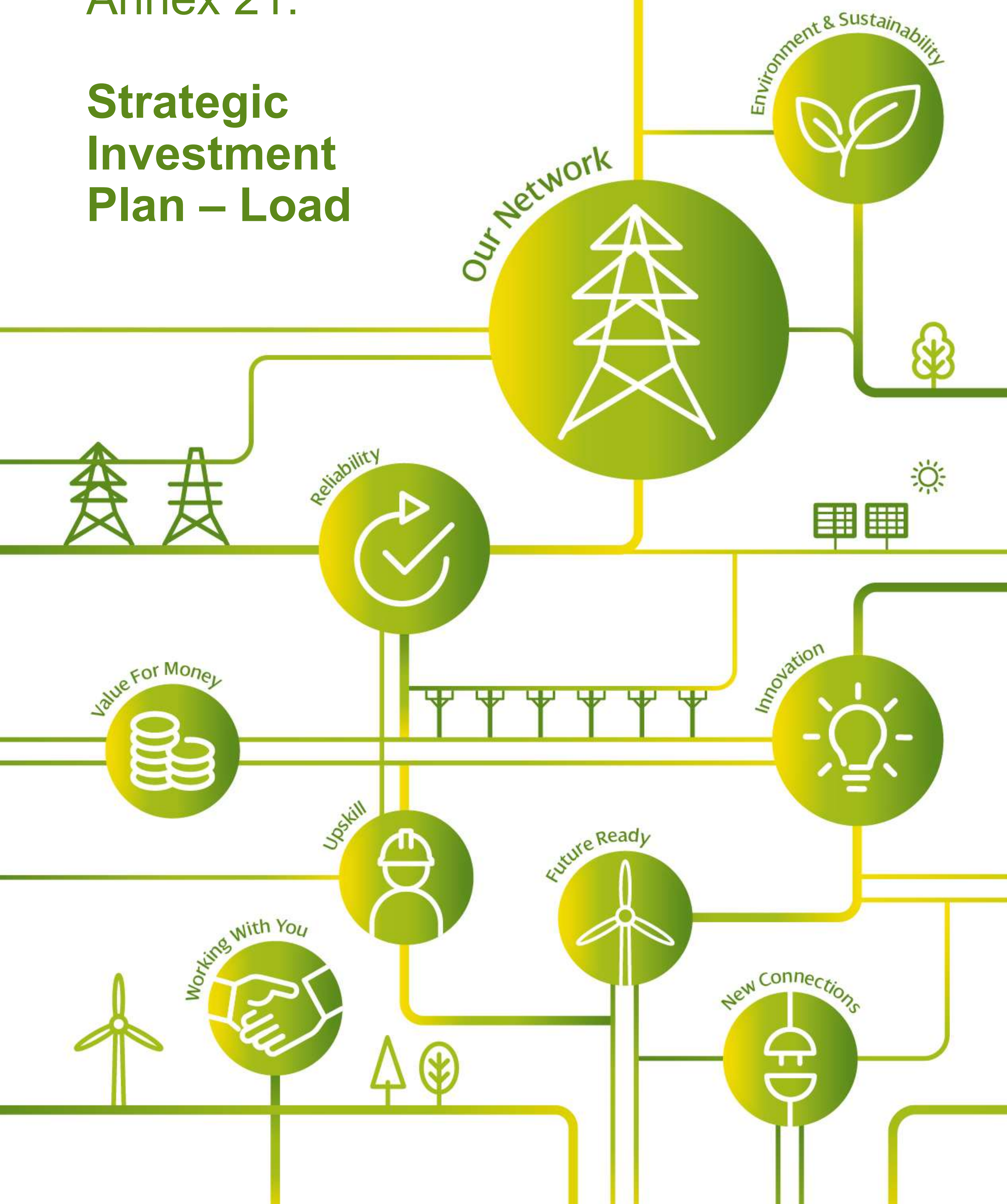
SP Energy Networks, RIIO-T2 Business Plan
December 2019 Submission

SP ENERGY NETWORKS

Annex 21:

Strategic Investment Plan – Load



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INTRODUCTION

Our RIIO T2 business plan includes a number of generation connection, wider works and NOA projects, each with its own engineering justification paper. It is, however, important to note that these projects work together to provide network capacity and to ensure that our network remains operable. This paper outlines the interactions between projects and how various projects work together. We also provide some background on how we have determined the need for these projects and how different solutions are evaluated.

During the development of our plan, we considered a wide range of build and non-build solutions, including whole system solutions where these are feasible, such as equipment installed on DNO networks. We are working closely with the ESO on its Pathfinder projects[1] and have provided flexibility in our plan in case those initiatives lead to changes in requirements for our network.

A separate Annex (Annex 4: Strategic Reinforcements) provides details of how NOA boundary reinforcement projects are coordinated between the TOs and the ESO. This paper makes reference to these projects and how they interact with other wider works included in the SPT RIIO-T2 business plan.

NETWORK PLANNING

The SQSS[2] is the standard by which the GB transmission network is planned and operated. The SQSS ensures that all Users connected to the transmission system are provided with a minimum level of supply security and sets the limits within which the system must be operated. Our license requires us to comply with the SQSS and to do so in an economic and efficient manner. Essentially we, and the other TOs, have to provide the ESO with a network that will be economic and efficient to operate for a wide range of possible and evolving network, demand and generation conditions.

We test if our network complies with the SQSS by simulating the network with a computer model of the whole GB transmission system. This allows us to study the network for a range of scenarios and operating conditions at different points in time. Typically, the network is subjected to a wide range of faults or contingencies and the study results are then compared to the requirements of the SQSS to check if the standard is met. E.g. to establish the capability of a boundary, the power flow in the circuits crossing the boundary is progressively increased[3] and a number of outages (typically single or double-circuit faults) are applied. As soon as the network becomes marginally non-compliant with the SQSS (e.g. a circuit is loaded to full capacity or the voltage at a node is at its minimum limit), the maximum boundary capability has been reached. If greater capability is required, various options to reinforce the network can now be implemented in the study network and tested in the same way. Options that provide sufficient boundary capability uplift can now be compared and evaluated further in terms of cost, delivery timescales, losses, land requirements, etc. For boundary upgrade projects, the best options are also submitted to the NOA process for more detailed economic evaluation.

A similar process is followed to test the network against a range of static and dynamic SQSS requirements, such as voltage, fault level or stability and to evaluate the performance of options to restore compliance where and when required. As the network evolves to accommodate an increasing penetration of renewable generation and new technologies, more sophisticated and complex network models are used, e.g. to consider fast transients, oscillatory events and other risks in more detail.

Our network models allow us to design and evaluate a wide range of solutions to any network limitations, non-compliance or risks identified. Normally a wide range of potential solutions is investigated, including build and non-build options, with the aim of developing an economic and efficient transmission network. Some options can provide solutions to multiple issues, e.g. a new overhead line circuit will provide additional capacity, but might also solve a voltage problem. We therefore study the impact of multiple options and projects working together and only study solutions in isolation when this is technically justifiable.

[1] https://www.nationalgrideso.com/insights/network-options-assessment-noa/network-development-roadmap
[2] National Electricity Transmission System Security and Quality of Supply Standard
[3] In practice a more sophisticated, faster algorithm is used to find the maximum power flow.

WIDER WORKS PROJECTS

Load-related investment for RIIO-T2 in the SPT area is generally driven by increasing renewable generation in Scotland. There are works to connect new generation and projects to create network capacity to transmit power from these new generators to demand in England and Wales. Depending on the scenario considered, net peak transmission demand in the SPT area reduces or remains constant until the mid-2030's[4] and therefore does not lead to additional wider network investment. However, net minimum transmission demand is expected to continue to reduce, mainly due to increases in embedded renewable generation. This has the effect of unloading the transmission network at times, leading to high voltages and other operational issues. At the same time, large conventional power stations are closing, leading to a reduction in system strength.

Our business plan includes a range of wider network reinforcements that work together to improve network capacity and also deal with operational problems as summarised in Figure 1 and Table 1 below.

RENEWABLES AND SYSTEM OPERABILITY CHALLENGES

Almost all our wider works projects provide reinforcement for a system with increased renewable generation. Our projects will provide network support that will help to realise the ESO's ambition to operate a zero-carbon electricity system by 2025[5] and provide some of the electricity system building blocks that will help to ensure that Net Zero can be met. For the ESO's ambition to become a reality, a number of key challenges need to be overcome, including the ability to manage more rapidly changing system frequency and voltages, ensuring sufficient inertia and fault infeed and accurate monitoring of the network[6].

The ESO is currently tendering for stability services as part of their Stability Pathfinder project[7]. We expect this and future tender phases to provide system strength and stability services from a number of service providers across the GB network. However, the location, timing and amount of system strength that will be provided in this way is not yet known. If insufficient stability services are contracted in the SPT area, our synchronous compensator projects [1] will assist with any shortfall in much-needed system strength to support a network with very high output from renewable generators. An uncertainty mechanism ensures that these projects will only be funded if suitable alternatives do not emerge from the Stability Pathfinder process.

Commercial stability services and our synchronous compensators will work with other shunt compensation [2, 3, 4, 5], harmonic filters [6] and our smart systems [7, 8] to maximise renewable generation output and circuit loading, to ensure that a zero-carbon system can be operated successfully while maintaining system stability.

Our programme to modernise our system monitoring equipment [9] will provide much better visibility of how the network performs and will better highlight emerging operability or stability issues, extending to the sub-synchronous and harmonic frequency ranges.

HUNTERSTON

A number of projects interact at Hunterston to improve the capability of the Western Link, while also improving wider system strength and voltage control in the area.

The closure of Hunterston nuclear power station in 2023 leads to a significant reduction in local network support that is required for unconstrained operation of the Western Link. The Hunterston East – Neilston 400kV reinforcement (NOA project HNNO) [10] provides an increase in fault level and thermal capacity, particularly under certain network outage conditions, by reconfiguring the network and adding a supergrid transformer at Neilston. The operating range of the Western Link is further improved by commercial stability services or the installation of a synchronous compensator (SPT200137) [1]. A stability service or synchronous compensator will not replace the full reactive range of the Hunterston

[4] Baringa and Element Energy, SPT RIIO-T2 Planning Scenarios 2019 Update, September 2019. Also see Business Plan Data Table A5.1.
[5] https://www.nationalgrideso.com/news/zero-carbon-operation-great-britains-electricity-system-2025
[6] https://www.nationalgrideso.com/document/141031/download
[7] Phase 1 tender closing 17 January 2020 for stability services starting between April 2020 and April 2021. https://www.nationalgrideso.com/balancing-services/system-security-services/transmission-constraint-management?market-information

units and the additional shunt reactor [3] makes up some of the shortfall. Also note that the shunt reactor provides reactive compensation with much lower losses than a synchronous compensator.

BLACK START

A key aim of our business plan is to ensure that our network can recover as quickly as possible in the very unlikely event of a complete blackout. Our Black Start project [11] reduces switching risks during a system restoration, but also reduces transients and disturbances during normal operation.

A number of other schemes will establish network support that will be vital as the network is rebuilt from outside our area. Suitable stability services or our synchronous compensators will provide system strength and are essential to reduce restoration times. They also make it possible for renewable generators to be used to pick up load during the restoration of the system. Our shunt compensation projects provide facilities to control network voltage, particularly during the early stages of restoration while the network is very lightly loaded.

Unreliable telecommunication links to substations will impair network restoration efforts. Therefore, we are planning to modernise and significantly improve the resilience of our telecommunications systems, which will help to ensure reliable communications in the event of a black start [12].

SHUNT COMPENSATION

Our reactive shunt compensation projects provide a coordinated mixture of static and faster-acting dynamic compensation. Simple fixed shunt reactors can be switched in or out as required to control high voltages, while dynamic compensation, such as the STATCOM proposed for Mark Hill [4] can respond very rapidly during fault conditions. Synchronous compensators can also provide dynamic reactive compensation, although they are slower to respond than a STATCOM. Our Phoenix project[8] combines a synchronous compensator and a STATCOM to provide the best of two worlds: The fast response of a STATCOM and the system strength provided by the synchronous compensator.

We are scaling up the Phoenix technology at Eccles, where we are proposing two such hybrid installations (NOA project ECVC) [5]. At Eccles, a compensation device with rapid response will improve system stability following critical faults, thereby providing an increase in boundary capability. Eccles is a major network node and is likely to form part of a network spine during a system restoration. Therefore, it is also an optimal location for a synchronous compensator. Further, a hybrid synchronous compensator at Eccles will ensure that boundary capability and system strength can be maintained when Torness nuclear power station closes.

FAULT LEVELS

The closure of large conventional generation plant leads to a reduction in transmission network fault levels, while the growth in embedded generation leads to increases in fault levels at grid supply points. Unfortunately, the transformers used at grid supply points mean that the two systems only have a limited impact on each other, e.g. a reduced fault level at transmission voltages reduces the distribution fault level by only a small amount and vice versa.

At the transmission level, stability services and our synchronous compensators will help to increase the fault level, while projects like the harmonic filters help to deal with some of the consequences of reduced system strength and fault level.

In the distribution system, high fault levels often block the connection of new embedded generation until mitigation can be implemented. Working with SPD, we have taken a whole-system approach to this problem and are using opportunities to reduce the fault level at the same time as replacing equipment that is reaching the end of its life (SPT20060 – SPT20084), creating substantial headroom for the connection of embedded generation.

CONCLUSION

The range of conditions and backgrounds over which our network has to operate is widening. New approaches are required to deal with these changes to the electricity system. Our plan proposes an ambitious range of projects to ensure that these challenges can be met and that the network can continue to be operated in a safe, efficient, economic and stable

[8] https://www.spenergynetworks.co.uk/pages/phoenix.aspx

manner while ensuring that the required changes in energy generation and consumption on the path to Net Zero can be made.

We are proposing projects to improve system operability, increase network capacity to transport more renewable energy and maximise utilisation of the network.

We are also working on new proposals to increase operability and capacity beyond RIIO-T2, such as new AC and HVDC circuits and the possible installation of three further synchronous compensators [1].

SUPPORTING DOCUMENTATION

The following Engineering Justification Papers refer (also see Table 1 below, which shows project numbers):

1. EJP_SPT_SPT200137-142, Synchronous Compensators
2. EJP_SPT_SPT200124, Shunt Compensation - Operability (60Mvar Reactors)
3. EJP_SPT_SPT200122, Shunt Compensation - Operability (Hunterston)
4. EJP_SPT_SPT200134, Shunt Compensation - Mark Hill
5. EJP_SPT_SPT200120_ECVC, NOA Project, Eccles Shunt Compensation and Real Time Rating Scheme
6. EJP_SPT_SPT200126, Harmonic Filters
7. EJP_SPT_SPT200130, Circuit Rating Management System
8. EJP_SPT_SPT200132, Generation Export Management System (GEMS)
9. EJP_SPT_SPNLT2051, System Monitoring Modernisation
10. EJP_SPT_SPT200112_HNNO, NOA Project, Hunterston East - Neilston 400kV Reinforcement
11. EJP_SPT_SPT200128, Black Start
12. EJP_SPT_SPNLT2055, 400kV and 275kV Resilience Project

Our plans to adapt to a changing landscape

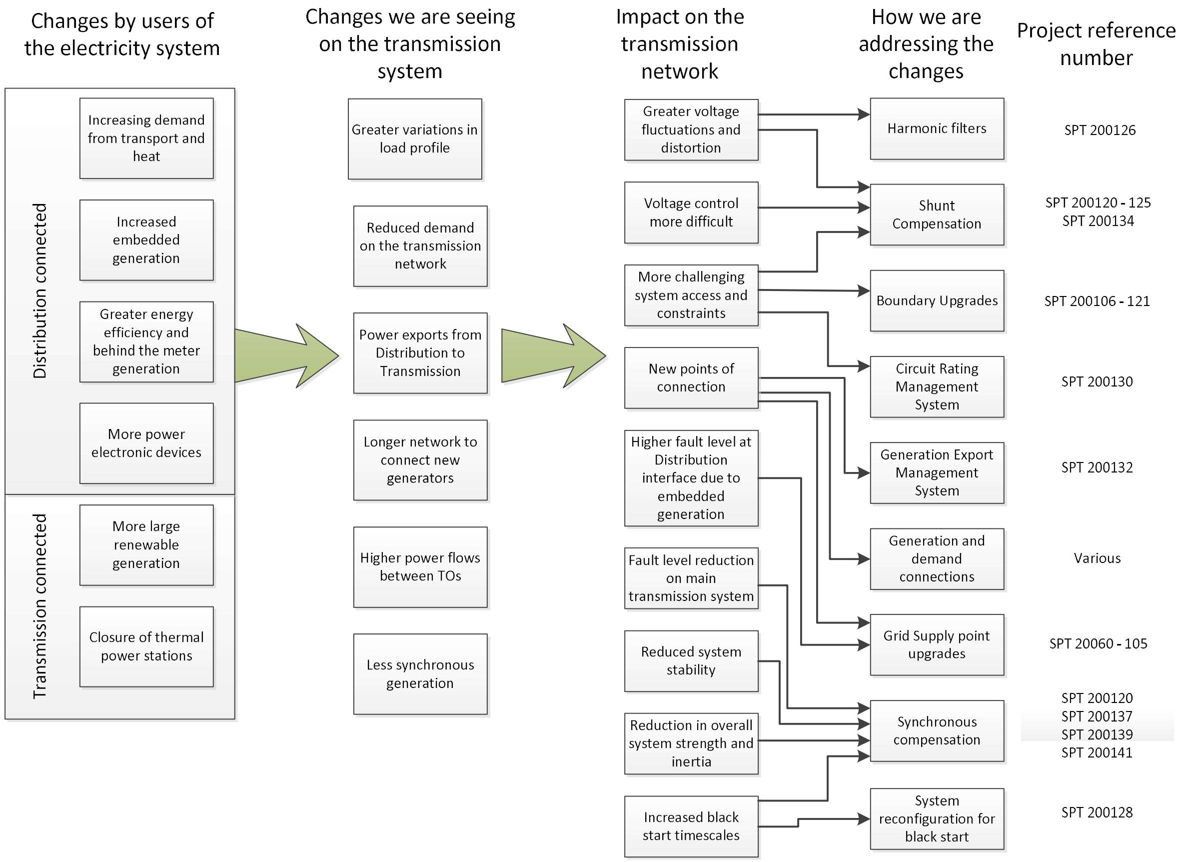

Figure 1. Changes on our transmission network and how our plan is adapting it for the future.

Table 1. Project interaction and impact.

Project Number	Project	Thermal Capacity	System Operability						Black Start	Enable Renewables
			System Strength		Voltage	System Stability	Power Quality			
			Fault Level	Inertia						
SPT200106	DWNO Denny to Wishaw 400kV Reinforcement	X				X			X
SPT200108	ECU2 East Coast Onshore 275kV Upgrade	X							X
SPT200110	ECUP - East Coast 400kV Incremental Reinforcement	X							X
SPT200112	HNNO - Hunterston East-Neilston 400 kV Reinforcement	X	X			X			X
SPT200114	E2DC - Onshore - Eastern Subsea HVDC Link from Torness to Hawthorn Pit	X							X
SPT200118	WLTI Windyhill - Lambhill - Longannet 275kV Circuit Turn-in to Denny North 275kV substation	X							X
SPT200120	ECVC Eccles Shunt Compensation (hybrid devices)	X	X	X	X	X	X	X	X
SPT200122	Shunt Compensation - Operability (Hunterston)				X			X	X
SPT200124	Shunt Compensation - Operability (Reactors)				X			X	X
SPT200126	Harmonic Filters (MOFF, NECU, BLAH, MARG, LINM, NETS)						X		X
SPT200128	Black Start						X	X	
SPT200130	Circuit Rating Management System	X							X
SPT200132	South West Scotland Generation Export Management System (GEMS)	X							X
SPT200134	Shunt Compensation - Mark Hill (STATCOM)				X	X	X	X	X
SPT200137	Synchronous Compensation – Hunterston *		X	X	X	X	X	X	X
SPT200139	Synchronous Compensation – Kincardine *		X	X	X	X	X	X	X
SPT200141	Synchronous Compensation – Strathaven *		X	X	X	X	X	X	X
-	Stability Services (ESO Stability Pathfinder)		X	X	U	X	U	U	X

NOA projects are shaded, * – Uncertainty mechanism, X – has impact, U – uncertain.