| Torness 400kV Shunt reactors replacement – OFGEM justification paper | |
|---|---|
| **Name of Scheme/Programme** | Torness 400kV Shunt reactor replacement |
| **Primary Investment Driver** | Asset Health (Lead asset – Shunt reactor) |
| **Scheme reference/ mechanism or category** | SPNLT 2047 (Transformer) |
| **Output references/type** | NLRT2SP2047 (400kV Transformer) |
| **Cost** | £ 7.80m |
| **Delivery Year** | 2024 |
| **Reporting Table** | C0.7 / C2.2a_CI / C2.2a_AP / C2.3 / C2.4b / C2.5 / C2.5a |
| **Outputs included in RIIO T1 Business Plan** | No |

| Issue Date | Issue No | Amendment Details |
|---|---|---|
| July 2019 | Issue 1 | First issue of document |
| December 2019 | Issue 2 | Gross cost, NPV, Monetised Risk, Long Term Risk Benefit values, delivery year and future pathways – Net zero text updated. |

## Table of contents

# 1 Introduction

The existing Torness 400kV substation comprises a Reyrolle YG GIS, 8 switch mesh substation with the shunt reactors connected to the 400kV mesh via ABB ELK circuit breakers. The shunt reactors circuits are banked with the Strathaven and Eccles 1 circuits for R1 and R2 respectively.

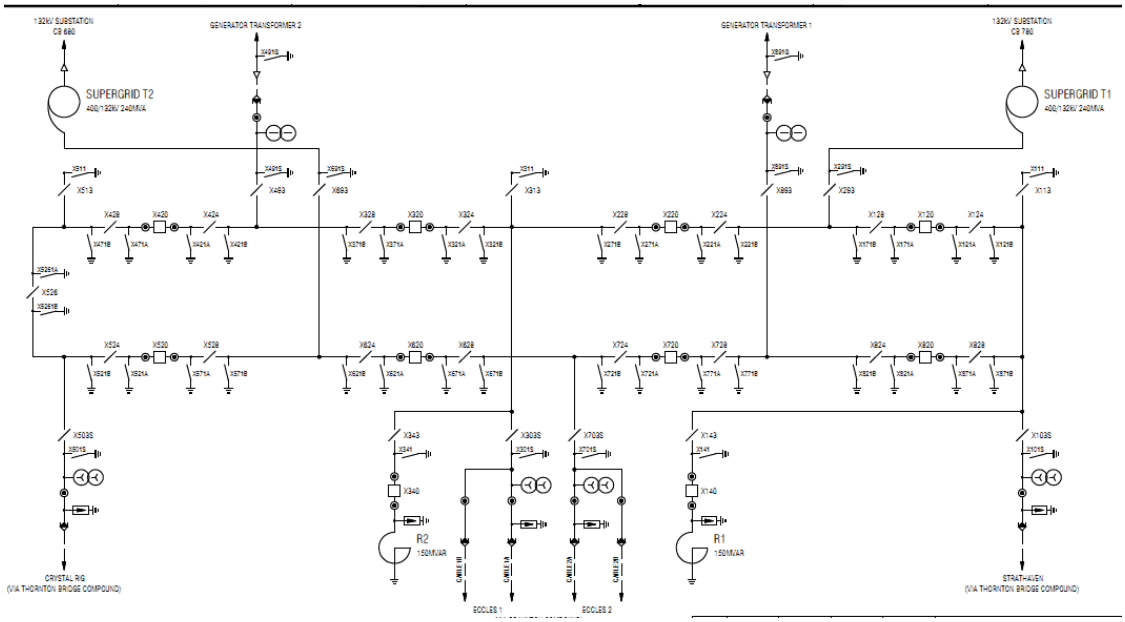


*Figure 1: Torness 400kV GSN*

Torness shunt reactors R1 & R2 are 400kV 150MVAr Parson Peebles units which were commissioned in 1983. Their intended functions was to provide reactive compensation to counteract the capacitive effect from the long length Strathaven and Eccles 400kV circuits but are currently in service to provide general reactive compensation required by network conditions.

SP Transmission has carried out detailed condition assessment and oil sample tests on the reactors R1 and R2. The assessment has shown that the paper insulation in both the reactors has breached the defined 'end of life' limit with no residual life remaining (DP higher than 200). Further the insulating oil in both the reactors is characterised as 'Poor' as defined by IEC 60422. Over the samples checked, the breakdown voltage has decreased with periods of time showing a dramatic reduction in the oil's dielectric strength of both the reactors. Detailed condition assessment reports for both the reactors are available.

As both the reactors have entered an end of life phase, any corrective action taken to improve moisture content, dielectric strength or acidity will not be cost efficient or technically feasible. Considering the inherent issues and in accordance with the scores from NARM methodology, reactors R1 and R2 are now proposed for replacement within RIIO T2 period.

In line with the above, the proposed lead asset outputs for the selected option are:

- 400kV Transformer disposal – 2 unit
- 400kV Transformer addition – 2 unit
-

The replacement works are planned to be completed over 2 outage seasons.

## 2 Background Information

Based on the values determined in accordance with the NARM methodology, Reactor R1 and R2 at Torness 400kV substation has an EoL modifier score of 12.82 and 14.49 (at end of RIIO-T2 period without any intervention), and based on ongoing issues detected during condition assessment have been identified for replacement.

Accordingly this paper supports a proposal to replace the existing reactors R1 and R2 (400kV 150MVAr) units on a like for like basis within the RIIO T2 period.

This is also in line with the SP Transmission investment strategy for transformers to replace assets at or approaching end of life, particularly those with high Dissolved Gas Analysis (DGA) readings and poor site specific, condition based assessment ranked through our type based operational adequacy methodology TRAN-02-002[1].

Please find details of the lead asset proposed to be replaced:

| Asset Description | Manufacturer | Year of Manufacture | EoL score (Transformer) (End of RIIO T2) | Monetised risk |
|---|---|---|---|---|
| TORN400SHRR1 | Parsons Peebles | 1983 | 12.82 | £ 397,557.98 |
| TORN400SHRR2 | Parsons Peebles | 1983 | 14.49 | £559,659.68 |

*Figure 2: Torness 400kV substation*

[1] Assessment of Operational Adequacy of Transformers & Reactors (33kV & Above)

For this project, no intervention is envisaged on the existing 400kV GIS unit at Torness with the existing ABB ELK circuit breaker being reused for the new reactors as well. As the new reactor would have a different design / connection detail compared to the existing reactors, the GIB connection / coupling arrangement would need to be modified to suit the new reactors.

Note the project will be co-ordinated with 'SPNLT2091 Torness 400kV (Mech replacement) works.

The existing building requires to be modified to allow the dismantling and removal of existing reactors and installation of new reactors.

No intervention is proposed on the existing auxiliary supply system at Torness 400kV substation.

## 3 Optioneering

The following is a summary of the options considered for this project. The respective associated drawings for each of these options are available.

| | **Option** | **Status** | **Reason for rejection** |
|---|---|---|---|
| | Baseline option: Do nothing in RIIO-T2 period with investment deferred to RIIO-T3 period. Scope of works similar to option 1. | Proposed | - |
| 1 | In situ online replacements of existing reactors R1 / R2 on a like for like basis (400kV 150MVAr) | Proposed | - |
| 2 | Offline replacements of existing reactors R1 / R2 on a like for like basis (400kV 150MVAr) | Rejected | Torness 400kV substation is an existing 8 switch mesh corner GIS substation located indoors. Reactors R1 and R2 are Teed off Strathaven / Eccles 1 circuits. Any new location considered for Reactors R1 / R2 offline replacement would need to satisfy the existing connection requirement.<br><br>With the limited space available inside the existing building, an offline build is not possible. Any offline build outside the existing building would not be feasible technically or economically. |
| 3 | In situ refurbishment of existing 400kV reactors R1 / R2 | Rejected | As explained in section 1 as both the reactors have reached their end of life, any corrective action taken to improve the insulation condition, moisture content, dielectric strength or acidity will not be cost efficient or technically feasible. |
| 4 | Remove reactors R1 / R2 | Rejected | Both the reactors are required for reactive compensation on the 400kV transmission network. If these are removed, then significant investment would require to be made elsewhere on the network for providing this reactive compensation. |

Based on engineering design studies to determine the costs of the options identified as addressing the asset condition issues, the following 2 options have been considered for further review for this project:

- Baseline option: Do nothing in RIIO-T2 period with investment deferred to RIIO-T3 period. Scope of works similar to Option 1.
- Option 1: In situ online replacements of existing reactors R1 / R2 on a like for like basis (400kV 150MVAr)

# 4 Detailed analysis

Both the options considered achieve the main objective of replacing the reactors while intervening on non-lead assets as required and thereby reducing the overall risks to the network.

As the scope of works is identical for the two options with the only difference being the timing of investment, a common description has been included below which refer to both the options:

## 4.1 Scope of works

- Replace the 400kV shunt reactors, R1 and R2, at Torness 400kV substation on a like-for-like basis with the location for the reactors remaining the same. Existing building to be modified / adjacent wall to be removed for existing reactor removal / new reactor installation works.
- Modifications to the 400kV GIB connecting to the reactor SF6/oil bushings in line with the new reactor design.
- Each reactor connects to the 400kV system via a dedicated 400kV GIS ABB type circuit breaker. Retain and reuse the GIS circuit-breakers as is with only modifications to the associated GIB connection.
- Replacement of the reactor protection systems shall be included in the project and the Point-on-Wave switching scheme deployed on the circuits shall remain.
- Note final rating of the shunt reactors will be confirmed after detailed design calculation at project delivery stage.

## 4.2 Specific factors contributing to additional cost

The following factors were identified specifically for this project which is resulting in additional cost:

- Existing reactors are located within the 400kV substation building. Substantial building modification works are required to dismantle, remove and install new 400kV 150MVAr shunt reactors.
- The existing reactors are connected via 400kV GIBs to circuit-breakers X140 / X340. While it is proposed to retain the ABB ELK type 400kV GIS circuit-breaker as is, the associated GIB connections will require substantial modification along with revised coupling arrangement to suit the new reactors. This impacts the overall costing. The GIB costs considered currently are based on a survey carried out by ABB.
- As the works are required within the Torness nuclear power station premises, only authorised contractors can work on this project. Additional design and working requirements are required. This affects the site costs.
- Asbestos contamination in existing infrastructure viz. existing building.
- The existing fire suppression system will need to be modified for the new reactors.

## 4.3 Selected option

Please find below a cost and construction timescale summary of the short-listed options reviewed:

| | Baseline option – Do nothing in RIIO-T2 with investment deferred to RIIO-T3 period. Scope of works similar to Option 1. | Option 1 - In situ online replacements of existing reactors R1 / R2 on a like for like basis (400kV 150MVAr) |
|---|---|---|
| Cost (£m) | £ 7.80m | £ 7.80m |
| Construction timescales | 2 outage seasons | |

Please also find below a summary of the CBA analysis carried out on the 2 options.

| **Options** | **Deferral** | **NPV (£m)** |
|---|---|---|
| Baseline | Do nothing - works deferred to RIIO-T3. Scope of works similar to option 1. | £ 12.69 |
| 1 | In situ online replacements of existing 275/33kV 120MVA SGT1 and SGT2 units with new SGT1 and SGT2 275/33kV 90MVA transformers. | £ 16.21 |

Based on the technical review carried out, CBA analysis option 1 is the selected option.

Note that the costs have been built up from individual costs for each element and included in a bill of quantities. The bill of quantities has been engineered from the design layouts developed for each option. The basis of individual unit costs has been the SP Transmission MoSC (Manual of Standard Costs) tool which makes reference to costs incurred during previous similar projects.

## 4.4 Environment & Sustainability

Oil leaks have been recorded in the past from the existing R1 and R2 reactors installed.

As part of this project, we are removing the reactors which were the source of these oil leaks and replacing them with new units thereby reducing the environmental risks associated with these assets.

# 5 Conclusion

Both the options proposed have been reviewed in terms of scope, costs, timescales, construction risk, and sustainability requirements and have been found to be deliverable.

They also achieve the main objective of reducing the network risks due to existing 400kV 150MVAr reactors R1 / R2 and so are acceptable.

Based on the CBA analysis carried out, Option 1 with a higher NPV has been considered as the preferred option.

- Total project forecast costs for SGT1 / SGT2 replacement: £ 7.80m
- Timing of investment: 2024
- Total monetised risk benefit (for R1 and R2): Lr£23.79m
- Declared 400kV lead asset (Transformers) output in RIIO T2 period: Addition – 2 units / Disposal – 2 units

# 6 Future Pathways – Net Zero

## 6.1 Primary Economic Driver

The primary driver for this investment is asset condition and risk. The investment does not have a strong reliance on environmental benefits.

## 6.2 Payback Periods

The CBA indicates that a positive NPV results in all assessment periods (10, 20, 30 & 45 years) which is consistent with the lifetime of the intervention. Consumers benefit from reduced network risk immediately on completion of the project.

## 6.3 Pathways and End Points

The network capacity and capability that result from the proposed option has been tested against and has been found to be consistent with the network requirements determined from the ETYS and NOA processes. Additionally, the proposed option is consistent with the site-specific capacity requirements from SPT's Energy Scenarios.

## 6.4 Asset Stranding Risks

Electricity generation, demand and system transfers are forecast to increase under all scenarios. The stranding risk is therefore considered to be very low.

## 6.5 Sensitivity to Carbon Prices

Carbon price sensitivities have been applied using the higher case CBA template. The CBA outcome is influenced by losses and is sensitive to carbon prices.

## 6.6 Future Asset Utilisation

It has been assessed that the preferred option is consistent with the future generation and demand scenarios and that the risk of stranding is very low.

### 6.7 Whole Systems Benefits

Whole system benefits have been considered as part of this proposal. The capacity and capability of the preferred option is consistent with the provision of whole system solutions.

## 7 Outputs included in RIIO T1 Plans

N/A