Network Rail Marshall Meadows Capacity Increase			
Name of Scheme/Programme	*Network Rail Marshall Meadows Capacity Increase*		
Primary Investment Driver	*Load – Thermal Capacity*		
Scheme reference/ mechanism or category	*SPT20096* *SPT20097* *SPT20098*		
Output references/type	*LRT2SP2036*		
Cost	• *£11.924m – total project costs* ○ Network Rail funded – £1.960m ○ SPT funded – £9.964m		
Delivery Year	*RIIO T2 – 2024*		
Reporting Table	*B0.7 Load Master Data* *B4.2a Scheme Summary* *B4.5 Scheme Asset Data* *B4.5a Scheme Asset Data* *B4.6 Scheme Output Profile*		
Outputs included in RIIO T1 Business Plan	*No*		
Spend apportionment (£m)	**T1**	**T2**	**T3**
	0.044	**11.880**	**0.0**

Issue Date	Issue No	Amendment Details
July 2020	Issue 1	First issue of document – Draft Determination Update

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1. Introduction

An application was received from Network Rail, to permit an increase in demand supplied to the Marshall Meadows substation and the subsequent offer was accepted. A TO Construction Agreement (SPT-TOCO-447) is in place for these works.

Due to the relatively low fault level at Berwick 132kV and Marshall Meadows, we cannot simply install larger transformers at the substation site as this would increase the voltage unbalance, resulting from the unbalanced network loading, beyond the limits outlined in CC.6.1.5 (b) and CC.6.1.6 of the Grid Code[1]. It has been agreed with Network Rail that they are to install a Static Frequency Converter (SFC), based on Integrated Gate Commutated Thyristor (IGCT) technology, which will take a 3-phase supply from SP Transmission and convert it to a 2-phase supply, i.e. the unbalanced demand appears balanced at the connection point. The SP Transmission works associated with this scheme are the upgrade of the existing two 2-phase circuits between Berwick and Marshall Meadows to two 3-phase circuits.

The primary driver for investment at Marshall Meadows 132kV substation is the provision of increased thermal capacity to Network Rail in response to the connection application received. In developing the proposed solution at the substation, we have worked collaboratively with Network Rail to ensure the whole electricity system is considered and that an economic, co-ordinated and efficient solution is selected.

2. Background Information

This paper supports the proposal for an increased demand connection by Network Rail at the Marshall Meadows site located in the Scottish Borders area. Network Rail currently have a 25kV supply from Marshall Meadows, serviced by two 132/25kV 10MVA transformers connected to two 132kV 2-phase circuits, CJ(N) and CJ(S), which tee into the Eccles to Berwick 132kV OHL circuits.

Network Rail are seeking to increase their demand connection from 10MVA (30 min average) to 25.1MVA (30 min average) and 38.4MVA (1 min average). Due to Marshall Meadows being a radial feed in a relatively weak network, this demand increase cannot be accommodated via the traditional approach of installing larger transformers at the 132/25kV substation, as this will lead to excessive voltage unbalance, or Negative Phase Sequence (NPS) voltages at Berwick, where it will impact on other network Users. Maximum transmission NPS voltage limits are outlined in the Grid Code.

This engineering justification paper outlines the works proposed to facilitate the increase in demand thermal capacity that has been included in baseline funding as part of our business plan. Network Rail are already at present contracted to connect, with the associated works progressing through the project development phase.

[1] Also see Engineering Recommendations P24 and P29.

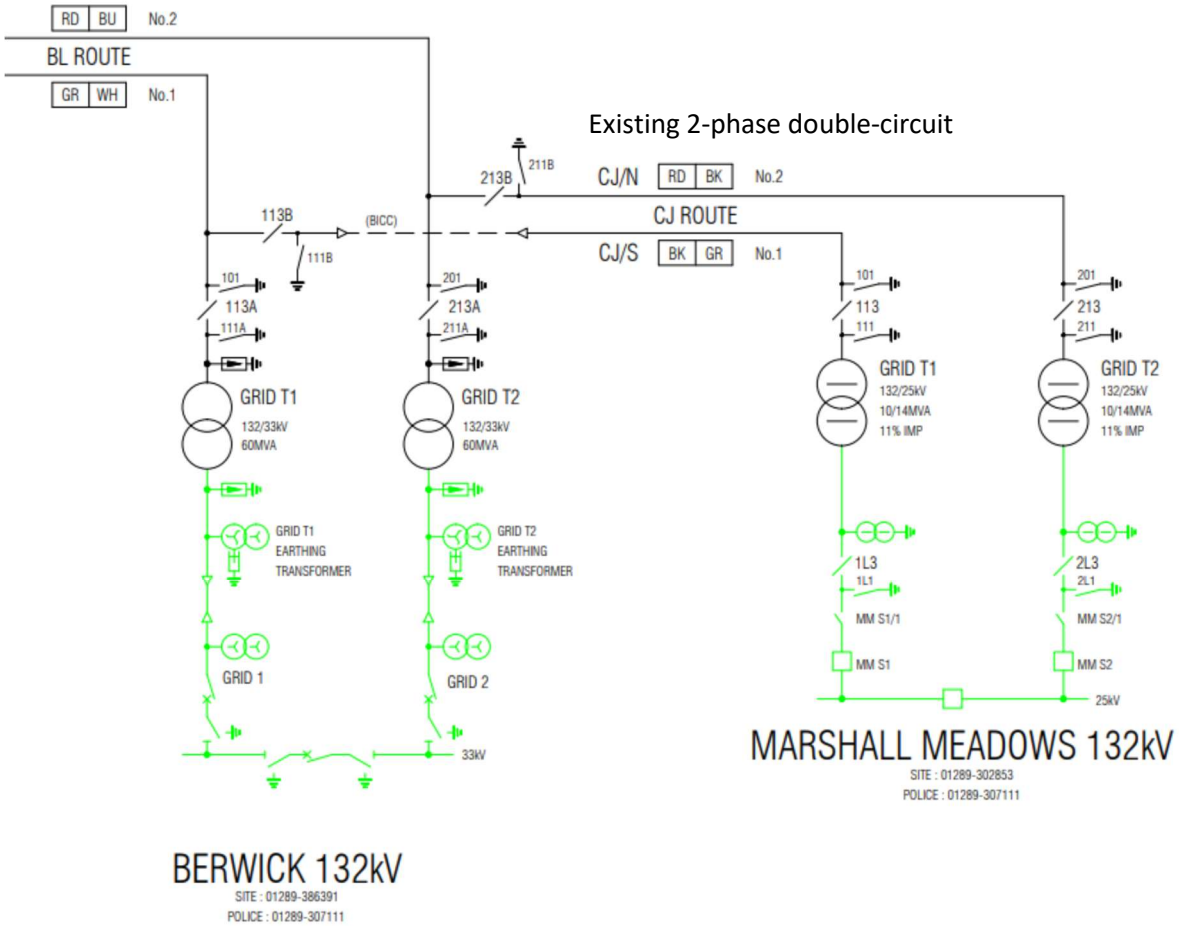

Figure 1. Existing Network at Berwick/Marshall Meadows Substation

3. Optioneering

The table below presents a summary of the options considered for this project.

	Option	Status	Reason for rejection
(a)	No Intervention	Rejected	Not compliant with SQSS.
(b)	Upgrade Marshall Meadows T1 and T2.	Rejected	NPS voltage limits will be exceeded at Berwick.
(c)	Upgrade Marshall Meadows T1 and T2 and install a load balancing device at Berwick.	Rejected	High cost and high risk of exceeding harmonic voltage limits at Berwick and elsewhere in the network.
(d)	Upgrade Marshall Meadows T1 and T2, upgrade Berwick – Marshall Meadows to 3-phase operation and install a load balancing device at Marshall Meadows.	Rejected	High cost and high risk of exceeding harmonic voltage limits at Berwick and elsewhere in the network.
(e)	Upgrade Berwick – Marshall Meadows to 3-phase operation and connect Network Rail as a balanced load via SFC (owned by Network Rail).	Proposed	-

4. Detailed Analysis

Due to the weak network associated with Berwick and Marshall Meadows substations and the impact on NPS voltage levels associated with the increase in demand, an alternative solution is proposed to facilitate Network Rails requirements at the substation.

It is proposed that Network Rail will install a SFC on their side of the Point of Connection. This SFC converts a three-phase supply into a single-phase supply by modulating the firing of IGCT valves. This means that from an SPT perspective, a balanced 3-phase supply can be provided to Network Rail and it will be converted to 25kV single phase through this device. This means that the issues relating to NPS limits being breached will not occur.

At Marshall Meadows substation, the existing two 132/25kV 10MVA transformers and line disconnectors will be removed and replaced with two new 132kV circuit metering breakers, metering class instrument transformers and associated disconnectors. This will form the Point of Connection with Network Rail carrying out the remainder of the works. A schematic of the proposed works is given in Figure 2.

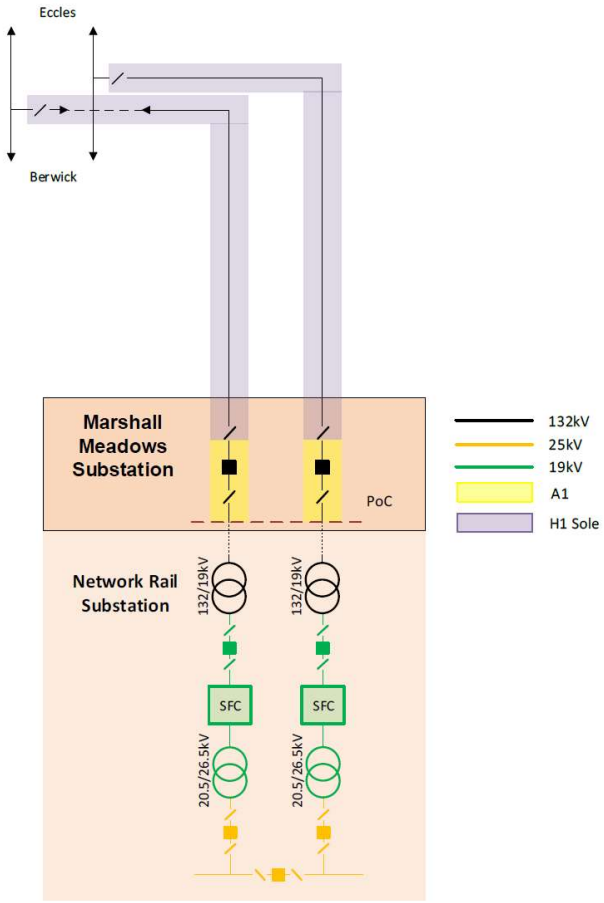

Figure 2. Proposed network configuration

At Berwick substation, the existing 2-phase disconnectors will need to be removed and new 132kV rated 3-phase line disconnectors installed. New busbar sections will be required to be installed along with a short cable section on the Eccles/Berwick/Marshall Meadows No.1 circuit. This cable section is approximately 100m in length and it is proposed to install 800mm2 Al XLPE cable.

It is proposed to install Wolf conductor (150mm^2 ACSR) between Berwick substation and Marshall Meadows substation (the route length is approximately 4.4km). This will meet the capacity required by Network Rail. Additional supporting poles may be required to be installed along the route to support the additional weight of the 3 conductor phases.

The existing distance protection in place on the Eccles-Berwick-Marshall Meadows circuit will be replaced with a three-ended unit protection scheme.

Network Rail will require to interface with the existing Eccles/Berwick Load Management Scheme (LMS). Each new train being used on the East Coast Mainline will have up to 5MW of power export available to it via the train's regenerative braking system. This is nothing new with regards to electric trains, however if a number of trains brake at the same time this could cause a large power export to spill onto the SPT system. To mitigate this risk it is proposed to notify Network Rail when this LMS scheme is armed, i.e. if an overload is detected on SGT1 and/or SGT2 at Eccles or T1 and/or T2 at Berwick. Upon receipt of this notification Network Rail are able block any export through the SFC by utilising the technology within the power electronics. The single line diagram below aims to shows the protection and control requirements for the extension of the existing Eccles to Berwick LMS.

Note that the equipment shown at Eccles and Berwick is already existing, therefore only the equipment shown at Marshall Meadows is required as part of these works.

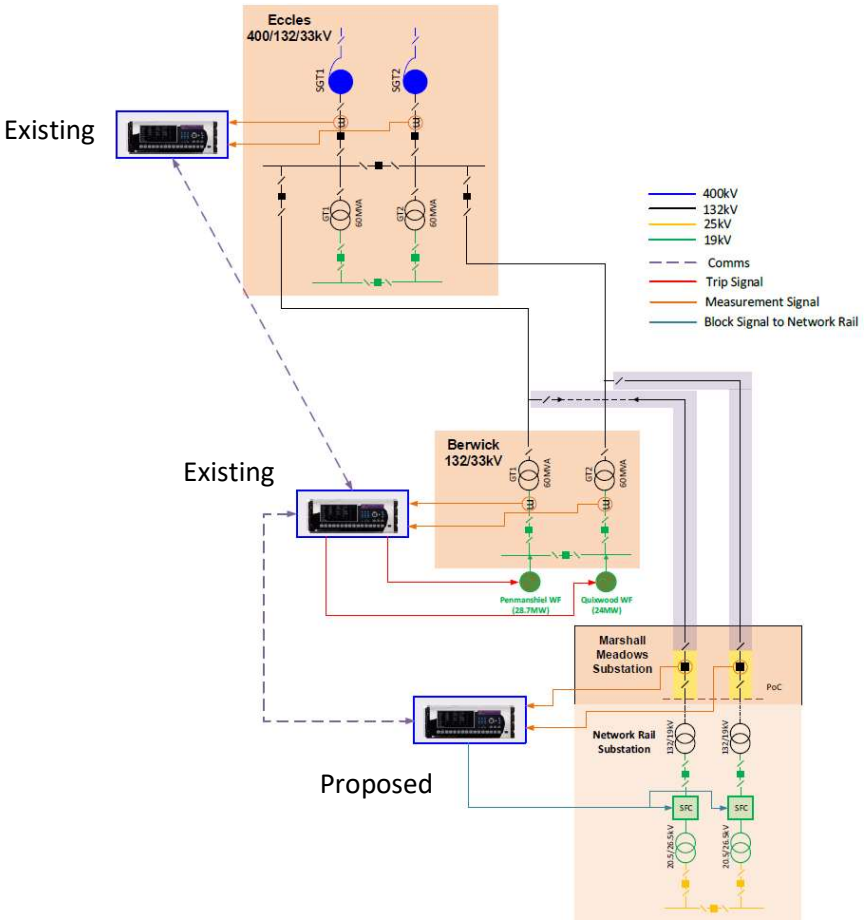

Figure 3. Proposed Protection Network requirements

5. Conclusion

SP Transmission has a statutory obligation, that on notification from the System Operator (National Grid ESO) of a receipt of an application for connection or modification of an existing connection: to offer to enter into an agreement with the system operator to connect the third party.

The proposed solution has been developed in co-ordination with Network Rail. Due to the weak network associated with Berwick and Marshall Meadows substations and the impact on NPS voltage associated with the increase in unbalanced demand, an alternative solution that is balanced at the connection point has been proposed.

Project Summary:

- Forecast Costs – £11.924m
  - SPT funded – £9.964m
  - Network Rail funded – £1.960m
- Timing of Investment – 2021/2024
- Outputs:
  - Addition – Additional phase conductor connecting Berwick to Marshall Meadows 132kV substation; 2 x 132kV metering Circuit Breakers
  - Disposal – 2 x 132/25kV 10MVA dual winding transformers

Outputs included in RIIO T1 Plans

Not Applicable.

6. Future Pathways – Net Zero

Primary Economic Driver

The primary driver for investment for the proposed works is the increase of demand supplied to the Network Rail customer connecting at Marshall Meadows Substation.

Payback Periods

A CBA has not been undertaken for the proposed scheme installation.

Pathways and End Points

The proposed solution has suitable capacity to accommodate the currently proposed demand at the site and also accommodate the regenerative braking associated with the new trains that will utilise the railway tracks fed from this site.

Asset Stranding Risks

There is no risk of asset stranding associated with the installation of the proposed works as the existing substation feeds the existing East Coast Mainline. Should the developers terminate, the proposed works will be revised and the scope amended as appropriate.

Sensitivity to Carbon Prices

The proposed scheme is not sensitive to carbon price.

Future Asset Utilisation

The utilisation of the proposed assets would be increased by increased traffic on the Network Rail system.

Whole Systems Benefits

The works proposed are to facilitate increasing electrification of the rail network as such there is some Whole System interaction with Transport networks.