Scottish & Southern Electricity Networks

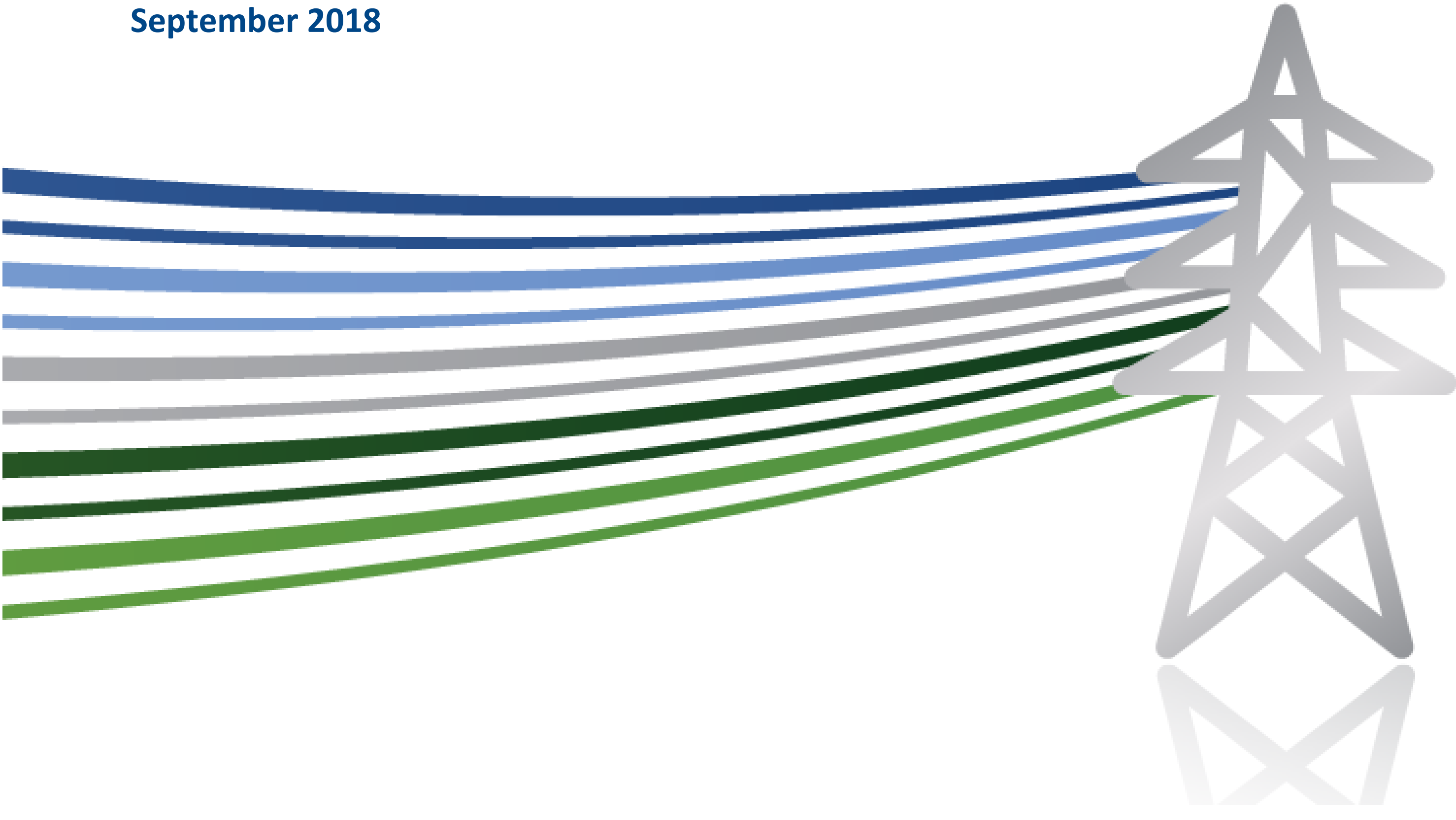
SHE Transmission

New Suite of Transmission Structures: NeSTS (SSEN003)

Stage Gate (Appendix 6)

TNEI Refresh of Overhead Line Volumes

September 2018



A specialist energy consultancy

Refresh of Overhead Line Volumes

New Suite of Transmission Structures Project

Scottish and Southern Electricity Networks

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COMMERCIAL IN CONFIDENCE

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TNEI Services Ltd

Company Registration Number: 03891836 **VAT Registration Number: 239 0146 20**

Registered Address	7th Floor	
Bainbridge House	West One	Queens House
86-90 London Road	Forth Banks	19 St. Vincent Place
Manchester	Newcastle upon Tyne	Glasgow
M1 2PW	NE1 1PA	G1 2DT
Tel:+44 (0)161 233 4800	Tel:+44 (0)191 211 1400	Tel:+44 (0)141 428 3180
Fax:+44 (0)161 233 4801		

TNEI Africa (Pty) Ltd

Registered: Mazars House, Rialto Rd, Grand Moorings Precinct, 7441 Century City, South Africa

Company Number: 2016/088929/07

1st Floor
Willowbridge Centre
Carl Cronje Drive
Cape Town
South Africa, 7530
Tel: +27 (0)21 974 6181

Executive Summary

TNEI Services Ltd was commissioned in 2015 by Scottish Hydro Electric Transmission Ltd (SHE Transmission) to investigate the volume of overhead lines (OHL) that will be constructed up to 2050.

This study was provided to support the Network Innovation Competition (NIC) bid entitled New Suite of Transmission Structures (NeSTS). The purpose of the original report was to establish the business case for the availability of a new tower design by understanding the need for new tower construction up to 2050.

The NIC bid was won and work commenced on the project. The project itself was split into two phases: a design stage and a practical implementation stage. Before moving to the practical implementation stage the project must pass a Stage Gate process.

Part of the work required for the Stage Gate was a review of the original business case with updated datasets, which is the purpose of this refresh study.

To estimate the amount of OHL needed by the Great Britain (GB) transmission system up to 2050 the study identified the main drivers of OHL in the transmission system and analysed the data associated with these drivers:

- Transmission line reinforcement in the National Grid Electricity Transmission (NGET), Scottish Power Transmission (SPT) and SHE Transmission (SHE-T) regions;
- 132 kV distribution line upgrade and replacement by the DNOs in England and Wales; and
- 132 kV and 275 kV generation grid connections.

The estimate of OHL considered only new structures being built at 132 kV, and 275 kV. It was assumed that 400 kV OHL in England and Wales will be built using the T-Pylon, and that 400 kV OHL in Scotland will be built using SSE400 supports. Consequently, 400 kV OHL was not considered in the estimate.

The analysis on transmission line reinforcement determined a cyclical build programme with SHE-T responsible for the bulk of the 132 kV and 275 kV transmission OHL construction. However, there was some construction planned by SPT and NGET.

An analysis on the English and Welsh distribution lines was not considered to be necessary as the reinforcement work was considered not applicable, in accordance with the original study.

The analysis on the generation grid connections found a much lower need for OHL in comparison to transmission line reinforcement. The timing and amount of OHL required for grid connections was almost random in nature due the changeability of connecting projects. The majority of projects are connecting in SHE-T license area, with fewer connections being required in the SPT license area. It was found that there were no applicable generators in the NGET license area. This was due to generators connecting either via underground cable, wooden pole, using pre-existing assets, or was otherwise not considered applicable.

Overall the main generation technologies driving the need for OHL were found to be onshore wind and pumped hydro connections.

Overall there was a clear and consistent requirement for 132 kV and 275 kV OHL in GB, with at least 4,000 km of line required by 2050 across all FES scenarios. It was also clear that the vast majority of the need for 132 kV and 275 kV OHL was in Scotland due to the transmission upgrades in England/Wales primarily being at 400 kV.

Contents

1 Introduction

TNEI Services Ltd was commissioned in 2015 by Scottish Hydro Electric Transmission Ltd (SHE Transmission) to investigate the volume of overhead lines (OHL) that will be constructed up to 2050.

The study was required to support the Network Innovation Competition (NIC) bid entitled 'New Suite of Transmission Structures' (NeSTS). The purpose of the original report was to establish the business case for the adoption of a new tower design via understanding the need for new tower construction up to 2050.

The bid was won and work commenced on the project. The project itself is split into two phases: a design stage and a practical implementation stage. Before moving to the practical implementation stage the Project must pass a Stage Gate process.

Part of the work required for the Stage Gate is a review of the original business case with updated datasets, which is the purpose of this refresh study.

2 Methodology

The methodology used for TNEI's initial report was reviewed and found to be accurate. Using this methodology, it was found that there were three drivers for the construction of 132 kV and 275 kV overhead lines in the UK over the next 32 years, as follows:

- Transmission line reinforcement in the National Grid Electricity Transmission (NGET), Scottish Power Transmission (SPT) and SHE Transmission (SHE-T) regions;
- 132 kV distribution line upgrade and replacement by the DNOs in England and Wales; and
- 132 kV and 275 kV generation grid connections.

Input data for these drivers come from the following sources respectively:

- National Grid Electricity Ten Year Statement (ETYS);
- RIIO Business Plans for English/Welsh DNOs; and
- The Transmission Entry Capacity (TEC) Register.

The EYTS, RIIO, and TEC datasets were dated from 2017 and covered a time period up to 2027, so more information was required to estimate the volume of OHL between 2027 and 2050. To convert this period an estimate was produced based on the National Grid Future Energy Scenarios (FES) 2018 document which outlines four possible growth scenarios for the UK energy sector up to 2050.

The assumptions used in interpreting these data sets are outlined in their respective sections.

2.1 National Grid Electricity Ten Year Statement

When a potential generator or load is connecting to the grid there may be a requirement for reinforcement on the network side of the Point of Common Coupling (PCC). The National Grid Electricity Ten Year Statement (ETYS) was used to forecast the need for OHL from the networks side.

Each Transmission Owner (TO) will strategically plan network upgrades in co-ordination with the other TOs and the System Operator (SO). The SO, National Grid, then details the planned changes to the transmission system in the National Grid Electricity Ten Year Statement (ETYS). The ETYS was used as input information for this study. It is publicly available from National Grid's website.

The majority of OHL construction described in the ETYS is for transmission line reinforcement. There are a number of factors that will drive the need to construct new transmission assets. These may include an increase in demand, the replacement and upgrading of existing assets, the removal of constraints, and to facilitate the connection of new generation.

The ETYS is a spreadsheet that lists details for each connection. These details include the two connection nodes, the year of construction, the length, the circuit type, and the connection status. The original TNEI OHL volume estimate study, undertaken in 2015, was based on the 2014 ETYS; the refresh of this study utilises the 2017 ETYS which provides data for network upgrades up to 2027.

It was found that not all of the changes listed in the ETYS would be applicable, so the following filters were applied to the data:

- The ETYS included all transmission voltages from 132 kV and above - upgrades specific to 400 kV were removed as it was assumed they will use the new National Grid T-Pylon or SSE400 design;
- Only upgrades classed as 'addition' were used. Those classed as 'change' were assumed to refer to conductor restringing;

- Where two overhead lines of the same length were listed, this was assumed to be a double stringed tower so only one length was used.

2.2 DNO RIIO Business Plans

In England and Wales, the 132 kV voltage level is considered part of the distribution network and not the transmission grid. As such, in order to capture the OHL demand fully in the UK, the 132 kV grid must be considered separately from the transmission grid in England and Wales. This could have been undertaken via inspection of the RIIO (Revenue equals Incentives plus Innovation plus Outputs) business plans of the Distribution Network Operators (DNOs) in England and Wales. However, it was decided not to include any of the OHL reinforcements from these networks in the original study for the following reasons:

- Much of the costs quoted will be spent on refurbishment and replacement rather than building new overhead lines;
- New 132 kV circuits are likely to be either buried underground (in urban environments) or installed as wooden pole OHLs (in rural environments).

As both of these reasons remain valid it was considered, after discussion with the Client, that the need for OHL in the distribution network of England and Wales remain discounted.

2.3 Transmission Entry Capacity Register

The ETYS was used to estimate the new OHL required for generation or demand within the transmission network. The TEC register was used to estimate the new OHL required for generation connections from the generator to the Point of Common Coupling (PCC) on the grid.

All future generation connection applications that could use the new suite of tower designs are listed in the Transmission Entry Capacity (TEC) Register. This register covers all generation that is contracted to National Grid for transmission entry rights, whether that be connection via transmission line or embedded within the distribution network.

For economic reasons, generation projects tend to be built as close as possible to a suitable grid entry point. They therefore represent a relatively small percentage of the overall overhead line or cable connections installed in GB. In order to obtain a figure for the annual volume of overhead line for generation connections that could use a revised tower structure the following assumptions were made:

- All generation below 32 MW was assumed to be embedded in the distribution network and was disregarded;
- Any generation lower than 90 MVA and connected at 132 kV was discarded. Below 90 MVA it is possible to use a wooden pole design and project economics would dictate that this method would be used; and
- Any generation above 1500 MW was considered as connecting at 400 kV. This was based on the rating of a 275 kV overhead line. Any 400 kV line was assumed to use the new National Grid T-Pylon or SSE400 design.

Once the above filters were applied the remaining generation applicants were investigated. As limited information is available regarding the grid connections of the generation applications the following assumptions were made:

- Where the location of the project and the connecting substation could be identified, an as-the-crow-flies OHL distance was assumed;

- Where the location of the project was known but the connecting substation could not be identified, the distance of the OHL was assumed to be as-the-crow-flies to the nearest local load centre;
- Where the project substation was fully identified (with voltage level) and had the same name as the project, it was assumed that the project was in close proximity and an assumption of 2 km was used for such cases; and
- All offshore projects, wind and marine, were considered to have no OHL connections on land as this is not typical industry practice for offshore grid connections.

A final filter was applied to the TEC register to account for any projects that may not go ahead, because not all generators within the register will be built due to project issues such as planning consents. The filter depended on the status of the project. The TEC Register lists projects with one of the four following statuses: Scoping, Awaiting Consents, Consents approved or Under Construction/ Commissioning. The following weightings were applied depending on the status of the project.

Table 2.1 Project Success Rate

Project Status	Success Rate (%)
Scoping	30
Awaiting Consents	50
Consents Approved	80
Under Construction/Commissioning	100

2.4 Application of Future Energy Scenarios

After 2027 the growth trend of the future energy scenarios was applied to the average annual growth during the known data period. Electricity usage was used to calculate transmission upgrades and generation growth was used for overhead line build for generation connections.

Each of these growth strategies was calculated for the following four scenarios:

- Steady Progression, which does not achieve the 2050 climate change target and has a centralised model of generation.
- Two Degrees, which achieves the 2050 climate change target through a centralised model of generation.
- Consumer Evolution, which does not achieve the 2050 climate change target and has a decentralised model of generation.
- Community Renewables, which achieves the 2050 climate change target through a decentralised model of generation.

Figure 2.1 below shows the growth scenarios driven by electricity usage while Figure 2.2 shows the growth scenarios driven by generation.

Figure 2.1 Future Energy Scenarios Demand Growth in Terawatt Hours

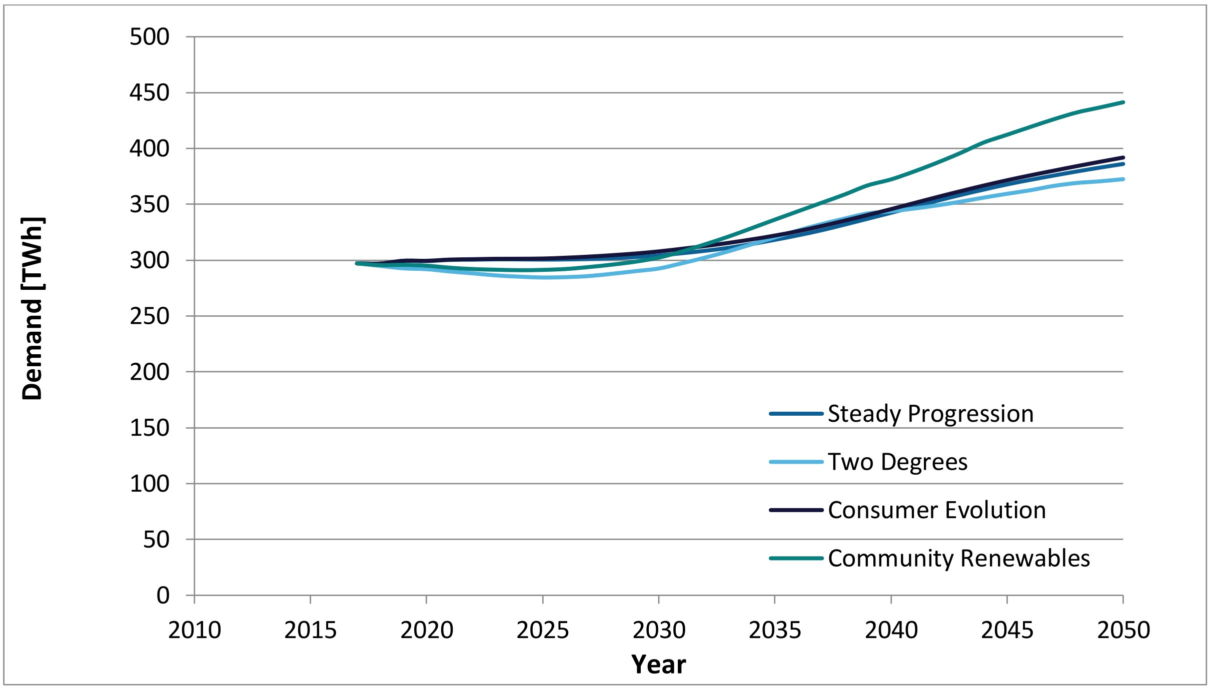
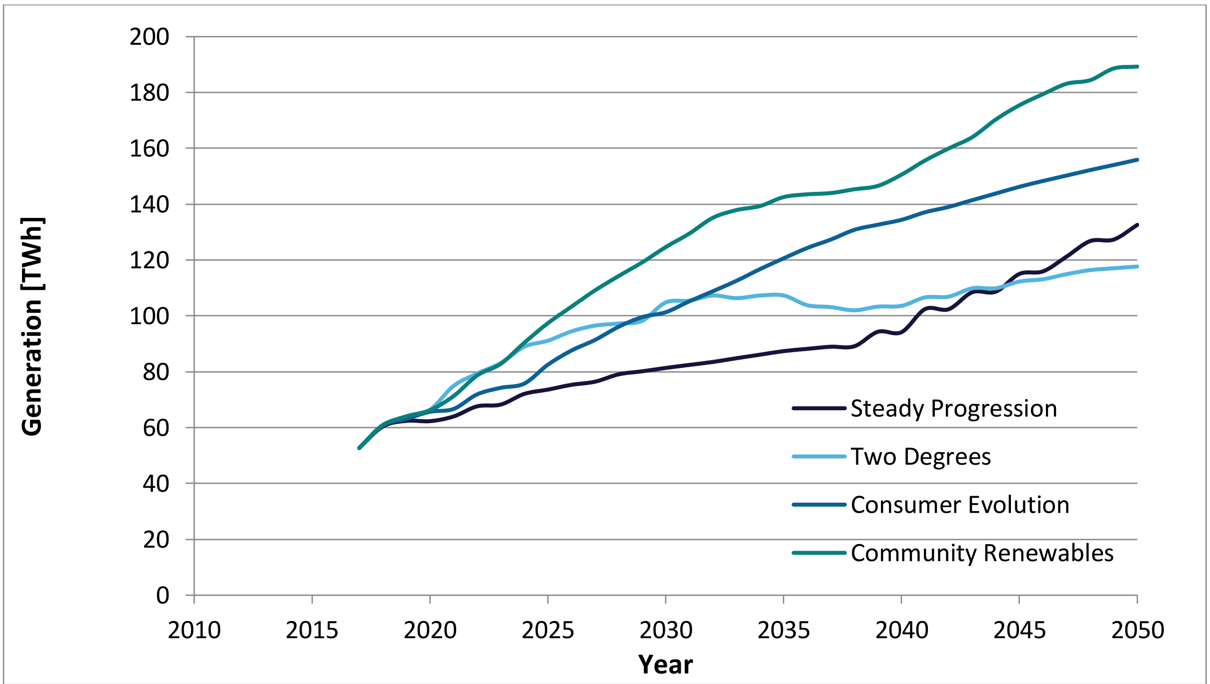


Figure 2.2 Future Energy Scenarios 132/275 kV Applicable Generation Growth in Terawatt Hours



3 Results and Discussion

In order to give a full understanding of the results, an example has been presented of the need for OHL from transmission upgrades and generator grid connections for the Steady Progression scenario. This is the most conservative growth scenario of the four. The example provides an idea of where the need for OHL is greatest in GB and this was broadly consistent across all scenarios.

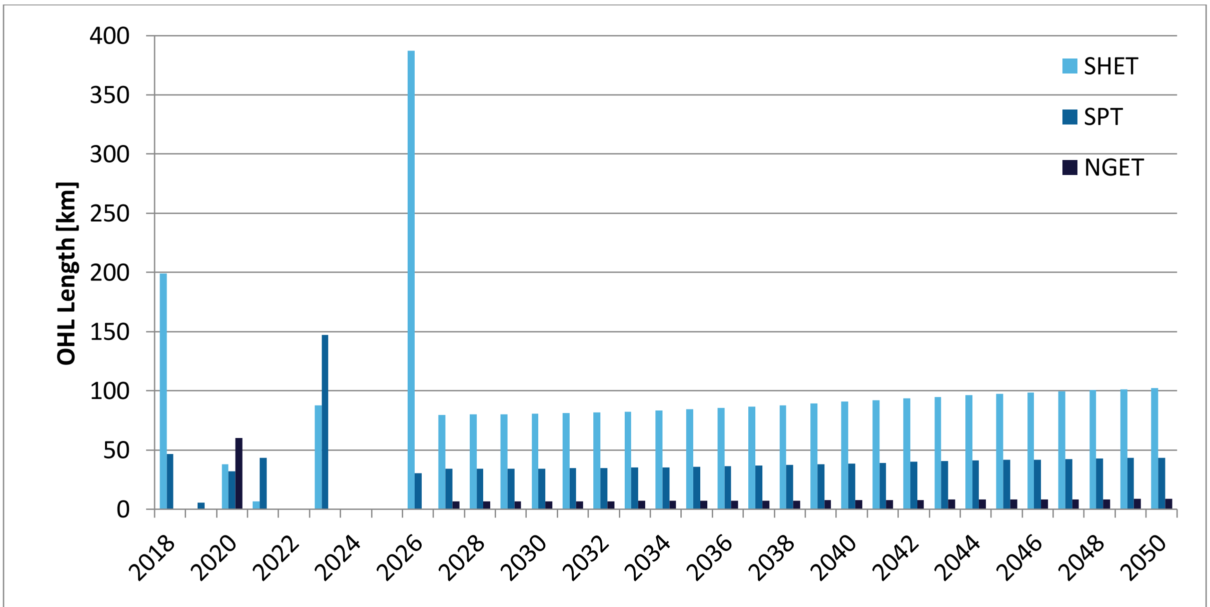
The total need for OHL from each scenario was then described numerically and graphically.

3.1 Need for OHL from Transmission Upgrades

The results indicated a cyclical build programme with SHE-T responsible for the bulk of the 132 kV and 275 kV transmission OHL construction. However, there was some construction planned by SPT and NGET in the middle of the ETYS planning period.

There is limited activity from NGET in the results which was as expected due to the filters placed on the data (see section 2.1 for more detail regarding data interpretation).

Figure 3.1 Need for OHL in the Steady Progression Forecast – Transmission Upgrades Only



3.2 Need for OHL from Generator Grid Connections

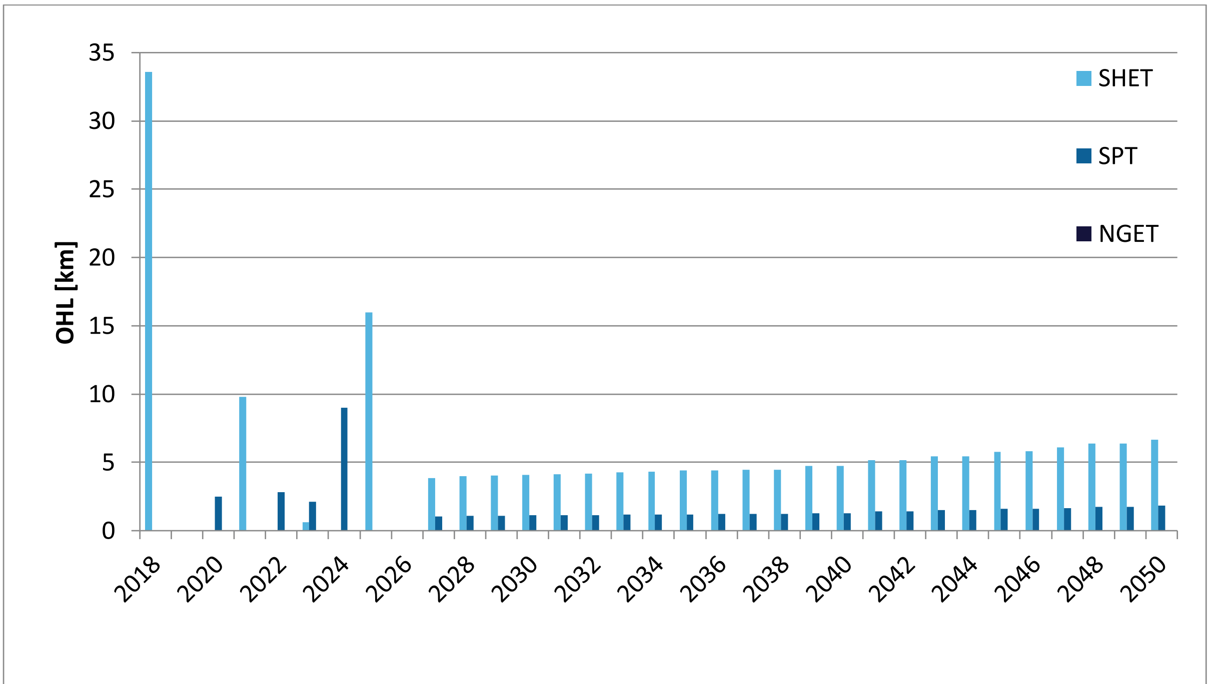
The analysis on the generation grid connections found a much lower need for OHL in comparison to transmission line reinforcement. The timing and amount of OHL required for grid connections was almost random in nature due the changeability of connecting projects. The majority of projects are connecting in SHE-T license area, with fewer connections being required in the SPT license area. It was found that there were no applicable generators in the NGET license area. This was due to generators connecting either via underground cable, wooden pole, using pre-existing assets, or not fitting the filter/assumptions criteria as outlined in section 2.1.

The main generation technologies driving the need for OHL were found to be onshore wind and pumped hydro connections.

Overall it was clear that the contribution from generator side grid connections is comparatively small when considered alongside transmission upgrades. This is not unexpected as, due to the difficulty in obtaining planning permission, the vast majority of private generation developers avoid the use of lattice towers.

It is quite possible therefore that having a less objectionable tower design may increase the take up of OHL grid connection solutions as these are typically significantly cheaper than underground cable solutions.

Figure 3.2 Need for OHL in the Steady Progression Forecast – Generator Grid Connections Only



3.3 Total Need for OHL

Figure 3.3 to Figure 3.6 present the total need for OHL up to 2050 that was suitable for the new suite of tower designs. The graphical information is summarised numerically in Table 3.1.

Table 3.1 Total Need for OHL in Scotland for each of the Four FES Scenarios

Scenario	Total OHL Demand by 2050 in Scotland (km)
Community Renewables	4,528
Consumer Evolution	4,349
Two Degrees	4,466
Steady Progression	4,320

Overall there was a clear and consistent requirement for 132 kV and 275 kV OHL in GB, with at least 4,000 km of OHL required by 2050 across all FES scenarios.

It was clear that the vast majority of the need for OHL was in Scotland due to the transmission upgrades in England/Wales primarily being at 400 kV.

Figure 3.3 Total Need for OHL in the Community Renewables Scenario

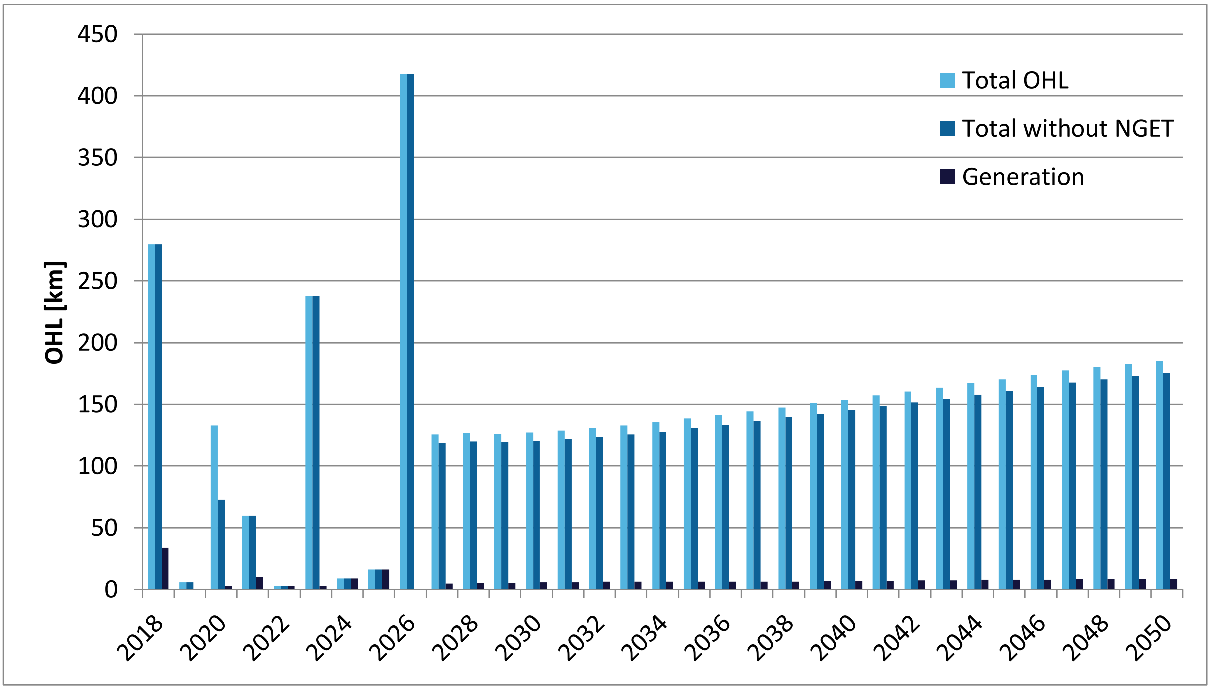


Figure 3.4 Total Need for OHL in the Consumer Evolution Scenario

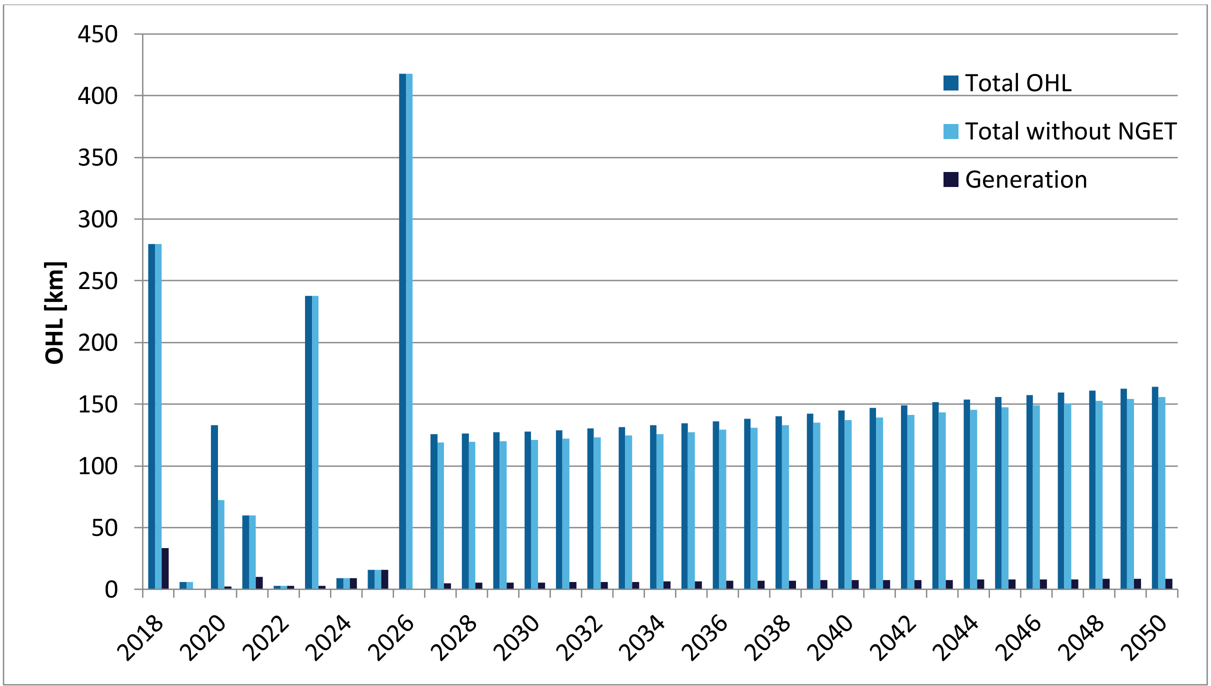


Figure 3.5 Total Need for OHL in the Two Degrees Scenario

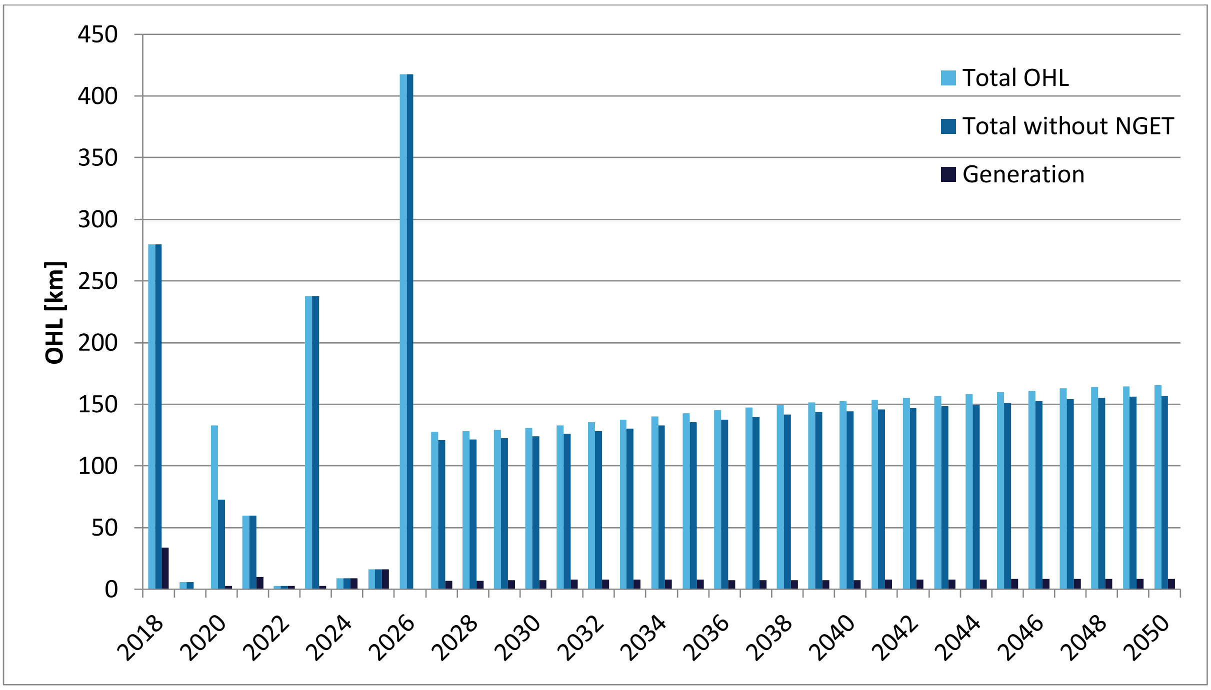
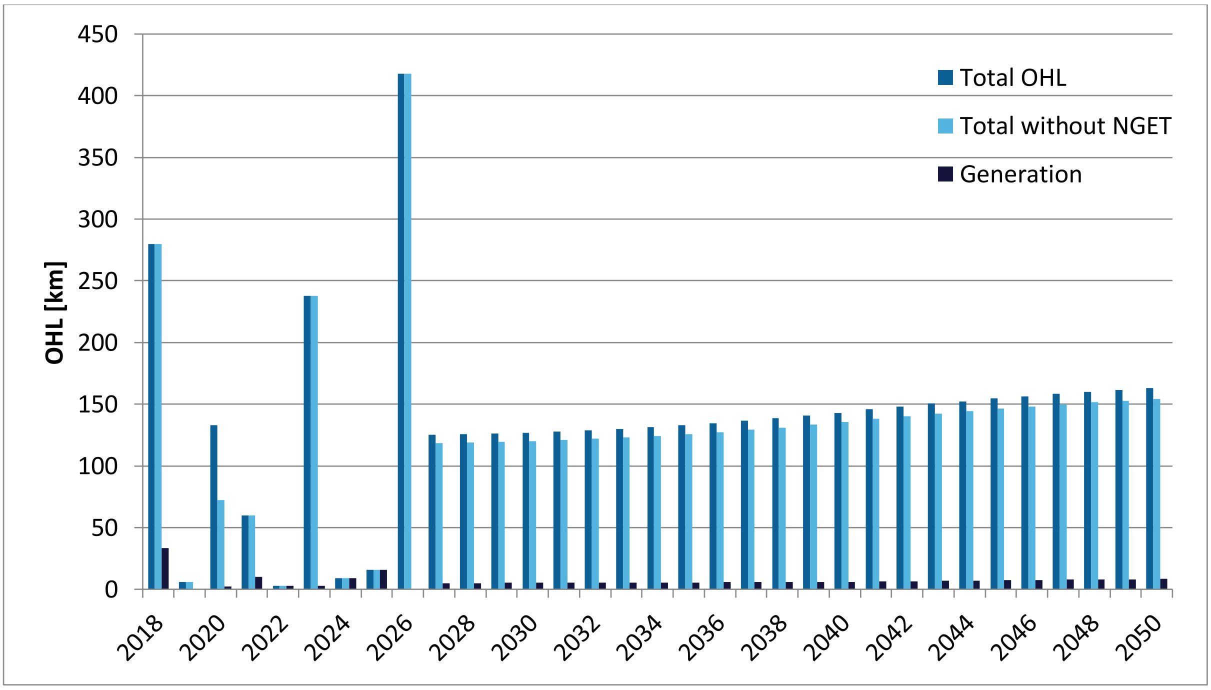


Figure 3.6 Total Need for OHL in the Steady Progression Scenario



4 Conclusions

The analysis on transmission line reinforcement determined a cyclical build programme with SHE-T responsible for the bulk of 132 kV and 275 kV transmission OHL construction. However, there was some construction planned by SPT and NGET in the middle of the ETYS planning period.

An analysis on the English and Welsh distribution lines was not considered to be necessary as the reinforcement work was considered not applicable, in accordance with the original study.

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