GSP East Kilbride Fault Level Mitigation			
Name of Scheme/Programme	*Scheme – GSP East Kilbride Fault Level Mitigation*		
Primary Investment Driver	*Load – Fault Level Mitigation*		
Scheme reference/ mechanism or category	*SPT20083* *SPT20084*		
Output references/type	*LRT2SP2031*		
Cost	*£2.893m – total project costs (SPD funded)*		
Delivery Year	*RIIO T2 – 2022*		
Reporting Table	*B0.7 Load Master Data* *B4.2a Scheme Summary* *B4.5 Scheme Asset Data* *B4.5a Scheme Asset Data* *B4.6 Scheme Output Profile*		
Outputs included in RIIO T1 Business Plan	*No*		
Spend apportionment	T1	T2	T3
	-	£2.893	-

Issue Date	**Issue No**	**Amendment Details**
July 2019	Issue 1	First issue of document
December 2019	Issue 2	Updated monetary values, added section 6 and minor edits and corrections.

Contents

1. Introduction

East Kilbride GSP substation is located in South Lanarkshire, approximately 3km north of East Kilbride. The substation supplies the local town and is interconnected with Strathaven GSP.

There is at present no generation contracted to connect into East Kilbride GSP substation. The site currently has a fault level that is in excess of the system design rating, this is managed in the short term operationally.

East Kilbride GSP 275/33kV transformers were installed in 2003 and the 33kV switchboard in 2002, consisting of 13 bays of ABB ZV2 switchgear.

The primary driver for investment at East Kilbride GSP is the reduction of the fault level on the 33kV switchboard to facilitate additional future connections.

2. Background Information

This paper supports a proposal to install 2 x 33kV 120 MVA series reactors in the LV side of the existing transformers. The fault level issue is pre-existing and has been highlighted by SPD as one of the top 11 sites requiring intervention within the ED-1/T-2 timescales. To achieve the required fault level infeed from the Transmission network the impedance of both units shall be no less than 6.92% on 120 MVA (2 mH).

The existing generation at East Kilbride GSP is given in Table 1 below. There is only one site connected into the substation at present with no further generation contracted to connect.

Table 1: Existing Generation (as per SPD 2018 LTDS)

Generator	Connection Status	Size (MW)
Hydro Leasing Ltd	Connected	0.5

The fault level of the existing networks is given in Table 2.

Table 2: Existing Fault Level (2018 LTDS)

	Initial Peak (ip)	RMS Break (Ib)
Fault Level Value (kA)	52.19	18.30
Design Rating (kA)	50	17.5
% of Rating	104.38%	104.57%

The SPT scenarios indicate that the net peak demand at East Kilbride GSP is forecast to reach a maximum of 55.4MW by 2040 as shown in Table 3. The present demand is 53.5MW as such there will be a slight increase in peak GSP demand. The FES also indicates the embedded generation installed capacity could increase to ~31MW and would lead to a decrease in the net GSP Peak Demand.

Table 3: East Kilbride demand and generation scenarios

Scenarios	2018		2040 Forecast		
	Net GSP Demand	Generation Capacity	Total Demand	Generation Capacity	Net GSP Peak Demand
Community Renewables	53.5	0.5	84.5	4.0	46.7
Two Degrees	53.5	0.5	82.3	6.1	46.4
Steady Progression	53.5	0.5	73.4	4.4	55.4
Consumer Evolution	53.5	0.5	72.2	2.7	54.0
Maximum			**73.4**	**4.4**	**55.4**

Shown in Table 4 is the associated condition of the assets at East Kilbride GSP substation.

Table 4: East Kilbride GSP Asset Condition information

Asset ID	Asset Description	Manufacturer	Year of Manufacture	Years to Nominal EOL
14256947	EKIL275TRXSGT2	ABB	2003	25.04
14254252	EKIL275TRXSGT1	ABB	2003	25.04

3. Optioneering

The following is a summary of the options considered for this project.

Table 5: Longlist Proposed Options

	Option	**Status**	**Reason for rejection**
1	No Intervention	Rejected	It is not possible to undertake no intervention as a Mod App has been received from SPD specifically requesting a reduction in fault level infeed from the SP Transmission Network.
2	Enhanced Fault Level Assessment	Rejected	Improved modelling of the network through data collection and real time networks operating conditions would allow for a more accurate model of fault level this does not reduce fault level and so has been discounted.
3	Transformer Auto-Changeover and network reconfiguration	Rejected	Allows for high levels of fault level reduction but reduces the overall thermal capacity available at the site. Also opens up to customer service issues with temporary loss of supply during network reconfiguration.
4	Bus Section Reactor 33kV (Distribution Solution)	Proposed	-

5	Series Reactors 33kV 60MVA	Proposed	-
6	Replacement 132/33kV Transformers (60MVA)	Proposed	-
7	Series Reactors 132kV 60MVA	Rejected	The installation of series reactors on the 132kV side of the transformers would also serve to increase the impedance however the higher voltage would lead to increase costs for the associated reactors and as such has been discounted from the short list options.
8	New 132/33kV GSP	Rejected	Installation of a new 132/33kV GSP would reduce the fault level infeed from the transmission network The required works for this project when compared against others on costs and timescales mean that it is not viable and as such has been discounted from the short list selection.
9	Resistive Superconducting Fault Current Limiter	Rejected	A solid state device which under normal operating conditions provides minimal resistance but in the event of a fault the conductor moves out of superconducting state and becomes a resistor. This device doesn't reduce fault current present on the network, it also introduces complex operational and maintenance requirements with the introduction of cryogenic systems onto the network. These devices are also costly when compared to other options both in capital costs to install and also operational costs to maintain.
10	Pre-Saturated Core Fault Current Limiter	Rejected	This device limits fault current during a fault. This system is only available from one supplier and would introduce complicated operational and maintenance requirements into the business as such it has not been taken forward as a short list option.
11	Is-Limiter	Rejected	The use of such a device which relies on an explosive charge would introduce complex operational and maintenance requirements onto the network. As such this has not been taken forward to the short list selection.
12	Install higher rated switchgear and increase system fault level limit	Rejected	Installing higher rated switchgear could allow for increased fault level capacity allowing for additional generation to connect to the network. This however has implications on other plant and equipment connecting and connected to the network and on any existing EHV customers. We would also require reviewing the capability of other plant and apparatus to withstand the higher fault level. As such this has not been taken forward as the proposed solution.
13	Generation TX standards	Rejected	Creating new standards for newly connected generation. This would allow the DNO to stipulate that the connection requires higher impedance transformers. This comes at a higher cost to the generator but may enable a connection. As this does not provide any additional capacity it has not been taken forward as the preferred solution for the short list.

Based on engineering design studies and assessment against the associated critical success factors the following options have been considered for further detailed review within both the CBA and the Engineering Justification Paper.

4. Detailed analysis

All of the proposed options achieve the main objective of providing mitigating the fault level at the East Kilbride GSP.

a. Baseline: Replacement of 275/33kV Transformer at End of Life

This option would involve the replacement of the existing transformers with new units of higher impedance. This would increase the impedance between the transmission and distribution network, reducing the transmission fault level infeed.

A proposed layout of this installation is shown in Figure 1 below.

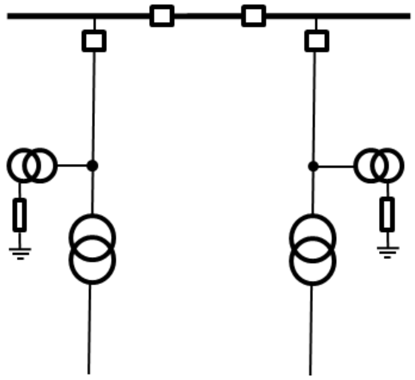

Figure 1: Proposed New Transformer Layout

Costs associated with this option are £8.3m; this includes the associated civil works (bund, plinth, etc.) as well protection & control and BOP works. New 33kV single core cables shall be installed between the switchboard and new transformer circuits.

It is envisaged that the transformers will require online installation resulting in outages on SGT1 and SGT2 to allow for the removal of the existing transformers, replace the existing civil assets and install the new transformers.

b. Option 1: Installation of Series Reactor in transformer LV circuits

This option involves commissioning a reactor between the 33 kV Circuit breakers and each of the 275/33 kV Transformer/Auxiliary Transformer. This will increase the impedance between the transmission and distribution network, reducing the transmission fault infeed.

A proposed layout of the installation considered is included below:

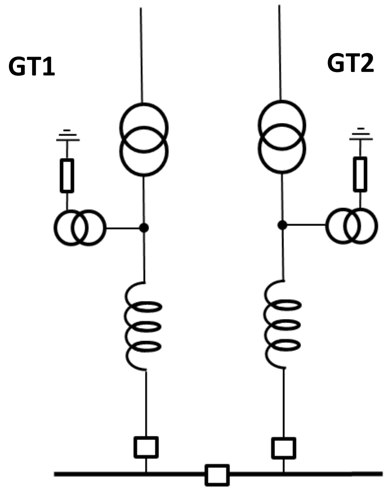

Figure 2: Proposed Series Reactor Layout

Costs associated with this option are £ 2.9m; this includes the associated civil works as well protection & control and BOP works. New 33kV single core cables shall be installed between the switchboard/transformer and the proposed series reactors at East Kilbride GSP.

It is envisaged that the reactors could be installed offline reducing outage time. However, an outage on SGT1 and SGT2 will be required in order to commission the reactors onto the network.

c. Option 2:275/33kV Transformer early replacement

This option is as in the baseline but with the acceleration of the transformer replacement to the T2 period rather than as specified via the asset end of life indication. The cost associated with this option is equivalent to the costs provided in the Baseline solution. As the existing assets are under 45 years old they are not yet fully depreciated and would incur early replacement charges should this be the progressed solution, these charges have not been factored into the capital cost of this option.

It is envisaged that the transformers will require online installation resulting in outages on SGT1 and SGT2 to allow for the removal of the existing transformers, replace the existing civil assets and install the new transformers.

d. Option 3: Installation of 2 New 3-Winding Transformers (120/60/60 MVA)

This option would involve replacing the existing transformers with new 3-Winding transformers (275/33/33 kV, 120/60/60 MVA). This will increase the impedance between the transmission and distribution network, reducing the transmission fault infeed. Given the existing layout of the GSP an additional 33kV switchboard would be required at the substation to provide suitable fault level mitigation.

A proposed layout of the installation considered is included below:

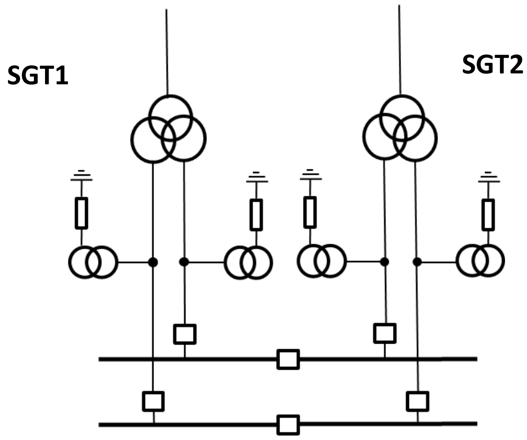

Figure 3: Proposed New 3-Winding Transformers Layout

It is envisaged that the transformers will require online installation resulting in outages on SGT1 and SGT2 to allow for the removal of the existing transformers, replace the existing civil assets and install the new transformers.

Costs associated with this option are £ 9.1m his includes the associated civil works (bund, plinth, etc.) as well protection & control and BOP works. New 33kV single core cables shall be installed between the switchboard and new transformer circuits.

e. Option 4: Installation of a new 33 kV Switchboard + Bus Section Reactor (SPD Solution)

The switchgear at East Kilbride GSP is 33kV ABB ZV2 type from 2002 with a fault level rating in excess of the system design limit. There are no spare circuit breakers or bays remaining at the substation due to additional connections at the GSP.

The only acceptable distribution solution that meets the technical objectives of the project is the installation of a 33 kV bus section reactor. Given that there is no space to install the required reactor control circuit breakers on the existing board, the 33 kV board would require to be replaced within a larger housing and plinth.

The new Switchboard will be of a modern fixed pattern type installed with a minimum of 15 panels that will include two breakers to control the reactors and space for up to a total of 21 bays within the switchboard, this will allow for the site to accommodate any future generation connections.

A proposed layout of the installation considered is included below:

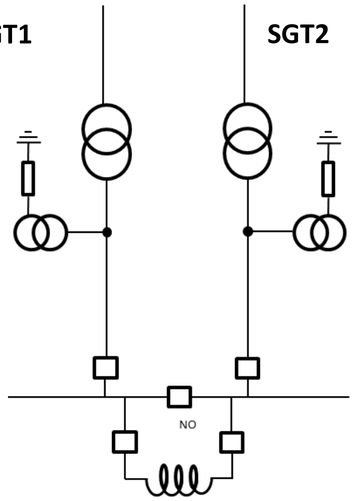

Figure 4: Proposed Layout of SPD solution

The existing 33 kV board at East Kilbride GSP is only 16 years old. Consideration should be given to potential sites where it could be reused to minimise the financial impact of the early replacement of the existing assets prior to the end of the associated financial life.

A protection scheme shall be required to avoid reverse power flow from the generators feeding through the primary transformers in the event of the loss of a 275 kV incomer. An auto bus section scheme shall be installed to close the bus section breaker in the event of an incomer failure at the GSP.

The cost of this proposed solution is £ 3.8m

An alternative scheme to the proposed option would be the installation of the bus section reactor via two three-panel 33kV switchboards looped into existing 33kV circuits, shown in Figure 5. This option would facilitate the fault level mitigation; however, any further generation seeking to connect would require a new 33kV switchboard as such the overall cost of this solution would be higher.

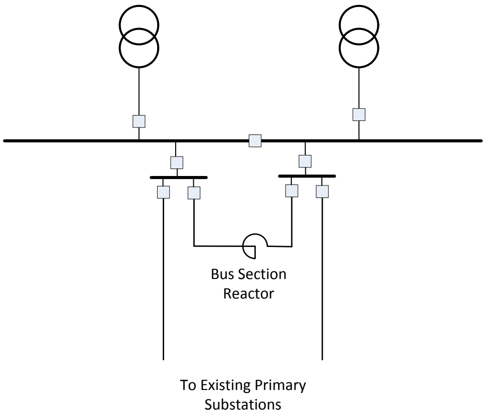

Figure 5 Alternative Bus Section Reactor Proposal

f. Option 5: Replacement 375/33kV Transformers (90MVA)

This option is equivalent to option 2, but instead of installing two new 120 MVA transformers, this option proposes the installation of two new 90 MVA transformers.

The cost of this option is £ 6.4m. This is lower than the cost of option 2, due to a lower transformer cost and reduced cable costs.

Although this option reduces the thermal capacity of the site, the analysis in Section 2 indicates that a 90 MVA firm capacity is adequate. However, this option is otherwise equivalent to option 2 and the discussion in Section c still applies.

g. CBA Results

A summary of the CBA results is given in Table 6 below. The values provided based on the Community Renewables generation uptake at East Kilbride GSP substation, detailed CBA results can be found in the associated CBA workbook.

Table 6: Summary NPV East Kilbride GSP (Community Renewables)

					NPVs based on Payback periods (£m)					
Option No.	Desc. Of Option	Preferred Option	Total Forecast Expenditure (£m)	Spend Area (RRP Table Reference)	Total NPV	Delta (Option to baseline)	10 Years	20 Years	30 Years	45 Years
Baseline	Transformer Replacement End of Life	N	-£ 8.34	N/A	-£6.98	£ -	-£4.31	-£6.10		
1	Series Reactors 33kV 120MVA	Y	-£ 9.27	B4.2a Scheme Summary	-£4.47	£ 2.51	-£0.79	-£1.71	-£3.17	-£4.39
2	Replacement 275/33kV Transformers (120MVA)	N	-£ 8.34	N/A	-£7.00	-£ 0.02	-£3.84	-£5.22	-£6.23	-£7.01
3	New 275/33kV 120MVA Dual LV Winding Transformers	N	-£ 9.09	N/A	-£7.76	-£ 0.78	-£4.26	-£5.81	-£6.92	-£7.77
4	Bus Section Reactor 33kV	N	-£ 12.21	N/A	-£6.23	£ 0.75	-£1.38	-£2.52	-£4.49	-£6.12
5	Replacement 275/33kV Transformers (90MVA)	N	-£ 6.38	N/A	-£5.02	£ 1.96	-£2.76	-£3.70	-£4.45	-£5.03

Options 1, 4 and 5 as proposed deliver a positive NPV, when considered alongside the associated benefits under the Community Renewables scenario relative to the Baseline solution of transformer replacement at end of life. Based on the NPV value and expenditure within price control it is proposed that Option 1, installation of 33kV series reactors be the proposed solution.

5. Conclusion

All proposed solutions have been review in terms of scope, costs, timescales, construction risk and feasibility. All options considered against the baseline, meet the required primary objective of providing additional fault level capacity.

The proposed solution, Option 1 involves the installation of 33kV series reactors on the LV circuits of the existing 275/33kV 120MVA transformers, in addition to this the costs allow for the replacement of the existing single core cables to accommodate the required reactors.

This design has the following advantages:

1. Minimal impact on existing infrastructure, reactors can be installed offline minimising the interaction with the existing assets.
2. Maximises the use of existing infrastructure, transformers and switchgear relatively recently installed as such still have significant lifetime remaining. This option maximises the use of existing assets.

The design has the following disadvantages:

1. The solution doesn't fully address the secondary objective of managing network risk as the reactors would be additional plant to manage on the network.
2. Installation of reactors will have an increase in losses at the site (loading dependent).

Summary Information

- Forecast Costs – *£2.893*
- Timing of Investment – 2023
- Outputs:
    - Addition – 2 x 33kV series reactors.

Outputs included in RIIO T1 Plans

Not Applicable

6. Future Pathways – Net Zero

Primary Economic Driver

The primary driver for this investment is to reduce the fault level at East Kilbride 33kV.

Payback Periods

No payback period has been assessed for this project.

Pathways and End Points

The proposed solution mitigates the fault level constraint at East Kilbride 33kV network, but also provides some headroom for the connection of new embedded generation in the area; most of it likely to be renewable. This solution is justified in all Future Energy Scenarios and provides a solution that includes headroom for new generation to enable the achievement of Net Zero.

Asset Stranding Risks

There is no asset stranding risk associated with this funding.

Sensitivity to Carbon Prices

The proposed solution is itself not sensitive to carbon prices.

Future Asset Utilisation

We expect utilisation of the assets to continue to increase as future demand and generation connected to the site increase.

Whole Systems Benefits

This paper proposes a transmission solution to a distribution problem. Both transmission and distribution solutions have been evaluated in cooperation with SPD. A whole-system approach has been taken to identify the most economic and efficient solution while also taking changes for Net Zero into account.