Scottish and Southern Energy
Power Distribution

Scottish Hydro Electric Transmission Limited

Keeping the lights on and supporting growth

Our strategy for a smarter network

Contents

Introduction

Keeping the lights on and supporting growth

This document has been prepared by Scottish Hydro Electric Transmission Limited (SHETL) as part of its innovation strategy. SHETL, Scottish Hydro Electric Power Distribution plc (SHEPD) and Southern Electric Power Distribution plc (SEPD) are part of Scottish & Southern Energy Power Distribution (SSEPD), which is wholly owned by SSE plc.

Our core purpose within SHETL is to provide the energy people need in a reliable and sustainable way. To deliver our core purpose in these challenging times we recognise that innovation is a necessity. Ofgem introduced the Innovation Funding Incentive (IFI) to distribution network operators (DNOs) in 2005, allowing DNOs to spend 0.5% of combined distribution revenue on eligible projects. The aim of this was to encourage research and development focused on the technical development of distribution networks, and deliver value to end customers. At transmission level this was brought in with the advent of the Transmission Price Control Review 4 (TPCR4) in 2007. After much success from companies through the application of the IFI, Ofgem are introducing new incentives to encourage greater levels of innovation in the upcoming RIIO price control.

In transmission, the need for innovation is driven by a change in the demands being placed on our extra high voltage networks. These challenges are placing an increasing, and urgent, demand on SHETL to provide the capacity required for the development of renewable energy generation.

Proposals for renewable energy generation are distributed across a vast geographical area with relatively sparse core infrastructure. Building the required infrastructure will be a demanding task requiring considerable investment.

At SHETL we are always aiming to be smarter, consistent with the SSE goal of "being the most innovative company in Europe by 2016". Our vision for the next generation of transmission investment will ensure we not only discuss being smart, but deliver on the assurances that we make to our stakeholders.

This challenge is one that we embrace, and we know that a dynamic approach is required to ensure that our transmission network supports the UK's transition to a low carbon economy. In SSE's 2010/11 Annual Report we identified that demonstrating innovation in the management of electricity and gas networks is a core operational priority for 2011/12.

Here we explain how we have worked with people and companies who have an interest in the north of Scotland transmission network, allowing us to identify the areas in which we should concentrate our innovation activity – these are our stakeholders.

By listening to what our stakeholders have told us, we have developed an innovation strategy focused on delivering real benefits. Our discussions have reinforced that the over-arching priorities are to maintain security of supply and keep costs down. They have made clear that we need to provide capacity for the connection of renewables, and provide it quickly.

Innovation is not new to SHETL; despite lower levels of incentives for innovation in previous years, we have introduced a wide range of innovative practices which are already delivering benefits for our customers, both those who provide electricity, and those who use it. Since the inception of the IFI at transmission level we have increased our spend on innovation. We are using the IFI to research projects that will make us better by reducing costs, maximising the use of existing infrastructure, improving our safety and environmental performance, and improving network availability. The drive within SHETL to become more innovative has ignited a culture where we strive to do things better, and as a result we have found ourselves delivering projects in a Business As Usual manner, in addition to those projects funded by IFI. Examples of such Business As Usual innovations are:

- The use of circuit switchers to provide a cost effective alternative to traditional circuit breaker and isolator combinations within substations.
- Installation of mechanically switched capacitor damping networks for reactive power control, allowing more renewable generation to connect to the network.
- Hydraulic "nibbler" allowing towers to be dismantled in a safe manner.
- Recycling tyres and using these as an alternative to gabion baskets in civil engineering works.

During RIIO we would like to expand on these innovations, sharing our experience with such projects to be shared with the other transmission owners.

Our strategy document includes a review of key innovations that we have introduced using the IFI, and highlights those in current development. By building on this experience we will ensure that our innovation activity makes a substantial contribution to providing the energy people need in a reliable and sustainable way.

At SHETL we believe that "innovation with a purpose" is central to our strategy, and this purpose is the implementation of innovation to deliver real benefits to our stakeholders. To this end we have attached an appendix with an outline of how we evaluate and implement innovation projects. See appendix A.

As part of SSEPD we have strong synergies between our sister companies. We do not view our innovation strategy for transmission in isolation from distribution. Within this document we mention projects being carried out under distribution funding that have a direct influence on the future of SHETL innovation.

The European perspective

In November 2010, the European Commission adopted a 'strategy for competitive, sustainable and secure energy'. It stated that Europe's energy sector is on the threshold of 'an unprecedented period of change... [and would need] to diversify existing resources and replace equipment and to cater for challenging and changing energy requirements'.

For SHETL, these 'challenging and changing energy requirements' mean we must deliver upgraded electricity transmission networks by maximising the use of our existing infrastructure, improving our operational efficiency, and innovating as we respond to the decarbonisation and decentralisation of energy.

We have experience working with many different organisations both as collaborative partners and as funding sources. Examples include the Department of Environment and Climate Change in the UK, for the battery solution on Shetland, through to the European Union, for the Moray Hub project. We use monies from these third parties to leverage our innovation funding to deliver the best possible benefit for our stakeholders. Additionally we have leveraged external funding sources for our work with academia through bodies such as the Technology Strategy Board, the Institution of Engineering and Technology Power Networks Research Academy (IET PNRA), and the Engineering and Physical Sciences Research Council to help academia understand the issues at hand within the industry for today and the future. At SHETL we will continue to leverage our innovation allowance as part of RIIO-T1 through accessing third party funding opportunities. We view this as a standard process to achieve the best value for our stakeholders.

We also see collaboration as a key component of our innovation strategy to ensure we balance project risk accordingly. At present we are collaborating with Scottish Power and National Grid on a variety of projects, and with the advent of RIIO funding we would like to engage with them on an increased scale. At European level we would like to actively share and participate in the European Network of Transmission System Operators for Electricity (ENTSO-E) research and development programme, and the ENTSO-E Twenties project. With increased funding we will look to get involved with the Electric Power Research Institute to obtain a wider perspective of the innovation available to the UK market.

1. Identifying stakeholder priorities

Stakeholders

Our innovation strategy is driven by the needs and aspirations of our stakeholders.

In developing an understanding of our customers' needs and the aspirations of our broader stakeholder base, we have gathered information from:

- Day to day contact with domestic and industrial demand customers.
- Developers of new and existing generation.
- Academia.
- Industrial Partners.
- Engagement with equipment suppliers.
- The development and implementation phases of transmission and distribution projects, including the Orkney Registered Power Zone and the Northern Isles New Energy Solutions project.
- Community liaison events associated with our major projects.
- Industry events such as the Distributed Generation Forum.
- Industry reports.
- A formal consultation process as part of our developing Business Plan: 'Keeping the lights on and supporting growth.'

'Keeping the Lights On and Supporting Growth'

'Keeping the Lights On and Supporting Growth' is the name of the business plan that SHETL developed in 2011 for delivery between 2013 and 2021. As part of this we sought the views of customers and other stakeholders on the key activities and investments that should be included within our plan for the new electricity Transmission Price Control. The suite of documents included in this business plan are available on our website www.ssepd.co.uk/projects/transmissionpricecontrolreview/

Community liaison on major projects

Our transmission team employ a number of community liaison officers who provide a valuable point of contact for members of the public. Our presence in areas that are affected by our developments is now very strong and allows us to better understand the concerns and ambitions of the communities in which we operate. This allows us to use their feedback effectively in running our network.

It is clear from these sources that customers are keen to see developments and improvements in many aspects of our business. The views expressed by stakeholders through these forums have allowed us to identify our core innovation purpose:

To safely provide capacity for new connections as quickly and at the lowest possible cost, while continuing to provide the energy people need in a reliable and sustainable way.

To deliver this, we are committed to seven high level innovation objectives, which have been identified through analysis of our stakeholders' views.

Our Innovation Objectives

Here we consider each objective in turn and consider the customer needs and aspirations that have shaped them.

Innovation Objectives

- Accelerate network development and connections including the integration of increasing amounts of renewable generation.
- Minimise the cost of providing network capacity.
- Maximise the use of existing assets to deliver capacity and speed connection.
- Maintain and improve safety and environmental performance.
- Maintain and improve network performance.
- Provide more accurate information on the short and long term asset condition information to allow more informed decision making.
- Remain at the forefront of innovation to maintain our record of providing the highest standards of service at the lowest possible cost.

SHETL has identified a set of innovation themes, which can be seen at the rear of this document (Figure 5). We utilise these themes to help address the innovation objectives identified by our stakeholder groups.

Accelerate network development and connections including the integration of increasing amounts of renewable generation

Historically the priority of SHETL has been to ensure that electricity supplies are available with minimal interruptions: to 'keep the lights on'. Over the years we have supported innovative practices in this area to improve our overall performance.

In recent years the challenges faced by our networks have significantly changed, driven by the UK's move towards a low carbon economy. Our transmission network is evolving from a relatively simple state, delivering energy from a small number of large generation sources to a large number of customers, to a more complex situation where it must accommodate bidirectional power flows created by an influx of new generators, both large and small.

Such demand for new connections is unprecedented. The transmission network, mostly built 50 years ago, was not designed to accommodate the collection of energy from such geographically disparate locations. The rate of increase in demand for such connections was not previously matched with innovative funding, disallowing us to meet the new challenges created by the needs of developers in innovative ways.

This is an area which will benefit greatly from new innovation investment.

> "If better forecasting and therefore investments were made in transmission innovation and upgrades then more timely connection could be made."
>
> Community Energy Scotland

> "The decarbonisation of electricity must be a central policy goal and the supply network must be managed to facilitate this... It is also critical that process improvements are put in place that reduce the delay currently being experienced by renewable energy schemes once they achieve planning permission."
>
> Aberdeen City and Shire

> "One of the aims of new or upgraded transmission infrastructure should be that it facilitates a move towards low-carbon electricity supply."
>
> Scottish Natural Heritage

> "The grid connection issue is felt to be the biggest detriment to growth of [renewable energy]."
>
> Scottish Rural Property and Business Association

Minimise the cost of providing network capacity

Whilst it is clear we need to act swiftly and effectively to provide the capacity required by our customers, we must ensure that in meeting this demand we minimise the costs of the work required.

Our ultimate stakeholder is the UK electricity consumer; people who pay electricity bills have a legitimate interest in how they are made up. Given that transmission costs are a contributor to energy bills, it is important that we minimise the cost of running our transmission network. Our electricity connections customers, and other stakeholders with an interest in the availability of grid capacity, have a direct interest in the costs associated with the development and operation of the transmission system. They wish to see costs minimised, but at the same time wish for the network to provide capacity quickly and easily to allow them to pursue their plans.

The need for SHETL to ensure the costs are kept to a minimum is illustrated in quotations from two stakeholder organisations with a direct interest in the matter.

> "We are committed to ensuring these challenges are met in a way that provides value for money for consumers."
>
> Ofgem

> "Domestic energy bills already carry a growing number of 'surcharges' to fund a variety of energy policies. Those in fuel poverty cannot afford to pay such regressive surcharges."
>
> Age UK

Maximise the use of existing assets to deliver capacity and speed connection

Widely favoured by our stakeholders, one of the most efficient ways to swiftly provide capacity for new renewable energy developments is to 'make the most of what we have' – to maximise the efficiency with which we use current assets.

Transmission networks have extra capacity which is traditionally reserved to provide security of supply. This is known as system redundancy, an as yet largely untapped resource which could provide capacity for generation connections, reduce waiting times, and lower costs.

We do not limit the definition of 'what we have' to SHETL assets; we believe that all network operators in the UK have a responsibility to work together to ensure that synergies between the different networks are exploited through the use of flexible generation contracts.

Efficiently using our existing assets is an approach supported by a wide range of stakeholders including those whose primary role is as a generation developer, and those committed to protecting the natural assets of the area in which we operate.

We have led the way in the development and implementation of innovative approaches to maximise the use of our existing distribution network as evidenced by the Orkney RPZ. This scheme uses active network management to manage generation output in real time to match the available network capacity. To date, 7.7MW of generation has been connected, and a total of 20MW is contracted to connect. This system uses a smart grid methodology costing less than £500,000, as compared to a cost in the order of £30,000,000 for an additional 33kV circuit.

"[SHETL must] consider how they can work with gas networks, district heating networks and their own asset replacements and developments to deliver lowest cost low carbon heat and electricity to users."

Renewables UK

"Find ways of providing more electric vehicle charging points whilst minimising network reinforcement."

Renewables UK

"Reduction of system redundancy – through innovation and design standard."

Community Energy Scotland

Maintain and improve network performance

The past performance of our transmission network has been excellent. As the UK's energy infrastructure evolves to accommodate more widespread generation sources, we must adapt to ensure this high standard of performance is maintained.

It is notable that customers appear to take this aspect of SHETL's responsibilities as 'a given'. This is reflected in the infrequency that system reliability was mentioned as a priority by our stakeholders. In contrast we strongly believe that in line with our company's core purpose of providing the energy people need in a reliable and sustainable way, this should remain as a focal point for our future development. As such, maintaining and improving network performance is one of our innovation objectives.

"The Council would wish to see the current high levels of reliability maintained."

Orkney Islands Council

"SHETL should concentrate in some areas on the quality of the transmission they provide."

Scottish Rural Property and Business Association

Maintain and improve safety and environmental performance

SHETL's primary responsibility to its stakeholders – including employees, contractors and customers – is to ensure their safety. Safety is the number one value of our company where we pride ourselves on 'doing everything safely, or not at all'.

In keeping with our commitment to sustainability, SHETL's target every year is to achieve zero environmental incidents.

These priorities are shared by our stakeholders, who have expressed their desire for safety and sustainability to be identified as priorities in a number of ways.

"Safety, reliability and environmental concerns should be of a primary concern for all transmission businesses."

EDF Energy

"It is through research that, for example, alternatives to the use of SF6 as an insulator may be found allowing for possible phasing out of this potent greenhouse gas."

SEPA

"Operating in this sensitive ecosystem, consideration of potential environmental impacts is paramount. SEPA welcomes SHETL's commitment to minimising their impact on this environment."

SEPA

Provide more accurate information on the short and long term asset condition information to allow more informed decision making

There is a desire amongst stakeholders that SHETL makes the best possible use of existing assets. A key way of doing that is to ensure that assets are maintained and replaced at the right time – before they fail, but at a time when they have contributed as much as possible to the network. Currently our assets are replaced in line with a standard methodology agreed jointly with National Grid (NG), Scottish Power Transmission (SPT) and SHETL. We believe that to meet our customers' needs we must make the most of existing infrastructure to maximise security of supply and minimise costs. We must gain a better understanding of how our assets age and fail, and put in place a programme which best meets this.

Similarly innovations and techniques can allow the re-use of existing assets in new roles, for example insulated crossarms allowing existing towers to carry higher voltages.

"Transmission infrastructure should be such as to minimise its carbon footprint [including] taking account of construction materials and processes."

Scottish Natural Heritage

Remain at the forefront of innovation to maintain our record of providing the highest standards of service at the lowest possible cost

New ideas, improvements to process and design, and innovation have been key to SHETL's success to date and are fundamental to our ability to adapt to the challenges of the future. To deliver the changes and improvements our stakeholders desire, we must maintain a strong culture of innovation within SHETL, by actively promoting and supporting new idea generation to provide the feedstock for tomorrow's innovations. We are building on our underlying innovative flair and will utilise the Network Innovation Allowance (NIA) to push the boundaries and accelerate the rate and effectiveness of innovation on the network.

As a spur to employee participation, idea generation, continuous improvement and operational excellence, we promote a systematic approach to implementing ideas that add value. This is through the Licence to Innovate (L2i) scheme, under which any employee can suggest ideas for improving the way SHETL operates, consistent with our core values. People with ideas with significant potential are granted a L2i, under which they can spend two months further researching their proposal. Subject to the outcome of the research, the idea may then be piloted prior to full implementation.

Our focus on innovation complements our work in research and development, where new processes, services, products and technologies are created, which will enable us to remain a successful company in the future. The SSE Group's corporate research and development function prioritises actionable projects focused on 'the day after tomorrow' which can be delivered by employees, working with external organisations. In total, during 2010/11, and working with partners, SSE Group initiated research and development projects with a value of almost £10m.

The SSEPD IFI programme is an ongoing multimillion pound plan containing a wide range of projects. One of these is an engagement with the Energy Innovation Centre (EIC) to accelerate relevant innovation investments. The EIC is a spin out of EA Technology Ltd. and takes the form of a "Dragons Den". It is aimed at ideas from SMEs, academics and individuals from out with the industry. The centre ensures that ideas are given support and can be developed in a way that is aligned with the needs of the business whilst ensuring that other forms of funding are being leveraged prior to specifically seeking IFI funding. Ultimately the process ensures that ideas are considered and steered through development to a point where they have a business case.

In addition to the EIC, SSEPD are funding partners of the IET PNRA which provides outstanding graduates with the support and finance for a high-status postgraduate university course. This shows our continued commitment to developing the engineers and engineering solutions that we see as vital to meeting the challenges of the years ahead.

A key challenge for the industry is recruitment. Innovation has a secondary but important purpose of making utilities an attractive and challenging career for the engineers of the future. SHETL work with universities and other groups to gain leverage from innovation in this context.

Retaining and recruiting skilled staff is very important to SHETL, as our innovation programme and the implementation thereof depends upon it.

> "The RIIO model seeks to promote this behaviour by rewarding innovation and setting a long-term framework to encourage a more flexible and forward looking approach from network companies."
>
> Ofgem

> "I think it is great that innovation is embraced. I get a chance to develop ideas to make routine processes easier."
>
> SSE Colleague

> "The continual challenge of change and innovation in the business make the job that I have interesting."
>
> SSE Colleague

Why we must innovate

It is clear that stakeholders wish to see substantial change in the way we plan, manage and maintain our networks and it is important that we rise to these challenges. To deliver this using 'Business As Usual' methods in a timescale that is acceptable to stakeholders would be extremely difficult. By looking at our objectives we can show that without innovation SHETL will not have the ability to meet the dynamic challenges of the future.

Accelerate network development and connections including the integration of increasing amounts of renewable generation

Current methods of network development do not specifically provide for the effective connection of more renewables. These require greater levels of active system management due to the variability of their electrical output. Innovation in this area is essential to ensure we are able to connect greater levels of renewable energy and meet the 2020 carbon objectives.

Minimise the cost of providing network capacity

Transmission operators have an obligation to provide capacity for customers wishing to connect to the UK grid. The cost of reinforcement is in part picked up by electricity bill-paying customers. Given the upward pressure on energy prices caused largely by wholesale prices, it is ever more important that all controllable energy costs are minimised. If we fail to innovate, the costs of providing network capacity by traditional means will be higher, resulting in higher bills for UK electricity consumers.

It is important to consider the effects of not innovating on the developers of large scale renewable energy developments. Lobbying groups representing developers frequently cite the cost of connections as a barrier to creation of more renewable capacity. Failing to act to reduce these costs could be a contributing factor to the UK falling short of its 2020 carbon targets.

Maximise the use of existing assets to deliver capacity and speed connection

An important part of maximising the use of existing assets is avoiding the need for additional or replacement transmission lines. If we did not consider new or alternative transmission technologies, such as new tower designs, planners would have a strong basis, for rejecting planning applications for environmentally sensitive developments. This will generate additional costs, delays and damage the relationship between ourselves and our stakeholders. This could push back the connection of new renewable energy sources and hinder progress towards the UK 2020 carbon targets.

Furthermore, traditional methods of network upgrade are extremely labour and resource intensive. If we continue the traditional approach to network development, the situation could arise where the need to carry out several such projects simultaneously could cause significant resource shortages. For example, increased outage constraints on the network would definitely impact on our customers, negatively affecting progress on all projects as well.

Maintain and improve safety and environmental performance

Environmental and safety legislation is becoming ever more stringent. Couple this with our stated primary responsibility of ensuring the safety of our employees, contractors and customers, it is essential that we innovate. Failure to do so could result in injuries being sustained by personnel or damage to the environment, and ultimately in additional costs from fines and legal proceedings as infringements and incidents are more likely to occur.

Maintain and improve network performance

The way in which we manage our network must change so we can maintain network performance in the most cost effective way possible. If we were to rely entirely on traditional methods of managing network performance, we may fail to adopt technologies which would reduce costs.

Provide more accurate information on the short and long term asset condition information to allow more informed decision making

Key to operating sustainably is making the most of existing assets. If we continue to replace assets in line with a standard, age-related programme, rather than a system where maintenance and replacement are condition dependent, it is likely that many hundreds of network components would be replaced earlier than required. Similarly, heavily-used assets may fault before scheduled work is undertaken, posing a threat to electricity supplies.

We have assets exposed to some of the most harsh environments in the UK, with improved monitoring we can be better informed of the conditions that they are exposed to.

Continuing with the traditional approach will result in higher than needed levels of natural resources being used, higher costs, and lower standards of supply security. Condition monitoring will allow us to identify heavily stressed assets which we can then monitor.

Remain at the forefront of innovation to maintain our record of providing the highest standards of service at the lowest possible cost

SHETL believe that the incentives created by RIIO are valuable to ensure that transmission companies maintain high standards of service to customers and the broader spectrum of stakeholders. If we fail to innovate in important areas of our business, SHETL will perform poorly during the RIIO price control.

2. Supporting stakeholder priorities through innovation

SHETL has an innate focus on innovation, as described earlier. Innovation for innovation's sake has no place in our company. We are experienced in developing innovations for transfer to Business As Usual, as illustrated by the following examples of successful implementation:

- In 2003, we were the first company in Europe to install the American Superconductor D-Var device to manage reactive power flows on our Orkney network. Further development of a similar technology was established at Tealing substation in the east of Scotland, in the form of the Static Var Compensator. These technologies prove we are keen to adopt a flexible AC transmission system capable of regulating voltage within safe limits, and balancing reactive power to operate the system as efficiently as possible.
- In 2009, again in Orkney, in what we believe to be a world first, our sister company SHEPD connected new generation to a fully operational Active Network Management system to manage multiple network constraints from multiple generators. This system will allow an additional 20MW of renewable generation to connect, and has served as a hub of several innovative solutions since it was conceived.
- We have installed Quad Booster devices at strategic points on our system to increase the transfer of power between the sources of renewable generation in the north of the country and the increasing levels of demand further south. These have successfully allowed us to connect more generation customers to our system in much quicker time scales than would traditionally be required.

Current innovation projects

During the TPCR4 reporting period we moved a number of projects through several stages of the Technology Readiness Level (TRL) scale which allowed us to closely follow their development. TRLs are an industry standard approach for measuring how ready innovations are for Business As Usual implementation. Here, with consideration of the stakeholders' priorities which drive them, we summarise some of SHETL's current suite of innovative projects which are progressing to Business As Usual.

Accelerate network development and connections including the integration of increasing amounts of renewable generation

Unique Conductor Development

The delivery of the unique 625mm^2 conductor produced by Lamifil on the Beauly-Dounreay circuit has created a highly rated asset capable of being strung on the existing transmission infrastructure. We have significantly reduced the time required to build a new circuit capable of transferring generation from decentralised sources. The conductor's increased capacity has provided the platform for more renewable generation connections without breaching the Electricity Safety, Quality and Continuity of Supply Regulations.

Minimise the cost of providing network capacity

ACCC Conductor

A third circuit was installed between Peterhead and St. Fergus at 132kV using Aluminium Conductor Composite Core (ACCC) conductor. This uses innovative composite core technology to give the conductor a very high current rating with very little sag. This means the structures on which the conductor is strung do not have to be as high, or as heavily engineered, as those required to carry its traditional alternative. Costs were significantly reduced in this project through the use of 'Trident' wood pole construction, rather than galvanised steel towers. SHETL has led the world's first installation of this type of conductor onto pole structures.

Maximise the use of existing assets to deliver capacity and speed connection

Dynamic Line Rating

At present the SHETL system is designed to ensure safety clearances (primarily the distance between the conductor and the ground) are within prescribed limits at all times. Dynamic line rating involves using real time data to make informed decisions about how much power can flow through a conductor without breaching these limits. This allows the maximum rating of the asset to be utilised, and unlocks the potential for more generation to be connected to the system.

To facilitate this, SHETL has trialled the Nexans CAT-1 transmission line monitoring system which allows accurate real-time rating of transmission lines by monitoring the tension on power lines. These field trials are taking place on our Inveraray-Port Ann-Carradale circuits where there is extensive renewable generation connected. The installation took place in 2008, and we believe this to be the first live installation on the UK transmission network.

Maintain and improve network performance

Flow Battery

Batteries can provide energy storage on transmission networks, an important ancillary service which can help manage peaks and troughs on the system. Little is understood in the UK about the suitability of the various types of batteries for different purposes. In 2008 we connected a flow battery, the first to be installed on the UK system, to the DC supplies of a transmission substation.

The primary aim of the project was to understand the technology, assess its potential to improve network performance and explore alternative energy storage options. The original battery was designed for the American market, and through IFI funding we have gained experience and insight into this technology for the UK system, and have developed a proposed specification. Further development should lead to advancement in the understanding of how this battery can improve network performance on the SHETL system both as a DC supply and as a larger network support mechanism.

Maintain and improve safety and environmental performance

Alternative Tower Construction Methods

A particularly challenging aspect of building transmission towers is creating access for the heavy machinery required for their construction. Traditionally, this has required roads to be built, accompanied with their associated environmental impacts.

SHETL are addressing this issue by trialling alternative methods of tower construction, focusing particularly on the use of a modified emergency return to service (ERS) system as a lightweight crane to erect and dismantle transmission towers. This would avoid the need to construct access roads suitable for heavy and cumbersome traditional mobile crane.

We have analysed the benefits of this system, and subsequently purchased the equipment necessary for this project to be put into the trial stage. We plan to fully trial this system, invest in staff training and in purchasing more equipment before moving the process to Business As Usual.

Provide more accurate information on the short and long term asset condition information to allow more informed decision making

Mobile Condition Monitoring System

Working with our partners in industry SHETL has been trialling a new, non-contact, non-invasive condition monitoring system suitable for the condition assessment of Open Busbar Transmission Substations. The system has been constructed and has been installed for a number of months at one of our substations. This type of equipment can be used to monitor items of plant that have operational restrictions placed against them, allowing operational personnel to work in greater safety in the vicinity of any affected plant. The key to this system is that it is non-contact and non-invasive, thus allowing a high level of safety to be maintained during monitoring of plant. The plant's integrity is maintained as the system is non-invasive and avoids any problems associated with interfering with plant. This technology will allow SHETL to take an increasingly planned and proactive line in both network and asset management.

Remain at the forefront of innovation to maintain our record of providing the highest standards of service at the lowest possible cost

IEC-61850 Protection Standard

The application of the IEC-61850 standard for substation communications is becoming wide spread in substation automation systems around the world. Recognising that this is an issue best tackled on a collaborative basis, we are working with all UK transmission network owners and specialist academic institutions to evaluate the opportunities that may be offered by the possible future deployment of IEC-61850-based protection systems. To gain the greatest level of benefit for our stakeholders it was recognised that the collaborative project should be initiated with the other UK transmission owners (NG and SPT). By working together we have been able to achieve a coherent view of this new and emerging international standard for transmission system protection and control. This is important to ensure that the UK energy industry as a whole remains at the forefront of innovation to ensure we meet our stakeholder needs in the coming years.

3. Innovation, Ready For The Next Step

In the preceding parts of this strategy document we have explained what drives SHETL's innovation plans and have illustrated our track record in undertaking innovation that can quickly move to Business As Usual.

We are committed to developing innovative solutions which will help support our stakeholders' ambitions. We have found our previous allowance during TPCR4 to be useful in developing academic studies into real world engineering solutions, and in bringing about limited scale field trials – notably with our Flow Battery and Dynamic Line Rating projects. We believe that the full complement of innovation allowance during RIIO-T1 will allow us to accelerate the development of our projects. This will aid us in bringing about the greatest revolution in transmission planning, design, construction and management seen since the 1950s.

We have a pipeline of innovation, ranging from projects which have already been adopted for day to day use, to a large number in early development, all of which are focused on supporting our stakeholders' priorities.

In the middle of this spectrum we have a rich variety of projects at the higher end of the TRL scale, which can be quickly brought to Business As Usual level within one to three years. With the full complement of RIIO-T1 innovation allowance, we will have the ability to deliver extensive network benefits within a short period of time.

Here we summarise just two of the projects which are poised to have a positive and lasting effect on our networks within one to three years, helping to meet our stakeholders' ambitions in a short period of time.

Novel Tower Construction

Transmission tower construction is dependent on large civil engineering works to allow the transportation of heavy machinery and materials to site. This is an environmentally damaging activity, with some sites taking a long time to return to their previous state. This Novel Tower Construction aims to validate the use of ERS technology to erect and dismantle transmission towers where traffic access is difficult, the route is environmentally sensitive or where other impracticalities exist. By employing this technology and all terrain vehicles, the requirement for temporary roads will be significantly reduced or removed, and we anticipate a reduction on the impact on the environment. Successful implementation of this method will provide a safer working environment and considerably reduce construction costs.

There has been a steady spend on this project during TPCR4 with a single unit purchased and some small evaluation trials taking place. Field operatives have praised the impact this innovation will have on their occupational health and safety, whilst we have exhibited our focus on stakeholder values by mitigating our environmental impact and providing a minimum cost solution to providing system reinforcement.

Figure 1: Novel Tower Construction

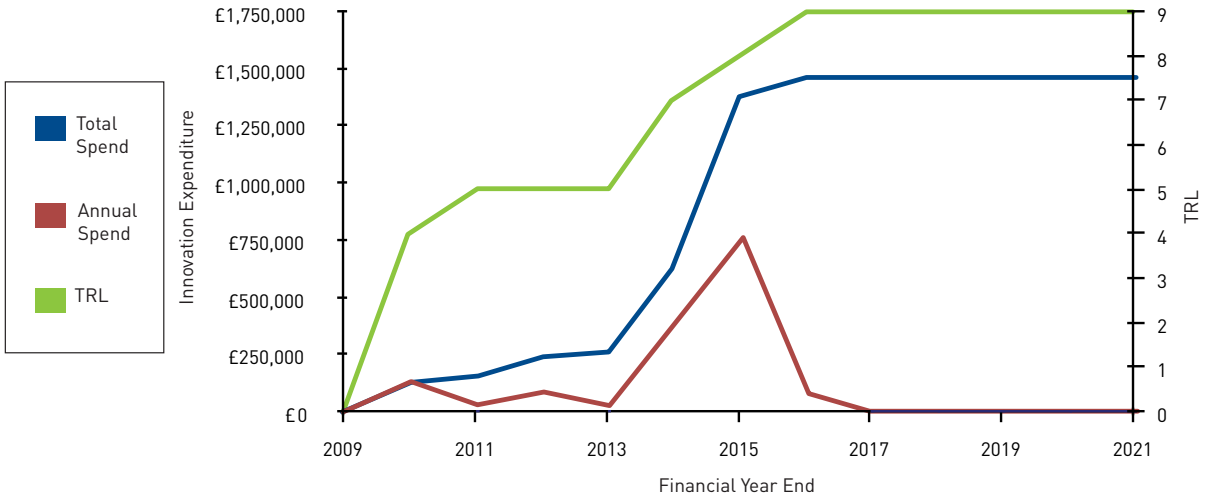


Figure 1 indicatively outlines how innovation expenditure will be invested in the Novel Tower Construction project, and how the TRL will develop before the idea is adopted as Business As Usual. Justification for this is predominantly based on the purchase of several construction rigs, allowing this technique to be used to construct a complete tower line. We will follow this with carbon emission and environmental impact assessments, and an internal cost evaluation to ensure comprehensive proof of the innovations potential is realised.

We believe that investment in this programme will deliver a wide range of benefits at a Business As Usual level, including its potential for SHETL to meet our stakeholder concerns in a cost effective manner.

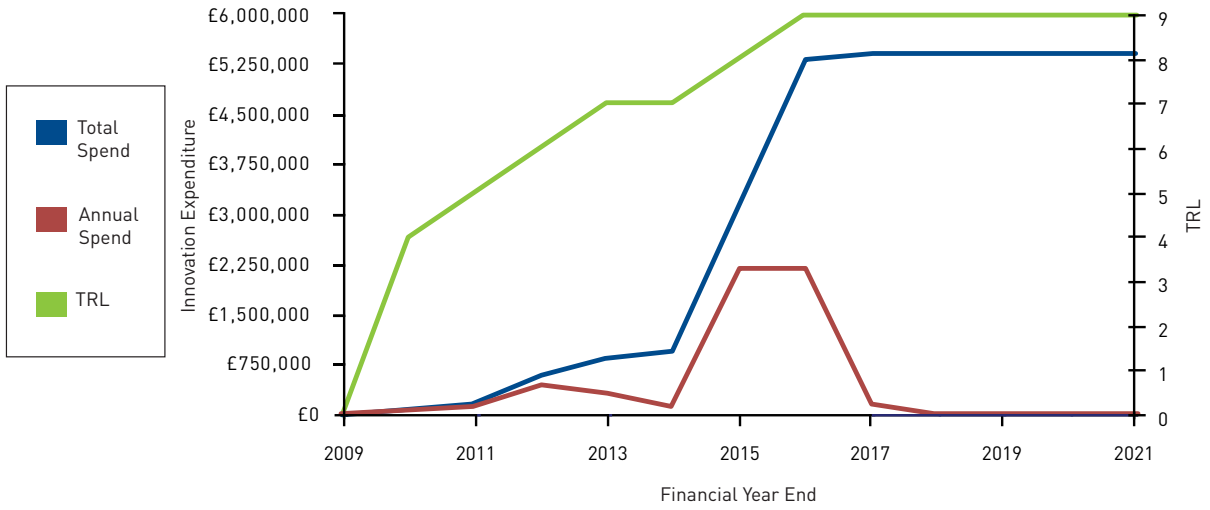
Insulated Crossarm

Tower crossarms form a fundamental part of the transmission tower structure, effectively holding the wires clear of the tower body. Traditionally the live circuits are separated from the earthed crossarm using insulators which provide an acceptable solution to maintaining a safe power system. By combining both the crossarm and insulators in a single product real benefits can be achieved. Working in conjunction with our colleagues at NG and Manchester University, SHETL has contributed to the development of an insulated crossarm product. The comparison between the traditional and insulated crossarm can be seen in Figure 2.

Figure 2: Insulated Crossarm

The first product was developed to replace the crossarm of an L3 type tower allowing the tower to increase its operating voltage from 275kV to 400kV without the need for major reconstruction. This increase in voltage is accompanied by an increased ability to transmit power across large distances, allowing us to meet our stakeholder objectives, notably accelerating the development of the network and providing the platform for renewable generation to connect. It will allow us to maximise the use of our existing asset base without the need for significant investment in the system. The insulated cross arm has the potential to be retrofitted to exisiting towers thus extending the useful life of the asset, avoiding the need to transport excessive materials to site, thus significantly reducing any civil infrastructure that may be required.

Figure 3: Insulated Crossarm



TPCR4 expenditure was predominantly used to collaborate with our partners to deliver a working prototype, and test it at two trial sites on the SHETL system. As the RIIO-T1 period begins we anticipate that a full circuit trial will be necessary to understand the full benefits of the product in meeting our stakeholder driven innovation objectives. Meaningful cost savings will be passed onto our stakeholders through the avoidance of constructing new transmission lines to provide additional capacity on our network. In addition to this the implementation of the insulated crossarm as Business As Usual will result in a considerable reduction in the level of both logistics and materials for a given existing circuit upgrade.

These two projects outline some of the work that SHETL has carried out during TPCR4 utilising our innovation allowance to the greatest benefit possible. These technologies are now at a stage where a significant increase in spending is required to see their potential realised to the benefit our stakeholders.

4. Forward Thinking: RIIO-T1 Innovation Programme

The challenge being presented to the UK transmission network is immediate and pressing. The success of our innovation strategy in addressing that challenge depends on ensuring we support our stakeholders' aims by delivering the right changes at the optimum time.

We have a pipeline of innovations, ranging from those already in day to day use to a large number in early development. In between lie those which are poised for adoption. We summarised two particularly valuable examples of innovations at this stage in the previous chapter – novel tower construction and insulated crossarms.

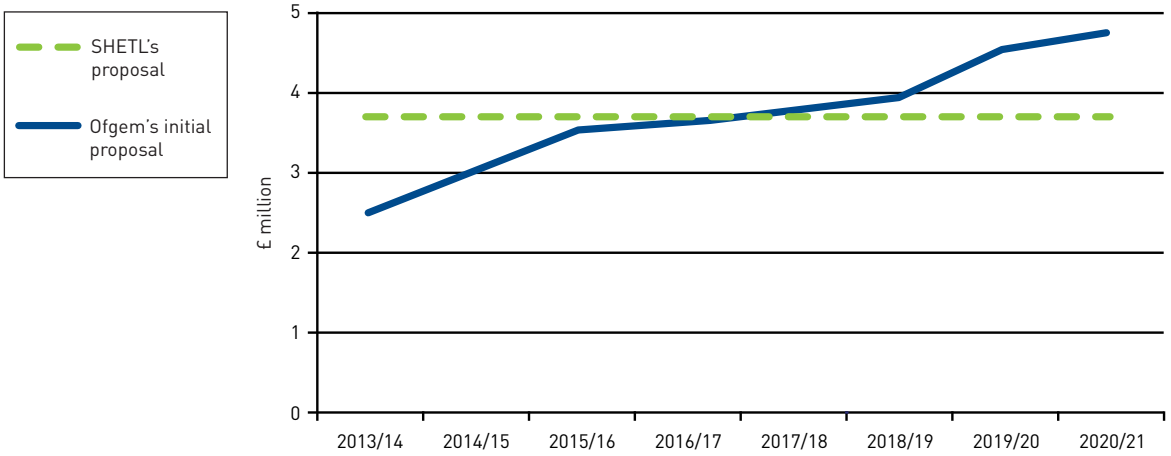
In order that the maximum benefit for stakeholders is delivered in RIIO-T1 we are keen to bring as many innovations to business as usual within the period. To achieve this we propose a change to the traditional allowance profile. Rather than our allowance being directly linked to our annual revenue, we suggest that our total allowance be divided evenly across the eight years of the RIIO-T1 period, as illustrated in Figure 4 overleaf.

By placing emphasis on investment in innovation at the beginning of this period, we will initiate many projects that could be taken through to Business As Usual in the second half of RIIO-T1. These include the novel tower construction and insulated cross arms projects, where seed funding under TPCR4 has led to us being in a position to push through with full scale trials. The aim of these trials is to show that the systems could be used as Business as Usual. Under the current proposed funding profile, many projects will have to wait until the latter years of the RIIO-T1 period to be commenced, with consequent delays to the adaption of successful technologies and techniques as part of Business As Usual activity.

Along with our programme of innovation we will construct testing facilities early in RIIO-T1 to be used throughout the period to evaluate new materials and equipment in real environmental settings without risking the network. This will allow us to assess new products in detail before any installation takes place on the network. These testing facilities will take the form of two installations; the first in a live coastal location to assess how equipment functions in a harsh saline/ polluted environment the second being at high altitude exposed to extreme winds and temperatures. We will develop these facilities at locations on our network which are being made redundant due to our transmission development programme. The installation of gas insulated switchgear at Dounreay has has created available space within the substation which we will seek to utilise, while the delayed removal of transmission towers on areas of our network provide the opportunity for mechanical testing. Upfront funding will allow these testing facilities to be created early in the price control period which would bring real benefits in the innovation programme and thus to our stakeholders. We will work in collaboration with our colleagues in other UK transmission companies to ensure that the facilities are fit for purpose and we would seek to collaborate on projects that would utilise them.

There will be four main tranches of work that SHETL will carry out in the early years of RIIO-T1; follow on work from TPCR 4 projects, the construction of testing facilities, creation of a programme of RIIO-T1 works, and continuous work on ideas and concepts for the Network Innovation Competition (NIC). We believe that to gain the most from the NIC there will need to be a significant leverage of NIA projects to feed in the appropriate

Figure 4: Allowance Proposals



systems and concepts to ensure successful bids are created. These four areas show a high degree of overlap that will require a significant level of investment for their potential to be achieved in full within the control period to assist our stakeholder aims.

The following projects are a high level selection of our proposed innovation programme for RIIO-T1. We have designed it to align with the objectives of our stakeholders.

Minimise the cost of providing network capacity

1. Aluminium Sheathed 132kV Cables – At present SHETL use lead sheathed cables due to their corrosion resistance when put in contact with moisture. They are more expensive, have a larger diameter, and have a larger mass than aluminium sheathed cable. By assessing the possibility of using aluminium sheathed conductor we can significantly reduce the cost of providing network capacity, and as a result reduce the handling of lead base compounds improving the occupational health of our staff.
2. Monopole Tower Structures On 275kV Circuits – At present SHETL only use traditional Steel Lattice towers at this voltage level. On voltages above 132kV we will seek to change this to offer a range of designs. Public perception of infrastructure on the landscape is very important and has led to lengthy delays and cancellations of projects due to objections. Simplified monopole designs will help reduce the visual impact of our infrastructure on the countryside and could potentially accelerate the planning process.

Maximise the use of existing assets to deliver increased capacity and speed up the connection process

1. Aluminium Conductor Composite Reinforced (ACCR) – This conductor consists of an inner core of fibre reinforced matrix embedded in high purity aluminium, surrounded by strands of temperature resistant aluminium zirconium to provide a conductor with high ampacity and mechanical strength, whilst significantly reducing the weight compared to Aluminium Core Steel Reinforced conductors. The installation of this conductor on the system will allow us to maximise the use of existing transmission tower infrastructure, which would otherwise be unsuitable using traditional conductor technologies. Conductor uprating using ACCR ensures safety clearances will not be breached under high power transfer conditions.

Maintain and improve network performance

1. ERS Towers – Temporary tower structures exist within SHETL at present that can be both complicated and time consuming to construct. This proposal will see simplified towers being used to reduce the ERS time during faults and construction work. With an ever more unpredictable climate ahead it is important that SHETL is ready to maintain supplies should a significant event occur that damaged our transmission infrastructure.
2. Intelligent Alarm System – Our Network Management Centre receives a large number of alarms constantly from SHETL sites to provide a comprehensive overview of the plant alarms and operations, communication failures and protection trips on the system. Currently one screen exists for the transmission system, providing a terminal for information and acknowledgement of alarms. The rapid expansion of the SHETL transmission network in the coming years will impinge on the control engineer's ability to maintain a comprehensive overview of every alarm on the network. This project will provide concise updates on the alarms present to provide decision making assistance, helping to maintain a high level of network performance. It has the potential to be developed into a useful asset management tool with the ability to archive all incoming alarms to provide a comprehensive history of our asset use.

Maintain and improve safety and environmental performance

1. Using Helicopters for Tower Construction – This method is used in other countries and could be utilised in our construction plans for the future. Using helicopters to take tower structures and other components to site will result in a significant reduction in environmental impact and potentially cost. There will be a reduction in transport infrastructure as current tower construction methods require cranes, further reducing our environmental impact.
2. Online Simulator – This will incorporate network connectivity from SCADA, prescribed system limits, power flows, network parameters and use state estimation to analyse the power flows in an Online Simulator. A contingency analysis will then run, the output of which will be sent directly to the control engineers display. This removes the need for the manual creation of PSSE (power system analysis software) models to provide essential network information. As the transmission system becomes more complex, the need for decision making assistance through an Online Simulator will ensure the system is operated safely to its limits. In addition, real time information on the flows through each of our assets will allow SHETL to make informed decisions about how best to utilise our assets.

Provide more accurate information on the short and long term asset condition information to allow more informed decision making

1. SCADA + Relay Integration to Identify Breaker Trip Time – Maintenance of modern transmission circuit breakers require outages of approximately one day to adequately perform all maintenance tasks including a circuit breaker timing test. This is carried out on a routine basis every four years, regardless of the duty that may have been put on the asset during this time. This project will develop a system for automatically interrogating relays post fault to evaluate the trip time of the breaker. Using the information from the relays, we can develop a more proactive maintenance programme, ensuring we maintain high levels of network performance in relation to the increasing levels of transmission infrastructure. By capturing the fault waveform, we can develop fault location techniques to improve the occupational safety of our operatives, and return the network to its normal state more rapidly.
2. Managing Large Populations of Subsea Cables – In the coming years, we will have a large number of strategic subsea cables under our ownership. Our sister company SHEPD has a depth of knowledge in this field due to the ownership of a very large number of subsea distribution cables. The increase in power flows at transmission level create the challenge of stepping the technology up to a higher value system in terms of both voltage and population. To that end we will look to carry out projects aimed at continuous monitoring of the subsea assets that could communicate the asset condition to engineers on shore. This may allow pre-emptive action to be taken to repair or replace the asset prior disruptive failure occurring.

Accelerate network development and connections including the integration of increasing amounts of renewable generation

1. Modern Novel Conductor Deployment – Modern conductor types could prove to be a major benefit to the network in the years to come. Composite cores allow conductors to achieve much higher temperatures than was possible before, allowing a greater level of power to be transmitted through the existing rights of way. This will allow connections of large generators using existing infrastructure such as poles or towers with minimal interference, inherently accelerating the reinforcement process

2. Dynamic Line Rating (DLR) – SHETL has ran limited scale trials using DLR systems. Under RIIO-T1 we would see this scaled up to unlock the full potential of our existing infrastructure. This would be coupled with new commercial arrangements with generators based on the network connections real time rating so that generation could be matched to network capacity at a local level.
3. Active Network Management (ANM) – Following on from the success of the world's first ANM scheme on Orkney by our sister company SHEPD we would seek to implement this methodology on the transmission system to access the latent capacity of the infrastucture in real time. By marrying new commercial arrangements along with emerging technologies such as DLR it could be possible to connect many more generators to the network than is currently available under traditional approaches.
4. Transmission Energy Storage Park – Many of our projects contain a significant amount of commercial innovation, one such example is the Orkney Energy Storage Park. This project is currently being developed under Low Carbon Network Fund Tier 1 funding in our distribution business. It uses physical and commercial contracts, and markets to encourage third party energy storage providers to locate and provide services to facilitate the management of distribution constraints. We anticipate expanding and adapting this principle to transmission applications during RIIO-T1 under NIA or NIC funding as appropriate.

Remain at the forefront of innovation to maintain our record of providing the highest standards of service at the lowest possible cost

1. Copperless Substation – Due to the significant increase in metal theft throughout the UK it would be prudent to investigate the possibility of reducing copper use. There are technologies in development to reduce the use of copper in substation earthing systems that could be developed to allow this aim to be achieved. The move towards using the IEC-61850 protection protocol protection will inherently aid this, as it utilises ethernet cables rather than copper wires within substation control panels.
2. Shetland Study – Following on from the leading edge work being carried out by SHEPD on Shetland through the NINES project we would investigate the applicability of these concepts to the transmission system in collaboration with our partners in the UK transmission community.
3. HVDC Control Centre – With the future holding a large number of HVDC installations on the horizon, we must prepare for the integration of these with the AC system. Equally important is the integration of different control system architectures from different manufacturers, and understanding how they will interact with one another in multiple terminal installations. SHETL is leading the stage with the Moray Hub project and we will seek to continue being a leading light in this area.

We have identified several projects that will qualify for the NIA, and we have considerably more thoughts that have not been brought out in this document. To complement these smaller projects we are developing a number of bold projects for the NIC which would be developed using a small proportion of our NIA funding. This will permit sufficient time and resources for critical evaluation of these ideas, ensuring our bid process is given sufficient financial backing, and providing the NIC with projects that have the potential to revolutionise the transmission system beyond the perceived challenges of the coming years.

As we move through the period of RIIO-T1, SHETL will remain flexible to the demands on a modern transmission network to meet the changing demands of our stakeholders, and ensure the business meets the objectives set out in this strategy. We will continue to be open to innovative developments that will help us to achieve our strategic goals of maximising our use of existing infrastructure, minimising costs, and improving our safety and environmental performance. Through our innovation evaluation process we are always scanning for academic developments, manufacturer products and internal ideas to ensure we are prepared for the future network.

Delivering

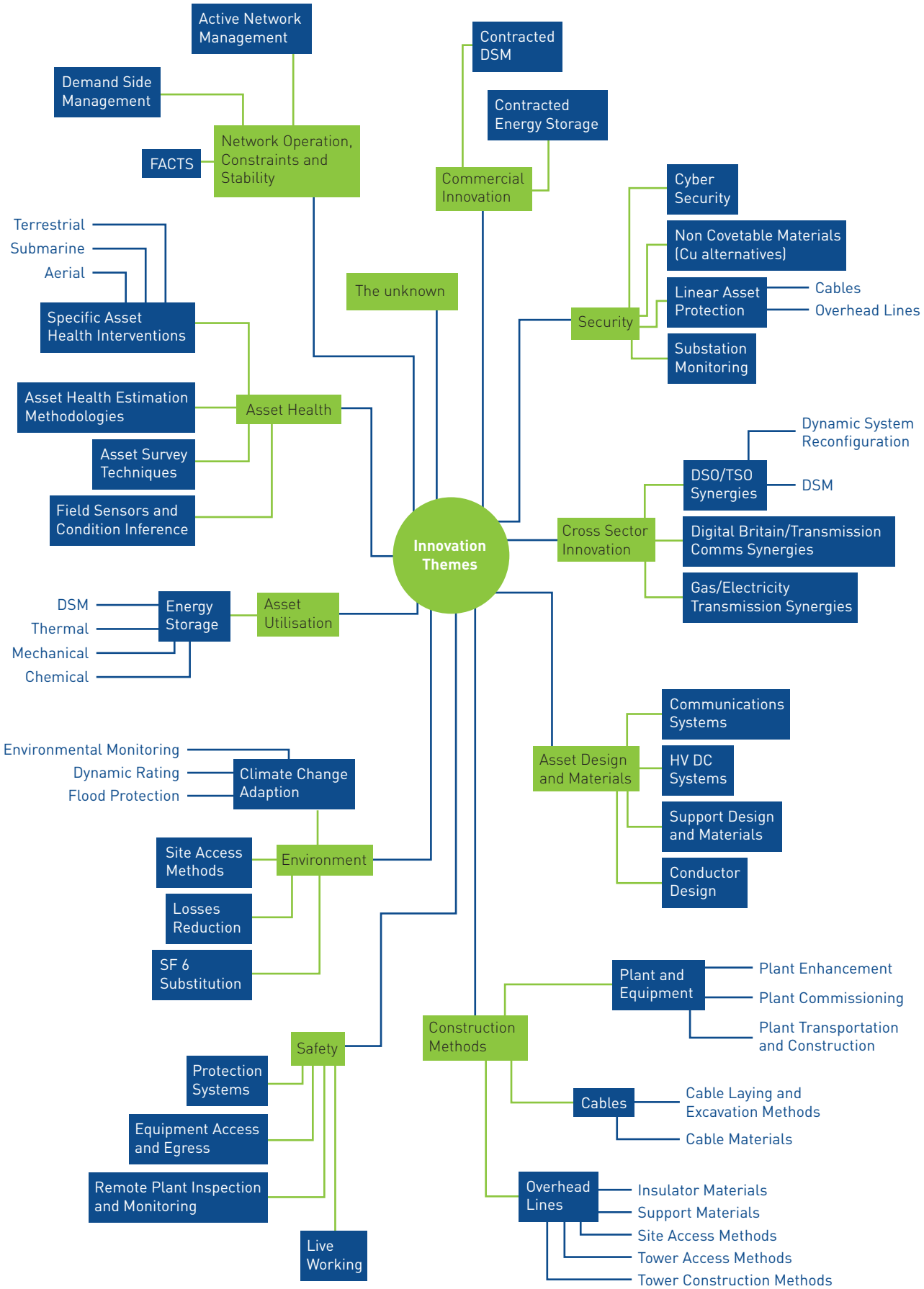
To best meet the aspirations of our stakeholders, the right innovations must be delivered to business as usual at the optimum time. To do this, we must ensure that appropriate funding is available at the times when it is needed.

To achieve that, we propose a variation to the mechanism set out in Ofgem's March Strategy Document that would allow us to spend some of our allowance sooner than under the original approach. Rather than our allowance being directly linked to our revenue, we propose that our total allowance be divided evenly across the eight years of the RIIO-T1 period. Any adjustment as a consequence of differences between our forecast and actual revenues will then be adjusted at the end of the period.

Profiling our innovation allowance in this way will greatly aid our ability to meet our stakeholders' needs by implementing innovations in a timely manner which will:

- Accelerate the connection of renewable generation
- Minimise the costs of providing network capacity
- Maximise the use of existing assets
- Maintain and improve network performance
- Provide more accurate information on asset condition

Figure 5: Our detailed innovation themes



Appendix A: Innovation Evaluation Process

SHETL's Innovation Evaluation Process

SHETL has a well defined policy and procedure for the selection of innovative projects, outlined in Figure 6 – Innovation Evaluation Process. The heart of the system is the creation of business benefit and the dissemination of learning to our various stakeholders throughout the process.

The centre of the process is an Evaluation method that has inputs from three areas: Policy, Business Drivers and Stakeholders. The feedstock to this Evaluation is our Idea Screening stage with the outcome being a Delivery Programme with Learning and Business As Usual adoption being the end goal.

Stakeholders

Stakeholders are at the heart of SHETL's innovation approach. Our motivation to innovate comes from our desire to deliver a better service to our customers and collaborators; we see these as our key stakeholders. SHETL engages with its stakeholders throughout our innovation projects. These would be any person or organisation that has an interest in our industry and business including but not limited to: Government, the Scottish Environmental Protection Agency, Scottish Natural Heritage, customer groups, community groups, academia, industry groupings etc. Currently SHETL provide feedback to our stakeholders through internal engagement, and to external stakeholders through our IFI reports. We will expand this engagement under RIIO–T1 as resources allow.

Policy

SHETL has an extensive Policy base covering all areas of work that we carry out. These policy documents inform the criteria by which we choose to pursue innovative projects. Policy documents may be viewed in two ways: as documents that are definitive and those that are iterative. The definitive documents lay out a clear path for how SHETL conducts its' business and the manner in which this is carried out. These processes are followed throughout the selection and management process. Iterative documents may be technical guidance documents or procedures detailing the currently approved methods and processes to be followed by SHETL, however these are subject to change on an ongoing basis. The feedback loops that have been included within the innovation policy allow for this iterative process to occur as easily as possible.

Business Drivers

SHETL is a part of the SSE Group of companies and as such adheres to the SSE SET values. These are: Safety, Service, Efficiency, Sustainability, Excellence and Teamwork. Each of these six values have a direct impact on the evaluation criteria that we set. Innovation projects must be able to clearly demonstrate a benefit to the business through these values. This business benefit can take shape in a number of ways including a reduction in cost, increased utilisation of our existing infrastructure, or an increase in the health and safety of our staff. Drivers may change from time to time, however the end result will always be the same. Only projects that align with SHETL's objectives will be approved to deliver a clear benefit to end customers.

Idea Screening & Evaluation

The outputs from Stakeholders, Policy, and Business Drivers come together in our Idea Screening & Evaluation processes where we sift through project concepts from various sources and then evaluate them. Concepts can come from a variety of sources both internal and external. The L2i scheme allows any member of staff to propose an innovative idea to an open minded panel of managers, a proportion of these ideas make it through to SHETL's innovation programme. Concepts can come from our external partners and collaborators such as equipment manufacturers and academic contacts. All of these concepts and ideas are evaluated against the criteria created out of the fusion of the three inputs.

Delivery Programme

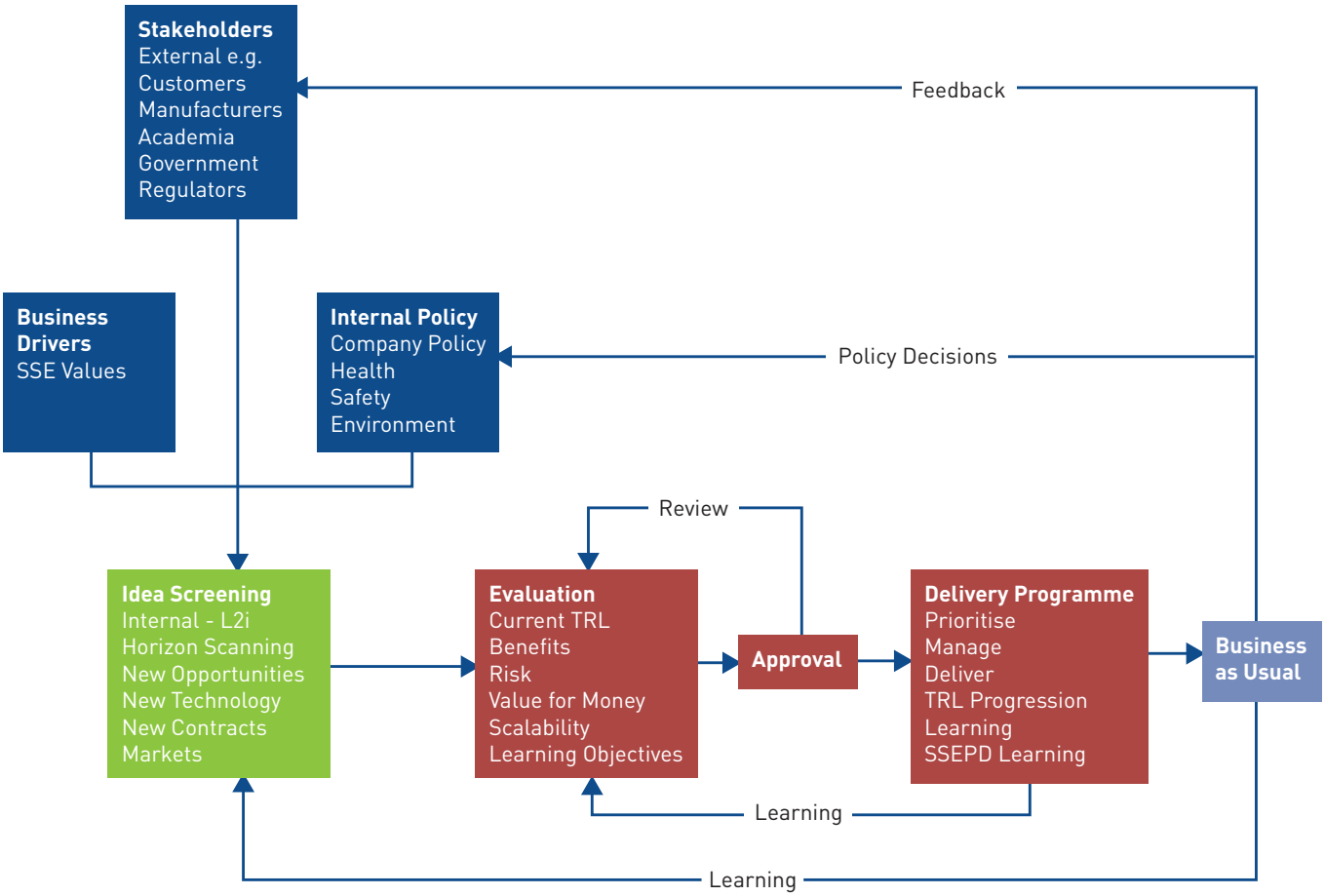
The successful concepts are taken through to our Delivery Programme where they are prioritised, managed and delivered. SHETL has a proven track record in the delivery of large and innovative projects. There are tried and tested procedures that are followed to ensure the successful delivery of projects within SHETL. Along with delivery, a key aim of any innovation project that we undertake is to achieve Learning throughout the implementation of the project.

This learning is fed back into the business in a number of ways. There is feedback into both the Screening and Evaluation processes to ensure that as much knowledge as possible is captured. Our dedication to the capture of knowledge and learning is demonstrated in the appointment of a dedicated Knowledge Manager whose role is to make certain as much information is kept within the organisation as possible and to enable us to learn from each project that is undertaken. Currently the main feedback method is through the annual IFI report, however we are in the process of increasing our stakeholder feedback via various routes. We will maintain a high level of stakeholder engagement throughout RIIO-T1 to ensure our stakeholders have a strong input to our plans.

Business As Usual (BAU)

The end goal of all our innovation projects is that they will be implemented as BAU. This could take form in a number of ways such as a Policy Document change or the adoption of a novel piece of equipment or procedure. Through BAU there is constant feedback of learning into the idea screening process as there will be always be flows of knowledge.

Figure 6: Innovation Evaluation Process



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