RIIO T1 Business Plan

Section 5 Non-Load Related Expenditure

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Non Load Narrative

Executive Summary

The strategy for the existing 132-400kV transmission network aims to ensure an optimum level of investment through a prioritised and targeted project specific approach. This is necessary to effectively manage the business risk, ensure cost-efficient investment and continue the long term sustainability of this key UK asset.

Our investment plan for RIIO-T1 involves £697m (Best View) for non-load related investment associated with the replacement of assets which are at end of life. The investment plan has been developed utilising our Asset Risk Management policies and procedures, which reflect the nationally agreed Network Output Measures methodology. This has involved extensive use of current asset condition information, combined with our asset replacement age based modelling. The use of condition and modelling data, along with site criticality, has ensured our plans reflect the key investment priorities. As a result, prioritised detailed work programmes are developed, at a circuit or substation site specific level.

Our non-load investment plan has been kept below the outputs expected through age based modelling to minimise costs to customers. This applies both against our own (SKM model) and Ofgem's model

- Our investment is 30 to 40% less than the Ofgem model
- Our investment is 40 to 50% less than our (SKM) model

In addition, again the minimise cost increases to customers we have built our non-load related investment in RIIO-T1 in the following manner

- Lower plan (Baseline Ex-ante) totalling £626m
- A Best View plan totalling £697m (incl Baseline)
- An Upper Case plan totalling £811m

We propose the use of uncertainty mechanisms - triggers or volume drivers - to scale between Baseline and Upper Case.

In our Best View plan the two key investment areas involving £427m (61% of the non-load investment programme) are:-

1. Overhead Lines (£309m =44% of non-load programme) Our plan is to address 44% (519km) of the large population of 1960s ACSR conductor on the 275kV and 400kV network in RIIO-T1 with a further 671km (56%) in RIIO-T2; to manage the end of life risk associated with this conductor type. In addition, a further 24% (359km) of the 132kV network will be reconductored.
2. Switchgear (£118m =17% of non-load programme) We plan to replace 50% (81 CBs) of the large population of 1950/60s Air Blast and Bulk Oil circuit breakers which have become less reliable and difficult to maintain due to a lack of spares and, manufacturer support. There are significant costs associated with maintenance of this equipment associated with modern Health & Safety requirements along with extended outage durations. A further 62 circuit breakers will be replaced (39%) in RIIO-T2, with the residual 17 units replaced (11%) in early-RIIO-T3 to manage the end of life risk with this equipment.

In the other non-load areas investment is targeted at obsolete and/or poorly performing and unreliable equipment. We will continue to invest in the modernisation of Protection, Control & Telecoms equipment, £80m (11% of non load programme). Ongoing asset replacement of transformers (£54m =8%) is necessary to address end of life BSP transformers, and to maintain our strategy of replacing unreliable Bruce Peebles transformers. Investment on underground cables is significantly reduced during RIIO-T1 to £16m. This is, down from £13m pa in TPCR4 to £2m pa, following the successful completion of our programme to replace unreliable gas compression cables.

Contents

1 Introduction

The 132-400kV transmission network is a key, UK strategic asset, which has historically facilitated the bulk transfer of power from thermal generating stations to large urban load centres. The rapid increase in renewable forms of generation is causing the dynamic nature of load flows to change, necessitating an increased boundary transfer capability of energy from Scotland to National Grid in England & Wales as the network evolves towards 2050. Most of the network was built in the 1950s - 1960s and now a significant portion requires replacement due to its condition.

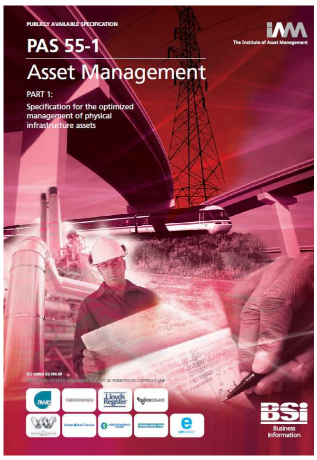
This document details the Non Load Transmission Network Investment Strategy for 132-400kV network assets. It explains

- our risk management and process methodology,
- the overall strategies developed, including the two key elements:
    - **All Health Index 5 1960's 275kV conductor replaced prior to 60 years old by the end of RIIO-T2 (2029) with 44% replaced during RIIO-T1**
    - **All Health Index 5 bulk oil and air blast circuit breakers to be replaced by the beginning of RIIO-T3 with 50% replaced during RIIO-T1.**
- our approach to providing a "Best View" "Upper" and "Lower" investment plan, utilising trigger or volume drivers to manage uncertainty.
- the application of the network output measures methodology,
- the use of condition information
- the application of age based non load modelling
- the results from the application of these approach on switchgear, overhead lines, transformers, cables and other investment areas; showing a few case studies
- the cost benefit analysis for the main asset categories
- the outputs delivered by the programme
- the process for delivering risk based, prioritised asset interventions.

In addition there are extensive appendices discussing the needs case for each project within the plan.

1.1 Integrated Management System

ScottishPower EnergyNetworks (SPEN), on behalf of SP Transmission Limited, manages all physical assets utilising an Integrated Management System which combines the requirements of the Asset Management System specification (PAS55), the Quality Management System international standard (ISO9001), the Occupational Health & Safety Management System international standard (ISO18001) and the Environmental Management System international standard (ISO14001). This facilitates:



- An integrated approach to link the long term investment plan to delivered outputs; allowing optimisation of the asset management interventions.
- The demonstration of asset management compliance to external parties
- The facilitation of an independent audit regime

- An Internationally accepted best practice
- The integration of other management systems.

Further information relating to the Integrated Management System, and the Strategy and policy methodologies utilised are detailed within SPEN documents:

- IMS-01-002, SP Energy Networks Integrated Management System Manual

1.2 Risk Management

Risk assessment and risk management is a vital component of SPENs overall asset management strategy, within the context of a corporate risk management hierarchy. Our Asset Management Investment Planning process, sits within the hierarchy of Risk management systems as detailed below:

The Asset Management Investment Planning process ensures that Investment Plans are developed to address the risks presented by the transmission network, which are identified through the risk management approach. Within the risk management approach the Scottish Power document, *Process Safety - Risk Tolerability* defines process risk and risk tolerability. This document outlines ScottishPower's Tolerable Risk Criteria and approach to managing major process and technical risks to As Low As Reasonably Practicable. Risk assessment methods are used to determine priorities and to set objectives for reducing risk to an acceptable level. Risks are categorised into three areas:

- Health and Safety
- Environmental
- System

Wherever possible, hazards and associated risks are eliminated through selection and design of assets, facilities, equipment and processes. This is achieved through mitigation plans which can include investment to reduce the risk.

In addition to investment activities risks are also managed through inspection and maintenance activities. SPEN ensures all 132-400kV assets comply with all statutory legislation; specifically the ESQC and PUWER Regulations. Asset inspections are undertaken on a periodic basis in accordance with ASSET-01-021. Maintenance is undertaken in accordance with SUB-01-009.

1.3 Network Outputs Methodology

To ensure that risks are effectively managed the outputs from investments need to be clearly understood. To aid this understanding the three transmission owner companies have developed a network outputs methodology through consultative working over the past four years. This has resulted in a documented joint methodology, which is available on the [1]Ofgem website. The methodology details the approach to asset health and criticality and the application of replacement priorities.

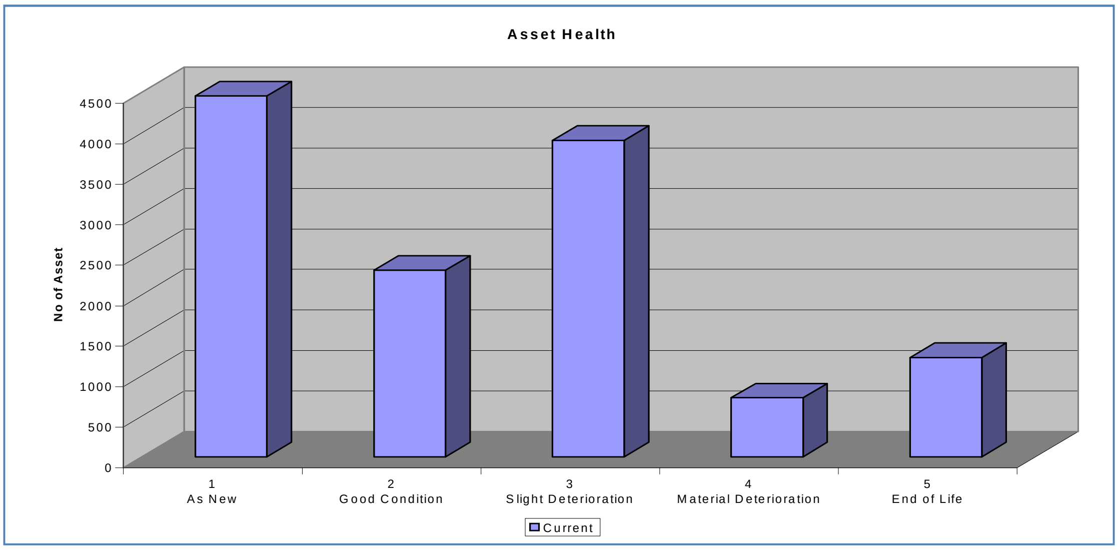
1.3.1 Asset Health Indices

We have well developed methodology for the development of Health Indices which facilitate the targeting of investment on the poorest condition assets. The more detailed and meticulous the condition assessment, the more accurately and efficiently investment can be targeted. Asset health depends on collected engineering information, knowledge and experience from managers, engineers and specialised craftsmen. They have the expertise to identify and assign appropriate weight to relevant information for particular assets, which can be used to determine health, degradation and failure. It is based on a structured and repeatable approach, and provides both quantitative and qualitative engineering analysis.

ASSET-01-019, details SPENs methodology for the development of Health Indices. Based on the available condition information an asset health index is produced for the relevant asset category. The Asset health index assigns a relative health/condition value of between 1 and 5 to each asset dependant on the factors affecting its health. The number of assets in each specified category is depicted graphically to demonstrate the overall health of the asset category as shown below.

1

http://www.ofgem.gov.uk/Networks/Trans/RegReporting/Documents1/Licensees%20proposed%20joint%20NOM%20methodology.pdf



Health Indices are produced and updated taking account of:

- Asset specific Condition Based Assessment (CBA) parameters
- Periodic asset specific CBA's
- Asset *Type* specific information
- Outputs delivered

An assessment of the length of time it takes for a typical asset to deteriorate between asset categories is derived based on engineering knowledge of the criteria for each asset health category. This provides the rate of deterioration over the assets life and is directly linked to the average expected asset life. This allows the current Health Indices to be utilised to develop forward looking health indices with and without intervention which are considered when developing asset specific interventions.

1.3.2 Asset Criticality

Asset criticality is measured in terms of the stakeholder impact resulting from a failure of asset function. There are three elements to criticality:

- Safety – based on the exposure and proximity to the public and personnel
- Environment – based on the environmental exposure from the asset and the sensitivity of the geographical area local to the asset.
- System – based on the impact of the transmission system not delivering services to stakeholders or the smooth operation of the UK services and economy

The criticality in each element is assigned a level of Very High, High, Medium or Low. The overall asset criticality is based on the highest of the 3 assessments. The criticality, or site 'importance', of each substation is assessed first. The interconnecting overhead line and cable circuits are then classified on a similar basis, taking account of the relative importance of the relevant substations.

1.3.3 Replacement Priorities

Replacement priority is used as a representation of asset risk. Combining asset health (likelihood of failure) with criticality (consequences of failure) provides a replacement priority driven by risk. The matrix below details the replacement priority (RP1 to RP4) related to each combination of asset health and criticality.

		Criticality			
		Very High	High	Medium	Low
Asset Health	HI5	RP1	RP1	RP2	RP2
	HI4	RP1	RP2	RP3	RP3
	HI3	RP4	RP4	RP4	RP4
	HI2	RP4	RP4	RP4	RP4
	HI1	RP4	RP4	RP4	RP4

A replacement priority relates to a preferred timeline for replacement of the asset as detailed below.

- RP1 – Consider replacement within next 0 to 2 years (Very High priority)
- RP2 – Consider replacement within next 2 to 5 years (High priority)
- RP3 – Consider replacement within next 5 to 10 years (Medium priority)
- RP4 – Consider replacement beyond 10 years (Low priority)

As can be seen from the matrix all assets with a health index of HI3 or lower have a replacement priority of RP4. HI3 assets have only slight deterioration and therefore only require consideration of monitoring in the short term. Therefore until these assets deteriorate further it is appropriate to apply the lowest replacement priority as replacement doesn't need to be considered within 10 years.

Focusing investment on assets with the highest replacement priority ensures that the most significant stakeholder risks are addressed.

2 Transmission Network Strategy

The investment strategy for the 132-400kV transmission network aims to ensure an optimum level of investment by adopting a prioritised and targeted project specific approach. This is necessary to effectively manage the business risk and ensure long term sustainability of this key UK asset, utilising appropriate engineering interventions and risk management. Specifically our strategy aims to:

- **Maintain safety, integrity and performance of the network as its age increases whilst ensuring long term sustainability and to support network growth.**
- **To intervene prior to asset failure:** When asset performance and reliability fall below acceptable operational limits and cannot be restored without an unacceptable financial risk and / or system risk exposure.
- **Minimise failures, through interventions targeted on assets at or approaching of end of life (Health Index 5):** Utilising engineering condition or type information, as appropriate.
- **Target investment based on an assessment of risk through probability (Asset Health) and Criticality:** Taking account of factors such as public and staff safety, strategic importance, customer sensitivity to supply disturbances, asset performance and environmental considerations.

The investment plan has been developed utilising our Asset Risk Management policies and procedures, which reflect the nationally agreed Network Output Measures methodology. It has been developed using extensive current asset condition information, our asset replacement age based modelling, and cost benefit analysis. Condition and modelling data, along with site criticality, has been used to ensure our plans reflect the key investment priorities. Our prioritised detailed work programmes are developed, at a circuit or substation site specific level.

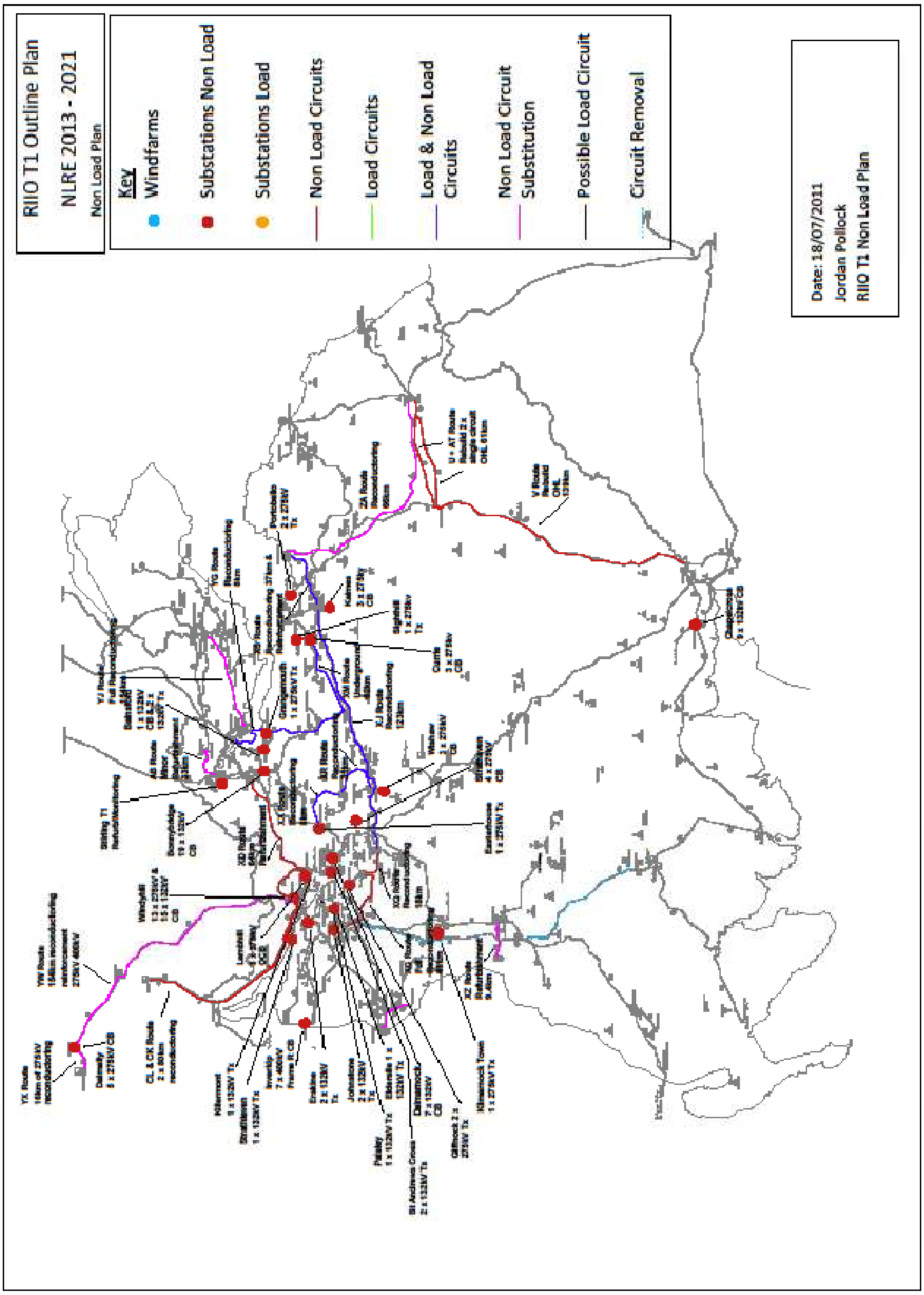
2.1 Investment Plan

To minimise costs to customers, we have built our non load related investment in RIIO-T1 in the following manner

- Lower plan (baseline ex ante) totalling £626m where there is high level of certainty over the projects (~80% of Best view for Switchgear and OHL)
- A Best View plan totalling £697m (incl Baseline) where the additional 20% of switchgear & OHL (+£71m is funded by uncertainty mechanisms where there are some dependencies associated with Load related investment rather than through ex-ante funding.
- An Upper Case plan totalling £811m where we have considered further projects for investment, which would normally be planned as RIIO-T2 investment. However they may require to be brought forward due to further benefits linked to load related projects.

Each of these plans would deliver Outputs associated with improvements in Asset Health.

Our overall non-load investment plan is summarised in Table 1 and is graphically illustrated in the diagram below:-


RIIO T1 Outline Plan
NLRE 2013 - 2021
Non Load Plan
Key
Windfarms
Substations Non Load
Substations Load
Non Load Circuits
Load Circuits
Load & Non Load Circuits
Non Load Circuit Substitution
Possible Load Circuit
Circuit Removal
Date: 18/07/2011
Jordan Pollock
RIIO T1 Non Load Plan

Oncosted, 2009/10 real prices	RIIO-T1 Capex Lower View (Baseline ex ante) (£m)	RIIO-T1 Capex Best View (Baseline & Trigger) (£m)	RIIO-T1 Capex Upper View (Baseline & Trigger) (£m)
1. Overhead Lines	£248.7	£308.9	£423.2
2. Switchgear	£107.8	£118.4	£118.4
3. Protection & Control	£80.4	£80.4	£80.4
4. Transformers	£54.4	£54.4	£54.4
5. Other NLRE	£60.6	£60.6	£60.6
6. Underground Cables	£15.7	£15.7	£15.7
7. Substation Other	£48.8	£48.8	£48.8
8. Other TO	£8.7	£8.7	£8.7
9. Metering	£0.7	£0.7	£0.7
Total Non Load	£ 625.8	£ 696.6	£ 810.9

Table 1: Investment Plan Summary

As can been seen from the programme above, it primarily focus' on two main areas, switchgear and overhead lines. These two key areas in the Best View involve £427m (61% of the non load investment programme) comprising:

1. **Overhead Lines** (£308.9m =44% of best view non load programme); where we plan to address, through a strategy to 2029 (end RIIO-T2), the large population of Health Index 5 (pre 1970s) ACSR conductor on the 275kV and 400kV network.
    a. Our plans will replace 519km (44%) of this conductor in RIIO-T1 with a further 671km (56%) in RIIO-T2, to manage the end of life risk.
    b. Our rebuild approach is minimised in RIIO-T1 to reflect our priority of efficient life extension through refurbishment, with rebuild limited to a few 132kV routes
        i. U&AT Route (30 route km): 2 single cct lines to be rebuilt as double cct
        ii. V Route (44 route km) of substandard steel construction (World War 2 wartime surplus towers)
    c. On the 132kV network a total of 359km (24%)of the 132kV network will be reconductored (incl rebuild) dealing with 44% of the pre 1970 conductor.
    d. We will also continue our minor refurbishment programme of circuits in mid life.

Section 4 details our overall overhead line asset management approach.

2. **Switchgear** (£118.4m =17% of best view non load programme) : where we plan to address through a strategy to 2029 (end RIIO-T2), the large population of 1950s and 60s Air Blast and Bulk Oil circuit breakers. They are obsolete, less reliable and difficult to maintain due to a lack of spares, manufacturer support and there is significant cost and outage time associated with maintenance. The key tenets of this strategy are:-
   a. A plan to replace 81 CBs (50%) in RIIO-T1
   b. Replacement of a further 62 (39%) circuit breakers in RIIO-T2 and the balance of 17 units (11%) to be replaced in early RIIO-T3 to manage the end of life risk with this equipment
   c. To replace all the faulty FMJL CTs (£3.4m) where catastrophic failures have occurred.

   Section 5 details our overall switchgear asset management approach

Other non load investment areas include:-

3. Protection Control & Telecom £80.4m (11% of Best View))
   a. **Protection** – (£9.8m) From our type based asset risk approach used to consistently quantify the health of protection relay types, a programme of work has been scoped to replace all end of life protections on the system by 2021. Currently 48% of the main protections are at, or near end of life. When possible associated protections will be replaced as part of other capital works. This funding also includes £3m for replacement of battery systems, and voltage control equipment.
   b. **Telecoms** – (£33.9m) The majority of investment in the areas of telecoms relates to modernisation work essential to maintaining the integrity of underground pilot wires (£10m) and fibre optic wrap (£10m) deployed on tower lines due to poor fault performance issues with these assets. Replacement of active signalling equipment covers most of the remaining £14m in this area, where the obsolescence of electronic equipment is the key investment driver.
   c. **SCADA** – (£13.1m) Expenditure in the SCADA area is required to address obsolescence issues with both central system hardware & software (£8.8m) and the continued replacement of the legacy Ferranti MKIIA RTUs (£2.3m). Some expenditure is also required for central system software upgrades. This also includes £2m for cyber security.
   d. **Black Start** – (£23.6m). This investment is required to provide diesel generators at 78% (97 off) sites where resilience does not meet 54hour capabilities for auxiliary supplies. This is in accordance with ETG & NGET guidance and industry discussions with Ofgem to ensure that the network can be effectively re-energised / re-started following a “black start” scenario.
4. **Transformers** (£54.4m=8% of best view non load programme) continue to address end of life transformers with high DGA and poor site condition (132kV Bulk Supply Point transformers). We are also continuing our strategy of replacing unreliable 275kV/33kV 120MVA Bruce Peebles transformers. Investment in shunt reactors and their associated CBs is also required due to the current duty (since BETTA was implemented) is causing lifetimes to be less than we had previously expected. However our condition reviews have not

justified any investment in inter-bus transformers. Section **Error! Reference source not found.** explains this investment in further detail.

5. **Other Non Load Related** (£60.6m)
    a. **Weather Resilience** : (Flood protection) (£31.1m) for protection of 3 key substations (Kincardine, Longannet & Glenlee)
    b. **BT21CN** (£18.3m) : Out of the 220 affected circuits at the start of TPCR4, this investment will address the 46% (98 off) remaining affected BT signalling circuits that are used for substation to substation protection signalling that will be affected by BTs migration to a new (IP based) signalling system. During TPCR4 our programme associated with mitigation of protection signalling against BT21CN development was re-profiled in TPCR4 following the announcement from BT that the deadlines for the project completion was due to extend until 2018.
    c. **Security Resilience** : (£11.2m) To improve security at key sites, to ensure network assets, which are critical to the UK, are adequately protected from interference & trespass & threats.
6. **Cables** (£15.7m) has a smaller programme over RIIO-T1, down from the £13m pa average over TPCR4, to an average of £2m pa following the successful completion of a replacement programme for the unreliable gas compression cables during TPCR4. Our programme in RIIO-T1 focuses on replacement of poorly performing transformer LV cables (33kV) (£6m), a reactive programme to replacement small sections of oil cables with excessive leakage (£7m), and on the replacement of end of life cable ancillaries (£1.3m). Section **Error! Reference source not found.** details our overall cable asset management approach.
7. **Substation Others** (£48.8m) comprises auxiliary plant replacement (£2m), civil refurbishment (£13m) of buildings/ structures that are not accommodated within the main asset modernisation projects, and system monitoring equipment replacement (£3m). Fault expenditure (£31m) is also included to reflect asset repair and replacement activity that is a result of equipment failures on the network.
8. **Other TO** : (£8.7m) This includes substation environmental improvements (£4m) (e.g. Oil containment, noise abatement that are not accommodated within the main asset modernisation projects), and (£5m) for servitudes to ensure permanent rights of access to equipment rather than annual wayleave payments.
9. **Metering** : (£0.7m) This funding continues the delivery of a programme of replacement of obsolete unsupported metering equipment at bulk supply points.

2.2 Network Risks : Impacting on Programme Mix

The investment levels within the programme have been built up through our asset management process, & reflect the risks and issues currently recognised as key to our long business sustainability. To minimise costs to customers, we have identified five key long term risks, which although not ideal, can be managed through short term mitigation programme through RIIO-T1, which minimises investment in these key areas, thus avoiding further cost increases to customers

1. We are investing far less in the 132kV OHL network than modelling suggest we should,
2. Our focus is concentrating more on the 275kV / 400kV OHL network
3. In substations our attention is on dealing with end of life circuit breakers,
4. by letting the health of the transformer population deteriorate through RIIO-T1

5. We are minimising our investment in cable in RIIO-T1, and reducing the programme from TPCR4

These risks are expanded further below and in the following table

1. We are investing far less in the ~1500km 132kV OHL network than modelling suggest we should (and network rebuild at 132kV) during RIIO-T1. We are only planning to address less than 25% (359km) of the end of life conductor
    a. The 132kV network has a much lesser role in this function and mainly provides supply to Scottish demand customers. In addition, if the performance of the 132kV network deteriorations to an unacceptable level, the capabilities to ramp up investment at this voltage level are easier (than 275kV /400kV) , due to the lighter engineering capabilities, larger contractor base available and the easier availability of outages (non MITS). (Explained further in Risks 1 & 2 in the table below).
2. Our investment plans concentrate a strong focus on 275kV and 400kV conductor replacement, where we intend to address ~40% of the end of life conductor (519km).
    a. We believe this is fully justified as the ~1300km of 275kV and 400kV Main Interconnected Transmission System (MITS) has far high consequences for Scotland and the UK due to its essential role in providing transfer of energy from Scottish Power Stations (renewable and conventional) to England and Wales
3. We are concentrating on the replacement of unsupportable breakers through RIIO-T1, whilst letting the health deteriorate in transformers.
    a. This is due to the higher proportion of end of life CBs relative to transformers, and
4. We believe that access to transformers through our "pipeline" of transformers being purchased through RIIO-T1 will enable us to manage the risks on unexpected failures.
    a. We are however likely to see a higher proportion of transformers in Health Index 5 at the end of the period, than at the start, with an expected increase in transformer replacements in RIIO-T2. (Risks 3 & 4 in the table below).
5. We are minimising our investment in cable, below TPCR4 levels, as we will have completed the replacement of the unreliable gas compression cables, and are limiting our investment to having some capability to deal with deteriorating cables, but leave any significant planned replacement of oil filled cable until RIIO-T2. (Risks 5 in the table below).

Long Term Risks

Risk	Consequence	Short Term Control	Long Term Control
1. Widespread failure of ACSR conductor as majority (60% (1300km)) of 275kV and 400kV conductor (ACSR Zebra) will be at end of life over by the end of RIIO-T1, without intervention	Costs increase if left too long to allow tension stringing, with extended outages. If not addressed, then widespread failure risks significant, This could fundamentally compromise transmission network (MITS) transfers / capabilities.	Start long term replacement program, which is cost beneficial to customers. Develop improved techniques through R&D to better predict end of life to influence RIIO-T2 investment. Have uncertainty mechanisms to ramp up or down investment programme	Programme to replace all pre 1970 conductor (60% of current network) by end RIIO-T2 (2029)

Risk	Consequence	Short Term Control	Long Term Control
2. Pace of progress in RIIO-T1 only targeting ~360 km of end of life conductor is inadequate as (majority (58% / 1500km) of 132kV conductor (ACSR Lynx) will be at end of life over next few years.)	Costs increase if left too long to allow tension stringing, with extended outages. Risk of local failures if not addressed.	Start long term replacement programme. Monitor performance of network, and accelerate programme in RIIO-T1 and into T2 if performance degrades un acceptably	Programme to replace 24% of 132kV conductor by end RIIO-T1 with a further plan, which can be scaled up in RIIO-T2 (2029)
3. Inability to repair or maintain Air Blast & Bulk Oil CBs due to lack of spares or support (Breakers have no support)	Unable to repair failure of CB due to lack of parts. Resulting "Gap" in network leading to high constraint costs & risk of loss supply to customers.	Start long term replacement programme. Use recovered parts from decommissioned breakers to support (from long term programme).	Programme to replace all Bulk Oil & Air Blast CBs by beginning of RIIO-T3 (2030). Programme in RIIO-T1 to include a mix of all types to ensure spares available
4. Transformer failures increase over RIIO-T1 as Transformer health is predicted to be worse at end of RIIO-T1	Failure of transformer prior to replacement, resulting in long replacement times, risking security of supply to customers.	Ensure planned replacement programme has transformers in pipeline, which could be diverted to manage risk	Programme to replace 17 units by end RIIO-T1 with a further plan, which can be scaled up in RIIO-T2 (2029)
5. Cable faults / cable oil leaks significantly increase	Unplanned replacement of cables	Repair / overlay sections on a reactive basis as required. Monitor performance	Programme to replace sections of poorly performing circuits (c5cctkms) by end RIIO-T1. Review failure rates for future plans, which can be scaled up in RIIO-T2 (2029).

These replacement plans have been considered against long terms age based modelling, as discussed below, and for the key asset areas, cost benefit analysis. All these consideration reinforce the justification for our investment plans.

2.3 Age Based Modelling

Long term age based modelling is undertaken to provide strategic context for asset replacement volumes and future capital expenditure needs and is utilised to refine the Investment plan. The model is also utilised to predict long-term asset replacement volumes for each asset category and thus enable early identification of potential peaks in future workload. The age based modelling methodology complements the bottom up condition assessment process, enabling immediate and longer term risks to be adequately managed. The asset replacement model records information relating to age, voltage and circuit parameters for the different categories of assets employed on transmission networks, including:

- Cables
- Transformers

- Overhead Lines
- Switchgear

The modelling methodology can be utilised in two ways. The first applies SPENs view of nominal asset life to each asset category to determine future long term, replacement volumes. This approach provides a view based on SPENs knowledge of the asset base and its expected service life. The second uses historic replacement volumes to provide an inferred asset life equivalent to the volume. This 'tuned' asset life is then used to predict future replacement volumes. This approach provides a view based on continuation of historical strategy and provides a useful comparison with the first approach.

In developing our plans for RIIO-T1 we have used two age based models.

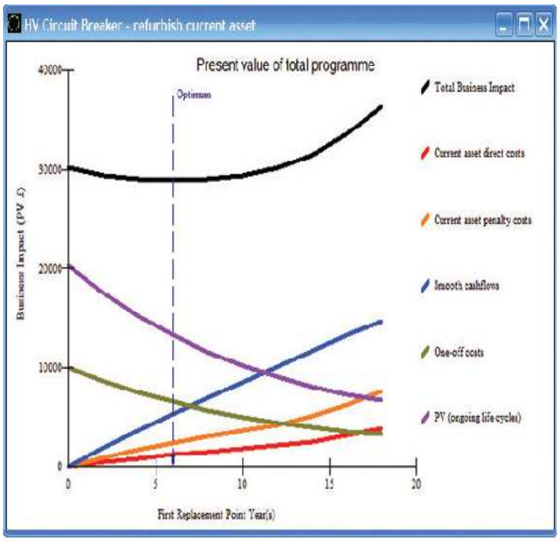
1. We have been using the first model, developed by SKM, for many years.
2. The second model has been developed by Ofgem, in consultation with the TOs, for RIIO-T1.
   The output from both models is future asset volumes.

The total non-load related investment plan (Best View) is £697m during RIIO-T1. Asset modelling is undertaken on the four primary asset groups only, as cited in the table below - equivalent to £497m or 71% of non-load investment. In addition, modelling of asset replacement excludes costs associated with pre-construction works, overhead line towers, foundations and refurbishment works. Furthermore, as the modelling is undertaken on a prime costs basis, our RIIO-T1 plan 'best view' translates to an equivalent capital investment of £352m (prime) for modelled asset replacement.

- Our overall plans, in all case are less that both Ofgems, and our own (SKM) model outputs
    - 30% to 40% lower than Ofgems model
    - 40% to 50% lower than our (SKM) model
- As discussed throughout this document our plans are condition based, so as condition drivers in individual asset areas may be slightly different than a pure age based model, we have built our submission to reflect the true asset condition issues.

The overall expenditure is lower than the four model outputs, as detailed in the table below.

Asset Category	SPEN Best View	**Ofgem Model**		**SKM Model**	
		SP Asset Lives	**Historic Volumes**	**SP Asset Lives**	**Historic Volumes**
	£m	£m	£m	£m	£m
Transformers	47	99	117	110	117
Switchgear	98	115	156	125	158
Overhead Lines	194	265	169	339	173
Underground Cables	13	127	79	152	145
Modelling Total	**352**	**606**	**521**	**726**	**593**



2.4 Cost Benefit Analysis

We utilise the Woodhouse APT toolset (as detailed in **Error! Reference source not found.**) as part of our optimal asset management decision making process. This model allows us to visualise and consider Total Business Impact (£), where the optimum is the lowest point on the Total Business impact curve taking into account the following factors.

- Total Business Impact – Sum of the other curves
- Costs & consequences of failure, in terms of both
  - direct costs both for major failure, requiring significant replacement
  - penalty costs (e.g. energy not supplied financial impact)
- Smooth Cashflow – This is the costs required to keep the asset going (increasing replacement or maintenance costs)
- One off costs (if required)
- PV life cycle – This is the money you need to set aside today to replace the asset in future (assuming planned replacement).

Our two key asset replacement areas in RIIO-T1 are

1. End of Life Air Blast and Bulk Oil circuit Breakers
2. End of Life Overhead Line Conductor

In these areas we have utilised the APT – Lifespan model as part of our decision making process. The outputs from this model substantiate our investment plans. The summary outputs from this model are tabled below, with further details provided in the appropriate asset areas.

One key sensitivity we considered was the impact of constraint costs affecting UK customers. From NGETs Electricity Scenario's Illustrator, the average cost of constraints in Scotland is £192m pa over RIIO-T1. Taking this factor into account at >£0.5m per day does impact on the model output. Whether the constraints are applied, or not, the model confirms that we should be, or have been already, investing in end of life replacement of these assets.

Asset	Optimum Replacement (no constraints) (Yrs Old)	Optimum Replacement (with constraints) (Yrs Old)	Comment
Frame R 400kV ABCB *(Strategy based on replacement of OD site Inverkip by end RIIO-T1)*	38yrs	28yrs	Inverkip (7 units outdoor) was built in 1974 (currently 37yrs old) *(Note: Hunterston 400kV is ID and is expected to be replaced in RIIO-T2 on retiral of power station post 2021. The one CB at Devolmoor 400kV is in replacement plans prior to RIIO-T1)*
OBR 275kV ABCB *(Strategy based on all replaced by end of RIIO-T2)*	38yrs	28yrs	~30 units on network built between 1962 & 1965 (currently 49-52 yrs old)
Bulk Oil 132kV CB *(Strategy based on all replaced by end of RIIO-T2)*	50yrs	N/A	~80 units on network built between 1951 and 1970 (Ave 1968) (currently 43-60 yrs old)
Zebra ACSR OHL Conductor *(Strategy based on removal of conductor to maintain < 60 years throughout RIIO-T1 and RIIO-T2.)*	58yrs	52 yrs	Key economic factor is the cost increase as aging forces higher cost replacement techniques to be applied. This moves from tension stringing, to cradle block, to conductor lowering, each increasing in cost

These cost benefit model outputs fully support our investment plans for RIIO-T1 for switchgear and overhead line conductor. The detailed results are provided within each Asset specific sections.

2.5 Deliverability & Efficiency

The transmission network has significant access constraints which determine that a high level of forward planning is required, to deliver agreed outputs. The investment planning process takes cognisance of the asset condition, network criticality, business risk and deliverability capability and endeavours to deliver efficient, optimised interventions for the long term, ensuring that in general no further interventions are required on a site specific basis in the following price control period. The optimised interventions look to exploit advances in new technology, where appropriate, and avoid replacing assets on a like for like basis, focussing on value by delivering outputs in an efficient manner.

2.6 Targeted, Appropriate Asset Interventions based on Engineering need

Intervention drivers are based on site specific condition or manufacturer type information, utilising on line and off line monitoring diagnostics, where available. Interventions are appropriate to the condition of the asset taking account of the wider business risk including the cost benefit analysis of replacement versus refurbishment and endeavour to maximise remaining useful life, while minimising the risk of unexpected failures.

2.7 Holistic Interventions

Where interventions are deemed necessary, a holistic approach to combining works is adopted, to minimise circuit and substation outages and site workforce mobilisation inefficiencies. This may include undertaking asset modernisation interventions with reinforcement works to optimise outage opportunities, facilitating the efficient delivery of outputs. Using this holistic approach some assets may be replaced early, as a result of reinforcement (load) related work.

2.8 Outputs

The RIIO framework provides a focus on output delivery as a result of investment in the asset base. Outputs are classified into six key areas:

1. Safety
2. Reliability and Availability
3. Environment
4. Customer satisfaction
5. Connections
6. Social Obligations

SPENs non load investment plan will have a direct impact in the 1st three of these areas and a contribution to the 4th. The outputs in each of these areas are discussed below.

2.8.1 Safety

Safety is of paramount importance to SPEN. A key objective is to ensure that all risks to public and staff safety are as low as reasonable practicable. This will be achieved through application of our risk management philosophy which ensures that safety risks are identified and managed effectively.

The primary output measure in this area is compliance with health and safety legislation.

- Throughout RIIO-T1 SPEN will continue to strive to ensure compliance with all appropriate safety legislation.
- Safety is also a key consideration in determining asset health and replacement priorities.
- Resultantly non load investment addresses assets in the poorest condition with the highest probability of failure and therefore the greatest safety risk.
- Our opex programme of inspection & maintenance provides ongoing care of our assets and ensures that the assets are inspected and maintained in accordance with legislation and industry best practice.

2.8.2 Reliability and Availability

Maintaining the current level of security of supply has emerged as a key focus for stakeholders through our engagement process. Our transmission strategy is therefore focussed on ensuring that there is no deterioration in our performance through continuation of our intervention prior to failure approach.

2.8.2.1 Energy Not Supplied (ENS)

The primary output in this area is Energy Not Supplied (ENS). This is a measure of the amount of energy, measured in MWh, which has not been supplied to customers as a result of customer affecting outages on the transmission network. The measure excludes the impact of ENS resulting from severe weather events as these are beyond our control. Throughout RIIO-T1 SPEN will be incentivised to deliver improvements against an annual target level of ENS and will face penalties for failure to deliver the target level.

Although this is a new measure for SPEN we have been able to review historic outage information to determine our performance. Based on outage information between 2001/02 and 2010/11 the annual historic performance was 224.4MWh. Typically annual performance is dominated by a single large event and resultantly there is no discernible trend in performance. This means that investment cannot be targeted to improve this level of performance. However continuation of our intervention prior to failure approach should ensure that our ENS performance is maintained. We anticipate that our output for RIIO-T1 will be as per the table below

ENS	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
MWH	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4

2.8.2.2 Network Output Measures

In addition to ENS SPEN will also be measured against performance in delivering improvements in asset risk. Asset risk is measured in terms of replacement priorities based on asset health and criticality. Within each asset category (transformers, switchgear, overhead lines and underground cables) the asset health and criticality of each asset is assessed to provide a replacement priority between 1 and 4, where 1 represents the highest replacement priority.

- For RIIO-T1 SPEN will deliver a reduction in the number of replacement priority 1 and 2 assets. Failure to deliver this reduction will result in financial penalties linked to the level of under delivery.

The classification of asset health and criticality has been developed through consultative working amount the three transmission owner companies over the past four years. This has resulted in a documented joint methodology, which is available on Ofgem's website. The methodology details the approach to asset health and criticality and the application of replacement priorities.

We expect the outputs from our plans to reflect

Area	Measure	Replacement Priority 1	Replacement Priority 2	Replacement Priority 3	Replacement Priority 4
Switchgear	Units	81	20	0	0

Transformers and Reactors	Units	23	3	0	0
Overhead Line Conductor	Circuit Km	101	773	0	0
Cables	Cable laid Km	0	12	0	16

2.8.2.3 Short-term constraint payments

When an outage is taken on the SPEN transmission network it can result in limits being placed on the MW which can be exported by generators. In these cases constraint payments are made by the System Operator, SO, (National Grid) to the generator. In 2009/10 constraint costs for the GB system totalled £139m with £16m associated with constraints within Scotland and £86m associated with the Scotland/England boundary.

SPEN recognises that its actions can result on the level of short-term constraint costs through minimising outages. However all network outages are planned and agreed with the SO in advance to minimise overall constraint costs and no outages are taken without appropriate need. To ensure that the outputs associated with RIIO-T1 investment can be delivered SPEN requires access to the network to undertake improvements. This will require greater co-ordination of outages between SPEN and the SO and among the transmission owners.

- To facilitate this SPEN has developed a Network Availability Policy which details our approach to outage planning and provides the SO with a standard level of service we will provide. If SPEN do not comply with this policy during RIIO –T1 Ofgem will apply penalties based on the non-compliance.

2.8.3 Environment

Delivery of a sustainable energy sector is a key objective of the RIIO framework. Fulfilling this objective requires a strong focus on delivery of environmental targets. A significant contribution to the UKs low carbon goals will be delivered by SPENs load related investment programme through the connection of renewable generation. Although the non load investment won't have such a direct impact it will contribute to these goals in specific direct emissions such as SF6 leakage.

2.8.3.1 SF_6 leakage

Leakage of SF6 into the atmosphere has a damaging effect on the environment. SPEN utilise equipment containing SF6 as it provides a safe and cost efficient electrical insulation medium. All new equipment procured by SPEN complies with relevant British and International standards which require the equipment has a maximum leakage level of 0.5% or 1% per annum. These standards have been tightened over recent years to reflect the environmental impact of SF6. The historic SF6 equipment on SPENs transmission network has leakage rates of up to 3%.

Currently almost all transmission assets have been purchased and installed to specification IEC 60694, although we do intend to buy some 132kV indoor gas insulated switchgear to specification IEC 62271-203 (0.5%). We are also likely to purchase 275kV / 400kV outdoor SF6 switchgear to specification 62271-1, which design may have a leakage rate of up to 1%.

Specifications summary

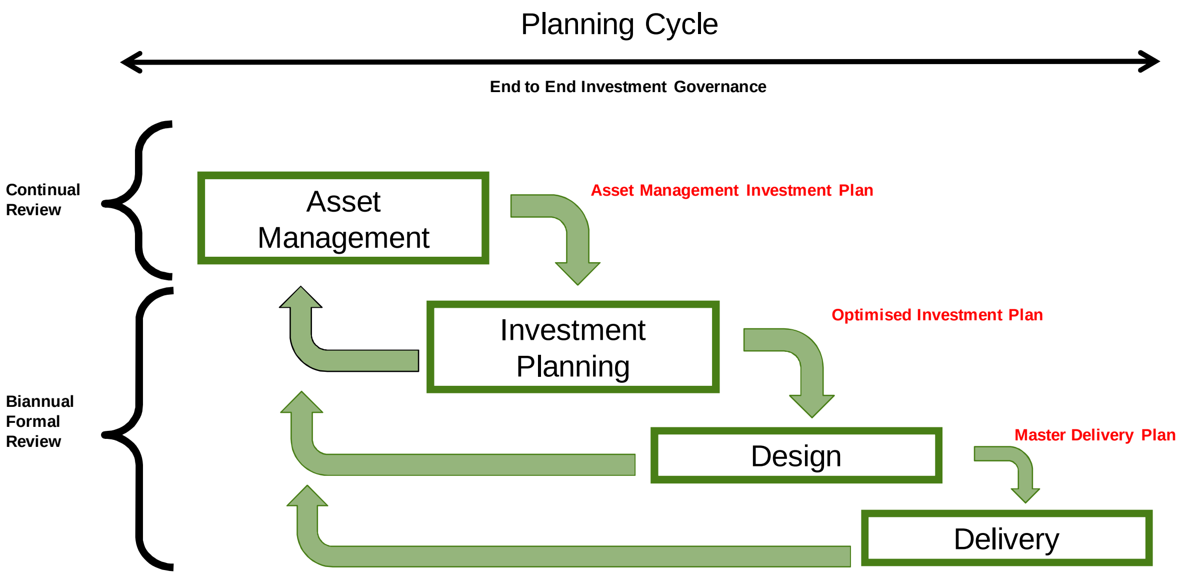
- IEC 62271-1, the appropriate specification for much of our asset population (previously IEC 60694) quotes a maximum leakage rate of 3% for outdoor switchgear.
- IEC 62271-203 – Gas insulated metal clad switchgear >52kV only, and does not include outdoor live & dead tank circuit breakers or SF6 CTs. The leakage rate published shall not exceed 0.5% per year)
- IEC 60517 (predecessor of the above). The design leakage rate published shall not exceed 1%

Our operating regime is already performing much better than the equipment specification (3% leakage). We have focussed on minimising the amount of SF6 leakage from equipment. Throughout RIIO-T1 we will continue this focus and replace life expired SF6 equipment with modern equivalent equipment when the opportunity arises. However, the absolute level of SF6 leakage will increase over RIIO-T1 as life expired oil circuit breakers, presenting a different environmental hazard, are replaced with SF6 breakers. We anticipate that our output for RIIO-T1 will be as per the table below.

SF6	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
kgs	833	853	919	943	1079	1079	1176	1275

3 Investment Planning Cycle

Our Transmission Network Strategy is delivered utilising a PAS55 accredited Asset Management system. This has developed from methodologies utilised on the distribution network, which have been enhanced and extended to include 132-400kV transmission assets. The Investment Planning cycle detailed below, culminates in a robust Master Delivery Plan (Order Book) and financial forecast. The investment planning cycle is iterative, utilising ongoing condition based surveillance information and type assessment methodologies, refined to an Order Book for delivery. The Asset Management investment plan is reviewed and updated on an ongoing basis, utilising agreed engineering inputs and delivered outputs, as appropriate. The Asset Management Order Book is updated to facilitate review on a periodic basis.



3.1 Deliverability

Outage availability and interaction is considered to be the key delivery constraint. The scale and extent of the modernisation programme is such that it is not possible to consider a delivery methodology which is independent of the network access taking into account both the reinforcement and generation connection projects requirements.

- As such, the Asset Health and Criticality replacement priority order may not be delivered in a sequential manner due to system access limitations.
- A wider view of the total network access position requires be adopted and consideration of how load and non load programmes are scheduled to minimise the interaction between project issues.,
- Specifically it is necessary to schedule and interlace the modernisation projects with the reinforcement and generation schemes, to ensure the delivery of the appropriate outputs, within the delivery outage plans.
- Equally, certain projects require to be phased, as to avoid requiring co-incident and incompatible outages. It is therefore essential as the load programme evolves in line with third party developments, that a review is conducted of how the non- load projects are to be re-phased in order to meet the overall modernisation objectives and outputs.

During the early years of RIIO T1 the transmission outage plan will be essentially dictated by two major reinforcement projects (shown overleaf on the network diagram).

1. A series of interventions are required along the (Southern) East West corridor between Smeaton and Strathaven, to deliver the up-rating to 400kV of both transmission circuits along this corridor.
2. Also along the northern corridor between Longannet and Windyhill an extensive sequence of outages will be taken to re-arrange the network to establish the Denny Substation as the connecting point for the uprated circuits to Beauly, being established in conjunction with the SSE works programme.

These two projects will have mutual interactions and the non load strategy is to take advantage of these extensive outage opportunities and to package and bundle the required switchgear and overhead line modernisation interventions into the available outage windows.

An important element of the modernisation strategy is that we plan to deal with certain asset condition issues over a two price review period as described in more detail elsewhere in this document. A view has been taken of the overall task; and in identifying the programme for RIIO-T1,

- advantage has been taken of the opportunities discussed above in prioritising and planning a delivery programme.
- This consideration affords a degree of flexibility in approach between individual priorities should a major change be introduced to the delivery as a result of third party decisions impacting on the load schemes.
- We have plans in place to consider substitute areas for specific elements of the delivery plan with equivalent alternatives, should it be both convenient and efficient.

- The flexibility thus available will ensure that we can optimise the overall programme to minimise outage requirements over the medium term.

It is paramount therefore to have a fully developed and prioritised modernisation scheme over the medium term in order that the necessary pre engineering and investment decisions can be taken into account for coordinated delivery when the load driven proposals come to the point when detailed, delivery and outage plans are being discussed.

The diagram on the next page shows

- The two corridors described above.
- Green circuit highlighting shows the main “like for like” asset replacement of conductor
- Pink shows the circuits that are targeted for asset replacement of conductor, and also has uprating associated with load (East /West upgrade)
- Dark Blue circuit highlighting shows two options for end of life conductor asset replacement. Only one is expected to be progressed in RIIO-T1. The one that will be done is the one that is selected for load related investment to increase North / South power transfers (East Coast AC upgrade).
- Light Blue circuit highlighting shows some possible “alternative” circuits which are not included in our investment plan, but which we have identified as possible substitute circuits if we have difficulty getting access as planned to the network.
- The diagram also shows details of
    - the planned transformer replacements (red boxes at substations) and
    - circuit breaker works at individual 275kV and 400kV substations, (light blue, grey, green boxes show different types of switchgear being replaced at substations) and
    - circuit breakers at 132kV substations (dark blue).
- The clarity of this detail is brought out better geographically in other diagrams within this document.

SP ENERGY NETWORKS