Scottish & Southern Electricity Networks

Your Plan, Our Future: RIIO-T2

The Future Operation of our Network

Scottish Hydro Electric Transmission plc
RIIO-T2 Business Plan

February 2019

www.ssen-transmission.co.uk

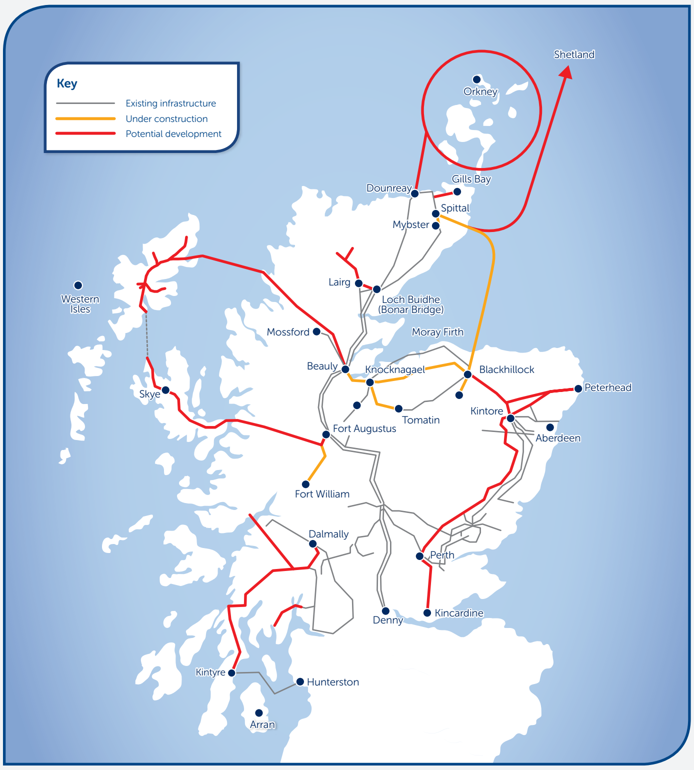
About this paper

Scottish Hydro Electric Transmission plc operate under licence for the transmission of electricity in the north of Scotland. We own and maintain the 132kV, 275kV and 400kV electricity transmission network in our licence area. Our network comprises of underground of subsea cables, overhead conductor, wooden and composite poles, steel towers and electricity substations, and it extends over a quarter of the UK land mass across some of its most challenging terrain.

As a natural monopoly, we are closely regulated by the GB energy regulator, Ofgem, who determine how much revenue we are allowed to earn for maintaining and renovating our transmission network in the north of Scotland. These costs are shared between all those using the transmission system, including generation developers and electricity consumers.

The next price control period will run from 1st April 2021 to 31st March 2026. This document is a summary of our plans to ensure our future network is safe, secure and reliable

Figure 1: North of Scotland Energy Network, January 2019



Operating our Network

Our network is contained within uniquely challenging terrain, and we need to ensure that the network can be operated safely and efficiently, even in the most demanding conditions. Our network has also experienced significant growth during the existing price control and the complexities of managing this network are now very different to what has gone before.

The safe and reliable supply of electricity is a necessity for everyday life and we rely on it more than we realise. From heating and lighting through to banking and healthcare provision, there are few aspects of our day-to-day lives which are not somehow reliant on a constant provision of power.

There is a high economic and social cost for households and businesses if their supply of electricity is interrupted. A study of the rolling blackouts in California in 2000-01 estimated that GDP was depressed by 0.7-1.5% as a consequence. Unsurprisingly both household and business electricity users report that they would pay significant sums to avoid power cuts. A recent study reported the cost to the Scottish Economy of a Black Start Event (the total loss of electrical power in GB) to be £913m per day.

Investment over the past decade means that the reliability of the GB transmission system is now greater than 99.99%. However, energy sector changes – such as decarbonisation and decentralisation – along with emerging global risks – including climate change, cyber security and physical security – mean that the prevailing reliability cannot be taken for granted.
We have reviewed our historic performance and, in light of ongoing stakeholder expectations, we have outlined our emerging thinking for how we will continue to ensure our network is available and reliable for all those who use it. This will be discussed in more detail at our Stakeholder Engagement Event in Edinburgh on 5th March.

Our record for delivery

Ofgem has assessed us to have "performed well" to date . It uses four measures, which it calls primary outputs, to measure the performance of electricity transmission network owners. These are: reliability, connections, environment and customer satisfaction. The key outputs delivered through safe and secure operation of our network are reliability and management of SF_6[2] emissions.

Reliability

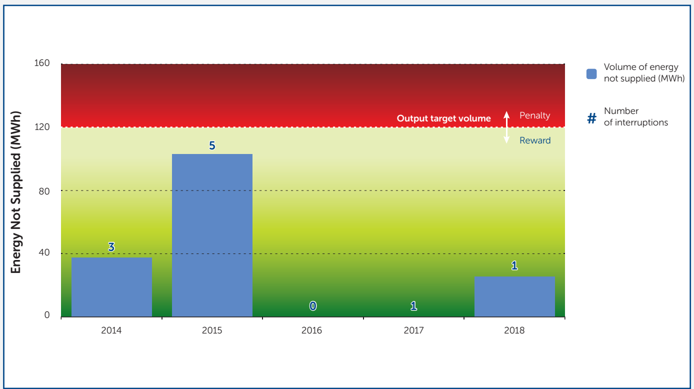


Figure 2: Reliability of our transmission network 2013-2018

The reliability of the GB transmission system is measured by the number of loss of supply incidents and the volume of energy that does not reach household and business customers during those events[3]. Over the first five years of the current price control period, we have had ten loss of supply incidents that resulted in 170 MWh of electricity not being supplied to end consumers (Figure 2). We are the only GB transmission company to offer a compensation scheme for homes and businesses affected by a power cut on our network.

Total Fault Volumes

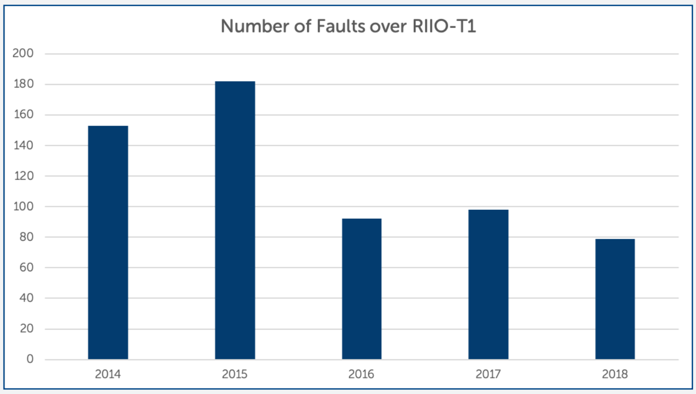


Figure 3: Faults on our transmission network 2013-2018

In addition to Loss of Supply events described above, other faults can occur on the Transmission network which do not impact our customers, but we use as an overall measure of our network performance. These faults can be of three different types; "DAR" events, which occur due to the operation of protection on our network and typically only last a few seconds, emergency outages to intervene on an asset which is not operating as expected, and genuine asset failures. The majority of our fault volume is due to DAR events and only a handful of faults result in a loss of supply to the customer (as shown in Figure 2).

As Figure 3 shows, our fault volumes have fallen significantly over the price control to date, from their peak of 182 in 2014/15 to just 79 in 2017/18. This 43% reduction has been driven by a number of factors, most particularly the establishment of a stand-alone Transmission Operations & Maintenance department in the 2015/16 year. A review of our treecutting and SF_6 management strategies have also contributed towards the reduced figures.

[2]SF_6, or sulphur hexafluoride, is used as an insulating medium within some of our assets. Whilst it is an excellent insulating medium, it has a Greenhouse Warming Potential (GWP) of 23,500

[3]Households and businesses are not connected directly to our network, but indirectly connected via SHEPD's network. In some instances, SHEPD is responsible for maintaining security of supply when we are undertaking maintenance or construction work on our network. Loss of supply in those circumstances is not attributed to transmission reliability.

SF_6 Emissions

We use sulphur hexafluoride (SF_6) in our assets due to its excellent performance as an insulating medium. However, we recognise that leakage of this gas harmful to the environment.

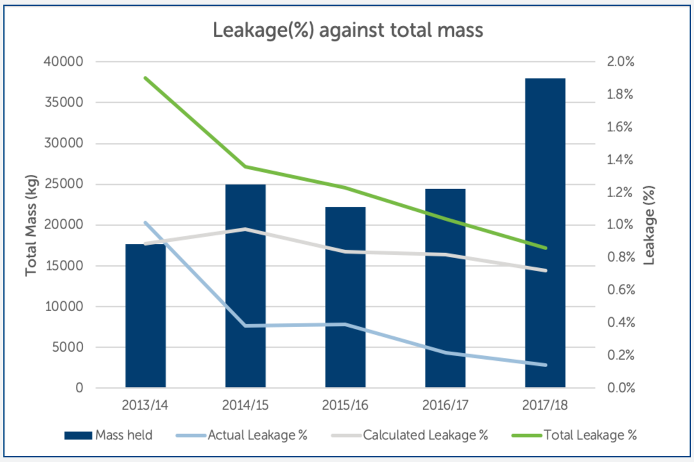


Figure 4: Leakage against total mass (%)[4]

Our leakage of SF_6 has fallen over the course of the T1 price control. As can be seen from the graphs below, absolute leakage has not fallen significantly over the price control (335.7kg in 2013/14 to 327kg in 2017/18).

Total leakage, which was 1.9% of our asset base in 2013/14, was less than half that in 2017/18, at 0.9%. The mass which is “topped-up” each year has had an even more significant reduction, falling from 1.0% in 2013/14 to just 0.1% in 2017/18. SF_6 leakage reduction is part of our overall environmental strategy. The reduced levels of gas leakage have been achieved through improved asset management and innovative operational practices. Whilst our asset base has more than doubled from 17.6 to 38 tonnes since the beginning of RIIO-T1, our leakage has more than halved.

[4]Calculated leakage is a fixed percentage based on manufacturers’ estimates of theoretical

Stakeholder engagement

Because electricity is an essential service, which people, organisations and businesses rely on every day, there is an extra level of responsibility on our business to conduct itself in a way that enhances value to society while meeting core business objectives.

Every day, across all activities at every level of our business, we engage with people (our stakeholders) who have an interest in what we do and how we do it. Naturally, not all stakeholders will be interested in, or affected by, every aspect of our activities. Our targeted engagement programme focuses on the most pertinent issue/s for each stakeholder group, to encourage active participation and ensure meaningful feedback.

Customer Expectations

Stakeholder engagement in the past has shown that customers have four key expectations:

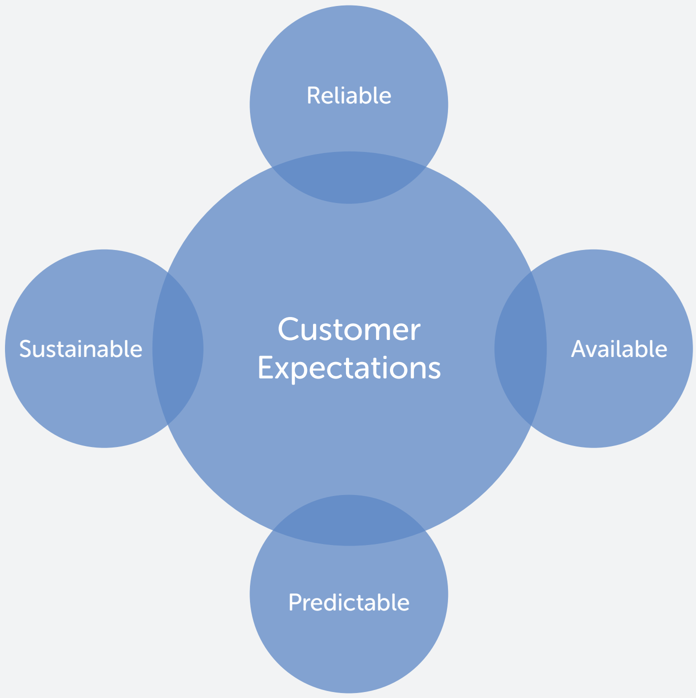
Reliable: Assets should not breakdown

Available: Assets should operate when required and are easy to maintain

Predictable: The requirement for intervention can be forecast to prevent breakdown and ensure long-term availability

Sustainable: Assets should be adaptable and offer value for money over their whole life. They should allow for continuous improvement and be easy to decommission.

Figure 5: Customer Expectations



Risks to delivery

We engaged with internal stakeholders to determine what were the key risks which might materialise to inhibit us from delivering our customers' expectations.

We looked at two specific risk groups, those derived from the business and its processes, and those derived from our assets themselves. In these two groups, we identified ten top risks to delivering expectations, as can be seen in Figure 7.

We have looked at what our customers want, and the risks to these expectations, and we developed solutions to mitigate these risks. Subject matter experts have been heavily involved in this development and we produced a three-tier approach to our development:

1 Minimum requirements

The bare minimum required to "keep the lights on" & maintain legal/regulatory compliance

2 Responsible operator

A more resilient network for longer term customer benefit

3 Progressive network enabler

An adaptable, sustainable and flexible network providing enhanced value to current and future customers.

Risk Categories

- Risks derived from the business and its processes
- Risks derived from the physical constraints on the assets/network

Figure 6: Risk categories

Risk

- Management of an Ageing Fleet & its data
- Recovery Planning
- Adaptability to a Future Network Operating Model
- Management of Stocks & Spares
- Single Points of Failure
- Black Start
- Control Centre Location & Accessibility
- Operational Communications
- Protection Systems
- Climate Change

Figure 7: Top 10 risks

Adapting for a changing world

Electricity is an essential public service, underpinned by safe and secure energy networks. The Government defines critical national infrastructure, such as energy networks, as assets and associated systems which if lost could result in major detrimental impact on essential services or national security. Planning to manage the risks we face, including business continuity following an incident, is an essential part of what we do.

However, the dependency on electricity has now become integral to the social stability of any modern society, regardless of whether the asset is critical. There have been numerous studies of recent natural disasters (New Orleans, Hurricane Katrina 2005, Haiti earthquake 2010), that have highlighted our dependency on a secure electrical supply. This has shown that the loss of critical services has led to unexpected events that have caused further chaos at a local and national levels.

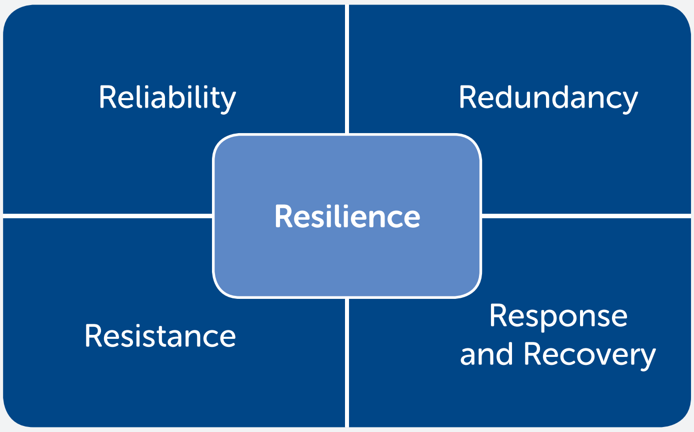
This includes, but is not restricted to;

- Loss of electricity, gas, water and sewage networks
- Cessation of communications, internet, telephonic and radio systems
- Breakdown of basic health care provision
- Interruption of law and order
- Detrimental short and long-term effect on the environment

[4] Cabinet Office, Keeping the Country Running: Natural Hazards and Infrastructure (October 2011): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61342/natural-hazards-infrastructure.pdf

Resilience

There are many definitions of resilience available, but we use the definition of resilience adopted by the Cabinet Office in their 2011 Natural Hazards and Infrastructure report : "Resilience is the ability of assets, networks and systems to anticipate, absorb, adapt to and / or rapidly recover from a disruptive event." The report identifies four components to infrastructure resilience: resistance (level of protection), reliability, redundancy (spare capacity), and response & recovery. In this paper, we outline how we intend to address all four aspects of resilience of our network.



Given the range of risks facing our network, it is right that we select combinations of actions from all four of these components to develop a strategy that will deliver the most cost effective and proportionate risk management response.

The Resistance element of resilience is focused on providing protection. The objective is to prevent damage or disruption by providing the strength or protection to resist the danger and its effects.

The Reliability component is concerned with ensuring that our assets well managed over their whole life and can operate as expected. Reliability cannot be guaranteed, but redundancy ensure that any failure can be managed at an acceptable level until normal network operations can be restored.

The Redundancy element is concerned with the design and capacity of the network. The availability of the network will enable energy to be diverted to alternative circuits in the event of disruptions.

Response & Recovery aims to enable a fast and effective return to normal operations, should we experience a disruptive event. How we respond to an event will depend on specific circumstances, but to ensure effectiveness, we have plans in place to respond quickly.

[5]Cabinet Office, Keeping the Country Running: Natural Hazards and Infrastructure (October 2011):
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61342/natural-hazards-infrastructure.pdf
[6]Households and businesses are not connected directly to our network, but indirectly connected via SHEPD's network. In some instances, SHEPD is responsible for maintaining security of supply when we are undertaking maintenance or construction work on our network. Loss of supply in those circumstances is not attributed to transmission reliability

Resistance

Protection and control

These systems, whilst not considered "lead" assets, are critical to the secure and sustainable operation of our network. A protection system acts as a "fuse-box", protecting assets from fault damage, whilst also allowing us to operate our assets in a safe and secure manner.

Outdated protection can cause unexpected impact on our assets, most dramatically illustrated in 2017 with the failure of Nant Grid Transformer, caused by a trip relay failing to clear a fault. Our proposal takes a holistic approach to protection and monitoring, to ensure a complete and consistent approach. This approach also represents best value for the customer insofar as network access is minimised and optimum use of outages are made.

The concept of relay hardware and firmware management has been introduced. Relays have previously been considered by SHE Transmission as "fit-and-forget" assets, only to be supported by periodic maintenance. The reality is that microprocessor-based protection relays are subject to software and firmware "bugs" like any other electronic device, and as a responsible operator, SHE Transmission need to proactively manage the risk of relay maloperation.

2018 saw the introduction of STCP 27-01, a protocol which will provide us with appropriate and accurate synchronised data to monitor asset and overall system performance thus permitting secure operation, optimum utilisation of the system and the ability to clearly evidence the cause and sequencing of system events.

Our proposals are currently costed at between £35m and £39m within the T2 period. Our baseline programme is estimated at £35m whilst the additional £4m will deliver significant improvements on that baseline.

Cyber Security

The threat of cyber-attack is now a very real and present threat. The Wannacry attack in May 2017 infected some 200,000 computers in over 150 countries. It impacted just 1% of NHS activities in the UK but cost the NHS £92m. A similar attack on electrical infrastructure could have a catastrophic impact on the UK.

In order to ensure that our assets are as safe as possible from this threat, we are proposing to invest between £6m and £8.5m in substation technology. This investment would include third party testing of our cyber security and would also address elements of technology obsolescence.

Site Security

As well as protecting our assets from cyber-attack, we also need to ensure they are safe from physical interference, and that the public is protected from accidental contact with electrical equipment. To that end, we have identified some improvements required to the physical security at a number of substations, including changes to fencing and improvements to CCTV and alarm systems. We currently propose to invest around £20m in this area.

Environmental Impact

Changes in land use over the last fifty years have caused changes to flood plains and a Responsible Operator is required to assess these changes and their impact on our assets. While we have assessed the flood risk to our substations over the course of RIIO-T1, no similar risk assessment has been carried out for overhead lines. Climate change has also been associated with an increased number of landslides, as experienced by SHE Transmission in November 2018. We are currently proposing to invest £8m to undertake survey works which will allow us to understand the risk posed to our overhead lines, with a view to undertaking any mitigation works within the RIIO-T3 period.

Risk-based Maintainance

We currently inspect and maintain our assets using a well-established time-based methodology, where all activities are carried out according to timeline dictated by asset management timescales. This has provided a basis for ensuring that the requirements of statutory, regulatory and internal policy and procedure are met.

It is however fair to say that there are areas of improvement that are evident which if addressed could lead to improved delivery of operations and maintenance activities. These improvements in turn would lead to increased operational efficiency, along with ensuring the system is safe, reliable and available. Moving to a risk-based model would deliver significant improvements in operational efficiency, through effective scheduling of works.

Reliability

Smart monitoring

Effective system and condition monitoring within asset management plays a significant role in improving the performance, reliability and longevity of electrical and mechanical assets.

Accurate and timely diagnosis of critical or high value, long lead time assets, such as power transformers, is critical for the reliable and cost-effective operation of the transmission network.

Implementation of an integrated condition monitoring system will allow an improved understanding of the behaviour of the Network and key assets, and we are currently proposing to spend £2.1m in RIIO-T2 to begin the development of this. This will lead to the implementation of preventative and condition-based maintenance along with improvements in specifications for future installations. We are also looking to establish a data analysis function to enable effective proactive maintenance to take place based on this improved understanding. This function will also enable informed decisions to take place with regards to equipment performance and improved fault response performance.

Efficiencies can be recognised in time and resources spent in decision making for investment requirements through an integrated condition monitoring system where actual investment decisions are be based on condition, monitoring and evaluation and the risk involved for a major fault on an asset.

Risk Based Replacement

We use site and asset specific information to determine the asset risk held on our network. This is calculated using the Network Output Measures (NOMs) Methodology recently agreed between all three Transmission Owners (TOs)[5]. In SHE Transmission, we use a tool called "CBRM" to calculate our asset risk.

At the current time, the tool is being rebuilt to align with the new methodology and we are unable to fully confirm its outputs against our plans. However, initial results are favourable, and the current timeline indicates that this will be fully confirmed by the end of April 2019.

These assets have been identified for replacement through site visits and condition assessments. Further work is required to refine this list and develop the scopes of each project. Costs shown against the schemes listed below will be further refined in the coming months.

Our current proposed plan is shown at a high level in the table below:

Asset Type	Volume	Forecast (£m)
OHL Conductor (km)	741	556
OHL Fittings (km)	64	19
Reactors	1	5
Switchgear	60	140
Transformers	28	100
Transformer Interventions	8	4
Underground Cable (km)	10	10
TOTAL		**£949m**

Table 1: Initial Proposed Risk-Based Replacement plan

[5] https://www.ofgem.gov.uk/system/files/docs/2018/08/noms_common_methodology_issue_18.pdf

Operational Communications

We have identified that secure, diverse, resilient operational communications are a critical component to ensure integrity of the protection and control of the Transmission system.

Additionally, the industry is undergoing significant changes in both the quantity of system data available and the way that information is collated. For transmission networks in the UK, increasing levels of data capture and transfer for both existing and new power system monitoring equipment is placing a higher demand on information transfer capacity. This is resulting in the rise of Internet Protocol based networks in the substation environment.

The intent is to deliver a holistic network strategy at a cost of £6.7m-£8.4m, which will provide synergies and cost savings to SHE Transmission in the longer term.

Sulphur Hexafluoride (SF_6)

SF6 is an excellent insulating medium which we use in a number of our assets to extinguish electrical arcs. However, it is around 23,500 times more harmful to the environment than carbon dioxide.

We have been working with equipment manufacturers to test alternatives to SF6 and we are currently in trial stages for two new technologies.

In RIIO-T2, where there is a technically and commercially viable alternative, **we will no longer install SF6 on our network.**

Polychlorinated Biphenyls (PCBs)

PCBs are organic compounds which were once widely deployed as dielectric and coolant fluid in electrical plant.

However, they have been discovered to be highly environmentally toxic and carcinogenic and were banned by UN treaty in 2001 (footnote 6).

Historic examination of our assets indicates that **we have no PCBs within assets on our network.** We will undertake further examinations to confirm this prior to the commencement of RIIO-T2 and invest in this area if required.

Redundancy

Warehousing & Spares

Prior to the decarbonisation of the electricity system and the significant growth of our network, there was little need for us to establish sizeable warehousing facilities and we commonly used operational locations as secure storage facilities. However, as an organisation with a Regulated Asset Value of £3.6Bn and a significant spares holding, we now need to invest to ensure that our spares are managed effectively and that we can respond quickly in the event of a failure.

Our current facilities are constrained by their age and lack of capacity and are not in locations which facilitate the storage of strategic operational assets such as Transformers.

We are proposing to construct two storage facilities which would further enhance our operational capability and would include the required staff and transportation equipment to reduce the requirement/reliance of third party contractors.

We are also proposing the implementation of an Inventory Management system to enable efficient use of time and resources. These proposals are currently costed at £15m.

Network Vulnerabilities

We are, on an ongoing basis, identifying and reviewing the critical points on the network. We define criticality on an asset-by-asset basis, being a function the impact of failure on both the customer and the wider network.

Our work to date has identified £55 million of investment in cost-effective interventions that will reduce the number of critical points, for example by removing some single points of failure. For other critical points where investment is not possible or cost-effective, monitoring and inspection may be increased, and contingency plans will be reviewed.

Response & Recovery

Control Centre and Disaster Recovery Site

Our Control Centre, from where we monitor and operate the network is a vital component of the electricity network within Great Britain. This means that we are required to have certain levels of security at the Control Centre to protect it from physical and cyber intrusion.

Our existing Control Centre does not have this security and retrofitting the existing site would not be cost effective. We intend to rebuild our Control Centre at a new site which would fully meet the requirements of the CPNI. Current estimates for this centre sit at £17m

We are also considering the construction of a second, similar centre, to provide the business with a modern and secure Control Centre and Disaster Recovery Site (DRS). This centre would be geographically separated from the new Control Centre so as to mitigate regional disaster. Whilst it would replicate facilities in the Control Centre, it would also include a Smart Monitoring Centre for the analysis and interpretation of asset data and events, as well as an Incident Response Centre, from where major incidents on the Transmission Network could be managed. Current estimates for this centre sit at £17m.

Black Start

The recent changes in the GB generation mix, particularly the decommissioning of traditional power plants, have provoked a revision of the GB Black Start plan and, within SHE Transmission, an examination of our capability to support it.

The role of Scottish generation in the provision of GB wide power production will be significant, potentially greater than 20%. Generating capacity will be more than double the SHE Transmission area demand, potentially giving a large surplus if system conditions were right. With wind providing significant energy, tools will be required to provide inertia and voltage to utilise it and stabilise the power island. With good system tools, a SHE Transmission power island generation could supply Scotland demand and provide surplus to assist further south. Our proposals have identified £270m of potential investment to improve our response to a Black Start Event.

What next?

Upcoming events	Stakeholder Engagement Event, Edinburgh International Conference Centre, 5th March 2019

www.ssen.co.uk

www.ssen-transmission.co.uk

Contact details

We hope you have found this paper useful and informative.

We welcome your views on any of the emerging thinking in this paper, or any other topic relevant to the future of the GB energy sector.

Please get in touch:
yourplanourfuture@sse.com

We plan to publish more details on our RIIO-T2 business plan in late June 2019.