
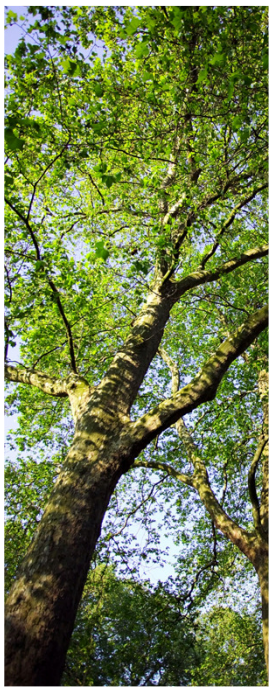


# Transmission Investment for Renewable Generation

Project Completion Report

June 2012

National Grid

Mott MacDonald

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# Content

# Executive Summary

Mott MacDonald has been appointed as independent auditor to review National Grid's implemented network reinforcement projects in line with the Transmission Investment for Renewable Generation (TIRG) output measures. The review has been undertaken as a desktop study based on documentation submitted by National Grid. This report presents the outcome of this review.

The review has only considered the National Grid Scotland-England Interconnector TIRG 'Baseline' projects.

The National Grid Scotland-England Interconnector TIRG projects contribute positively to the overall drivers of:

- Increasing thermal limits
- Increasing the stability limits and thus the transfer capability from 2.2GW to 2.8GW (through reduction of circuit impedance)
- Reducing transmission losses (through reduction of circuit impedance).

Through review of National Grid Scheme documentation, we are satisfied that all major works have been completed to deliver the TIRG Scotland-England Interconnetor project. We have confirmed that the scope of work of each individual investment related to these projects is in line with the overall requirements specified.

The review has identified that, under current conditions, the circuits addressed by the project all meet the thermal requirements defined by the agreed output measures with the exception of the Blyth to Heddon Tee branch of the East Coast circuits. It is envisaged that this non-compliance will be addressed following completion of Blyth 400kV substation as part of a customer connection project planned for completion in 2017.

Considering the impedance specified in the output measures, only one part of the project (the line from Stella West to Heddon Tee) has failed to comply with the requirements. There is a variance of 10% of the desired value which is due to an error in the original calculations and cannot reasonably be mitigated.

National Grid has argued that, if the overall impedance from Stella West to the SPT boundary of the Eccles circuits, and the overall combined impedance of the Stella West-Eccles-Blyth circuits are considered, then the impact on overall system performance is negligible. We consider this argument to be reasonable and that the required transfer levels of 2.8GW have been achieved following completion of the East and West Coast Interconnector works.

In view of the position outlined above, we consider it reasonable to accept that TIRG Scotland-England Interconnector project is complete and that no further works are planned (or could reasonably be proposed) to reduce the Stella West – Heddon Tee impedance further.

# 1. Introduction

## 1.1 Objective

The purpose of this Completion Report is to provide an independent review of National Grid's implemented network reinforcement projects in line with the "Transmission Investment for Renewable Generation (TIRG) Final Proposals" Report and Special Condition Modifications of the Transmission Licence obligations. The review has been limited to the Scotland – England interconnector works. This report is to assist Ofgem with its assessment of the investment against the pre-agreed output measures as at the end of the financial year 2010/11.

## 1.2 TIRG Background

Over the period 2000-2004, in response to incentives put in place by the UK Government, substantial volumes of renewable generation plant were planned and it become clear that investment was required to reinforce the transmission system, particularly in Scotland and the North of England. No allowance had been made for this investment when the transmission price controls were set in 1999 and 2000[1].

Consequently the TIRG mechanism was proposed with the objective of funding transmission projects which were assessed to be critical to connecting renewable generation. These were funded outside the normal price control mechanism so as to minimise connection delays. The TIRG consultation process began in October 2003 between Ofgem and the three licensed transmission owners (SHETL, SPT and NG). The transmission reinforcement proposals were published in the "TIRG Final Proposals", December 2004.

Table 1.1 and Figure 1.1 show a summary of the projects considered under "TIRG Final Proposals":

Table 1.1: Overview of Transmission Reinforcements Assessed under TIRG

| Reinforcement | TIRG Category* | Forecast Completion Data | Transmission Company |
|---|---|---|---|
| Beauly-Denny | Baseline | 2008 | SPT/SHETL |
| Sloy | Baseline | 2008 | SHETL |
| South West Scotland (Kendoon) | Baseline | 2009 | SPT |
| Scotland-England Interconnector | Baseline | 2010 | NG |
| North East Ring | Incremental | 2012 | NG |
| Heysham Ring | Additional | 2012 | NG |
| Beauly to Keith | Additional | 2012 | SHETL |
| Beauly to islands | Additional | - | SHETL |

Source: TIRG Final Proposals, December 2004

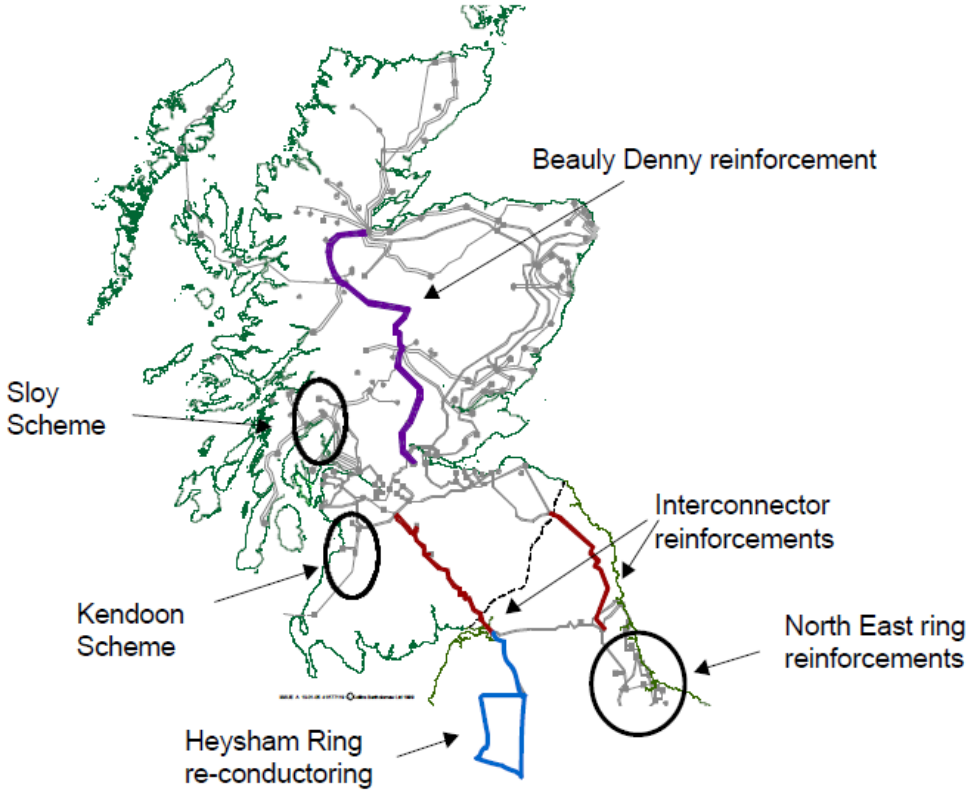
** TIRG category:*

- *'Baseline' – these were projects that appeared to be clearly justifiable in terms of savings;*
- *'Incremental' – these were projects where there was some uncertainty regarding the savings;*
- *'Additional' – these were projects where there was significant uncertainty in terms of savings and consequently high risk to GB consumers.*

[1] TIRG Final Proposals, December 2004

Reinforcement of National Grid's Scotland-England Interconnector was classified as 'Baseline' under TIRG; whereas the North Ring and the Heysham Ring projects were classified as 'Incremental' and 'Additional' works respectively. In the context of this review, only the 'Baseline' Scotland-England Interconnector has been assessed.

Figure 1.1: Overview of Transmission Reinforcements Assessed under TIRG




Source: National Grid/CIGRE, 2004 (http://www.cigre-uk.org/Technicalactivities_files/network_impact_renewables.pdf)

As part of Ofgem's "TIRG Final Proposals" Report, Ofgem undertook an assessment of the investment projects put forward by the transmission licensees to establish whether they could be justified in terms of reducing the cost of network constraints and transmission losses. The assessment was done to ensure that investment was carried out in a timely and efficient manner, which in turn should protect consumers from the costs of stranded assets and leading to charges for generators that are no higher than is necessary. The results of the "TIRG Final Proposals" Report have been the drivers behind the modifications on the TIRG Special Conditions of the Transmission Licence effective since December 2005.

As an incentive to invest appropriately within TIRG projects, output measures were set prior to construction outlining requirements in terms of deliverables in order to receive full allowances for returns and depreciation. These outputs have been used as key performance indicators on which this report is based.

The transmission system is designed and operated in accordance with the Transmission Licence. Standard Licence condition C17 requires National Grid to design and operate the transmission system in accordance with the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS).

## 1.3 Drivers for Transmission Reinforcements on the Scotland-England Interconnectors

As mentioned earlier, one of the overall drivers of TIRG was the reduction of cost of network constraints and transmission losses.

To meet the required operating standards, the interconnector circuits must have the post-fault capability to transfer all generation exports across the Scotland/England boundary following the loss of one of the double circuit overhead lines between Strathaven & Harker/Eccles & Stella West. With the pre-TIRG network arrangement this capacity was limited to 2.2GW due to stability limits, and was planned to increase to 2.8GW on the completion of the TIRG 'Baseline' project works.

The surplus generation available for export from Scotland exceeds this 2.2GW for most of the year, and as a result National Grid has been forced to limit power transfers from Scotland into England. National Grid must therefore 'constrain off' Scottish generators, i.e. pay them not to generate electricity and possibly also to pay other generators further South for replacement electricity. The implementation of this TIRG works will reduce these network constraint costs, which are ultimately absorbed by the customers.

As part of TIRG 'Incremental' projects, there is potential to maximise the export capability of these circuits from 2.8GW to 3.3GW by implementing further transmission reinforcements, such as the Spennymoor to Norton 400kV overhead line upgrade.

It is also important to note that the TIRG 'Baseline' projects will reduce the impedance of the Scotland-England Interconnector routes which, in addition to reducing transmission losses, will most importantly increase the stability limit across the boundary. Stability limits appear to impose a more restrictive constraint than thermal limits under current arrangements.

'Stability' relates to the behaviour / response of generators to changes occurring on the network to which they are connected and is a reflection of the electrical "strength" of system.

*Note: Following the TIRG enhancements, the existing 400kV circuits from Scotland will have sufficient thermal rating to achieve a transfer capacity of approximately 5GW. Studies in accordance with the NETS SQSS standard show that generators in Scotland would become unstable at higher levels of transfers to England, following faults or incidents on the system. To operate above the 2.8GW rating would lead to a high risk that generators would become unstable which could lead to generator tripping (automatic disconnection from the system), and possible damage, together with significant effects on security of supply for consumers[2].*

[2] National Grid, "Proposed Spennymoor to Norton 400kV Overhead Line, Environmental Statement", July 2009.

## 1.4 Documentation Submitted by National Grid

In order to allow us to follow the projects through from their inceptions through the delivery phases, National Grid has submitted the following documentation to be assessed as part of this desktop review:

Table 1.2: Documentation Submitted by National Grid

| Document Title | Revision | Date |
|---|---|---|
| **Investment 20564 – Blyth 400/275 Interbus Transformers** | | |
| Scheme Design Specification | 2 | 26/03/07 |
| Design Intent Document – Investment Proposal Stage 3 (DIDIP3) | A | 21/06/08 |
| Commission Report | - | 07/12/10 |
| Investment Proposal Stage 4 (IP4) | 1 | 01/03/11 |
| **Investment 15062 – Blyth – Stella West (YG) Route 400 kV Upgrade** | | |
| Scheme Design Specification | 4 | 11/12/08 |
| Design Intent Document – Investment Proposal Stage 3 (DIDIP3) | A | 31/03/08 |
| Commissioning Panel Meeting - Model Format and Documentation | - | March-April 2009 |
| Fixed Asset Confirmation Certificate (FACC) | - | 05/08/09 |
| **Investment 15063 - Uprate Stella West - Eccles 4ZY 400kV Route** | | |
| Scheme Design Specification | 2 | 26/04/07 |
| Design Intent Document – Investment Proposal Stage 3 (DIDIP3) by Electricity Alliance North | 7 | 22/09/10 |
| Design Intent Document – Investment Proposal Stage 3 (DIDIP3) by Electricity Alliance East | A | 16/09/07 |
| **Investment 15064 – Harker and ZV Route Uprating** | | |
| Asset Register Data / Technical Data Workbook | - | 16/06/11 |
| Harker Border Rating Schedule | | 22/09/10 |
| **Investment 20267B – Blyth 275kV 1st MSCDN** | | |
| Project Definition Document | 2 | November 2005 |
| **Investment 15069 – RETS Substation Development – Harker Border Rebuild & MSC** | | |
| Investment Design Specification | A | 12/05/06 |
| Design Status Report | C | 08/05/06 |
| Project Development Paper | 0 | 16/06/06 |
| Commissioning Panel Meeting | - | October 2009 |
| **General Documentation** | | |
| Transmission Investment for Renewable Generation - Post-construction technical report | - | 30/06/11 |
| Thermal Rating Schedules | | 2010/2011/2012 |
| NGET Licence | - | 07/10/08 |
| NG TIRG Technical Report Explanatory Notes | - | 13/06/12 |
| NG TIRG Combined Impedance Calculations | - | 28/06/12 |
| NG Transfer Capacity Evidence (Dec 11 – Mar 12) | - | 28/06/12 |

Source: National Grid

# 2. Key Performance Indicators

This report is assessing the technical performance of National Grid's implemented network reinforcement projects in line with the Special Conditions D3 of NGET Licence. This section presents Ofgem's proposed performance and output measures which are split into three stages.

## 2.1 Stages of Assessment of Output Measures

### 2.1.1 Stage 1

Assess the additional level of capacity to be delivered by each project based on the investment plans including:

- MVA capability for each line (for defined ambient temperature/season)
- Line resistance and
- Line reactance

### 2.1.2 Stage 2

The transmission licensees would notify Ofgem when commissioning each investment project and would provide a commissioning report explaining how each of the pre-agreed output measures had been satisfied.

### 2.1.3 Stage 3

In due course the transmission licensee would provide Ofgem with a new asset reliability report for each network investment covering the initial five years post commissioning, with information about how the line had performed (fault rate and unavailability including planned outages) and confirming that its capability had not suffered any derating.

## 2.2 Scotland-England Interconnector Output Measures

The Scotland-England interconnector involves reinforcing the transmission circuits in the west and east of Great Britain that link together the electricity transmission systems in Scotland and the north of England.

### 2.2.1 Scotland-England East Coast Interconnection

As stated in section 2.1.1, below is the summary of the east coast interconnector project requirements:

Table 2.1: East Coast Interconnector Transmission Line Impedances

| Scope of Work; Reduction in Line Impedance | Impedance as at 31st March 2005 | Forecast Impedance prior to Construction Start Date | Forecast Impedance post Construction |
|---|---|---|---|
| | % on 100 MVA | % on 100 MVA | % on 100 MVA |
| Line A | 0.833 | 0.833 | 0.721 |
| Line B | 0.070 | 0.070 | 0.059 |
| Line C | N/A | N/A | 1.128 |
| Combined Impedance | 1.349 | 1.349 | 1.045 |

Source: NG Transmission Licence Modifications

Where:

- Line A: Tee Point to Scottish Border (400 kV circuit);
- Line B: Tee Point to Stella West (400 kV circuit); and
- Line C: Tee Point to Blyth 275 kV (400 kV circuit and two 400/275 kV transformers).

The combined impedance is the reactance between the Scottish border and the 275 kV network in the north east of England; calculated by Line A in series with (B' paralleled with C) where B' is line B in series with the existing four 400/275 kV transformers at Stella West.

Table 2.2: East Coast Interconnector Transmission Line Circuit Ratings

| Scope of Work | Post Fault Continuous Circuit Ratings (31st March 2005) | | Forecast Post Fault Continuous Circuit Ratings Prior To Construction Start | | Forecast Post Fault Continuous Circuit Ratings Post Construction | |
|---|---|---|---|---|---|---|
| | Winter | Sumer | Winter | Summer | Winter | Summer |
| | (MVA) | (MVA) | (MVA) | (MVA) | (MVA) | (MVA) |
| Line A | 1390 | 1110 | 1390 | 1110 | 3070 | 2420 |
| Line B | 1390 | 1110 | 1390 | 1110 | 3070 | 2420 |
| Line C | 955 | 760 | 955 | 760 | 1390 | 1110 |

Source: NG Transmission Licence Modifications

For Line C the rating prior to construction is for 275 kV operation and post construction is at 400 kV.

### 2.2.2 *Scotland –England West Coast Interconnection*

Line upgrade from Scotland - England border to Harker substation.

Table 2.3: West Coast Interconnection Transmission Line Circuit Ratings

| Scope of Work | Capability as at 31st of March 2005 | | Forecast Circuit Ratings Post Construction | | Forecast Circuit Ratings Post Construction | |
|---|---|---|---|---|---|---|
| | | Post Fault Continuous | | Post Fault Continuous | | Post Fault Continuous |
| | kV | MVA | kV | MVA | kV | MVA |
| Line upgrade from Scotland - England border to Harker substation | 275 | 1130 | 275 | 1130 | 400 | 2010 |

Source: NG Transmission Licence Modifications

## 2.3 *Scotland-England Interconnector Reactive Compensation Output Measures*

Installation of a 150MVAr mechanically switched capacitor bank at a location to be chosen by National Grid so as to maximize its effectiveness given the reinforcements to be undertaken in Scotland.

## 2.4 *Over Delivery of Output Measures*

If a transmission licensee has delivered additional outputs that benefit network users then it will be for consideration as to whether it should earn higher returns (assuming it has spent less than the original cost projections) or whether an extra allowance should be made for these costs (if it has spent more than the original cost projections).

# 3. National Grid Investment Projects

In order to comply with the TIRG project requirements of the 'Baseline' Scotland-England Interconnector, National Grid has delivered a number of investment projects which were completed by 2010/2011 (see Table 3.1). This section describes the scope of works of each investment.

Information on the installed assets has been obtained from:

- Narratives from NG Investment Scheme documentation;
- Single line diagrams and layout drawings provided by NG;
- Published documentation (Seven Year Statement).

Table 3.1: TIRG Investments Raised by National Grid

| Investment No. | Investment Title | Delivery Organisation |
|---|---|---|
| **Scotland-England East Coast Interconnector** | | |
| 20564 | Blyth 400/275 Interbus Transformers | Electricity Alliance North (DDD) |
| 15062 | Blyth – Stella West (YG) Route 400 kV Upgrade | Electricity Alliance East (DDD) |
| 15063 | Uprate Stella West - Eccles 4ZY 400kV Route | Electricity Alliance North / Electricity Alliance East (DDD) |
| **Scotland-England West Coast Interconnection** | | |
| 15064 | Harker-Gretna (ZV) Route Uprating | |
| 15069 | Harker 400kV Substation Additional Bays | Electricity Alliance North (DDD) |
| **Scotland – England Interconnector Reactive Compensation** | | |
| 20267B | Blyth 275kV 2nd MSCDN | Electricity Alliance North (DDD) |

Source: National Grid, Documentation Submitted as Part of the Review

Table 3.2: Other Investments Raised by National Grid which Interact with TIRG 'Baseline' Projects

| Investment No. | Investment Title | Delivery Organisation |
|---|---|---|
| **Scotland-England East Coast Interconnector** | | |
| 15056 | Stella West New 400kV Substation | Electricity Alliance North / Electricity Alliance East (DDD) |
| 20605 | Blyth 400kV Substation | IP1 |
| **Scotland-England West Coast Interconnection** | | |
| N/A | N/A | N/A |
| **Scotland – England Interconnector Reactive Compensation** | | |
| 20267 | Blyth 275kV 1st MSCDN | Electricity Alliance North (DDD) |
| 20145 | Reactive - Harker - 1st | NG UK Legacy (IP4) |
| 20277 | Harker MSC | Electricity Alliance North (DDD) |

Source: National Grid

## *3.1 Scotland-England East Coast Interconnector*

Two new 400/275kV transformers have been installed at Blyth 275kV substation. A new double tee-point has been constructed to connect these transformers to the Stella West-Eccles 400kV double circuit using part of the existing Blyth-Stella West/Blyth-Fourstones 275kV double-circuit line (the YG route). The existing YG route (between the transformers and the Tee point) has been uprated to 400kV operation and re-strung with 2x570mm$^2$ AAAC aluminium alloy conductor (NG SYS planned works).

The Fourstones-Blyth 275kV circuit and Blyth-Stella West 275kV circuit have been reconfigured to form a new Stella West - Fourstones 275kV circuit. A section of the YG route to the west of the new Stella West-Eccles 400kV double tee point has been decommissioned and dismantled.

The Stella West-Eccles 400kV double-circuit route has been re-strung with 3x700mm$^2$ AAAC conductor.

Further details of the works are given by Investment Scheme in the sections that follow:

### *3.1.1 Investment 20564 – Blyth 400/275 Interbus Transformers*

Under this Investment Scheme, two new 400/275kV, 1100MVA SGT's (SGT5 & SGT6) have been installed at Blyth and connected directly to the Eccles - Stella West - Blyth 1 & 2 400kV circuits. The SGT5 & SGT6 LV terminals are terminated at the ex-Fourstones and ex-Stella West 2 bays at Blyth 275kV substation.

These works form part of a staged development of Blyth which will involve the construction of a new Blyth 400kV GIS substation and reconfiguring SGT5/SGT6 as interbus transformers. These additional works are outside the scope of Investment Scheme 20564.

### *3.1.2 Investment 15062 – Blyth – Heddon (YG) Route 400 kV Upgrade*

The scope of this Investment Scheme covered the following works which are directly related to the TIRG output measures:

- Creation of a new double tee connection from the Stella West – Eccles circuits at Heddon (the point where the 4ZY route crosses the YG route);
- Reinsulating the YG route between Blyth substation & the Stella West – Eccles circuit crossing at Heddon for 400 kV operation;
- Reconductoring & refurbishing the YG route between Blyth & Heddon;
- Establishment of two new 400kV Stella West – Blyth – Eccles circuits;

The following works were also included in the Investment Scheme and were associated with the TIRG requirements:

- Reconfiguring tower XB254 (located at the point where the YG route forms a tee connection with the Stella West – Fourstones XB route) to create a new Stella West – Fourstones circuit. This was required to replace the Stella West – Blyth and Blyth – Fourstones circuits.
- Dismantling and removal of the YG route between Heddon and tower XB254. These were redundant following completion of the TIRG works

#### YG Route Works

The existing YG route between Heddon and Blyth has been reinsulated for operation at 400 kV and re-conductored with 2x570mm$^2$ conductor. The SDS specifies the objective of achieving a target impedance of no more than 2.090% on 100 MVA per circuit, between the tee point and the 275 kV terminal of the Blyth transformer.

The parts of the YG route being retained (from the tee point to Blyth) have been fully refurbished, addressing the following areas:

- Foundations
  - Strengthening as necessary
  - Refurbishment for wear and tear

- Muffs
- Plates
- Anti climbing devices
- Any necessary steelwork replacement
  - Strengthening as necessary
  - Refurbishment for wear and tear
- Replace existing earth wire with Keziah equivalent OPGW and creation of a tee-in to the existing OPGW on the 4ZY route.
- Construction of an earthwire shield using conventional ACSR conductor over the tee-in at Heddon.

XB Route Works

Tower XB254 has been reconfigured and jumpers installed across it to eliminate the Blyth tee.

Lines becoming Surplus

- Six towers (YG76 – YG81) between tower XB254 and Heddon are to be dismantled and removed. These are of 275kV L2 construction strung with 2x400 $mm^2$ conductor.

### *3.1.3 Investment 15063 – Uprate Stella West – Eccles 4ZY 400 kV Route*

The scope of this Investment covered the following works which are directly related to the TIRG output measures:

Stella West-Eccles Re-Conductoring

The Stella West-Eccles 400kV double-circuit route has been re-strung with 3x700$mm^2$ AAAC conductor. The works were coordinated with SPTL to ensure completion of the replacement of overhead line conductor on the Eccles - Stella West 400kV double circuit from Eccles to the NG area.

The following works were also included in the Investment and were associated with the TIRG requirements:

Fourstones Circuit

The ex-Blyth 2 circuit has been re-designated the Fourstones circuit and diverted into the ex-Spennymoor 2 bay at Stella West 275kV substation. This involved the installation of a new cable system (1 conductor per phase) with associated outdoor cable sealing ends, busbar connections, structures and foundations. The cable will operate at 275 kV although 400kV rated equipment has been supplied... Some of the existing AIS switchgear was removed; current transformers (3-off), RCP disconnector /earth switch, post insulators (3-off) and associated busbars/connections. At the ex-Spennymoor 2 circuit the existing CVT's (3-off) were removed. The existing line earth switch (L11A) foundation was modified.

Downleads from tower 4TQ111 (Spennymoor 2) to Spennymoor 2 circuit OHL landing gantry were removed.

Condition assessment and refurbishment of the ex-Spennymoor 2 bay was outside the scope of this investment.

SGT9 Bay

The Blyth 2/SGT9 teed circuit at Stella West 275kV substation has been reconfigured into two independent circuits designated Fourstones and SGT9. The Fourstones circuit has been diverted into the ex-Spennymoor 2 bay (see above) leaving SGT9 connected to a dedicated bay.

## 3.2 Scotland-England West Coast Interconnection

### 3.2.1 Investment 15064 – Harker-Gretna ZV Route 400 kV Uprating

This Investment Scheme required reinsulation of the NGET/SPTL Harker-Gretna-Strathaven 275kV circuit to 400kV (single circuit only, the other side of the double circuit ZV route was already operating at 400kV).

### 3.2.2 Investment 15069 – Harker 400 kV Additional Bays

Under Investment 15069, the existing 400 kV GIS at Harker has been extended by three bays (one feeder bay, one bus coupler and one MSC bay). The new feeder bay has been used to connect the Gretna circuit. Associated works included the removal of redundant 275 kV oil filled cables and accessories between terminal tower ZV401 and Mesh Corner 3 of the 275 kV substation.

## 3.3 Scotland-England Interconnector Reactive Compensation

### 3.3.1 Investment 20267B – Blyth 275 kV 2nd MSCDN

The scope of this Investment Scheme was to install an additional 150MVAr MSCDN at Blyth 275kV substation. The MSC has been connected to an existing redundant bay at Blyth 275kV substation.

## 3.4 Other Investments Interacting with TIRG Projects

National Grid has delivered a number of further Investment Schemes which interact with TIRG 'Baseline' projects. This section describes the scope of works of these investments.

### 3.4.1 Investment 20605 – Blyth 400 kV Substation

A new 400kV substation was to be constructed at Blyth as part of a package of works to uprate the NE ring to 400kV operation. This was to facilitate additional power transfers across the Anglo-Scottish boundary which has been superseded by upgrades of Stella West-Spennymoor-Norton circuits.

### 3.4.2 Investment 20145 – Additional Reactive Power Compensation

A new MSCDN has been installed at Harker 275 kV substation and is rated at 150 MVAr. It was completed in 2007.

### 3.4.3 Investment 20277 – Harker MSC

A new MSCDN has been installed at Harker 400kV and is rated at 225 MVAr. It was completed in 2008.

### 3.4.4 Investment 20267 – Blyth 275 kV 1st MSCDN

A further 150MVAr MSCDN has been installed at Blyth 275kV.

### 3.4.5 Investment 15056 – Stella West New 400 kV Substation

These works comprise construction of a new 400 kV 12 bay double busbar substation at Stella West with 4 feeder bays, 2 inter-bus transformer bays, 1 MSC bay, 2 bus couplers and 2 skeletal bays. The scope also covers the installation of a new 400kV 225MVAr MSCDN at Stella West.

# 4. National Grid Investment Project Outputs

The following table presents a comparison of output data from completed projects against Ofgem output measures as required in Special Conditions D3 of NGET Licence. Specified TIRG outputs are highlighted; non-compliances are shaded in red.

Table 4.1: Comparison of Project Outputs against Ofgem Pre-Agreed Outputs (SDS)

| | | | | | Project Outputs | | | | | | Pre Agreed Outputs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Pre-Fault Continuous Circuit Rating | | Post Fault Continuous Circuit Rating | | Circuit Parameters | | Reactance | Post Fault Continuous Circuit Rating | |
| Circuit Identity | Type | Investment | Circuit Voltage kV | Conductor Arrangement | Winter MVA SDS / TRS | Summer MVA SDS / TRS | Winter MVA SDS / TRS | Summer MVA SDS / TRS | R % on 100 MVA | X % on 100 MVA | X % on 100 MVA | Winter MVA | Summer MVA |
| **England-Scotland East Coast Interconnector** | | | | | | | | | | | | | |
| Eccles – Heddon Tee 1 (Line A) | OHL | 15063 | 400 | 3x700mm$^2$ | 2580/ 2330(TRS) | 2030 / 2310(TRS) | 3070 / 3100(TRS) | 2420 / 2960(TRS) | 0.038 | 0.713 | 0.721 | 3070 | 2420 |
| Eccles – Heddon Tee 2 (Line A) | OHL | 15063 | 400 | 3x700mm$^2$ | 2580/ 2330(TRS) | 2030 / 2310(TRS) | 3070 / 3100(TRS) | 2420 / 2960(TRS) | | | | 3070 | 2420 |
| Stella West – Heddon Tee 1 (Line B) | OHL | 15063 | 400 | 3x700mm$^2$ | 2580/1170(TRS) | 2030 / 930(TRS) | 3070 / 3330(TRS) | 2420 / 3330(TRS) | 0.005 | 0.065 | 0.059 | 3070 | 2420 |
| Stella West – Heddon Tee 2 (Line B) | OHL | 15063 | 400 | 3x700mm$^2$ | 2580/3330(TRS) | 2030 / 3170(TRS) | 3070 / 3330(TRS) | 2420 / 3330(TRS) | | | | 3070 | 2420 |
| Blyth – Heddon Tee 1 (Line C) | OHL/Tfr | 15062 | 400 | 2x570mm$^2$ | 1170 / 1110(TRS) | 930 / 1020(TRS) | 1390 / 1150(TRS) | 1110 / 1020(TRS) | 0.027 | 1.128 | 1.128 | 1390 | 1110 |
| Blyth – Heddon Tee 2 (Line C) | OHL/Tfr | 15062 | 400 | 2x570mm$^2$ | 1170 / 1110(TRS) | 930 / 1020(TRS) | 1390 / 1150(TRS) | 1110 / 1020(TRS) | | | | 1390 | 1110 |
| Combined Impedance (Border to Stella West/Blyth) | OHL | 15062/15063 | 400 | 3x700mm$^2$ and 2x570mm$^2$ | N/A | N/A | N/A | N/A | 0.044 | 1.039 | 1.045 | N/A | N/A |
| **England-Scotland West Coast Interconnector** | | | | | | | | | | | | | |
| Gretna – Harker | OHL | 15064 | 400 | 2x500mm$^2$ | 1690 / 1660(TRS) | 1470 / 1440(TRS) | 2010 /2010(TRS) | 1750 / 1710(TRS) | N/A | N/A | N/A | **2010** | N/A |
| Elvanfoot - Harker | OHL | 15064 | 400 | 2x500mm$^2$ | 1690 / 1660(TRS) | 1470 / 1440(TRS) | 2010 / 2010(TRS) | 1750 / 1710(TRS) | N/A | N/A | N/A | **2010** | N/A |

The thermal ratings of the circuits have been taken from both the Scheme Design Specification (SDS) and Thermal Rating Schedules (TRS). The resistance and reactances project output values have been taken from NG calculation results presented in the "TIRG Post-Construction Technical Report" and are for two circuits operating in parallel (i.e. 50% of the single circuit resistance/reactance).

The impedance of the Blyth – Heddon tee circuits includes the 1100MVA transformers at Blyth. The impedance of the Stella West – Heddon tee circuits does not include the 400/275kV transformers at Stella West. However these have been taken into account in calculation of the combined impedance.

Special Conditions D3 of NGET Licence define the combined impedance as the reactance between the Scottish border and the 275 kV network in the north east of England; calculated by Line A in series with (B' paralleled with C) where B' is line B in series with the existing four 400/275 kV transformers at Stella West. The calculation for the achieved combined impedance has been provided by National Grid and we considered this calculation to be acceptable.

Table 4.2: Reactive Compensation Project Outputs Comparison against Ofgem Pre-Agreed Outputs

| Substation | | Year of | Pre-Agreed | Project Outputs |
|---|---|---|---|---|
| | Investment | Commissioning | MVAr Rating | MVAr Rating |
| Blyth | 20267B | TBC | 150 | 150 |

# 5. Evaluation of Investment Performance against Agreed Output Measures

## 5.1 Efficiency in Achievement of Output Measures

The technical performance of National Grid's implemented network reinforcement projects has been assessed in line with the Special Conditions D3 of NGET Licence and the results are summarised in Table 4.1/Table 4.2.

The following commentary discusses the variations that have been identified.

### 5.1.1 Scotland-England East Coast Interconnector

#### 5.1.1.1 Eccles – Heddon Tee Branch

The 2011 Thermal Rating Schedules provided by National Grid (and summarised in the SYS) indicated that the Eccles to Heddon tee branch did not fully meet the thermal rating specified in the output measures.

During our initial review we established that this non compliance was related to a short section of overhead line in the Scottish Power service area, close to Eccles substation, which had been strung with 2x620mm² GZTACSR 'Gap' conductor rather than 3x700 mm² AAAC. The Thermal Rating Schedule indicated that a temporary restriction was to be applied, limiting the post fault winter rating to 2770MVA. This is in line with normal UK practice which is to impose a temporary rating reduction to new conductor due to its lower emissivity before natural ageing occurs.

The GZTACSR section was installed during 2010 and the temporary restriction has now been lifted. A review of the 2012 Thermal Rating Schedules has confirmed that the thermal rating of the Branch is now in accordance with the TIRG output measures. Circuit rating is now restricted by the Scottish Power switchgear at Eccles.

Based on the information now available, we have concluded that National Grid's output measures were achieved.

Impedance data provided confirms that National Grid achieved a better reactance for the Eccles – Heddon Tee branch; 0.0713 an opposed to 0.721 specified as the output measure. We have reviewed the methodology for calculating circuit impedances and are in agreement with the approach adopted.

#### 5.1.1.2 Stella West – Heddon Tee Branch

The Thermal Rating Schedules indicate that the Stella West to Heddon tee 1 and 2 circuits meet the thermal rating specified in the output measures.

However, impedance data provided by National Grid suggests that the reactance of the Stella West – Heddon Tee branch (excluding the impedance of the 400/275kV transformers at Stella West) does not comply with the specified output measures and exceeds the desired value by 10%. National Grid has advised that this discrepancy was due to an error in the original calculations resulting from the position of the tee point being incorrectly identified.

Further reduction of the Stella West – Heddon Tee impedance is not practicable and National Grid has thus not proposed any remedial measures. They have claimed, and we are in agreement, that this will have a relatively small effect on the overall impedance of the circuits, since the length of the Stella West – Heddon Tee branch (7km) is short in comparison with the Eccles – Heddon Tee branch (approximately 100km) and its impedance is dominated by the transformers at Stella West (which are excluded from the branch assessment but included in the combined impedance measure).

It should further be noted that if the combined impedance of the Stella West – Heddon Tee branch and the National Grid part of the Heddon Tee – Eccles branch are considered then the achieved value (0.778%) is very close to the target (0.780%). This probably reflects the original error made in identifying the location of the new tee point at Heddon.

#### 5.1.1.3 Blyth – Heddon Tee Branch

The Thermal Rating Schedules indicate that the Blyth to Heddon tee branch does not fully meet the thermal rating specified in the output measures.

The limitation on the bushings is a consequence of the design rating of the substation which was 2000A (950MVA at 275kV). Whilst equipments have been individually assessed for their capabilities allowing a modest enhancement of this figure, it is unrealistic to expect a significant increase without substantial investment. It was not intended that this investment should form part of the TIRG works.

This rating limitation was to be removed by the planned development of a 400kV substation at Blyth, which was part of a separate load-related Scheme. This development was delayed in line with changes in the load-related background but is now planned for completion in 2017 as part of infrastructure works for a customer connection. The limitation will then be removed.

Impedance data provided by National Grid confirms that the reactance of the Blyth – Heddon Tee branch is in line with the specified output measures. We have reviewed the methodology for calculating circuit impedances and are in agreement with the approach adopted.

#### 5.1.1.4 Scottish Border and the 275 kV Network Combined Impedance

When the reduction of the combined impedance of the three circuit legs between the border and the NE 275kV network is considered (as defined in the output measures, to include the Stella West transformers), the achieved value is 1.039% against the target of 1.045%. Since the stability performance of the Scotland – England boundary is largely dependant on the overall circuit reactance achieved, it can be concluded that the overall network performance will be as intended when setting the output measures.

### *5.1.2 Scotland-England West Coast Interconnector*

We consider that the NG Thermal Rating Schedules indicate that the Gretna – Harker and Elvanfoot - Harker circuits meet the thermal rating specified in the output measures. This conclusion is supported by the ratings published in the 2010/11 SYS.

However, some data provided by NG suggests that the circuit may be strung in pre-1986 (32.5 nΩ.m) conductor which has a marginally lower rating than the 31.2 nΩ.m that we have assumed. It is our understanding that this conductor was installed after 1986 and thus has the lower resistivity.

There are no impedance requirements in the output measures.

### 5.1.3 Scotland-England Interconnectors – Reactive Compensation

A 150MVAr 275kV MSC has been installed at Blyth as part of the TIRG Scotland-England Interconnector works. This satisfies the required output measures.

## 5.2 Completion of the Works

Through review of National Grid Scheme documentation, we are satisfied that all major works have been completed to deliver the TIRG Scotland-England Interconnetor project. We have confirmed that the scope of work of each individual investment related to these projects is in line with the overall requirements specified. We have also confirmed that Operation Diagrams including the associated TIRG project works have been released and have been uploaded in the National Grid Integrated Document Management System (IDMS Livelink).

The review has identified that, under current conditions, the circuits addressed by the project all meet the thermal requirements defined by the agreed output measures with the exception of the Blyth to Heddon branch, which has been adversely impacted by postponement of a separate load-related project. It is envisaged that this non-compliance will now be addressed following completion of Blyth 400kV substation as part of a customer connection project planned for completion in 2017.

Nevertheless, National Grid has provided evidence from their Network Operation department confirming that the transfer levels achieved following completion of the East and West Coast Interconnector works have reached 3.3GW, which exceeds the objective of 2.8GW.

Considering the impedance specified in the output measures, only one part of the project (the line from Stella West to Heddon Tee) has failed to comply with the requirements. There is a variance of 10% of the desired value which is due to an error in the original calculations and cannot reasonably be mitigated.

National Grid has argued that, if the combined impedance from the SPT boundary of the Eccles circuits, to the NE 275kV network is considered, then the impact of this non-conformance on system performance is negligible. We consider this argument to be reasonable.

In view of the position outlined above, we consider it reasonable to accept that TIRG Scotland-England Interconnector project is complete and that no further works are planned (or could reasonably be proposed) to reduce the Stella West – Heddon Tee impedance further.

We have provided a completion certificate for these works (Appendix A).

# Appendices

# Appendix A. Construction Completion Certificate

**TRANSMISSION INVESTMENTS FOR RENEWABLE GENERATION CONSTRUCTION COMPLETION CERTIFICATE**

Licensee: National Grid Electricity Transmission Plc (NGET)

Schemes: Scotland – England East Coast and West Coast Interconnectors

Scotland – England Interconnection Reactive Compensation

I/We certify 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 Annex A to Special Condition D3; Adjustment to the Transmission Network Revenue Restriction due to Transmission Investment for Renewable Generation.

Signature: 

Name: Paul Fletcher

Date: 29th June 2012

Designation: Technical Director, Transmission & Distribution, Mott MacDonald Ltd