Scottish & Southern Electricity Networks

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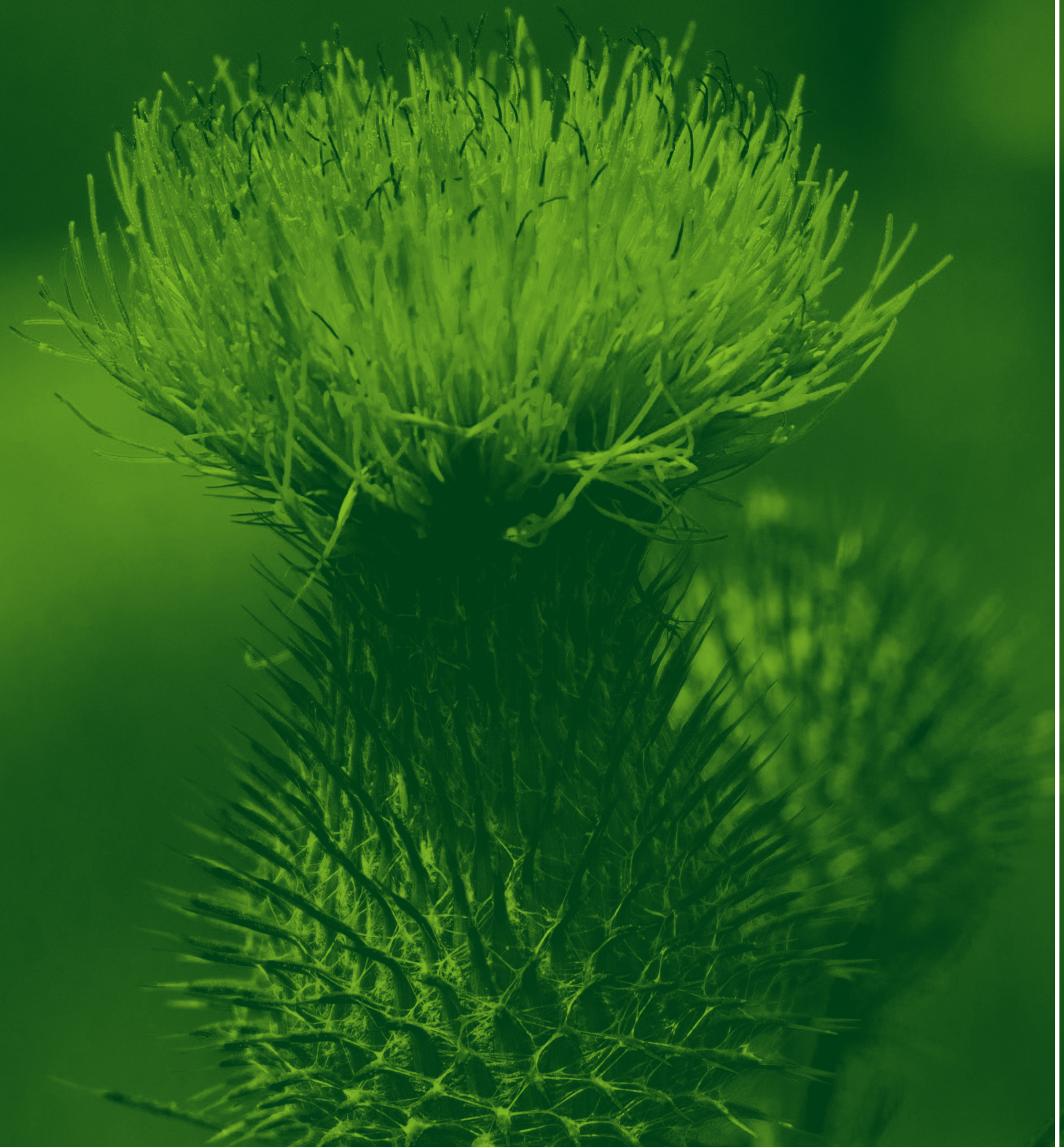

Enabling Whole Energy System Outcomes

December 2019

Scottish Hydro Electric Transmission plc

About us

Scottish Hydro Electric (SHE) Transmission is the owner of the high voltage electricity network in the north of Scotland. As the Transmission Owner (TO) we own and operate the 132kV, 220kV, 275kV and 400kV electricity equipment. Our network consists of underground and subsea cables, overhead lines on wooden and composite poles and steel towers, and electricity substations, extending over a quarter of the UK's land mass and across some of its most challenging terrain.

As part of Scottish and Southern Electricity Networks (SSEN), which includes our sister company Scottish Hydro Electric Power Distribution (SHEPD) the owner of the adjoining low voltage distribution network, our electricity network is responsible for ensuring a safe, reliable supply of electricity to around 770,000 homes and businesses (Figure 1). We also provide grid access for over 7 GW of generation, contributing around one third of GB's renewable energy capacity.

We power our communities by providing a safe and reliable supply of electricity. We do so by taking the electricity from generators and transporting it at high voltages, over long distances through our transmission network for distribution to homes and businesses in villages, towns and cities.

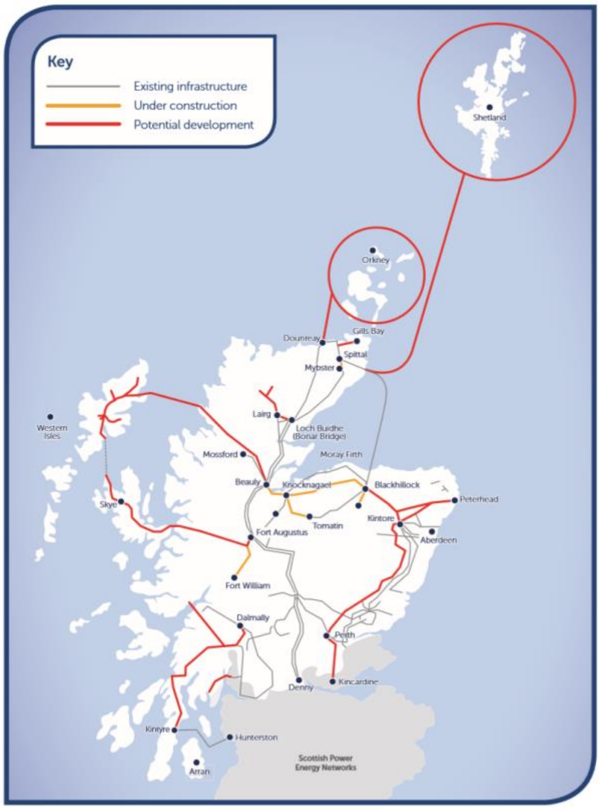

Figure 1 The SHE Transmission network and operating area

About this paper

This paper is Supporting Document 20 to our final RIIO-T2 Business Plan. It sets out our objective and approach to planning and developing the north of Scotland transmission system as part of the wider energy system. A whole system approach will result in better value outcomes for the GB energy customer and stakeholder. We explain how we have applied whole system approaches to the development of our RIIO-T2 Business Plan, and how we plan to work with others to significantly develop these approaches during the RIIO-T2 period and beyond.

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Next steps

We have set up our organisation to focus our efforts on the development and implementation of whole energy system approaches. This is led by our dedicated Whole System team, but involves all departments across our organisation.

We are committed to:

- Review this document every two years to ensure it remains relevant.
- To report on annually on our progress against the outcomes identified in this paper.

If you would like to be involved with our whole system plans or have any feedback, then please get in touch with: andrew.urquhart@sse.com

1 What is the Whole Energy System?

1.1 In order to develop whole system working it's important to start with a clear definition. To us:

"The whole energy system comprises electricity, gas, heat and transport networks and components that serve GB society"

1.2 This definition recognises that there are many parts to the energy system and through co-ordination it should be possible to achieve better outcomes for consumers.

1.3 Currently, the GB energy system operates largely as standalone elements. Our interest is in identifying and working with those other elements that impact on the economic development of the north of Scotland electricity transmission system.

1.4 **Gas** is used as a fuel to generate electricity, which requires an electrical connection to export. Gas-fired generation acts in the electricity markets to provide ancillary or balancing services. It may be that through whole system thinking, those connections could either be better sited, or controlled flexibly, to optimise the required network reinforcement whilst still getting the same level of network support.

1.5 **Gas** is also used as primary fuel for heating buildings. One option for the decarbonisation of heating is through electrification. This would increase the load on the electricity networks. Likewise, the planned electrification of the **transport** will increase electrical load and require extra electrical infrastructure being available to charge electric vehicles (EVs). Both will have value for the wider society through delivering decarbonisation, however if approached in isolation, rather than through consideration of the whole energy system, there is the potential for inefficient outcomes.

1.6 **Components** refer to devices that either take energy from, or give energy to, the transmission network. This includes all types of generation from solar through to oil-fired generators, as well as interconnectors between international jurisdictions. It also includes energy storage devices, encompassing electrical energy storage or 'vector shift' technologies like hydrogen electrolysers. Installation of these devices drives energy system infrastructure cost, however once installed they can drive infrastructure savings. It's important to carefully consider these technology types on a whole system basis to optimise where they are installed and how they plan to operate.

1.7 **The critical aspect of our definition of the whole energy system is the realisation of GB society benefit.** In this context, we look beyond the electricity bill payer to the overall costs and benefits to GB society, environment and the economy. For example, greenhouse gas (GHG) emissions reduction, increased biodiversity and other sustainable criteria are benefits. We also ascribe a time value. For example, the Committee for Climate Change [1] recommends that "many networks will need to be upgraded in a timely manner and future-proofed to limit costs and enable the rapid uptake of electric vehicles and heat pumps", i.e. delayed action can inhibit benefits realisation elsewhere in the whole energy system.

[1] www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

Whole energy system working

1.8 Conventionally, the energy industry works in isolated elements arranged by either energy vector (gas or electricity), industry type (networks or generation), or voltage / pressure levels (distribution or transmission). For example, if a generator wanted to connect to the electricity network, that generator would make a choice whether to apply to the local distribution or transmission network owner. Upon receiving the application, the network owner would then assess the most efficient connection option in isolation of other network or system options. This isolated approach is enshrined in our longstanding industry structures, regulations and ways of working.

1.9 A whole system approach is different to this. That same connection application would be considered jointly by distribution and transmission, in a whole energy system study that potentially takes account of non-network solutions and the wider context of heat and transport changes. Previously where conventional transmission reinforcement might have been proposed, a network service might be identified by the Electricity System Operator (ESO) to avoid reinforcement. Alternatively the local distribution and transmission network might be reconfigured to both provide the connection and enable planned heat and transport decarbonisation.

1.10 Whole system approaches also impact on activities to maintain the existing gas and electricity networks. For example, currently when we identify that the condition of assets in a substation are of sufficient risk to require intervention, we undertake optioneering based on known load factors. A whole system approach would look to explore detailed intelligence on local network requirements. Collaboration at this stage is key, working with local authorities, community groups and other networks to understand and plan for long term whole system needs.

Whole system working in the north of Scotland

1.11 The north of Scotland is a unique environment for whole system working. When compared with the rest of the UK there are some key differences:

1.12 The total population of the north of Scotland is around 1.3 million[2], compared to the total in Scotland of 5.4 million[3] and the UK at 66.4 million[4]. These people also tend to be more thinly spread leading to a lower population density. There are only four substantial conurbations –Aberdeen, Dundee, Perth and Inverness, with Aberdeen being the largest. However, it ranks as only the 29th largest town in the UK, with Dundee 48th, Perth 214th and Inverness 216th [5].

1.13 Our North of Scotland Future Energy Scenarios[6] demonstrate the variations in energy consumption between consumers in the north of Scotland and the rest of the UK:

[2] Derived from local authority data
[3] www2.gov.scot/Topics/People/Equality/Equalities/PopulationMigration
[4] www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/august2019
[5] www.thegeographist.com/uk-cities-population-1000/
[6] www.ssen-transmission.co.uk/media/2912/north-of-scotland-future-energy-scenarios-full-report.pdf

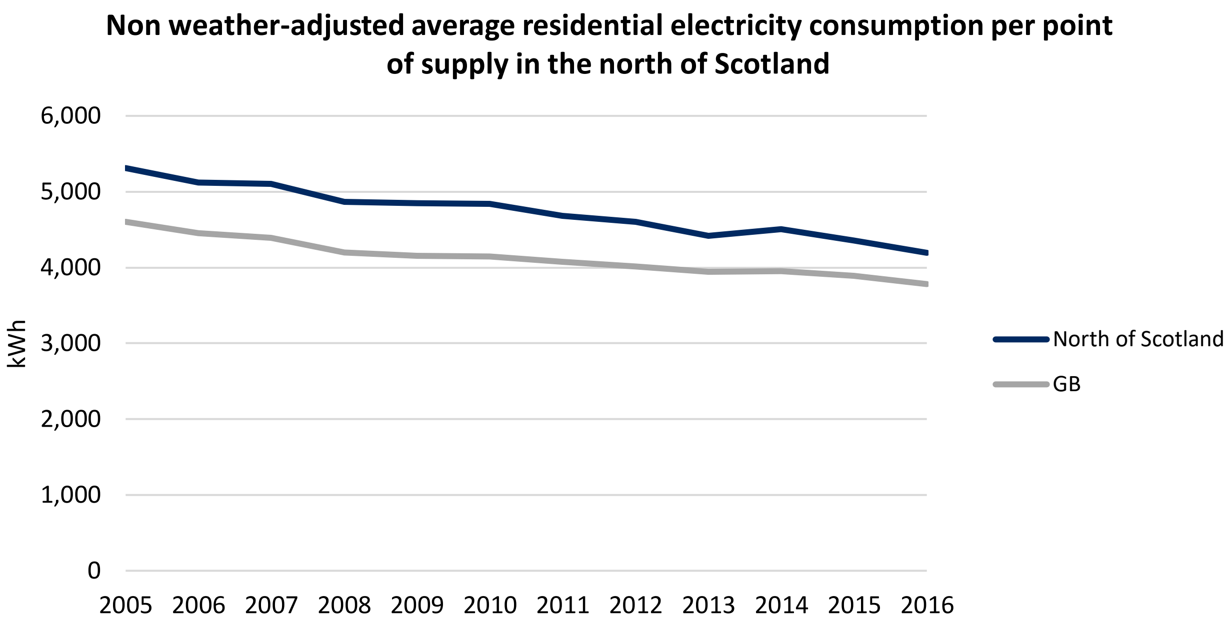


Figure 2 Residential electricity demand in the north of Scotland

- Residential electrical demand is around 10% higher than it is for the rest of the UK (Figure 2), although both are trending down.
- Gas consumption is low: 51% of properties using gas for heating, whereas the across UK that figure is 85%.
- The different industrial mix results in different trends from the rest of the UK in both electricity and demand consumption.
- EV penetration reached 1,878 licensed vehicles being 0.24% to total vehicles in our operating area. In comparison across the UK there were 127,158 licensed vehicles equal to 0.35% of the total.

1.14 In contrast, the north of Scotland has a wealth of renewable energy potential underpinned by the highest average wind speeds in the UK:

- In the north of Scotland, renewable energy stands at 82% of the overall electricity generation mix in comparison to the UK value of 33%[7].
- 48% of generation comes from onshore wind, in comparison to 31%[7] for the rest of UK.
- Combined Cycle Gas Turbines (CCGT) make up 10% of the north of Scotland overall generation mix, compared to the rest of the UK where that figure rises to 39%[7].

1.15 The north of Scotland transmission system has been designed and developed to connect both remote communities and remote renewable generators. This gives it unique characteristics, such as low interconnectivity and high intermittent generation. This brings specific challenges around network resilience and operation.

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/840015/DUKES_2019_MASTER_COPY.pdf

1.16 The final factor that influences whole system approaches is the devolved powers of the Scottish Government. In the Scottish Energy Strategy[8], published in December 2017, Scottish Government laid out their vision for the Scottish Energy Industry in 2050. Whole system was listed as one of three core principles that would be adhered in guiding the Scottish energy system as it developed. Their view of whole system aligns with the scope set out in this document around whole energy systems with the inclusion of electricity, heat and transport. The Scottish Energy Strategy stresses that development of each of these vectors cannot be done in isolation from the others if full value is to be realised, which this document supports.

1.17 For transport, Scotland has a legislated target to have no new fossil fuelled cars by 2032. This is eight years earlier than the target of the Westminster Government. This ambition can be seen to be directly affecting the north of Scotland where the A9, the main trunk round to the highlands, is being targeted for electrification and installation of EV infrastructure.

1.18 The Scottish Government has set a target for locally owned or community energy of 1 GW by 2020 and 2 GW by 2030. Progress currently stands at 695MW. There is no corresponding target across the rest of the UK. Community projects are by their very definition fixed by location, so are a key consideration for us when developing our network.

1.19 What these differences highlight is that the north of Scotland is different to the rest of the UK, thus whole system approaches must be tailored to those local considerations rather than adopt a UK-wide model. By focusing on developing the best whole system approaches for the north of Scotland needs, we can then inform the wider development of whole system across the UK and so contribute to the best overall outcomes for GB society.

[8] www.gov.scot/publications/scottish-energy-strategy-future-energy-scotland-9781788515276/

2 Drivers for Whole System Working

2.1 Our GB electricity system is undergoing a period of sustained change driven by national targets for net zero GHG emissions by 2050 (2045 in Scotland). New technologies are driving new ways of producing and consuming energy. How we generate and distribute that energy is becoming increasingly important, ensuring we do so in a sustainable and economic manner. Energy consumers are seeking greater involvement in the development and decision-making of our energy system.

2.2 With this increased focus comes new challenges such as:

- More variable two-way power flow, driven by generation and demand, at parts of the network that traditionally have serviced smaller scale demand;
- New failure modes possibly caused by overloading or power quality; and
- Increased reliance on third parties providing network services (increasing or decreasing their power consumption) for the ongoing safe, secure and economic operation of the system.

2.3 These challenges span not only the electricity industry, but also the gas, heat and transport sectors as we transition to a net zero economy.

2.4 Quite simply, it makes sense to work together to identify how best to meet these challenges and support the overall transition. A whole system approach allows network owners and stakeholders to develop solutions together in a way that accounts for impacts across traditional network boundaries, energy vectors and over time to realise benefits for GB society that would not otherwise be achieved.

Drivers and enablers

2.5 There are key changes happening now that are either driving or enabling the development of whole system working:

2.6 *Drivers* include decarbonisation, decentralisation and democratisation.

2.7 Decarbonisation of our economy is essential to achieve net zero targets by 2050 (2045 in Scotland). Taking a whole system approach allows for decarbonisation benefits to be explicitly and holistically considered in energy planning, realising more efficient, lower cost and timely cross vector outcomes.

2.8 Decentralisation also drives the development of whole system. For example, in contrast to historic GB electricity planning assumptions, many of the points of physical connection between the transmission and distribution networks export power onto our transmission network for significant periods of time. This is caused by the growing shift from large centralised power stations to more Distributed Energy Resources (DER). Engaging with DER parties is essential to understanding their current and future business models. In the north of Scotland, much of this DER is distant from the large demand sites and, hence, relies on our transmission network for power to be transported to where the energy is needed. Without taking a whole system approach, the electrical networks could develop inefficiently.

2.9 Democratisation targets greater public participation and involvement in how energy networks develop. It is both a driver and an enabler. As a driver it forces the energy industry to take a more whole system approach to meet the needs of those it serves. Understanding those needs and being able to deliver that efficiently is key. It is also an enabler as it requires more published development plans allowing the public a greater say. This information allows more participation in proposed network developments by parties who could provide network services. Whole system solutions can include service provision deferring network reinforcement.

2.10 *Enablers* include digitalisation, and commercial and policy reform.

2.11 Digitalisation is the use of digital technologies (including sensors, connected devices and big data principles) to improve how the energy sector performs without increasing costs. With increased levels of digitalisation comes a greater opportunity to better understand network challenges and adopt technology-driven solutions, in particular in the adoption of smart, flexible grids.

2.12 Commercial and policy reform reflects industry efforts to change its working practices to enable whole system working. Two key current projects are:

- The Future Charging and Access[9] review has the potential to enable whole system. It is focused on creating a level playing field between transmission and distribution consumer and customer charging. This can enable whole system thinking as there could be, proportionally, less commercial difference depending on whether the connection is made at transmission or distribution. Thus, customer choice is no longer driven by disproportionate charging arrangements.
- The Energy Code Review[10] is focused on reviewing the 11 different energy codes to see how to make the codes more adaptable to change and enable new parties to engage with the industry. This could reduce the number of codes and look to have better alignment across energy vector codes. This would enable whole system through a broader common governance and code framework.

[9] www.chargingfutures.com/
[10] www.gov.uk/government/consultations/reforming-the-energy-industry-codes

3 A New Way of Working

3.1 Our approach to the development and operation of the north of Scotland transmission system has evolved over many years to ensure that we are efficient, sustainable and acting in the best interests of our customers and stakeholders. It is critical that we maintain that discipline as we expand our approach to encompass the whole energy system.

Objective

3.2 We are clear that the objective of whole energy system working is to:

"Optimise the development, delivery, construction, operation and maintenance of our network, by working across traditional energy vector boundaries to deliver benefit to GB society"

3.3 To implement this approach, it is essential to have a transparent and consistent methodology for measuring the benefits. This methodology should allow the relative costs and benefits of different options (both traditional and whole system) to achieve an outcome to be measured and, hence, the option of greatest benefit to GB society to be selected.

3.4 We believe that cost benefit analysis (CBA) is critical to whole energy system working. CBA techniques allow both the costs and benefits of different intervention options to be measured (either quantitatively or qualitatively) over time, and compared on a level playing field. We have recently developed our CBA methodology to include for social and environmental factors, in additional to traditional economic measures. For example, a whole system solution could include electricity transmission, distribution or network services, or solutions from other energy vectors. CBA allows for a meaningful comparison by analysing all the costs and benefits associated with each, thus enabling informed decision making.

3.5 However, our existing CBA methodology[11] will need to expand beyond the electricity transmission system. Through CBA we may identify that one party must spend more than they would under a traditional approach to achieve the maximum GB society benefit. Robust, consistent CBA tools are essential to support this outcome.

Building Blocks

3.1 We can't do this alone. And we can't do this using just our existing analytical tools and technologies. There are three essential building blocks on which the establishment of whole system working depends (Figure 3):

- Engaging stakeholders to gain a common understanding of the desired outcomes;
- Working collaboratively to identify and assess possible solutions; and
- Supporting innovation to improve outcomes for GB society.

[11] https://www.ssen-transmission.co.uk/riio-t2-plan/cost-benefit-analysis-methodology/

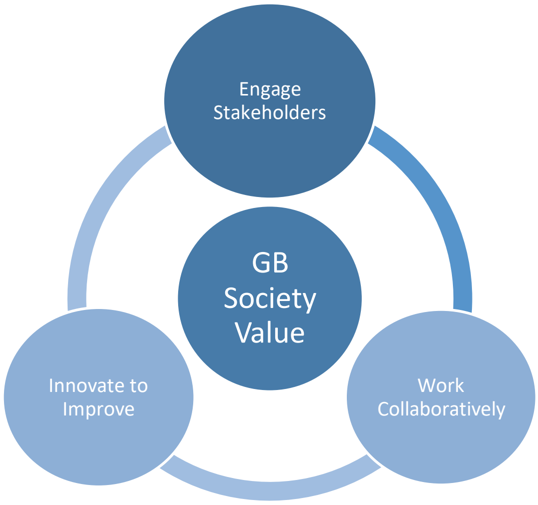


Figure 3 Whole system working building blocks

Engage stakeholders

3.2 Whilst developing and implementing a whole energy system approach it is essential that we engage with north of Scotland and GB stakeholders. In our Stakeholder Engagement Strategy[12] we define stakeholders as:

"Any individual, group of individuals, or organisations that affect and/ or could be affected by our activities, products or services, and/or associated performance", which includes customers and consumers."

3.3 Whole system approaches, by their very nature, have impacts across the energy sector. This includes both the current participants in the industry, potential new entrants and the end consumers that are impacted by whole system outcomes.

3.4 Identifying who is impacted and how requires consistent flows of information between all the potential parties. We recognise that establishing this communication needs to start with all parties being open to the sharing information that is necessary to develop a shared understanding. Having a consistent view across all parties of the whole energy system will enable informed discussion to identify opportunities to work together. It is also essential to quantify costs, benefits, timing and other aspects of any proposed solution.

3.5 We will need to tailor our engagement approach, being wide reaching in who we engage with and open minded to understand what their requirement is of the energy networks. It might be that a local authority is keen to understand the network capacity that could be realised and made available, for say EV infrastructure. Knowing that allows us to work together to design solutions that optimise the costs and benefits.

[12] www.ssen-transmission.co.uk/media/3560/shet-stakeholder-engagement-strategy-final-document.pdf

Work collaboratively

3.6 Despite the multiple parties involved, the electricity network in GB operates as one coordinated system, which is connected to European markets through interconnectors. The secure and efficient operation of the electricity system is contingent upon effective coordination and collaboration between the different parties. As one part of that system, we play a significant role in facilitating this collaboration through the interfaces prescribed in industry frameworks and codes.

3.7 However, as set out in the definition of whole energy system, our future ways of working must look beyond the electricity sector. To achieve this, the existing codes and frameworks will need to be reviewed, revised and expanded. The scale of the transformation required in collaborative working is illustrated in Table 1.

3.8 It is essential that as we are developing whole system thinking and embedding it through new or existing frameworks that we work collaboratively across industry. We must develop these using a common basis of definition, objective and value appraisal. Forums for this will include, but are not limited to, working within the Energy Networks Association (ENA), other existing networks owners and system operators and wider stakeholder forums, such as the Energy Systems Catapult and Scottish Government Energy Advisory Board.

Interface	**GB Society Benefit**	**Existing or New Framework**
TO-ESO *(Planning and outages)*	Faster access to low marginal cost/ renewable energy	Existing
	Lower constraint costs	Existing
TO-DNO *(Planning and outages)*	Reduced costs through optimal network development	Existing
ESO-DNO *(Planning and outages)*	Efficient system operation	Existing
TO-Customer *(Connection applications)*	Reduced cost through optimal network solutions	Existing
	Improved power quality and network operation	Existing
TO-Wider Energy Industry	Further optimal network development	Existing and New
	Lower carbon network delivered	New
TO-DSO	Further optimal network development	New
ESO-DSO-Wider Energy Industry	More efficient energy market	New

TO = Transmission Owner; ESO = Electricity System Operator; DNO = Distribution Network Owner; DSO = Distribution System Operator

Table 1 Examples of the collaborations that need to be reviewed to achieve whole energy system working

Innovate to Improve

3.9 For whole system to become established it will require new ways of working to be established into Business as Usual (BaU). Our Innovation Policy[13] defines innovation as a way of:

"Identifying and proving new ways of working for the long-term benefit of our stakeholders and ourselves."

3.10 We have completed and have in-progress innovation projects that can help deliver whole system. These include:

- Active Network Management (ANM) and flexible connections – Through joint working with the ESO, SHEPD and affected customers, we have developed new commercial processes for applying for flexible connections to address transmission network constraints. By detailed study of the constraints affecting the connections, we have been able to build up connection designs that are monitored to manage the risk of overload, a key whole system aspect resulting in the potential to delay future network investment. The majority of our generation connection customers now benefit from flexible connection arrangements.
- Probabilistic planning standards – We are working with others to study the potential to shift from deterministic standards to probabilistic ones. By doing this, we will be better able to take advantage of network services in an area; for example to manage the risk of low probability events that would otherwise drive larger reinforcement.
- Whole system modelling – Through a Network Innovation Allowance (NIA) funded project, we are working with SHEPD to better understand how to inform and model local authority plans for decarbonisation.

3.11 We also look to learn from others across industry and participate in national forums. By engaging with the innovation community through the Energy Networks Association (ENA), we are able to keep abreast of whole system projects being developed and participate or learn from depending on the scope.

3.12 Where we want to test new ways of working, and where there is no existing project that we can work with or learn from, we will look to establish a project to test the concept. That could be funded either through our base allowances or through specific innovation stimulus available through Ofgem or other third parties. We will look to deliver that project with project partners and so that the end outcome has application and/or learning across the industry.

[13] https://www.ssen-transmission.co.uk/riio-t2-plan/innovation-strategy/

4 Implementing Whole System Working

4.1 Our definition of the whole energy system incorporates gas, heat and transport. We believe that substantial progress towards whole energy system working can be achieved in the short to medium term. In the longer term though we see that benefits can be accrued to GB society from whole system working with other industries. These include water authorities, sustainability agencies and telecoms companies. In meeting our ambitions, we understand that there will need to be consistent across industry. We seek to play a leadership role in this development.

4.2 We describe three stages to the implementation of whole energy system working (Figure 4).

4.3 The **framework** stage looks to prepare us for the start of the RIIO-T2 period. Building on existing interfaces, and keeping it restricted to electricity, we are working with stakeholders to understand where whole system can be best applied. Although starting with existing interfaces, we recognise that the major barrier is a lack of industry frameworks for whole system analysis. Thus our primary objective is to establish the necessary frameworks that allow us to compare different network solutions be those network development or general operation and maintenance activities.

4.4 In order to have a more informed framework ready for the start of the RIIO-T2 period, we are targeting different projects as pathfinders. One of those is outlined in our Local Area Energy Plan (LAEP) [14] for Dundee City. Through working with SHEPD and the local authority, we will look to identify local drivers for the development of the local transmission and distribution networks. For each of the options to meet the drivers we will look to quantify the associated costs and benefits and use this to inform our overall network solution. This will allow us to gain learning in the optimal ways of engaging with local parties as well as gathering and analysing data, allowing us to identify well justified whole system solutions.

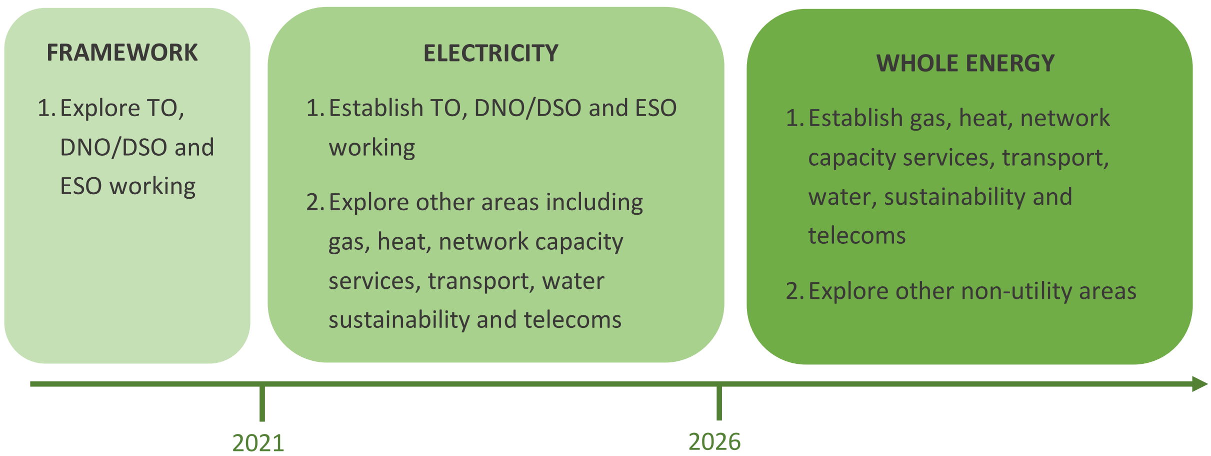


Figure 4 Timeline for whole energy system working implementation

[14] https://www.ssen-transmission.co.uk/riio-t2-plan/local-energy-area-plans-community-energy/

4.5 Key outcomes from the framework stage include:

- Agreement of a common industry definition of whole energy system, which will allow parties involved to share what is in scope for whole system working
- A common CBA toolkit and methodology, which will allow the value of any proposed whole system value to be identified across the vectors. This is essential to making sure that all the costs and benefits are identified, and the overall best decisions are made on what to progress
- Data sharing processes, including for the population of the common CBA model. At the framework stage, the parties involved are primarily system operators, network owners and network users
- Modifications to existing codes and regulations as required

4.6 The **electricity** stage looks to take the learning from the framework stage and establish it as BaU. Building on those frameworks and new ways of working, we will look to expand whole system to other energy vectors where it makes sense to do so. As a minimum we expect this to cover transport, gas and heat networks.

4.7 One example of an electricity stage whole system solution is our approach to the future of the transmission network that serves the island of Skye. During the RIIO-T2 period we will progress replacement of the existing Skye network, both improving security of supply and unlocking the local renewable energy potential. To identify the optimal solution, we are engaging with local stakeholders to better understand future energy requirements for both demand and generation and, hence, build up local energy scenarios. Understanding all these drivers will allow us to design a whole system solution, through integrated transmission and distribution network development, that efficiently meets all local drivers. It will deliver benefits for our and SHEPD customers as well as to the wider GB consumer through lower system operation costs.

4.8 During the electricity stage, we also expect that development work will progress on expanding whole system further: for example, to water, sustainability and telecoms. The critical aspect of this expansion will be identifying activities where whole system working might result in benefits to GB society, and then developing and implementing the necessary frameworks for collaboration across vectors. These frameworks will need to facilitate a comparison between any proposed solution from each vector to allow whole system solutions to be identified and delivered. In addition to the framework, there will need to be a role created for an independent party to allow determinations to be made should there be any conflicts between the various solutions.

4.9 The outcomes from the electricity stage will be informed by the outcomes from the framework stage. A key element will be the application of the learning from the framework stage and making enhancements to the industry frameworks. There will be a further outcome around identifying the potential whole system value that could be realised from expanding to other energy vectors. Those vectors that show value will then become the focus for building on to establish a whole system framework for the whole energy stage.

4.10 The **whole energy** stage will look to establish as BaU the other vectors developed from the electricity stage. Further work will focus on identifying further vectors that could deliver whole system benefits and developing the frameworks to encompass them if they do.

Data

4.11 Good quality, accessible data is central to achieving whole system outcomes.

4.12 Data is essential to many aspects of transmission system development and operation:

- Network data covering development planning, load flow analysis, headroom assessment and forecasting;
- Asset data covering the network assets, their condition, rating and locations;
- Operational data that covers the network arrangement, outage planning and constraints;
- Commercial data around access and service arrangements; and
- Real time data around aspects such as flexible connections and real time power flow effects.

4.13 During the framework and electricity stages, we expect enhanced data requirements to focus on the inputs to cross-vector network development plans and cost benefit analysis. This includes increasing the granularity and scale of current and forecast generation and demand data, as well as real time network asset data.

4.14 We are committed in our RIIO-T2 Business Plan to working collaboratively in the development of local authorities' LAEP across the north of Scotland. From this, and working with SHEPD and the ESO, our goal is to create whole system local Future Energy Scenarios (FES).

4.15 Sharing local FES and potential whole system development pathways will then drive benefit for current and future network users. Together, we can then identify opportunities for whole system network development. As a prospective energy network user, or existing network user of either the transmission or distribution networks, visibility of local FES and potential network developments would allow a more coordinated approach for using existing or future assets.

4.16 In addition to the network development data, whole system also will rely heavily on operational and real time data. That data will allow us to better define probalistic working through captured evidence, as well as being able to identify when contracted services need dispatched.

4.17 We recognise the value that the availability of this data can release. We also recognise that this level of information could have commercial confidentiality and security impacts. As we develop these data flows, we will be mindful of these considerations. The Energy Data Taskforce[15] work provides an important common framework to take this work forwards.

[15] www.gov.uk/government/groups/energy-data-taskforce

5 Application of Whole System Working in our RIIO-T2 Business Plan

5.1 We have applied our three whole system building blocks in the development of our RIIO-T2 Business Plan.

Example: Engaging stakeholders

5.2 Our RIIO-T2 Business Plan is stakeholder led.

5.3 In order to better understand what stakeholders wanted from our network, we started engaging on current and future energy network users' requirements. Starting in 2017, we delved into targeted known network requirements: industrial and commercial electricity demand, storage and generation, heat and energy efficiency and electric vehicles. We also gathered general input on network requirements from stakeholders, which we collated into a series of reports that were published and consulted upon. This information was used to build three possible future energy scenarios that show how energy use in the north of Scotland might change:

- Scenario one, Proactive Decarbonisation, was the potential outcome if Scottish consumers were greatly in favour of decarbonisation and the low carbon technology and principles that would drive.
- Scenario two, Local Optimisation, is based on Scottish consumers being driven by decarbonisation and cost reduction.
- Scenario three, Cost Limitation, where decarbonisation is a secondary consideration to cost reduction.

5.4 The final output was our North of Scotland Future Energy Scenarios report, published in 2018, which was the result of engaging with circa 150 of our stakeholders and informed our views on the potential uncertainty in our RIIO-T2 Business Plan[16].

5.5 This exercise was a prime example of whole system working. Firstly, it gathered information, not just about current drivers of our network development round generation or demand, but also about future drivers. It also looked wider than just electricity by looking at local plans for increasing EV take up, as well as plans for heating and energy efficiency. This whole system information was then used to support decisions on the certainty of investment during the RIIO-T2 period, based not just on what on current drivers but also future drivers from electricity and beyond.

Example: Working collaboratively

5.6 Our RIIO-T2 Business Plan is the largest, wide ranging exercise in collaboration and co-creation that we have undertaken. This built upon our experience in working with others to deliver complex network developments.

5.7 Significant learning about effective collaboration has come from our work with Scottish Islands' stakeholders. For example, when we were developing the best solution for reinforcing the Orkney Islands, we engaged extensively across a wide range of stakeholders, including local authorities, generation developers, Scottish Government, ESO, SHEPD, Ofgem, BEIS and the wider energy industry. Through this we identified blockers to unlocking the islands' renewable energy potential, which we worked with those same stakeholders to resolve. The factors were wide ranging including planning, subsidy requirements, regulatory arrangement and the

[16] https://www.ssen-transmission.co.uk/riio-t2-plan/planning-for-net-zero-scenarios-certain-view-and-likely-outturn/

industry commercial framework. Working together, we co-ordinated a whole system solution, termed the Orkney Alternative Approach[17], which we led in seeking industry reform.

5.8 Through our Stakeholder Engagement Strategy, we intend to apply the collaborative approaches developed for the Scottish Islands across our business activities. This is central to our RIIO-T2 Business Plan approach and ambition.

5.9 An example is in supporting EV plans for our area. Our North of Scotland Future Energy Scenarios work showed that the existing network could accommodate local authority aspirations for EV penetration through to 2025. However, we recognise we have an important contribution to make to future rollout plans. We are party to a joint project with Scottish Government and Scottish Power Energy Networks to to better understand the impact from city developments of EVs on major trunk roads, through tourism and in Dundee City. Outputs from these collaborative projects will further inform our local development plans.

5.10 This approach taught us a lot on the importance of taking a whole system view when developing our network. Our plans do not just affect ourselves and our stakeholders, they have wider implications across our industry and society. We have replicated this approach throughout development of our RIIO-T2 Business Plan; for example in the development of our social, environmental and economic CBA methodology, our industry leading Networks Access Policy[18] and approach to quantifying and reporting on innovation benefits.

Example: Innovate to improve

5.11 Our holistic Innovation Policy has whole system thinking at its core. Not only through the way it has been developed as a strategy, but also through how innovation opportunities are identified, developed and subsequently tracked for their benefits.

5.12 A good example of innovation delivering whole system value is embodied by our overall ambition to reduce our greenhouse gas emissions (GHG) by a third by the end of RIIO-T2. A key part of delivering that is our strategy[19] for reducing our emissions from Sulphur Hexafluoride (SF_6). SF_6 is a gas that is used internationally as an insulation and interruption gas (IIG). Whilst it is inherently safer than other insulants and very good at that purpose, it is one of the four gasses captured under the Kyoto Protocol, thus reducing its use is a key focus for us.

5.13 Innovation plays an important role as it helps identify new ways of managing use on our existing stock, through identification of leaks and ways to repair them. Innovation also plays a part in identifying new IIGs that can avoid its use. Working with suppliers and stakeholders we have identified two alternatives to SF_6 that we are in the process of trialling on our network. Our forthcoming projects at Fort Augusts and New Deer substations will use GEs switchgear and busbar with g^3, their equivalent to SF_6. The Fort Augustus project will be the first transmission site in the UK to have a fully g^3-insulated substation and the New Deer site will see the largest volume of the gas deployed in one location. This will avoid installation of the equivalent of 200,00 tonnes of CO_2.

[17] www.ssen-transmission.co.uk/projects/orkney/
[18] https://www.ssen-transmission.co.uk/riio-t2-plan/network-access-policy/
[19] https://www.ssen-transmission.co.uk/riio-t2-plan/our-strategy-for-the-management-of-insulation-interruption-gases/

Figure 5 Fort Augustus Substation

5.14 This approach demonstrates our whole system approach as we take the risk of deploying it, and the associated increased expense through BaU, that will ultimately deliver GB society benefit. We are also informing other licensees own plans for reducing SF_6 usage.

5.15 We are also working with the ESO to identify new ways of working where there are whole system issues and solutions. Examples include the ESO pathfinder projects on stability and a probalistic approach. Through the stability project we are working together to support the ESO better identify and define the impact of reducing fault levels and inertia on the system. We are also actively taking part in providing solution options to resolve these issues. For example we have responded to the Request For Information with potential solutions which not only enhance system stability but also help increase resilience. We will also look to better understand and work together in developing probalistic planning standards that work for our area and across the UK.

6 RIIO-T2: the Electricity Stage

6.1 Our two ambitions for the development of whole system working during the RIIO-T2 period are (Figure 4):

i) establishing whole system working as BaU across electricity; and

ii) expanding the whole system framework to encompass other energy vectors.

6.2 We intend to pursue a 'learning through doing' approach, where whole system working can be developed through its application to current network requirements and, hence, realising immediate benefits for GB society. This approach will increase the breadth and depth of learning, as different network issues occur across GB.

6.3 A key outcome from the electricity stage in the north of Scotland will be achieved through Local Area Energy Plans. The development of these Plans by each local authority is a central forum to bring together all local energy stakeholders to share future energy requirements. We expect this collaboration to result in local future energy scenarios that encompass the range of potential energy (electricity, gas, transport and heat) needs. From this, we can transparently develop energy network pathways that incorporate non-network and third party solutions.

6.4 Energy network development pathways will incorporate flexibility, either as a service or through infrastructure provision, whose inclusion will be underpinned by appropriate probalistic planning standards. The flexibility will either be at distribution or transmission level and will either be through existing or new ancillary or capacity service markets. In identifying the potential benefits of a flexible approach, we will advocate for its adoption through GB industry frameworks.

6.5 It is critical that network development is efficient as possible, on a whole system and whole life basis, through maintaining investment at the right time. Consistent with the guidance from the Committee on Climate Change, our whole system analysis will demonstrate where an earlier investment would deliver longer term benefits for GB society. This analysis will be underpinned by CBA that looks to identify the whole system beneficiaries each option and the total cost.

6.6 As this way of working becomes established for electricity then we will look to build upon it with the inclusion of other energy vectors starting with gas, transport and heat. Over the coming years we intend to widen the range of stakeholders we engage with to explore where whole system working will be of benefit to GB society. Our 'learning through doing' approach to real world problems should ensure that this expansion is of immediate practical benefit.

6.7 Throughout the RIIO-T2 period, we will also feed our learning in to the wider industry, as we learn from others work, to ensure that whole system develops GB wide. This includes consistent review of the application of existing codes and regulations that can either help or hinder whole system working. Where necessary, and based on our practical learning and our stakeholders' needs, we will work with appropriate parties to modify industry codes and frameworks.

Case study: Engage stakeholders – Dundee City

6.8 The Dundee City transmission network is formed of a 132kV double circuit that forms a ring around the city, starting and ending at the same transmission substation, Tealing. Through a mixture of overhead and underground cable, it links four 132/33kV substations through mostly built up areas. The network largely accommodates household and commercial demand, with this set to increase with the local economic development plans. Additionally, the local authority is progressive it comes to the development of infrastructure to support EVs. This demand requirement is being offset by an increase in distributed generation, including the potential for large scale storage devices.

6.9 There are a number of drivers for whole system working in the Dundee City area. There is the accommodation of changes in network use: generation, demand and storage. There is also an opportunity to increase the resilience of the network. This is driven by the historic design arrangement of the network which means that a fault on the overhead sections of the network would result in loss of the majority of one of the ring circuits, leaving Dundee on a single circuit risk.

6.10 A whole system approach requires close collaboration with stakeholders, in particular the local authority, with SHEPD and the ESO. Through collaboration we can achieve:

- Reduced network costs for the developers and wider consumers. These could be delivered through either better use of existing distribution or transmission network assets or ESO dispatched network services managing potential overloads;
- Capital investment efficiencies by designing across transmission and distribution, so considering a wider range of options and reducing stranding risk; and
- GB society benefiting from the facilitation of more renewable energy into the overall energy market and reduced use of fossil fuelled transport.

6.11 Through RIIO-T2 we will deliver a design that addresses the captured drivers described above. Our current plan is to be ready to start implementation in RIIO-T3. However, should the drivers require addressing before that time, then we may opt to use the Co-ordinated Adjustment Mechanism[20] as a reopener to progress.

Case study: Work collaboratively – North East 400kV investment

6.12 The North East transmission network comprises the overhead lines and cables connecting supergrid substations at Blackhillock, Kintore and Peterhead (Figure 5). The North East 400kV investment is part of the Certain View in our RIIO-T2 Business Plan. The investment involves uprating the existing 275kV overhead line circuits between Peterhead, New Deer, Rothienorman, Blackhillock and Kintore substations to 400kV operation through re-insulation and reconductoring, the construction of a new 400kV busbar at Peterhead and associated works at New Deer, Rothienorman, Kintore and Blackhillock substations to enable 400kV connectivity.

6.13 The need for the North East 400kV project encompasses local asset condition and performance, and current and future generation and demand users' requirements. The investment is also necessary to enable the future

[20] https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_core_30.5.19.pdf

upgrade of the east of Scotland transmission system, as indicated with a 'proceed' signal in the ESO Network Options Assessment.

Figure 5 North East 400kV investment

6.14 A whole system approach to the development of the North East 400kV investment has been undertaken, also taking into account the long term network development plans for the East Coast Onshore 275kV Upgrade, the East Coast Onshore 400kV Upgrade and the Eastern HVDC Link. A wide range of factors have been considered in the development of the North East 400kV investment: generation, demand, asset condition and performance, system operation and outages, environmental constraints, supply chain and deliverability, and maintaining security of supply. Collaboration with the ESO, SHEPD and current and future generators has enable whole electricity system thinking. The combination of works and timing has been demonstrated through cost benefit analysis to represent the optimal outcome for GB society.

6.15 The North East 400kV investment is due to go into construction in 2020. The learning from this whole system working has materially improved our cost benefit analysis methodology and network planning. It emphasises the criticality of considering long term network development pathways in realising efficient and timely system outcomes. We are pursuing this regional approach as standard in our RIIO-T2 Business Plan as applied in, for example, Skye and Argyll.

Case study: Innovate to improve – Shetland

6.16 The Shetland electricity distribution network is owned and operated by SHEPD. The Shetland archipelago has no connection to the GB mainland transmission or distribution networks but is supplied from Lerwick Power Station (LPS) supported by Sullom Voe Terminal and onshore wind. LPS was constructed in the 1950s and as a result of new environmental legislation and its advanced age, will have to close in the 2020s. We have recently submitted plans for investment approval, through the RIIO-T1 Strategic Wider Works mechanism, to build a 600 MW HVDC link from Shetland to the mainland enabling renewable energy on the islands and improving security of supply.

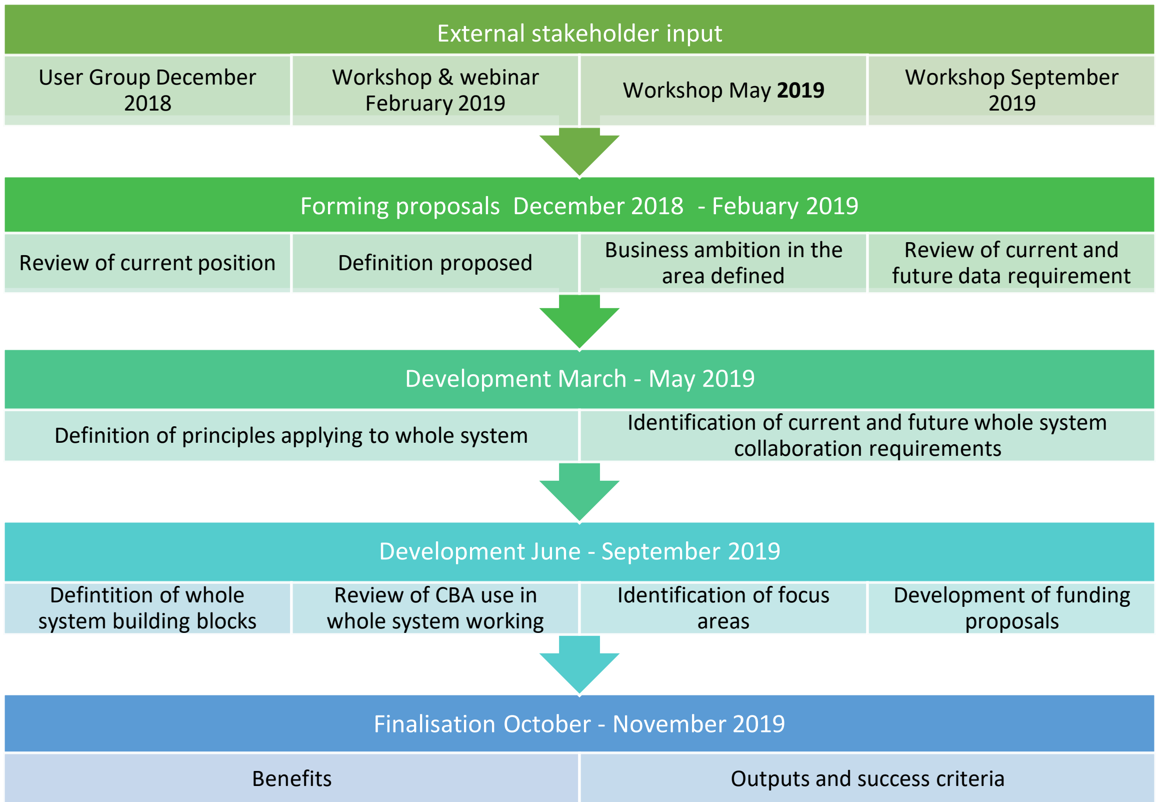
6.17 The Shetland project is probably the most advanced example of whole system working in GB led by our sister network SHEPD. The Shetland Islands have been the testbed for network-led local energy management systems, including ANM and demand-side management and response. Collaboration with the community and wider stakeholders has been central throughout.

6.18 Currently our innovation focus is on how we can go beyond conventional planning standards to increase the capacity of generation that can use the proposed 600 MW HVDC link. Maximising the utilisation of the transmission infrastructure increases the efficiency of the investment and increases benefits to the islanders and GB society. In particular we are exploring how low probability network excursions can be mitigated through real time monitoring and control of network components.

6.19 This work will inform our transition to probalistic planning standards with a real life 'learning by doing' example. We will also learn how value can be realigned between two separate licensed entities and how that could be replicate for other whole system solutions.

Appendix 1 Stakeholder Engagement

We've worked with stakeholders, colleagues and across industry in the development of this document. We have developed initial proposals identified through research, which we've tested at various events. We've captured their feedback and used it to further develop and improve our proposals, ensuring they reflect what is important for our stakeholders.



Further detail on the three targeted whole system events in February[21], May[22] and September[23] can be found at the associated links.

Across these activities we have engaged with the following stakeholders:

ABB Ltd	Energyline	Nortech Management Ltd	Scottish Power
ABO Wind	General Electric	Ofgem	SGN
Aquatera	Glasgow Caledonian University	Open Grid	SHEPD
Balfour Beatty	Green Cat Renewables	Power and Renewables	SSE Renewables
BayWa r.e.	Innogy	Powerline Technologies	Siemens
Corrie Construction	Local Energy Scotland	RES	The Cyberhawk
DP Energy	LS Transmission Consultancy Ltd	R J McLeod	TNEI
EDF Energy Renewables	Morgan Sindall	Russet Engineering	Transport Scotland
EMEC	National Grid	Scottish Enterprise	Xero Energy

[21] https://www.ssen-transmission.co.uk/media/3398/riio-t2-connections-innovation-and-whole-systems-stakeholder-engagement-event-february-2019-output-report.pdf

[22] https://www.ssen-transmission.co.uk/media/3453/riio-t2-connections-innovation-and-whole-systems-stakeholder-engagement-events-may-2019-output-report.pdf

[23] https://www.ssen-transmission.co.uk/media/3651/riio-t2-stakeholder-engagement-events-september-2019-output-report.pdf

	ESO		
Energy Saving Trust	National Grid TO	Scottish Government	

The comments and feedback we have received has shaped this whole system policy document:

Comment	How we accounted for it
“For any developer, the boundary between distribution and transmission is a false one. We should be thinking more widely across gas and electricity.”	Definition and objective redrafted to reflect cross vector working
“The benefits relate to customer costs and the support of decarbonisation.”	Objective expanded to target GB society benefit and not just consumer benefits, thus allowing wider nonmonetised benefits
“I think it feels about right, focusing first on distribution and transmission.”	Ambition and associated timelines redrafted following May event to clarify beginner, intermediate and advanced and associated timelines
“I don’t quite get the benefits”	Focus areas drafted following May event to help explanation with associated benefits
“I don’t entirely understand your role in all of this. For example, do you drive the strategy?	Whole system development to start with us driving consensus through industry for definition, objective and CBA
“As you start considering more components and systems get bigger, it will be much more difficult to ensure that everyone wins	Will use CBA to justify whole system schemes that deliver net GB society benefits not just that all vectors must benefit
Stakeholder agreed that we had not missed any focus areas	Left focus areas as discussed at event and as evidenced through the examples explained in this document

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