under network modernisation and digitalisation of power network clusters can directly create efficiencies for the transmission owners.

However, moving towards RIIO-T2 as we adopt whole system approach and interact more with DNOs and DSO network for daily operation flexibility generated through cross sector and cross boundary interaction the innovation portfolio will be more balanced with almost equal focus on all four clusters.

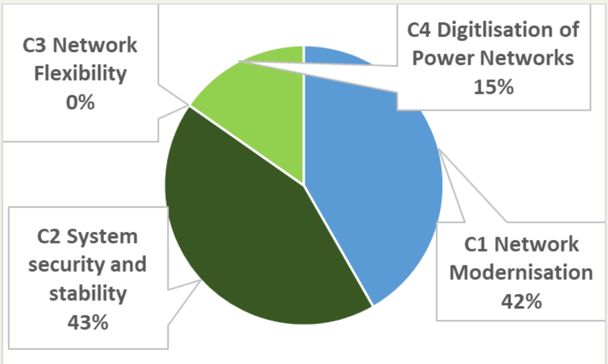


Figure 5 RIIO-T1 Innovation Expenditure Profile-Clusters

Our four major projects funded through the NIC and IRM were focussed on the themes to introduce digitalisation, new materials, processes and technologies, increasing grid observability and controllability. SP Transmission has actively engaged in the innovation funding mechanisms and developed globally innovative projects through the NIC mechanism such as

- VISOR (NIC in collaboration with NGET TO, SSEN, NG ESO & GE) (£7.3 m) – The project successfully delivered GB's 1st wide area monitoring system providing dynamic visibility of the GB network to the ESO and TOs across GB.

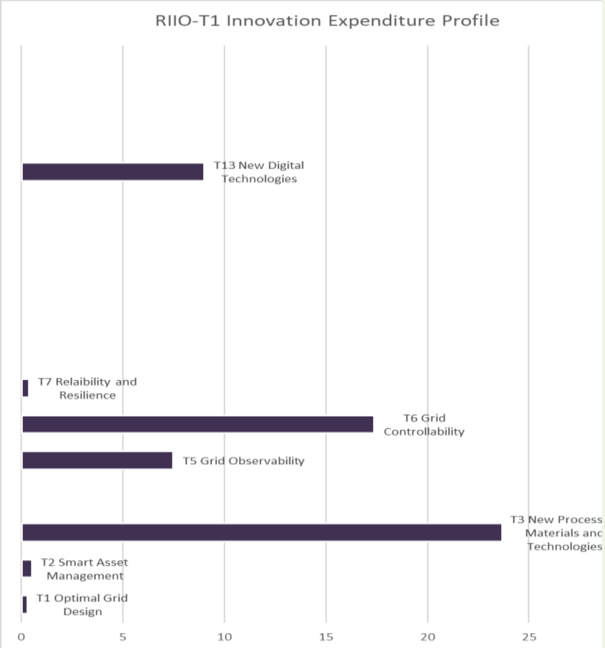


Figure 6 RIIO-T1 Innovation Expenditure Profile-Themes

- FITNESS (NIC in collaboration with ABB, GE, Synaptec, the University of Manchester) (£9.45m) – FITNESS successfully commissioned GB's first multi-vendor digital substation solution and is an internationally important project for informing international standard bodies and other network owners enabling seamless roll-out of digital substations.
- Phoenix (NIC in collaboration with NGET ESO ABB, University of Strathclyde, Denmark Technical University) (£17.64m) – The project demonstrates use of a globally innovative hybrid synchronous compensator to compensate for fast declining essential grid services such as inertia, short-circuit level and reactive power compensation.
- HTLS Conductor (IRM in collaboration with 3M) - The HTLS conductor is designed to operate at higher temperatures than conventional conductors and offers greater transfer capacity across the network.

The aforementioned 4 NIC and IRM projects account for 86% of SP Transmission's RIIO-T1 innovation investment (the rest 14% is NIA funding allocated). The total investment of £59.46m is managed by SP Transmission; in other words, we are the gate-keepers of the funding ensuring the project delivery is according to the innovation governance and on schedule. Circa 85-90% of the NIA and NIC investment funding is directly allocated to 3rd parties such as vendors, SMEs, universities, other network owners and used for knowledge dissemination such as conferences, trainings and stakeholder engagement activities thus invested back into the wider economy.

The total investment made under all the 3 funding mechanisms by SP Transmission licensee in RIIO-T1 period are as follows:

*note: All SPT innovation projects are on track for delivery for end of RIIO-T1

	IRM (£m)	NIA(£m)	NIC(£m)	Total (£m)
To Date (2018/19 RRP)	11.4	6.4	21.74	39.54
End of RIIO-T1 Forecast	20	9.02	32.9	61.92

Table 2 RIIO-T1 Innovation expenditure profile

The breakdown of the £44.4m benefits generated through the roll-out of RIIO-T1 innovation projects in our RIIO-T2 business plan just through roll-out of these projects on SP Transmission network is shown in the graph below. Out of this, £30m of benefits are generated through our large scale innovation projects representing 86% of the funding allocated to us, accounting for 50% payback in the RIIO-T2 period on the innovation investment led by us in RIIO-T1.

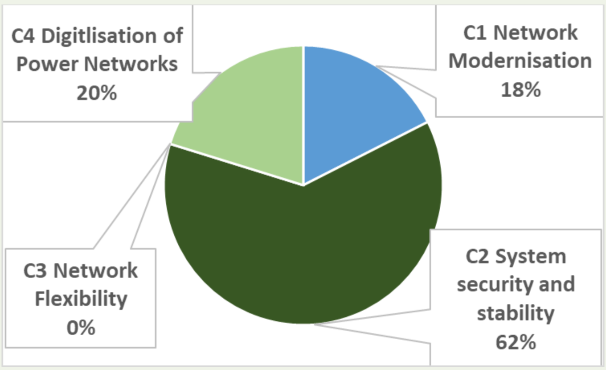


Figure 7 RIIO-T2 Benefits profile from RIIO-T1 innovation roll-out -Clusters

Yearly Expenditure Profile (£m)	2022	2023	2024	2025	2026	IR	NIA
C1 Network Modernisation	1.2	1.6	1.4	1.2	0.1	2.4	3.1
C2 System Security and Stability	0.80	1.20	1.00	0.50	-	0.8	2.7
C3 Network Flexibility	0.95	0.95	0.95	0.90	0.90	1	3.65
C4 Digitalisation of Power Networks	0.85	0.95	1.10	1.10	1.00	1	4
Total	3.8	4.7	4.45	3.7	2	5.2	13.45

Table 3 RIIO-T2 Innovation yearly expenditure profile

6.2 Our ambition for RIIO-T2

6.2.1 NIA and Innovation Roll-Out

In RIIO-T2 our innovation strategy in the following sections presents our ambition to deliver a more balanced innovation portfolio across all four clusters and sixteen themes. The objectives underpinning our RIIO-T2 innovation ambition and underlying objectives for all our innovation clusters and themes are as follows:

- Advancing research and development and lower TRL projects focused on addressing energy system transition challenges Accelerate adoption of large scale disruptive/ transformative innovation aimed to deliver longer term benefits
- Enabling whole system approach
- Empowering our consumers and addressing consumer vulnerability

The details of the breakdown of the innovation funding request of £18.65m can be found in the following sections and yearly breakdown of the proposed innovation investment is shown in Table 3.

The £18.65m combined funding request is to enable innovation roll-out (IR) (£5.2 m) of successful innovation projects and for funding RIIO-T2 NIA projects (£13.45m). We will balance our innovation funding across all four clusters and also focus on creating more network flexibility through whole system approach as shown in Figure 8 and Figure 9.

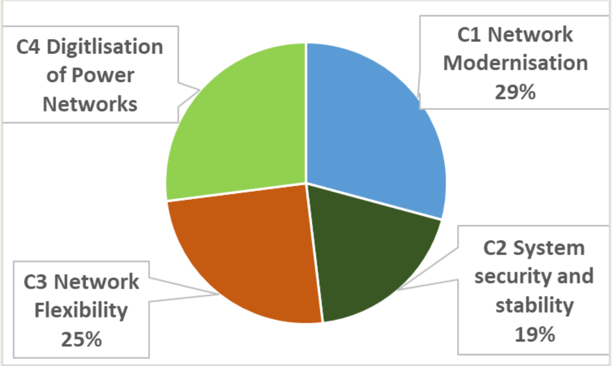


Figure 8 RIIO-T2 Innovation Expenditure Profile-Clusters

The total allowance for NIA and IR is requested over the length of RIIO-T2. SP Transmission commit a 10% compulsory contribution to this funding. The level of innovation funding expenditure will be adjusted on annual basis between clusters and themes based on the outcome of annual stage gate reviews.

The level of NIA funding requested is £7m higher than that allocated for RIIO-T1 (comparing by the 5-year period allocation). The higher request for NIA is aligned with the increasing requirements for investment in network flexibility and requirement for investigation into enhanced services on network.

RIIO-T2 and T3 Benefits (£m)	TO Benefits	System Benefits	Wider Benefits
C1 Network Modernisation	28.78	0.60	77.51
C2 System Security and Stability	9.10	82.00	62.71
Enhanced Data Analytics and Data Flow	20.50	246.00	375.03
C4 Digitalisation of Power Networks	14.26	156.00	162.16
Total	72.64	484.60	677.40

Table 4 RIIO-T2 Innovation Benefits Breakdown

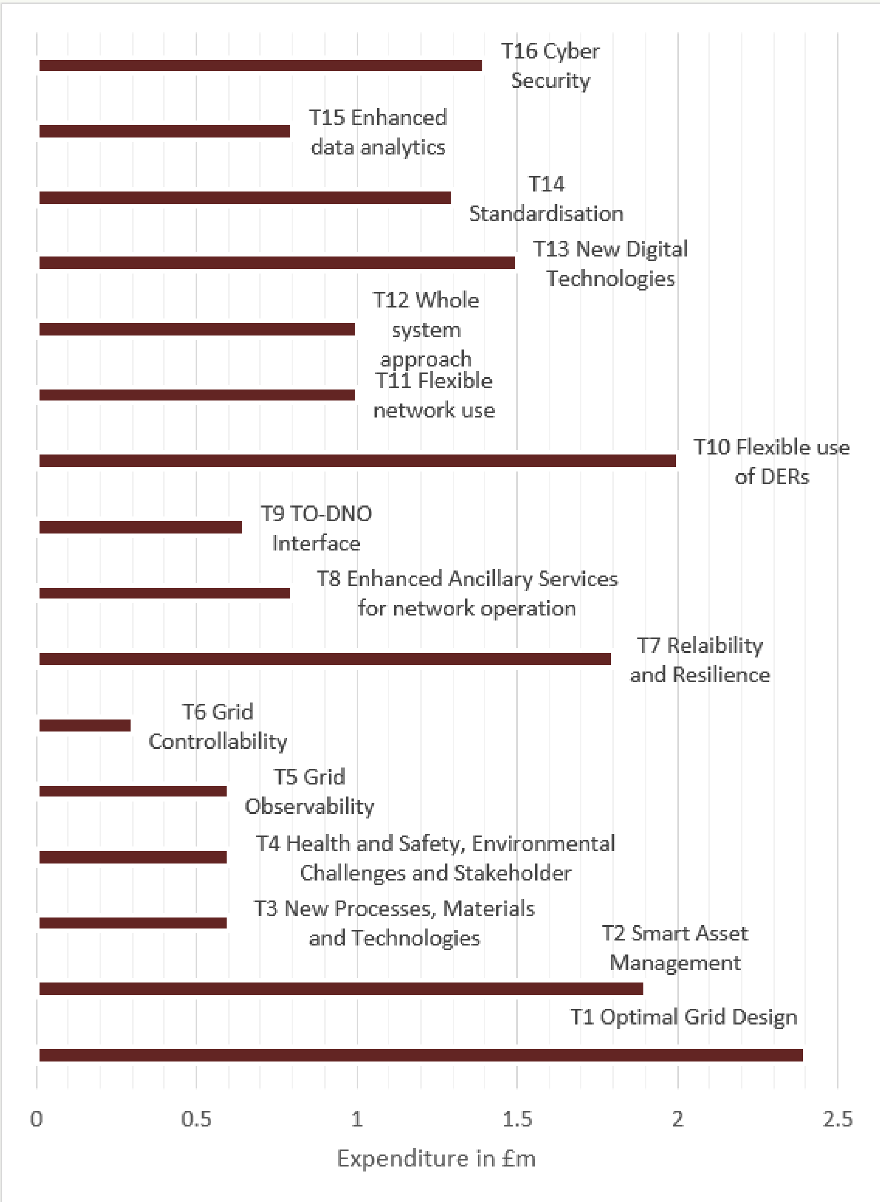


Figure 9 RIIO-T2 Innovation Expenditure Profile-Theme

6.2.2 Strategic Innovation Fund

We will work with Ofgem to further develop the details of strategic innovation fund to replace NIC in the coming months. The energy system transition challenges identified in this strategy for transmission network owner and the system operator could be adopted as energy system transition challenges for this fund.

We will utilise this fund in RIIO-T2 to develop large strategic innovation projects and dependent on the nature of the project may vary our compulsory contribution to fund more innovation through business as usual.

6.3 Benefits Assessment

We have estimated at this stage net TO benefits of £73m and wider system benefits of £484.60m that will be generated in RIIO-T3 through innovation incentives in RIIO-T2. The financial benefits shown in Table 4 are calculated using the RIIO-T2 CBA methodology. And approximate assumptions regarding potential roll-out of the proposed themes on the network. The breakdown of the project benefits across the clusters is shown in Figure 10.

The majority of the wider and system benefits according to the assumptions and calculations made are based on successful roll-out of whole system approach and increased flexibility generated through interaction with distribution network. Cluster 3 Network flexibility through whole system approach will be one of the key areas of focus in RIIO-T2.

The second highest set of projected benefits are projected from roll-out of innovation themes under Cluster 4 Digitalisation of power networks. The shift in paradigm in the industry towards more digitalisation is projected to deliver financial and societal benefits. Digitalisation enables faster integration, increased safety and improves sustainability through lesser use of materials on our network. Cluster C1 and C2 will deliver financial benefits to the transmission owners and the system operator through improved asset management, whole system modelling, optimal grid design and enhanced grid services.

The financial and wider benefits through roll-out of solutions under each cluster and theme are described under the individual clusters in the following sections of this strategy.

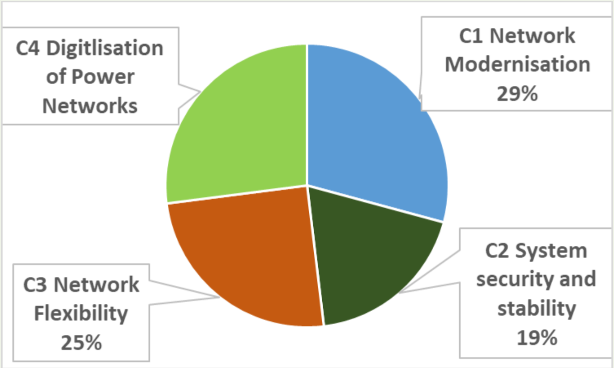
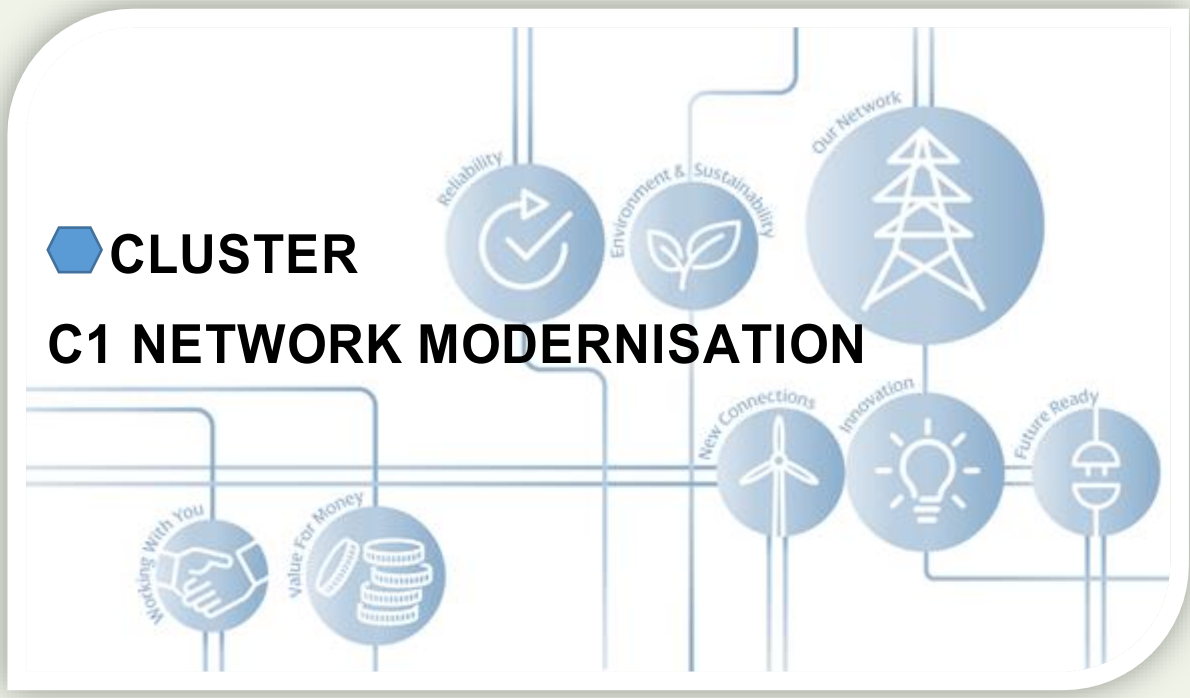


Figure 10 Percentage breakdown of benefits in RIIO-T2 and RIIO-T3 across clusters

CLUSTER

C1 NETWORK MODERNISATION



7 C1 NETWORK MODERNISATION

“Our vision is that SP Energy Networks will enable our consumers to take advantage of new technologies and opportunities, enabling the connection of more low carbon technologies and paving the way for the Net Zero economy”.

SP Transmission manages the network infrastructure from voltage levels 132kV to 400kV in southern Scotland that spans over 156 substations and 4300km of overhead lines and cables. We play a strategic role in GB transmission network sharing boundaries with NGET and SSEN transmission. The fast changing energy landscape means we need to focus on optimal grid design based on the use of the most innovative and cost-effective technologies/ solutions that enable more network capability and flexibility. We also need to keep pace with innovations in materials, technologies and processes and where applicable implement them on our network. The aim is to enable a sustainable network, reduce environmental impact, improve health and safety and lower costs to consumers.

Our innovation strategy and business plan also explore solutions to maximise value for money through real-time monitoring of the health of our assets and improved methodologies to support condition based maintenance decisions.

We also aim to improve public acceptance and stakeholders’ participation in transmission infrastructure development to improve transparency of our network investment for our consumers. We constantly strive to create and demonstrate value for money and use the investment in our network to better the lives of those who rely on us to “keep the lights on.” The “Network Modernisation” cluster addresses following energy system transition challenges:

- New requirements for reinforcement of our network in light of changing energy landscape
- Replacement, operation and maintenance of aging assets to enable a resilient and sustainable network for future
- Improving the sustainability of our network and business processes and empowering our consumers
- Challenges related to increased grid dynamics and black start

T1 Optimal Grid Design

T2 Smart Asset Management

T3 New Materials, Processes and Technologies

T4 Our customers and Environment

T1 OPTIMAL GRID DESIGN

7.1 T1 optimal grid design

In RIIO-T1 we invested £1.987bn on the load and non-load related expenditure on our network. These were in forms of new builds, replacements and connections. There were also reinforcement schemes undertaken to strengthen the boundaries of the network and the network across the east-west of Scotland to allow for more power flow capacity and increase network strength.

Our system planning team captures future needs, and identifies economic options for our grid development to create a balance between investment required for the future energy landscape and maintaining network resilience and security in avoiding unplanned outages. Innovation has played a crucial role under this theme in informing decisions to enable optimal grid design.

7.1.1 SP Transmission Led Activities

R1T1.1 The two major investments on our network in RIIO-T1 to increase boundary power flow between Scotland and England were western HVDC link and series compensation. The technologies applied in both projects were a mixture of the application of tried-and-tested and innovative solutions. Additional studies were undertaken through business as usual to allow for installation of GB's first 600kV sub-sea cable for the Western HVDC Link, with innovative protection and control systems on both the AC and DC side. Similarly, studies were undertaken to assess the benefits and risks associated in application of fixed series compensation on our network which allowed for increasing boundary transfer capability by 1.1 GW. The R&D for these investments on our network were funded through our TOTEX allowance as it was deemed to be core and incremental innovation.

R1T1.2 Our network planning and development team also engages in the network options assessment (NOA) process with NGET and SSEN. Although the NOA applies proven technologies on our network, the studies, economic and risk assessment part of the NOA process is novel and innovative in our planning process. The NOA process continues to expand and there is a push to do more of the same types of analysis, i.e. more scenarios, more combinations of options, more snapshots in time. In RIIO-T2 innovation can allow for stream-lining and automating the NOA analysis process, and the models that underpin them, to allow greater throughput of studies without increasing the effort and thus improving efficiency of the process.

R1T1.3 The rise of renewables and fast changing nature of demand has increased the uncertainty for future network design. We need to think across the boundaries of the transmission network and understand the needs of the distribution network. Our NIA project "Managing uncertainty in future load related investment" (NIA_SPT_1504) helped us better manage this uncertainty by informing our key decisions regarding in RIIO-T2 load related investment through development of a tool for the analysis of distribution network performance under uncertain operating conditions. This tool models the behaviour of low carbon technologies (LCTs) of different types (including wind generation, PV generation and electric vehicle charging load) and of "traditional" load from underlying statistically and historically based models, including the representation of diversity effects and assumptions about geographical correlation.

The learning has been produced on the relative economic value of traditional and novel interventions to provide additional network headroom: further work is required to understand the relationship between the amount of headroom required, the cause of the shortfall (e.g. load and generation types) and the economic characteristics of possible investment and operational actions to further enable regional optimisation of grid design, for which we request innovation roll-out funding of £0.5m for RIIO-T2.

Learning from Others

R1T14: One of the major challenges at transmission and distribution boundaries called the grid supply points GSPs on our network is the need for better fault level mitigation to allow for more renewable generation connection. We considered some of the fault level mitigation methods tried by distribution companies such as "whole-system growth scenario modelling", "active fault level management" and "superconducting fault current limiter" (NIA_SSEN_0030, NIA_SPEN0014, NIA_NGET0051 respectively) for application on our network at the Westfield GSP. The cost benefit analysis favoured the selection of a conventional solution, however we see merits in some of these technologies that can be applied elsewhere.

We have also reviewed outcomes from European research project "GARPUR – (Generally Accepted Reliability Principle with uncertainty modelling and through probabilistic risk assessment)" to re-examine the N-1 security criterion in light of the on-going transformations in energy systems. We plan to further study the outcomes in RIIO-T2 as part of our network planning process.

7.1.2 Our RIIO-T2 Ambition

R2T1.1 We identify the lack of accurate modelling for non-synchronous generation to enable us to analyse grid dynamics and interactions as a key area for innovation development in RIIO-T2. This is a significant area of concern and requires immediate attention as the lack of understanding may lead to a large scale system impact that is currently not adequately studied or understood. Improvements will be made through greater collaboration with ESO and others, and possibly by changes to Grid Code or other industry rules. In the coming years we will have to decide whether we stay mainly with RMS phasor-domain dynamic modelling, or if we build our capability in electromagnetic transient (EMT) modelling.

This will require investment in new software as well as skills. Innovation is likely in the way we engage with others and try to access the most appropriate analysis capabilities, even if not in-house. We propose a neutral model sharing platform that would enable a greater degree of collaboration among network owners. We also propose a review of system modelling tools and enabling enhanced computation, possibly through cloud based platforms.

There will be a few factors under consideration here in terms of use and sharing of data, cyber security and potential use of machine learning to characterise different system scenarios. This "Modelling and Studies platform with enhanced computational capability" will be a truly innovative initiative in GB, however it is building on learnings from other international innovations in this field.

R2T1.2 One of the other areas to explore will be optimal grid design based on whole system approach. This concept has been used in the past to enable grid design, taking into account the transmission and distribution networks and connected generation and demand to a limited extent. This approach can be extended to look for storage solutions in the gas network and connected generation to reduce network investment costs. The conventional network hierarchy (distribution, wide-area transmission and interconnection) is being increasingly called into question by the growth of interconnection capabilities, which are gradually addressing bottlenecks through grid modelling and assessment of the whole system. The synergies between the electricity and gas transmission and distribution networks and connected generation can be better explored through "Whole System Modelling".

We request £2m of innovation funding in terms of network innovation allowance for enabling enhanced and whole system modelling approaches to support optimal grid design on our network.

7.1.3 T1 RIIO-T2 Funding Request

Description	Ref	Type	Value (£m)
Managing Uncertainty in Load related Investment	R1T1.3	IR	0.5
Modelling and Studies platform with enhanced computational capability	R2T1.1	NIA	1.0
Whole System Modelling	R2T1.2	NIA	0.9

Table 5 T1 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	Value	Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)
Innovation Roll-Out	£0.5m	Enabling regional capacity generation and optimizing network investment £52m
Network Innovation Allowance	£1.9m	£10-20m/year in deferred investment and network risks Total: £78.3m

Table 6 T1 RIIO-T2 Business Plan Funding Request Summary

7.2 T2 smart asset management

The smart asset management theme focuses on operation, maintenance and replacement of assets on our network based on condition and real-time monitoring information. The smart asset management techniques help better plan maintenance and replacement based on an improved knowledge of the asset health in light of real-time and historical data and understanding of the operational environment and characteristics.

The approach to smart asset management is a combination of routine checks and sampling combined with more digital technologies such as use of sensors, simulation, statistical correlation analysis and advanced asset modelling

7.2.1 RIIO-T1 Innovation & Roll-Out

SP Transmission Led Activities

R1T2.1 The SP Transmission business deploys multiple condition monitoring techniques which can be classified as core and incremental innovation on our network. The examples of continuous and routine asset monitoring systems are as follows:

- Dissolved Gas Analysis (DGA)
- GIS Gas Density (SF_6 and g^3) monitoring
- Partial Discharge (PD) monitoring
- Use of thermo vision cameras for thermal imaging
- Use of drones and Unmanned Arial Vehicles (UAVs)

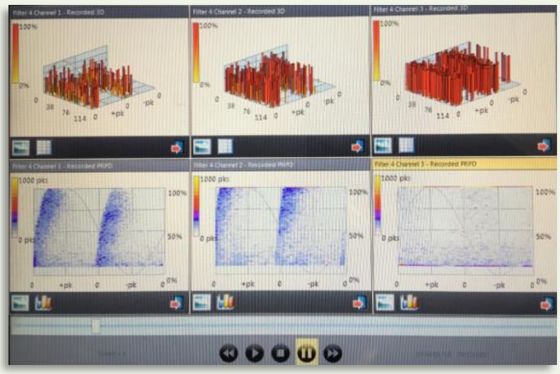


Figure 11 Partial Discharge Monitoring

In our daily operations we use various technologies to perform PD monitoring at bushings, voltage and current transformers, outdoor cable terminations, circuit breakers, busbars, joints and connections. In RIIO-T1 as part of our core innovation activities we compared and adopted methods for PD monitoring such as

Figure 12 Re-Use of concrete assets

online PD monitoring and different portable PD monitoring devices analysing high frequency and ultra-high frequency (UHF) waves generated during a PD event. Some of these techniques were deployed on our network as a world's first in the 1990s.

This has helped us in avoiding faults on the network and taking prevent measures before a fault occurs thus avoiding unplanned outages.

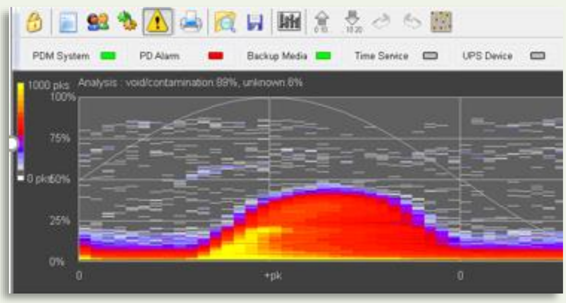


Figure 13 Online Partial Discharge Monitoring

The use of condition monitoring data has allowed us to significantly improve our asset intervention strategy and refurbishment programme. One such example in our business plan is our new transformer refurbishment programme which allows for longer operational life of our transformers instead of replacement under a time-based approach. This BaU innovation has resulted in £50m in deferred investment costs in RIIO-T2 non-load programme.

R1T2.2 Our NIA project "reuse of existing concrete structures" enables us to extend the life of existing structures rather than just replacing them with steel ones which is the current widely adopted practice. After a successful trial in RIIO-1, this method was applied to our non-load switchgear replacement programmes at Windyhill 275kV, Westfield 275kV and Devol Moor 132kV substation. The majority of concrete structures tested were found to be in a reasonably good condition with only low levels of corrosion, which would indicate that certain structures can be re-used with certain restrictions, although, as expected, some did exhibit severe signs of degradation which will make it difficult to re-use these structures. It was found that the structural assessments demonstrated that the columns and beams of the structures assessed are underutilised and have sufficient capacity to withstand the loads acting on the structure under the Ultimate Limit State (ULS) combination.

R1T2.3 NIA SPT 1602 "UAV Platform Development for Automated Asset Condition Diagnosis" means inspections carried out by UAVs also known as drones. will be able to access components and areas not accessible by helicopters, reduce the number of crews sent to inspect areas of difficult access, and reduce the personnel climbing towers for taking a closer look at the components.

Figure 14 Use of drones for overhead line assessment

We also recognise that carrying out surveys by drone takes much longer than a helicopter based approach, and therefore will be deploying them only when they are the most appropriate choice, for example when we want more detailed photographs of fittings, conductor or in areas that cannot be flown by helicopter. The application of drones is carefully chosen to complement other inspection techniques, where working a height can be avoided and more detailed pictures are required for better assessment.

We have also been considering alternative technologies as part of our policy review, which we can use to complement our existing methods. We feel the increased flexibility offered by drones will reduce the requirement for our staff to climb towers to inspect fixtures and fittings, reducing our requirements to work at height.

R1T2.4 Our NIA_SPT_1306 "HVDC Cable Condition Monitoring system" provides early warning of faults and allows direct preventative maintenance of cables. The roll-out of this technology at the Moyle interconnector has improved operating efficiency through the use of 'holistic' condition monitoring (CM) technology solutions and a corresponding, robust condition based management (CBM) approach to managing these assets. The monitoring technology should also 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.

This technology was then further rolled out at our Western HVDC link and will be applied to future cable systems. The follow up NIA project NIA_SPT_1605 "Cable diagnostics for HVDC cables" builds on the condition monitoring project to enable further research into a work plan will be based on laboratory experimentation as well as computer simulation (where appropriate) to allow a better understanding of how partial discharges are generated in a HVDC cable system and the mechanism responsible for degradation of cable insulation systems. These projects have created significant learning, aiding in the process of the selection of cable with higher grade insulation to ensure longer operation without failure.

Learning from Others

R1T2.5 In RIIO-T2 we plan to apply the methods developed through NGET's "Detection and Measurement of ACSR Corrosion" (NIA_NGET0011) project to our existing ACSR conductor base. Corrosion monitoring is important in the case of ACSR conductors. The conductors are prone to it and it can lead to major outages and require high investment to repair in case of a failure.

The method developed through this project of using advanced sensor technology leading to development of line scout and newer cormon testing provides a cost-effective method for assessing the condition of plant, and provides a mechanism whereby life-cycle costs may be minimised. We need to adopt the innovative method developed through this project to allow us to continue to monitor our ACSR conductor base in a more efficient manner than our existing practices and methods for ACSR conductors.

R1T2.6 The NIA_NGET0206 project “Novel methodology for assessing environmental exposure of OHL routes” has created a platform to combine weather parameters and data to create correlation to aging of overhead conductors, fittings and towers. This will provide an additional parameter for predictive maintenance on conductors, fittings and towers. In RIIO-T2 we plan to adopt the learning generated from this project to our whole conductor base.

Building upon the learning from these projects we plan to extend conductor, fittings and tower health and condition parametrisation to include environmental classification to include corrosion, wind induced effects and site specific static ratings. A similar approach can be extended to cable condition assessment, to include soil abrasivity and water level condition considerations to accurately predict the health and condition of the cable.

R1T2.7 Our innovation review also included projects from gas transmission and distribution, and we have identified innovative concepts that can be adopted into our business as usual applications. One example of such projects is NIA_NGGT0103 “Artificial Intelligence for Pipe Coating Inspection”. This concept can be extended for operation and maintenance of overhead lines through analysis of photographs and samples from overhead lines’ routine inspections using artificial intelligence to provide a better assessment of the health and condition of the conductor.

7.2.2 Our RIIO-T2 Ambition

R2T2.1 The majority of assets on our network are aging, however these are the assets that are in urgent need of condition monitoring. This applies to OHL, cables, switchgear and also substation secondary equipment such as protection and control assets. The new assets installed on our network can be easily fitted with sensors and/or already can be procured with desired monitoring features. This is however more challenging when it comes to aging assets. One such example is SF_6 leakage in older switchgear.

We need more non-intrusive methods for condition monitoring and management of such assets which are not immediately due replacement. There are many developments in this field however the challenge remains in adoption and integration of such technologies with our legacy systems. The NIA funding requested under this work theme will be utilised explore new methods, technologies and processes for non-intrusive condition monitoring technologies that will allow us to better manage aging assets and prevent development of faults on the same. It will also look into trial of developments in robotic technologies, automation and intelligence to do more predictive maintenance on aging assets.

R2T2.2 We aim to develop and enable an “System Health Map”. The system health map will allow us to identify any trends in changes in asset condition to be captured early, to allow for assets to be taken offline and repaired prior to catastrophic failure. The analysis enabled through the asset health map approach will also enable enhanced condition based maintenance plans. Collectively this will increase asset lifespan and utilisation. The estimated benefit through enabling of the asset health map would be a significant effort saving through staff time. The system health map will be designed from a responsive need from the business to manage the increasing data analysis problem associated with this monitoring. Much of the data gathered currently requires manual intervention for data collection, collation or analysis which is labour intensive and requires management of discrete software platforms.

The anticipated benefits through enabling of system health map will be cumulative benefit of £5.3m by the end of RIIO-T2 and £8.9m by 2030. The system health map will be funded through BaU innovation.

7.2.3 T2 RIIO-T2 Funding Request

Description	Ref	Type	Value (£m)
Detection and Measurement of ACSR Corrosion	R1T2.5	IR	0.5
Novel methodology for assessing	R1T2.6	IR	0.3

environmental exposure of OHL routes			
Artificial Intelligence for Asset Management	R1T2.7	IR	0.5
Investigation into non-intrusive condition monitoring techniques	R2T2.1	NIA	0.6

Table 7 T2 RIIO-T2 Innovation Funding Breakdown

Business Plan funding request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3)** **(undiscounted)**
Innovation Roll-Out	£1.3m	£29.6m
Network Innovation Allowance	£0.6m	£1.5m

Table 8 T2 Business Plan Funding Request Summary

T3 NEW MATERIALS, PROCESSES AND TECHNOLOGIES

7.3 T3 New Materials, Processes and Technologies

The new materials, processes and technologies theme is focussed on creating a sustainable, environmentally friendly, efficient and flexible transmission network for the future. Our aim in this theme is to keep pace with changes in technology and think differently to enable new processes so that we can increase energy efficiency, reduce costs, enable more power flow and reduce our carbon footprint. The experts in our business have worked tirelessly with suppliers to improve and adapt the supply chain to introduce new materials and technologies to our network.

In RIIO-T1, innovation projects enabled the trial of high performance assets such as HTLS conductors, and digital technologies to create more information and add intelligence to our substations. We also trialled environmentally friendly alternatives for transformer oil and SF6 gas. We additionally introduced optical measurement techniques and sensor technologies that are low power instruments with no oil and gas, thus reducing risk of explosion and improving safety at substations.

7.3.1 RIIO-T1 Innovation & Roll-Out

SP Transmission Led Activities

New Materials and Technologies

Our assets deploy a mixture of technologies such as air insulated switchgear (AIS), gas insulated switchgear (GIS), AC lines and cables and DC cables. As digitalisation has become more significant, to create information and visibility of our network and assets we also rely on a vast telecommunication infrastructure. The power system industry, technology and materials have changed and there are many innovations that can be applied to our network. The challenge for us is to find the balance. We cannot change our network as fast as the technology changes, however we still need to move quickly. So with every new project, replacement and new build we aim to deploy new technologies that we have risk assessed and deem to be safe, economical and good for the environment.

R1T3.1 In RIIO-T1 we tried an environmentally friendly alternative to transformer oil, “MIDEL”, at our transmission sites.

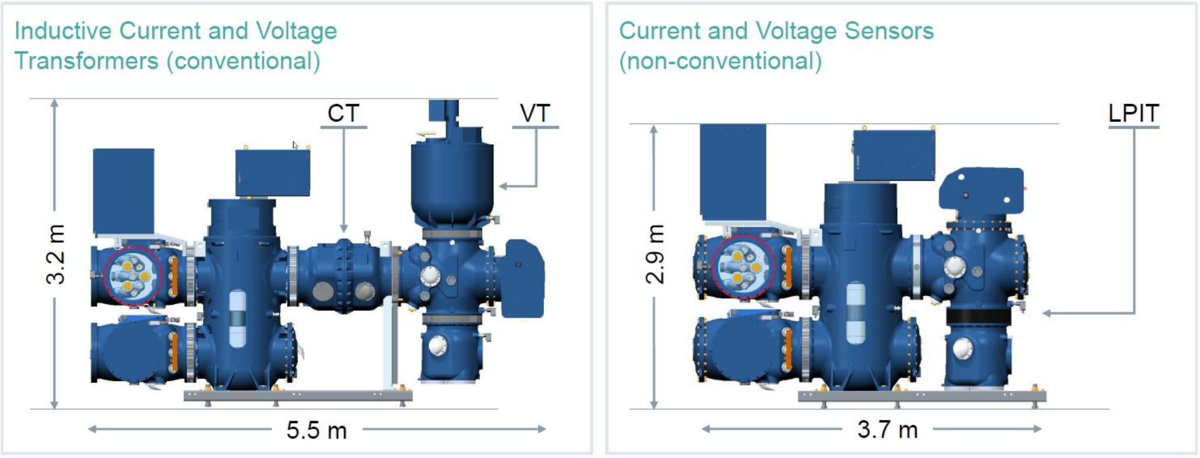


Figure 15 Reduction in GIS size with use of non-conventional LPITs (Source: SIEMENS)

This transition is part of our core innovation activities adopted from application in the distribution network. Transformer oil leakage is a common issue especially in older transformers. MIDEL ester transformer fluids are fully and readily biodegradable and fire safe with a high flashpoint– properties not found in mineral oil. As such, ester fluids present a much lower risk to the local environment if spillage occurs. (Source: MIDEL website)

The key benefit from use of MIDEL is the reduction in fire pool area, and removal of fire wall/ fire enclosure around transformers where applicable thus saving civil costs. This is crucial in smaller, compact sites with more than one power transformer, or at sites with public access in proximity to the proposed transformer location, thus increasing safety, sustainability and reducing the footprint of the transformer design.

Figure 16 GE g^3 alternative to SF_6

R1T3.2 Our GIS substations offer great benefits in terms of build times and space savings as compared to the AIS substations. Conventional GIS however uses SF_6 which is a potent greenhouse gas. We collaborated with the manufacturers and other network operators to identify environmental friendly alternatives to SF_6 (NIA_SPT_1604). Lister drive 132kV gas insulated switchgear (GIS) in our SP Manweb area (RIIO-ED1) and gas insulated busbars (GIBs) at 400kV SP Transmission site Kilmarnock South were delivered in RIIO-T1 with GE Grid solutions' innovative SF_6 alternative product g^3. The subsequent reduction in use of SF_6 by 1.4 tonnes equates to a reduction 36k tonnes of CO_2 over 40 years.

In RIIO-T2 non-SF_6 solutions will be rolled out for the wider transmission network including solutions for all our 132kV GIS and AIS circuit breakers and 132kV, and 275kV and 400kV gas insulated busbars (GIB) replacements. The use of the environmentally friendly alternatives to SF_6 will increase the cost of the switchgear as there is a premium attached to using this alternative. So we need to be innovative and deploy other innovations to reduce costs in other areas. We will do so by deploying low power instrument transformers in conjunction with environmentally friendly alternatives to SF_6.

R1T3.3 Low power instrument transformers (LPITs) are an alternative to using conventional current and voltage transformers. Conventional current and voltage transformers use electromagnetic principles for measurement which typically use oil or gas for insulation. There have been instances of explosions in the past due to moisture ingress in the CTs, and as they are hardwired to the secondary they can create unsafe working conditions if not isolated and managed properly. Through our NIC project FITNESS we introduced use of a variant of LPITs, namely optical CTs, which are significantly lighter than their conventional counterparts, do not have oil or gas and measure using the faraday effect. There are many types of LPITs such as Rogowski coils, electro VTs and optical VTs.

In RIIO-T2 we plan to roll-out LPITs as a standard way of measurement in substations for new builds and in environmentally friendly GIS. This application of LPITs in the new GIS substations will reduce the size of the switchgear and thus create savings in civils and through reduction in size of the control building. The introduction of LPITs in GIS will reduce the size of the switchgear by ~30% and the weight by ~1500kg (ref: SIEMENS slides).

Figure 17 Optical instrument transformers installed at Wishaw 275kV substation (project FITNESS)

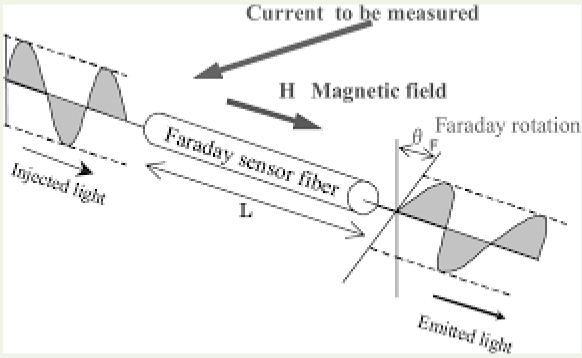


Figure 18 Faraday magnetooptic effect underlying measurement principle of optical current transformer (Source: Wiley Online)

R1T3.4 In 2016, we reported on plans to re-conductor two 275kV overhead line routes in the south-west of Scotland using a new High-Temperature Low-Sag (HTLS) conductor system funded through the innovation roll-out mechanism. The system has been designed to operate at higher temperatures than conventional conductors to offer greater transfer capacity. The HTLS technology has directly replaced 'Zebra' and 'Rubus' conductors without the need for tower reinforcement. The two routes are the Kilmarnock South to Coylton 15.5km double-circuit (known as the XY Route), and the Coylton to Mark Hill 49.5km single-circuit (known as the YY Route). Coupled with the over-arching 'South West Scotland' project, the work is expected to increase the total export capability from Coylton to the wider 275kV and 400kV network and contribute 1.7GW by 2021 (and 2.1GW by 2023) of additional renewable generation to the GB system, representing 40% of the onshore wind generation in Scotland. This was completed in 2016, 8 years earlier than the business as usual alternative of developing new routes and constructing new towers and lines.

In RIIO-T2 we will be applying the HTLS conductor technology at our Gretna-Ewe Hill reinforcement scheme enabling extra capacity on this route.

Figure 19 HTLS Conductor cross-section

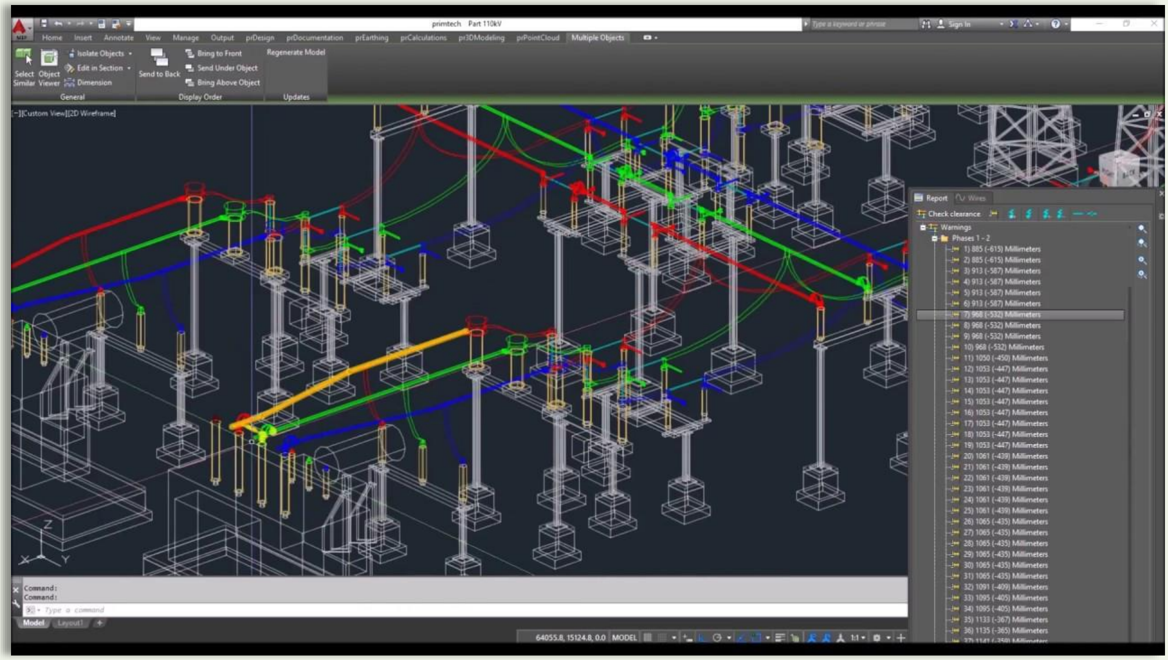


Figure 20 Building Information Model of substations with primtech software (source: Primtech)

7.3.2 Our RIIO-T2 Ambition

R2T3.1 Section R1T3.3 describes innovative digital measurement technologies that were trialled under various projects in RIIO-T1. The global developments in this area are fast changing. We need to keep in pace with these changes to adopt more digital measurement techniques as they are safer and lighter to install and easier to integrate with future systems.

Energy systems Catapult's report on "A strategy for modern digitalised energy system" highlights two major steps for delivering energy system visibility which are supportive of more investment and research in digital measurement techniques in RIIO-T2.

"***Visibility of infrastructure and assets:*** *Increased system visibility will allow for much more granular and accurate assessment of asset location, connection, availability, function and potential interactions. It will also offer greater understanding of infrastructure requirements, operational constraints and investment needs.*

How do our assets perform*: Better data will enable assets to be managed more effectively, faults predicted, maintenance optimised, and lifetime cost minimised Pooling asset performance data between organisations could create even more efficiencies."*

OHL Condition Assessment	NIA_NGET0140

Dynamic Line Rating CAT1	NIA_SHET_0004
Tablet interface for a SF6 mass flow top-up device	NIA_NGET0013
Partial Discharge on Existing HV Cable	NIA_NGET0092
Online Gas in Oil Analysis on Existing HV Cables	NIA_NGET0093
Condition Monitoring of Power Assets (COMPASS)	NIA_NGET0147
Condition Monitoring of Circuit Breakers - iCASE	NIA_NGET0186
Partial Discharge Monitoring to Reduce Safety Criticality	NIA_SHET_0014
Automatic Thermovision Surveys (ACTS)	NIA_SHET_0019
HVDC Cable Condition Monitoring System	NIA_SPT_1306
Transformer Intrascope	NIA_SHET_0005, NIA_SHET_0018
Bushing and Instrument Transformer Test Tap Connection Condition Assessment Tool	NIA_NGET0109
Novel acoustic attenuation feasibility study	NIA_NGET0203
Combined On-line Transformer Monitoring	NIA_ENWL004

Virtual World Asset Management	NIA_SPEN0002
Enhanced Real-Time Cable Temperature Monitoring	NIA_SPEN0003
Instrument for the identification of Live and Not Live HV and LV cables	NIA_SPEN0020
Thermal imaging Observation techniques for Underground CAble Networks (TOUCAN)	NIA_SSEPD_0021
Optimising overhead line conductor inspection & condition assessment	NIA_UKPN0017
Airborne Inspection Phase 1	NIA_WPD_007

Table 9 NIA projects trialling digital measurement and assessment techniques

In RIIO-T1 circa 20-30% of all NIA projects focused on sensor and other digital technologies and circa 70-80% projects involved trial of some form of digital technology mostly focussed around measurement and condition monitoring technologies some of the examples are listed in Table 9. Some of the projects were only in prototype stage and others more advanced for direct application to our network. The developments in digital and fibre based measurement techniques is fast accelerating and it is prudent that we focus on roll-out of prototypes trialled in RIIO-T1 and investigate further research in this area in RIIO-T2.

New Processes

In RIIO-T1 we led the development of the specifications for Gas Insulated Substations which has enabled the use of the latest generation of equipment and resulted in savings of approximately £25m in the wider works programme. In addition to technology innovations, business innovations have allowed for increased efficiency and reduced cost. The move to a disaggregated delivery model was viewed as innovative for the UK. In addition, the access to the global market granted by the model brought innovation to the company's procurement model. This approach resulted in savings of around £10m in the shunt compensation projects (known as MSCDN). These are only a few of the examples which highlight that significant savings can be achieved through innovation in business processes and practices.

R2T3.2 Overhead lines (OHL) are one of major network components, and a considerable part of our TOTEX investment is dedicated to building, operating and maintaining our OHL infrastructure. We have identified various methods to create efficiencies in the expenditure on OHLs which will result in savings, and increase sustainability and environmental benefits in RIIO-T2. This signifies core process changes and innovation that we deliver through BaU. One such process change is related to access roads required for maintenance, refurbishment and construction of OHLs.

In RIIO-T2 we aim to make it a part of the contract specification to provide alternatives to building access roads for OHLs. For wooden pole sites we will deploy all-terrain vehicles (ATVs), helicopters and mud mats. These alternatives to access road building will result in estimated savings of £2.1m in RIIO-T2.

We also plan to create benefits of up to £2.5m through deployment of "smarter forecasting methods" for OHL refurbishment programmes. These methods will allow us to better plan and forecast need for access roads and speed up the refurbishment process by reducing the number of planning and building consents required in the process.

Learning from Others

R2T3.3 In RIIO-T2 we want to try and test a "modular substation building" approach based on 3-D building models and pre-fabricated concrete structures. It is our ambition to take forward the successful application of building information model (BIM) from gas transmission network NIA projects (NIA_NGGT0024, NIA_NGGT0057). Our engagement with NGET gas transmission helped us understand that BIM has helped them reduce costs and improve efficiencies in engineering design process.

BIM is changing the way in which designers, and contractors work. It can be seen that the initial phases of design, coordination and analysis in a BIM environment take more set up. However, this extra time requirement gets completely nullified in the later phases of prefabrication, installation and avoided rework related to design changes of the project.

The same file can be used for analysis, as data rich BIM families are user friendly compared to 2D drawings. Integrated 3D virtual reality modelling and analysis techniques can trace out uncertainties about various design elements at the early stage of project implementation. This is achieved through the automatic or semi-automatic phasing of projects and n-dimensional construction planning activities such as scheduling, costing and life cycle analysis. Combined with the ability to use a single platform for varied detailed analyses both pre- and post-construction, the benefits are visualisation, coordination, flexibility to changes, ease of data sharing, a realistic model for analysis, waste and rework reduction, detection of orphan elements, automatic conflict detection and automatic or semi-automatic calculations, value engineering, and lifecycle deployment.

However, while applying BIM, many challenges such as hardware cost, software cost, training cost, customized families and tools development are to be overcome. Compared to 2D-CAD modelling, substantial skill and discipline are required to develop and operate in a BIM environment. However, it is necessary to have an integrated user friendly platform with the facilities such as automatic generation of single line diagrams, feeder schedules with voltage drops, cable sizing and circuit breaker sizing, as per the approved codes. Such an integrated platform can enable us to take full advantage of the model data for system analysis.

It is our ambition to roll-out BIM enabled modelling in RIIO-T2, transforming the way we design, build, commission and maintain our assets through business as usual innovation.

7.3.3 T3 RIIO-T2 Funding Request

Description	Ref	Type	Value (£m)
Investigation into novel digital measurement technologies	R2T3.1	IR	0.6

Table 10 T3 RIIO-T2 Innovation Funding Breakdown

Business Plan funding request

Funding Type	Value	Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)
Innovation Roll-Out	£0.6m	**£11.5m**
Network Innovation Allowance	-	-

Table 11 T3 Business Plan Funding Request Summary

T4 HEALTH & SAFETY ENVIRONMENT AND STAKEHOLDERS

7.4 T4 Health & Safety Environment and Stakeholders

Our stakeholders may wonder why the theme of our consumers and environment is under the cluster for network modernisation. Our consumers are part of our network, at the heart of every investment decision and every innovation and are why we own and operate our network. It is important that the investment in our network doesn't negatively impact our customers, and that our desire to reinforce and build our network is in harmony with our customers' interests, especially of our vulnerable customers. We also recognise that our customers are increasingly producers of energy as well. Our prosumers' play an active part in the energy infrastructure; it is our responsibility to provide them with faster and economic connections, keep them informed regarding the developments in the network and the impact of their actions on the wider performance of the network.

Equally important to consider as part of every business decision is our environment. The human impact on climate and our environment needs to be addressed, and negative impact reduced through sustainable practices. Hence it was important for us to make this theme a part of our core business cluster.

7.4.1 RIIO-T1 Innovation & Roll-Out

SP Transmission Led Activities

R1T4.1 The innovation stimulus is designed and aimed at delivering benefits to GB consumers. In RIIO-T1 we engaged in many customer facing activities to share our initiatives with our customer base through stakeholder engagement programs and knowledge dissemination activities. We have organised and participated as SP Energy Networks and as part of the wider ScottishPower group in various customer facing activities in RIIO-T1. One of our key focusses in RIIO-T2 will be to engage in even more customer focussing activities through our wider stakeholder engagement and innovation activities. We can enable this through webinars, consultations and roadshows to share more information with our consumers and gather feedback from them. We can then build this into our innovation portfolio and business activities.

R1T4.2 Sustainability is the key driver for innovation RIIO-T1. All innovation projects were conceptualised with the aim to enable a net zero future, reduce environmental footprint and create consumer benefits. Key examples of these are

Figure 21 Our "Prosumers" – Biomass Generation Plant

highlighted under theme 3 "new materials, technologies and processes", such as alternatives to SF_6, life time carbon analysis, reduction of oil and gas in substations, digital substations and re-use of concrete assets. We also have undertaken NIA projects such as NIA_SPT_1608 "Reducing Energy Losses from Transmission Substations" focussed at enabling methods and technologies to increase energy efficiency in substations. The detailed activities are under the sustainability measure which is closely linked to our innovation strategy, and can be found in our sustainability strategy.

R1T4.3 SPEN's efforts to achieve sustainability and reduce environmental impact go beyond reducing carbon dioxide emissions. We've completed phase 1 of a pilot study with Scottish Wildlife Trust and Aecom that looked at the Natural Capital dependencies and impacts of our assets in the Cumbernauld Living Landscapes Area. We've been working with stakeholders in the Loch Lomond and the Trossachs National Park to evaluate how we can reduce visual impacts from our assets using innovative techniques that go beyond traditional undergrounding, including re-routing infrastructure, enhancing other aspects of the landscape quality, and sensitive vegetation management to help screen the infrastructure. Whilst fighting against the threat of climate change, we're adapting to the growing threat of the effects of in-built climate change by reviewing the vulnerability of our assets to extreme weather events, such as flooding and wind storms, acknowledging concerns in the scientific community that there will be no new normal weather in our lifetime. We have improved the resilience to floods at a number of sites and have improved our response capability to downed transmission towers by investing in temporary transmission tower technology.

R1T4.4 In RIIO-T1 we have implemented a £100,000 sustainability fund named SI – Sustainable Ideas, funded through success in the Environmental Discretionary Reward. The purpose of the fund is to improve the sustainability performance of the organisation, with staff responsible for identifying and implementing their own projects.

Figure 22 Sustainable Ideas Fund

7.4.2 Our RIIO-T2 Ambition

R2T4.1 In RIIO-T2 we want to break the barriers through innovation between a transmission licensee and the consumers by driving themes of innovation that are directly focussed on the consumers. This will help to change the perception that innovation in transmission does not have a direct impact on our prosumers. We aim to have projects which will collect prosumer feedback regarding sustainability, connecting to our assets and participating in providing distributed energy resource services. It is our priority to improve public awareness of long-term energy challenges, and the need to build and protect transmission infrastructure to increase the social benefit of electrification of demand.

R2T4.2 We will work with SP Distribution on the wider DSO incentive to enable more consumer participation in energy system balancing and service requirements by enabling localised markets. We have described this in more detail in our cluster C3 "network flexibility".

R2T4.3 In RIIO-T2 we will also reinforce our participation in community energy projects and use innovation to better assess and study societal shifts in perception and the impact of policy and regulation on our vulnerable consumers. There are large scale surveys conducted across Scotland collecting data regarding consumer needs and behaviours. Within the perimeters of data protection, we can use the results to assess our most vulnerable consumers and make them our priorities. Through our engagement in community projects we can enable the future generations to better understand and use the energy sector to their advantage. The softer aspect of societal behaviour can be assessed through social science studies and using the outcomes to inform our future investment decisions.

R2T4.4 We will continue our work from RIIO-T1 to use innovation to enable environmentally friendly and sustainable technologies and solutions. We are already on the path to minimise use of oil and greenhouse gases in our substations. We will also opt for more modular designs such as prefabricated control buildings and structures where possible to reduce use of concrete in substations. It will also help reduce substation footprint, use of materials and time on site, all adding to reducing our carbon footprint and paving our way to become a truly sustainable transmission network owner.

As manufacturers and utilities are more aware of the impact of use materials that have a carbon footprint and/or have adverse health impacts on people working with them or in the vicinity the new life cycle analysis methods calculates impact of various equipment from cradle to grave.

In RIIO-T2 we will use this innovation theme to investigate with manufacturers and researchers more environmentally friendly alternatives for power system equipment and devices. As some of the materials used have not changed over the course of years, this will a research of unique kind to find suitable alternatives to reduce our carbon footprint and at the same time find materials which still maintain reliability and operability of the equipment.

7.4.3 T4 RIIO-T2 Funding Request

Description	Ref	Type	Value (£m)
Investigation into environmentally friendly alternatives of substations build and design	R2T4.4	NIA	0.6

Table 12 T3 RIIO-T2 Innovation Funding Breakdown

Business Plan funding request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)**
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£0.6m	**To be Estimated**

Table 13 T3 Business Plan Funding Request Summary

8 C2 System Security and Stability

SP Transmission is the critical electricity service provider for 80% of Scotland's population. We know that the changes to Scotland's energy mix and the closure of the country's last coal-powered power station means resilience and network stability is becoming our key priority in the energy system transition challenge. Through our innovation projects we aim to focus on different aspects of system security and stability.

Based on decades of experience with large synchronous generators connected to the transmission network, system behaviour could be predicted with high confidence. The control centres at transmission owner level were adequately equipped to analyse network changes due to switching on the network and connected generators. The characteristics and dynamic behaviour of the synchronous generators is also well understood. However, with recent changes and fast increase in non-synchronous generation connected to the network this is not the case anymore. The loss of large synchronous generators has made our network "light" and more prone to system dynamics.

The loss of large synchronous generation has also created an urgent need to backfill essential grid services. We will be collaborating with the ESO and using innovation to assess the risks and find innovative solutions to mitigate the risks posed through loss of grid services.

Furthermore, this cluster of our innovation aims to improve the black start plans using a common system approach, including developing a new procedure and strategy for innovative ancillary services coming from different sources such as DERs, and storage and innovative methods for restorative action schemes. The security and system stability cluster aligns with the energy system transition challenges of:

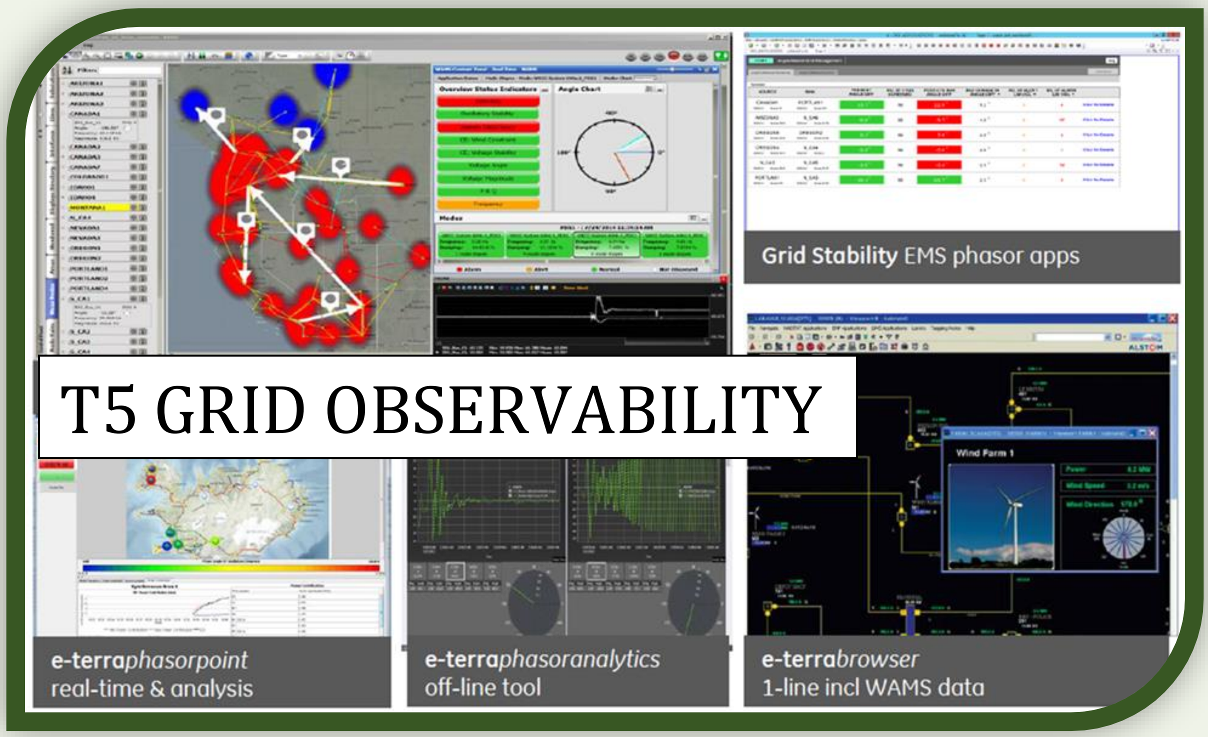
- Maintaining system security and stability: despite reduced grid services, lower system strength, and increased grid dynamics and interactions
- Challenges related to increased grid dynamics and black start

T5 Grid Observability

T2 Grid Controllability

T3 Reliability and Resilience

T4 Enhanced Ancillary Services



8.1 T5 Grid Observability

Why is grid observability important? Our analogy discussed during project VISOR team meetings is that of walking on a cliff edge in fog. In order to be safe and not fall off the edge one will walk away from the edge: the question is by how much? We can draw parallels with the cliff edge being the point beyond which the system will collapse and may lead to an outage or in a worse case a blackout. With good visibility, the path or the operating point of the system can be moved closer to the security limit. With the fog, the situation is different, as it is difficult for our planners and engineers to determine what the system security limit is, so we continue to operate our system further way from the edge and even further way from the security limit.

This has an economic impact on our system as we are not using the full capacity of the transmission network. The lack of visibility also poses a huge risk on the network operation as the operating point could be between the security and stability limit, and within milliseconds could lead to system collapse.

The system wide blackouts worldwide are often caused by fast cascading faults that could have been avoided by having grid visibility of the system dynamics.

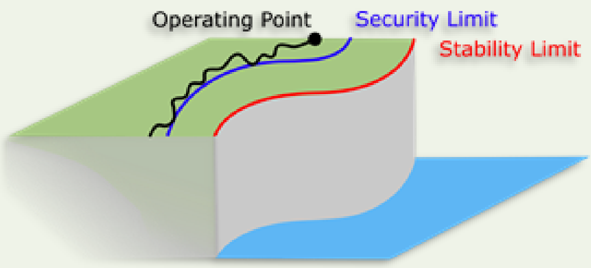


Figure 23 Grid Observability Cliff Edge Analogy

8.1.1 RIIO-T1 Innovation & Roll-Out

SP Transmission Led Activities

R1T5.1 In anticipation of the requirement of more grid visibility we have already installed over 80 phasor measurement units (PMUs) on our network. PMUs provide dynamic visibility of the network by measurement of magnitude and angle of voltage and current on the network. The synchronised nature of PMU measurements enables comparison of phase angle across the power system. This gives a direct measure of the system state - which is otherwise approximated through model-driven numerical estimation using un-synchronised SCADA sweeps of measurements and switch/ breaker states. This is valuable in areas such as awareness of network constraints and stress, and management of islanding and resynchronisation.

The fast update rate provides visibility of system dynamic behaviour such as oscillations and disturbances. This enables solutions such as management of oscillatory stability, system model validation and response and analysis of system events.

We used this and other technologies such as waveform measurement units (WMUs), high speed communication channels and centralised enhanced analysis software to create GB's first wide area monitoring systems (WAMS) through project VISOR. The Visualisation of Real-Time System Dynamics Using Enhanced Monitoring (VISOR) project was led by SP Energy Networks (SPEN) funded through Ofgem's Network Innovation Competition (NIC) framework with the objective of establishing a next-generation WAMS across the whole mainland of GB.

We established this new WAMS in collaboration with SSEN, NGET TO and NG ESO with the aim to assist all parties in maintaining safe and reliable operation by providing an accurate instantaneous view of the network by using time-synchronised measurements and a suite of analysis applications, unlocking a number of benefits.

The VISOR project has been rolled out into business as usual at SP Energy Networks. In collaboration with NGET, following the successful outcome and learnings of this project, the System Operator Transmission Owner Code (STC) has been updated to include dynamic PMU measurements as part of the dynamic visibility requirements of the network.

VISOR has also enabled globally innovative sub-synchronous oscillation (SSO) monitoring. Sub synchronous oscillations are present on the network due to the characteristics of the connected assets and their dynamic interaction. In the past the interactions were mostly limited to those between connected synchronous generators, which have fixed modes of oscillation, and the network, whose characteristics change only with topology change. These interactions are now more dynamic because of increased non-synchronous generation and associated converters. VISOR highlighted issues on our network where real-time interactions were recorded enabling us to take required steps and make changes to eliminate and/or better manage the observed interactions. This is a major breakthrough in increasing grid observability and creating benefits by mitigation of risks to the safety and security of our network operation.

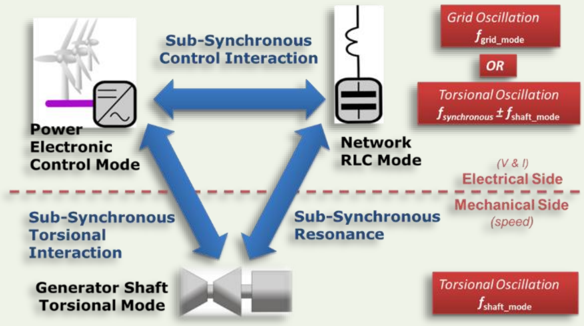


Figure 24 Types of sub-synchronous interactions

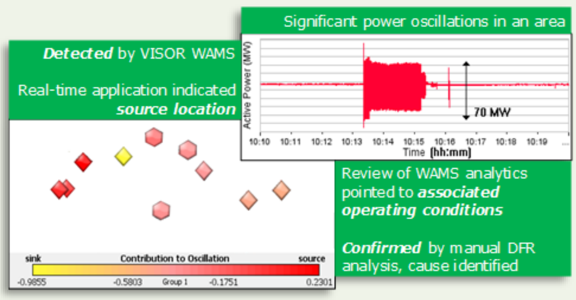


Figure 25 Network sub-synchronous interactions captured on VISOR system

We estimate operational benefits of £1-5m through GB-wide roll-out of the VISOR WAMS in RIIO-T2. The project will enable these benefits of increased system efficiency and lower network investment through:

Better Visibility –

- providing control room operators and network planners with increased visibility and diagnostics of network operation and post-event diagnosis and recovery. It will also reduce the uncertainty in real-time of the network state to allow the network to be run closer to the true physical limits

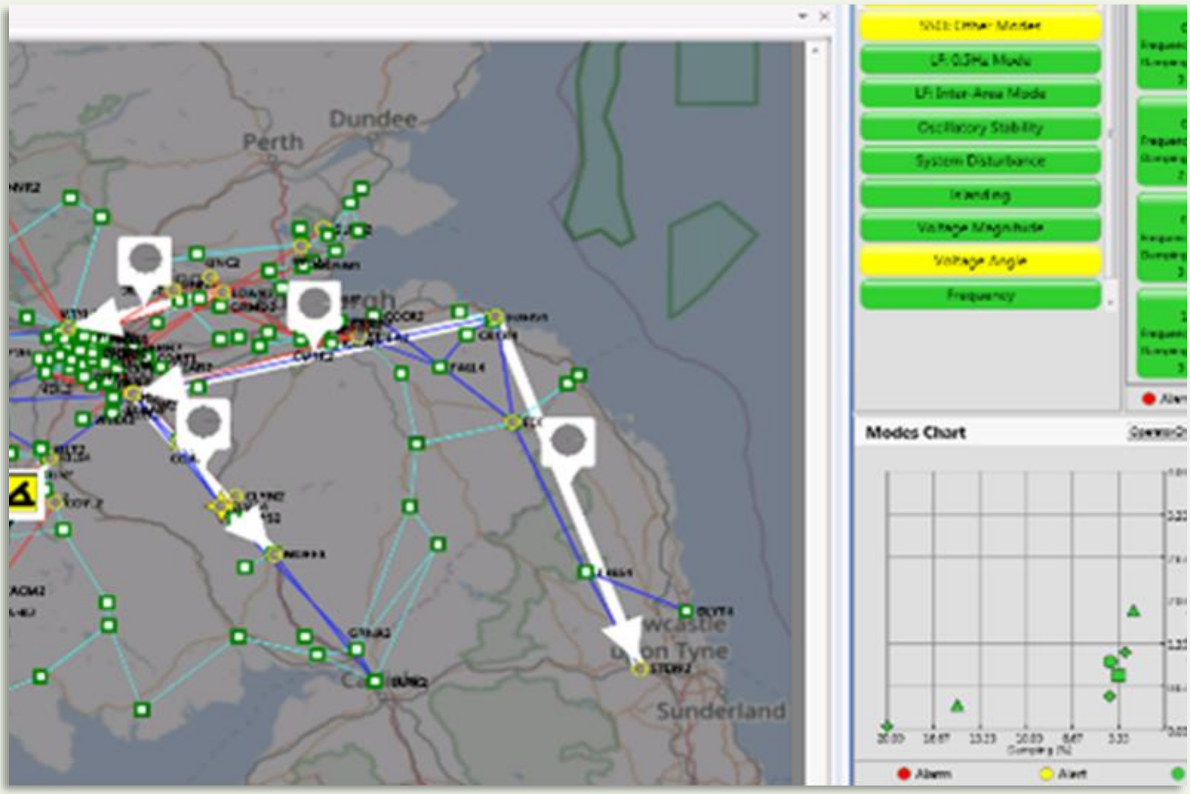


Figure 26 EMS-WAMS Integration

Better Understanding –

- improving the characterisation of the transmission network and reducing model and measurement uncertainty that currently requires higher operational safety margins to be applied

R1T5.2 IN RIIO-1 our FITNESS project Substation-to-System Information and Control Integration work package addresses monitoring, protection and control capabilities using digital measurement chains (explained in detail in Cluster 4 digitalisation of power network). Within this work package for FITNESS we addressed the specification, implementation and testing of the substation measurement chain, increasing network visibility and adding intelligence to our substations. It begins at the primary instrument transformer and ends at the values reported by measurement IEDs (Intelligent Electronic Devices), specifically:

- 50fps phasors: synchrophasor measurement as performed by typical PMUs.
- 200fps “fast” phasors: 200Hz reporting rate designed to provide a faster response and to better capture fault behaviour.
- 200Hz waveforms: previously demonstrated under the VISOR project.
- Harmonics: standard harmonic measurements, typically logged locally at present, interleaved in the 50Hz PMU stream.
- Fault Records and fault location.

The fast phasor measurement type was deployed for the first time on a GB network. Fast phasors are calculated at update rates higher than nominal frequency, using shorter windows e.g. a single cycle of the 50Hz waveform. The faster update rate and shorter calculation window provides better visibility of fast transient behaviour such as transmission system faults. FITNESS explored the feasibility of their use in fault information management – specifically fault characterisation and system fault current contribution mapping.

The harmonics measurement and characterisation enabled through this project will help our operations engineers to better locate and identify sources of harmonics in future, thus enabling the path to harmonics mapping as explained further below.

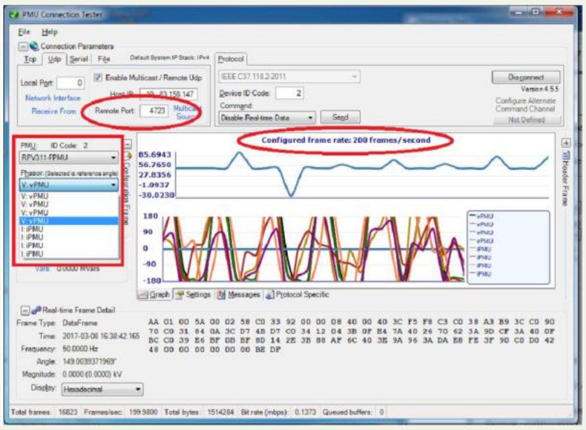


Figure 27 FITNESS fast-phasors improving actionable observability

8.1.2 Our RIIO-T2 Ambition

R2T5.1 In RIIO-T2 we plan to roll-out the WAMS enabled by VISOR project to our control centre enabling enhanced systems dynamic visibility for our control centre engineers.

The key use case for this is basic incorporation of WAMS measurements, analytics and alarms within the EMS display at the control centre which can add benefit by improving our engineers' understanding and visibility of system dynamics and help prevent low-probability high impact events such as system wide blackouts.

Nowhere is this more apparent than in the United States, where wide-area measurement was reportedly first introduced following the blackout in 1965, which led to a body of research and the ultimate development of the first PMU prototype in 1988. However, it was not until the major 2003 North East blackout that led the US Department of Energy to launch the synchrophasor initiative that has been the major driving force behind the coordinated uptake of WAMS in the US. Similar cases of large-scale WAMS deployments following outages are becoming commonplace across the world, as large-scale blackouts in the north-eastern region of India led to recommendations of unified WAMS between regions, and China, which has a very large implementation of WAMS incorporating oscillation management applications.

WAMS measurements, analytics and alarms can be valuable to the control centre and planning engineers in a number of cases including the one highlighted above. It is important that any WAMS information presented to a control centre engineer is relevant and presented in a comprehensible manner – displayed clearly and concisely, without extraneous detail. This will often be achieved through integrating WAMS information into the conventional EMS displays and tools that the engineers are more familiar with in their daily activities.

The WAMS-EMS Demonstration System (WEDS) "Sandbox" environment created under the VISOR project will facilitate this transition. The WEDS incorporates a mirror of the SPEN EMS and a PhasorPoint WAMS server, both receiving live data - its purpose being to enable exploration, experimentation, and familiarisation with WAMS-EMS integration.

The proposed solution for this scheme in RRIO-T2 retains the WAMS-EMS Demonstration & Training system set up by VISOR, and augments it with a Dynamic Dispatcher Training Simulator. At present, the Demonstration & Training system operates on live EMS and WAMS data – the training Simulator adds the capability to feed the system with real-time simulated scenarios, as well as replaying historical events. Operators can start from an EMS snapshot, and then through the Simulator user interface they can trigger actions such as breaker operation or transmission faults.

This integration will further enable benefits of £5-10m/year in operational cost savings after roll-out in future price control periods.

R2T5.2 The ideal AC voltage on the electricity transmission and distribution network is a pure sinusoidal wave at 50Hz. However, in practice this waveform can be distorted by non-ideal currents drawn by non-linear loads and power electronic converter-based plant – examples of which include variable speed motors, common types of wind and solar generation plant, arc furnaces, HVDC links and flexible AC transmission system (FACTS) plant. Any such distortion of the 50Hz mains waveform can be expressed as a collection of "harmonics" – added oscillations with frequencies that are integer multiples of the fundamental 50Hz frequency.

Harmonic "pollution" introduced at one location will travel across the grid, affecting other users – including increased losses, possible mal-operation, or asset damage. Industry and GB standards restrict both the levels of harmonics that may be introduced by an individual grid user, and the levels permitted on the network. Network Owners have two particular roles regarding harmonics: proactively in assessing, planning, designing, and specifying and validating the compliance of the network and its users to harmonic standards; and reactively in detecting, investigating and mitigating harmonics issues that arise.

The recent proliferation of transmission-connected power electronic converters, and increasing variability in generation/ demand and grid conditions, has made harmonic activity a growing concern at the transmission level across a wide-area. There is a need to shift from a primarily offline assessment approach to real-time, continuous, wide-area monitoring in order to be able to quickly detect and identify issues that arise, the locations affected and an indication of the source better known as harmonics mapping. We aim to enable harmonics mapping through innovative analysis and real-time monitoring of harmonics on our network, which is currently limited to off-line assessment. A wide-area view will aid in identifying contributors to harmonic problems, to support operational mitigation and offline investigation. An example of such real-time harmonics mapping can be seen in the following figure.

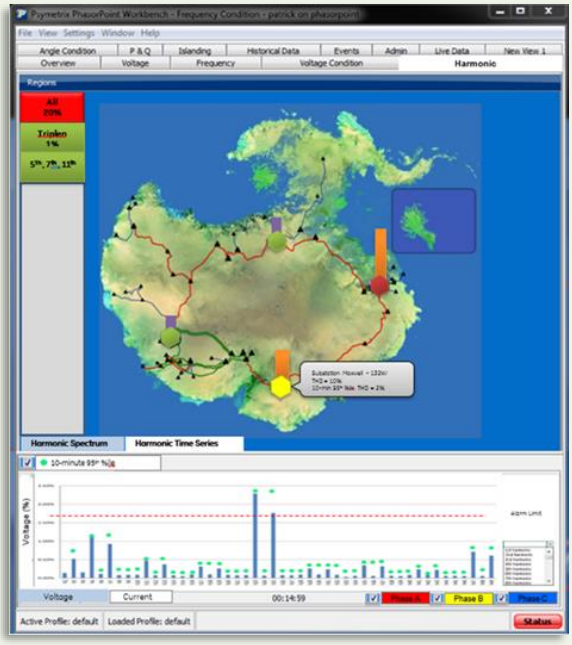


Figure 28 Harmonics Mapping Example

8.1.3 T5 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)
Power quality analysis and mapping	R2T5.2	NIA	0.6

Table 14 T5 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	Value	Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£0.6m	**To be Estimated**

Table 15 T5 Business Plan Funding Request Summary

8.2 T6 Grid Controllability

The ESO is responsible for operating the system and it includes, but is not limited to, voltage, frequency and power flow management. We as TOs also play an important role as we connect and maintain assets to our network which allow the ESO to control the grid efficiently. Traditionally the ESO has relied on large synchronous generators to provide most of the grid control related services. TOs have supported this through the connected Mechanically Switched Capacitors with Damping Network (MSCDN), Static VAR compensators (SVC) and shunt reactors. The fast changes in the power network and connected generation mean the grid controllability has become a key EST challenge.

Through our work in the VISOR project we have also identified that the issue of grid controllability goes beyond the task of backfilling grid services. Synchronous generators were primarily responsible for inertia and maintaining short circuit capacity/fault level on the system. The AC power system currently in operation is largely dependent on minimum levels of these two parameters to successfully to survive transient events and maintain required levels of power quality. We need new solutions that will maintain grid controllability in absence of inertia and fault level.

Innovation plays a crucial role in identifying solutions and technologies to backfill essential grid services to allow for effective grid controllability. In RIIO-T1 we have also identified new tools and methods to ensure stability and security of the transmission network under increasingly dynamic conditions.

8.2.1 RIIO-T1 Innovation & Roll-Out

SP Transmission Led Activities

R1T6.1 We improved grid controllability in RIIO-T1 through our business as usual innovation activities, through installation of series compensation equipment across the boundary circuits between SPT and National Grid. Alongside the East-West upgrade, these works, as a key part of the programme, increased the boundary capability of this boundary to 4400 MW from 3300MW. This was achieved through increased grid controllability through reactive power compensation.

Series compensation effectively makes circuits appear electrically shorter, improving power transfer capability. However, series compensation introduces a risk of Sub-Synchronous Resonance (SSR). This is a well-known phenomenon that causes potentially damaging interactions between the series compensation equipment and large generator shafts. SPEN took an innovative approach to SSR mitigation, combining system analysis with the procurement process: instead of specifying a solution, a minimum SSR damping characteristic was specified. This meant that the equipment manufacturers were encouraged to innovate and indeed several different designs were offered and we achieved better grid controllability through design of innovative damping characteristics.

This approach made it possible to substantially reduce the cost of the installations when compared with the design pursued by NGET. SPT's series compensation equipment is the first of its kind in the world and represents an excellent balance between performance, complexity, availability and cost, and resulted in efficiencies of around £46m in RIIO-T1.

R1T6.2 Our NIC project Phoenix is demonstrating a sustainable design, deployment and operational control of a Synchronous Compensator (SC) with innovative hybrid co-ordinated control system combined with a static compensator (STATCOM, FACTS device) referred to in the project as Hybrid Synchronous Compensator (H-SC).

SCs can improve the voltage of the surrounding network through import or export of MVArs. These MVArs are used to control voltage within the grid, and improve power transfer. Two operating conditions are possible according to the capability curve of individual SCs are:

- Over-excitation: generation of reactive power with leading power factor (capacitive behaviour);
- Under-excitation: absorption of reactive power with lagging power factor (inductive behaviour).

Additionally, because of the rotating mass and characteristics similar to synchronous generators (except for producing active power), SCs can contribute to system inertia and SCL. At a regional level the effect of inertia provided by SCs is much greater than the whole system perspective. These services are increasingly important given the changes to the grid and help mitigate the following challenges:

- Challenges to maintain system voltage during short-circuit faults.
- Increased risk of failure of key protection systems
- Increased risk of commutation failures in LCC HVDC links e.g. the Western link caused by disturbances on the AC side of the converter.
- Adverse effect on power quality, such as increasing levels of harmonics, flicker and voltage and current distortion.

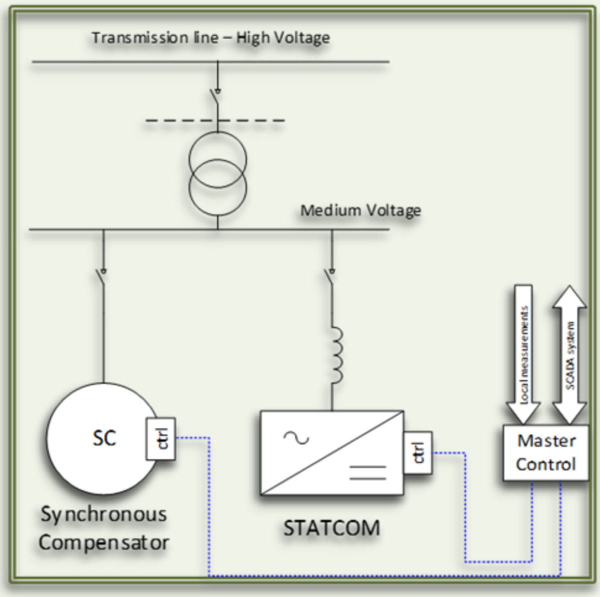


Figure 29 Phoenix Hybrid Synchronous Compensator

Phoenix H-SC solution will be commissioned at the Neilston 275kV substation – a strategic point on the SP Transmission network – investigating possible coordination and interaction with power electronic based compensation devices, in order to maximize customer values of these complementary technologies. Neilston substation is geographically, and through network topology, in proximity of the Hunterston western HVDC link; thus installation of the H-SC at Neilston will provide some fault level contribution required for efficient operation of the western HVDC link.

The project has also undertaken system studies and a cost benefit analysis to further develop the commercial mechanisms available to incentivise the roll-out of SCs along with FACTS devices in collaboration with the ESO and an independent market specialist. The project is also analysing the

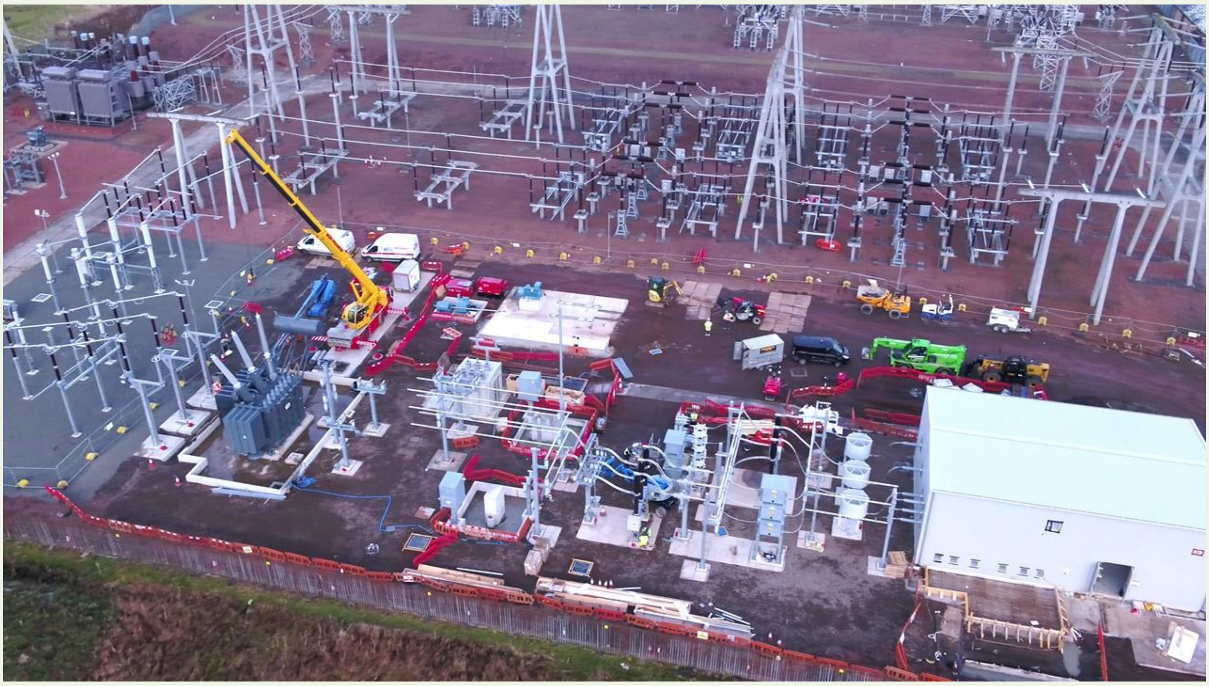


Figure 30 Phoenix installation in progress at Neilston 275kV substation

impact of installing several compensators at various strategic locations in the GB system, and their impact on the performance of the GB power system in the coming decades.

The project will enable an efficient and composite solution that will enhance system stability and security while maintaining power quality resulting in minimising risks of blackouts and delivering significant benefits to GB consumers, thus providing more grid controllability to us and to the ESO.

The role out of the H-SC solution on our network alone in RIIO-T2 will generate £20m worth of benefits in RIIO-T2 through:

- Increased transient stability
- Increase power transfer capability
- Improved fault level on the network
- Improved power quality
- Playing a role in our black-start strategy

And will create benefits for the ESO through:

- Increased voltage and frequency controllability
- Playing a role in our black-start strategy

R1T6.3 In RIIO-T1 our NIA projects NIA_SPT_1610 "Innovative approaches for Transmission harmonic issues" and NIA_SPT_1506 "Development of a standard 33kV Damped Harmonic Filter Design" had key objectives to:

- Reduce costs by deploying a standardised design for a harmonic filter
- Improve the management of harmonic voltage levels on transmission networks
- Substantially reduce the risk of harmonic non-compliance
- Provide an increased level of certainty regarding harmonic mitigation requirements to developers

The projects undertook detailed studies, including harmonic impedance scans on our network, to develop a filter design that helps us better manage and control harmonics on our network.

Traditionally the management and control of harmonics is passed on to the connected asset, increasing cost per user. It is also inefficient; instead we can take a whole system approach to the issue of harmonic management, which can optimise the investment required for harmonics management and improve controllability. Our harmonic filter design and adoption on our network will save our connected users the cost of deploying a harmonic filter themselves, and is developed on a whole system approach to harmonic management.

This design will be rolled out in RIIO-T2 at Linmill, Moffat, New Cumnock, Black Hill, Margree and Newton Stewart to prevent voltage harmonics in excess of planning and compatibility limits on our

132kV network. The net benefits generated from this standardised design is up to £5m in RIIO-T2.

8.2.2 Our RIIO-T2 Ambition

R2T6.1 In RIIO-T2 we want to better analyse and focus on the challenge of active power oscillation damping. In recent years, as discussed under the grid observability theme, we have observed various low frequency oscillations associated with connected renewable generation. We need to study these and come up with active power oscillation damping solutions and/or preventive measures to be enabled through STATCOMs and/or converter technologies connected to our network.

Figure 31 Harmonic Filters at Western HVDC converter station

Power system oscillations are a relatively new but fast emerging challenge on our network. The biggest challenges in tackling power system oscillation and preventing a large scale interaction that can cause major damage are the lack of visibility and lack of control. Lack of visibility can be tackled to a large extent through wide spread deployment of WAMS. Lack of control needs to be further studied and developed through active power system oscillation damping techniques.

According to DNV GL's analysis the key aspects to be studied for power system oscillation damping are

the key aspects to performing a reliable, robust and practically applicable damping analysis are as follows:

- Ability to define and extract dominant modes of oscillation in frequency range of interest
- Utilization of relative magnitude/energy of the oscillatory mode in conjunction with damping ratio to comment on the applicability of that mode
- Robustness and flexibility in algorithms being utilized
- Automation capability to enable damping analysis across machines within a large power system network
- Flexibility to allow the user to choose the timeframe across which the damping analysis needs to be performed

Active power oscillation damping is deployed on networks but have limitations in terms of sophistication and automation. In the context of widespread application on the GB system will require extensive research and development, and engagement with suppliers to enable suitable solutions on our network. This will be one of the key areas of focus for innovation in RIIO-T2.

8.2.3 T6 RIIO-T2 Funding request

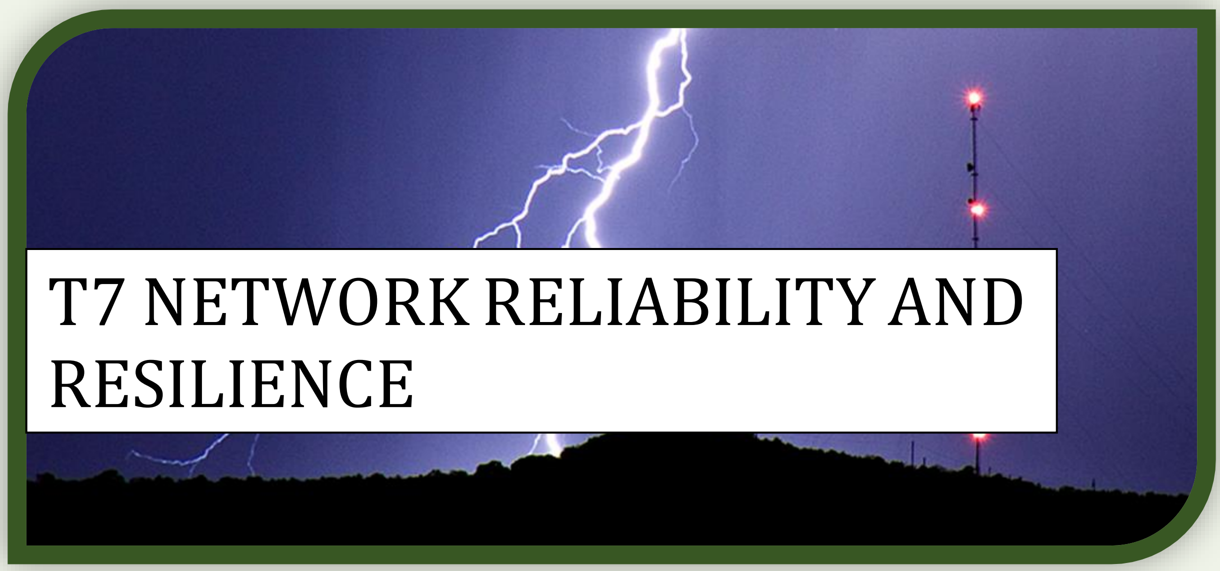
Description	Ref	Type	Value (£m)
Investigation into Power System Oscillations	R2T6.1	NIA	0.3

Table 16 T6 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3)** **(undiscounted)**
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£0.3m	**To be Estimated**

Table 17 T6 Business Plan Funding Request Summary



T7 NETWORK RELIABILITY AND RESILIENCE

8.3 T7 Network reliability and resilience

Network reliability and resilience are the key performance indicators of any power system network owner and operator. As our key duty is "keeping the lights on".

In electricity sector, reliability can be defined as the ability of the power system to deliver electricity in the quantity and with the quality demanded by users. Reliability means that lights are always on in a consistent manner. This is a binary view of system performance where systems are either functional or failed.

Resilience, stemming from the root, "resilio", meaning to leap or spring back, is concerned with the ability of a system to recover and, in some cases, transform from adversity. The US National Infrastructure Advisory Council defines critical infrastructure resilience as:

"…the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event." Resilience approaches emphasise the idea that disruptive events occur regularly and that systems should be designed to bounce back quicker and stronger to reduce their impact.

The power system protection systems (also referred to as secondary systems in substations) and wide area protection and control (WAPC) schemes, such as system integrity protection schemes, ensure the system remains reliable and operates within the parameters it is designed for.

They also protect the system against power system faults and incidents which can affect system stability and security. The restorative actions planned in case of an outage bring the system back up and running after an unplanned outage. These also form part of our wider black start strategy and account for system resilience.

Resilience is becoming a key factor and key concern without dispatchable generation and with significantly lower levels of controllable generation in Scotland. There will be requirements for new WAPC schemes in different parts of the SPT network to maintain balance between generation and demand and, if required, shed generation and/or load to maintain system integrity. This means we need fast acting load shedding and intertripping schemes and we need to find new technologies to enable them.

8.3.1 *RIIO-T1 Innovation & Roll-Out*

SP Transmission Led Activities

R1T7.1 Our NIA project NIA_SPEN_1803 SIARA "System Integrity and Restorative Actions"

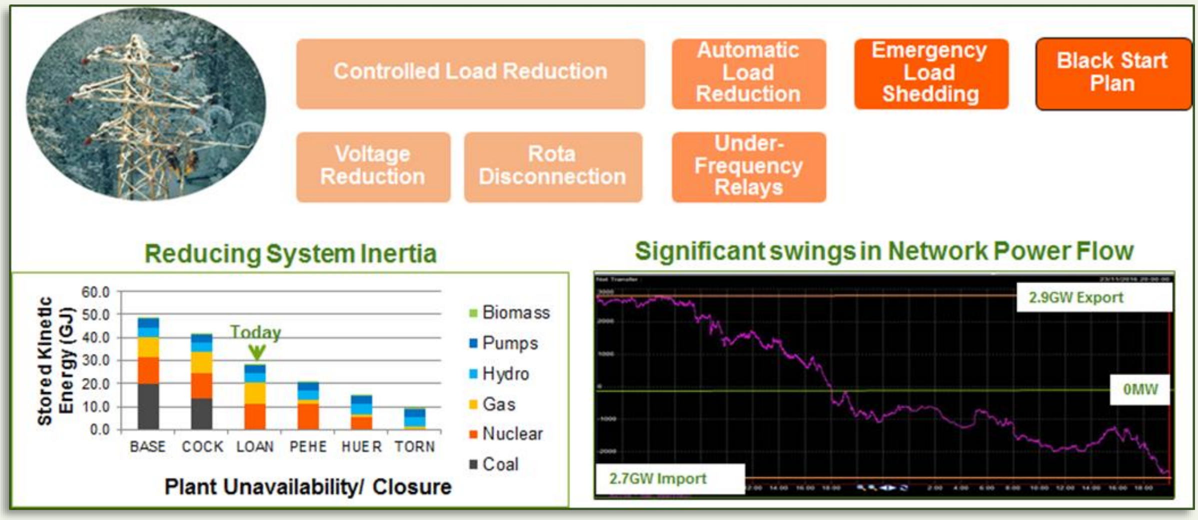


Figure 32 Effects of closure of large scale synchronous generation on Scottish power system

explored the feasibility of deploying wide area protection and control in SPEN's network using state of the art routable GOOSE (R-GOOSE). SIARA enabled use of R-GOOSE for future operational intertripping and load management schemes over wide area network (WAN). The project itself was designed to highlight the communication, time-synchronisation and other infrastructure requirements for future roll-out of R-GOOSE through offsite testing and small scale site trials.

As the complexity of our power system increases we will need a feasible option to collect real-time load data from across all the grid supply points to be considered and fed into a centralised automated load shedding WAPC scheme. The low latency and reliability of data transfer and speed of operation will be of paramount importance in case of such WAPC schemes.

The successful completion of this project has enabled us to greatly reduce the number of IEDs and protocol converters required in future WAPC schemes and simplify the scheme architectures. The project has generated learning regarding increased efficiency, reduction in number of IEDs used and improvement in performance and speed through use of R-GOOSE. It has also highlighted requirements for communication infrastructure and cyber security measures for wide scale roll-out of WAPC schemes based on R-GOOSE.

The roll-out of the SIARA technology at substations has the potential to generate £0.2m worth of benefits per application of WAPC scheme on our network, as the financial savings will be achieved through the reduction of number of IEDs (for example for 10 circuits from 42 to 22 devices), generating TOTEX savings and improving performance of operation.

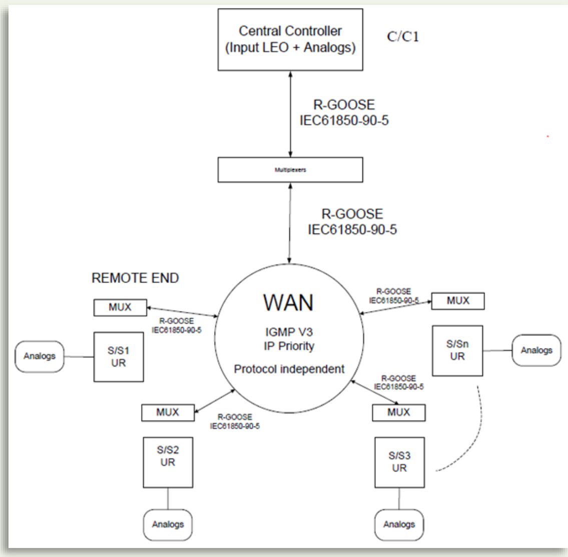


Figure 33 Project System Integrity and Restorative Actions architecture

R1T7.2 The NIA project NIA_SPT_1503 "Protection Settings to Cater for the Evolving Transmission Network", reviewed our current protection settings and the applicability of the same in future low fault level and changing system dynamics conditions of the network.

The project highlighted the requirement for a complete review of our protection and control system reliability in light of increased non-synchronous generation on our network. It also identified the potential need for adaptive protection enabled through wide area monitoring and real-time state estimation at substation level. Although there is no immediate need for this application, this has provided valuable knowledge allowing advanced planning for the next decade, with a steep rise in the percentage of non-synchronous generation on our network.

8.3.2 Our RIIO-T2 Ambition

Learning from others

R2T7.1 The increasing penetration of non-synchronous generation has introduced significant challenges for transmission and distribution network operators. One of the key challenges is the potential impact of the increasing amount of non-synchronous generation on the reliable operation of existing protection systems. Non-synchronous generations are typically interfaced with the network via power electronics devices, and due to the nature of their control and hardware constraints, these devices contribute limited short circuit power (in comparison to synchronous generators of similar ratings) during faults.

The fault current contribution from converters may also vary depending on the nature of the controllers and according to the specific manufacturer's practices. Existing European and GB grid codes require converter-interfaced infeeds to provide some form of fault current and fault ride-through capability, but exact quantifications for the nature of the responses are not yet fully defined and are somewhat generic. The specific and quantified behaviour of non-synchronous generation during faults and other disturbances is subject to definition at national level according to individual system operator requirements, and in alignment with the general principles laid out in European documents, such as the network code on requirement for grid connection of generators. This increases levels of uncertainly relating to converters' behaviours during faults and the associated response of the protection systems as identified through NIA projects NIA_NGET0182, NIA_SPT_1503 and NIA_NGET0106.

Furthermore, converter-interfaced sources could also introduce a higher level of harmonics to the power system. A high level of distortion of voltage and current waveforms has the potential to lead to changes in protection response under certain circumstances.

In RIIO-T2 we aim to perform comprehensive studies in collaboration with other TOs and the ESO, building on work carried out to date globally, through extensive simulations coupled with injection of actual protection relays in laboratory facilities, to fully evaluate the impact of non-synchronous generations upon power system protection – this could consider both main and back-up protection operation scenarios. Recommendations relating to desirable converter performance during faults could be established, thus potentially and if necessary informing the debate relating to national future grid code changes/ requirements.

This will be a significant piece of study that will be absolutely crucial to informing our future protection policy and quantifying the nature and magnitude of risk posed through the energy system transition on our existing protection and control systems. It will also inform our non-load and load related investment expenditures related to secondary systems for future price control periods.

R2T7.2 The closure of Longannet has had a significant impact on SP Transmission's black start timescales. In order to avoid entering a longer black start sequence it is important that we do everything to protect our system against unplanned outages or a blackout. Innovation plays a key role in increasing system visibility and enabling what can be termed as a "self-healing grid".

The South Australia blackout on the 28th September 2016 exposed the power system to a rate of change of frequency (RoCoF) in excess of 6 Hz/s where the under-frequency load shedding was designed based on a maximum RoCoF of 3 Hz/s (considered to be well above that designed for in international jurisdictions). The Australian power system, like the GB power system, is experiencing a steady decline in terms of the ratio of online synchronous to non-synchronous generation (including wind, solar, batteries, etc).

This causes the power system to be exposed to higher RoCoF in the event of system separation. This implies our future schemes need to capture cascading faults such as these much in advance of an actual system separation. We need detailed research to analyse the nature of cascading faults, to identify innovative solutions to capture cascading fault conditions, and develop procedures to maintain system integrity in case of loss of large scale generation and/or interconnection on the network. We plan to focus on this topic through detailed system analysis and trial of various innovative solutions, building on the knowledge gained from other big island networks such as Australia to ensure our network resilience.

8.3.3 T7 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)

Quantification of protection system challenges in future power grids	R2T7.1	NIA	1
Investigation into nature of future cascading faults	R2T7.2	NIA	0.8

Table 18 T7 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)**
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£1.8m	**Improved network resilience, £9.1m**

Table 19 T7 Business Plan Funding Request Summary

T8 ENHANCED ANCILLARY SERVICES

8.4 T8 Enhanced Ancillary Services

The ESO is primarily responsible for procuring ancillary services in GB. As transmission network owner it is our role to provide and manage connections to assets and generators providing ancillary services.

In the past decade, with the reduction in grid services, innovative solutions are required to provide faster and alternate sources of grid services. This forms a key part of the ESO's innovation portfolio. We have and will collaborate with the ESO in future to enable enhanced ancillary services on our network.

8.4.1 RIIO-T1 Innovation & Roll-Out

Learning from others

R1T8.1 In RIIO-T1 the ESO delivered two ground-breaking projects enabling enhanced ancillary services on GB system. The first project, enhanced frequency control, enabled fast frequency response form battery systems using a novel wide area control system with data provided from WAMS enabled by our VISOR project. The second project, Power Potential, is currently enabling enhanced responses from distribution connected assets through smart monitoring and control systems.

Our role as a TO in RIIO-T2 will be crucial in roll-out of these projects on our network. We need to work with the ESO to ensure there is adequate monitoring and reliable communication infrastructure in place to enable seamless execution of the solutions developed through these projects. We also need to ensure that we maintain control capability at all times to the connected assets for the ESO to be able to request services when required. Our own procedures and policies, and potentially the grid code, will need updating to ensure we have the enhanced ancillary services connection capability.

As part of our FITNESS project we have demonstrated the enhanced frequency control capability on a phasor controller platform in a laboratory environment. We will work with the ESO to ensure that this technology can be rolled out to our substations. This will imply upgrades to our existing communication and time synchronisation infrastructure to ensure that the ESO receives accurate and reliable data and information in real-time. It is our innovation priority to work with the ESO and other TOs to enable enhanced services across the GB power network.

8.4.2 Our RIIO-T2 Ambition

Learning from others

R2T8.2 In RIIO-T1he ESO has through its NIA project NIA_NGSO0026 launched an investigation into virtual synchronous machines to enable enhanced ancillary services from various connected converter-based assets.

The ESO has produced a potential functional specification for grid supporting requirements within the Grid Code Virtual Synchronous Machine (VSM) expert working group. It discusses a control philosophy applied to convertor-based technologies to meet the VSM specification.

The project will provide insight in the following areas:

- The project will validate at a modelling level the performance of an innovative control system against a structured series of performance tests,
- New performance test standards will be developed specific to the new areas of performance being demonstrated,
- New understanding over the design and specification of physical VSM- Battery solutions,
- A new process template for how future new stability supporting technologies can be developed, evaluated and demonstrated. This can then inform how the implementation of these technologies is managed,
- New understanding over how VSM performs will be able to provide for a Battery based approach moving into field trials.

The VSM implementation is to be applied across the whole electricity system in order for connected converters and other supporting technologies to comply with NG ESO requirements. As a TO we will be informed regarding the connection requirements for the VSM technology to our network, and we will collaborate with the ESO to enable the roll-out of VSM in RIIO-T2.

8.4.3 T8 RIIO-T2 Funding request

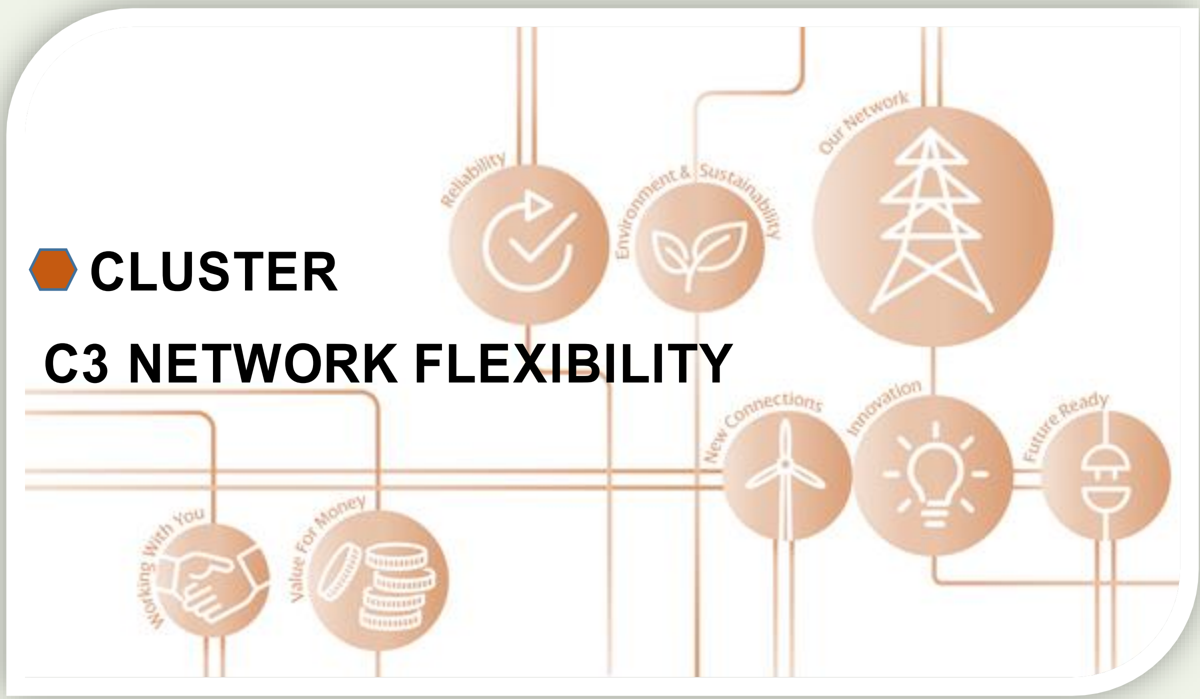
Description	**Ref**	**Type**	**Value (£m)**
Integration of virtual synchronous machines	R2T8.2	IR	0.8

Table 20 T8 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3)** **(undiscounted)**
Innovation Roll-Out	£0.8m	**Improved network resilience**
Network Innovation Allowance		

Table 21 T8 Business Plan Funding Request Summary



9 C3 Network Flexibility

The Future Power System Architecture (FPSA) project commissioned jointly by DECC (now BEIS) and Ofgem and completed by the IET and Energy Systems Catapult outlines some of the key future uses of the UK network and the challenges of realising this network. The report highlights seven key drivers of 'new or significantly extended functionality'. These drivers have been integral to SP Energy Networks' wider distribution system operator (DSO) vision. As part of this cluster we will work on these objectives playing our role as a transmission network owner. The transmission and distribution network owners and operators will work together in future price controls to create more network flexibility across the boundary.

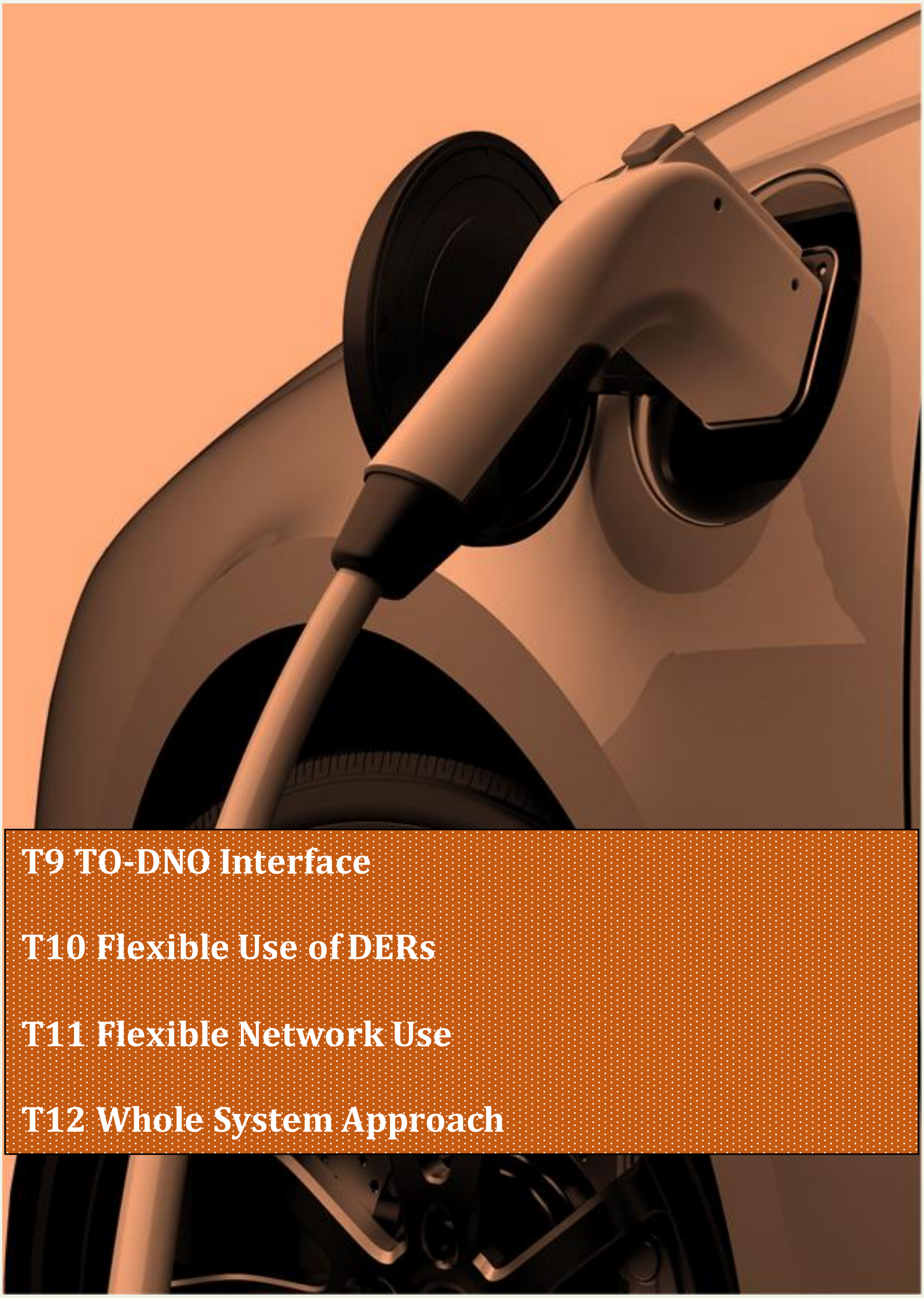
The changing generation mix is something that we have already experienced within our network. We have yet to witness significant penetration of electric vehicles and next generation electric heating, but fully expect these to ramp up considerably if the GB carbon reduction targets are to be met. These scenarios are ultimately based on an informed view of available evidence, therefore network companies must endeavour to make 'no regrets' investments that provide the capability and flexibility to deal with a range of scenarios.

The decrease in the proportion of conventional flexible generation means that new sources of network flexibility must be introduced to maintain the operability of our network. In future flexibility must be sourced from storage solutions, demand response, and the integration of EVs.

The transmission network itself will become a source of flexibility though the increased use of our assets through use of real-time dynamic rating to increase power flow across power boundaries, and through use of new methodologies that increase the use of transmission capacity in an economic manner.

The network flexibility cluster aligns with the following EST challenges

- Whole System Approach: Overcoming boundary restrictions between electricity and gas transmission owners (TOs) and distribution network operators (DNOs), transport and telecommunications sector with increased customer engagement.

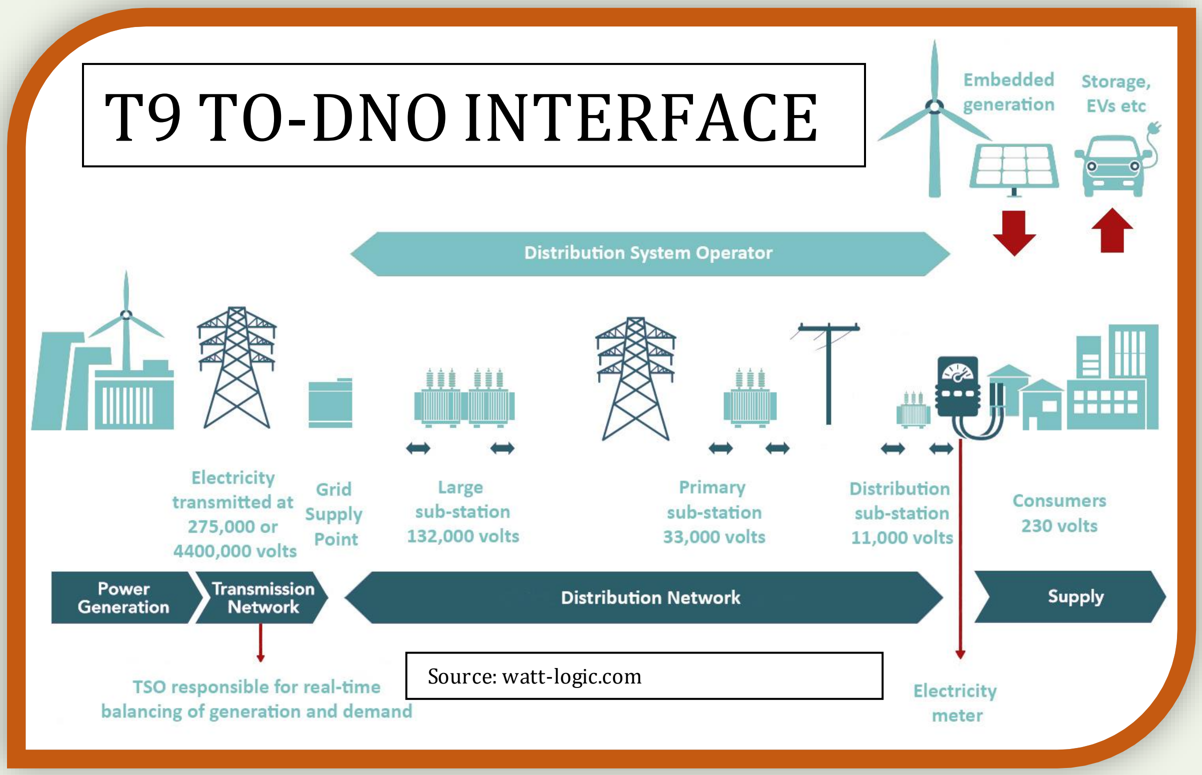


T9 TO-DNO Interface

T10 Flexible Use of DERs

T11 Flexible Network Use

T12 Whole System Approach



9.1 T9 TO-DNO Interface

The Future Power System Architecture (FPSA) drivers behind Theme 8 TO-DNO interface are as follows:

'The flexibility to meet changing but uncertain requirements recognising that the form, magnitude, timing and tipping points of future power system developments are not all predictable far in advance. Changes include uptake of new technologies (e.g. domestic generation and storage, electric vehicles, heat pumps) or active consumer participation (e.g. smart tariffs, home energy automation)."

We aim to achieve these objectives by:

- Enhancing data communication and visibility across TO-DNO boundary for better utilisation of DERs
- Accurate forecasting of demand through load modelling and forecasting techniques
- Establishment of islanding models to better manage local generation and demand under system restoration conditions

9.1.1 RIIO-T1 Innovation & Roll-Out

R1T9.1 In RIIO-T1 we have begun to enhance visibility of our distribution network for transmission operators through roll-out of active network management schemes. The visibility is limited mostly around the grid supply points however it still provides us a better picture of the power flow and the constraints in the distribution network.

We currently operate our transmission and distribution network on two different energy and distribution management systems (EMS, DMS) at our control centre level. As part of our EMS upgrade in RIIO-T2 it is our aim to combine both systems and thus provide the operators full visibility of the network in a more user friendly manner. We have also invested in significantly upgrading communication and information gathering model on our distribution network. This along with our wider network management schemes will significantly improve the transmission operator's visibility of the distribution network.

R1T9.2 In RIIO-T1 our combined T&D effort on NIA project NIA_SPEN009 "Data Intelligence for Network Operations (DINO)" we demonstrated how to better manage data on our distribution network to create meaningful information for our distribution network operators and increase visibility at the transmission network level.

DNO Network Management Centres (NMCs) are presently inundated with data from the network, be it analogues, alarms or events. As emerging 'smart' technology becomes more prevalent on our networks this issue will only be exacerbated, be it through the integration of smart meter data, Dynamic Rating / Active Network Management (ANM) schemes or additional sensors to monitor the impact of low carbon technology. It is estimated that this increase of data could be factors of 1,000 times greater than presently received, particularly if smart meter information is considered. Hence, the project aimed to turn large volumes of data into useful information suitable for supporting operational decisions at both distribution and transmission level.

The main objectives of the project were as follows:

- Modelling the solution in the Smart Grid Architecture Model (SGAM) framework
- The potential use of the Common Information Model (CIM) or other service oriented standards to help with data discovery and exchange
- Determining how systems and standards will work to handle the use cases emerging from multiple data streams e.g. smart meters, substation monitors, ANM etc.
- An indication of how we could move to an improved system in a step-wise fashion, given that many legacy systems will remain in-situ

The project concluded with some very useful findings and recommendations for future data management. In RIIO-T2 we plan to use the methods developed through the DINO project to enable information transfer between our transmission and distribution network operators. This will create more visibility of the distribution network behaviour and help us better assess its impact on the transmission system.

9.1.2 Our RIIO-T2 Ambition

Learning from others

R2T9.1 In RIIO-T2 one of the key aspects for us as a transmission network to focus on will be to model the changing nature of demand and its impact on the transmission system. Currently the rise of EVs and electrification of heat is marginal in Scotland. However as discussed before the future energy scenarios predict a fast rise in growth of EVs and there are targets for electrification of heat.

This is a challenge in itself not only for the DNOs but also the TOs as the underlying operating principles and maintaining the generation and demand balance on the transmission network is fast becoming a complex issue to resolve. Our studies will be focussed on a 10 -20-year period look ahead. It will help us better determine the role we as the TO will play in future electrification of demand and the kind of services we will need to maintain system security and resilience.

There are proposals for dynamic modelling of demand and improving information exchange in real-time to improve day ahead operation planning procedures and using state estimators to provide a better picture of the transmission network operation parameters. This is a fast emerging need as clearly any changes in the distribution network in future energy scenarios can significantly impact the transmission network as well.

The initial findings from our NIA SPT 1507 project "Modelling of Static and Dynamic Loads" show that accurate load models can support improved decision making when considering the required system expansion. It is expected that utilisation of the existing assets can be improved, potentially deferring network reinforcement and influencing fundamental network design principles.

A detailed understanding of demand behaviour is a prerequisite for integration of system operation actions at distribution and transmission levels.

In order for the project to deliver these benefits, we propose an approach for the estimation of the unknown load parameters of generic aggregated load models based on measurements recorded from the distribution/transmission system.

We aim to use innovation for studies, forecasting, modelling and application building for smart assessment of impact of changes in demand and distribution network operation on the transmission network.

9.1.3 T9 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)
Solutions for improving TO-DNO Interface	R2T9.1	NIA	0.65

Table 22 T9 RIIO-T2 Innovation Funding Breakdown

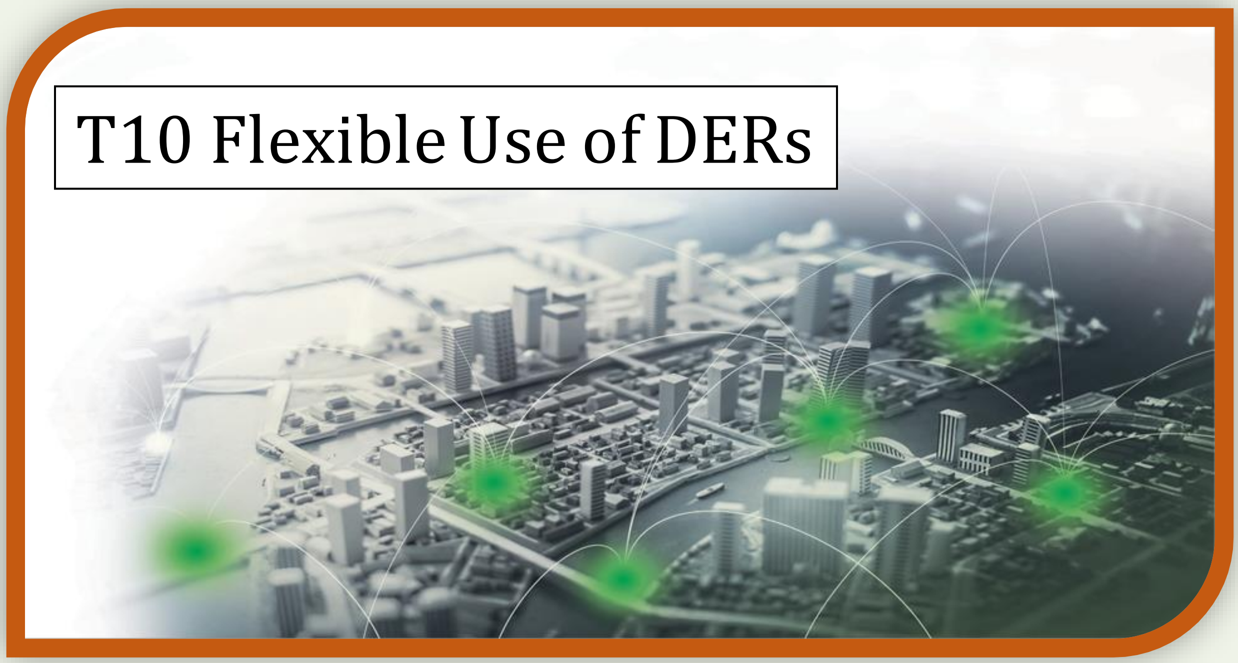
Business Plan Funding Request

Funding Type	Value	Estimated TO and ESO Benefits (RIIO-T2 and T3)

		(undiscounted)
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£0.65m	**Improving TO-DNO Interface** **£68m**

Table 23 T9 Business Plan Funding Request Summary

T10 Flexible Use of DERs



9.2 T10 Flexible Use of DERs

The Future Power System Architecture (FPSA) drivers behind Theme 8 TO-DNO interface are as follows:

"The change in mix of electricity generation will require new techniques to manage system frequency, stability and reliability as intermittent renewable sources and distributed generation grow to take up a much larger share of total generation."

"The use of price signals or other incentives will enable consumers to save money by becoming active participants in the power sector and, in doing so, to contribute to decarbonisation while keeping system balancing costs down."

The recovery from major outages will be far more challenging as the power system becomes more decentralised. Managing prolonged outages will require sophisticated coordination to reintroduce load and to reconnect distributed generation and storage.

We aim to achieve these objectives by:

- Enabling localised aggregation of distributed services by supporting SPEN's DSO vision
- Enabling transmission requirements for grid distributed services from distributed connected resources.

9.2.1 *RIIO-T1 Innovation & Roll-Out*

Working with others

R1T10.1 In RIIO-1 we launched our vision to become a total DSO. Our vision is that SPEN will transition towards becoming a full DSO, which will facilitate an open and inclusive balancing services market at the Transmission/ Distribution interface. The DSO will also carry out local system balancing, efficiently utilising the Distribution network. These DERs will be aggregated into Virtual Power Plants (VPPs) or Virtual Balancing Mechanism Units (VBMUs) which will interface with the SO, to act on balancing instructions. This aggregation will require the DSO to facilitate a market, and as such a mechanism will need to be developed to remunerate DERs for the services they provide, and/or provide pricing signals for DERs without direct control (e.g. groupings of domestic electric vehicle charging points) to react to system requirements.

1. Total TSO
2. DSO DER manager
3. Transmission support
4. Total DSO

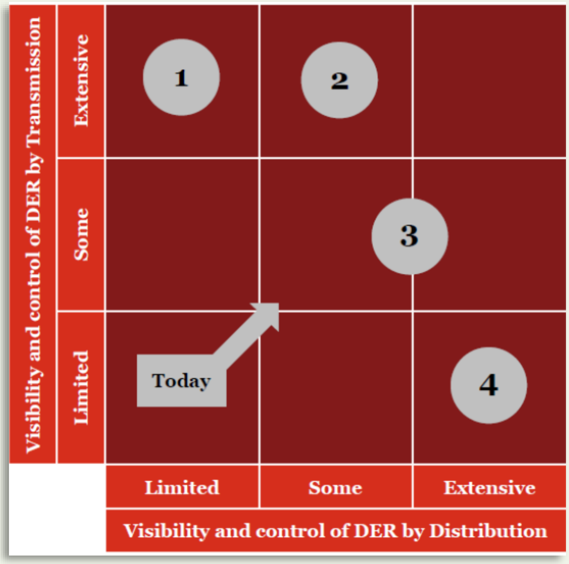


Figure 34 Distribution System Operator Options

We believe that this approach will be critical to ensure that the market is prepared for the emergence of new participants. The increased information on the system utilisation will also act as an investment driver, identifying where additional network reinforcement is required both in transmission and distribution network.

Our DSO model will be capable of enacting system balancing actions from the SO within timescales that best meet the needs of the SO and the capabilities of the DERs connected to our network areas. Critical to realising our DSO vision will be a communication infrastructure that provides a seamless interface between the TO and the ESO, our control facilities and the DER resources that we will aggregate. This will allow us to provide balancing services within an acceptable timeframe for the TSO. This will also need to be balanced against the capabilities of the DERs connected to our networks.

In RIIO-T2 we will help enable SP Energy Networks' DSO vision and create more network flexibility in transmission network through the DSO model.

R1T10.2 The project on black start from distributed energy resources (DER) "Project Distributed ResStart" led by GB Electricity System Operator (GB ESO) in collaboration with SP Energy Networks funded through RIIO-T1 NIC innovation funding is an important and timely initiative that will ultimately lead to significant benefits for electricity consumers in GB by reducing costs for Black Start services, and will also inform research and development in other countries. Black Start services need to evolve in line with changes in the energy landscape and support the transition to a net zero, decentralised future.

SPEN is at the forefront of industry activity on the integration of distributed energy resources and the development of new approaches to restoration of the power system following a black out event. SPEN as both a Transmission Owner (TO) and Distribution Network Owner (DNO) is already trialling various initiatives relevant to this project.

The method to be trialled in this innovation project is involves:

- Restarting an electricity system from a DER, or combination of DERs, from a blackout (without external power supply).
- Maintaining energisation of the newly-created distribution power island of aggregated DER and blocks of demand.
- Expanding and synchronising with other power islands, energising further generation, and establishing a skeleton transmission network.

The lack of sufficient large scale synchronous generation which could self-start in the event of a blackout has created the need to explore other options such as relying on DERs to backfill black start services. The power islands described above will be micro-grids purely sustained by DERs. This will require a considerable amount of system studies to ensure such islanded systems will be able to sustain themselves, in terms of maintaining system stability while the rest of the system is re-energised to allow for reconnection to the wider network. This project will be a key step towards creating network flexibility through flexible use of DERs.

The geographic regions served by SP Energy Networks in southern Scotland and north Wales are rich in renewable energy resources, and on our networks the growth in DER occurred earlier, faster and to a greater extent than most other parts of the country. The network areas for study

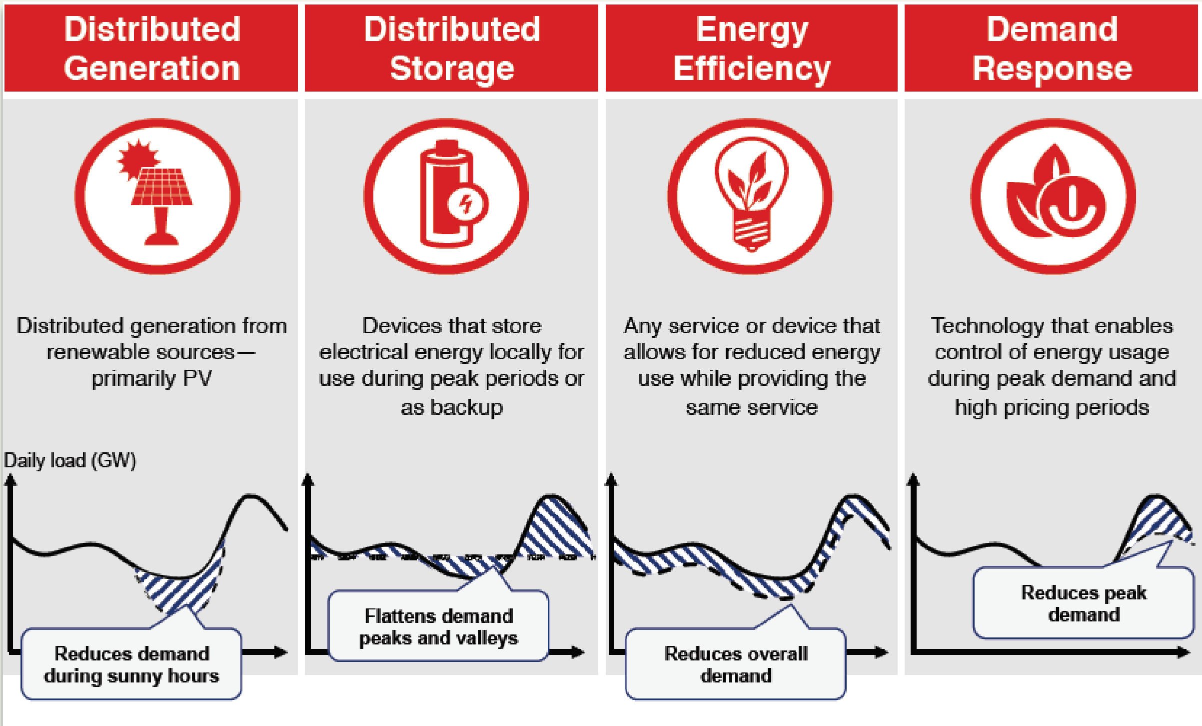


Figure 35 Flexible Management of DERs (Source: http://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf)

identified in SPEN under this project include a mixture of synchronous and non-synchronous generation and will provide valid learnings for GB-wide roll-out in RIIO-T2.

The Distributed ReStart project is an important step towards an innovative whole system approach that adds flexibility, improves resilience, and reduces future costs of critical grid services.

9.2.2 Our RIIO-T2 Ambition

Learning from others

R2T10.1 The SP Energy Networks DSO vision will enable flexible network services from DERs. This combined with the roll-out of black start from DERs will aid in creation of essential network services distributed resources. We plan to aid the ESO by rolling out these and other techniques developed through "Enhanced Frequency Control" and "Power Potential" projects to create more network flexibility. SP Energy Networks is also a part of the ENA open networks forum a collaboration amongst GB TOs and DNOs to enable flexible connection and use of DERs.

We need to enable more intelligence on our transmission network to enable visibility and state estimation of the distribution network. We will direct our innovation efforts in RIIO-T2 to enable more flexible use of DERs. The intelligence enabled at transmission and distribution level will enable more decentralisation that will allow the network owners to balance and better manage:

- DERs that reduce demand during sunny hours of the day.
- Distributed storage that stores energy locally for use during peak periods or as backup, flattening demand peaks and valleys.
- Create energy efficiency that allows for reduced energy use while providing the same service, reducing overall demand.
- Enable Demand response to enable control of energy use during peak demand and high pricing periods, reducing peak demand.

Demand flexibility creates value for consumers and the grid by shrinking customer bills (by as much as 40%), reducing peak demand and shifting consumption to lower price, off-peak hours. Demand flexibility also can help providers, in some cases, to avoid or defer investments in generation, transmission and distribution, and ancillary services. The global demand response market was clode to 68.8 gigawatts in 2018 – capacity will be able to be time shifted.

Demand response creates flexibility by providing price and volume signals and sometimes financial incentives to adjust the level of demand and generation resources (consumption, distributed generation and storage) at strategic times of the day.

As such, it is a critical resource for a cost-effective transition to a low-carbon electricity system. Energy policies around the world increasingly acknowledge the importance of demand response and are beginning to solve the challenges that hinder its full uptake. As more DERs come online, demand-response programmes will become even more flexible and by some estimates could reduce necessary annual investments in the grid infrastructure by 10%. (Source: http://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf)

The work in this area will include developing an aggregated model of the distributed generation in different parts of the wider network and enabling network services through adoption of dynamic distributed demand modelling and distributed grid control. As in the case of enabling black start from DERs, this will involve development of wide area visibility, communication infrastructure and protection and control schemes to enable more demand response, flexibility and.

9.2.3 T10 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)
Black Start from DERs	R1T10.2	IR	1.0
Intelligence in transmission system to enable Flexible Use of DERs	R2T10.1	NIA	1.0

Table 24 T10 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)**
Innovation Roll-Out	£1m	**£93m**
Network Innovation Allowance	£1m	**£62m**

Table 25 T10 Business Plan Funding Request Summary

9.3 T11 Flexible Network Use

The Future Power System Architecture (FPSA) drivers behind Theme 11 Flexible Network Use are:

"The active management of networks, generation, storage and demand will facilitate growth of intermittent and distributed generation and new loads such as heat pumps and electric vehicles, without unnecessary network constraints or costly upgrades."

"The use of price signals or other incentives will enable consumers to save money by becoming active participants in the power sector and, in doing so, to contribute to decarbonisation while keeping system balancing costs down."

We aim to achieve these objectives by:

- Enhancing power flow to and from the distribution network using active network management (ANM) and load management schemes (LMS).
- Dynamic rating of overhead lines and cables to enable more capacity on the network.

9.3.1 *RIIO-T1 Innovation & Roll-Out*

R1T11.1 SP Energy Networks has been at the forefront of the connection of Distributed Generation in the UK. Across our three franchise areas we have connected ~7GW of renewable generation. We have faced unique challenges within our Southern Scotland and North Wales regions where we are facilitating high levels of renewable generation.

These areas are resource rich in terms of wind yield and land but they are also areas of low population density and therefore low electrical demand. A good example of this is an area of South West Scotland where peak demand is around 177MW, however through our focus and innovation we have managed to connect 310MW of Renewable energy.

This surplus of generation in a sparsely populated area means that at key points of any given day wind generators are seeking to export across the Distribution network and onto a highly constrained Transmission network. SPT in collaboration with NG ESO have been discussing with developers the best way forward to manage the system and facilitate their connections due to this lack transmission capacity.

This has led to the development of South West Scotland Generation Export Management System (GEMS) that will curtail generation output in a controlled manner whilst maximising the utilisation of the transmission capacity available and maintaining security of supplies. The system will facilitate an SO commercial market for curtailment that all generators – transmission and embedded – can participate in, hence providing a level playing field for all developers. This will also facilitate the future connection of generators under the same commercial arrangements. This will create savings worth £50m per year for the GB power system and the consumers.

Learning from others

R1T11.2 In RIIO-T1 there were many innovation initiatives directed towards enabling additional capacity on the network through dynamic ratings using sensor technology and weather parameters. We will incorporate learnings from following innovation projects in our business plan

- IFI1001 SPEN Offline Planning Tool for Dynamic Thermal Rating
- NIA_SPEN_032 SPEN Transition to Dynamic Cable Rating Operation
- PRJ_1128 SPEN Enhanced Weather Modelling for Dynamic Line Rating
- NIA_SHET_004SSEN Dynamic Line Rating CAT1
- NIA_NGTO014 NGET Advanced Line Rating Analysis(ALiRA)
- NIA_NGET0047 NGET Dynamic Ratings for improved Operational Performance (DROP)
- NIA_NGET015 NGET & SPEN Enhanced Weather Modeling for Dynamic Line rating (DLR)

In RIIO-T2 we plan to roll this technology out on our wider transmission network and across key transmission line and interconnections. Assets have a capacity rating which is based on a number of assumptions, including the temperature at which they operate. We plan to create a new system which will use analytics and enhanced data processing to provide real-time measurement of asset ratings. This will include roll-out of the aforementioned innovation projects.

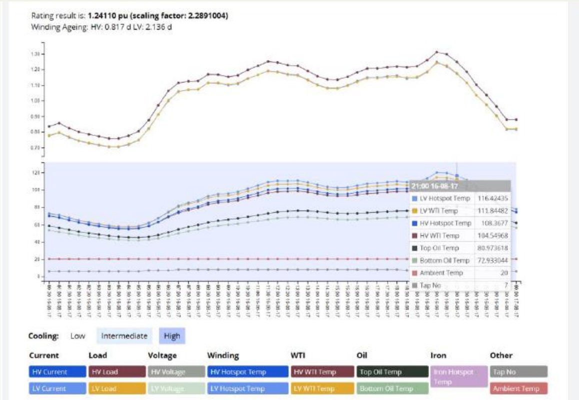


Figure 36 Capacity increase with dynamic rating example

A case study example of successful application of the dynamic ratings on cable to increase capacity on one of our cables is as follows:

"The ESO had requested an enhanced rating on a 400kV circuit. A rating enhancement was made available to the ESO, in line with their stated requirements at that time.

The ESO had requested a further increase to the enhanced rating as follows: pre-fault 935MVA, 1-hour post-fault rating 1550MVA, post fault continuous 1175MVA. Ground ambient temperature and soil resistivity measurements, at four of the critical locations on the cable route, were taken by the dynamic rating system supplier. On basis of the measured parameters and detailed analysis conducted by the supplier using the dynamic rating system following was made available to the ESO:

- *1100MVA Continuous Rating (as per IEC calculation, and in line with the originally assigned summer continuous rating, prior to de-rating in 2012); or*
- *935MVA Pre-Fault (as requested by NGET), followed by*
- *1550MVA 1hr Post-Fault (as requested by NGET), and*
- *1175MVA 6hr Post-Fault, following application of the 1-hour rating above.*

While the ESO had requested a 1175MVA post-fault rating on a continuous basis, the provision of 1175MVA only for a six-hour period post-fault was considered appropriate at this time, in part recognising that calculations thus far have focussed only on four critical sections."

The above case study highlights the potential of dynamic rating systems to increase capacity on our network through wide scale roll-out. This will help to increase the network capacity, reduce operational costs to the ESO and facilitate higher volumes of renewable generation. This *investment on our network will generate benefits of over £20m/pa.*

9.3.2 Our RIIO-T2 Ambition

Learning from others

R2T11.1 Conventional state estimation is a tool used by the ESO and TOs for obtaining the most accurate states of their electrical networks. The states of a power system can be described by the voltage magnitudes and phase angles at every bus. Such a description provides a basis for security and stability studies and thus helps ensure the safety of the network, it also allows for identifying potentials for generating more network capacity through change of network topology and accurate estimation of system security limits.

Conventional state estimation is a centralized algorithm which acquires data from the entire power network in a large sweep every few minutes. The data are not necessarily synchronised and may have seconds of time difference between different locations. Most of the existing applications of state estimation are based on Root Mean Square (RMS) measurements, for example voltage magnitude. Since the voltage phase angles are not measured in real-time, they may introduce large errors into the estimation results. Moreover, the scale of this solution means that it can overlook some switching events in the network: i.e. disconnection and connection of assets at substation level.

With a network integrating massive amounts of renewable resources and energy conversion systems, the power system may be pushed into operating close to its limits and more network flexibility is desired to avoid network constraints. Hence, a more distributed, accurate and responsive localised state estimation can a response to the desired network flexibility. By leveraging the breadth and depth of measurements available at the local level, captured at source in a faster manner than through classical central state estimation, a more accurate and reliable estimate of the substation state can be determined in a fraction of the time taken by a central state estimator. This estimate improves the quality of the local system awareness enabling novel control and monitoring possibilities and thus allowing more power flow through the network. The local state estimation may in turn lead to improvements of the accuracy, reliability and convergence time of the overall system state estimation and help reduce constraints on an hour by hour basis.

9.3.3 T11 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)
Localised state-estimation to enhance network capacity	R2T11.1	NIA	1.0

Table 26 T11 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3)** **(undiscounted)**
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£1m	**£86m**

Table 27 T11 Business Plan Funding Request Summary

T12 Whole System Approach

9.4 T12 Whole System Approach

The Future Power System Architecture (FPSA) drivers behind Theme 11 Flexible Network Use include:

“The need for some coordination across energy vectors (electricity, gas, biofuels, petroleum and heat networks) will become inevitable as the UK decarbonisation strategy proceeds with the electrification of heat and transport energy.”

We aim to achieve these objectives by:

- Enabling a whole system approach to energy system transition challenges
- Enabling cross-sector models and processes to create efficiencies
- Increasing visibility across various energy system vectors

9.4.1 RIIO-T1 Innovation & Roll-Out

R2T12.1 Our business plan for RIIO-T2 demonstrates the whole system approach to investment planning.

For our Load section of the business plan in RIIO-T2 we have taken a new approach to forecasting for projects in response to requests for new or modified connections seen throughout RIIO-T1 from SP Distribution and Network Rail. We have worked collaboratively with all demand stakeholders in developing the plan and have taken a Whole (Electricity) System and Whole Life assessment process when evaluating options to ensure the most economic and efficient approach.

The process when assessing the connection options available for Network Rail or other directly connected consumers differs in that the connection application must provide the lowest cost option to the customer; as such the options available are limited.

SP Distribution have throughout the course of RIIO-ED1 identified a number of sites that are approaching or exceeding the design limit for a variety of reasons including thermal, voltage and fault level constraints. The key driver behind a number of these sites is increasing levels of embedded generation. Working with SP Distribution we identified sites where a transmission solution would be viable; this was based on existing site layout, 33kV network design, and existing equipment capabilities among other issues. Once sites were identified, a timeline for intervention was agreed prioritising the higher risk sites and those requiring immediate intervention.

The next stage of the whole system/ life assessment process involves going through our Cost Benefit Analysis (CBA) process. The spreadsheet model is approved by OFGEM and standardised across all network operators, and the methodology we applied within the CBA was developed by SP Transmission from guidance within HM Treasury Green Book. The options developed as part of the longlist assessment covered both Distribution/Transmission/3rd Parties as well as, within each proposal, build or non-build solutions. These were then eliminated based on the Critical Success Factors appropriate to SP Transmission, narrowing from longlist down to shortlist. Examples of solutions considered at the shortlist stage across Distribution and Transmission include, installation of Bus Section Reactor (SPD), installation of ANM scheme (SPD), installation of STATCOM (SPD), installation of Series Reactors (SPT) and replacement of the existing grid incomer transformer (SPT).

The shortlist assessment involved comparison of the costs and benefits of each option. The main benefit in our assessment of the projects is the carbon abatement value given by the relieving of constraints on the network and so allowing generation to connect. The generation forecasted was based on our scenarios view developed from the National Grid System Operator FES; this provided a view of the sensitivity of each option based on the generation uptake seen at each site increasing the robustness of the assessment.

This CBA assessment process was combined with stakeholder views and engineering expertise within the business to provide a detailed view of the preferred solution at each intervention site. The examples developed were also used in conjunction with SP Distribution to prepare an uncertainty mechanism for demand connections should the requirement outstrip our initial forecasts.

We work closely with the other transmission owners and the ESO. This ensures our planning of the transmission system is coordinated and complies with the standards that govern the design and operation of the network thus truly enabling whole system approach within the energy sector.

9.4.2 Our RIIO-T2 Ambition

R2T12.1 In RIIO-T2 we will extend our whole system assessment model across the sectors. The underlying engineering principles will be covered under all clusters and themes. The theme T13, whole system approach, will deal with the cost benefit analysis model of each engineering decision to assess the financial and non-financial benefits created through the engineering decision – taking into account materials, services and methods that can be utilised and/or adopted from other sectors.

The whole system assessment model developed through this initiative will be a comprehensive risk vs benefits model which will provide weighted indices to success of any whole system approach. Of course this will also require support from regulation and policies and the wider case study approach developed through this will take the wider factors such as regulation and policies into account.

One example of application of such a model could be alignment between telecommunication and energy sectors. In order to enable digitalisation in the energy sector we are dependent on a strong communication infrastructure. In critical applications we may decide to own and operate our own communication channels, but for many other applications such data gathering, analysis, storage and communication we may rely on widely available cloud services and 4G-5G networks. This will result in significant savings for our sector and provide more opportunities for the telecommunications sector to expand their business model.

As an industry there is a significant overlap in the technologies and processes that are needed to meet the requirements of the end consumers; it is only prudent that we expand our investment assessment model to make best use of the available infrastructure in GB to create financial benefits and efficiency, to demonstrate value for money for our consumers. This will be our whole system innovation initiative in RIIO-T2.

9.4.3 T12 RIIO-T2 Funding request

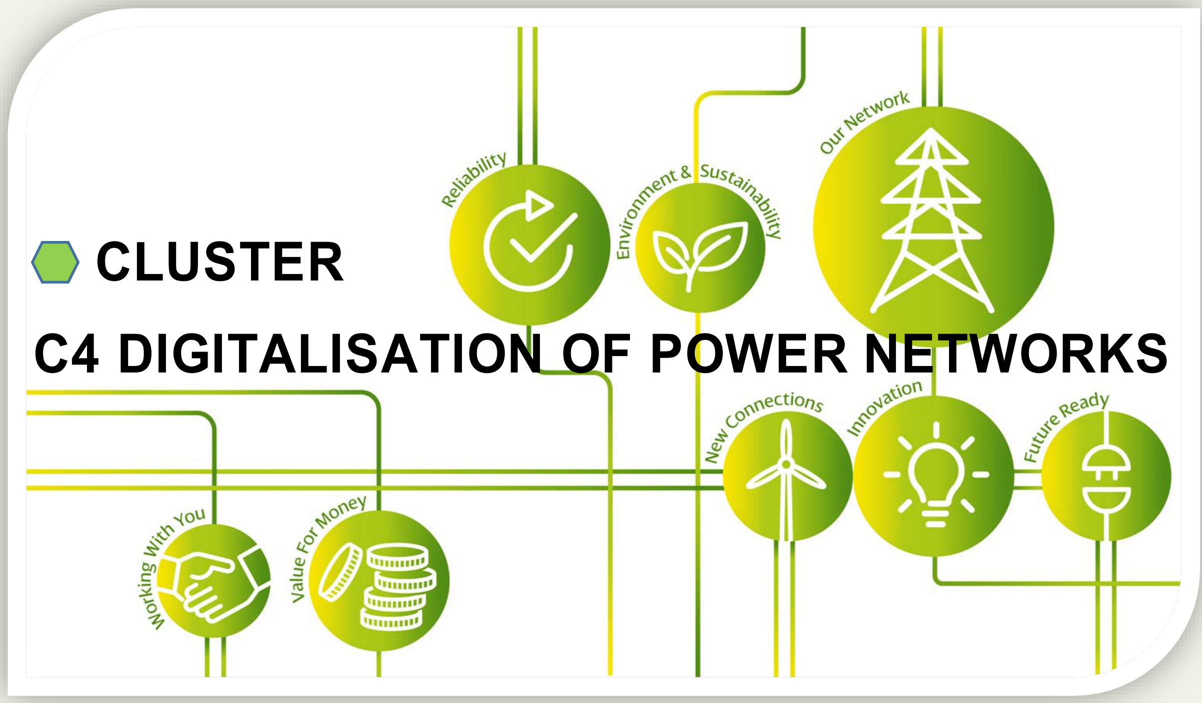
Description	Ref	Type	Value (£m)
Enabling whole system analysis	R2T12.1	NIA	1.0

Table 28 T12 RIIO-2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)**
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£1.0m	**£80m**

Table 29 T12 Business Plan Funding Request Summary



10 C4 Digitalisation of Power Networks

Digitalisation of power networks will result in long term cost reduction and more efficient use of existing networks. It enables advanced asset management and system analysis and increases networks security.

This cluster of our innovations is aimed at introduction of new digital technologies and enhanced data analytics through data-mining tools and development of standardised interfaces enabling data access to increase transparency in operation. It will also consider recommendations for standardisation activities and protocols for communications and data exchanges. This will ease the integration of new systems based on digital platforms. SP Transmission in RIIO-T2 will also aim to enable digital substation technologies and IP based communications along with higher quality sensors for substation secondary systems, that will reduce outage time and network constraints and will release capacity in the network to accommodate more low carbon generation.

Increased digitalisation and complexity of interconnected ICT systems in our network will also require updated cyber security policies, procedures and tools to mitigate cyber risks. The cluster will also aim to establish a collaborative cyber security strategy among TOs, DNOs and ESO to ensure security of supply and data protection of customer information.

The digitalisation of power networks cluster aligns with the following EST challenges

- Integrating new technologies and enabling digitalisation, standardisation and cyber security
- Improving the sustainability of our network and business processes and empowering our consumers

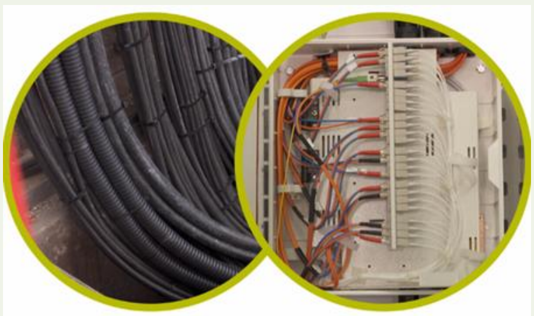


Figure 37 Copper to Fiber FITNESS Project

T13 New Digital Technologies

T14 Standardisation

T15 Enhanced Data Analytics

T16 Cyber Security

T13 New Digital Technologies

10.1 T13 New Digital Technologies

Digitalisation is a key driver for innovation and enabling sustainable solutions on our network. Digital technologies enable enhanced visibility, understanding and analysis of our network. They also help reduce footprint through smaller, lighter and easy to install intelligent devices replacing the bulk installations of conventional technologies which were in most cases a hybrid of hardwired and numerical technologies.

It is the next stage of evolution in digital technologies which take the ability of digital systems from pure computing to development of internet of things (IoT) which allows for communications, high speed data transfer, creation of meaningful information and increased computational power and analytics.

Most of our innovation incentives in RIIO-T1 had an element of digitalisation in them. We achieved this by:

- Introducing new digital technologies in substations for reduction in footprint, faster engineering process, reduction in outage times, enhanced safety, and for operation and maintenance reasons
- Introduction of new sensor technologies, measurement systems and wide area monitoring systems to provide information regarding asset and network performance and dynamic visibility of the grid

Digital technologies are the fastest growing innovation globally and the potential application of these technologies to improve our business efficiency and processes is unlimited. Digitalisation is and will be a key driver for our innovation initiatives in RIIO-T2.

10.1.1 RIIO-T1 Innovation & Roll-Out

R1T13.1 In RIIO-T1 we installed a mixture of sensor and digital measurement technologies on

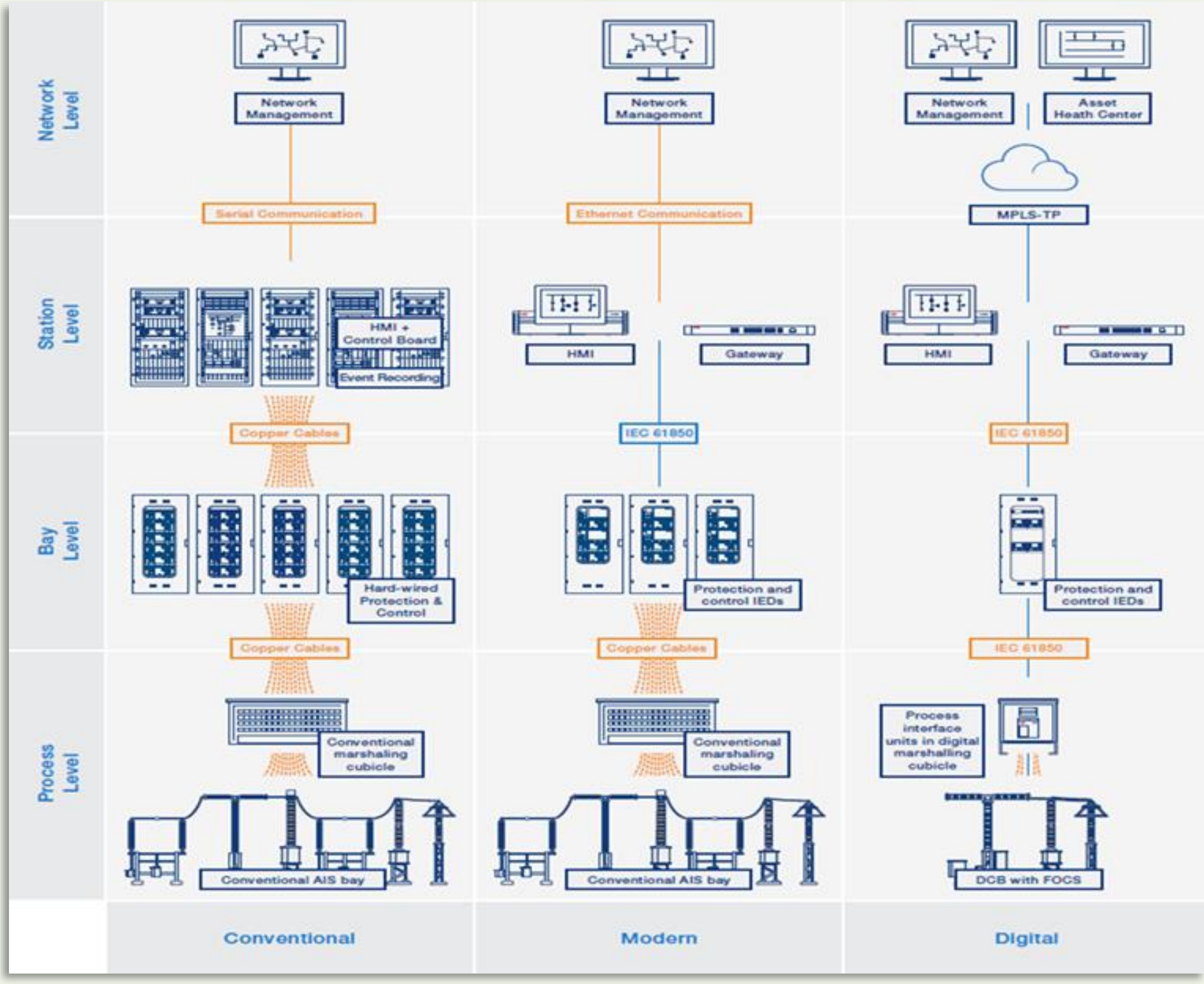


Figure 38 Transition of substations from conventional to fully digital

our network. More information regarding this can be found in our C1 network modernisation and C2 system security and stability clusters. These included condition monitoring systems and digital recording devices to monitor system behaviours. This is just the beginning, as in RIIO-T2 we plan to improve the condition assessment on our network and we will be rolling out even more sensor technology for monitoring asset and network behaviour in real-time.

R1T13.2 Our award winning project FITNESS "Future Intelligent Transmission Network Substation" led the way for roll-out of multi-vendor digital substation solutions on the GB network. It demonstrates a reduced outage and low risk approach to future substation monitoring, protection, automation and control by enabling faster deployment, greater availability, improved safety and greater controllability with a reduced footprint and lower cost than conventional design.

The evolution of substations from conventional to fully digital can be seen in the figure above. The current stage of application in GB system is that of a modern substation. The digital substation solution enabled by FITNESS replaces 80% of copper in substations with fibre based communication bringing digitalisation as close to the primary AC network as possible. It has also reduced the use of oil and gas in the substations and helped enable a method to reduce substation footprint by 30%.

It encompasses two circuits with protection, control and monitoring of the local substation as well as protection at the remote end. The non-conventional protection, instruments, control and monitoring systems are deployed at our Wishaw 275kV substation. FITNESS is a live demonstration of a multivendor, fully-digital substation solution with equipment from two major vendors and a SME. Through FITNESS we have proven interoperability at multiple levels and within a mixture of old and new technologies, and compared different communication architectures.

The goal of FITNESS is to enable GB Transmission Owners (TOs) and Distribution Network Owners (DNOs) to apply a digital substation design approach in future to facilitate reduced network costs and constraints, significantly benefitting GB consumers. Digital substations have the potential to deliver great financial and environmental benefits, and this is the technology being trialled through project FITNESS, which has been successfully commissioned in 2019. The key benefits after successful completion of project FITNESS, through future applications, are:

- 10% reduction of substation new-build and replacement costs
- 60% savings in operational costs of the secondary systems
- Increased network availability and reduction of constraint payments through reduced outage requirements
- Carbon savings through reduced use of materials in substations
- Greater operational flexibility leading to more efficient use of assets.

The operational flexibility of digital substations is achieved by allowing for 85% of secondary system commissioning tests to be completed offsite and landing a pre-fabricated, pre-tested system directly on site. Digital substations electrically isolate primary high voltage network from the secondary systems allowing for online replacement and maintenance of secondary systems without taking an actual outage on the network, and improving safety for staff.

Devices can be added more flexibly to the secondary systems on the fibre based network, enabling the concept of “plug and play” as compared to extensive wiring on a conventional system which requires outages on the network.

The success of project FITNESS has led to the launch of the digital substations initiative to build the necessary skills within our organisation, development of utility wide standards, specifications and requirements for successful roll-out of digital substations and, most importantly, to raise awareness regarding the benefits of digital substations. This, however, is a shift in paradigm and complete change in internal business practices of how we design, build, install and commission secondary systems in our substations. It is also based on the application of an international standard which requires a considerable amount of collaboration among network owners, suppliers and international research bodies for standardisation, validation and implementation. This initiative will enable seamless roll-out of digital substations on the network.

Figure 39 “Plug and Play” with digital as compared to days of wiring in conventional

In RIIO-T2 we will be rolling out our digital substations solution at all our new build and offline replacement projects such as Windyhill 275kV, Longannet 275kV, Westfield 275kV and Hunterston 132kV. This roll-out will enable us to create savings of £9m in RIIO-T2 – a complete payback for the innovation funding invested in project FITNESS.

10.1.2 Our RIIO-T2 Ambition

R2T13.1 In RIIO-T2 it is our ambition to use a combination of digital technologies to enable the future “digital twin” of our network. A digital twin is a virtual footprint of any physical system. The digital twin is the future means to monitor, predict, change and improve our network.

“The fourth wave in industry, known as Industry 4.0, is underway connecting the physical world to the digital. Digital twinning, the mapping of a physical asset to a digital platform, is one of the latest technologies to emerge from Industry 4.0. It uses data from sensors on the physical asset to analyse its efficiency, condition and real-time status. Up to 85 per cent of internet of things platforms will contain some form of this by 2020.” (Source: Orbis Research.)

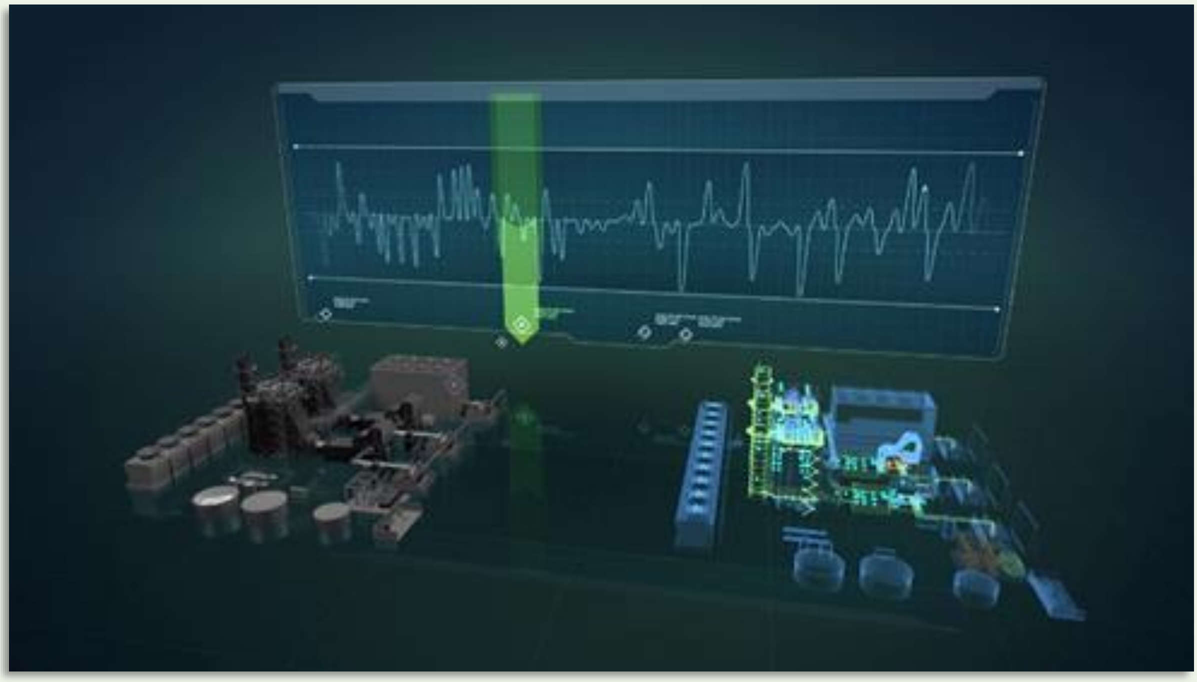


Figure 40 Digital Twin (Source GE)

Data collected by digital twins can predict failures before they happen and help our engineers intervene before the actual failure occurs. Many industries are beginning to adopt the digital twin approach for product design, including construction, and asset management of buildings and infrastructure.

The £15-billion Crossrail project, for example, has a digital twin model of the whole network. (Source: https://www.raconteur.net/business-innovation/digital-twinning-explained)

The Energy Systems Catapult Energy data task force report highlights the following five critical needs for digitalisation of power systems, four of them are directly addressed by the digital twin solution (ref Figure 41). The digital twin builds layers of information on the network that can enable the network owner and engineers to access various types of data in real-time without visiting the asset in question and enable different forms of direct reporting to regulator and other end users.

- *"Data Visibility: Understanding the data that exists, the data that is missing, which datasets are important, and making it easier to access and understand data.*
- *Infrastructure and Asset Visibility: Revealing system assets and infrastructure, where they are located and their capabilities, to inform system planning and management.*
- *Operational Optimisation: Enabling operational data to be layered across the assets to support system optimisation and facilitating multiple actors to participate at all levels across the system.*
- *Open Markets: Achieving much better price discovery, through unlocking new markets, informed by time, location and service value data.*
- *Agile Regulation: Enabling regulators to adopt a much more agile and risk reflective approach to regulation of the sector, by giving them access to more and better data."*

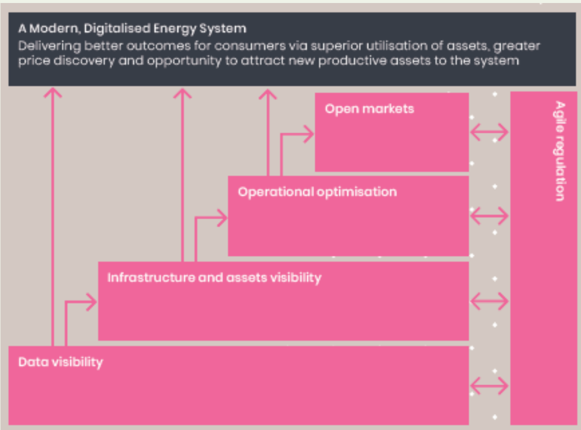


Figure 41 Energy data task force report "Modern Digitalised System"

The enabling of digital twins of our assets, which are a mixture of old and new, will take a few price control periods to complete. In RIIO-T2 we want to assess the risk, investment and benefits that can be generated from digital twinning. We will use the 3-D modelling enabled through BIM as described under theme T4, new materials, processes and technology, to build the foundation and define a roadmap to enable the "digital twin" of our network, enabling TOTEX benefits in future price control periods.

10.1.3 T13 RIIO-T2 Funding request

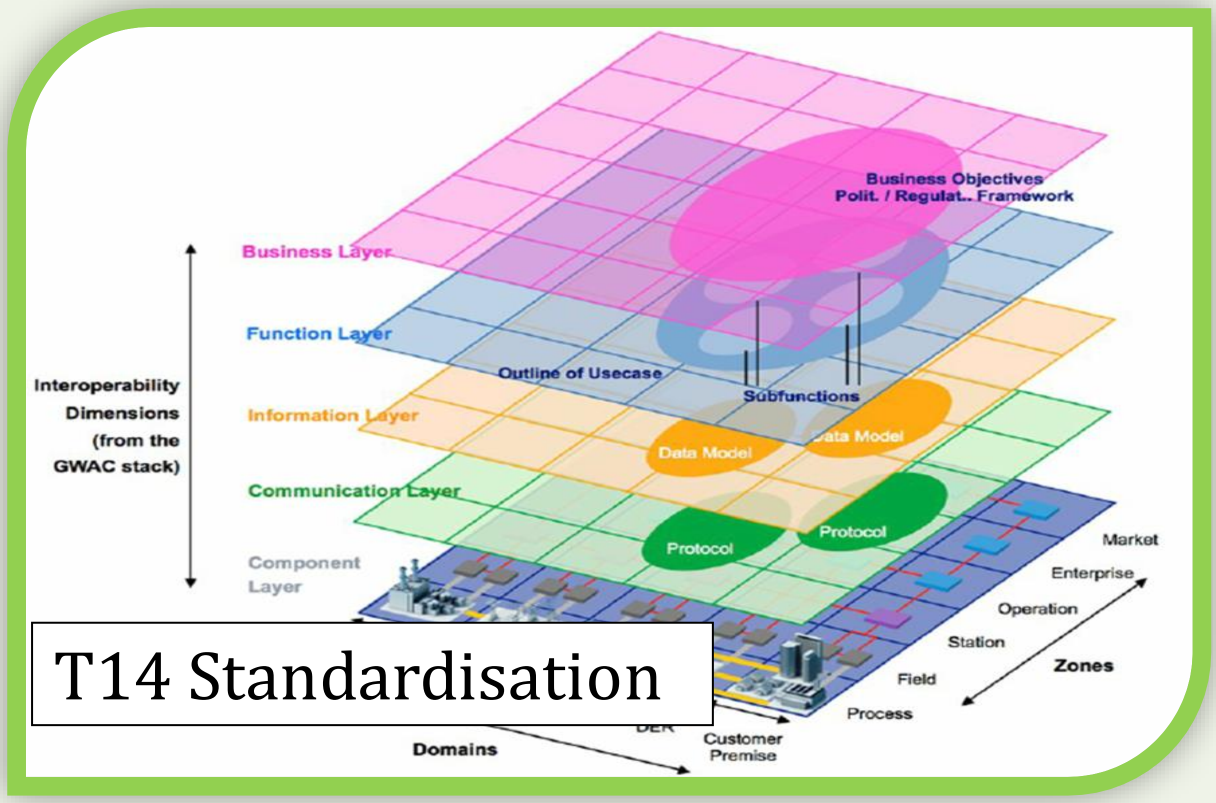
Description	Ref	Type	Value (£m)
Enabling Digital Twin	R2T13.1	NIA	1.5

Table 30 T13 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3)** **(undiscounted)**
Innovation Roll-Out	-	**-**
Network Innovation Allowance	£1.5m	**£201m**

Table 31 T13 Business Plan Funding Request Summary



10.2 T14 Standardisation

One of the key challenges in integration of digital technologies is the interface between different communication protocols and ensuring interoperability between new and legacy systems. Standardisation plays an important role in ensuring seamless roll-out of digital technologies on our network. We aim to utilise innovation to enable standardisation through:

- Adoption of international protocols, standards for communication, and data exchange in order to promote standardised information exchange solutions based on standardised protocols and to increase of integration with legacy data systems
- Updating GB's approval procedures to include more international standards for data exchange as part of equipment qualification

One of the key requirements for reduction of cost for internet of things and digital communications is enabling and adoption of international standards. This ensures that we have a larger supplier base for the digital solutions and drives down costs associated with the roll-out. Past experience shows that the fast changes in digital world can only be efficiently adopted if there are international standards established for data exchange.

10.2.1 RIIO-T1 Innovation & Roll-Out

R1T14.1 Project FITNESS demonstrated multi-vendor interoperability of following international standards:

- IEC 61850-5: 2013
- IEC 61850-8-1: 2011 Station level communication
- IEC 61850-9-2LE: 2011 Digital Measurements
- IEC/IEEE 61850-9-3 Time synchronisation
- IEC 62439-3: Industrial communication networks – High availability automation networks
- IEC 61869-9: Instrument transformers

The use of IEC 61850 and other international standards in project FITNESS ensures that future solutions will be compatible to the methods and processes developed through project FITNESS.

Similarly, we have enabled roll-out of various standards for communication between devices and transfer of data such as C37.118 and IEC 60870.

10.2.2 Our RIIO-T2 Ambition

R2T14.1 The growing complexity of the digital technologies and data exchange means fast evolution of international standards and protocols for communication.

The standardisation of the physical equipment, layouts and designs has led to significant TOTEX savings in the past, the standardisation of the digital layer of technologies can create even further savings and ensure fast adoption of digital technologies in future.

Energy Systems Catapult's Energy Data Task Force Report recommends

"Structures, Interfaces and Standards: A proportionate approach to standards

Data structure and interface standards should be adopted or developed where appropriate to enable data across organisations to be aggregated and utilised more easily."

The application of standardisation in power systems enabling digitalisation can be of different types. As shown in the smart grid architecture model (SGAM) in the cover picture for this theme standardisation starts at the ground level where application of standards enabling enterprise bus can help data to be accessed and distributed in a similar way. It can then extend up to industry, regulatory and government standards for energy system operation and management and data exchange among various entities.

Independent of the layer of application of standardisation it is an important aspect as identified in the "A strategy for modern digitalised energy system" for fast digitalisation of power system. Without standardisation data will always exist in silos with little or no communication and creation of information that will be crucial to efficient operation and management of power systems of the future. In light of changing energy systems and rise of smart grid applications an industry wide effort is required with collaboration across individual network owners, regulator and potentially government to identify, create and enforce right standards in the industry.

The theme standardisation of digital solutions in RIIO-T2 will critically assess requirements and gaps in standardisation across power systems and provide a roadmap to enable more standardisation in future.

R2T14.2 In RIIO-T1 we used innovation to adopt standards developed by international and national standard bodies. There is a growing need for utilities to actively participate in development of standards to applied in power systems.

In the past utilities have played more the role of adopter of the standard once it has been well developed by the market. This approach has some serious drawbacks as we do not adequately influence standards with our requirements, and we are often forced to adopt solutions developed for a different business case and application. Our engineers need training and need to adopt standards that are pre-defined by the industry.

In RIIO-T2 we plan to play a more active role in definition of international standards for digitalisation and standardisation through participation in standards working groups and user groups and actively voicing our requirements to the international standards committees.

We also need to update our GB approval bases such as Energy Networks Association (ENA) approvals procedure to adopt fast track testing and qualification of devices and solutions based on international standards leveraging on the learnings from the wider industry.

It is important that we as utilities participate in development of these standards, which are largely driven by vendors and their product roadmaps at the moment.

We need to actively relay our specifications, requirements and challenges in implementation of the standard to help in the evolution of international standards to better cater for the GB energy sector.

This activity will require engineers from our business actively participating and being involved in lead roles in standards bodies. This will be a significant amount of effort more than that involved in adoption and approval of devices and thus warrants use of innovation funding for advancement of digitalisation of power networks through the process of standardisation.

10.2.3 T14 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)
Standardisation of Digital Solutions	R2T14.1	IR	0.5
Collaboration and Research with national	R2T14.2	NIA	0.8

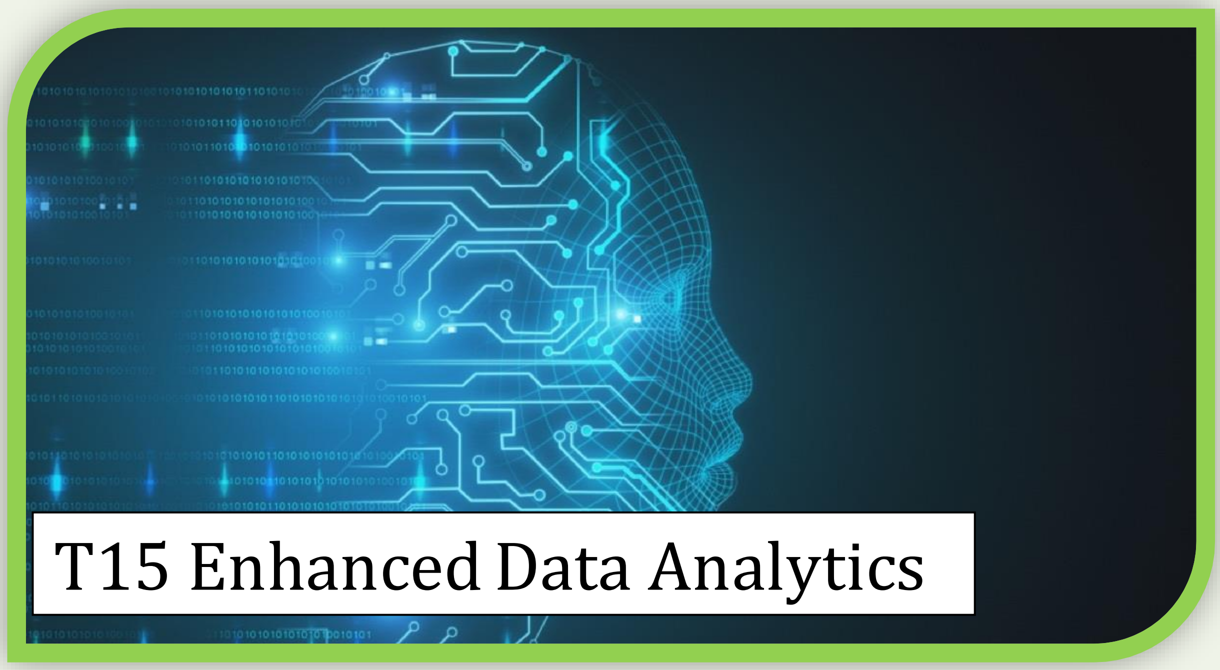
and international standard bodies			

Table 32 T14 RIIO-T2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3)** **(undiscounted)**
Innovation Roll-Out	£0.5m	Accelerated adoption of Digital technologies **£10.8m**
Network Innovation Allowance	0.8m	Accelerated adoption of Digital technologies

Table 33 T14 Business Plan Funding Request Summary



T15 Enhanced Data Analytics

10.3 T15 Enhanced Data Analytics

Data analytics is key to extracting meaningful information from volumes of data. It is the answer to the big data question. In power networks we do not have the issue of vast volumes of data as in the case of information technology industries. However, we do have the challenge of volumes of different types of data that are generated from complex operation of electrical power network.

Enhanced data analytics is required to enable pattern recognition and historical trending of different data types collected from our system. This can aid in various applications such as condition monitoring, predictive maintenance, system behaviour analysis, fault analysis, prevention of unplanned outages and restoration of the system.

As with digitalisation and standardisation, enhanced data analytics is required to ensure the engineers receive accurate alerts and alarms before the incident and can act in time to prevent failure of assets and/or of the system. In some cases, there might be no time for human intervention; machine learning and advanced analytics will be needed to take automatic preventive actions to ensure our systems can respond in milliseconds to avoid large scale events and faults to ensure system security and stability.

10.3.1 *RIIO-T1 Innovation & Roll-Out*

R1T15.1 In RIIO-T1 we used innovation incentives to enable system and asset data analytics through our wide area monitoring system and various condition monitoring systems described in detail under clusters C1, C2 and C3.

These systems have already created benefits by creating information regarding system dynamics and aiding us with corrective actions. Our condition monitoring systems provide us with a better assessment of the health of the assets than visual inspection and measurement instruments.

Our DINO project discussed under cluster C3 dealt with the challenge of creation of meaningful information from volumes of data collected from the distribution network.

These are some of the examples of the various data analytics platforms used by our engineers on a daily basis. In RIIO-T2 we aim to combine some of these platforms into one system health map as described in cluster C1 network modernisation.

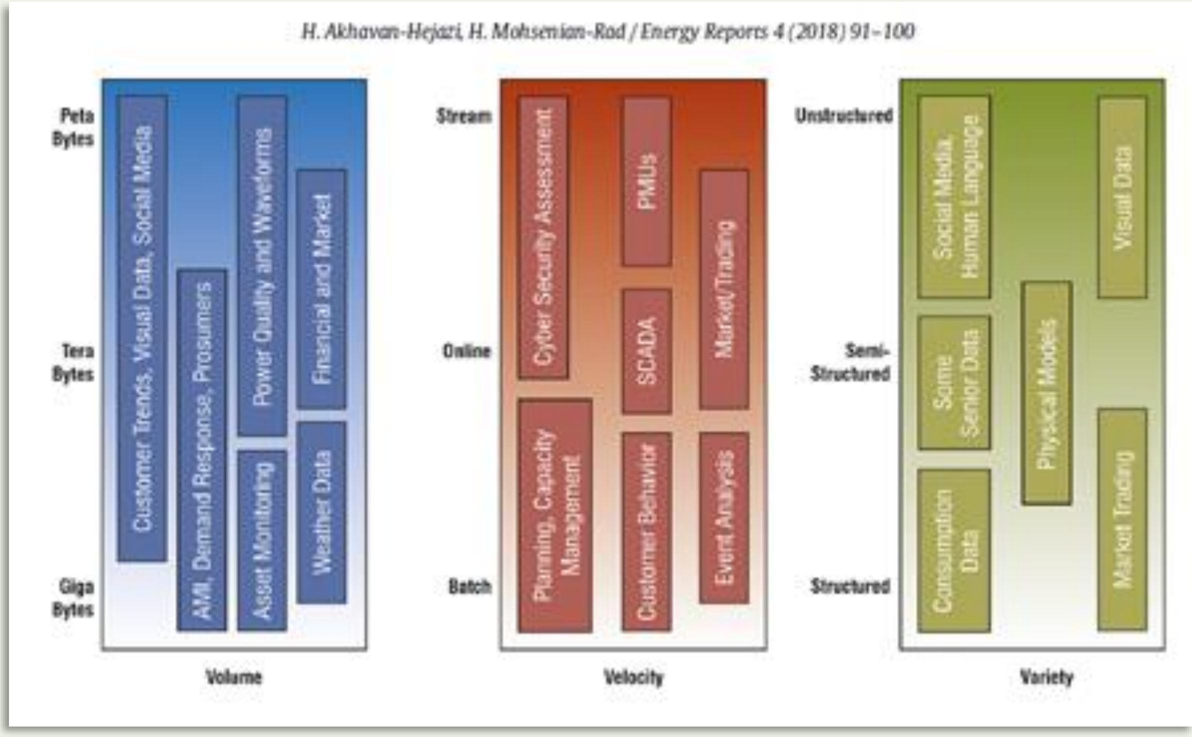


Figure 42 Big Data Attributes of the power system

10.3.2 Our RIIO-T2 Ambition

R2T15.1 The big data generated from a power system has three different attributes according to a paper published in Energy Reports by University of California. These attributes are volume, velocity and variety. The volume and variety of data is dependent on the type of measurement system. The velocity of update depends on the criticality of the information created from the data whether it is real-time within seconds, dynamic within milliseconds or data for historical trending and planning varying between hours to days.

The data generated from various systems need to be identified as mission critical, real-time or for historical analysis. Based on that the accurate type and speed of data analytics can be applied to each of them.

Many of our applications in power systems are with respect to automated operation/ control, requiring real-time data collection and real-time actions. These are with respect to automated operation control, requiring real-time data collection and real-time actions. This requirement is drastically different from many big data applications in the IT sector, since we own and operate critical infrastructure. The reliability, availability and quality of data plays an important role.

We plan to use innovation to enable enhanced data analytics across our network for the following two types of applications:

- System critical and day ahead planning applications
  - Predicting system state using state estimation and dynamic modelling to increase operational planning convergence
  - Use of machine learning and trending for fault finding and system integrity actions
  - Use of enhanced distributed state estimation for wide area monitoring, protection, automation and control applications enabling a self-healing grid
  - Use of aggregated model data from distributed resources for advanced demand-response
- Off-line applications
  - Use of artificial intelligence and machine learning for advanced condition assessment of assets based on pattern recognition using pictures, historical data and fault types

- Use of system data for offline studies and systems planning applications using dynamic models
- Prediction of system and asset faults for timely intervention using statistical trending and probabilistic methods

In order to enable enhanced data analytics, we need a secure and reliable communication network which ensures data and information quality is maintained for operators and other intelligent devices to reliably make decisions and perform control actions. The enhanced data analytics enabled through various innovation incentives will create benefits of up to £5-10m/year in operational benefits.

10.3.3 T15 RIIO-T2 Funding request

Description	Ref	Type	Value (£m)
Enhanced Data Analytics and Data Flow	R2T15.1	NIA	0.8

Table 34 T15 RIIO-2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)**
Innovation Roll-Out		-
Network Innovation Allowance	£0.8m	-

Table 35 T15 Business Plan Funding Request Summary

10.4 T16 Cyber Security

The increased reliance on digitalisation and various intelligent devices connected over a wide area network make cyber security a critical factor to be assessed, practiced and deployed to protect our assets, data and information from external cyber threats. Cyber security has increasingly become important over the decade and it is important the solutions and policies deployed to ensure cyber security meet the necessary standards and regulation. There is also a requirement for continuous improvement to take into account any new requirements and solutions available in the market to ensure we have adequate levels of cyber security in place on our network.

The Network Information System Directive (EU) was transposed into UK law as the NIS Regulations and these came into force May 2018 to enforce cyber security. This covers Operators of Essential Services (OES), and for SP Energy Networks these Regulations are enforced by Ofgem as the Competent Authority. The introduction of these regulations requires the completion of a Cyber Assessment Framework (CAF) which baselined the cyber security management of critical systems. This audit was completed internally within SP Energy Networks, and is then baselined and audited by Ofgem.

The assessment that was used by SPEN was baselined against an external audit undertaken by Indra. Indra used the NIST framework to complete this audit. While the NIST framework is different to those used in the NIS Regulations, it does however allow grouping to take place to compare the audit results. In addition, the audit undertaken by Indra was wider than required under the NIS Regulations.

Following the audits and our internal assessment of our network, the following plan has been proposed to enforce cyber security measures on our network. One of the key applications in this roadmap is deployment of Security Information and Event Management (SIEM) which is defined as a complex set of technologies brought together to provide a holistic view into a technical infrastructure. SIEM deployment will allow us to enable event and log collection and centralised security event management to alert in case of unusual activity is found in our communication network infrastructure.

One of the key applications in this roadmap is deployment of Security Information and Event Management (SIEM) which is defined as a complex set of technologies brought together to provide a holistic view into a technical infrastructure. SIEM deployment will allow us to enable event and log collection and centralised security event management to alert if unusual activity is found in our communication network infrastructure.

Further to high level development of cyber security polices and strategy, we require engineering solutions to enforce the policies that will secure our substations and real-time system, i.e. our critical infrastructure against external attacks. We will use innovation to develop and trial cyber security solutions including an application of solutions commercially available and our internal procedures and practices.

10.4.1 Our RIIO-T2 Ambition

R2T16.1 Wide area cyber security is a major challenge in power systems. Most cyber-attacks in the past are wide area based.

The malware used in the 2016 Ukraine attack "crashoverride" specifically looked for switchgear controls over the IEC 61850 definitions and IEC 60870-101/104 double bit commands – both standards extensively used in digital substations. The following diagram highlights some of the substation attack vectors that we need to focus our cyber security solution on.

As we plan to deploy more system integrity and restorative action schemes especially those described under Theme 7 Reliability and Resilience based on open standards such as IEC61850 and IP based standards such as IEC-104 wide area cyber security will be most important in securing these schemes that upon attack can affect larger areas of the power system.

There are many developments in this regard that allow cyber security on physical link, data and application level, however these can cost the network owner in terms of providing for the right bandwidth and purchase of key management systems. This is unavoidable and necessary, and will be covered through business as usual costs for cyber security. The R&D required in wide area cyber security which warrants NIA funding is related to identification of technological solutions and methods and development of future process keeping in line with market and wider developments in wide area security. This will enable network owners to procure and select equipment in future that provide level of security in the future.

As network owners and sectors will be even more interconnected and there will be various degrees of data exchange enabling digitalisation of powers sector investment in innovation related to wide are cyber security for data exchange, sending of remote control commands and automate schemes will be prudent and of extreme importance in RIIO-T2.

R2T16.2 The roll-out of digital substations based on standards enabling Ethernet based communication will require special focus on cyber security. The following two communication and access channels will require special focus from a cyber-security perspective:

- The communication between a digital substation and the central control centre
- Access to the intelligent electronic devices (IEDs) from external computers for commissioning, operation and maintenance

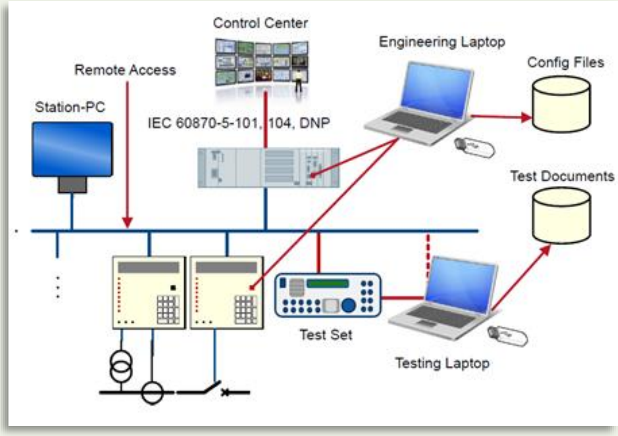


Figure 43 Cyber security attack vectors in a substation

Our ambition for RIIO-T2 is to deploy engineering solutions to enable the following countermeasures at substations:

- Two-factor authentication for remote access
- Establish secure process for file transfer to station computer
- Deploy intrusion detection at substation to manage computers connecting to the substation
- Limit protocols and access to the substation through the gateway externally
- Consider built-in, hardened computers with firewalled interfaces
- Provide secure solution for setting up access
- Disallow direct connection to IEDs
- Alarm on unauthorized computer access, unauthorized activity to control centre

- Deploy application whitelisting

The aforementioned are some of the many countermeasures that will be needed to secure our substations and control centre from external attacks. As digitalisation and connection over Ethernet will be inevitable for increasing operational flexibility and enabling other benefits we will need a continuous improvement process through business as usual cyber security policies and innovative engineering solutions to deploy the right levels of cyber security in our substations. The most important step in this direction will be deployment of a risk model to assess cyber security risk associated with each application of digital technology. As the cost of cyber security solutions can often be of a wide rage, this risk model will allow for close assessment of the cyber risks and application of security solutions best fitted to address these risks within the allowed perimeters of risk vs costs.

Why is it innovation? We need to stay ahead of what is already out there in terms of malware and attack vectors. As the business as usual cyber security strategy will focus on counteracting the risks already perceived and known to us, innovation will assist us in identifying future requirements for cyber measures. Innovation will also be needed to maintain engineering efficiency while deploying cyber security solutions.

10.4.2 T16 RIIO-T2 Funding request

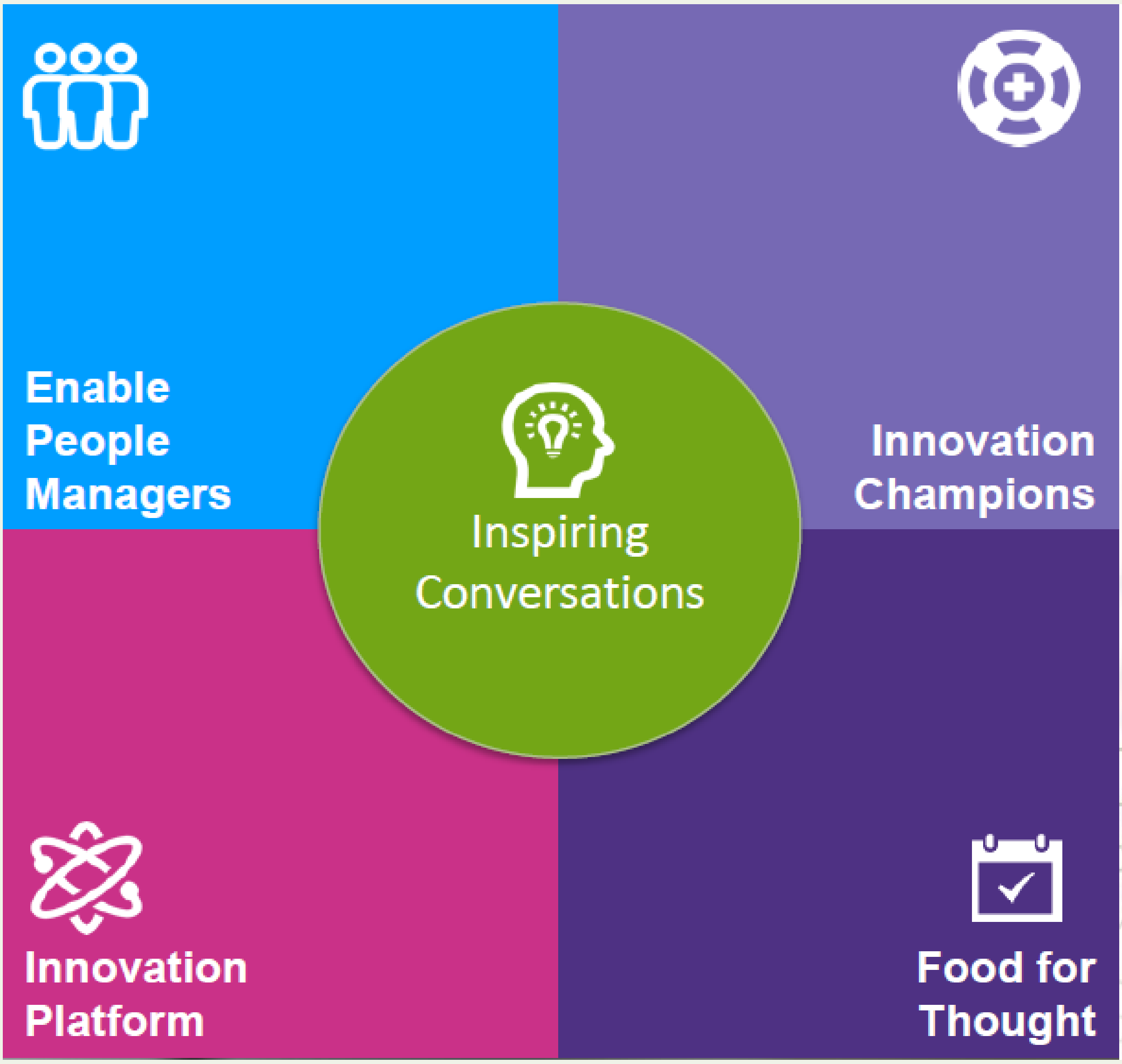
Description	**Ref**	**Type**	**Value (£m)**
Investigations into methods for wide-area cyber security	R2T16.1	IR	0.5
Investigation into future cyber security threats and risk model development	R2T16.2	NIA	0.9

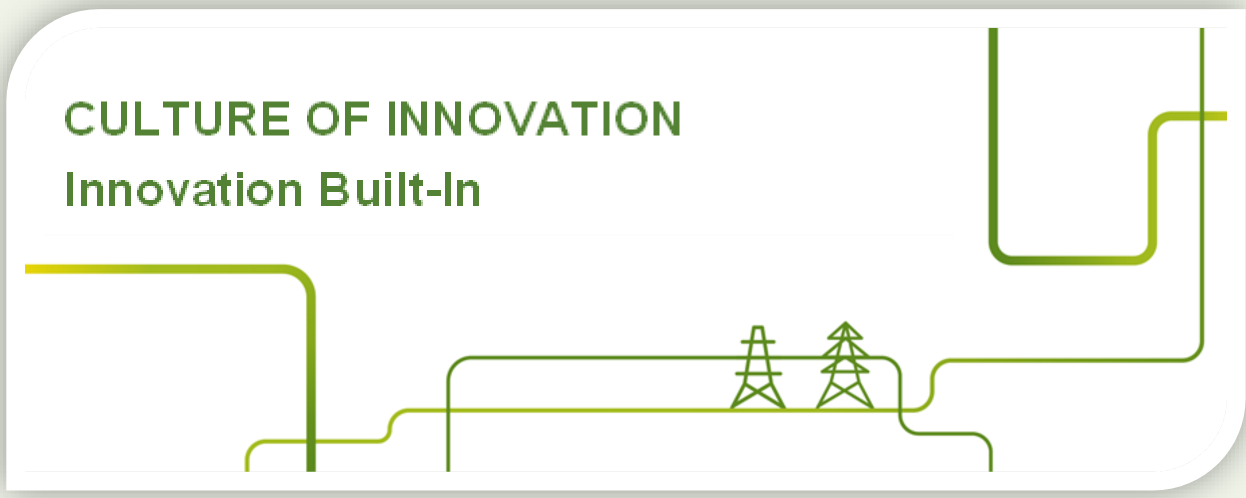
Table 36 T16 RIIO-2 Innovation Funding Breakdown

Business Plan Funding Request

Funding Type	**Value**	**Estimated TO and ESO Benefits (RIIO-T2 and T3) (undiscounted)**
Innovation Roll-Out	£0.5m	-
Network Innovation Allowance	£0.9m	-

Table 37 T16 Business Plan Funding Request Summary


Enable People Managers
Innovation Champions
Inspiring Conversations
Innovation Platform
Food for Thought



11 Culture of Innovation

Innovation, in essence, is the result of innovators thinking differently and coming up with new and alternative solutions to reduce cost, improve efficiency, drive down carbon footprint and improve sustainability. The innovation incentive in RIIO-1 has been successful in building a culture of innovation and driving changes through network owners' and operators' businesses. The nature of any regulated business with a highest priority to maintain security of supply is "risk averse". Innovative projects and pilot trials stimulate "out of the box" thinking and open up the prospects of tackling day to day challenges with new techniques and methods. Innovation is not just about applying these techniques and methods but the perception and willingness to change and do our day job differently, in order to drive efficiencies and meet the emerging challenges on our network.

11.1 Our People

Our internal innovation process stresses the development of our internal skillset. Traditionally innovation has been mostly led by technology providers, vendors and 3rd parties. This has worked in the past years as the changes in the network and technological advancements prior to RIIO-1 were relatively slow. However, the past decade has seen a steep change in technology, with digital technologies requiring our people to develop more soft skills and make more use of data analytics to better assess condition of our assets and visualise grid dynamics. This change in skillset needs to be facilitated as a part of our innovation initiative and model.

The value of innovation can only be created if the people affected by it know how to best use the innovation to their benefit. In the next page we can read views from different parts of SPEN and the effect of innovation on their day to day activities and the changes they would like to see in the innovation process moving forward. In order to promote innovation through the business, SPEN declared 2019 as "**The Year of Innovation**" to kick-off a 3-year programme which will promote innovation through various initiatives throughout the business. RIIO-T2 innovation will focus on further growth in this culture and the combined coherent approach that innovation is not just the responsibility of an individual or a team but of the business as a whole. The term coined for this is "institutionalised innovation" as it refers to a business delivering any innovative project and subsequent roll-out as within the business as a whole. As innovation can be seen as disruptive this approach is extremely important to ensure there is:

- Business pull for new technologies and processes
- A coordinated approach and business ownership for successful roll-out of innovation beyond pilot trials
- Continuous improvement and feedback loops to identify gaps in technology and

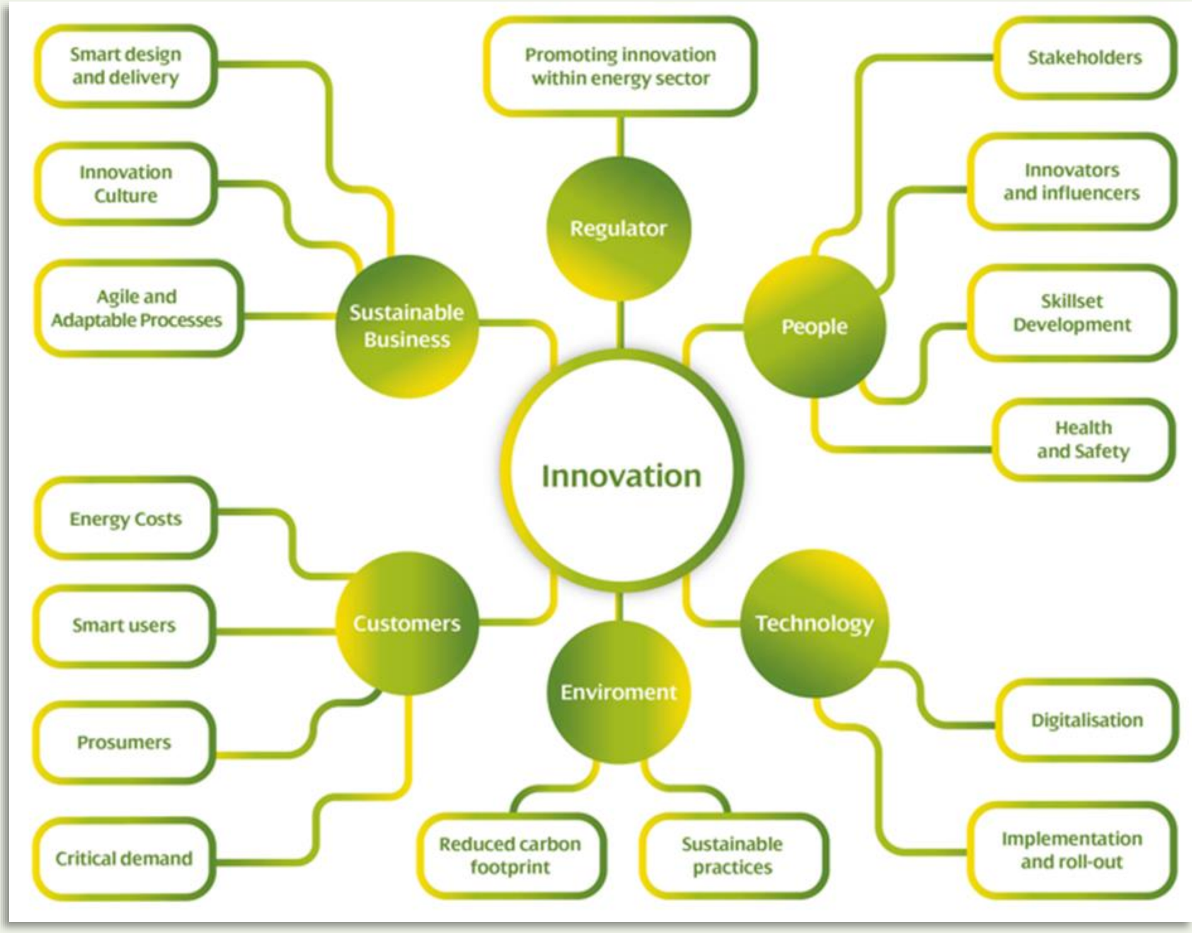


Figure 44 Culture of Innovation

resource skillset and build the required mitigation steps into project delivery

11.2 Our Stakeholders

No single network owner (NO) will be able to conquer the many challenges facing the electricity industry. In order to succeed, NOs must work together and collaborate with universities, research institutes, DSOs, generation companies, consumers and industrial manufacturers. Through close cooperation and cost-sharing, GB NOs can achieve their innovation goals and maximise results, Knowledge can be quickly disseminated and shared among stakeholders and interested parties.

Full-scale demonstrations of innovation projects must be coordinated across the industry. This drastically reduces demonstration costs and stimulates further innovation.

We will have the following approach:

- A driving role regarding interactions with other players and actors (universities, research institutes, DSOs, storage, equipment manufacturers) from the early stage to ensure that the system perspective, integration aspects, and interfaces are effectively considered
- Ensuring appropriate input to standardisation organisations aiming at adequate and interoperable standards.
- Efficiently accessing international organisations such as IEA, IEEE, JRC or CIGRÉ for mutual learning from innovation results.

Innovation stimulus helps in the growth of supply chain where outcomes from innovative projects provide market and economic drivers to suppliers and solution providers. Suppliers and solution providers have engaged with network licensees through innovation stimulus to create solutions for emerging challenges in the GB network which at the same time has provided them direction to develop their future products and solutions. The innovation stimulus has also encouraged vendors to engage with utilities to deliver solutions specific to requirements of GB network owners and operators and motivated the market to create more value for money.

The innovation stimulus has a wider socio-economic benefit of promoting SMEs and academic institutions to create innovative solutions through a focus on research areas identified by network licensees. This promotes wider social benefits for education and the small scale business sector. Innovation stimulus plays an important role in ensuring the widest range of the 3rd party involvement in innovation which is directed at the challenges faced by network companies.

The RIIO-1 innovation mechanism has placed NOs and GB SO at the forefront of global innovation. It has provided a platform for increased collaboration among GB licensees and international utilities. Evidence suggests that the GB's pilot projects have received attention and interest from international utilities who have in return shared their innovative solutions with GB licensees. This platform is unique in its nature; it has provided insight into new challenges in the power sector worldwide but also highlighted the need for knowledge sharing to create a global approach to address some of the key challenge areas. For example, there are similarities in challenges faced by transmission network in GB, Ireland, Texas (US) and Australia. Through innovation project work streams there has been the opportunity to enable mechanisms to share findings with utilities in these countries and through wider engagement directly relate to their innovation experiences.

In RIIO-T2 we will maintain the level of collaboration and engagement with our stakeholders and will further expand our stakeholder base to interact with other industries to promote more cross-sector collaboration to understand and build upon learnings from other energy and industry sectors. An example of such collaboration can be interaction has been initiated in RIIO-1 with multi-vector projects which target energy challenges with the "whole system approach". A perfect opportunity for such collaboration can also be created in the telecommunication sector with development of high speed reliable communication network, which is the key to the future digitalisation of the power system sector.

11.3 Our Consumers

Consumers are the heart of every innovation incentive we undertake. The innovation stimulus is designed and aimed at delivering benefits to GB consumers. In RIIO-T1 we engaged in many customer facing activities to share our initiatives with our customer base through stakeholder engagement programs and knowledge dissemination activities.

In RIIO-T2 we want to break the barriers through innovation between a transmission licensee and the consumers by driving themes of innovation that are directly focussed on them. This will help to change the perception that innovation in transmission does not have a direct impact on our prosumers. We aim to have projects which will collect prosumer feedback regarding sustainability, connecting to our assets and participating in providing distributed energy resource services. It is our priority to improve public awareness of long-term energy challenges and the need to build and protect transmission infrastructure to increase the social benefit of electrification of demand.

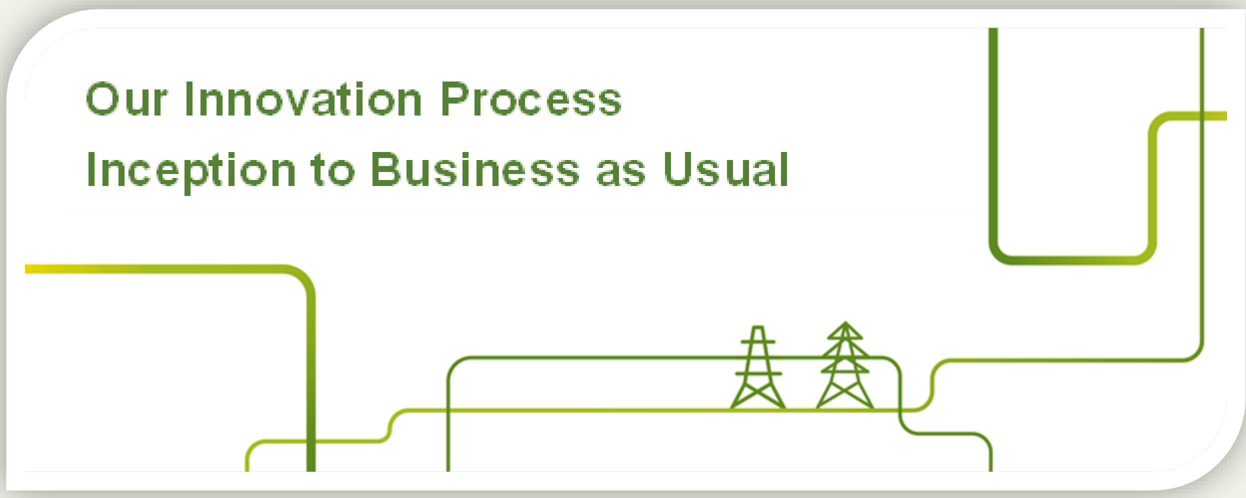
11.4 Our Regulator

We take on-board the reforms suggested by Ofgem for RIIO-2 innovation. These will make the most out of the RIIO-2 innovation funding mechanism, and maximise benefits through innovation roll-out.

In RIIO-T2 we will improve innovation deliverability, visibility of innovation outcomes and tracking of benefits to create more value through innovation.

We will be implementing the following reforms within our business to enhance our innovation ability in RIIO-T2:

We have demonstrated benefits generated through innovation in RIIO-1 through the rollout of successful innovation projects in our business plan, and we will continue to improve on this success in RIIO-2. We are committed to working with the regulator, other network owners and wider stakeholders to use the lessons learnt through the innovation process in RIIO-1.



11.5 Our Innovation Process

"The year to-year viability of a company depends on its ability to innovate. Given today's market expectations, global competitive pressures, and the extent and pace of structural change, this is truer than ever." Havard Business Review, 2012

SP Energy Networks has a well-established innovation process across both its transmission and distribution licenses. Our innovation process has matured over the last decade through the low carbon network incentive and RIIO NIC, NIA and IRM mechanisms. As innovation becomes ever more critical to the sustainability of the business and transmission and distribution sector we have greatly improved upon this process based on feedback from our stakeholders, 3rd parties, regulator Ofgem and experience of our employees developing and delivering innovation projects.

Innovation projects within SP Energy Networks go through 6 key phases, with intermediate gate reviews as shown in Figure 45:

- Inception Phase
- Creation Phase
- Delivery Phase
- Bridging Phase
- Transition Phase
- Business as Usual

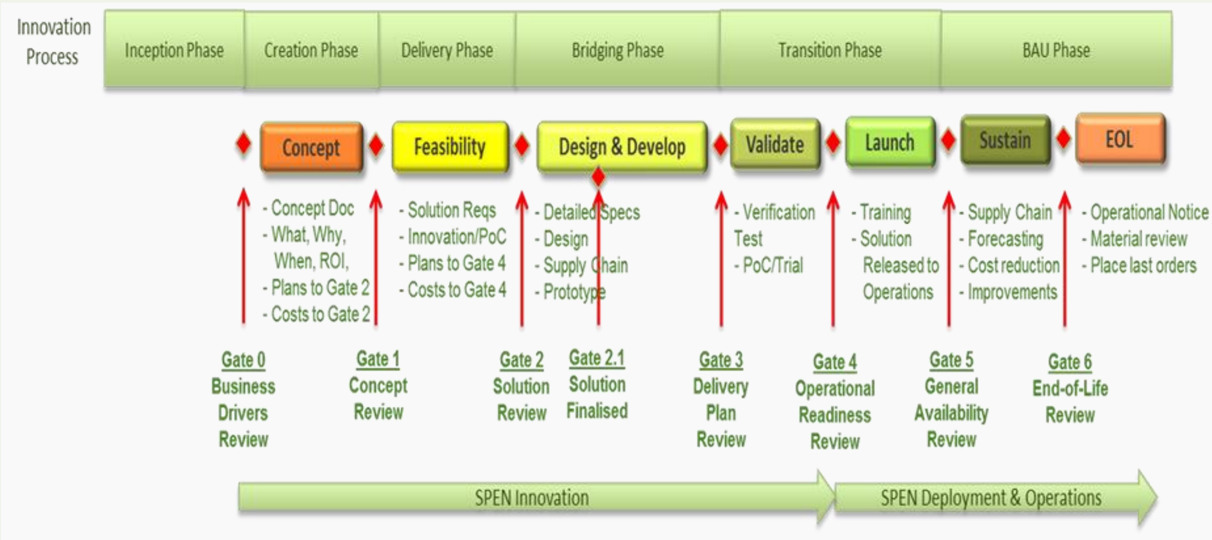


Figure 45 Innovation Process Map

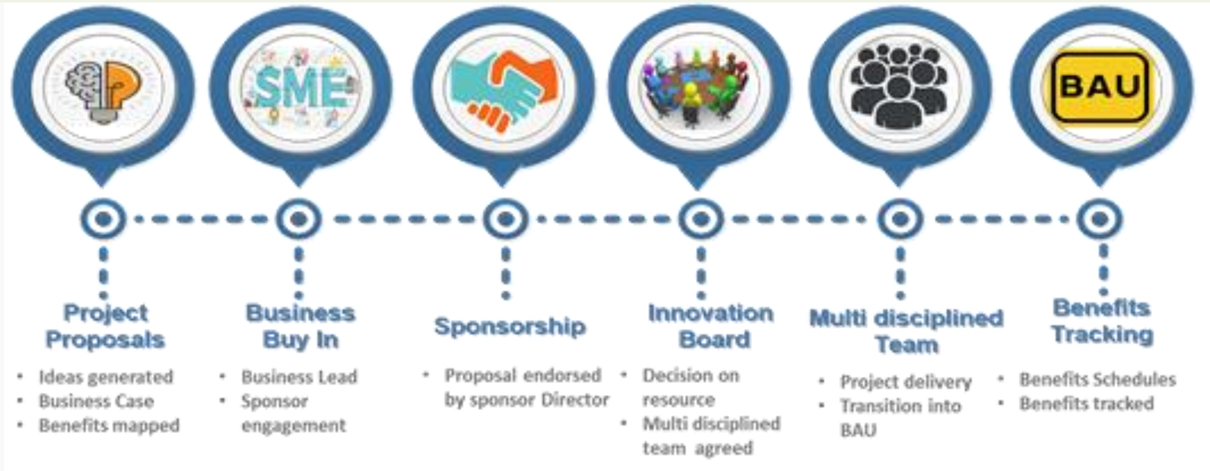


Figure 46 Innovation Project delivery key elements

A brief description of each of the phases and the steps taken by the innovation delivery and governance team to ensure the innovation investment is a right balance between risk and benefits is provided in this section. We have greatly improved upon the process in line with Ofgem's expectations for RIIO-2 with the aim of:

- Enabling more innovation through business as usual by transparent selection of projects based on value added through innovation process.
- Focussing our innovation efforts on transformative innovation projects with longer term impact: Aligned with Ofgem' s definition of energy system transition challenges and wider public sector innovation priorities.
- Development of industry-wide approaches for increasing general visibility of impact created through application and implementation of innovative projects through increased public reporting, development of collaborative innovation strategies and tracking of innovation benefits.
- Continuous reviews and improvement of the innovation portfolio and projects to ensure we balance and optimise our innovation efforts evenly across challenges and levels of risk.
- Gap analysis of innovation incentives and projects, to make sure projects are aligned to their original objectives and are on-track to deliver benefits.
- Increased collaboration across different sectors of the energy system to share and adopt learnings that drive transition.
- Increased third-party engagement through a transparent assessment process of third-party proposals and feedback procedures.
- Empower our consumers through increased engagement with community energy incentives, non-profit organisations and using innovation to address the needs of those in vulnerable situations.

The 6 key elements essential in our innovation process to achieve the aforementioned objectives are shown in Figure 46.

11.5.1 Project Inception

In section 11.9 we describe in detail how we engage with different stakeholders and 3rd parties to collect ideas and solutions for different energy system transition challenges. This engagement is a crucial step for us to ensure we test the market and a broad range potential project partners to identify the right innovative solution for the given set of challenges.

Independent of whether an innovation project proposal originates through engagement with external suppliers and 3rd parties or is a solution developed internally through our own business process, it goes through a detailed approvals procedure before TOTEX and/or innovation funding is spent to create and deliver the project..

Category	Score Criteria			
	0	4	7	10
Alignment to Strategy & Importance The degree of: -Alignment with the innovation strategy -Importance of the project to the company	-Lack of alignment with innovation strategy -Project does not seem to be important	-Somewhat aligned to innovation strategy -Project appears to be somewhat important	-Supports innovation strategy -Project seems to be important	-Considerable alignment to innovation strategy -Project looks very important
End User & Strategic Benefits The degree to which the project: -Offers greater benefits to the end user -Offers discrete benefits from other projects -Offers strategic benefits to the company	-Provides no new benefits to the end user -Provides no discrete benefits from other projects -Offers little or no strategic benefits	-Provides modestly differentiated benefits to the end user -Provides modestly differentiated benefits from other projects -Offers modest strategic benefits	-Provides reasonably differentiated benefits to the end user -Provides reasonably differentiated benefits from other projects -Offers reasonable strategic benefits	-Provides highly differentiated benefits to the end user -Provides highly differentiated benefits from other projects -Offers significant strategic benefits
Scalability -Scale of potential roll out -Ease of roll out -Likelihood of completed project leading to further projects	-Offers little or no scope to roll out across the business -Requires very complex roll out -Offers little or no scope to lead to further projects	-Can be rolled out to limited parts of the business -Requires fairly complex roll out -Offers modest scope to lead to further projects	-Can be rolled out reasonably widely across the business -Requires reasonably straightforward roll out -Offers reasonable scope to lead to further projects	-Can be widely rolled out across the business -Requires straightforward roll out -Offers significant scope to lead to further projects
Synergies & Core Competencies -Ability to leverage synergies with existing systems and working practices -Availability of required resources (skills, capability & experience)	-Limited or no ability to leverage synergies with existing systems and working practices -Required resources are not available and cannot be acquired	-Modest opportunity to leverage synergies with existing systems and working practices -Required resources are not available but some can be acquired	-Good opportunity to leverage synergies with existing systems and working practices -Required resources are available but all are not fully accessible	-Strong opportunity to leverage synergies with existing systems and working practices -Required resources are available and accessible
Technical Feasibility -Degree of technical complexity -Size of technical gap	-Highly complex technical solution -Very large technical gap	-Fairly complex technical solution -Large technical gap	-Somewhat complex technical solution -Modest technical gap	-Straightforward technical solution -Modest technical gap
Cost Benefit Analysis for integration to BaU -Degree of definition of cost benefit analysis -Positive cost benefit analysis	-No cost benefit analysis -Little / no benefits relative to cost of project implementation (negative CBA)	-Poorly defined cost benefit analysis -Modest benefits relative to cost of project implementation (neutral / modestly positive CBA)	-Reasonably defined cost benefit analysis -Reasonable benefits relative to cost of project implementation (positive CBA)	-Well defined cost benefit analysis -Significant benefits relative to cost of project implementation (very positive CBA)
Recommendation:			**Total Score:**	

Figure 47 Innovation project scoring criteria for project approval (Detailed description)

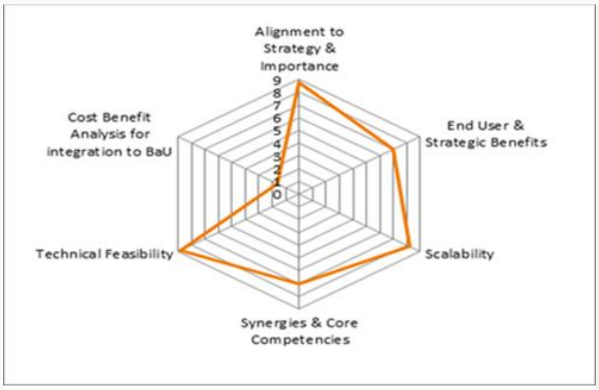


Figure 48 Innovation project scoring criteria for project approval

The six main criteria to check the eligibility of an innovation project for innovation expenditure are shown in Figure 48Figure 48 and explained in detail in Figure 47 are as follows:

- Alignment with business and industry innovation strategy and priority
- End user and strategic benefits
- Scalability
- Synergies and core competencies
- Technical Feasibility
- Cost Benefit Analysis projection for business as usual roll-out.

The project must score at least 4 or above in all criteria and above 7 in at least 3 categories including compulsory categories of 1, 2 and 5 (where applicable) in the initial analysis to be presented to the innovation governance board within the business for further interrogation and approval.

Avoiding Duplication

In RIIO-2 in project creation phase especially for projects funded through the innovation stimulus; the first priority is to ensure the is unique and avoids duplicating an activity already undertaken by fellow Licensed Network Operators. It can be achieved through a combination of direct contact with the Licensed Network Operators and through the investigation of projects using the Energy Networks Association (ENA) Smarter Networks Portal. Where we find that there is overlap with the proposal and existing or previous Licensed Network Operators projects we endeavour to extract the learning from those projects prior to making a decision to precede with a project or the Business as Usual adoption should the learning be sufficient to do so.

Section 11.6 and 11.7 detail the steps to be followed to ensure that we avoid any duplication in innovation themes and trials.

11.5.2 Project Creation

The project creation phase involves following 3 key elements of the innovation process

- Business buy-in
- Business Sponsorship
- Innovation Board Approval

Business Buy-In

It is important for the ultimate success and roll-out of any innovation project that there is a business pull to integrate the learning from the projects upon successful completion. While some innovation projects due to the inherent risk of the intended benefits not being realised may not reach the roll-out stage, it is still important to have the intent and process in place for roll-out at the project creation phase.

In order to ensure business buy in a detailed internal review process is undertaken prior to presentation to the innovation board for approval. The project proposal is circulated among the business teams responsible for roll-out and/or or effected by the roll-out of the innovation project. All comments and feedback are collected through the innovation process. The innovation proposal is then updated and modified as required for presentation to the innovation board. If a proposal fails to meet the criteria of business buy in it needs to be re-evaluated by the project proposal team again to ensure it meets the right level of requirements.

Business Sponsorship

To ensure that projects created are fit for purpose we need to ensure that the expected Business as Usual sponsors/owners of the solution approve of the planned approach, partnership and its deliverables. There are two types of sponsor/owner, the Business Sponsor and the System Sponsor, often these are one and the same, however, the prospective needs from both stand points needs to be considered.

Business Sponsor – The internal stakeholder within our business who will benefit from the outcome of the project if it is successful and delivered into business as usual. Their needs tend to focus on the creation of policy, financial approval and the realisation of benefits.

System Sponsor - The internal stakeholder within our business who will likely be responsible for operating and maintaining the solution if it is successful and delivered into business as usual. Their needs tend to focus the more practical aspects such as standards and specifications for procurement and operating and maintaining the equipment.

Innovation Board Approval

Only once the essential requirements of the project and its ownership have been defined can the project plan be completed and approved. The internal approval process is via the project sponsors and by either our Innovation Board. This approval precedes the registration and signing of any legal documents associated with the project.

Innovation Board (IB): This group consists of several SP Energy Networks Directors and Senior Managers. The IB is responsible for the approval of large scale innovation projects and the projects with a long lead time to adoption. The IB is also responsible for facilitating projects transition into Business as Usual and tracking the overall performance of our portfolio of innovation projects. The IB is primarily responsible for

- Setting the innovation strategy and
- Ensuring alignment of innovation priorities with wider stakeholders and other sectors.
- Tracking delivery and expenditure in overall innovation portfolio
- Stag gated review of innovation projects and facilitating their transition into Business as Usual.
- Approving Project Partners and Collaborators, and engaging with other sectors.

Registration of Projects and start of project reporting

All approved innovation projects are registered through the Energy Networks Association (ENA) Smarter Networks Portal; this process provides visibility to the wider industry, stakeholders and consumers alike of our intentions. For fellow Licensed Network Operators this also gives them an opportunity to register any concerns or desire to collaborate on the project.

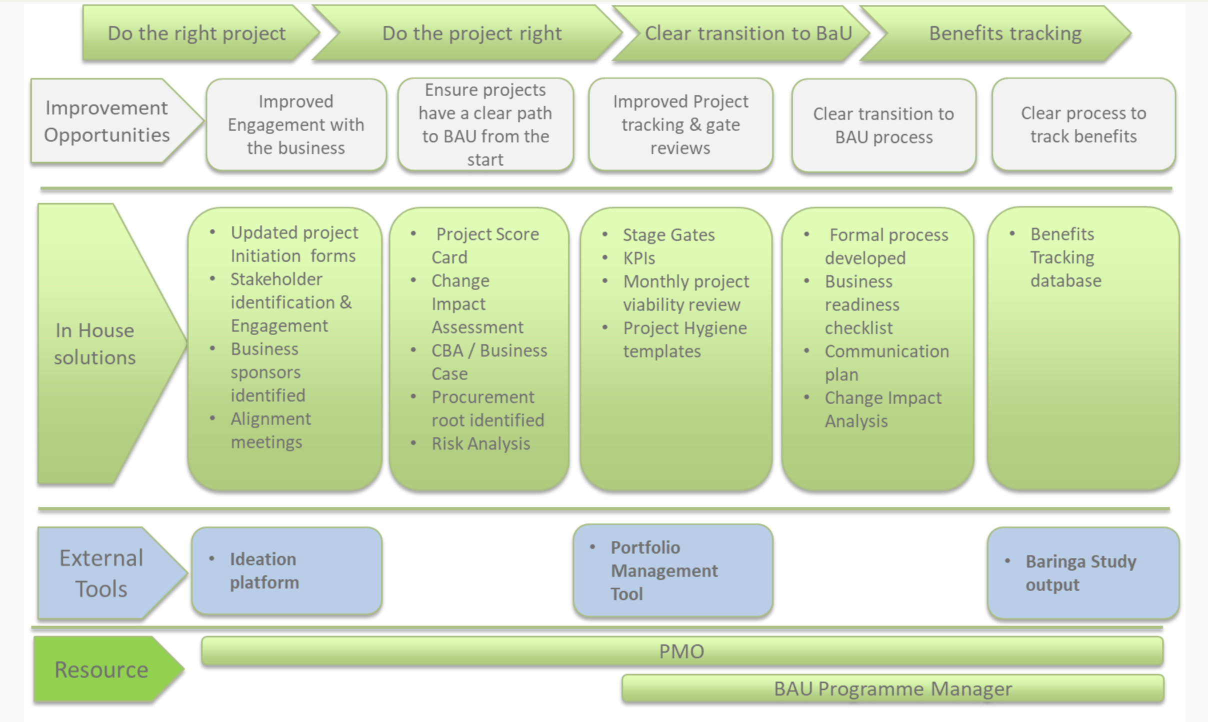


Figure 49 Innovation project delivery key considerations and elements

11.5.3 Project Delivery

The delivery of innovation projects is substantially different from every day conventional projects. There are extra layers of challenges encompassed into these types of projects. In turn they increase their complexity and unpredictability. From their inception and creation through to delivery and transition to Business as Usual. They key elements of project delivery phase are as follows:

- Successful Delivery Criteria
- Stage gate reviews
- Project Steering groups
- Multi-disciplined teams
- Project portfolio management
- Benefits tracking and reporting

The key considerations and elements for successful delivery of any innovation project are shown in Figure 49.

Successful delivery Criteria

The successful delivery criteria and key performance indices(KPIs) are defined for each project at the project inception and creation stage. These are the key criteria of assessment of successful delivery of any innovation project. The fixed set of success criteria and KPIs may vary from project but overall they should cover the following:

- Inclusion of a technical, process or method performance metric to enable assessment if the proposal has been a success
- The realisation of the network owner and Societal benefits defined in the business case
- The delivery of essential outputs such as policies, financial approvals, standards, specification, dissemination and training etc.
- Adequate knowledge dissemination within and outside the company

Stage Gate Reviews

Along with definition of successful delivery criteria and KPIs, it is critical to have stage gate reviews of innovation projects. Innovation projects are based on a set of assumptions during the definition and initial benefits estimation phase. As the project progresses through the delivery phase it is even more important that the gate reviews are conducted and the review findings are used to improve the overall deliverability of the project. It is safe to say stage gate reviews are an absolute must to ensure overall deliverability of the project and integration into business as usual.

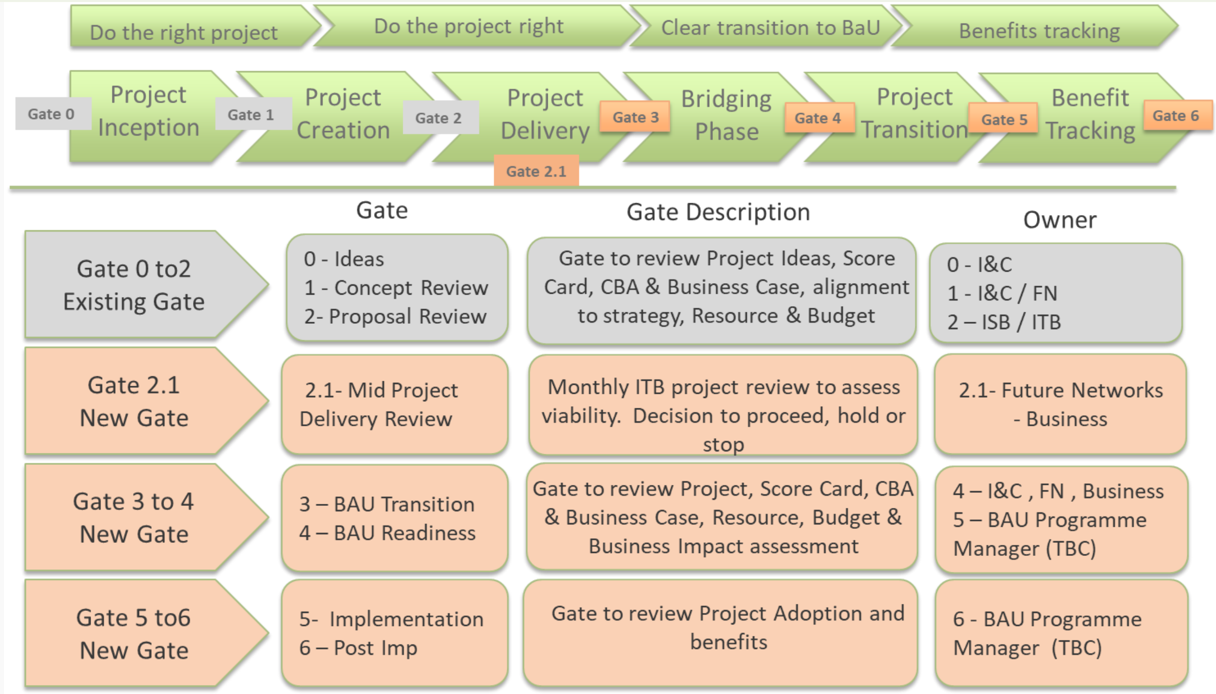


Figure 50 Stage gates and review process

The various stage gate reviews undertaken as part of the overall innovation process are shown in Figure 50. The rationale behind conducting the aforementioned 6 stage reviews is shown in Figure 51. In summary stage gates ensure:

Gate 0 to 2

- At project inception only projects that have potential to deliver benefits and mitigation measures available for identified risks are taken forward.

Gate 2.1

- Projects are delivered in time and on budget
- The project delivery meets the right levels of quality and is on track to deliver the perceived benefits. Any issues identified with same are rectified and/or the project deliverables are modified to bring it back on track to deliver benefits.
- There is adequate gap analysis to allow the project steering board to take measures to resolve any resource, budget issues. The gap analysis also allows for addition or removal of any project objectives that might be required and deemed appropriate.
- Allow for stopping any project that proves to be too risky for successful completion during project delivery stage. This will ensure that projects can be stopped in time and the investment can be redirected to other innovation activities that have more potential to deliver benefits.

Gate 3 to 4

- After project delivery and during bridging phase stage reviews allow to critically assess if the project in question was a success and whether there is sufficient ground for roll-out.

Gate 5 to 6

- In the project transition stage the stage gates allow for assessment for the roadmap, budget, processes, resources and governance in place to ensure successful roll-out of the project and resulting benefits are tracked and reported.

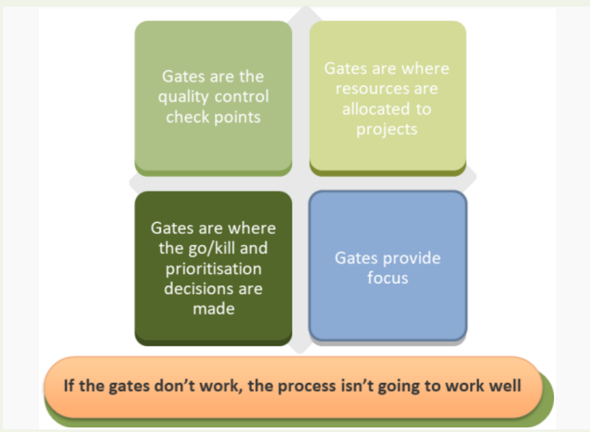


Figure 51 Rationale behind stage gate reviews

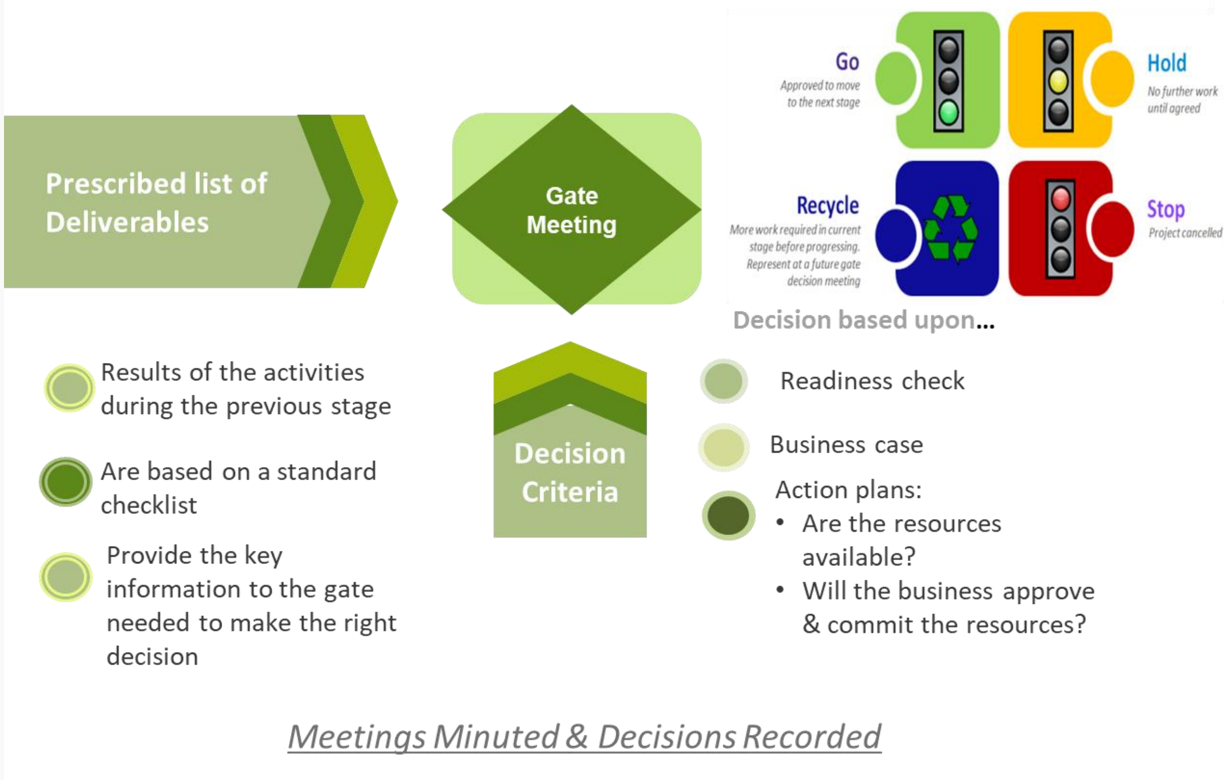


Figure 52 Project Steering Group Review process and outcome

Project Steering Groups

Project Steering groups in place for every project to ensure it stays on track as well as providing advice and guidance into the vital aspects of the project. These include project planning, allocating resources and managing budgets. These features are pivotal into shaping the outcomes of a successful project. The project steering group for most NIA projects is the IB. With NIC projects having individual steering boards.

The project steering boards generally comprise of senior managers and technical experts from different parts of the business. The steering board depending on the nature of the project may also have members from 3rd parties and suppliers. The project steering board is primarily responsible for stage gate reviews of innovation projects as shown in Figure 52. All steering board decisions are minuted, recorded and followed upon at the next steering board meeting.

Multi-disciplined teams

In RIIO-1 the SPEN innovation project delivery and business as usual integration are managed by different teams. As highlighted in previous schemes the innovation review group and the innovation board approve innovation projects then these projects are funded through different funding mechanisms and delivered by future networks. Future Networks then carries out a handover after the completion of the project to the business representatives for business as usual integration. For analogy if this step is considered to be handing over of the baton phase, it is the riskiest step and may result in the dropping of the baton and the project slowly losing its learnings. The innovation team produces various documents and analysis during the project which should be helpful for the next team to take over; however, these documents can be hard to understand for those only getting involved in the project after completion.

In RIIO-2 SPEN proposes multidisciplinary teams with representatives from business core teams that will be responsible for creation of new innovation projects, delivery and ultimate integration in business as usual. The multidisciplinary teams will be strongly interlinked for knowledge transfers and learning process from one team to the other thus minimising the risk of loss of communication, information and failure to handover or as per the analogy dropping of the baton. The overall project and stakeholder management of the innovation multi-disciplinary teams will be the responsibilities of central project management and communication management functions.

The concept of multi-disciplinary teams will involve individuals from different teams from around the business to bring in new ideas for innovation and also relay back the findings as the project progresses back to their teams.

Project portfolio management

Overall project portfolio management is one of the key elements for the success of individual projects and overall innovation program. It achieves following objectives as shown in the set of figures Figure 53:

- It provides an overview of the project progress on individual projects and puts it in the context of the overall innovation portfolio delivery progress and assessment.
- It allows the innovation board to take a step back from the details of progress on individual projects and assess the alignment of the overall portfolio with innovation strategy.
- It also allows the innovation boards to evaluate the number and scale of projects in different project delivery stages. It thus enables the board to plan and allocate resources and put process in place to support all ongoing innovation projects.
- It helps track of spending and budget allocation across different clusters and themes of innovation and across funding streams.
- It enables effective reporting and benefits tracking.
- It provides an opportunity for gap analysis and promote innovation projects in areas lacking focus, align projects better to the strategic focus for innovation and against changing business priorities.
- It allows for re-priotisation of overall innovation clusters and themes and better alignment with wider sectors and research and development work.

There is a precedent set by SP Energy Networks already in RIIO-1 for successful portfolio management, this process will be further enhanced in RIIO-2 for portfolio management across all innovation clusters and themes. As discussed before it will allow for better reporting of innovation activities against internal and industry wide innovation strategies.

Figure 53 Project Portfolio Management

Benefits tracking and reporting

There will be stage gated benefits tracking and reporting at every phase of the innovation project. The details of this process are listed in section 11.7.

The last three phases of the innovation process bridging phase, project transition and final benefits tracking are described in section 11.6 and 11.7.

Innovation Review and Roll-Out

11.6 Innovation Review and Roll-Out

The real value of any innovation project is in its actual implementation and roll-out. It is where the value for our consumers is created, where the innovation investment is paid back to the consumers and where the quantitative and qualitative benefits are realised.

The innovation process within SP Energy Networks ensures that there is a thorough review of all innovation projects led by us after completion. The stage gate review at this stage reviews the following aspects of the project

- Any change or update in business case for the project
- Estimated benefits to be generated based on the learning from the project
- Resources and process in place to enable roll-out
- Technical feasibility and change in technology readiness level (TRL) after completion of the project
- Impact assessment of the project on different aspects of business
- Assessment of accurate timing and opportunity for the roll-out

Industrywide Innovation Roll-Out

The process of stage gate review at the successful completion of an innovation project is not limited to the projects initiated and led by SP Energy Networks. There is a process in place to evaluate every innovation project undertaken by the electricity and gas sectors under network innovation funding streams within the business. There are many processes and tools in place to enable us to learn from successful innovation led by other network companies and ultimately enable roll-out on our network.

Industrywide innovation projects review tool

"Fast Follower" tool ref Figure 54 developed in-house within the business is linked up the ENA Smart Network Portal database. The tool enables internal reviewers to review all NIC, NIA, IRM projects undertaken by electricity and gas network owners, operators and the system operator. It allows the reviewer to post comments, download documents, request information and score on the individual projects roll-out feasibility on our network.

It also provides a snapshot view of all the projects completed in the past and on-going projects linked to the industry wide and business innovation strategy. Periodic reviews of the innovation projects on the portal allows the business to:

- Identify potential projects for collaboration with other network owners
- Rate projects and create priority list
- Indentify potential projects for roll-out
- Raise queries regarding projects
- Create a list of top 20 projects to review , follow on a regular basis and/or roll-out (Figure 55).

Each review in the fast follower tool provides guidance on action to be taken for each project

- Adopt.

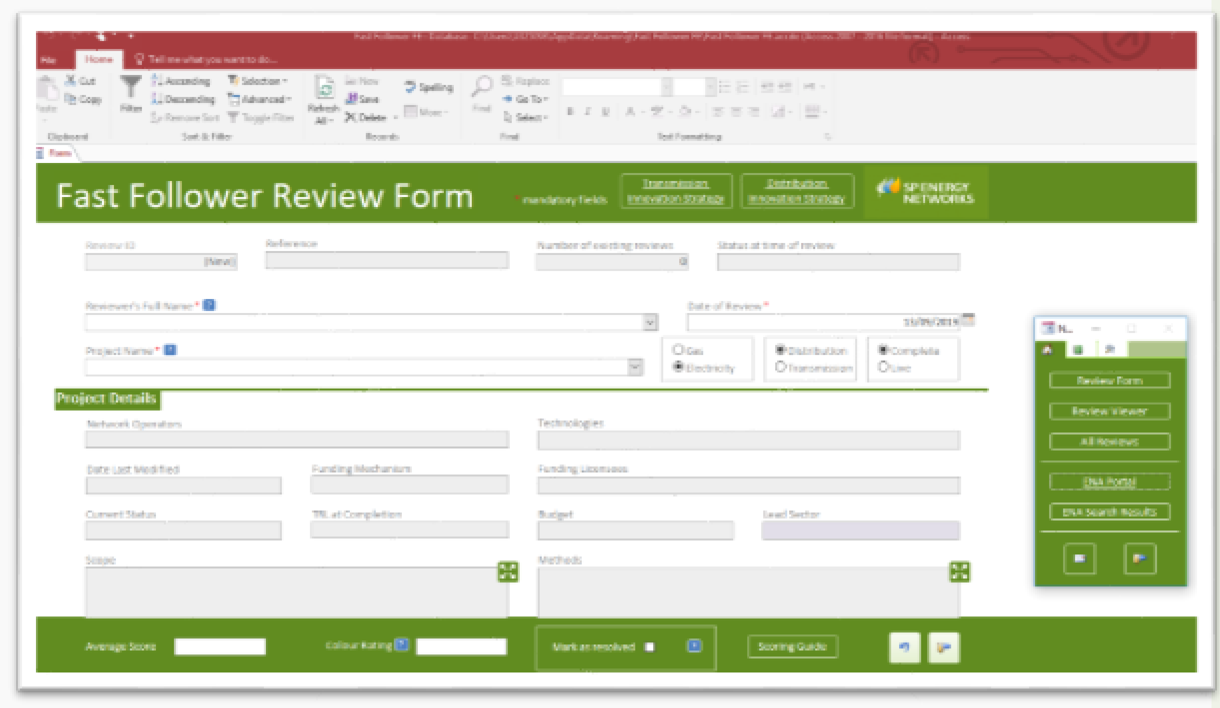


Figure 54 Fast follower tool for innovation project review

Figure 55 Top 20 projects to follow

- Abandon
- Review Later

The projects identified to be adopted proceed to the project bridging phase. The fast follower is a powerful tool that helps the reviewers and innovation board gain a quick overview of the industry activities. The tool has been further developed to create dashboards and be better linked to the industry wide strategy. It can also be developed to keep track of innovation projects actual roll-out statistics and net benefits generated Figure 56.

The fast follower tool can also be extended to include projects from other sectors (where a public database is available) in the review process, thus providing better opportunity to collaborate with other sectors.

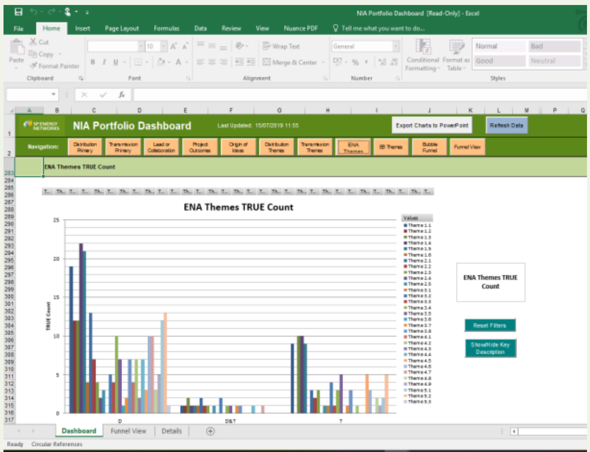


Figure 56 Projects linked to industry innovation strategy themes

Meetings, Conferences and Knowledge Dissemination Activities

One of the most effective methods to enable industry wide roll-out of successful innovation projects is direct collaboration and face to face meetings with other network owners, 3rd parties, suppliers and other network owners. The innovation engagement activities are explained in detail in Section 11.9.

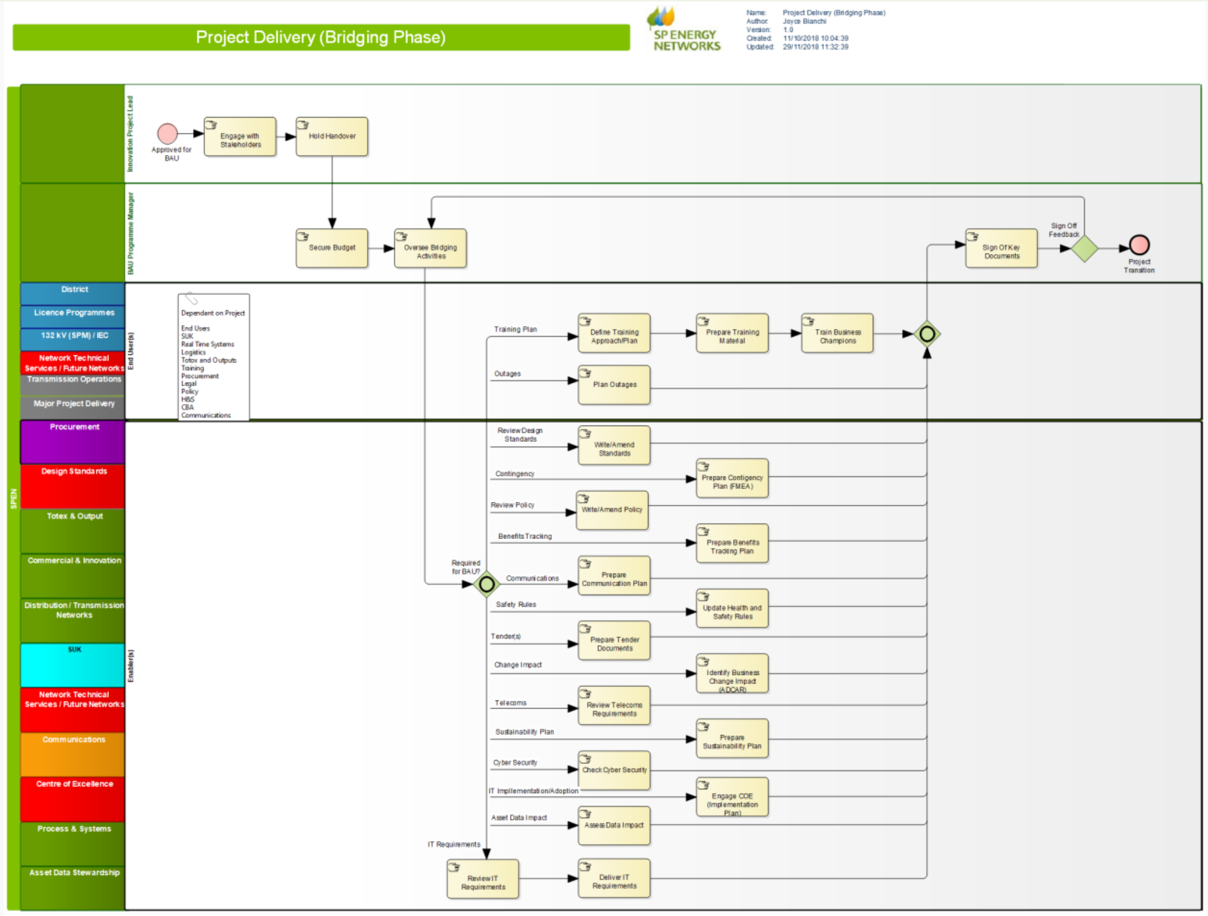


Figure 57 Project Bridging Phase

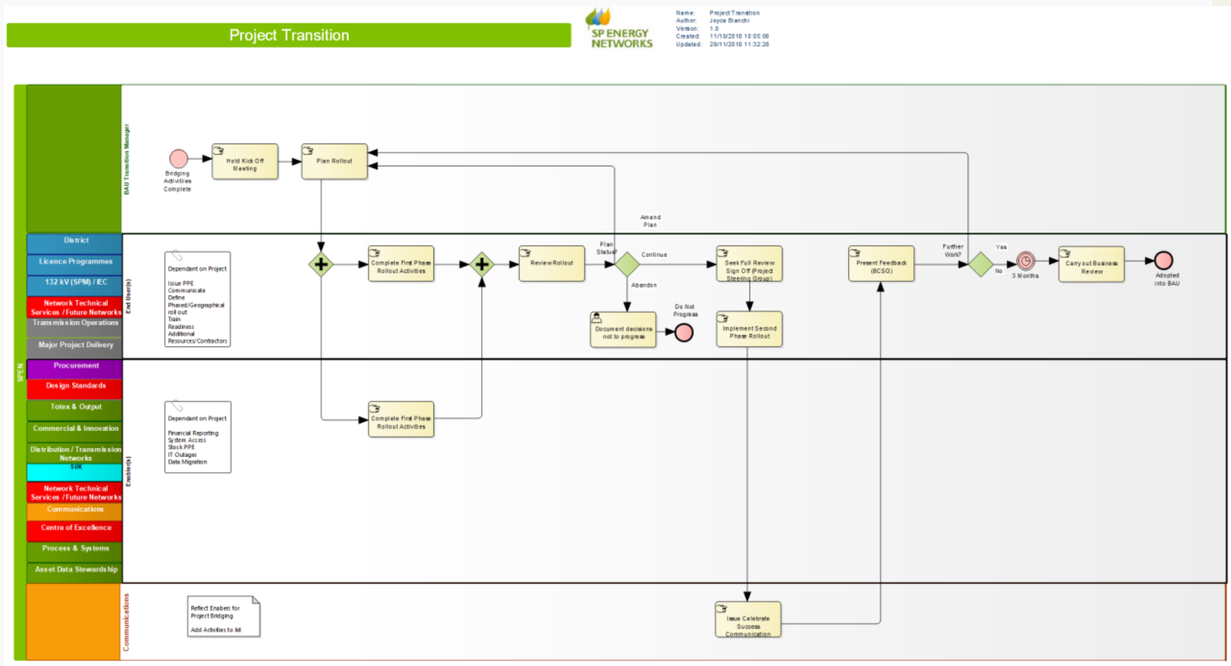


Figure 58 Project Transition Phase

11.6.1 Project Bridging and Transition Phase

The ultimate goal of each innovation project is their transition and/or adoption of the learning into Business as Usual, three little words when explored account for a great deal of effort. Independent of the project initiation by the business and/or other network owner identified for roll-out through fast follower review process they need to go through the project bridging and transition phase. These are easily the most challenging phases in the project delivery to enable business as usual integration as shown in Figure 57 and Figure 58.

The consideration and steps necessary to transition successful innovation projects to business as usual is not an afterthought but built into the fabric of each project right from the onset of the project. At crucial stages of the project and upon its completion the project stage gate reviews ensure that the project is on its trajectory to deliver the outputs against each of the essential elements below to ensure it is still suitable for Business as Usual adoption. The following checks and steps are undertaken to ensure successful roll-out of innovation projects:

Business Sponsorship

At the start of each project the Business and System Sponsors are identified for the solution should it make the transition to Business as Usual. Throughout the project and upon its closure the sponsorship of the project is periodically reviewed to ensure the right parties are involved in the project. Ultimately the decision to progress with the Business as Usual adoption resides with the owner(s), so it is essential that they are correctly identified and they are satisfied with each of the other essential elements prior to transition taking place.

Successful Delivery Criteria

First and foremost, the solution must be a success before it can be considered for adoption, with true innovation there is very real risk that the solution will perform differently to what was initially expected. It is therefore vital that we continually review the projects performance against its Success Criteria, with a thorough final review undertaken prior to proposing its Business as Usual adoption.

Realisation of Benefits

Prior to adoption it is essential that the initial business case is revisited and as many of the assumed benefits and costs as possible are replaced with actual findings uncovered through the project. Undertaking this analysis using an industry approved cost benefit analysis tool facilitates the transfer to Business as Usual within our existing regulatory framework, as well as the adoption by other Licensed Network Operators.

Financial Approval

Within a regulated industry a major challenge for all innovation projects is the timely identification of relevant funding for the solution upon Business as Usual adoption. Funding will likely require the removal of funding from tried and tested solutions and processes. This decision needs to be made by following stringent financial investment processes, the requirements of which need to be factored into the projects deliverables. This process highlights the need for certainty of the solutions performance and the benefits it is expected to delivery compared to the existing and alternative approaches. The financial approval at this stage signifies investment through the TOTEX allowance and/or through innovation roll-out mechanism to enable roll-out of the innovation project,

An approval process is initiated through the project the business change steering group (BCSG) and relevant technical and process review groups to assign funds to enable innovation roll-out. Depending on the level of risk involved in the roll-out of the project external funding may be requested to avoid significant negative impact on the business allowance. However, as the business has also adequate processes and methods in place to mitigate mageable project risks where possible innovation will be funded through the business as usual TOTEX allowance.

Policy Standards and Specifications

The ability to adopt an innovative solution is largely dependent on its ability to be absorbed by the business and this can only happen if the business has mandate and support to do so. It is imperative that these documents created to facilitate Business as Usual adoption are professionally authored and approved by the relevant authority as part of the project.

- **Policy**: These set the mandate for change, either through the update of existing policies or through the creation of new policies, be they internal to SP Energy Networks or wider industry.
- **Standards**: To provide the business with the ability to understand the technical criteria of the solution, the methods, processes and practices essential to operating and maintaining the solution.
- **Specifications**: To outline the precise requirements of the new solution,

essential to its procurement. Their production undertaken by the person(s) with the greatest understanding of the solution, which in most instances is the project delivery team.

Training and Knowledge Dissemination

The transition of the innovative solution by the business and wider industry is underpinned through the delivery effective training and dissemination. Prior to the closure and adoption, it is essential that all necessary training and dissemination material has been completed and shared accordingly. The dissemination of projects and findings is not exclusive to successful projects that are to be transitioned to Business as Usual, in many ways it is more important to share failures and shortcomings of projects and solutions to ensure others do not waste resources pursing a similar fate.

Project Roll-Out Roadmap

The innovation roll-out for large scale and transformative projects which have a larger impact on different parts of the business require a well thought-out roll-out roadmap to be created including

- Suppliers review to enable business procurement process to procure the best fit solution
- Gap analysis in business processes, infrastructure and services that need an update and identification of resource requirements.
- Roll-out time line and strategy identifying key milestones and prioritising work streams within the roll-out plan

Project roll-out roadmap is a useful tool that enables business hand-over of critical applications developed through the innovation process and ensures that the steps for roll-out are clearly defined and documented.

An example of such extensive roadmap can be found for VISOR project at: https://www.spenergynetworks.co.uk/userfiles/file/VISOR_Roadmap_%20December_2017.pdf

The success of this roadmap led to change in the STC code to enable dynamic measurement from across the GB network to be made available to the ESO and integration of WAMS in control centre (ref: Cluster 2, Theme 1: Grid Observability).

Project Transition Team

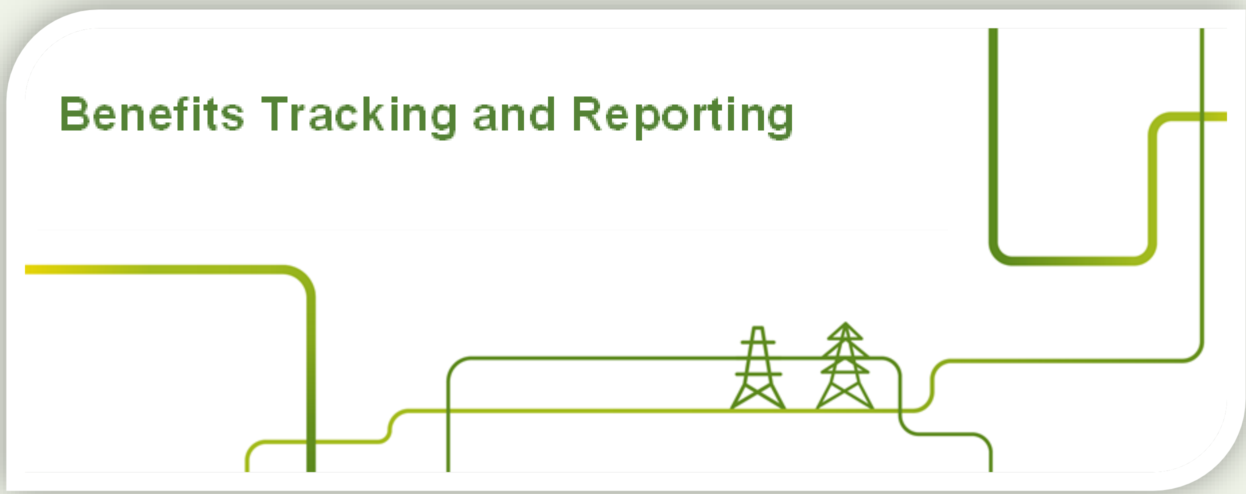
Similar to the project delivery team the project transition team needs to be a multi-disciplinary team with representatives from all parts of the business responsible for the successful roll-out of the innovation project.

Case Study Digital Substations Initiative

One successful example of the innovation roll-out process within the business enabling roll-out of digital substations within RIIO-T2 is the digital substations initiative launched by SP Energy Networks in Jan'19. The initiative will run for 4 years enabling the roll-out of digital substations on our network in RIIO-T2.

The digital substations initiative team is tasked to produce a case study for digital substations using learning from successful NIC project FITNESS and enabling roll-out of digital substations in RIIO-T2. The digital substations initiative is empowered to take an objective long view on the most appropriate deployment strategy — allowing it to deviate from conventional standards where necessary and found appropriate — without compromising the reliability, availability and dependability requirements for secondary systems especially protection and control. It has the authority and responsibility to design a transition program to be approved by the business change steering group. The team actively supports the RIIO-T2 planning team for digital substation engineering design for RIIO-T2 business plan.

Its key role will be to manage the change process required within different business units to enable a full scale design and implementation of a digital substation from design to operation and maintenance. The outcomes of the digital substations initiative are crucial to allow for seamless transition to digital substations, avoiding the challenges faced by our organisation in the past deployment of the technology. This strategy in its introduction provides a time-line and proposal for achieving the key steps to enable roll-out of digital substations.



11.7 Benefits Tracking and Reporting

The final stage of the innovation project delivery process is associated with quantifying and tracking the multiyear benefits realised by the project and solely applies to those projects and solutions that transitioned into Business as Usual. This stage is not necessarily a component of the project, but it is essential that is given consideration and a strategy for undertaking it is in place ahead of the projects closure.

11.7.1 Why is this Benefit Tracking important?

- First and foremost, it ensures that Business as Usual adoption has taken place and the realisation of benefits from the innovation is enduring.
- Internally it helps justify the benefit adopting innovation has to the business and our consumers, and by doing so strengthens our commitment to delivering innovation.
- Externally there are formal requirements to report the enduring benefits delivered by innovation. Doing so plays a vital role in justifying the GBs ongoing commitment to supporting innovation within our industry and the economic benefits it creates.

11.7.2 How do we do it?

In the ideal world the benefit from innovation should be measurable on an ongoing basis, unfortunately though this is not always possible so our approach is split in two categories:

Measurable Benefits - Where the solution delivers a measureable change in the business performance on an enduring basis our approach utilises these measurements alongside the cost of the solutions deployment to quantify the benefits.

Forecasted Benefits - Where the benefits cannot be measured on an enduring basis our existing approach to quantifying the benefits is based on the detailed cost benefit analysis undertaken at the projects transition to Business as Usual. Wherever possible the cost benefit analysis tool is modified to enable the compiler to identify the benefits achieved by simply inputting the cost and volume of the solutions deployment in any given year. The modified Cost Benefit Analysis (CBA) tool built by the project team uses this information to automatically calculate the benefit delivered over the course of the solutions life.

The benefits tracking and reporting is done at key stages of the project, namely at the onset of the project, during mid delivery period and at the end of the project before business as usual implementation. The innovation process has evolved significantly in this aspect over recent years. It is important that we are transparent to our consumers and wider stakeholders regarding the benefits generated though innovation and the significance of each innovation project in tackling energy system transition challenges and creating value for our consumers.

In RIIO-2 we will also publicly report our qualitative and quantitative benefits using a sector-wide generic method for benefits tracking and reporting which we are currently in the process of developing with the ENA.

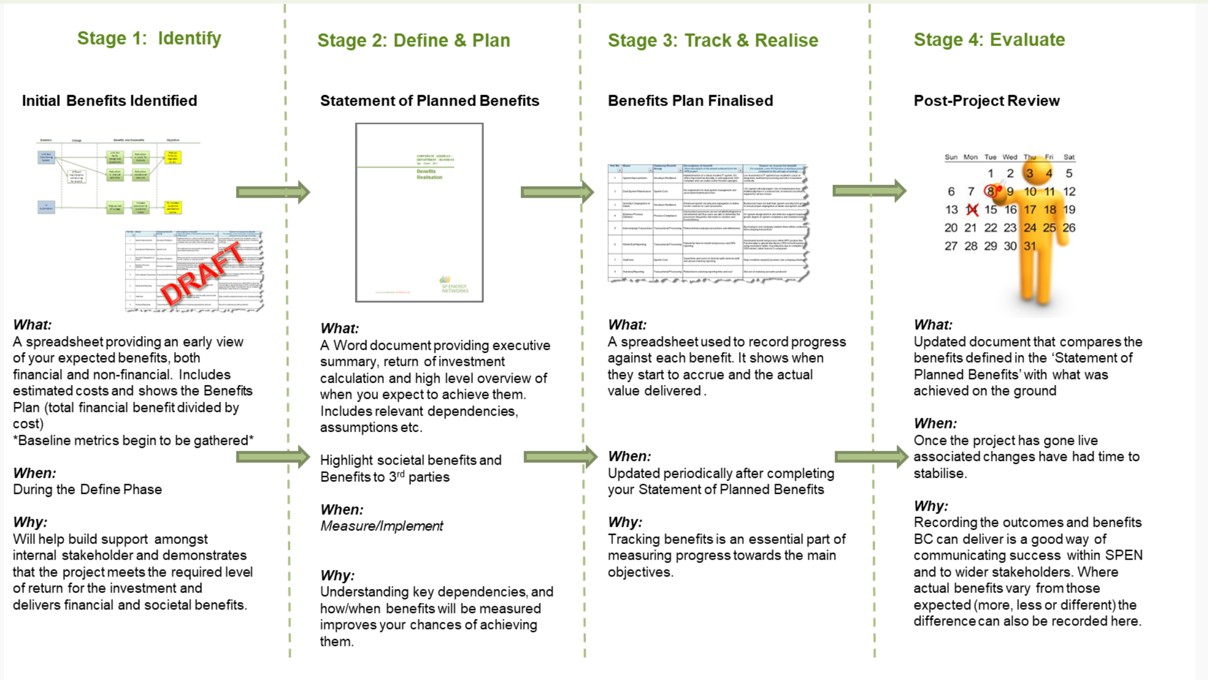


Figure 59 Benefits Tracking and Reporting Methodology

11.7.3 Benefits Tracking and Reporting Methodology

The benefits tracking and reporting methodology followed at different phases of the innovation project delivery is shown in Figure 59.

Identify

The initial benefits projected for the business and wider stakeholders is assessed in this stage. A CBA process is implemented to calculate the financial and societal benefits to be generated through execution of the innovation project.

Define and Plan

The benefits identified are summarised in a statement of planned benefits and published for review by the innovation board and wider stakeholders. The statement of planned benefits can also be a summary of benefits according the innovation cluster or theme.

The statement of planned benefits also provides a timeline and progress forecast for realisation of benefits. As the initial benefits estimation has certain assumptions associated with it, the statement of benefits also provides a timeline if and when these assumptions can be tested during the project delivery phase.

The document also includes a risk assessment that highlights the risks to overall delivery, success of the project and ultimate realisation of benefits. The risk matrix and scores are maintained and updated throughout the project through regular project meetings.

Track and Realise

The project delivery team tracks the benefits and the risk scores throughout the delivery, bridging and transition phase and reports it to the project steering board. The estimation of benefits at this stage is also provided in the annual summary reports and will be provided in the industry wide benefits report in RIIO-2.

Evaluate

At the end of the project before integration into business as usual the CBA process is repeated based on the learning throughout the project. If the outcome of this process highlights the perceived benefits do not provide a business case or any societal benefit and/or the risk score remains high the project may be referred for further work or stopped all together. This is one of the expected outcomes from innovation projects.

In most case the innovation projects do deliver benefits and the risk score for implementation is substantially reduced throughout the lifecycle of the project. In this case a further year on year benefits tracking projection is created and included in project roll-out roadmap for future tracking and reporting of benefits.

11.7.4 Proposal for Managing Innovation Benefits throughout the innovation process

In RIIO-T2 there is even a greater need to publish benefits through a unified benefits tracking and reporting mechanism. This will exist in addition to our internal benefits tracking process to provide GB stakeholders and consumers a better picture and more transparency regarding use of innovation funding in our industry to create benefits. Over the last 6 months in 2019 following Ofgem's sector specific consultation decision in May 2019 the GB network owners both gas and electricity have worked together with the ENA to develop the ENA benefits tracking framework details of which can be found at http://www.energynetworks.org/electricity/futures/network-innovation/network-innovation.html. The purpose of creating an ENA Benefits Reporting Framework is to:

- Enable consistent and transparent measurement of innovation costs and benefits delivered across GB
- Demonstrate progress against innovation strategies, both individual network and sector wide
- Report on innovation that has been transferred to Business as Usual (BAU), both within the network working on a project and how it has been adopted across other networks where relevant
- Ensure mechanisms are clear so that Ofgem can incorporate these into the relevant RIIO-2 innovation governance documents

Table 38 summarises ENA proposals for RIIO-2 and beyond. In order to develop this proposal, the team has analysed the existing industry framework, which combines decades of operational excellence experience together with 'lean thinking', innovation and exceptional service design. The team have also considered existing regulatory reporting systems and Industrial reports, such as the Pathways for the Great Britain Electricity Sector to 2030 and the Wholesale Market Report 2019.

In order to develop this Framework, ENA and its Members have committed to continue engaging with wider stakeholders, to ensure that the way benefits are reported are transparent, and relevant. As well as the participating Members, the existing EIC Framework underwent significant stakeholder engagement with a range of key industry parties including Ofgem, BEIS, Ofwat, Sustainability First, Energy UK and Citizens Advice. The feedback from these sessions was very useful and significantly shaped the format of the Framework

.

Proposed Innovation Benefits Reporting (RIIO-2)*
Bi-Annual: • Electricity/Gas Network Innovation Strategies (ENA)   o *Review of priorities and progress against objectives*

Annual Reporting:
• Annual ENA Industry report
    o *Cumulative reporting tables*
    o *Narrative section from each LNO*
• LNO Specific Annual Summary Reports
    o *Including ENA agreed Innovation balance scorecard*
    o *Including Implementation Log (BAU rollout) Summary*
    o *Evidence of collaboration, knowledge sharing and fast following*
• Consistent Innovation Benefits Tables with detail behind scorecard
• Individual Project Completion Reports
    o *Individual Project Progress to be captured in Annual Summaries*
• Annual Innovation Conference
• Smarter Networks Portal
    o *With improved project templates and analytics to provide enhanced visibility of innovation benefits*

Table 38 ENA Benefits Reporting Framework Summary Table

Innovation Through Business as Usual

11.8 Innovation through Business as Usual

One of the key innovation reforms for RIIO-2 is to fund and deliver more innovation through business as usual. This has been the key focus of SP Energy Networks' "Culture of Innovation" campaign launched in 2019. The "Culture of Innovation" is a 3-year campaign running from year 2019 to 2021 designed to embed innovation in the DNA of the business and encourage more people within the business to participate in the innovation process.

SP Energy Networks and our parent company Iberdrola are invested in innovation and progress of culture of innovation across the business. SP Transmission led and delivered many key and transformative innovation projects through the innovation funding mechanism in RIIO-T1. However, the innovation within the business is not limited to innovation funding mechanisms and large scale innovation projects. It is our firm belief that innovation should start from the grass root level and the best way of creating efficiencies and value out of innovation is through investment in people within the company and their participation in the innovation process.

The culture of innovation campaign is aimed at promoting more innovation through the business as usual process and through contribution from each and every employee within the business. This takes innovation beyond the scope of fixed teams and/or representatives and opens it to everyone within the business. Some of the best ideas for innovation within the business originate from employees about their daily jobs and how to make it better. The year of innovation encourages more innovation in action through:

- Driving awareness across the business of all of the types of innovative activities going on, as well as importance/relevance of innovation to the wider business objectives.
- Driving a shift in perception of innovation across the business, that innovation is something everyone should get involved in.
- Driving the realisation that people could be innovating without realising
- Creating a sense of pride in/inspiration from not only the specific work of the innovation team and others around the business' success stories, but in the innovative approach and culture at SP Energy Networks as a business.

The key objectives and outcomes of this campaign are shown in Figure 60. The key planned outcomes of the campaign are to promote more

- Decentralised innovation across the business
- Multi-disciplinary innovation across teams within the business
- Cross-boundary collaboration within the company and across the sector
- Innovation a useful and important tool to tackle business priorities

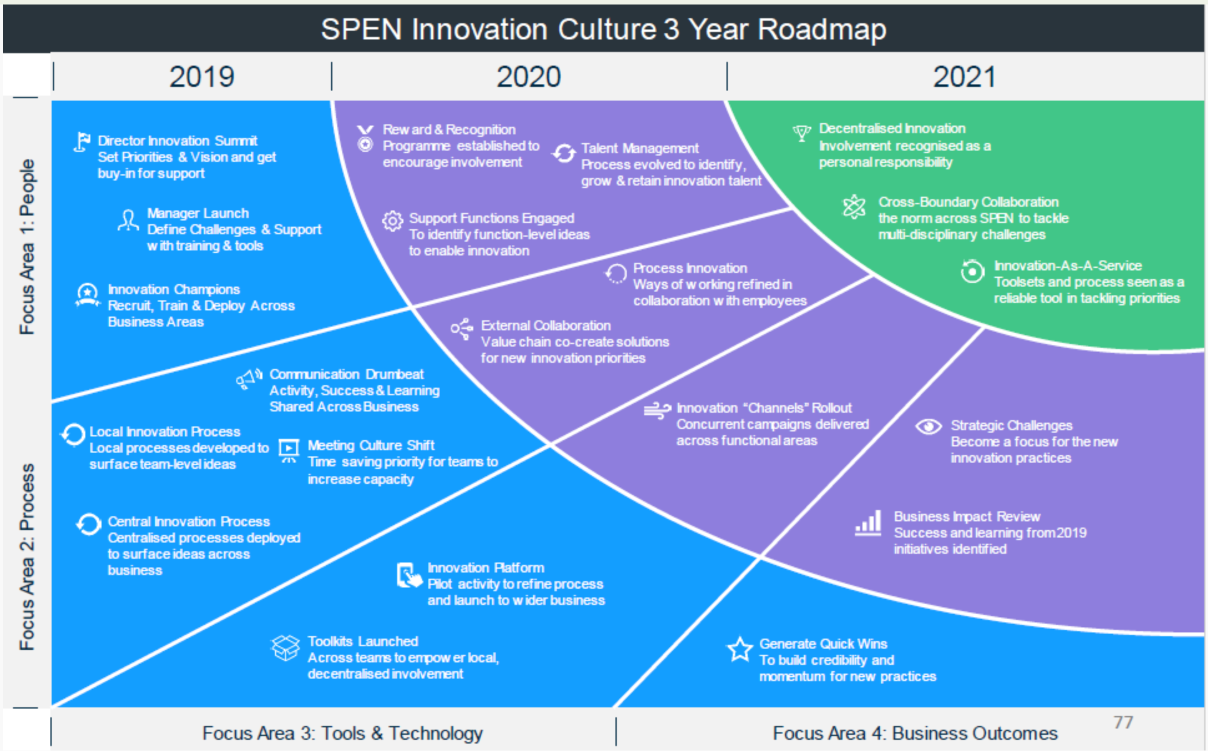


Figure 60 SP Energy Networks culture of innovation roadmap

- Encourage more external collaboration to co-create solutions for innovation priorities set by the business and people

The culture of innovation campaign focusses on following 5 key elements:

A programme of communications aimed at making innovation at SPEN relevant, accessible and inspiring people to get involved. From highlighting what innovation means across the business, to explaining the process for getting involved, and sharing success stories and lessons learned.

To help Team leaders and Managers create the time and environment to support and encourage innovation in their teams.

Building culture by developing individuals who make innovation relevant at a grass roots level, across offices and field teams.

Food for Thought is a really simple idea. Get people together in a relaxed and informal setting, over food, and invoke discussion to generate ideas, tackle ongoing issues or to share and celebrate success stories

A digital platform to share ideas in response to real business challenges set by the business, or to seek new opportunities: iHUB (Figure 62)

Figure 61 Vision of culture of innovation campaign

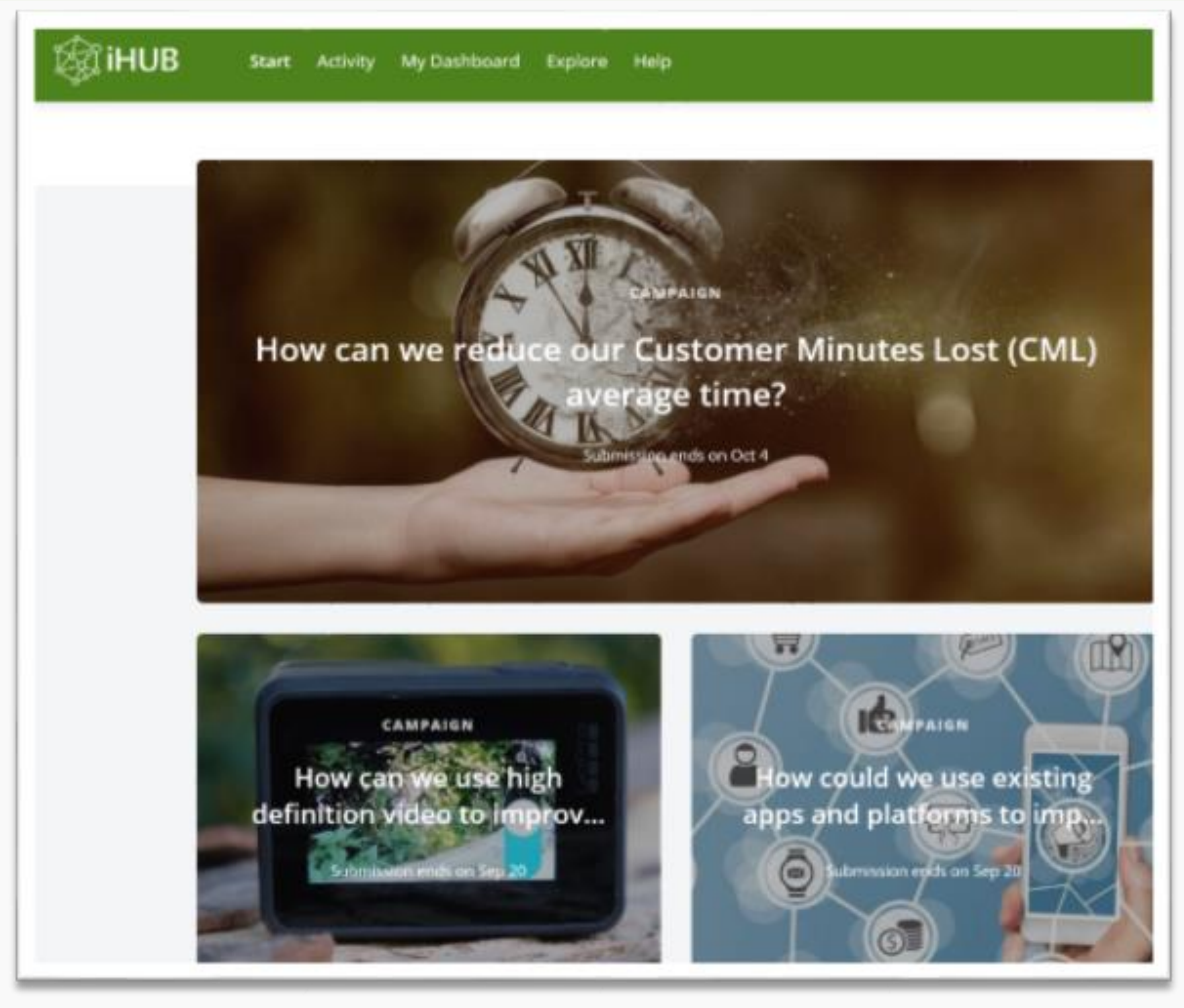


Figure 62 SP Energy Networks culture of innovation portal iHub

11.8.1 Innovation Portal iHUB

The digital portal will be a method for our business to be able to engage more people than we could fit into a room in a new and dynamic environment. That's where the iHub came from. Going digital means that we can all get involved in innovation — wherever we are! It has been launched with the aim to achieve the following:

- Strategic Innovation areas where SP Energy Networks Innovation strategy and innovation goals will be recorded and ideas relevant to these areas can be submitted at any time.
- Dedicated area for campaigns that will be run by campaign managers. Campaigns will actively ask for ideas to address business problems and will be time limited.
- The platform will allow employees to submit ideas via a mobile app, desktop computer. Employees will be able to collaborate on ideas by commenting & building on ideas submitted by fellow colleagues, sharing ideas or by voting on them.
- Ability to add videos, photos and documents to the campaign
- Ability to configure the idea submission form specific to each campaign
- Campaign dashboard required to allow the innovation managers to track the latest activity and ideas received
- The platform will allow the campaign manager to cluster ideas and drop them into specific pools with the ability to split and merge ideas. The system should also identify similar ideas and automatically put them in the relevant pool.
- The campaign manager will be able to define the evaluation team

- Ability to track the progress of the evaluation stage and send out reminders to the team where necessary
- Evaluation results to be displayed in a dashboard where the innovation manager is able to weight and short list the results.
- Feedback is to be provided on ideas submitted

11.8.2 Post Campaign phase

The culture of innovation campaign is planned to be closed by 2021, at the onset of RIIO-2. Following which the digital portal will be used to:

- Evaluation tools will be provided to assess each innovation project. It will provide a pre-determined scorecard and business impact assessment form to be embedded within the tool to assess each innovation idea originating within the company and/or from 3rd parties.
- Configurable CBA and business case templates will be implemented within the tool to evaluate each innovation project initiated.
- It will implement a Project Portfolio management to enable tracking of concept implementation to include forecasting, milestone tracking and forecasting of future innovation projects
- It will implement an option to conduct stage gate review process.
- It will provide reporting options for internal and external stakeholders.

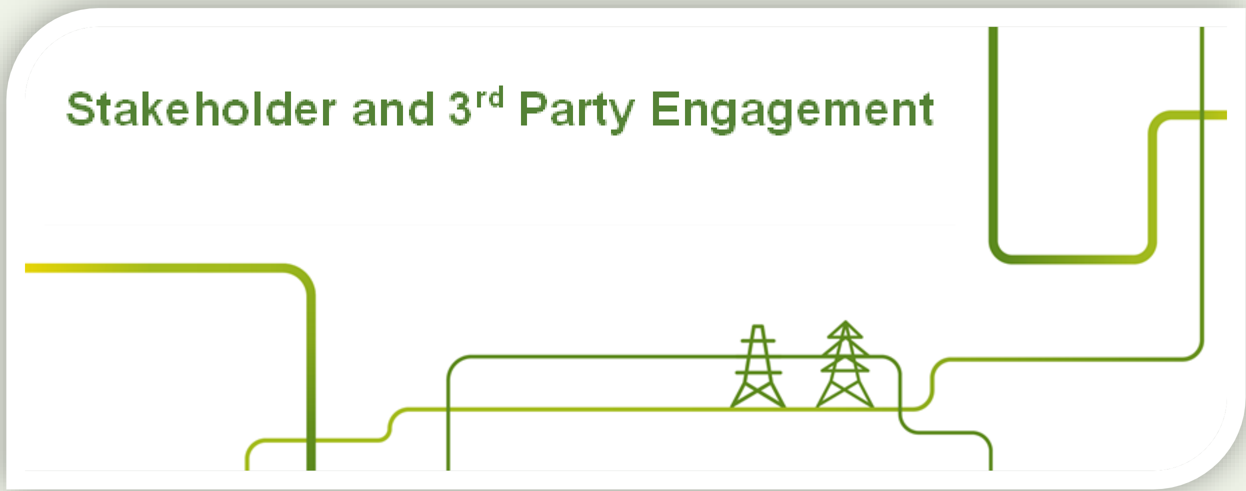
In summary, after the successful completion of the culture of innovation campaign the digital platform will be used to plan, manage and track innovation projects in RIIO-2. It will report on the percentage of innovation ideas originating from within the business, from 3rd parties and project portfolio breakdown for core, incremental and transformative innovation. It will also create KPIs to be evaluated against the industry wide innovation impact assessment scale as described in section 11.7.

11.8.3 Innovation through wider collaboration

In addition to the culture of innovation campaign there are various others measures in place within the company to encourage more innovation through business as usual:

- **Global Practice Groups (GPGs)** exist across the utilities under Iberdrola which promote exchange of ideas and innovation among representatives from companies from across the globe. The GPGs promote best practice adoption and sharing among countries and enhance global innovation across a range of technical topics across the business. The GPGs focus on driving efficiencies within the business through innovation.
- **Continuous engagement with suppliers and 3rd parties:** As part of our standards and specifications activities we continuously engage with vendors through roadshows, dedicated meetings to assess the innovation in their product roadmaps and where appropriate adopt innovative solutions applicable to our business. Some of the examples of efficiencies created through such engagement can be seen through our series compensation and GIS optimisation projects. We have also driven product portfolio for certain vendors with constant engagement with them on topics such as fault recording, phasor measurements and wide area monitoring applications.
- **Membership and Participation in international research bodies:** Many of our engineers and the business itself is a member of international committees such as Cigre, ENTSOE, IEEE and others. There is constant engagement with these committees and sharing of best practices that help bring globally innovative ideas and solutions into our day to day business areas.

Innovation through business as-usual is already a norm within the business and will only be further developed upon in RIIO-T2.



11.9 Stakeholder and 3rd Party Engagement

We recognise the value in casting our net as wide as possible when looking for innovative ideas and solutions with the potential to benefit our consumers. We believe we have established an open-door policy for innovation that makes us accessible to anyone inside or outside of our company to bring forward novel ideas and solutions. This approach is reflected in our Project Portfolio which consists of solutions and ideas from all the sources outlined below.

For Stakeholders and consumers alike, we are keen to be made aware of opportunities to collaborate and deploy innovative solutions that are aligned with the Opportunities and Challenges outlined in our Innovation Strategy. In particular, we are looking for opportunities centred on the themes and clusters defined earlier.

The good news is that through a number of our strategic partners as well as ourselves, innovators, consumers or stakeholders do not have to attempt to answer these questions alone. There are several ways they can gain access to support to develop proposals and get further insight into our innovation needs. The following section provides an overview of all the ways 3rd parties can get in touch, outlining the role each of our strategic partners plays in the delivery of innovative solutions

11.9.1 Stakeholder Engagement forums

Visit the SP Energy Networks website

Our Innovation section is kept up to date with the latest news on our activities, the challenges we are facing and opportunities for innovation Figure 63.
https://www.spenergynetworks.co.uk/pages/innovation.aspx

Email the SP Energy Networks Innovation Team

You can register your idea by contacting our innovation team at SPInnovation@spenergynetworks.com. Our team will endeavour to give your enquiry consideration against our innovation priorities and commence further engagement or provide constructive feedback from our business experts.

Join our Stakeholder Panel

If you or your organization operate in our license areas, we would welcome you to join our Stakeholder Panel. As a member you will have the opportunity to directly feed into the evolution of our innovation strategy and the prioritization of challenges.

Meet the Innovation Team

This is the UKs flagship conference from disseminating the learning

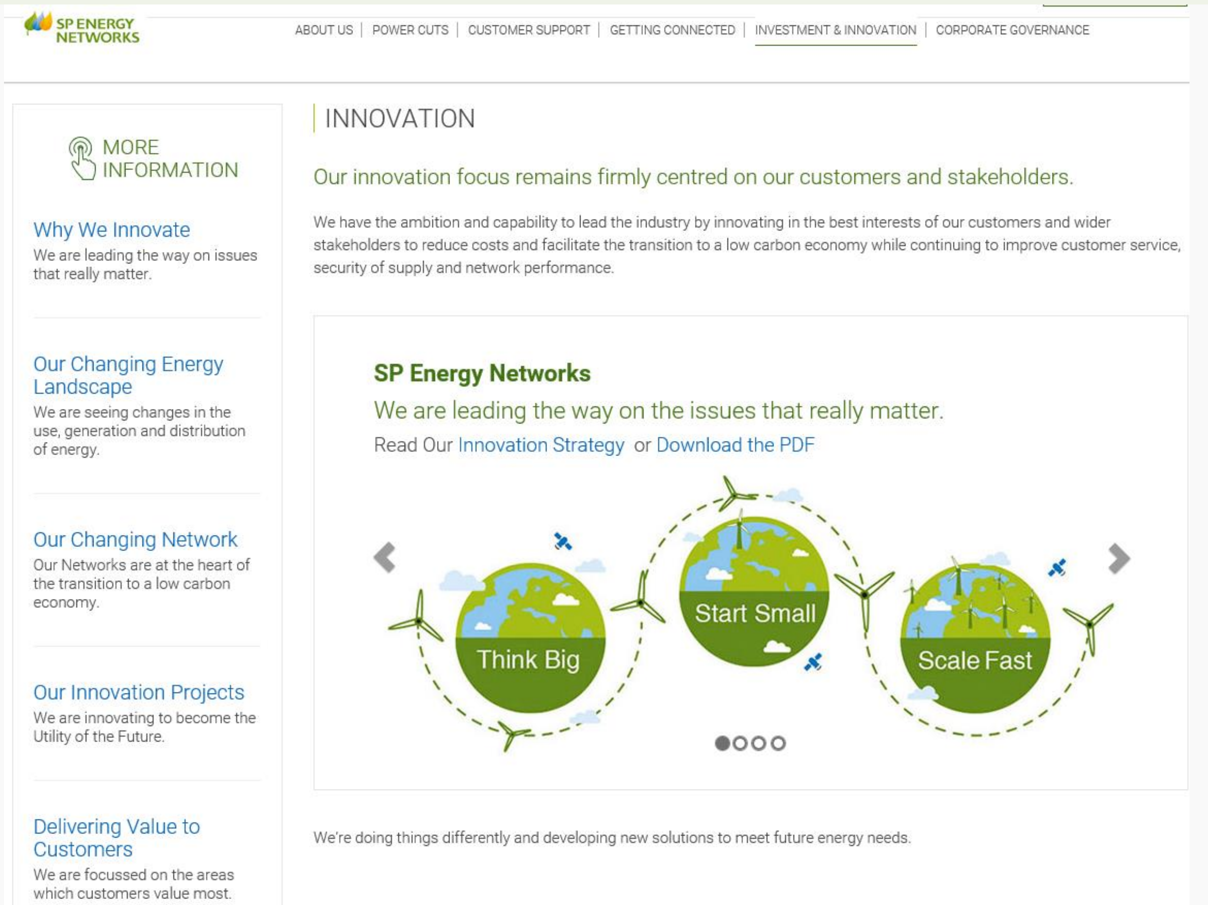


Figure 63 SP Energy Networks Innovation website

from each of our innovation projects. Each year we are very pro-active in ensuring that each project is disseminated to as many delegates as possible, ensuring that many of our project leads are present to discuss the project or for further information. www.lcniconference.org/

Direct Engagement on strategic projects: Refer to section 11.9.2.

Smarter Network Portal

This portal enables innovator to research NIC and NIA projects undertaken by License Network Operators (LNOs) to date and by doing so assess the suitability of their own proposal. www.smarternetworks.org

Network Innovation Collaboration Portal

This portal enables Innovators to make Project Proposals directly to all UK LNOs and LNOs to invite innovators to participate in planned projects. www.nicollaborationportal.org/

Contact the Power Networks Demonstration Centre (PNDC)

The PNDC is a collaborative venture, bringing together academia, government agencies and industry. The PNDC consists of a small-scale 11kV distribution network which simulates a real energy system and enables innovators to accelerate and de-risk new technologies prior to deployment on electricity networks. [www.pndc.co.uk, pndc@strath.ac.uk](www.pndc.co.uk)

Scottish Enterprise is a sponsored non-departmental public body of the Scottish Government which encourages economic development, enterprise, innovation and investment in business. www.scottish-enterprise.com

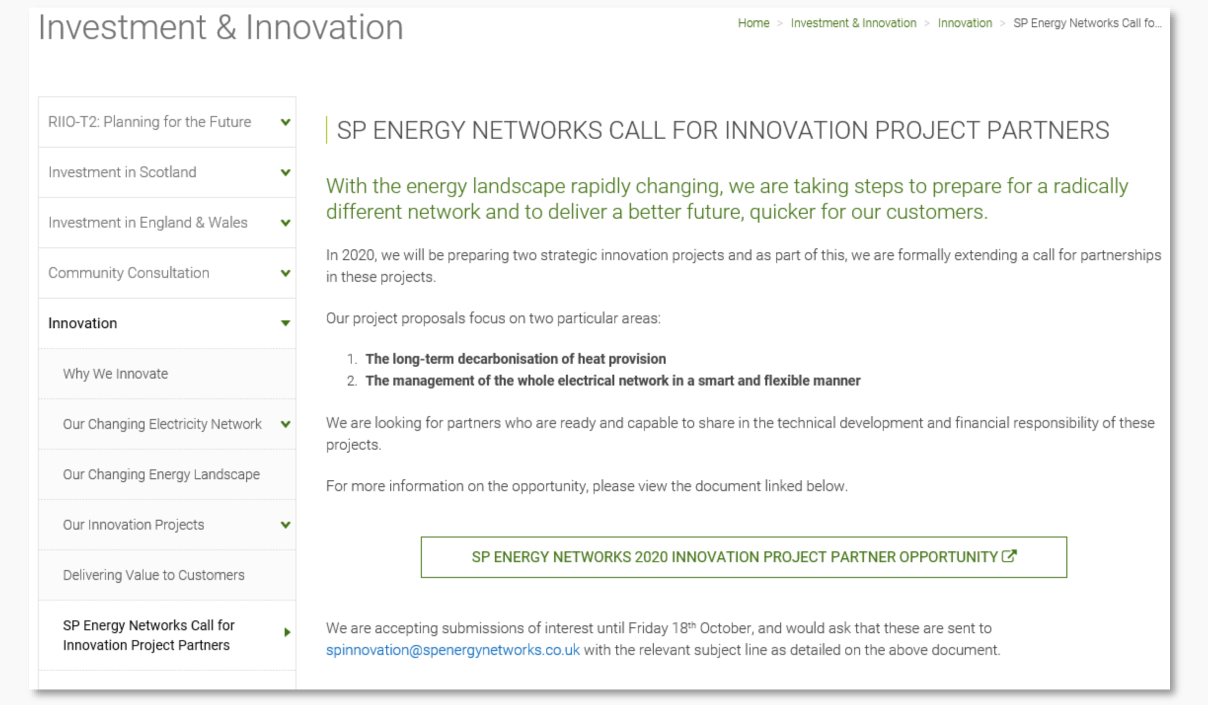


Figure 64 SP Energy Networks Call for partners link

11.9.2 3rd Party Engagement in Innovation Projects

The majority to almost all of our innovation projects have 3rd parties involved in them as a supplier, academic, SME and/or as a lead project partner. Circa 85%-90% of our innovation investment is directly allocated to 3rd parties. We are always open to ideas from 3rd parties and encourage direct involvement in all our innovation projects through

- Annual call for ideas through the ENA, the EIC and the NIC collaboration portal for large scale strategic projects addressing network and system challenges.
- Call for collaboration on new and existing NIA and NIC projects through our website https://www.spenergynetworks.co.uk/pages/spen_innovation_project_partners.aspx

We perform a detailed assessment on the ideas received and where required have bilateral with 3rd parties regarding the solution. We include our business sponsors and experts in these meetings to be able select ideas based on their merit and level of innovation. The ideas are then scored using the metric described in Section 11.5.1 project inception.

The ideas selected through this process are then progressed to the next round of discussion. 3rd parties are then asked to prepare detailed project proposals depending on the nature and scale of the project. For large scale projects and/or for projects with competing proposals from 3rd parties a partner selection assessment is conducted to select the suitable partner(s) based on a defined set of criteria. In case of a commercially available solution applied in an innovative way a detailed procurement and tendering process is followed with a defined set of technical and functional specifications during the partner selection phase.

The selected partners, suppliers, 3rd parties are then included in the project delivery team and appropriate contracts and IP arrangements are put in place according to the NIC and NIA governance requirements to ensure maximum knowledge gathering and sharing from the project.

3rd parties not selected through this process are provided appropriate feedback. A 3rd party can always request further information regarding the assessment of their proposal

After completion of the project depending on the nature of the project and the success of the trial the 3rd party project partner may be asked to participate in the project roll-out and/or an appropriate tendering process is put in place to compare similar solutions available in the market.

11.9.3 Enhanced 3rd Party Engagement in Innovation Projects in RIIO-T2

In RIIO-T2 we plan to enhance our engagement with 3rd parties by providing more transparency to the wider stakeholders regarding the following

- Statistics of number and type of 3rd parties engaged with
- Number and percentage of 3rd parties engaged with
- With consent from the 3rd party decision and supporting information regarding acceptance or rejection of 3rd party proposals
- Inclusion of 3rd party engagement summary in the annual benefits tracking report as discussed in section 11.7.

In order to encourage more 3rd party engagement in our projects we will also launch a webinar with publishing of our annually innovation strategies and annual reports. We will provide details of potential areas of engagement and request feedback and proposals from 3rd parties. We will also provide a mechanism for 3rd parties to provide feedback and suggestions on our innovation portal along with access to our existing innovation email address **spinnovation@spenergynetworks.com.**

We have also organised "Dragon's Den" style pitching sessions at the LCNI conference, where independent ideas can be presented to an expert panel with the potential to be awarded innovation funding if the idea is chosen by the expert panel. We will increase the number of such sessions throughout the year provided there is a measurable increase in 3rd party engagement through this process.

11.9.4 Engagement with public sector and European innovation funding mechanisms

SP Energy Networks has successfully engaged and partnered with European TSOs and academic bodies through the European innovation funding mechanism Horizon 2020 (H2020).

Through this mechanism we collaborated on to successfully awarded projects

1. MIGRATE https://www.h2020-migrate.eu/
2. Ruggedised https://ruggedised.eu/home/

We will continue this engagement with European TSOs in RIIO-T2 to further expand our research areas and 3rd party engagement across Europe.

In RIIO-T2 dependent on the outcomes of the "Strategic Innovation Funding" pot, it may enable strategic collaboration with other public funding streams. We will explore opportunities for collaboration on cross-sector projects and leveraging innovation funding through public sector funding streams as well. However, there need to be appropriate and adequate governance measures in place regarding the reporting and tracking of innovation projects funded through public sector funding in combination with "Strategic Innovation Fund".

11.9.5 Stakeholder Feedback and Engagement for RIIO-T2

Over the course of RIIO-T2 innovation strategy development we conducted three stakeholder engagement events and one consultation over a month to present and collect feedback from a range of stakeholders. We also engaged with the ENA, other network owners and with regulator Ofgem in definition of innovation and innovation benefits tracking process for RIIO-T2.

In order to effectively engage on our innovation strategy, we sub-divided stakeholders into different categories and engaged using a variety of channels such conferences, events, bilaterals and webinars.

Influencers and Gatekeepers – including Ofgem, who manage innovation funding and governance; the Energy Networks Association (ENA), who are the collective voice of the networks, network owners; and the system operator, who define key priorities for innovation and develop network-wide approaches for innovation benefits tracking.

Challengers – for the first time ever, we have been able to engage with independent Transmission User Group and Ofgem's Challenge Group to gain feedback on our methodology for innovation across the price control period. We have also engaged with independent third parties such as generation companies, the Energy Innovation Centre (EIC) and academics to make our plan as forward-thinking and cost-effective as possible.

End Users and Collaborators – these are experts within our business who will be responsible for the successful roll-out of innovation projects, as well as collaborators including vendors, universities and SMEs who will input into our innovation processes and solutions.

Consumers – we've engaged with bill payers throughout the development of our innovation plans. We asked them how important they think it is for us to invest in innovation, how much they are willing to pay for this type of activity and finally checking whether they accept our proposals.

Over the course of our engagement we received various questions from the transmission user group and challenge group which are documented as part of our wider stakeholder engagement summary. Some of the key individual comments and suggestions received through stakeholder engagement directly on innovation are listed below:

Questions

How are you going to train and change your workforce and culture to enable Technology Innovation in T2?

What are the next steps from today, the Innovation plan/ roadmap from here to the start of T2?

What T1 projects will support the T2 innovation plan?

Why is the T2 investment ask 1/3 of what it was in T1?

Comments

SPEN: Do you think our innovation strategy adequately addresses energy system transition challenges?

"As one of UK leading researchers on the digitisation of power networks and cyber security of digital grids, I am very pleased to see that the road map to RIIO-T2 has included the digitisation of power networks. This is a step change in how use digital technologies that allows for two-way communication between the utility and its consumers. Enable customer participation, this will help UK to address the zero carbon emission challenge by 2050."

"Yes, it is an ongoing process and must react to emerging issues (e.g. EVs, reducing inertia/generation), but on track now."

"Not entirely in my view, please see the comments I submitted online. Any strategy (including for Transmission) that is silent on the "missing D" (democratisation) strikes me as having only a partial view of the future."

"Yes - lots to do but this seems to be focused in the right areas."

"Yes, Key drivers for innovation, including decarbonisation, decentralisation and digitisation, are adequate."

"I think the presented strategy covers a comprehensive range of aspects that need to be tackled."

"Yes, however there is considerable work to do which can't be underestimated."

SPEN: Do you think the clusters and themes cover all areas for transmission innovation? Do you have any suggestions for improvement?

"Yes, but must always be on the lookout for new areas requiring innovation."

"A good way of structuring the innovation landscape. Apologies if I've missed something, but you may like to consider adjusting the headings to include a 'whole system' perspective somewhere. For the future, Transmission can no longer be consider as "the system" and a silo of its own."

"yes I think it covers the areas well"

"Yes, they seem to cover the full spectrum"

"Yes, but more emphasizing on digitisation of power networks may be necessary as the application of computing, digital technologies, artificial intelligence and wide area monitoring technologies effectively increase the lifetime, efficiency and utilisation of electricity energy infrastructure as well as improve the ability and quality of monitoring and control of energy system to examine the system wide events."

"Yes, interesting ideas. Again please see my online comments including what I believe is fundamental to the future - achieving "system of systems" technical and commercial coordination across the whole energy supply chain. We still haven't got it established for electricity, and the sector needs to get that sorted before moving into multi-vector working. From the evidence I see, it appears that the utility companies are not stepping up to the mark to use their knowledge and influence. The FPSA project provides much documented evidence of the problem and some suggestions for ways forward. By being silent and unambitious I reluctantly conclude that the network companies are positioning themselves for demise."

"Yes, keen to explore solutions around Digital Twin."

"Yes, but would perhaps like to see more detail under C3 and C4."

SPEN: Do you think the level of NIA and IR investment requested by us is appropriate?

"Yes - but more may be required in future."

"We would like more innovation investment, seriously we think it is an appropriate level."

"Maybe could push for more here as one of the stronger innovators."

"I am not sure I can answer this question correctly. However, I do know the proposed key drivers, decarbonisation, decentralisation and digitisation for innovation are not trivial tasks. The higher level of NIA and IR investment are essential for Scottish Power to explore innovation and to try new technologies, hence to help UK to become neutral carbon society more quickly."

Other Comments

"I note Ofgem's change of position on innovation funding (thanks for explaining it well), but struggle with them expecting the network companies to anticipate and justify innovation needs at 5+ years ahead. Are you making the case with Ofgem for a re-opener; also will they let you have some 'generalised' innovation proposals that you can flex later when the actual needs emerge? (The concern we touched on about the risks associated with high convertor penetration could be such a topic area)."

"This may not strictly fit inside the innovation arena, but thinking it would be good if SPT could have more information available on the web to help developers like us work out where to locate generation and storage projects, e.g. Heat Maps/Generation Capacity Maps, Connection Cost Tools, etc."

"Overall I am very happy to learn the RIIO-T2 Innovation Strategy via the Webinar."

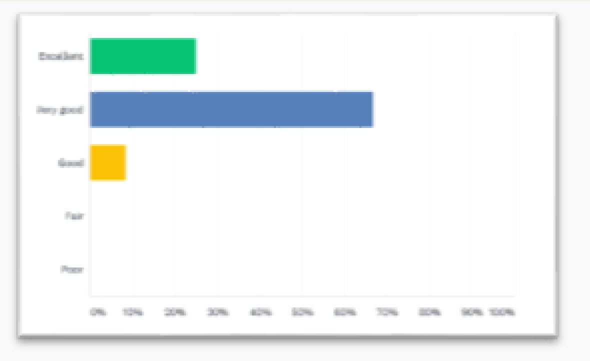


Figure 65 Overall rating of our innovation strategy stakeholder engagement webinar Sep'19

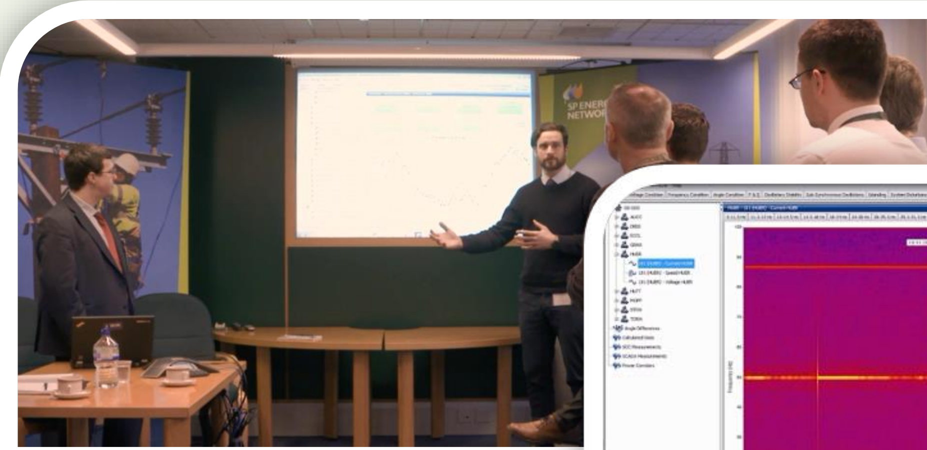
11.9.6 Our Actions following wider stakeholder feedback

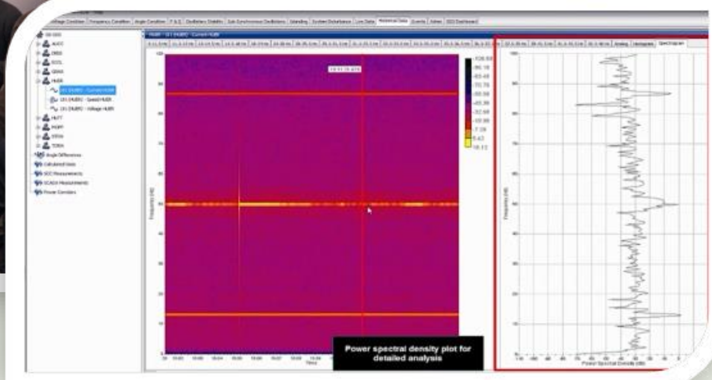
We are committed as a company to listen to our stakeholders and build their feedback into our innovation strategy for RIIO-T2. So what did we do?

- The regulator Ofgem challenged the areas of focus of innovation funding in RIIO-1. They expressed their desire for more transparency and inclusion of 3rd parties in innovation projects. The regulator also directed for more innovation to be undertaken as business as usual in RIIO-T2 and adoption of whole system approach in innovation.
- Our innovation strategy and key areas of focus are based on innovation clusters and themes addressing Ofgem's concern regarding creating strategic focus for innovation funding. The clusters and themes will also help 3rd parties and other network owners identify areas of collaboration in future.
- We are also developing a joint benefits tracking and reporting methodology in collaboration with other network owners and the ENA addressing the need to create more transparency for our stakeholders.
- The transmission user group feedback on the business plan helped us bring out more details regarding the innovation themes and activities to be undertaken in RIIO-T2 within the business plan and greatly enhance the innovation ambition in our plan.
- Our innovation strategy will adopt a whole system approach to innovation and proactively increase our collaboration with distribution operators, gas network and potentially telecommunication and transport network in future. It will allow us to more easily engage with new market entrants.
- We took the feedback from wider stakeholders and reviewed our innovation strategy between October and December submission to increase focus on whole system approach and digitalisation and cyber security. We also took on board the need for better democratisation, and though as a transmission owner we cannot enable this we will enable distribution network operators to build address democratisation to give our consumers and consumers a stronger voice.

"We have led the way in Great Britain's energy sector with our innovation activities. We have implemented new technologies and solutions on our network to address the challenges of the energy system transition.

Our goal is to increase efficiency through constant innovation as we had towards a sustainable, Net Zero future. We will do this by improving network flexibility and driving digitalisation."





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