Transmission Infrastructure for Renewable Generation

Scottish Power Transmission Limited England – Scotland Interconnection

POST CONSTRUCTION TECHNICAL REPORT

- Final Report
- 30 November 2012

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1. Executive Summary

In 2004, power flow between Scotland and England was facilitated by interconnection circuits on the west and east coasts of Great Britain. The combined capacity of the interconnections, under double (N-D) circuit contingencies, was limited in the summer to between 2000MW and 2200MW by the thermal rating of the east coast interconnection and in the winter to between 2200MW and 2300MW by transient stability issues. To meet the requirements of Scottish Power Transmission Limited (SPTL) licence conditions an interconnection capacity of approximately 3100MW was required by winter 2005/06. In late 2005, SPTL had contracted to connect 2830MW of renewable energy which was sufficient to meet the threshold requirements for initiating reinforcement of the interconnection circuits as stipulated by Ofgem in the Transmission Investments for Renewable Generation (TIRG) Final Proposals[1].

Following a review by the three UK transmission licensees, a proposal was made to increase the capability of the England – Scotland interconnection from 2200MW to 2800MW by upgrading of both the west and east coast interconnection circuits.

The aim of the west coast scheme was to facilitate reinforcement by upgrading of the existing 275kV circuit, stretching between Strathaven and Harker substations, to 400kV operation. This involved the provision of new 400kV substations at Coalburn and Elvanfoot; rebuild of the existing Linmill substation; upgrading of the existing Gretna substation; and new 400kV switchgear at Strathaven substation.

The east coast scheme was to facilitate reinforcement by upgrading of the 400kV overhead line conductor system between Eccles and Stella West substations. To mitigate potential overloads resulting from this upgrade the 132kV network around the Hawick area required some reconfiguration works.

The aim of this document is to provide a post construction technical report setting out the extent to which the England – Scotland Interconnection scheme complies with the TIRG output measures, as defined in SPTL's licence conditions, and to provide a post construction completion certificate. The report and certificate will enable SPTL to discharge its licence obligations under Special Licence Condition J3 –Restriction of Transmission Charges (Part B 10 (d) (ii)).

The output measures are specified in Schedule C of the SPTL TIRG licence for the interconnection schemes both prior to and post construction. They are shown in tables 1.1 and 1.2 for the west and east coast interconnections respectively.

[1] Transmission investment for renewable generation, Final proposals, December 2004, 288/04

Table 1.1 – West Coast Interconnection Output Measures

Project scope	Capability as at 31 March 2005			Forecast capability prior to construction start date			Forecast capability post construction		
Line upgrade	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)
Strathaven - Coalburn	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Coalburn - Elvanfoot	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Elvanfoot - Harker	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Strathaven - Gretna	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Gretna - Harker	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Coalburn 400/132 'SGT1'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240
Coalburn 400/132 'SGT2'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240
Elvanfoot 400/25 'SGT1'	Circuit does not presently exist			Circuit does not presently exist			400/25	80	80
Elvanfoot 400/25 'SGT2'	Circuit does not presently exist			Circuit does not presently exist			400/25	80	80

Project scope	Capability as at 31 March 2005			Forecast capability prior to construction start date			Forecast capability post construction		
Gretna 400/132 'SGT1'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240
Gretna 400/132 'SGT2'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240

Table 1.2 – East Coast Interconnection Output Measures

Project scope	Capability as at 31 March 2005			Forecast capability prior to construction start date			Forecast capability post construction		
Line upgrade	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)
Eccles - Stella West No.1	400	1390	1110	400	1390	1110	400	2770	2420
Eccles - Stella West No.2	400	1190	1110	400	1190	1110	400	2770	2420
Gretna - Hawick	132	132	106	132	132	106	132	132	106
Gretna - Junction V - Hawick	Circuit does not presently exist			Circuit does not presently exist			132	132	106
Hawick - Galashiels	132	132	106	132	132	106	132	132	106

The scheme design and reconfiguration works of both the west and east coast interconnection schemes are described in detail in section 4 of this report.

Site visits were undertaken to selected substations on 02 August 2012, whereby construction data and photographic evidence was collected to support verification of scheme completion. Power flows in the reconfigured networks were confirmed via recorded data taken from SCADA systems. Where site visits were not made supporting evidence was provided by SPTL.

Based on the evidence gathered it was verified that the works undertaken on both the west and east coast interconnection schemes fully meet the requirements of the output measures. A construction completion certificate is provided in Appendix A.

2. Introduction

SPTL appointed Sinclair Knight Merz (SKM) as Independent Technical Reviewers to carry out a post construction technical review to meet the TIRG licence conditions as set out by Ofgem. The Ofgem approved TIRG project under consideration is the England – Scotland Interconnection which comprises both east coast and west coast interconnection reinforcement schemes. The west coast scheme incorporates the upgrade of the 275kV circuit between Strathaven and Harker to 400kV operation which required construction of two new substations and modification works at three other substations. The east coast scheme incorporates an upgrade of the 400kV overhead line between Eccles and Stella West and reconfiguration of the 132kV substation at Hawick.

To discharge SPTL's licence obligations under Special Licence Condition J3 –Restriction of Transmission Charges (Part B 10 (d) (ii)), SKM were to provide:

- A post construction technical report setting out the extent to which the project complies with the TIRG output measures
- A construction completion certificate

This document fulfils the requirement for the post construction technical report. A construction completion certificate is provided in Appendix A.

To facilitate the review, site visits took place on 2nd August 2012 together with a visit to SPTL's offices in Bellshill on the 3rd August 2012. SPTL personnel presented a description of the project and the status in terms of the construction. Documentation related to the scheme construction was presented to SKM for review. SPTL's staff was very cooperative and SKM had access to all information requested and required for the purposes of the review. SPTL also provided additional documentation and evidence via e-mail when requested where additional clarifications were required following the consideration of the information obtained during the visit.

SKM is satisfied that it had access to the relevant documentary evidence that allowed review of the technical construction details of the scheme and to assess compliance with the appropriate output measures.

2.1. Methodology

To facilitate the post construction technical review, documentary and photographic evidence was collated to aid verification that the scheme:

i) has been constructed in accordance with the scheme designs outlined in the TIRG licence submissions;

ii) that construction is complete;

iii) that the scheme is in operational service;

iv) that the scheme forecast output measures are fully met.

The technical review provides an overview of scheme configuration and construction. High level design documentation has been reviewed and in some cases site visits undertaken to verify that the scheme complies with the outline TIRG scheme design and is complete. The technical review does not include a detailed design review of documents such as primary plant layouts, calculations, plant rating and design, civil works, protection & control and LVAC / LVDC schemes; nor is any review of quality of installation undertaken.

Verification of completion of construction and scheme operation is facilitated by:

i) review of plant “completion certificates”

ii) site visits and / or review of photographic evidence

iii) SCADA data

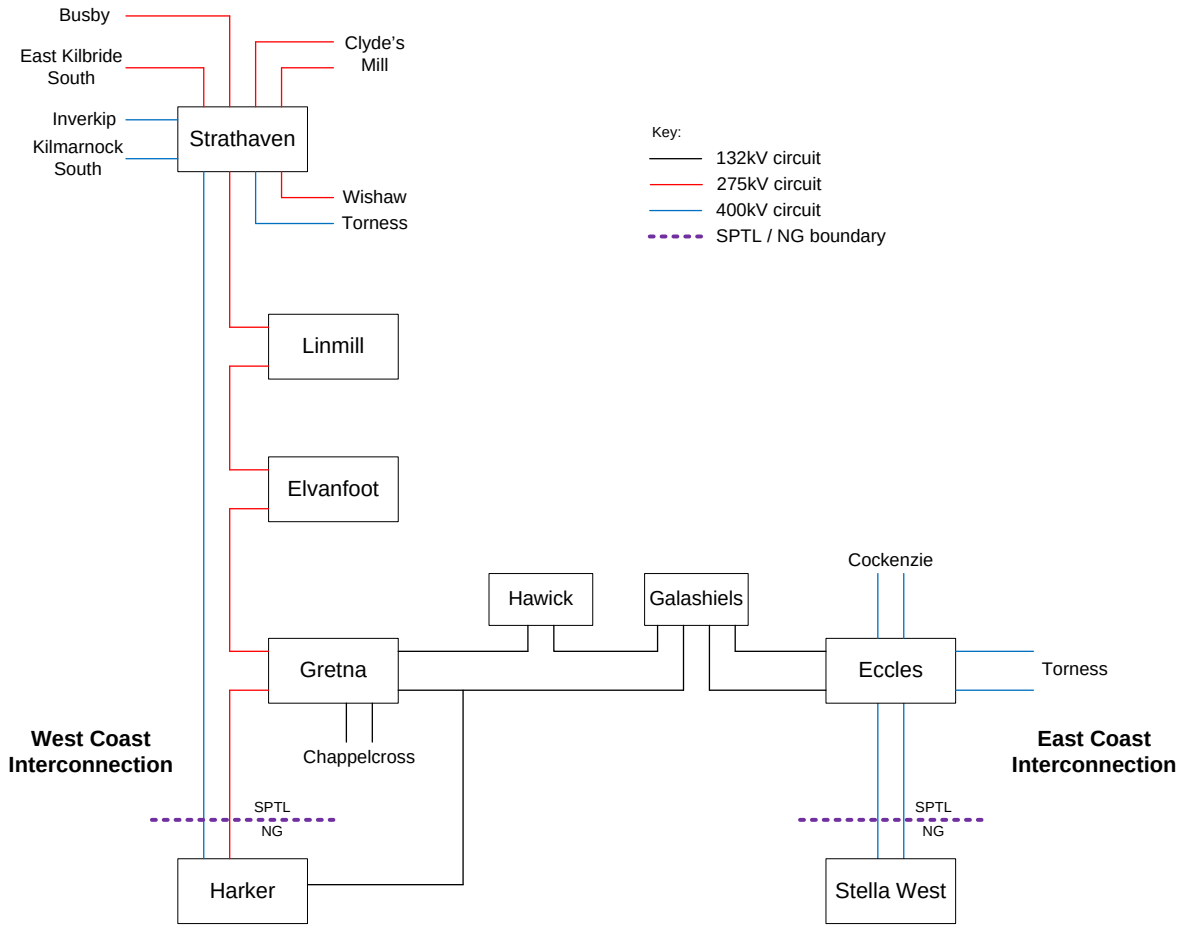
Capability of circuits given in forecast output measures is verified by review of circuit rating schedules that provide information on the limiting plant ratings of the circuit, or by review of design documentation and / or nameplate data in the case of transformer circuits.

3. Background

3.1. Requirement for Reinforcement

In 2004, power flow between Scotland and England was facilitated by interconnection circuits on the west and east coasts of Great Britain. On the west coast the interconnection comprised a 275kV circuit stretching between Strathaven and the National Grid (NG) owned Harker substations, looping into Linmill, Elvanfoot and Gretna en route; and a 400kV circuit between Strathaven and Harker. On the east coast the interconnection comprised two 400kV circuits between Eccles and the NG owned Stella West substation. A simplified illustration is shown in figure 3.1 below.

Figure 3.1 – England – Scotland Interconnection Circuits



In 2004 the capacity of the electrical interconnection, under double (N-D) circuit contingencies, was limited in the summer to between 2000MW and 2200MW by the thermal rating of the east coast interconnection and in the winter to between 2200MW and 2300MW by transient stability issues.

To meet the requirements of Great Britain Security and Quality of Supply Standards (SQSS) as part of SPTL licence conditions an interconnection capacity of approximately 3100MW was required by winter 2005/06. This was established with a background of 1500MW of contracted renewable generation forecast to be connected to the system by winter of 2005.

In late 2005, SPTL had contracted to connect 2830MW of renewable energy and were processing further connection offers leading up to around 6000MW total. This level of renewable generation was sufficient to meet the threshold requirements for initiating reinforcement of the interconnection as stipulated by Ofgem in the TIRG Final Proposals[2].

3.2. Proposed Solution

Following a review by the three UK transmission licensees, a proposal was made to increase the capability of the England – Scotland interconnection from 2200MW to 2800MW by upgrading of both the west and east coast interconnection circuits. This would facilitate power flows resulting from the connection of increased levels of renewable generation. The detailed proposals are described in the following.

3.2.1. West Coast Interconnection

To facilitate increased capacity on the west coast interconnection and overcome existing transient stability and thermal capacity limits, the existing 275kV circuit stretching from Strathaven to Harker was proposed for upgrading to 400kV operation.

The overhead line part of the 275kV circuit was originally built for 400kV operation and shared double circuit towers on the same route as the 400kV circuit between Strathaven and Harker. Other than modifications to facilitate diversions into new substations, no additional overhead line works were proposed.

The existing 275kV interconnection comprised the following circuits:

- Strathaven – Linmill
- Linmill – Elvanfoot
- Elvanfoot – Gretna
- Gretna – Harker

To allow for 400kV operation the following works were proposed:

[2] Transmission investment for renewable generation, Final proposals, December 2004, 288/04

- Transfer of the Strathaven – Linmill circuit from the 275kV busbar at Strathaven onto the 400kV busbar. This required the construction of a new 400kV bay at Strathaven.
- Construction of a new 400/132kV substation at Coalburn. Associated works including:
  - i) Diversion of the existing Strathaven – Harker 400kV circuit into Coalburn for connection to the new 400kV busbar.
  - ii) Disconnection of the 275kV double circuit overhead line from Linmill and diversion into Coalburn for connection to the new 132kV busbar.
- Rebuild works at Linmill to convert the substation from 275kV to 132kV operation.
- Construction of a new 400/275/25kV substation at Elvanfoot to replace the existing 275kV substation. Associated works including:
  - i) Diversion of the existing 275kV overhead line circuits at Elvanfoot substation into the new Elvanfoot substation for connection to the 400kV busbar. The switchgear bays installed to provide connection to the 400kV busbar were funded by a non-TIRG scheme.
  - ii) Diversion of the existing Strathaven – Harker 400kV circuit into Elvanfoot for connection to the new 400kV busbar.
- Upgrade of the existing 275/132kV substation at Gretna to 400/132kV operation.

Associated works were also required at the NG owned Harker substation to connect the existing 275kV overhead line into the 400kV busbar. These works were undertaken by NG and were coordinated with the proposed works outlined above.

Reconfiguration of the network due to the proposed works would lead to the following 400kV circuits:

- Strathaven – Elvanfoot
- Strathaven – Coalburn
- Coalburn – Elvanfoot
- Elvanfoot – Gretna
- Elvanfoot – Harker
- Gretna – Harker

3.2.2. East Coast Interconnection

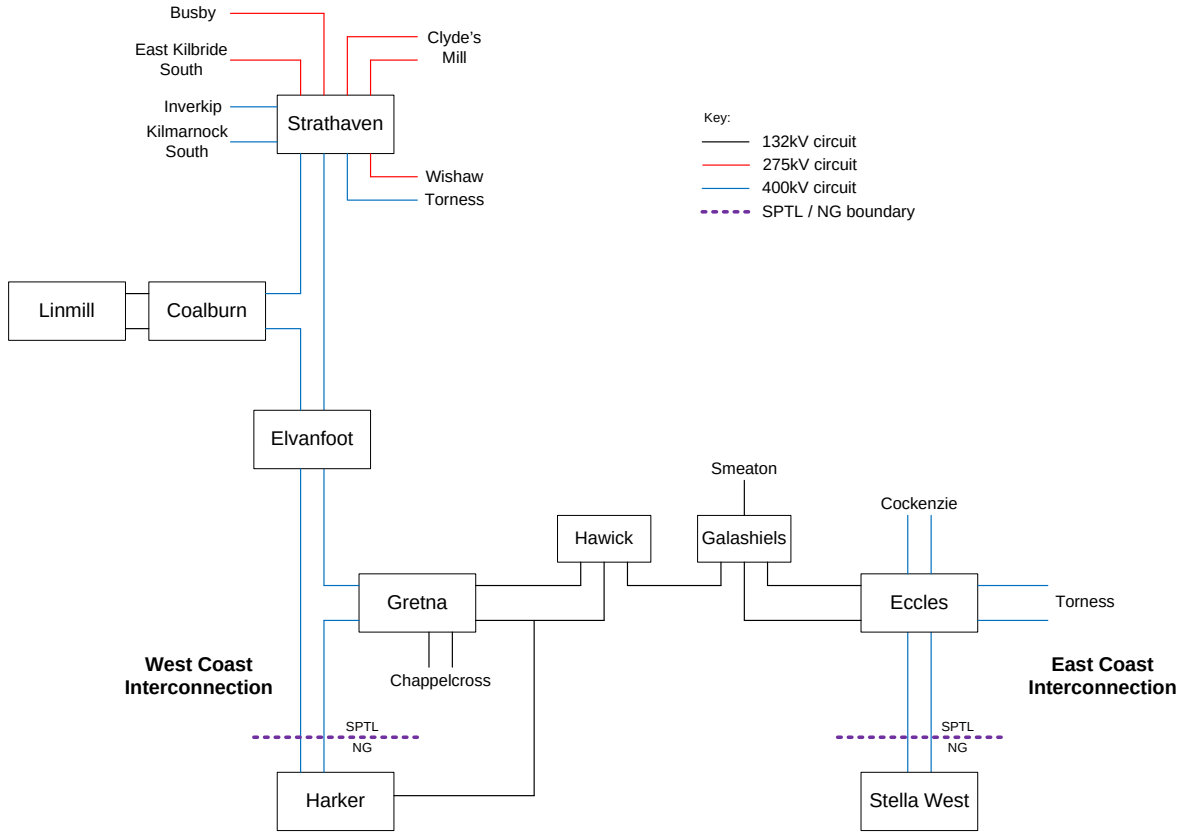
To facilitate increased capacity on the east coast interconnection to overcome thermal capacity limits, the 400kV circuits between Eccles and the NG owned Stella West substations were proposed for upgrading. This was to be achieved by replacement of the existing conductor system with conductors of a higher capacity.

The existing twin Zebra (2 x 400mm^2 ACSR) conductor system was proposed for replacement with a triple Araucaria (3 x 700mm^2 AAAC) conductor system on the Eccles – Stella West overhead line route. The replacement conductor system was selected to achieve the required reduction in circuit impedance.

A consequence of the proposed upgrading of the Eccles – Stella West conductor system was an overloading of the 132kV network in the border region under double (N-D) circuit contingencies of the east coast interconnection. Additional work was therefore proposed to mitigate this issue, which would be achieved by reconfiguring Hawick 132kV substation. The reconfiguration involved diversion of the existing Gretna – Harker – Galashiels circuit into Hawick with the existing Galashiels – Hawick circuit operating normally open but being made available for use in emergencies. The 132kV switchgear at Hawick was also proposed for replacement and reconfiguration.

A simplified illustration of the new transmission arrangement is shown in figure 3.2 below.

Figure 3.2 – Proposed Reinforcement of England – Scotland Interconnection Circuits



4. Review of Interconnection Works

This section provides technical details of the works undertaken on both the west and east coast interconnections and describes the changes to the configuration of the transmission network.

Site visits have been made to selected substations where major works have been completed to gather evidence in support of verification of scheme completion and operation. Where site visits were not made supporting evidence has been provided by SPTL.

4.1. West Coast Interconnection

In 2006, SPTL commenced development work on the proposed west coast interconnection. The scheme was intended to increase the capacity of the west coast interconnection with England by upgrading the existing 275kV circuit between Strathaven and Harker to 400kV operation.

The scheme encompassed works on both the SPTL network and the NG network. NG works amounted to the addition of a 400kV switchgear bay at Harker substation and modification of the circuit connection into the substation. Project management of the works was undertaken by SPTL except for works at Harker that were managed by NG.

SPTL have now completed the proposed works on their network which encompass modification works at Strathaven substation, new substations at Coalburn and Elvanfoot; refurbishment of Linmill substation and upgrade of Gretna substation. Overhead line diversion works were also undertaken in the surrounding areas of Coalburn and Elvanfoot to facilitate 400kV connection into each substation. Additional 132kV overhead line and underground cable works were undertaken to connect the refurbished Linmill substation to the 132kV busbar at Coalburn.

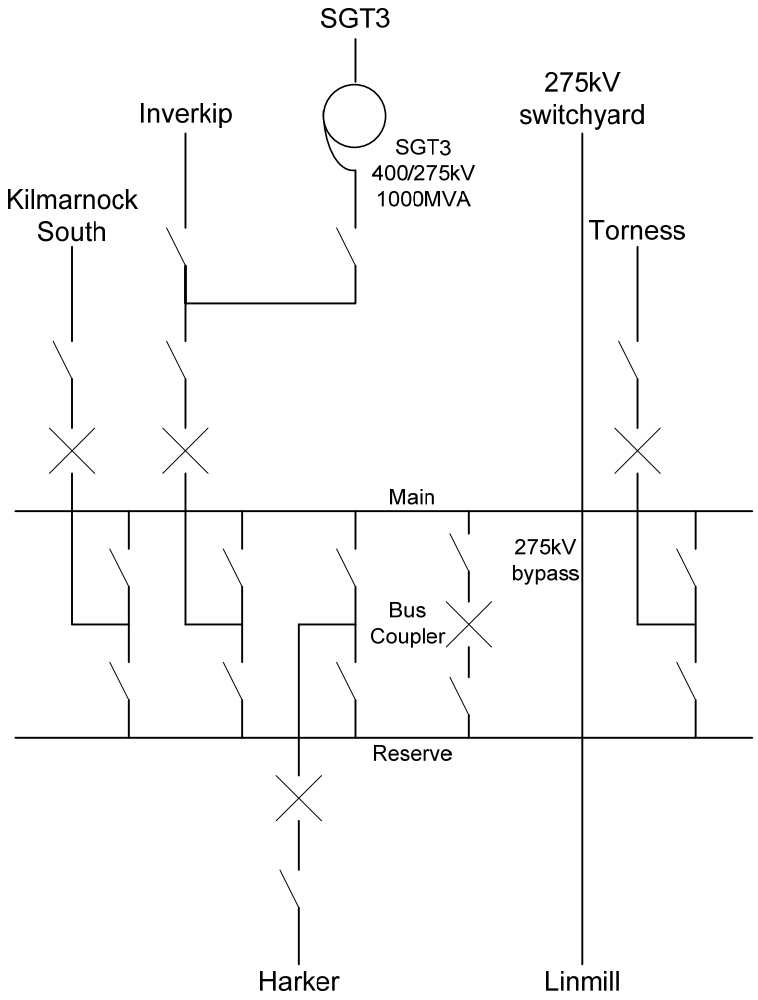
The scheme was commissioned during 2008 and 2009 prior to being put into full service in 2010.

4.1.1. Modifications at Strathaven 400/275/33kV Substation

4.1.1.1. Re-configuration of Substation

Prior to construction of the west coast interconnection upgrade, the Strathaven – Linmill 275kV circuit was connected to the 275kV busbar at Strathaven, which passed through the 400kV switchyard with a solid through circuit connection. A single line diagram of this arrangement is shown in figure 4.1 below.

Figure 4.1 – Single Line Diagram of Strathaven Substation (pre-upgrade)



To accommodate the requirements of the west coast interconnection upgrade the configuration of Strathaven substation required modification. The scope of modifications included:

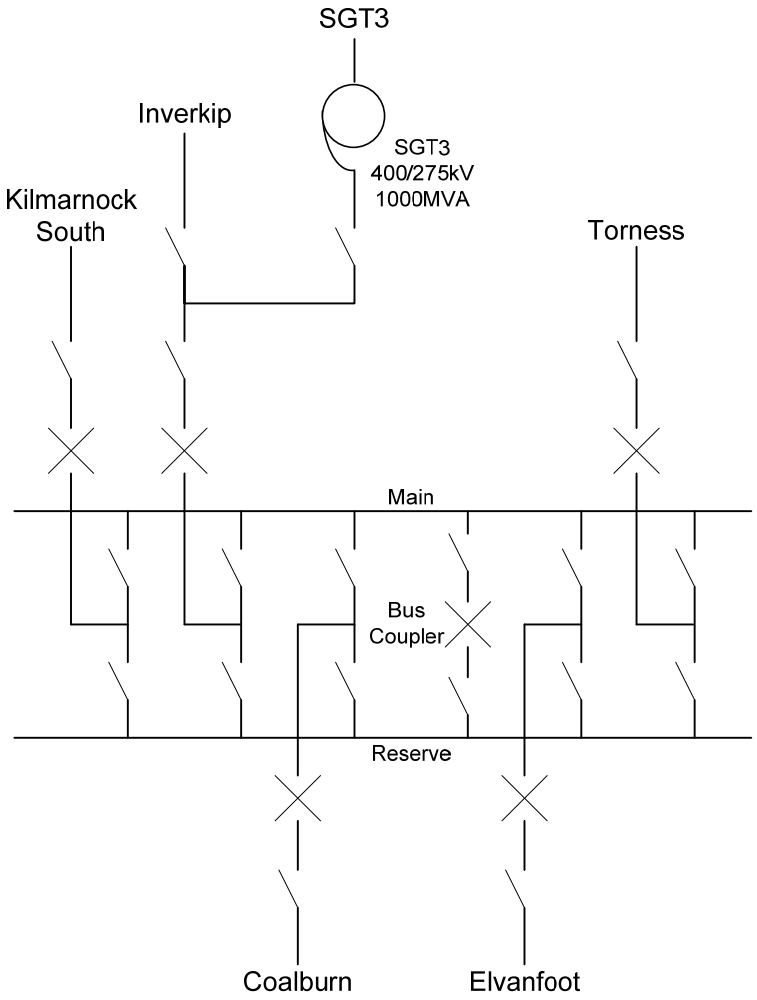
i) Removal of the 275kV Linmill circuit from the 275kV busbar and dismantling of all switchgear and connections associated with this circuit between the incoming line termination and the 275kV busbar.

ii) Construction of a new 400kV circuit bay (where the previous 275kV Linmill circuit passed through the 400kV switchyard) to facilitate connection of the Linmill overhead line circuit onto the 400kV busbar. This would become the new Elvanfoot circuit.

iii) Renaming of the Harker circuit to Coalburn.

A single line diagram of the new arrangement is shown in figure 4.2 below.

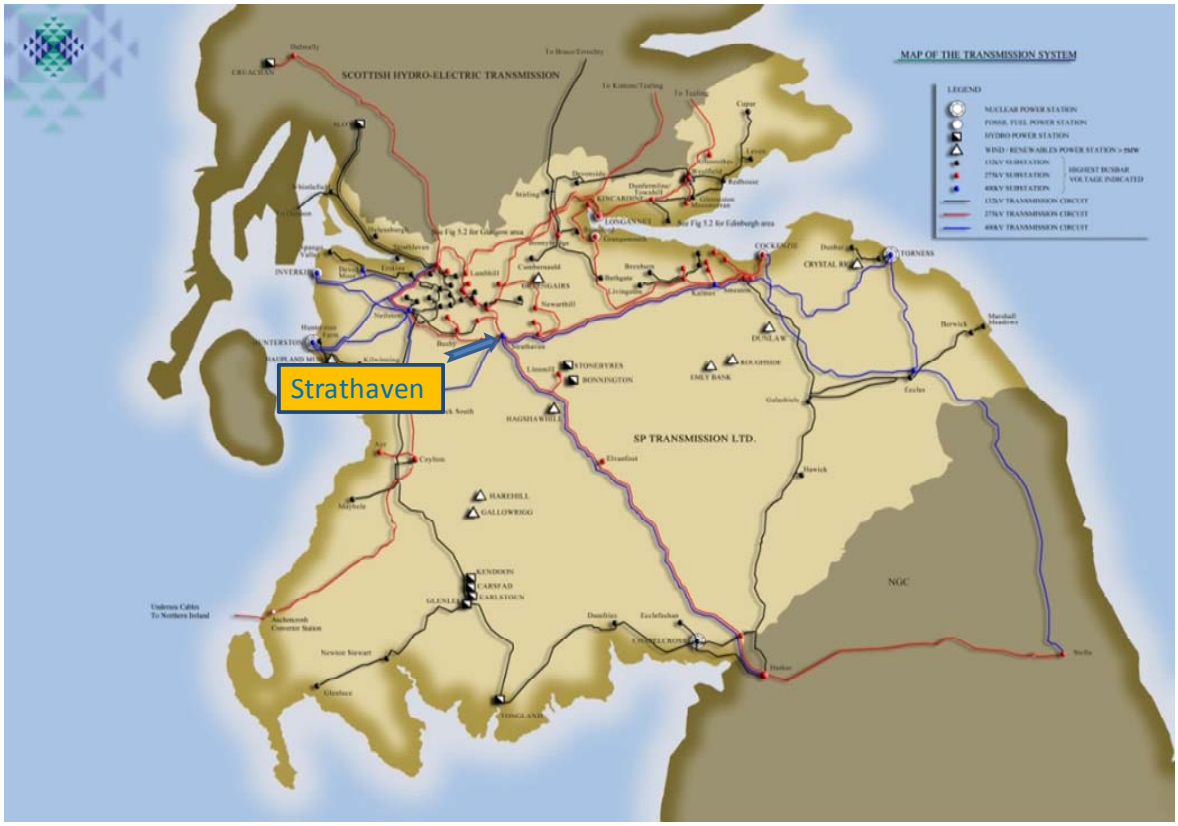
Figure 4.2 – Single Line Diagram of Strathaven Substation (post-upgrade)



4.1.1.2. Substation Location and 400kV Bay Construction

The substation site is located approximately 8.5km north of Strathaven. Figure 4.3 below shows a geographical representation of the location.

Figure 4.3 – Strathaven Substation Site



The 400kV switchyard required significant civil works for modification of equipment foundations and structures for the new plant and modification to trenches/ducts where necessary to accommodate new control wiring. The existing substation control buildings were utilised to accommodate new protection and control for the new 400kV circuit.

The design of the new 400kV switchyard circuit bay is based upon conventional air insulated switchgear construction. The circuit utilises switchgear equipment which includes:

- 400kV Open terminal circuit breaker
- 400kV Open terminal pantograph and rotating centre post disconnectors with integral earth switches
- 400kV Open terminal earth switches
- 400kV Capacitor voltage transformers
- 400kV Current transformers
- 400kV Surge arresters

The switchgear terminates onto the existing overhead line gantry and connects to the existing overhead line located at the southern end of the substation.

4.1.1.3. Construction Verification

A site visit has not been undertaken by SKM. In lieu of a site visit, evidence of "Completion Certificates" was presented by SPTL to confirm that construction and testing of the circuit was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots taken of SCADA outputs from Coalburn substation (see section 4.1.2.4) showed that the 400kV circuit was operational with a power flow recorded on the Strathaven circuit of 21.6MW.

SKM were satisfied that the information presented was sufficient to confirm that the new Elvanfoot 400kV circuit is in full operation.

4.1.2. New 400/132kV Substation at Coalburn

4.1.2.1. Configuration

Coalburn is a new 400/132kV substation and comprises both 400kV and 132kV switchyards within the boundary fence. A brief description of the configuration of each is described below.

4.1.2.1.1. 400kV Switchyard

The configuration of the 400kV switchyard is of the double busbar type and comprises main and reserve busbars. Each circuit is capable of being selected for connection via busbar disconnectors to either busbar. In the event of a fault to the main or reserve busbar each circuit can be transferred to the other busbar with minimal disruption to supply.

The 400kV switchyard also includes a busbar coupler circuit breaker between the main and reserve busbars to allow on-load transfer between the busbars; this provides operational flexibility and reduces outage risks when maintenance is required on a particular busbar section.

The 400kV switchyard also has two, 240MVA, 400/132kV SGT transformer circuits, namely SGT1 and SGT2, which facilitate connection onto the 132kV switchyard.

Prior to the construction of the substation there was a double circuit overhead line passing through the area which carried the 400kV Strathaven – Harker circuit and the 275kV Strathaven – Linmill and Linmill – Elvanfoot circuits. The tee connections to Linmill on the 275kV circuit have now been removed with the open ends of the line bridge connected. The 400kV Strathaven – Harker

circuit has also been split and diverted into the Coalburn 400kV busbar. The resulting 400kV circuits are:

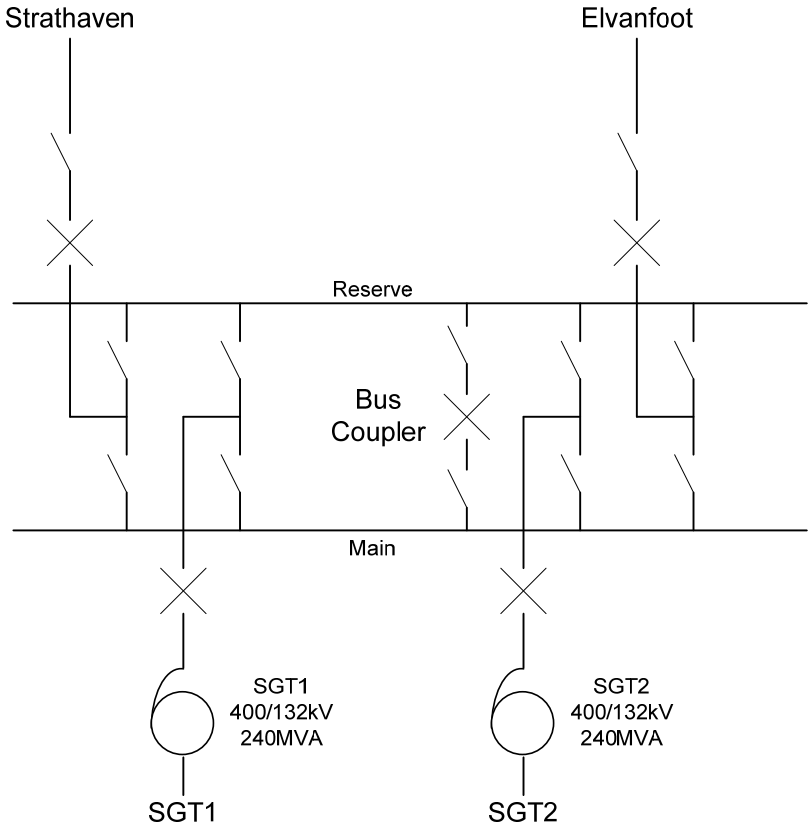
i) Strathaven – Elvanfoot

ii) Strathaven – Coalburn

iii) Coalburn – Elvanfoot

The basic single line diagram of the 400kV switchyard is shown in figure 4.7.

Figure 4.7 – Coalburn 400kV Single Line Diagram



4.1.2.1.2. 132kV Switchyard

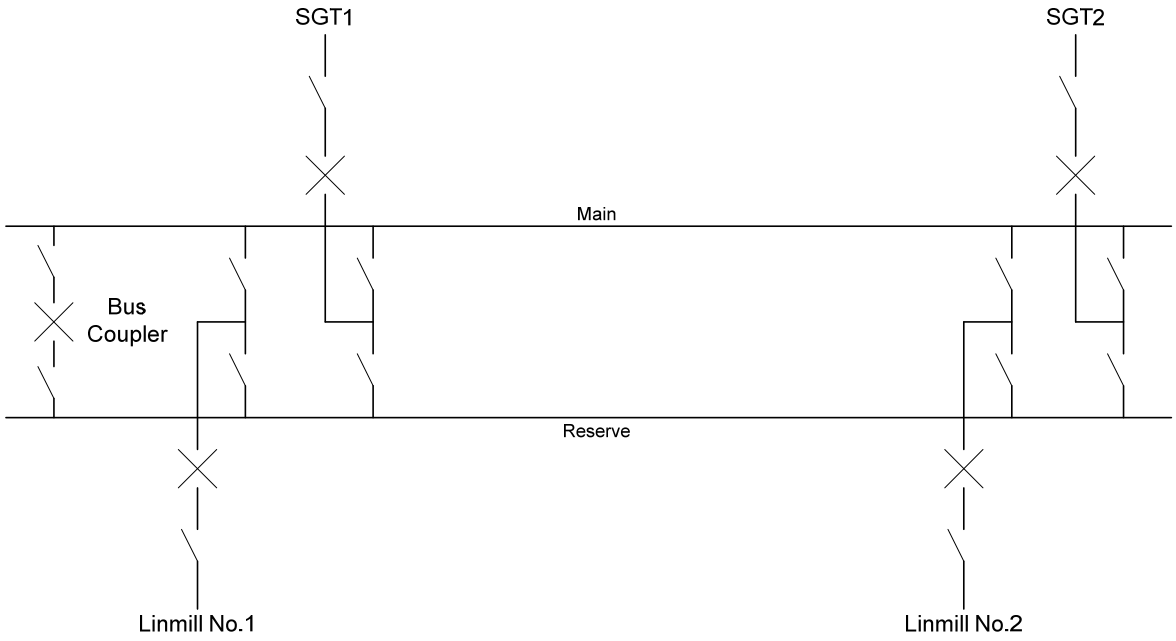
The configuration of the 132kV switchyard is similar to the 400kV in that it is also of the duplicate busbar type with main and reserve busbars.

The 132kV switchyard similarly has a busbar coupler circuit breaker connection between main and reserve.

Coalburn supplies Linmill from the 132kV substation which is fed via two circuits, Linmill No.1 & No.2. Each circuit is part cable, part overhead line. The cable part, of approximately 3.1km in length, leaves the substation and connects onto the existing overhead line (previously operated at 275kV) at tower YR6; located approximately 1.4km north east of the substation. The overhead line then completes the circuit into Linmill substation with a length of approximately 5.8km.

The basic single line diagram of the 132kV switchyard is shown in figure 4.8.

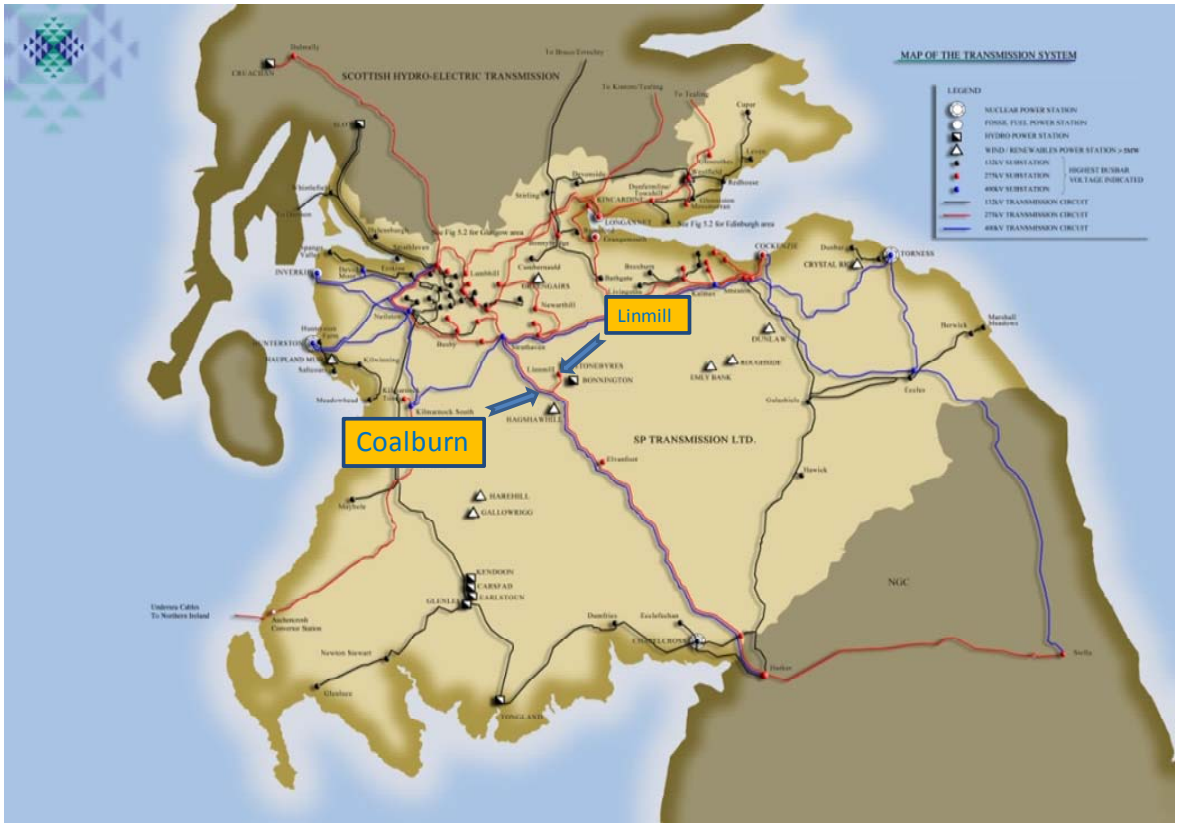
Figure 4.8 –Coalburn 132kV Single Line Diagram



4.1.2.2. Location, Layout and Construction

The substation site is located approximately 3km north east of Coalburn. Figure 4.9 below shows a geographical representation of the location.

Figure 4.9 – Coalburn Substation Site



The substation is built on a single level platform and required significant civil works to establish an embankment for the access road and a 40,000m^2 platform. The substation has a single storey control building which accommodates protection and control for both the 400kV and 132kV switchyards, LVAC switchgear, batteries and telecoms as well as a workshop, mess rooms and wash room facilities.

The size of the substation is approximately 36,000 m^2 and it is surrounded by a palisade security fence 2.74m high.

The substation comprises the following 400kV and 132kV circuits:

400kV circuits

- Feeder circuit, Strathaven

- Feeder circuit, Elvanfoot
- Supergrid transformer circuit, SGT No.1
- Supergrid transformer circuit, SGT No.2
- Bus coupler

132kV circuits

- Feeder circuit, Linmill No.1
- Feeder circuit, Linmill No.2
- Supergrid transformer circuit, SGT No.1
- Supergrid transformer circuit, SGT No.2
- Bus coupler

The design of both the 400kV and 132kV switchyards is based upon conventional air insulated switchgear construction. The layout comprises a two level construction with the main and reserve busbars at high level and the circuit connections at low level. The busbars run in parallel on a west-east plane and the circuit connections run in a north-south plane.

The circuits generally utilise switchgear equipment which includes:

400kV circuits

- 400kV Open terminal circuit breakers
- 400kV Open terminal pantograph and rotating centre post disconnectors with integral earth switches
- 400kV Open terminal earth switches
- 400kV Capacitor voltage transformers
- 400kV Current transformers
- 400kV Surge arresters

132kV circuits

- 132kV Dead tank circuit breakers with integral CT's
- 132kV Open terminal pantograph and rotating centre post disconnectors with integral earth switches
- 132kV Capacitor voltage transformers
- 132kV Surge arresters

- 132kV Cable sealing ends

The Strathaven and Elvanfoot circuits terminate onto a substation circuit entry directly via an overhead line connection. The double circuit terminal towers are located at the north western corner (Strathaven) and north eastern corner (Elvanfoot) outside of the substation boundary. The Linmill No.1 and No.2 circuits terminate onto the switchgear via 132kV cable circuits which connect to a double circuit tower in a new cable sealing end compound located approx 1.4km north east of the substation.

The substation has been designed on the basis that maintenance, extension and repairs can be carried out with a maximum of only one circuit and one busbar section out of service simultaneously. Clearances for maintenance access have been designed to allow for mobile access platforms, scaffolding, cranes etc.

Both the 400kV and 132kV switchyards incorporate space for future circuit connections. The spare bays have not been populated with any equipment or foundations.

Figure 4.10 below shows a view of the 400kV switchyard and figure 4.11 a view of the 132kV switchyard.

Figure 4.10 – View of 400kV Switchyard (main & reserve busbars)

Figure 4.11 – View of 132kV Switchyard (main & reserve busbars)

4.1.2.3. Overhead Line Reconfiguration

The double circuit overhead line route carrying the Strathaven – Linmill (275kV), Linmill – Elvanfoot (275kV) and Strathaven – Harker (400kV) circuits that ran adjacent to the site prior to construction have now been reconfigured.

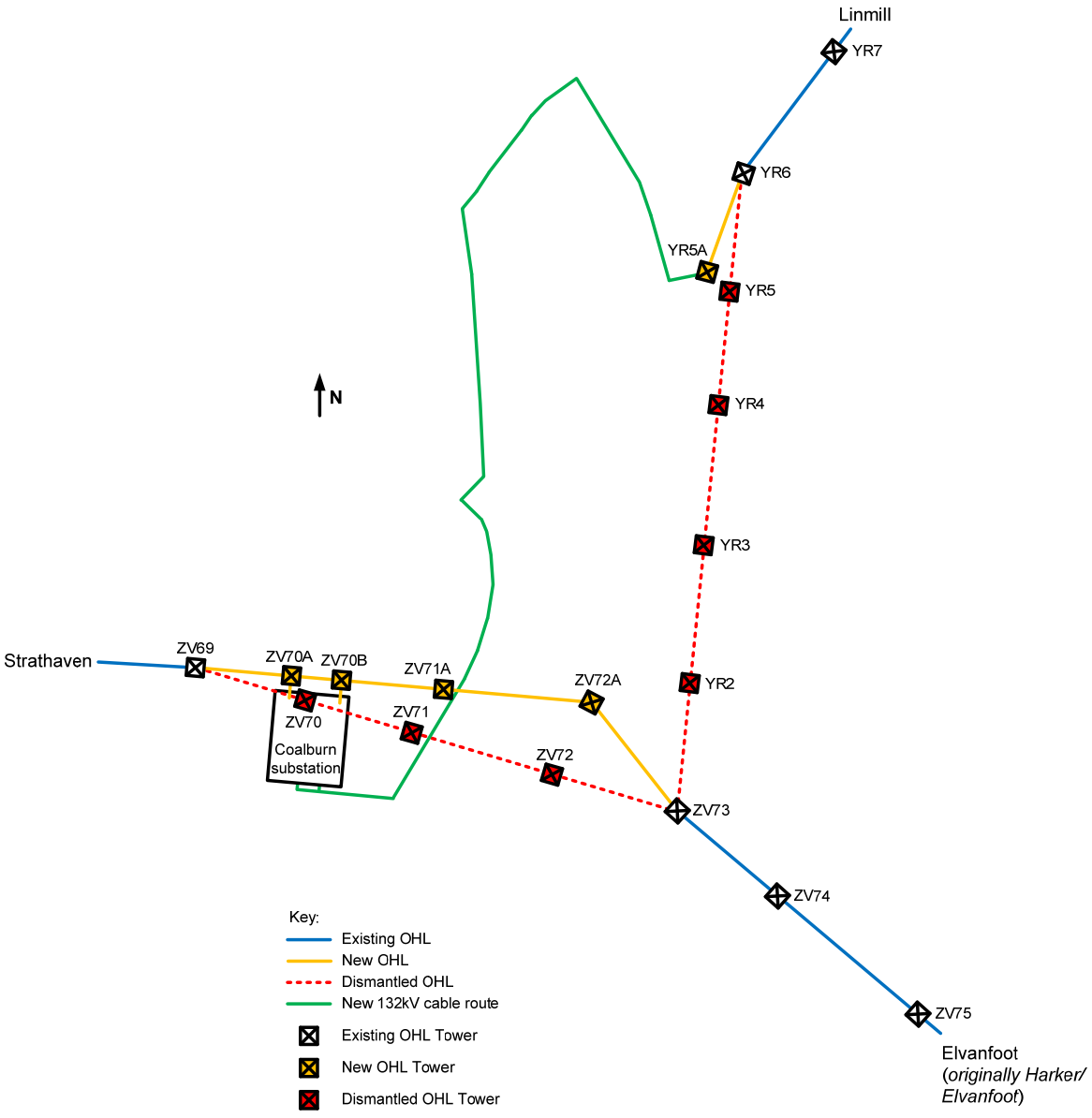
The Linmill circuit end connections were removed from tower ZV73 and towers YR2 through YR5 have been dismantled. Connection of the Linmill circuits into the Coalburn 132kV busbar is now facilitated by a 132kV cable connection between the substation and tower YR6 whereupon cable sealing ends provide connection onto the overhead lines.

To accommodate disconnection of the Linmill circuits and diversion of the 400kV Strathaven-Harker circuit into Coalburn, towers ZV70 through ZV72 were dismantled and the route diverted via new towers ZV70A, ZV70B, ZV71A and ZV72A. At towers ZV70A and B, located adjacent to the boundary fence at the northern end of the substation, the 400kV circuit is split and each circuit end terminated into the 400kV busbar. At tower ZV73, where the Linmill circuits were

disconnected, the new double circuit from tower ZV72A is terminated onto the existing double circuit to provide the onward circuit connections to Elvanfoot substation.

An overview of the overhead line reconfiguration is shown in figure 4.12.

Figure 4.12 – Overview of Overhead Line Reconfiguration



4.1.2.4. Construction Verification

SKM undertook a site visit to Coalburn substation on 02 August 2012 with a view to gathering evidence to confirm completion of construction and that the substation is fully operational.

Photographic evidence was gathered to illustrate completion of construction. Figures 4.13 through 4.17 present various parts of the 400kV and 132kV switchyards.

Figure 4.13 – Incoming 400kV Elvanfoot Line Termination

Figure 4.14 – 400kV Circuit Breaker & CT's

Figure 4.15 – SGT1 400/132kV Transformer

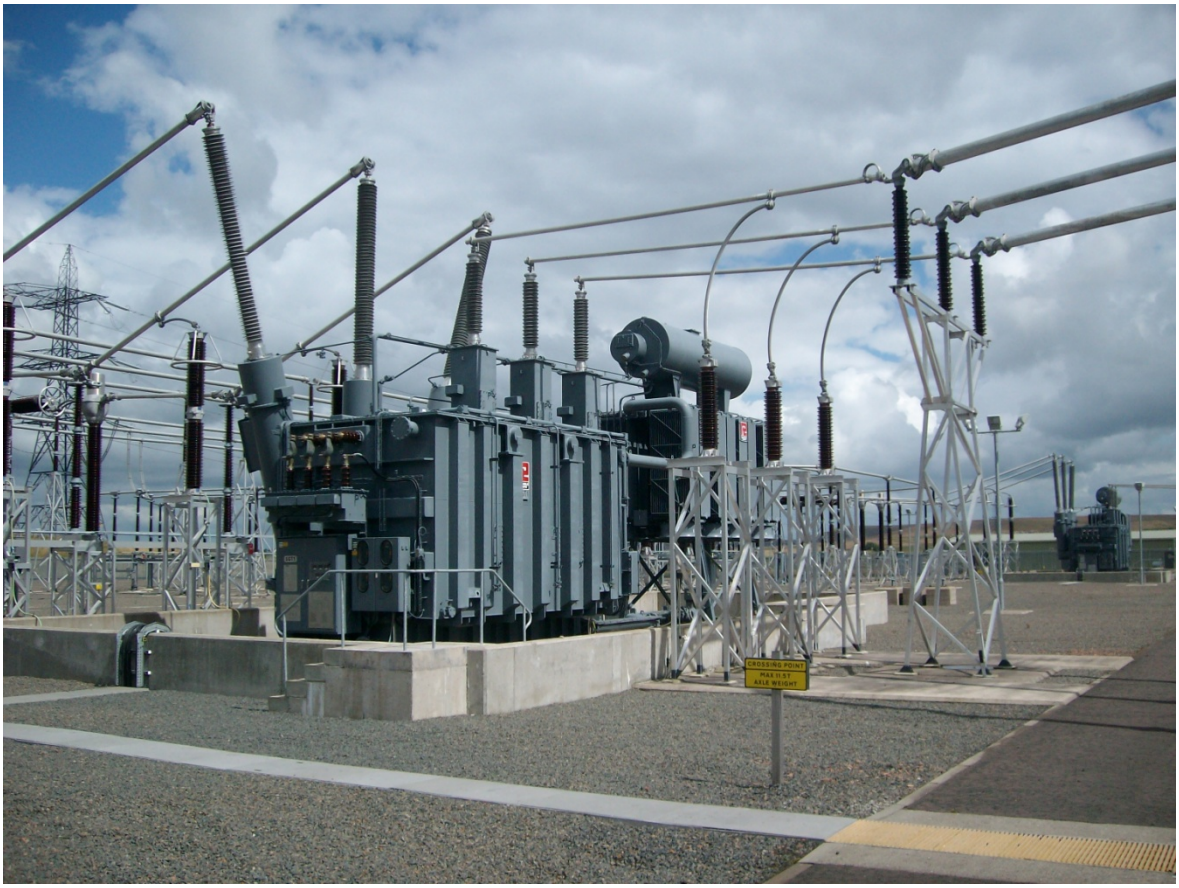


Figure 4.16 –132kV Bus Coupler Bay

Figure 4.17 –132kV Busbars

Evidence of “Completion Certificates” was also presented by SPTL to confirm that construction and testing of each circuit was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots were taken of SCADA outputs which showed that both the 400kV and 132kV switchyards were configured with all feeder circuits and the bus coupler circuit closed.

Power flows were observed through all circuits and recorded at 21.6MW (Strathaven); 30.9MW (Elvanfoot); 4.4MW (SGT1) and 3.9MW (SGT2).

SKM were satisfied that the information presented was sufficient to confirm that the Coalburn substation is in full operation.

4.1.3. Linmill 275/33kV Substation Refurbishment

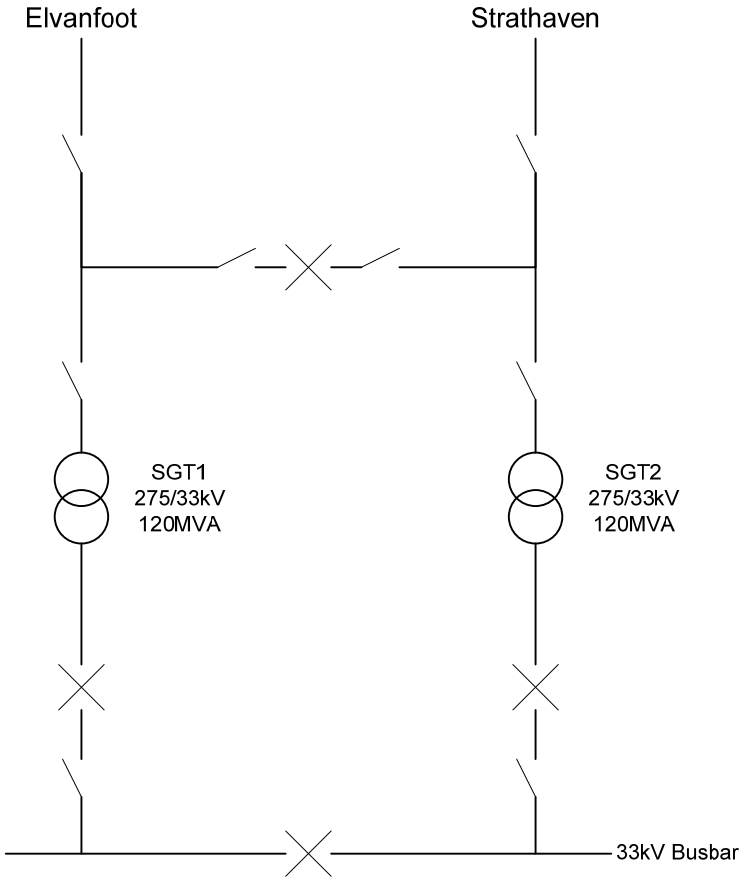
Linmill was originally a 275/33kV single switch substation fed by the 275kV network from Strathaven and Elvanfoot circuits. The substation included a 33kV single busbar switchyard fed by

two 120MVA, 275/33kV transformers. The substation was converted to 132/33kV operation and supplied by two 132kV transformer feeder circuits from Coalburn.

4.1.3.1. Re-configuration of Substation

Prior to construction of the west coast interconnection upgrade, the substation comprised two 275kV incoming circuits from Strathaven and Elvanfoot which were connected in a single switch mesh arrangement. A simplified single line diagram of this arrangement is shown in figure 4.18 below.

Figure 4.18 – Single Line Diagram of Linmill Substation (pre-upgrade)



To accommodate the requirements of the west coast interconnection upgrade the configuration of Linmill substation required modification. The scope of modifications included:

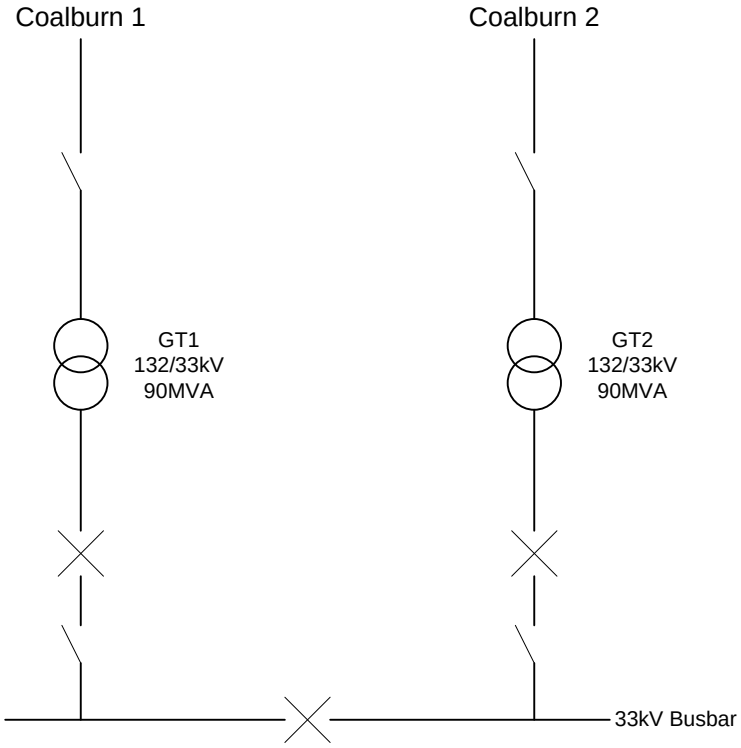
i) Dismantling of all 275kV switchgear and connections associated with the single switch mesh arrangement.

ii) Construction of two new 132kV transformer feeder circuit bays to facilitate connection of the existing overhead line circuits. The incoming overhead line circuits would become the new 132kV feeders from Coalburn.

iii) Replacement of the two existing 275/33kV, 120MVA transformers with 132/33kV, 90MVA transformers, including associated circuit connections into the existing 33kV switchyard.

A simplified single line diagram of the new arrangement is shown in figure 4.19 below.

Figure 4.19 – Single Line Diagram of Linmill Substation (post-upgrade)



4.1.3.2. Substation Construction

The new 132kV switchyard required significant civil works for modification of equipment foundations and structures for the new plant and modification to trenches/ducts where necessary to accommodate new control wiring. The existing substation control buildings were utilised to accommodate new protection and control for the new 132kV circuits.

The design of the new 132kV transformer feeder circuit bays is based upon conventional air insulated switchgear construction. The circuits generally utilise switchgear equipment which includes:

- 132kV Open terminal rotating centre post disconnectors with integral earth switches
- 132kV Capacitor voltage transformers
- 132kV Surge arresters

The two 132kV switchgear circuits terminate directly via the existing overhead line connections. The double circuit terminal tower is located on the eastern side of the substation outside of the boundary fence.

Figure 4.20 below shows a view of the substation.

Figure 4.20 – View of Linmill Substation

4.1.3.3. Construction Verification

A site visit has not been undertaken by SKM. In lieu of a site visit photographic evidence was presented by SPTL to illustrate completion of construction of the new 132kV transformer feeder circuits. Figures 4.21 and 4.22 present parts of the new 132kV circuits.

Figure 4.21 – Coalburn 1 Circuit

Figure 4.22 – Coalburn 2 Circuit

Evidence of “Completion Certificates” was also presented by SPTL to confirm that construction and testing of the circuits was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots taken of SCADA outputs from Coalburn substation (see section 4.1.2.4) showed that the 132kV transformer feeder circuits to Linmill were operational with a total power flow of 8.3MW.

SKM were satisfied that the information presented was sufficient to confirm that the reconfigured Linmill 132kV substation is in full operation.

4.1.4. New 400/275/25kV Substation at Elvanfoot

4.1.4.1. Configuration

Elvanfoot is a new 400/275/25kV substation which comprises 400kV and 275kV switchyards within the boundary fence. The 400kV switchyard also incorporates transformer circuit

connections to 25kV feeders. The 275kV switchyard was constructed after completion and setting into service of the substation and is outside of the scope of the TIRG works.

The configuration of the 400kV switchyard is of the double busbar type and comprises main and reserve busbars. Each circuit is capable of being selected for connection via busbar disconnectors to either busbar. In the event of a fault to the main or reserve busbar each circuit can be transferred to the other busbar with minimal disruption to supply.

The 400kV switchyard also includes a busbar coupler circuit breaker between the main and reserve busbars to allow on-load transfer between the busbars; this provides operational flexibility and reduces outage risks when maintenance is required on a particular busbar section.

The 400kV switchyard has two, 80MVA, 400/26.5kV SGT transformer circuits, namely SGT1B and SGT2B, which facilitate connection to the nearby Network Rail Elvanfoot trackside substation. Two, 500MVA, 400/275kV SGT transformer circuits, namely SGT1A and SGT2A are also connected to these circuits via a tee connection on the circuit side of the 400kV circuit breaker. These transformer circuits facilitate connection to a local wind farm and do not form part of the TIRG works. In the event of a fault on either of the SGT1A or SGT2A circuits the supply to the respective SGT1B or SGT2B transformer circuits supplying the Network Rail connection would be interrupted. However, each Network Rail circuit can be isolated from the respective wind farm circuit, as each circuit has its own disconnector located downstream of the tee connection, allowing the Network Rail circuit to be quickly returned to service after isolation of the wind farm circuit.

Prior to the construction of the substation there was a double circuit overhead line passing through the area which carried the 400kV Strathaven – Harker circuit and the 275kV Linmill – Elvanfoot and Elvanfoot – Gretna circuits. The 275kV Elvanfoot substation has now been removed and the open ends of the Elvanfoot overhead line circuits diverted into the Elvanfoot 400kV busbar. The 400kV Strathaven – Harker circuit has been split and diverted into the Elvanfoot 400kV busbar. Taking into consideration the circuit diversions described for Coalburn substation the resulting 400kV circuits are:

i) Strathaven – Elvanfoot

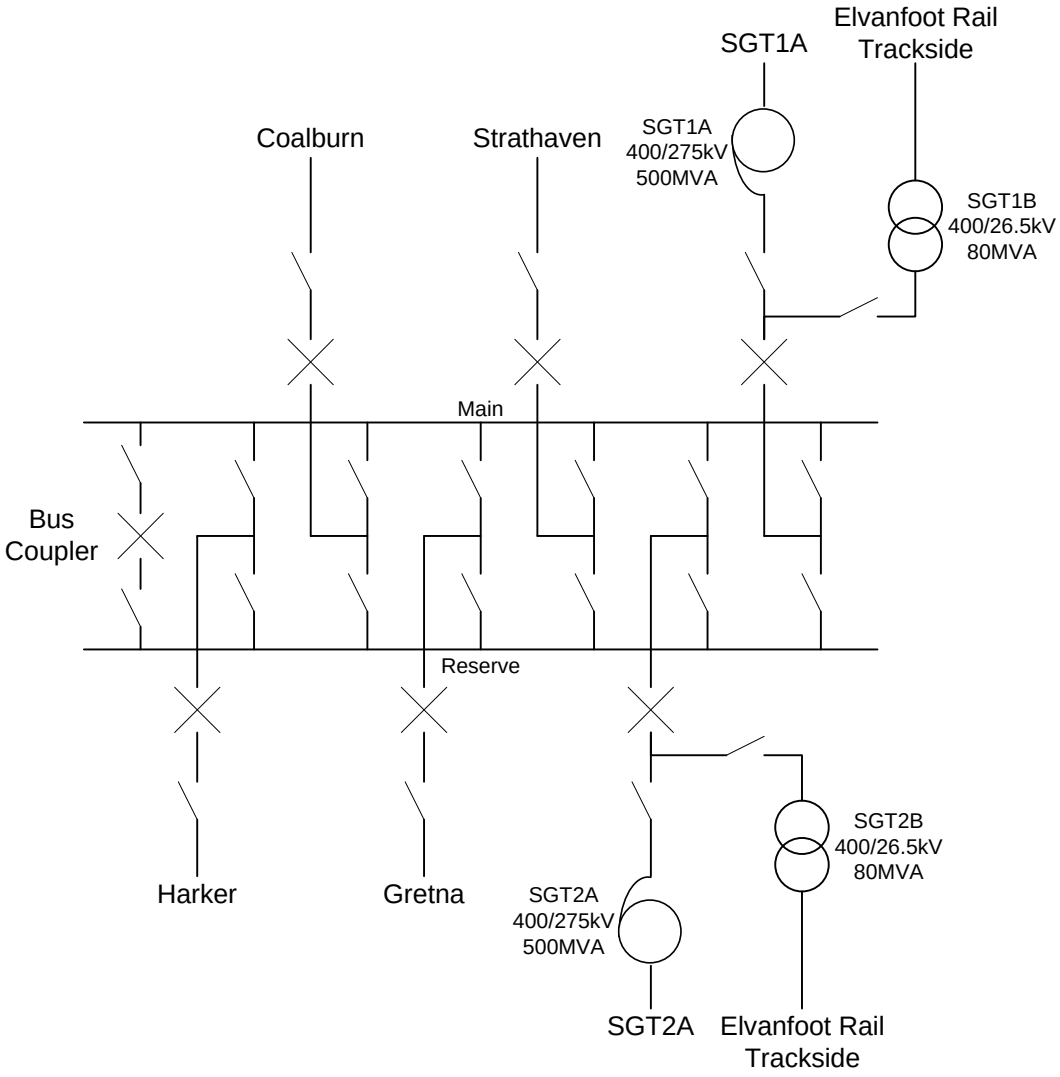
ii) Coalburn – Elvanfoot

iii) Elvanfoot – Gretna

iv) Elvanfoot – Harker

The basic single line diagram of the 400kV switchyard is shown in figure 4.23.

Figure 4.23 – Elvanfoot 400kV Single Line Diagram



4.1.4.2. Location, Layout and Construction

The substation site is located approximately 1km west of the village of Elvanfoot. Figure 4.24 below shows a geographical representation of the location.

Figure 4.24 – Elvanfoot Substation Site

The substation is built on a single level platform and required significant civil works to establish and the access road and an approximate 65,000m^2 platform. The substation has a single storey control building which accommodates protection and control for the 400kV and 275kV switchyards (including the 25kV connections), LVAC switchgear, batteries and telecoms as well as a workshop, mess rooms and wash room facilities.

The size of the substation is approximately 40,000 m^2 and it is surrounded by a palisade security fence 2.74m high.

The substation comprises the following 400kV circuits:

400kV circuits

- Feeder circuit, Coalburn
- Feeder circuit, Strathaven
- Feeder circuit, Harker
- Feeder circuit, Gretna
- Supergrid transformer circuit, SGT No.1A/1B

- Supergrid transformer circuit, SGT No.2A/2B
- Bus coupler

The design of the 400kV switchyard is based upon conventional air insulated switchgear construction. The layout comprises a two level construction with the main and reserve busbars at high level and the circuit connections at low level. The busbars run in parallel on a west-east plane and the circuit connections run in a north-south plane.

The circuits generally utilise switchgear equipment which includes:

400kV circuits

- 400kV Open terminal circuit breakers
- 400kV Open terminal pantograph and rotating centre post disconnectors with integral earth switches
- 400kV Open terminal earth switches
- 400kV Capacitor voltage transformers
- 400kV Current transformers
- 400kV Surge arresters

25kV circuits

- 25kV Dead tank circuit breaker with integral CT's
- 25kV Open terminal rotating centre post disconnectors with integral earth switches
- 25kV Voltage transformers
- 25kV Current transformers
- 25kV Surge arresters
- 25kV Cable sealing ends

The equipment located within the 275kV switchyard, which supplies the aforementioned local wind farm, is not listed here as these circuits do not form part of the scope of the TIRG project.

The Strathaven and Coalburn circuits terminate onto a substation circuit entry directly via an overhead line connection. The double circuit terminal tower is located at the north side of the substation outside of the boundary fence. The Harker and Gretna circuits also terminate onto a substation circuit entry directly via an overhead line connection; the double circuit terminal tower being located at the south side of the substation outside of the boundary fence.

The substation has been designed on the basis that maintenance, extension and repairs can be carried out with a maximum of only one circuit and one busbar section out of service simultaneously. The exception to this is the aforementioned SGT circuits where a fault on either of the SGT1A or SGT2A circuits would interrupt the supply to the respective SGT1B or SGT2B transformer circuits supplying the Network Rail connection. Clearances for maintenance access have been designed to allow for mobile access platforms, scaffolding, cranes etc.

The 400kV switchyard incorporates space for a future mechanically switched capacitor damping network (MSCDN) circuit. At the time of the substation visit the MSCDN was under construction.

Figure 4.25 below shows a view of the 400kV switchyard.

Figure 4.25 – View of 400kV Switchyard (main & reserve busbars)

4.1.4.3. Overhead Line Reconfiguration

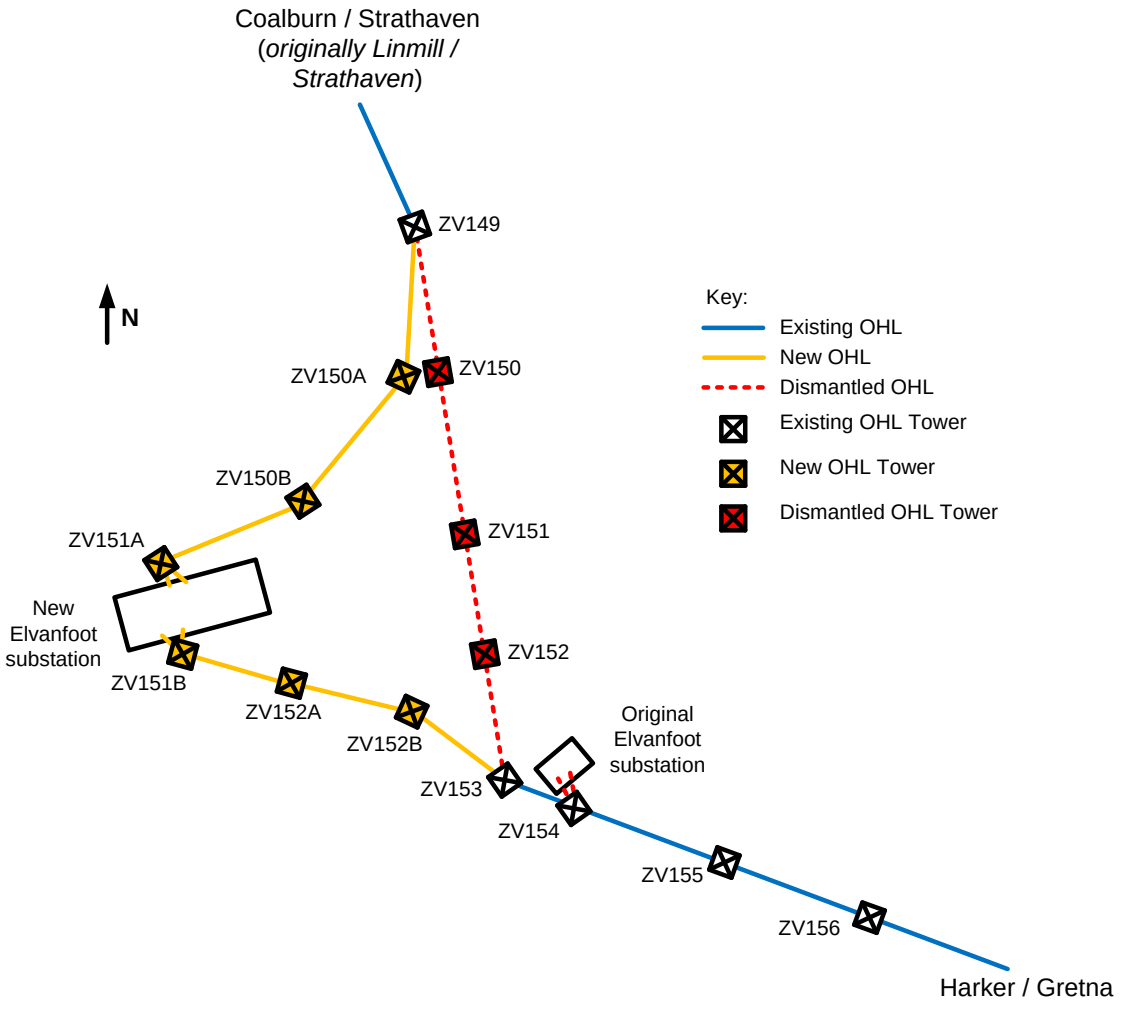
The double circuit overhead line route carrying the Linmill – Elvanfoot (275kV), Elvanfoot – Gretna (275kV) and Strathaven – Harker (400kV) circuits that ran adjacent to the site prior to construction have now been reconfigured.

To accommodate diversion of the circuits into Elvanfoot, towers ZV150 through ZV152 were dismantled and the route diverted via new towers ZV150A, ZV150B, ZV151A, ZV151B, ZV152A and ZV152B. Furthermore, the Linmill and Gretna circuit connections into the original 275kV Elvanfoot substation were removed from tower ZV154 and the circuit ends joined at this tower to provide connection between Gretna and Elvanfoot.

At towers ZV151A and B, located adjacent to the substation boundary fence at the northern and southern ends respectively, the double circuit is split and each circuit end terminated into the 400kV busbar.

An overview of the overhead line reconfiguration is shown in figure 4.26.

Figure 4.26 – Overview of Overhead Line Reconfiguration



4.1.4.4. Construction Verification

SKM undertook a site visit to Elvanfoot substation on 02 August 2012 with a view to gathering evidence to confirm completion of construction and that the substation is fully operational.

Photographic evidence was gathered to illustrate completion of construction. Figures 4.27 through 4.30 present various parts of the substation.

Figure 4.27 – Incoming Coalburn Line Termination

Figure 4.28 – 400kV Bus Coupler Circuit Breaker & CT's

Figure 4.29 – SGT1B 400/26.5kV Transformer

Figure 4.30 – 25kV Feeder Circuit (National Rail)

Evidence of “Completion Certificates” was also presented by SPTL to confirm that construction and testing of each circuit was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots were taken of SCADA outputs which showed that the 400kV switchyard was configured with all feeder circuits and the bus coupler circuit closed.

Power flows were observed through all circuits and recorded at 63.1MW (Coalburn); 10.2MW (Strathaven); 38.3MW (Harker), 32.1MW (Gretna), 4.3MW (SGT1A) and 0.9MW (SGT2A). The power contribution on the SGT circuits was attributed to power import from the local wind farm connection as the power recorded to the National Rail connection was recorded at zero.

SKM were satisfied that the information presented was sufficient to confirm that the Elvanfoot substation is in full operation.

4.1.5. Upgrade of Gretna 275/132kV Substation

4.1.5.1. Configuration

Gretna was originally commissioned in October 2003 as a 275/132kVsubstation incorporating 275kV and 132kV switchyards within the boundary fence. To facilitate future upgrade to 400kV operation the busbars and busbar disconnectors were built to 400kV specifications. The remaining 275kV switchgear of the incoming / outgoing feeder and transformer circuits has therefore been replaced with 400kV switchgear to upgrade the 275kV switchyard to a 400kV rating. The existing 275/132kV transformers have also been replaced with new 400/132kV, 240MVA transformers located in the existing noise enclosures that housed the original transformers. No work has been undertaken on the 132kV switchyard as part of the TIRG works, excepting any minor works required to facilitate connection of the 132kV switchyard onto the new transformers.

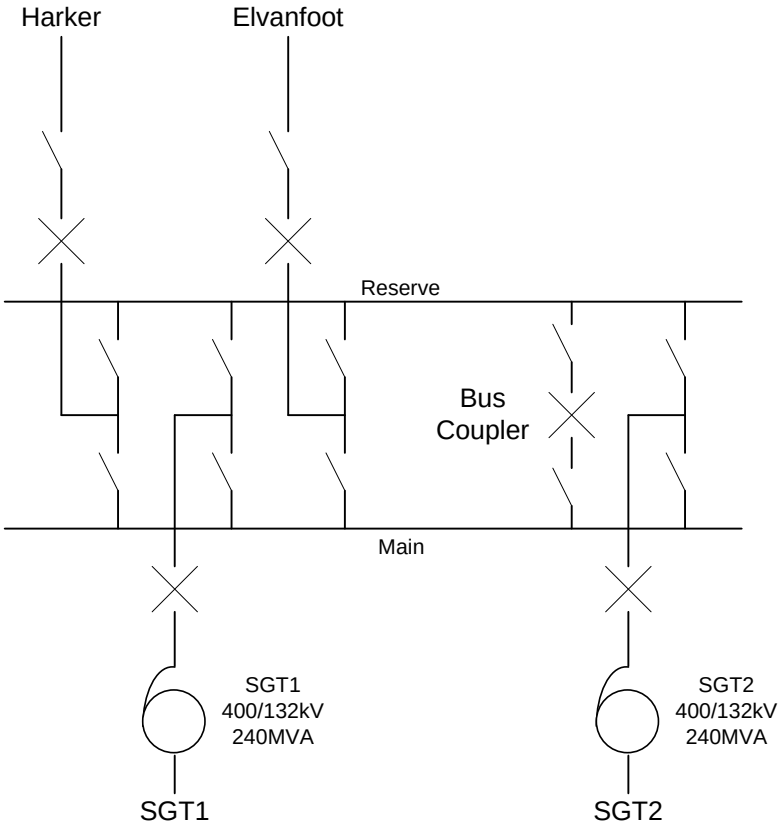
The configuration of the 400kV switchyard is also of the double busbar type and comprises main and reserve busbars. Each circuit is capable of being selected for connection via busbar disconnectors to either busbar. In the event of a fault to the main or reserve busbar each circuit can be transferred to the other busbar with minimal disruption to supply.

The 400kV switchyard also includes a busbar coupler circuit breaker between the main and reserve busbars to allow on-load transfer between the busbars; this provides operational flexibility and reduces outage risks when maintenance is required on a particular busbar section.

The 400kV switchyard has two, 240MVA, 400/132kV SGT transformer circuits, namely SGT1 and SGT2, which facilitate connection to the 132kV switchyard.

The basic single line diagram of the 400kV switchyard is shown in figure 4.31.

Figure 4.31 – Gretna 400kV Single Line Diagram



4.1.5.2. Location, Layout and Construction

The substation site is located approximately 4km north east of Gretna. Figure 4.32 below shows a geographical representation of the location.

Figure 4.32 – Gretna Substation Site

The 400kV switchyard required significant civil works for replacement of equipment foundations and structures for the plant and modification to trenches / ducts where necessary to accommodate new control wiring. The existing substation single storey control building was utilised to accommodate new protection and control for the 400kV switchyard in replacement of the existing 275kV protection and control equipment.

The substation comprises the following 400kV circuits:

400kV circuits

- Feeder circuit, Harker
- Feeder circuit, Elvanfoot
- Supergrid transformer circuit, SGT No.1
- Supergrid transformer circuit, SGT No.2
- Bus coupler

The design of the 400kV switchyard is based upon conventional air insulated switchgear construction. The layout comprises a two level construction with the main and reserve busbars at high level and the circuit connections at low level. The busbars run in parallel on a north west-south east plane and the circuit connections run in a north east-south west plane.

The circuits generally utilise switchgear equipment which includes:

400kV circuits

- 400kV Open terminal circuit breakers
- 400kV Open terminal pantograph and rotating centre post disconnectors with integral earth switches
- 400kV Open terminal earth switches
- 400kV Capacitor voltage transformers
- 400kV Current transformers
- 400kV Surge arresters

The Harker and Elvanfoot circuits terminate onto a substation circuit entry directly via an overhead line connection. The double circuit terminal tower is located at the west side of the substation outside of the boundary fence.

The 400kV switchyard has been designed on the basis that maintenance, extension and repairs can be carried out with a maximum of only one circuit and one busbar section out of service simultaneously. Clearances for maintenance access have been designed to allow for mobile access platforms, scaffolding, cranes etc.

Figure 4.33 below shows a view of the 400kV switchyard.

Figure 4.33 – View of 400kV Switchyard (main & reserve busbars)

4.1.5.3. Construction Verification

SKM undertook a site visit to Gretna substation on 02 August 2012 with a view to gathering evidence to confirm completion of construction and that the substation is fully operational.

Photographic evidence was gathered to illustrate completion of construction. Figures 4.34 through 4.36 present various parts of the substation.

Figure 4.34 – Incoming 400kV Elvanfoot Line Termination

Figure 4.35 – 400kV Bus Coupler Circuit Breaker & CT's

Figure 4.36 – SGT2 400/132kV Transformer

Evidence of “Completion Certificates” was also presented by SPTL to confirm that construction and testing of each circuit was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots were taken of SCADA outputs which showed that the 400kV switchyard was configured with all feeder circuits and the bus coupler circuit closed.

Power flows were observed through all circuits and recorded at 77.7MW (Harker), 38.9MW (Elvanfoot), 14.6MW (SGT1) and 13.8MW (SGT2).

SKM were satisfied that the information presented was sufficient to confirm that the Gretna 400kV switchyard is in full operation.

4.2. East Coast Interconnection

Development work on the proposed east coast interconnection commenced in 2006. The scheme was intended to increase the capacity of the east coast interconnection with England by upgrading of the existing 400kV double circuit between Eccles and the NG owned Stella West substations. The scheme encompassed works on both the SPTL network and the NG network.

The Eccles – Stella West double circuit overhead line spans a route length of approximately 102km of which 7km is owned by SPTL. As the route was predominantly owned by NG the works for the entire 102km route were undertaken by NG under a single contract. Operational control of the 7km section of line owned by SPTL was transferred to NG for the duration of the works. Construction and project management of the works was undertaken by NG for the duration of the project.

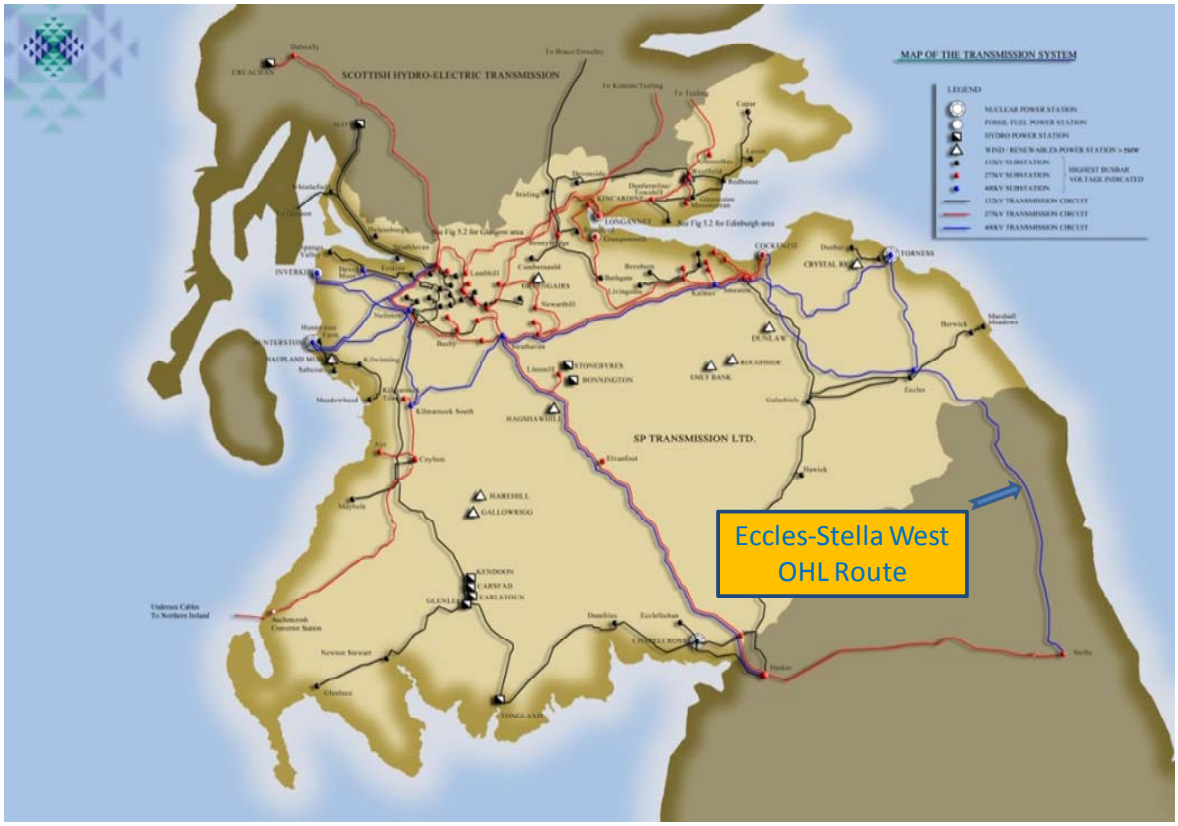
SPTL works comprised the reconfiguration of the 132kV network into Hawick substation to mitigate overloading of the 132kV network under double (N-D) circuit contingencies of the east coast interconnection.

Both NG and SPTL have now completed the proposed works on their respective networks with the scheme being commissioned and put into full service during 2009 / 2010.

4.2.1. Eccles – Stella West 400kV Overhead Line Upgrading

The existing twin Zebra (2 x 400mm^2 ACSR) conductor system on the Eccles – Stella West double circuit overhead line has now been replaced with a triple Araucaria (3 x 700mm^2 AAAC) conductor system on the entire 102km route. The route location is shown in figure 4.37 below.

Figure 4.37 – Overview of Eccles – Stella West Double Circuit Overhead Line Route



A site inspection of the refurbished conductor system has not been undertaken by SKM. In lieu of a site inspection photographic evidence was presented by SPTL to illustrate construction of the new 400kV circuit conductors. Figure 4.38 shows part of the overhead line during the re-conductoring works.

Figure 4.38 – Re-conductoring of 400kV Eccles – Stella West Overhead Line Circuits

Evidence of NG "System Change Certificates" was presented by SPTL to confirm that construction of the upgraded circuits was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots taken of SCADA outputs from Eccles substation showed that the 400kV circuits were operational with a power flow recorded on the Stella West No.1 circuit of 1MW and on the Stella West No.2 circuit of 2MW.

SKM were satisfied that the information presented was sufficient to confirm that the upgraded 400kV Eccles – Stella West circuits are in full operation.

4.2.2. Hawick 132/33kV Substation Refurbishment

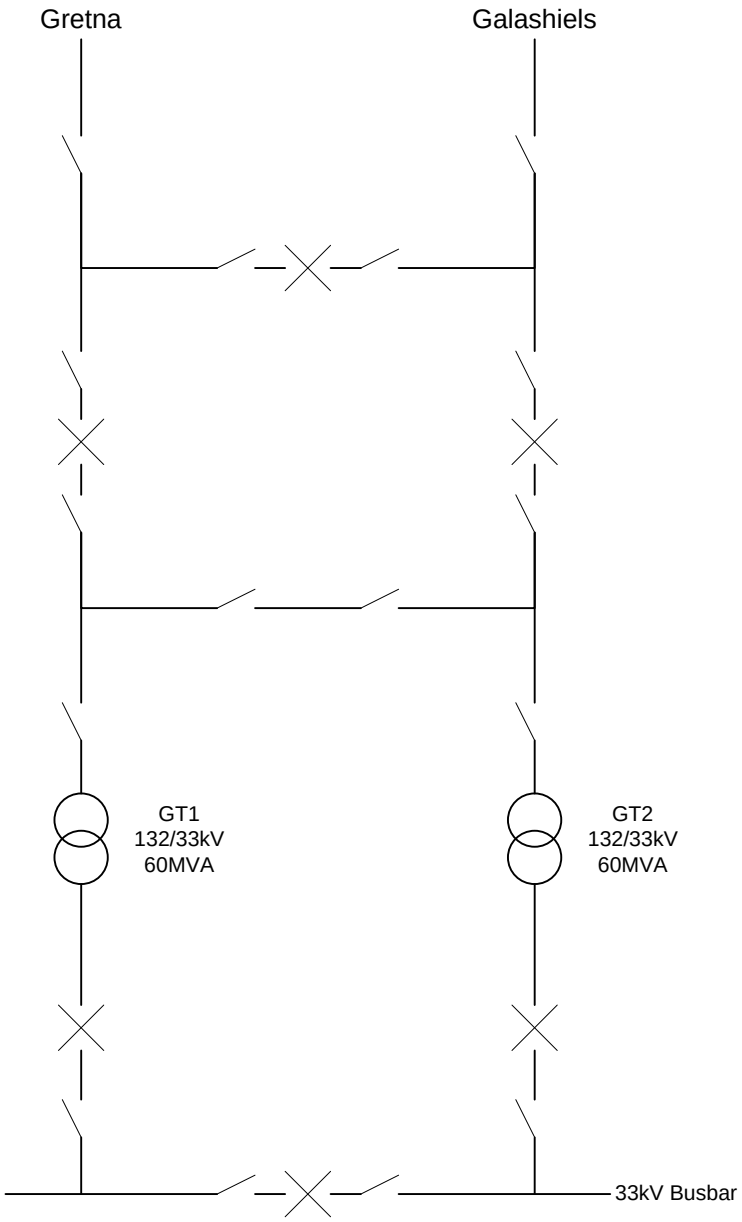
Hawick was originally a 132/33kV three switch substation fed by the 132kV network from Gretna and Galashiels. The 132kV network has been reconfigured such that Hawick is now fed by circuits from Gretna and Gretna – Harker. The original circuit from Galashiels has been reconfigured to

provide alternative supply arrangements for emergency contingencies. The 132kV switchgear has been replaced but the existing 132/33kV transformers and 33kV switchgear has been retained.

4.2.2.1. Re-configuration of Substation

Prior to construction of the east coast interconnection upgrade, the substation comprised two 132kV incoming circuits from Gretna and Galashiels which were connected in a three switch mesh arrangement. A simplified single line diagram of this arrangement is shown in figure 4.39 below.

Figure 4.39 – Single Line Diagram of Hawick 132/33kV Substation (pre-upgrade)



To accommodate the requirements of the east coast interconnection upgrade the configuration of Hawick substation required modification. The scope of modifications included:

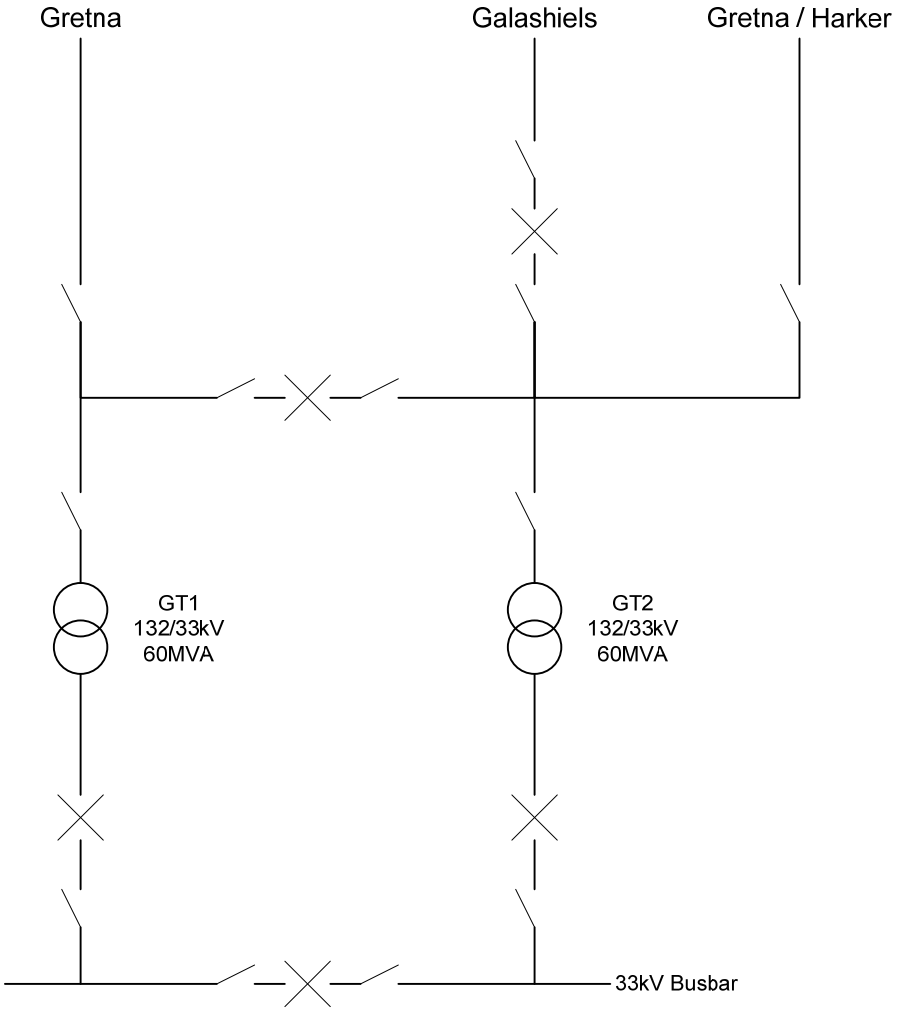
iv) Replacement of all 132kV switchgear to convert the original three switch mesh into a two switch mesh.

v) Splitting of the 132kV overhead line circuit between Gretna – Harker – Galashiels and diversion of the Gretna – Harker circuit into Hawick; including a parallel connection of the Galashiels circuit with the existing Galashiels – Hawick circuit.

vi) Provision of additional 132kV switchgear to connect the diverted Gretna – Harker circuit into the new two switch mesh.

A simplified single line diagram of the new arrangement is shown in figure 4.40 below.

Figure 4.40 – Single Line Diagram of Hawick 132/33kV Substation (post-upgrade)



4.2.2.2. Construction

The 132kV switchyard required significant civil works for modification of equipment foundations and structures for the new / reconfigured plant and modification to trenches/ducts where necessary to accommodate new control wiring. The existing substation control buildings were utilised to accommodate new / modified protection and control for the 132kV circuits.

The design of the new 132kV circuit bays is based upon conventional air insulated switchgear construction. The circuits generally utilise switchgear equipment which includes:

- 132kV Open terminal dead tank circuit breakers with integral current transformers
- 132kV Open terminal rotating centre post disconnectors with integral earth switches
- 132kV Open terminal earth switches
- 132kV Current transformers
- 132kV Capacitor voltage transformers
- 132kV Surge arresters
- 132kV Cable sealing ends

The Gretna and Galashiels 132kV circuits terminate directly via the existing overhead line connections. The double circuit terminal tower is located on the northern side of the substation outside of the boundary fence. The Gretna – Harker 132kV circuit terminates, via a short cable length, onto a new wooden terminal pole.

4.2.2.3. Overhead Line Reconfiguration

The 132kV double circuit overhead line route carrying the Gretna – Harker – Galashiels, Gretna – Hawick and Galashiels – Hawick circuits that ran close to the site prior to the proposed works have now been reconfigured.

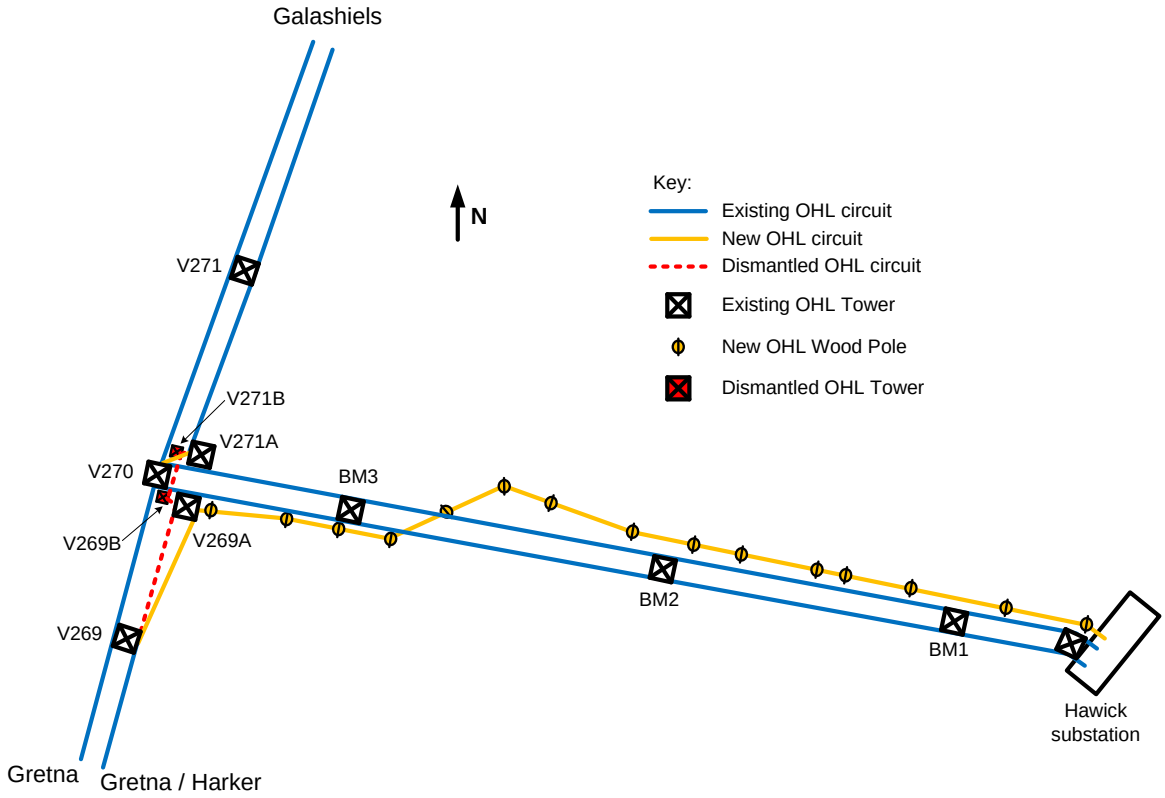
The Gretna – Harker – Galashiels circuit has been split by dismantling of the conductors between towers V269, V269A, V269B, V271A and V271B. Towers V269B and V271B have also been dismantled. The Gretna – Harker circuit end at tower V269 has been diverted into Hawick to create a new Gretna – Harker – Hawick circuit. This is facilitated by a new connection between towers V269 and V269A and the construction of a new 132kV single circuit wood pole overhead line between tower V269A and Hawick substation.

Furthermore, the two circuits fed from Galashiels; the original Hawick and Gretna – Harker circuits; have been connected in parallel between the Galashiels substation and tower V270 to form one Hawick feeder circuit. This is facilitated by the provision of shorting connections at tower V359 (within the boundary of Galashiels substation) and tower V270, which then feeds into

Hawick via the original overhead line circuit between tower V270 and Hawick. At Galashiels substation the mesh corner switchgear which originally fed the Hawick circuit has been removed and the original Gretna – Harker mesh corner switchgear has been renamed to Hawick.

An overview of the overhead line reconfiguration is shown in figure 4.42.

Figure 4.42 – Overview of Overhead Line Reconfiguration



4.2.2.4. Construction Verification

A site visit has not been undertaken by SKM. In lieu of a site visit, evidence of "Disconnection and Commissioning Certificates" was presented by SPTL to confirm that construction and testing of the circuits was complete, fit for purpose and available for energisation.

Operational evidence was gathered in the form of recorded data taken from the SCADA system. Screenshots taken of SCADA outputs from Hawick substation showed that the 132kV circuits were operational with power flows recorded on the Galashiels circuit of 22MW, on the Gretna/Harker circuit of 4MW and on the Gretna circuit of 2MW.

SKM were satisfied that the information presented was sufficient to confirm that the reconfigured Hawick 132kV substation is in full operation.

5. Output Measures

The extent to which the England – Scotland Interconnection scheme complies with the TIRG output measures is described below for both the west and east coast interconnections.

5.1. West Coast Interconnection

The output measures specified in Schedule C of the TIRG licence for the west coast interconnection scheme both prior to and post construction are given in table 5.1 below.

Table 5.1 – West Coast Interconnection Output Measures

Project scope	**Capability as at 31 March 2005**			**Forecast capability prior to construction start date**			**Forecast capability post construction**		
Line upgrade	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)
Strathaven - Coalburn	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Coalburn - Elvanfoot	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Elvanfoot - Harker	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Strathaven - Gretna	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Gretna - Harker	Circuit does not presently exist			Circuit does not presently exist			400	2010	1750
Coalburn 400/132 'SGT1'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240

Project scope	Capability as at 31 March 2005			Forecast capability prior to construction start date			Forecast capability post construction		
Coalburn 400/132 'SGT2'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240
Elvanfoot 400/25 'SGT1'	Circuit does not presently exist			Circuit does not presently exist			400/25	80	80
Elvanfoot 400/25 'SGT2'	Circuit does not presently exist			Circuit does not presently exist			400/25	80	80
Gretna 400/132 'SGT1'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240
Gretna 400/132 'SGT2'	Circuit does not presently exist			Circuit does not presently exist			400/132	240	240

The scheme has been constructed in accordance with the design established in 2006. The west coast interconnection has been reconfigured to provide the circuits listed in table 5.1 above. Note however, that the Strathaven – Gretna circuit has been split at Elvanfoot to create two new circuits; namely Strathaven – Elvanfoot and Elvanfoot – Gretna. These works did not form part of the TIRG scheme but were scheduled in the same time period as the TIRG works to minimise outages on the network. The output measures of the two new circuits were confirmed to remain the same as the original Strathaven – Gretna circuit.

The overhead line works did not entail any replacement of the existing circuit conductors with the increased capacities being achieved by upgrading of the operating voltage from the original 275kV to 400kV. The post construction forecast capability of the circuits listed in table 5.1; other than the 'SGT' circuits; were established based on the maximum ratings achievable with the existing overhead line twin Rubus (2 x 500mm^2 AAAC) conductor system. The circuit capabilities have been verified via review of equipment rating schedules supplied by STPL to the system operator, NG. The post-fault continuous overhead line circuit ratings are confirmed to have been established in accordance with NG Technical Guidance Note TGN(E) 26, Table B3.

The post construction forecast capability of the 'SGT' transformer circuits listed in table 5.1 were established based on the rated power of the new / replacement transformers. The transformer ratings have been verified by collection of nameplate data during site visits to Coalburn, Elvanfoot and Gretna substations.

The configuration, implementation and operation of the reconfigured network has been verified via the photographic and operational data gathered at meetings and during the site visits described in section 4.1.

Based on the data gathered and technical review outlined in section 4.1, SKM concludes that the forecast output measures are confirmed to have been fully delivered by the west coast interconnection scheme.

5.2. East Coast Interconnection

The output measures specified in Schedule C of the TIRG licence for the east coast interconnection scheme both prior to and post construction are given in table 5.2 below.

Table 5.2 – East Coast Interconnection Output Measures

Project scope	**Capability as at 31 March 2005**			**Forecast capability prior to construction start date**			**Forecast capability post construction**		
Line upgrade	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)	Circuit voltage (kV)	Winter rating (MVA)	Summer rating (MVA)
Eccles - Stella West No.1	400	1390	1110	400	1390	1110	400	2770	2420
Eccles - Stella West No.2	400	1190	1110	400	1190	1110	400	2770	2420
Gretna - Hawick	132	132	106	132	132	106	132	132	106
Gretna - Junction V - Hawick	Circuit does not presently exist			Circuit does not presently exist			132	132	106
Hawick - Galashiels	132	132	106	132	132	106	132	132	106

The scheme has been constructed in accordance with the design established in 2006. The 400kV Eccles – Stella West double circuit overhead line has been upgraded and the 132kV network reconfigured around the Hawick substation to provide the circuits listed in table 5.2 above.

Prior to the proposed works the limiting factor in achieving the maximum capacity of the 400kV Eccles – Stella West circuits was the rating of the existing twin Zebra (2 x 400mm^2 ACSR) conductor system. The 400kV Eccles – Stella West overhead line has now been upgraded via replacement of the existing conductor system with a triple Araucaria (3 x 700mm^2 AAAC) conductor system. The upgraded conductor system provides ratings of 4210MVA (Winter), 4050MVA (Spring / Autumn) and 3760 (Summer). These post-fault continuous overhead line circuit ratings are not yet provided in NG Technical Guidance Note TGN(E) 26; however, SPTL confirmed that the ratings have been established by NG in accordance with the underlying principles of the document and will be added to the tables of TGN(E) 26 in the near future.

In view of the increased overhead line ratings provided by the upgraded Eccles – Stella West conductor system, the post construction forecast capability of the 400kV Eccles – Stella West circuits were established based on the maximum ratings achievable with the existing 400kV switchgear at Eccles substation. The circuit capabilities have been verified via review of equipment rating schedules supplied by STPL to the system operator, NG and confirmed to be 2770MVA (Winter and Spring / Autumn) and 2660MVA (Summer) based on circuit breaker and disconnector ratings respectively.

The post construction forecast capability of the 132kV Gretna – Hawick and Hawick – Galashiels circuits listed in table 5.2 has not changed from those forecast prior to construction as they utilise the same overhead line circuits. The new Gretna – Junction V – Hawick circuit (described as Gretna – Harker – Hawick in section 4.2.2.1) was implemented by reconfiguration of the existing Gretna – Harker – Galashiels circuit thus the post construction forecast capability is identical to the existing rating of the Gretna – Harker – Galashiels circuit. The new circuit includes the construction of a short length (1.25km) of new wood pole overhead line; to connect the reconfigured circuit into Hawick; comprising a single Lynx (1 x 175mm^2 ACSR) conductor system rated at 132MVA (Winter) and 106MVA (Summer) which matches the rating of the existing Gretna – Harker – Galashiels circuit.

The configuration, implementation and operation of the reconfigured network has been verified via the photographic and operational data gathered as described in section 4.2.

Based on the data gathered and technical review outlined in section 4.2, SKM concludes that the forecast output measures are confirmed to have been fully delivered by the east coast interconnection scheme.

A construction completion certificate for the England – Scotland Interconnection scheme is provided in Appendix A.

Appendix A Construction Completion Certificate

TRANSMISSION INVESTMENTS FOR RENEWABLE GENERATION

CONSTRUCTION COMPLETION CERTIFICATE

Licensee: Scottish Power Transmission Limited (SPTL)……

Scheme: England – Scotland Interconnection……

It is hereby certified that the Licensee named above is considered to have completed all construction activities necessary to fulfil its obligations in terms of the output measures specified in Schedule C of the TIRG licence for the above named scheme. The construction activities were completed during the Licensee's 2010/2011 financial year.

Signature:  .....

Name: N Keeler .....

Date: 30/11/2012 .....

Designation: Senior Electrical Engineer .....