SHE Transmission

New Suite of Transmission Structures: NeSTS (SSEN003)

Outputs of Stakeholder Engagement

September 2017

Contents and Overview

Contents

Note: Appendices 2 and 3 are considered confidential.

Overview of NeSTS

Scottish Hydro Electric Transmission (SHE Transmission) proposes to develop and deploy a New Suite of Transmission Structures (NeSTS).

Overhead lines (OHLs) built using transmission structures are the most visible element of the transmission network, and the impact OHLs have on the environment can cause stakeholders concern.

The only available alternative to the steel lattice structures traditionally used in OHL construction is the T-Pylon. Developed by National Grid, the T-Pylon reduces the visual impact of OHLs but may be unsuited to areas with challenging terrain and propensity for severe weather events.

Establishing new infrastructure in these areas is essential to connect renewable generation, so there is a need for a new type of structure to address stakeholder concern.

The NeSTS project will develop innovative designs for OHL structures based on new technologies and techniques. The new suite of structures will then be deployed on the transmission network.

The NeSTS Project seeks to prove the following benefits:

- Improved OHL environmental performance by lowering visual and construction impacts; and
- Lower OHL whole life asset costs via reduced land, construction, maintenance and outage requirements.

Introduction

The Project has engaged with many different stakeholders, and the outputs of these engagements are driving the NeSTS design.

Work with statutory and non-statutory consultees to understand their concerns regarding the environmental impact of OHLs has been undertaken. This has included detailed explanation of the OHL design process and the practical constraints involved.

Their response to the subsequent design work is positive and validates that the engagement process has been effective.

Customers have been polled to confirm that their opinion aligns with that expressed by their consultee representatives.

Licensees have been engaged to understand lessons learned from previous projects, explain the Project objectives and designs, and share its learning.

The supply chain is contributing competing manufacturing and construction solutions to refine the designs and embody them efficiently for use in the trial OHL design.

This report and its appendices describe this process and document its outputs to date.

Appendix 1 lists the stakeholders engaged to date.

The Project has designed a medium duty suite of supports at 275kV which embodies these outputs, and is currently designing a 132kV medium duty suite of supports to suit a change in network requirements for the NeSTS trial OHL.

Stakeholder engagement continues, and review of the trial OHL design will provide the next opportunity to validate the process.

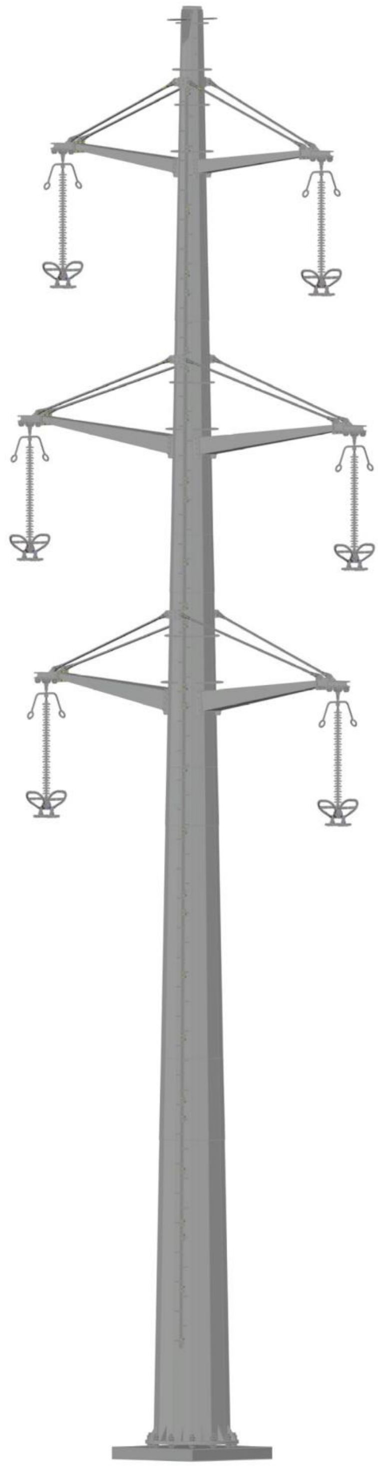


Figure 1: NeSTS 275kV Medium Duty D2 Support

Outputs of Stakeholder Engagement

Functional Requirements

Functional requirements for the NeSTS project were developed with internal stakeholders (the wider SHE Transmission team) at a design review on 4 February 2016.

A video summary of the event is available on the Project website - www.NeSTSproject.com.

The functional requirements are embodied in the design briefs for the suites of supports. The design briefs will form the bases of their technical specifications.

The design brief for the 275kV Medium Duty Suite is shown in Appendix 2.

The design brief for the 132kV Medium Duty Suite is shown in Appendix 3.

Figure 2: The 510x Design Concept

Concept Selection

8 design concepts, developed by the preceding Network Innovation Allowance project (NIA_SHET_0010), were compared.

In addition to comparison against the functional requirements gathered from the wider SHE Transmission team, and the requirements of regulations and technical specifications, consultee stakeholders were invited to assess the design concepts against their environmental requirements.

Their analysis was enabled by visualisations and assessments provided by Ash Design & Assessment, a company of landscape architects expert in this area, and by models and assessments provided by Energyline, the specialist overhead line design company employed to design the NeSTS.

The results were delivered at an event on 19 May 2016, and enabled the selection of a design concept to form the basis of the NeSTS design. The selected design concept is shown in Figure 2.

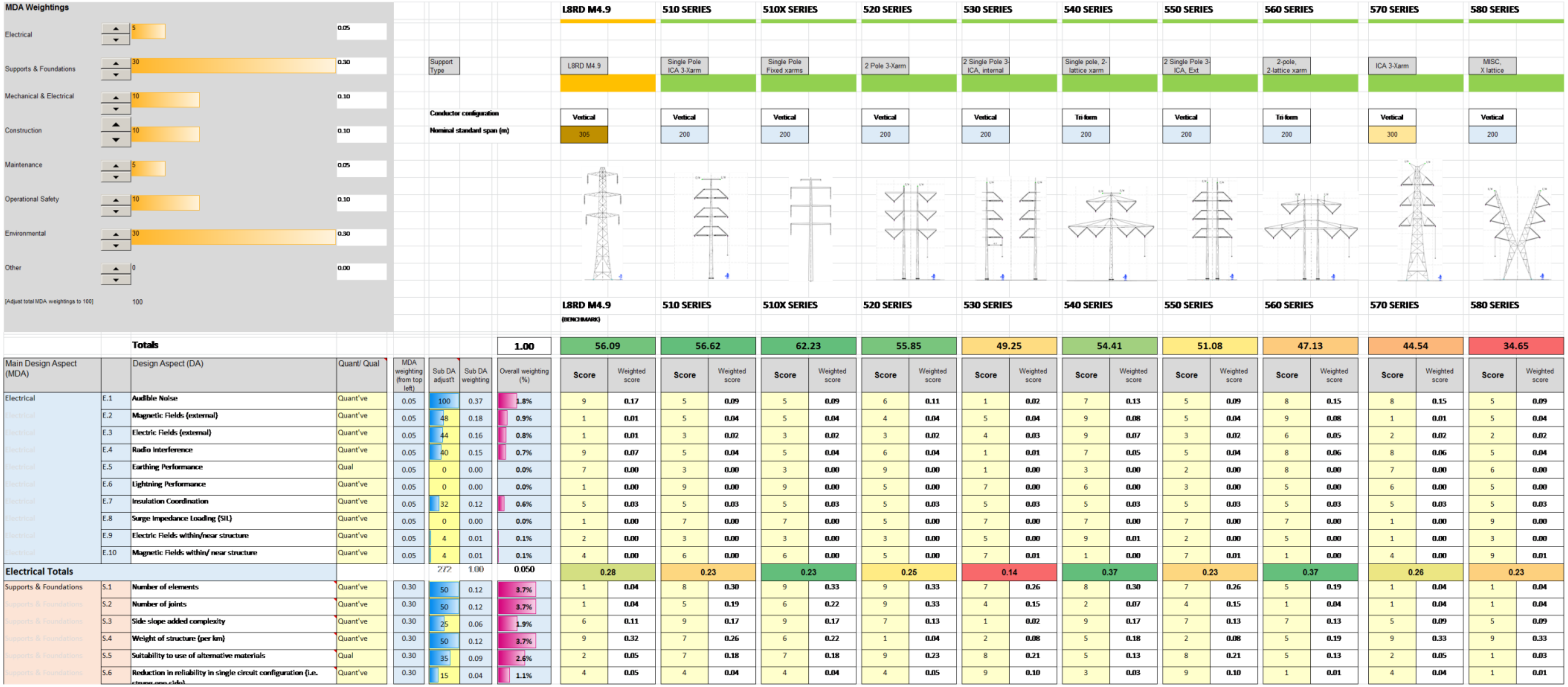
The event was facilitated by Social Market Research, independent experts in stakeholder engagement, whose reporting of the event is shown in Appendix 4.

The building design consensus was discussed with Great Britain (GB) Transmission Owners (TOs) on 13 July 2016 at an event kindly hosted by National Grid Electricity Transmission (NGET) at its Eakring training centre. Learning from the T-pylon and other OHL support work was shared, and its implications to NeSTS were discussed.

The combination of these assessments and learning were embodied in the Support Assessment Matrix (SAM) and the NeSTS Design Selection reported as the Project's first SDRC on 30 September 2016. A snapshot of the SAM is shown in Figure 3.

This learning was presented to the Low Carbon Networks and Innovation (LCNI) conference on 13 October 2016. Video summaries of both events, and electronic copies of the information presented to the LCNI conference are available on the Project website.

Outputs of Stakeholder Engagement



MDA Weightings		
Electrical	5	0.05
Supports & Foundations	30	0.30
Mechanical & Electrical	10	0.10
Construction	10	0.10
Maintenance	5	0.05
Operational Safety	10	0.10
Environmental	30	0.30
Other	0	0.00
[Adjust total MDA weightings to 100]	100	

	L8RD M4.9	510 SERIES	510X SERIES	520 SERIES	530 SERIES	540 SERIES	550 SERIES	560 SERIES	570 SERIES	580 SERIES
Support Type	L8RD M4.9	Single Pole ICA 3-Xarm	Single Pole Fixed xarms	2 Pole 3-Xarm	2 Single Pole 3-ICA, internal	Single pole, 2-lattice xarm	2 Single Pole 3-ICA, Ext	2-pole, 2-lattice xarm	ICA 3-Xarm	MISC, X lattice
Conductor configuration	Vertical	Vertical	Vertical	Vertical	Vertical	Tri-form	Vertical	Tri-form	Vertical	Vertical
Nominal standard span (m)	305	200	200	200	200	200	200	200	300	200

L8RD M4.9 (BENCHMARK) | 510 SERIES | 510X SERIES | 520 SERIES | 530 SERIES | 540 SERIES | 550 SERIES | 560 SERIES | 570 SERIES | 580 SERIES

Main Design Aspect (MDA)		Design Aspect (DA)	Quant/ Qual	MDA weighting (from top left)	Sub DA adjust't	Sub DA weighting	Overall weighting (%)
		Totals					1.00
Electrical	E.1	Audible Noise	Quant've	0.05	100	0.37	1.8%
Electrical	E.2	Magnetic Fields (external)	Quant've	0.05	48	0.18	0.9%
Electrical	E.3	Electric Fields (external)	Quant've	0.05	44	0.16	0.8%
Electrical	E.4	Radio Interference	Quant've	0.05	40	0.15	0.7%
Electrical	E.5	Earthing Performance	Qual	0.05	0	0.00	0.0%
Electrical	E.6	Lightning Performance	Quant've	0.05	0	0.00	0.0%
Electrical	E.7	Insulation Coordination	Quant've	0.05	32	0.12	0.6%
Electrical	E.8	Surge Impedance Loading (SIL)	Quant've	0.05	0	0.00	0.0%
Electrical	E.9	Electric Fields within/near structure	Quant've	0.05	4	0.01	0.1%
Electrical	E.10	Magnetic Fields within/ near structure	Quant've	0.05	4	0.01	0.1%
Electrical Totals					272	1.00	0.050
Supports & Foundations	S.1	Number of elements	Quant've	0.30	50	0.12	3.7%
Supports & Foundations	S.2	Number of joints	Quant've	0.30	50	0.12	3.7%
Supports & Foundations	S.3	Side slope added complexity	Quant've	0.30	25	0.06	1.9%
Supports & Foundations	S.4	Weight of structure (per km)	Quant've	0.30	50	0.12	3.7%
Supports & Foundations	S.5	Suitability to use of alternative materials	Qual	0.30	35	0.09	2.6%
Supports & Foundations	S.6	Reduction in reliability in single circuit configuration (i.e. strung one side)	Quant've	0.30	15	0.04	1.1%

	L8RD M4.9		510 SERIES		510X SERIES		520 SERIES		530 SERIES	
Totals	56.09		56.62		62.23		55.85		49.25	
	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score
E.1	9	0.17	5	0.09	5	0.09	6	0.11	1	0.02
E.2	1	0.01	5	0.04	5	0.04	4	0.04	5	0.04
E.3	1	0.01	3	0.02	3	0.02	3	0.02	4	0.03
E.4	9	0.07	5	0.04	5	0.04	6	0.04	1	0.01
E.5	7	0.00	3	0.00	3	0.00	9	0.00	1	0.00
E.6	1	0.00	9	0.00	9	0.00	5	0.00	7	0.00
E.7	5	0.03	5	0.03	5	0.03	5	0.03	5	0.03
E.8	1	0.00	7	0.00	7	0.00	5	0.00	7	0.00
E.9	2	0.00	3	0.00	3	0.00	3	0.00	5	0.00
E.10	4	0.00	6	0.00	6	0.00	5	0.00	7	0.01
Electrical Totals	0.28		0.23		0.23		0.25		0.14	
S.1	1	0.04	8	0.30	9	0.33	9	0.33	7	0.26
S.2	1	0.04	5	0.19	6	0.22	9	0.33	4	0.15
S.3	6	0.11	9	0.17	9	0.17	7	0.13	1	0.02
S.4	9	0.32	7	0.26	6	0.22	1	0.04	2	0.08
S.5	2	0.05	7	0.18	7	0.18	9	0.23	8	0.21
S.6	4	0.05	4	0.04	4	0.04	4	0.05	9	0.10

	540 SERIES		550 SERIES		560 SERIES		570 SERIES		580 SERIES	
Totals	54.41		51.08		47.13		44.54		34.65	
	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score
E.1	7	0.13	5	0.09	8	0.15	8	0.15	5	0.09
E.2	9	0.08	5	0.04	9	0.08	1	0.01	5	0.04
E.3	9	0.07	3	0.02	6	0.05	2	0.02	2	0.02
E.4	7	0.05	5	0.04	8	0.06	8	0.06	5	0.04
E.5	3	0.00	2	0.00	8	0.00	7	0.00	6	0.00
E.6	6	0.00	3	0.00	5	0.00	6	0.00	5	0.00
E.7	5	0.03	5	0.03	5	0.03	5	0.03	5	0.03
E.8	7	0.00	7	0.00	7	0.00	1	0.00	9	0.00
E.9	9	0.01	2	0.00	5	0.00	1	0.00	3	0.00
E.10	1	0.00	7	0.01	1	0.00	4	0.00	9	0.01
Electrical Totals	0.37		0.23		0.37		0.26		0.23	
S.1	8	0.30	7	0.26	5	0.19	1	0.04	1	0.04
S.2	2	0.07	4	0.15	1	0.04	1	0.04	1	0.04
S.3	9	0.17	7	0.13	7	0.13	5	0.09	5	0.09
S.4	5	0.18	2	0.08	5	0.19	9	0.33	9	0.33
S.5	5	0.13	8	0.21	5	0.13	2	0.05	1	0.03
S.6	3	0.03	9	0.10	1	0.01	4	0.04	1	0.01

Figure 3: Support Assessment Matrix Scores of the NeSTS Design Concepts and Benchmark

Span

The concept was originally designed for a standard span of 200m, resulting in lower structure heights than the benchmark L8RD lattice design (which has a standard span of 305m).

Stakeholders advised that the lower number of structures supporting an overhead line offered by an increase in standard span, and the consequent reduced visual clutter and requirements for access, more than offset the impact of increased height in most circumstances.

In response, the standard span for the NeSTS 275kV and 132kV suites was changed to 300m.

At 132kV, the lattice benchmark is the L7 which has a standard span of between 229 and 290m depending on the severity of the climatic loading.

At 275kV, NeSTS will deliver approximately the same number of supports per kilometre of OHL as the lattice steel equivalent. At 132kV, it will deliver a marginal reduction in the number of supports per kilometre.

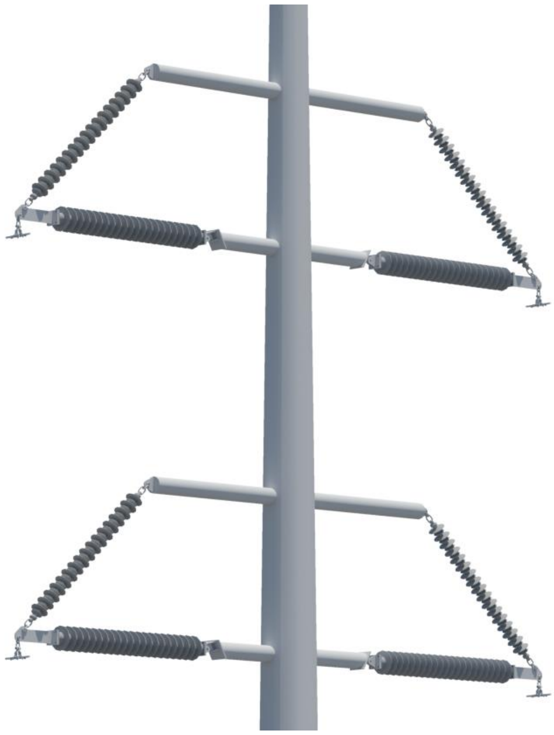


Figure 4: Insulators in Horizontal Vee Configuration

Insulator and Earth Wire Configuration

The use of insulators in horizontal vee configuration, illustrated in Figure 4,used on the 510 concept design enabled a compaction in OHL corridor width.

However, consultee stakeholders and landscape architects reacted negatively to their visual impact.

Furthermore, detailed assessment of their accessibility revealed that new access and earthing procedures would need to be developed to enable their use, and that these new procedures would fail to meet some functional requirements relating to access.

Therefore, the insulator configuration was changed to use the single strings preferred by consultees, which will meet the functional requirements, at the cost of the compaction in OHL corridor width.

This decision removed the need for a second earth wire, which had been required to enable safe maintenance in the compacted design.

So NeSTS designs will support a single earth wire.

Outputs of Stakeholder Engagement

Accessibility

Detailed analysis of maintenance procedures included examination of access provisions.

The functional requirements for safe access during a single circuit outage, and for access to be available for climbing operatives using standard equipment constrained this work.

The results were discussed at a Cross Arm and Access Design Review in October 2016 where options for cross arm and access detail design were developed with the SHE Transmission Operations team.

This resulted in the addition of 2 climbing tracks, each biased towards one circuit, and stays which connect the cross arm tips to the main pole body. These provide fall arrest anchorage and body support for operatives accessing the cross arms and earth wire.

Cross Arm Upsweep

A five degree upsweep was also approved at this review. It was recommended by the Project's landscape architects as an aesthetic improvement.

Following discussion with the supply chain, this was accentuated by tapering the profile of the cross arms towards their tips.

The output of these changes when applied to the NeSTS 275kV suspension support is shown in Figure 5. Please note that the increase in pole diameter shown relates to a change in conductor load (from single Araucaria to twin Rubus).

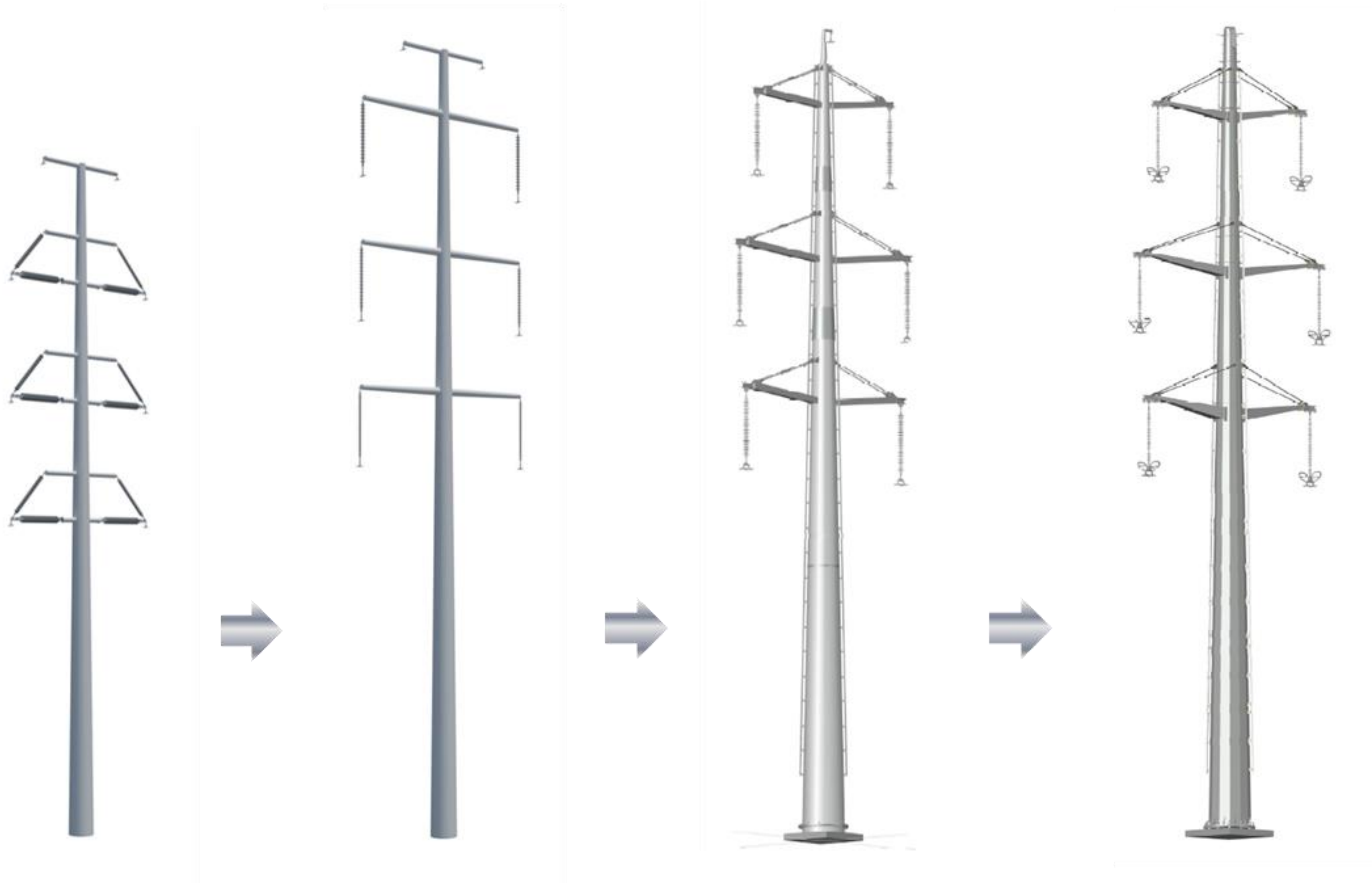


Figure 5: NeSTS 275kV Suspension Support Design Evolution to March 2017

Outputs of Stakeholder Engagement

Tension Support Continuity

Although the majority of the supports used in most overhead lines will be suspension supports, continuity with the various tension supports required is an important factor in overall visual impact.

Some discontinuity is inevitable because of the different plane of the insulators when in tension, and because of the associated increased clearance between the earthwire and the cross arms.

Discontinuity can be compounded where tension supports appear larger than suspension supports or use asymmetric cross arms in contrast to the symmetric arrangement on suspension supports.

This is a design aspect in the SAM and was therefore influential in the assessment of design concepts. Following discussion of this with consultee stakeholders and landscape architects, the Project prepared photomontages of tension support design options to establish how continuity can best be achieved.

This involved comparison of single and twin pole designs and of asymmetric and symmetric cross arms. It resulted in overwhelming rejection of the twin pole and asymmetric cross arm designs.

A visualisation to enable comparison is shown in Figure 6. A D30 tension structure is followed by 2 suspension structures then another D30 in each image.

Figure 6: Comparison of Single and twin Pole Tension Structures in Strath Landscape

Outputs of Stakeholder Engagement

Consultee Stakeholder Assessment

Consultee stakeholders agreed with this conclusion and ratified the design response to their inputs at an event on 27 February 2017 and at subsequent interviews—with those who could not attend the event—held through June 2017.

As previously, their analysis was enabled by visualisations and assessment methods provided by Ash Design & Assessment and by design information, models and contextual information provided by Energyline.

The evidence pack is available on the Project website, and a visual comparison between the NeSTS 275kV medium duty design and the benchmark L8RD lattice design in an upland moorland landscape is shown in Figure 7.

Figure 7: NeSTS 275kV MD and L8RD Benchmark in Upland Moorland

Outputs of Stakeholder Engagement

The visual impact assessment methodology used was developed by Ash and scrutinised by the late Mark Turnbull (Fellow of the Landscape Institute) following feedback from stakeholders regarding their use of the SAM in the first event.

It enables more qualitative assessment and is easier to use than the SAM. The intention is to develop this methodology to use in assessing the trial OHL which is currently being designed.

The methodology is shown in Appendix 5.

A graphical interpretation of the results of stakeholder assessments of the evidence at the second event using it is shown in Figure 8. A neutral response is translated into a 3, a very good response into a 5, and a very poor response into a 1. The thin coloured lines superimposed on the chart bars indicate the range of responses.

The chart shows that consultee stakeholders continue to anticipate a substantial reduction in the visual impact of OHLs constructed using NeSTS supports in comparison to lattice steel alternatives, and that their assessments of NeSTS are more convergent than their assessments of lattice steel.

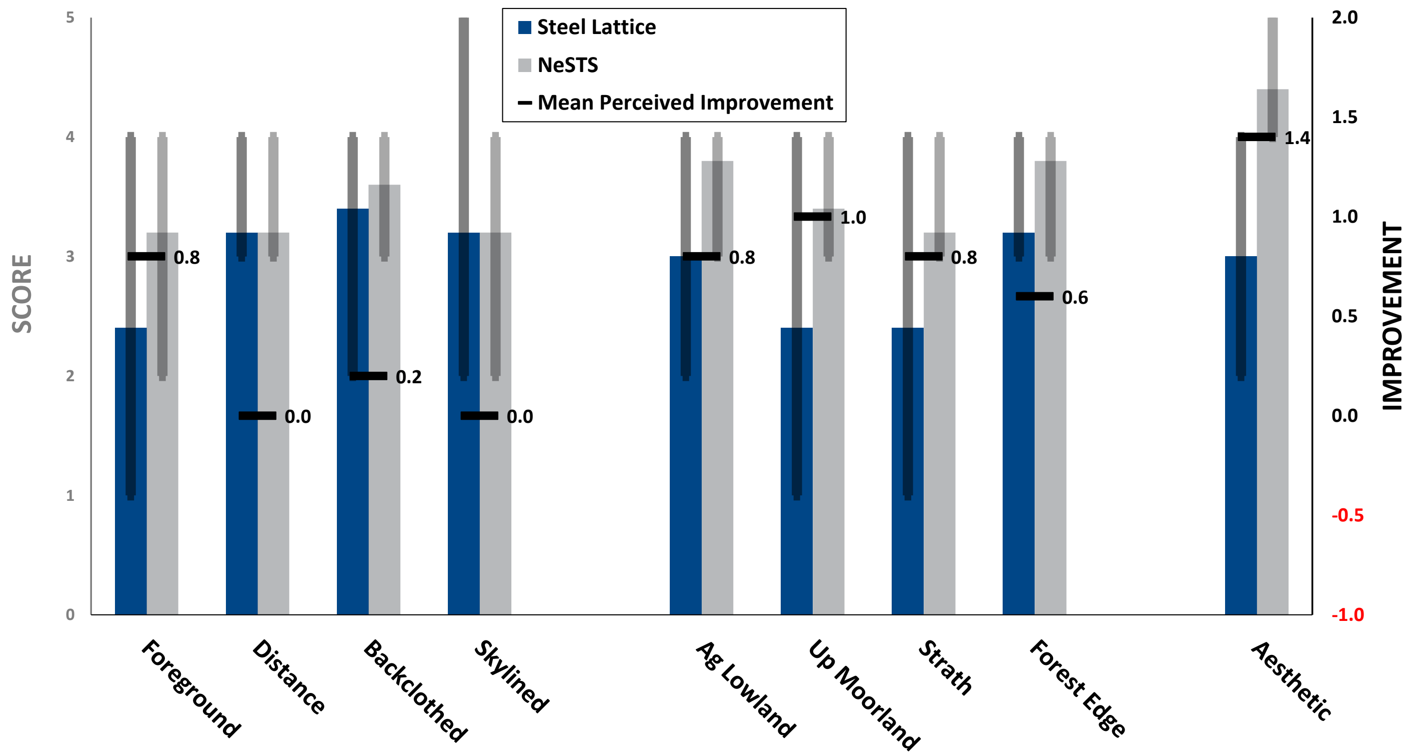


Figure 8: Consultee Stakeholder Visual Impact Assessment Summary

The event and interviews were facilitated by Social Market Research whose reporting of these is shown in Appendix 6.

The reports relay continued strong support and enthusiasm for the Project from consultee stakeholders.

A video summary of the event is available on the Project website.

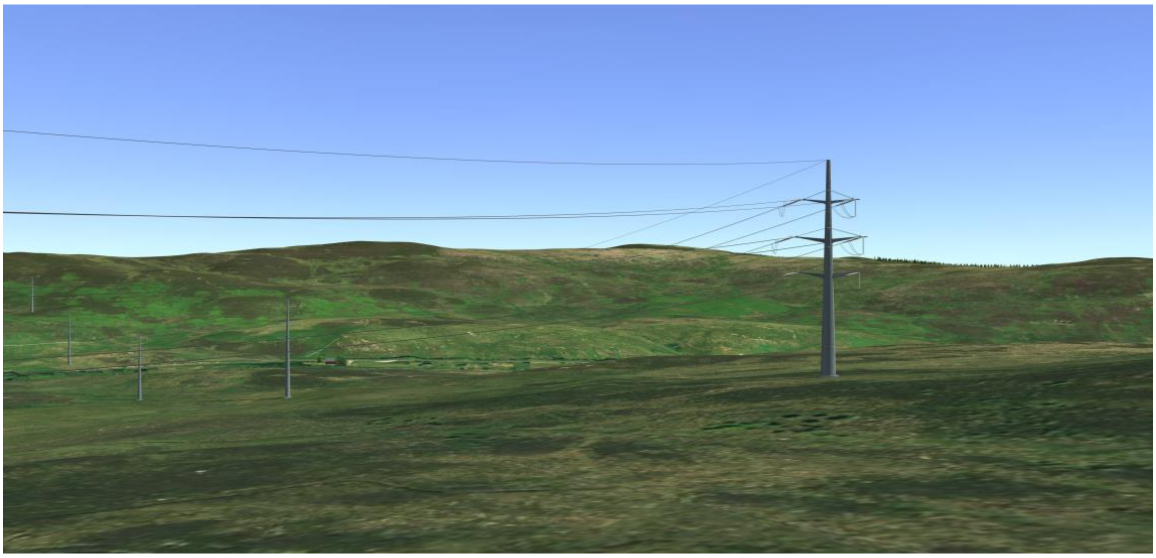
Visualisation Methodology

While the visualisation methodology used thus far will continue to be used, as required by the planning process, 3D visualisations are being developed to enable a richer interaction with the OHL for stakeholders.

This is in response to positive feedback regarding the use of physical models which have enabled understanding of the new structures in three dimensions at events to date.

With the design progressing into siting the new structures in an overhead line, physical models will become impractical and therefore virtual equivalents are being developed, building on the work done in this area by NGET.

Excerpted images from this work, showing a comparison of the NeSTS 275kV medium duty suite and a lattice design using the L8C suite are shown in Figure 9.



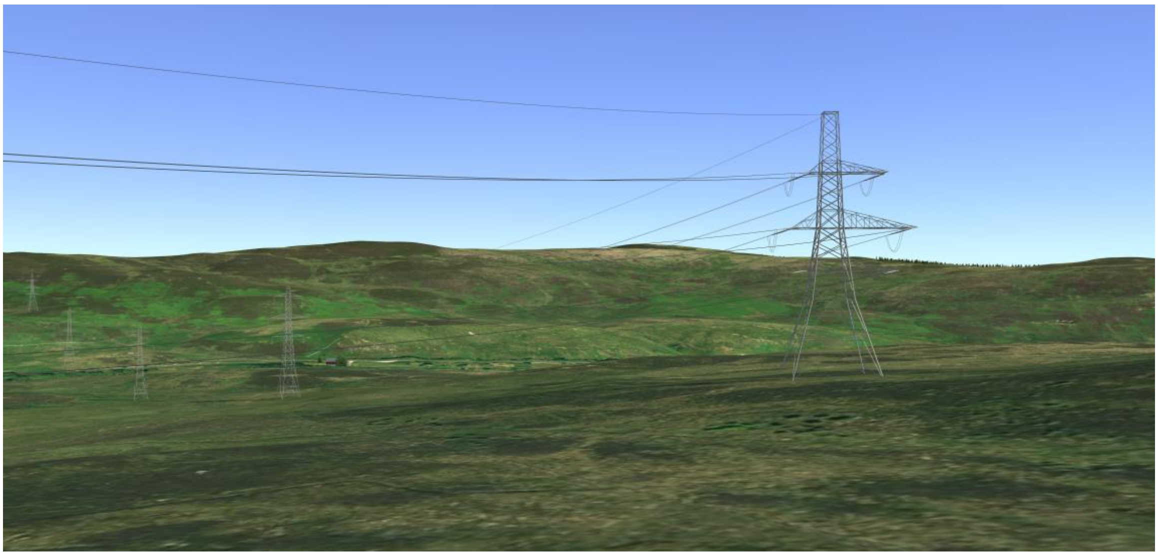


Figure 9: 3D model images of NeSTS and L8C OHLs

Outputs of Stakeholder Engagement

Manufacturing Method

Benchmarking activity has identified many different potential manufacturing methods.

The supply chain has been engaged to identify manufacturing constraints and match the Project's designs to the most cost effective manufacturing solutions.

The designs show the poles being made from folded steel plate comprising sections joined using slip joints, which the Project team currently expect to be the most cost effective solution.

Design optimisation work by manufacturers has already identified substantial opportunity for value engineering, and will result in many more design refinements in the coming months.

However, the Project remains broadly agnostic regarding how the designs are manufactured, and engagement with the supply chain is still active and multi-faceted.

Corrosion Protection

While benchmarking has identified several methods of corrosion protection, the Project currently anticipates that NeSTS supports will be hot dip galvanised.

This is because the method offers a large body of knowledge documenting its longevity.

The OHL support asset life of 80 years is unusually long compared to many other uses of similarly sized steel poles, and it is therefore difficult to transpose confidence in the various alternative solutions which some of them use to this application.

Supplementary protection will be provided externally by paint. There are several potential paint solutions offering coating life between 25 and 40 years, some of which are being tested by a Network Innovation Allowance Project (NIA_SPT_1603).

NeSTS 275kV Medium Duty Suite

The drawings of the NeSTS 275KV Medium Duty Suite are the latest published embodiment of these outputs of stakeholder engagement.

They are shown in Appendix 7.

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