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2 Alternatives: Transmission and Technology

2.1 Executive Summary

1. Alternatives to the proposed Tyrone – Cavan Interconnector have been thoroughly explored by SONI. The consideration of alternative technologies including the use of underground cable is described in detail in Chapter 4, Volume 2 of the Consolidated Environmental Statement (2013) and in Chapter 10, Volume 2 of the Consolidated Environmental Statement Addendum (2015).

2. The 'Do Nothing' alternative was considered. This is the scenario where no development occurs and as a consequence the environmental impacts, identified in the ES, both positive and negative, do not arise. Doing nothing will mean that the identified strategically important needs and objectives of this project, which become more critical as time progresses, will not be addressed. For this reason the 'Do Nothing' alternative was rejected.

3. Non-transmission network alternatives, such as the development of new electricity generation plants in Northern Ireland and/or a new interconnector with Great Britain were considered. It was found that there was no single or combination of such alternatives that would address the identified needs and objectives.

4. There is currently only one high capacity interconnector between Northern Ireland and the Republic of Ireland. The development of a second high capacity interconnector will adequately address all of the identified needs and objectives and is therefore being proposed by the respective applicants (SONI in Northern Ireland and EirGrid in Ireland).

5. There are two electricity transmission technologies by which the proposed Interconnector might be implemented, namely High Voltage Direct Current (HVDC) and High Voltage Alternating Current (HVAC). The HVDC alternative was rejected because it would introduce a significant risk for security of supply, would be significantly more expensive than an HVAC overhead line, and would not be in line with good international practice. An HVAC solution is therefore being proposed by the respective applicants.

6. Implementing the HVAC solution using underground cable was considered. The respective applicants found that due to the electrical characteristics of high voltage underground cable it would not be feasible to underground the entire approximately 135 km length of the proposed Interconnector. An AC overhead line with a power carrying capacity of 1,500 MW and operating voltage of 400 kV is therefore proposed.

7. The partial undergrounding of such an overhead line may be feasible. The respective applicants considered the environmental, technical and cost implications of undergrounding a section of the proposed Interconnector. It was found that installing high voltage underground cable would have an adverse environmental impact albeit the impact would be different to that of the overhead line; the maximum length in total that could be undergrounded would be less than about 10 km; and undergrounding 10 km would add as much as €70 million to the cost of the overall project.

8. The respective applicants did not identify any section of the proposed route which would justify partial undergrounding and are therefore proposing a solution that consists entirely of 400 kV overhead line.

2.2 About the Authors

9. Mr. Mark Norton is the manager of Network Planning at EirGrid Group. He has previously held management roles in Transmission Access Planning and Technology and Standards sections within EirGrid. Prior to joining EirGrid he also held positions in Eastern Electricity, in Great Britain. Overall he has 27 years' experience in the planning and design of electricity networks. He holds an Hons. Degree in Engineering from Anglia Polytechnic University, Cambridge. Mr Norton is a member of the UK Institution of Engineering and Technology (IET).

10. Mr Aidan Geoghegan is currently a technical specialist with EirGrid and is a Chartered Electrical Engineer with over 30 years' experience in the electricity utility industry. Prior to joining EirGrid he was a Project Manager with ESB International where he was responsible for the delivery of transmission projects comprising substations, overhead lines and underground cables. Before that he was the manager of Power System Operations for a utility in South Africa. He holds a degree in engineering from University

College Cork and a post graduate diploma in Project Management from Trinity College Dublin. He is a member of the Institution of Engineering and Technology (IET).

11. Dr Norman MacLeod is the Technical Director specialising in HVDC at Parsons Brinckerhoff. He was formerly Technical Director HVDC at Alstom Grid where he led teams developing 800kV DC technology and VSC HVDC technology. He is a Fellow of the UK Institution of Engineering and Technology (IET) and a Chartered Engineer. He is also a Member of the Institute of Electrical and Electronic Engineers (IEEE). He holds Bachelor and Doctoral degrees in Electrical and Electronic Engineering from the University of Strathclyde.

2.3 Summary of Documents

12. This technical report summarises and incorporates, by reference, the content of the documents submitted in support of the planning applications for the proposed Tyrone-Cavan Interconnector in respect of Transmission and Technology Alternatives. These documents are as follows:

- Section 4.2, Volume 2 of the Consolidated Environmental Statement (pages 61-93); and
- Section 10.2, Volume 2 of the Consolidated Environmental Statement Addendum (pages 124-163)

13. This technical report must therefore be read in conjunction with the Consolidated ES and the Consolidated ES Addendum, and not as a standalone document.

14. In addition it is explained in the Consolidated ES and the Consolidated ES Addendum that in their consideration of the technical alternatives the respective applicants (SONI and EirGrid) have had regard for the findings of a suite of technical reports. Some of these were commissioned by the respective applicants, some by government (UK, Ireland and Denmark) and others by NGOs. A brief summary of the more relevant of these can be found in the Consolidated ES (Sections 4.2.4. and 4.2.5) and/or the Consolidated ES Addendum (Sections 10.2.5 and 10.2.6).

15. In a general sense all EIA documentation is interrelated and, particularly with respect to the interaction of impacts, all the EIA documents are relevant. For clarity the documents the authors consider to be the key documents are summarised above. The reader should form his or her own view on what documents within the Consolidated ES and its Addendum are relevant, and key, to the topic under consideration.

16. In the interest of readability these documents are not reproduced in full in this technical report.

2.4 Scope of Assessment

17. The applicant has identified that there is a need for an electricity transmission development that satisfies the following objectives –

- Improve competition on the all-island electricity market;
- Improve the security of supply across the island; and
- Support the development of renewable generation.

18. The applicant has considered alternative ways by which these objectives might be satisfied. The description of the assessment of these alternatives can be found in Chapter 4, Volume 2 of the Consolidated ES (2013). The main alternatives considered were -

- The "do nothing" alternative;
- Alternatives to a transmission network solution; and
- Alternative transmission circuit technologies.

19. The 2015 Addendum to the Consolidated ES reviews and updates the assessment of alternatives to the proposed Tyrone-Cavan Interconnector.

20. This Technical Report summarises the reasons for the selection of an overhead line as opposed to other potential transmission technologies. It also includes reference to studies and reports produced by internationally recognised consultants, some commissioned

jointly by the applicant and EirGrid, and others independently commissioned by the Republic of Ireland Government. The conclusions from these reports informed SONI and EirGrid's assessment of the alternatives, and confirmed their view that the preferred solution to meet the need for interconnection would be an overhead transmission line.

2.5 The "Do Nothing" Alternative

21. It is best practice in environmental impact assessment to consider the "Do Nothing" alternative – where no development takes place and where no environmental impacts occur.

22. The "Do Nothing" alternative would not mitigate the risk of system separation and would therefore continue to constrain power flows on the existing interconnector. This alternative therefore would not address the three objectives, namely the need to improve the competitiveness of the SEM; address the security of electricity supply issue within the island of Ireland; and to facilitate the meeting of renewable generation targets. There is an immediate need for these objectives to be addressed but this will become even more important in the future. In particular the need to address the security of supply deficit in Northern Ireland which will reach a critical level beyond 2020 when the closure of ageing generation plant or the failure of a generator presents a significant risk of system blackouts and the cost of managing this risk escalates.

23. Given that the "Do Nothing" alternative does not address the three drivers previously mentioned it was not considered further.

2.6 Alternatives to Transmission Network Solutions

24. As outlined in 'Technical Report 1' which addresses the need for the project the security of supply issue in Northern Ireland has been highlighted in successive All Island Generation Capacity Statements.

25. The applicant has explored whether there is an electricity generation solution, rather than a transmission network solution, that might address this security of supply issue and this consideration is discussed in Section 4.2.3 of the Consolidated ES and updated in Section 10.2.3 of the Addendum.

26. It is conceivable that the addition of new generation in Northern Ireland would improve the security of supply issue. Indeed there has been some publicity regarding a new power station in Belfast and also a more mature proposal for the development of a compressed air storage generation plant in Larne. However these are not being proposed by SONI, they are the proposals of private developers, and there is no certainty that they will ever come to fruition.

27. SONI cannot rely on these proposals being delivered, or any other, as yet unknown, proposal for the development of new generation being delivered, when seeking a solution to the security of supply issue; and even if sufficient new generation was guaranteed to be delivered that would still not address either of the other two primary strategic needs, i.e. improving market competition or enabling the increased use of renewable energy.

28. This is because installing new generation in Northern Ireland will not resolve the strategic deficiency identified relating to the inefficiencies in the single electricity market as the transmission network would remain restricted. This transmission network restriction remains because there is still only a single interconnector. As explained in Appendix 3.1 of the Consolidated ES Addendum of the application, this will result in further cost to the consumer as there would be more generation unable to fully access the market on the island of Ireland.

29. Whilst a new generator may alleviate the adequacy issue in Northern Ireland in the short term, it would not deliver the same long term enduring security of supply benefits to the island of Ireland that the second North South interconnector would bring. In the long term the lack of secure interconnection which is essential in maximising the level of generation security that can be shared across the island would not be addressed, nor would the facilitation of renewable generation.

30. SONI continues to assess the connection of new generation and is not aware of any committed large scale generation projects in Northern Ireland which will make a significant contribution to security of supply.

31. A contributory factor to the security of supply issue in Northern Ireland is the fact that a number of existing large conventional generators are approaching their end-of-life and are

scheduled for closure. This was expected to result in a shortage of electricity generation in 2016 with a risk that demand could be not met at all times thereafter. To mitigate this risk SONI entered into an agreement with AES, the owner of Ballylumford Power Station, to delay retiring two of the generators in that station. This agreement will run from 2016 to 2018 (with an option to extend until the end of 2020) and will cost electricity customers in Northern Ireland £8.9 million per year for the first three years. Agreements such as this, which require extending the life of ageing and polluting plant, are short term and cannot be considered as enduring solutions to the security of supply issue.

32. Building further Interconnection to other electricity markets, such as that on the island of Great Britain, will also not resolve the strategic need identified relating to the inefficiencies in the single electricity market on the island of Ireland. With only a single high capacity interconnector between Ireland and Northern Ireland the operation of the single electricity market on the island of Ireland will remain restricted.

33. The most recent Generation Capacity Statement indicated a critical shortage in generation capacity in Northern Ireland beyond 2020. This means that there would then be insufficient generation to meet demand at certain times, requiring the rationing of electricity at those times in order to ensure the safe continuing operation of the system. At the same time there will be a surplus of electricity generation in the Republic of Ireland. The development of a second high capacity North South Interconnector will allow Northern Ireland to draw on that surplus when required. Such an Interconnector will address the security of supply issue while at the same time, as explained in 'Technical Report 1: Need', satisfying the objectives of improving competition on the all-island electricity market and supporting the development of renewable generation.

2.7 Alternative Transmission Technologies and Methods

34. There are several technological alternatives by which a transmission circuit of the capacity required for the second high capacity North South Interconnector could, in theory, be implemented. SONI and EirGrid (the respective applicants) have jointly undertaken an evaluation of the main such alternatives. The evaluation was informed by a number of studies and reports which evaluated potential transmission alternatives specifically for the proposed Interconnector.

35. The respective applicants' evaluation of the main technological alternatives is described in Section 4.2.4 of the Consolidated ES and updated in Section 10.2 of the Addendum. A brief summary of the supporting studies and reports can also be found in these Sections.

36. A comparative assessment of the main technological alternatives was carried out by comparing them against a number of key performance objectives which must be achieved regardless of the particular technological alternative that is actually employed.

37. The project objectives and / or design criteria identified for the comparative assessment are:-

a) Comply with all relevant safety standards;

b) Comply with all system reliability and security standards;

c) Provide an environmentally acceptable and cost effective solution;

d) Have a power carrying capacity in the region of 1,500 MW, and connect between appropriately robust points on the transmission networks north and south of the border;

e) Facilitate future reinforcement of the local transmission network in the north-east area of Ireland;

f) Facilitate future grid connections and reinforcements; and

g) Comply with 'Good Utility Practice' or 'best international practice'.

2.7.1 High Voltage Direct Current (HVDC) and High Voltage Alternating Current (HVAC) Technology

38. There are two forms of electricity technology than can be used for high voltage transmission circuits. These are high voltage direct current (HVDC) and high voltage alternating current (HVAC).

39. The existing electricity transmission system in Northern Ireland is a High Voltage Alternating Current (HVAC or AC) system. Any new transmission project that utilises

HVAC would therefore be an extension of the existing technology, and would fit seamlessly into the existing meshed transmission network on the island of Ireland.

40. High Voltage Direct Current (HVDC or DC) is mostly used to transmit bulk power from one point to another over long distances where HVAC is not technically or environmentally acceptable, e.g. a long (> 50 km) high capacity submarine cable, as used for the existing Moyle Interconnector between Northern Ireland and Scotland

41. Inserting a HVDC circuit between any two points in a HVAC network would require the HVAC electricity to be converted into HVDC electricity at one end, transmitted through cable or overhead line to the other end, where it is converted back from DC to AC, and then transmitted back into the HVAC network. This is inefficient (unless the HVDC circuit is very long) and costly (in terms of the requirement for converter stations) but it is technically feasible.

42. In their joint comparative assessment of HVDC as an alternative to HVAC, the respective applicants have concluded that any option using DC technology is not an appropriate option for the intended nature and purpose of the proposed Interconnector. Specifically –

- It would require a complex and bespoke control system in order to operate within the existing AC network and this brings with it considerable risk for system security and stability;

- It would not facilitate future grid connections and reinforcements as well as any AC option due to the requirement for a converter station at every point of connection to the AC network;

- It would be significantly more expensive to implement than a standard AC overhead line, €670 million more expensive[1]; and

- It would not be considered to comply with good utility practice as there are no examples in the world today of a HVDC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland.

[1] PB Power Technology and Cost Update (July 2013)

43. The use of HVDC technology whether implemented by means of overhead line or underground cable, on land or offshore, was therefore discounted. All further comparison of overhead line and underground cable technologies was restricted to HVAC

2.7.2 Consideration of High Voltage Alternating Current (HVAC) options

44. At 400 kV, overhead line technology conventionally utilises lattice steel towers to support the high voltage electricity conductors. Equivalent underground cable technology involves installation of specialised insulated cables under the ground.

45. An overhead line has a high level of reliability, with most faults being located easily and quickly repaired; it is a flexible technology which can adapt to a variety of topographies; it has a relatively low physical impact on the land it crosses (limited to the tower locations and land within the overhead line corridor); and is considered very cost effective compared with an underground system which has a more complicated construction and design. HVAC overhead line technology for transmission networks represents current international best practice and is the technology around which the transmission network in Northern Ireland, and indeed in Europe and internationally, has been developed to date.

46. Comparatively, international experience confirms that reliability is an issue with underground cable. In the short term, there is potential for prolonged unplanned circuit outages with underground cables. In the long term, the expectation is that as an underground cable gets older, it becomes less reliable. In addition, in the use of underground cable for HVAC transmission, the high capacitance of the cable – meaning that it is able to collect and hold a charge of electricity - presents design and operational difficulties. As a consequence, it is the case that there are no 400 kV HVAC underground cables in the world that are in any way near the length (circa 135 km) required for the proposed Interconnector. The longest of similar voltage and capacity being a circa 40km cable in Tokyo.

47. One of the main advantages of installing underground cables is a reduction in visual impacts associated with the overhead line option. However, installing buried cables introduces other environmental issues specific to that technology, e.g. potential impact on archaeology as a result of excavation works and permanent loss of habitat due to removal

of hedgerows. Furthermore, buried cables occupy a significant amount of land and introduce restrictions on the building of any structures over the cable route (due to the risk of damage during construction and preventing cable access if required).

48. Indeed, because of their higher cost and lower service availability, underground cable is generally only used in urban areas or wherever a constraint has been identified such that no alternative exists other than to use an underground cable.

49. Having regard to the above, in their careful and detailed consideration of alternative AC technology solutions the respective applicants concluded:

a) A 400 kV AC overhead line is the best technical solution for the proposed Interconnector;

b) An entirely undergrounded AC option is not an acceptable solution for the nature, purpose, and extent of this project for technical reasons. The use of long 400 kV AC underground cables on the transmission system is not feasible within the constraints of the respective applicants' statutory obligations to ensure a secure and reliable grid;

c) At 400 kV, an AC underground cable alternative would be significantly more costly to install than the AC overhead line option, €740 million more expensive[2];

2.7.3 Consideration of Partial Undergrounding

50. Partial undergrounding is the term used to describe the undergrounding of a short section, or short sections, of a long transmission circuit that is primarily comprised of an overhead line. Partial undergrounding of lower-voltage 110 kV transmission circuits is common practice in Ireland and internationally. There are no examples of partial undergrounding at the 400 kV level in Ireland; however there are numerous examples elsewhere in Europe. Partial undergrounding of 400 kV AC circuits is therefore technically feasible.

51. When considering partial undergrounding for a 400 kV project, it is essential to understand the environmental, technical and cost implications. These are considered in

[2] PB Power Technology and Cost Update (July 2013)

the round in Section 10.2 of the Consolidated Environmental Statement Addendum. While in Section 10.3 of the Addendum partial undergrounding is considered from the perspective of its potential for mitigating the impact of the proposed overhead line on sensitive landscapes. The issues arising are summarised below.

52. **Environmental Issues:** The width of any corridor that would be required for the number and type of AC underground cables required for the proposed Interconnector would be such that they could not be installed under public roads or under disused railway lines, as these roads and railways are not sufficiently wide. The only practical option would be to install the cables directly across farmland. This would among other things: result in much greater disruption to farming and other activities during the construction phase; require the cutting of a swathe through every hedgerow in its path (leaving a permanent gap); restrict development potential (as no buildings could be permitted to be constructed within an underground cable reserve); and make it necessary to have an enclosed compound (known as a ‘transition station’) at every location where the 400 kV circuit transitions from overhead line to underground cable, thereby requiring an additional land take of about one half of a hectare per transition station. Any section of partial undergrounding of the circuit would require two transition stations – one at either end of the underground portion unless one end is in a main terminal (i.e. end point) substation. These transition stations are themselves relatively large, akin to a small electricity substation, and therefore visually prominent above-ground features.

53. **Technical Considerations:** Inserting a section of underground cable into an overhead line circuit will have a negative effect on the reliability performance of the overall circuit. This is because the underground cable section can be expected to spend more time out of service for repairs (on a per km basis) than the overhead line section and if the cable is out of service then the overall circuit is out of service. In addition due to the previously discussed difficulties resulting from the relatively high capacitance of underground cables there is a limitation on the extent of high voltage underground cable that can be safely absorbed into a typical transmission network, that is an existing network made up almost exclusively of overhead lines. The maximum length of HVAC underground cable that can be absorbed into such transmission networks is directly proportional to the size of that network, the bigger the network the longer the allowable length of cable and vice versa.

For example, in the Netherlands the specified maximum permissible length of a single 400 kV underground cable is 20km. The longest 400 kV underground cable in Europe is a 20km cable installed in London. The transmission system on the island of Ireland is much smaller than that of Great Britain and indeed that of mainland Europe and, consequently, can only accommodate much shorter lengths of 400 kV underground cables than is the case in other larger countries. Having carefully considered the issue of partial undergrounding, and based on the present extent and configuration of the Irish network, the respective applicants consider that the maximum length of 400 kV underground cable which it would be technically feasible to install in total as part of the proposed Interconnector (inclusive of that part of the interconnector located in the Republic of Ireland) is approximately 10km, whether installed in one continuous length or in an accumulation of shorter lengths.

54. **Cost Issues**: 400kV AC underground cable would cost on average €5.4 million per km[3] more to install than the proposed AC overhead line. In addition, given that at least one, and potentially two, transition stations would be required for each section of the circuit that is undergrounded, depending upon the length of an underground section (and therefore the facilities required at each end), the required transition stations could add an additional approximately €5 - €15 million per installation. Based on this it can be estimated that undergrounding 10km of the proposed Interconnector, at some intermediate point on the route, would add an additional €60 to €70 million to the cost of the project.

55. Overall, the respective applicants concluded that partial undergrounding is feasible, if:

a) The length of the proposed Interconnector to be undergrounded is restricted, for technical and operational reasons, to less than approximately 10km, either in one continuous length or an accumulation of shorter lengths; and

b) The cost of using the short length(s) of underground cable can be proven to be an environmentally advantageous and cost-effective way of overcoming an otherwise unavoidable environmental or technical constraint to the preferred overhead line.

[3] €6.3m per km for UGC less €0.9m per km for OHL, PB Power Technology and Cost Update (July 2013).

56. In this regard, neither of the respective applicants has identified any section of the route of the proposed Interconnector where the environmental and / or technical impact of the preferred overhead line is of such significance that partial undergrounding is considered to be a preferable alternative. On the basis of this consideration of alternatives, the respective applicants are therefore proposing that the entire 400 kV circuit be implemented using 400 kV AC overhead line.

2.7.4 Overhead Line Design Alternatives

57. Having regard to the consideration of alternatives above regarding AC / DC and overhead line / underground cable technology, it is concluded that the only technical alternative that provides an acceptable method for achieving the strategic objectives of the proposed Interconnector is AC overhead line with a nominal capacity of 1,500MW. Consideration has been given to constructing the proposed Interconnector using a double circuit design of 275 kV, matching existing high capacity circuits in Northern Ireland, and indeed, the existing North South interconnector. This alternative would meet minimum technical requirements in the short term. However, such an alternative would have no longer term or lifetime cost saving in comparison with a single circuit 400 kV option. The 400 kV option will result in better voltage performance and reduced power losses. In addition to this, it would be the case that any 275 kV double-circuit option would also require the use of lattice-steel support structures, of a larger design, with consequent visual and other impact.

58. In considering alternative designs for the 400 kV overhead line support structures the respective applicants commissioned a number of studies which looked at a range of issues including visual impact on the landscape and technology considerations. The studies evaluated a range of designs that included a number of different lattice steel structures, wooden structures and steel monopole structures. The studies concluded that wooden structures would not be technically feasible for the necessary 400 kV overhead lines due to the heavy mechanical loading requirements and electrical clearance requirements. Steel monopole designs were found to be technically feasible with some benefits (such as a smaller footprint requiring a reduced corridor width and relatively shorter construction duration) when compared with traditional lattice steel structures.

59. However, having regard to the various environmental and technical issues, the studies found that for a 400 kV overhead line, located in a rural setting in Northern Ireland and/or Ireland, a lattice steel structure is preferred. This was on the basis that while monopole designs are sometimes preferred in urban and suburban areas due to a combination of their reduced visual impact and reduced corridor width; the same advantages would not apply for a 400 kV OHL in an entirely rural setting. At 400 kV the superstructure of the monopole design would be a large dense visually intrusive steel pole with a diameter of up to six metres at its base. In addition due to the shorter maximum span that can typically be achieved with a monopole design a greater number of structures are required per kilometre than is the case with the lattice steel design.

60. Having identified lattice steel as the preferred design for the support structures for the proposed Interconnector, different designs were considered. This resulted in four options being advanced for detailed comparative assessment, which were:

a) Classic or standard 401 type structure (as used in the mid-1980s for the existing 400 kV overhead lines in the Republic of Ireland);

b) Modern design of the ‘C-IVI’ (IVI) type;

c) Modern design of the VVV type; and

d) Modern design of the inverted delta type.

The four options are illustrated in Figure 1.

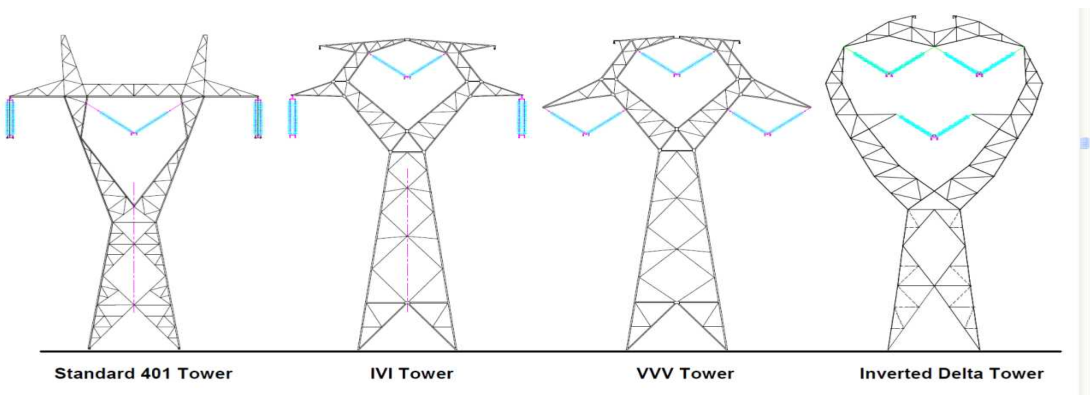

Figure 1: Outline Drawings of lattice Steel Towers

61. The comparative assessment found that the main difference in the visual appearance of the towers, and consequently their ability to more or less successfully be accommodated into the landscape, was related to specific design features, density, outline complexity and phasing arrangements. The 401 design features were such that a relatively denser and more complex structure was created, although the phasing arrangement (shown in blue in Figure 1) was relatively compact and simple. Tower designs IVI and VVV followed a relatively similar structure, although the phasing arrangement and design density was more complex in tower VVV than IVI increasing the former's visual prominence in the landscape. The increased height of the Inverted Delta tower combined with its greater width and bulk creates the most substantial and visually prominent form out of all the structures

62. On the basis of the comparative assessment studies it was considered that the tower design that would most satisfy all required criteria and which represents a balance between landscape and visual impacts and technical requirements for the proposed 400 kV overhead line is the lattice steel structure known as the IVI tower.

2.8 Response to Third Party and Statutory Consultee Submissions

63. None of the statutory consultees made reference to the consideration of alternatives in their submissions.

64. Between 2009 and 2012, there were approximately 6000 third party submissions made in relation to the proposed Tyrone - Cavan Interconnector. These were reviewed and taken into account in the writing of the Consolidated ES. Following the publication of that document in 2013 and between May 2013 and May 2015 2,957 third party submissions were made - of which 737 related to the applicant's preferred choice of technology. All submissions that were made have been taken into account in the writing of the Consolidated ES Addendum.

65. Between June 2015 and November 2016, there have been 594 third party submissions and of these approximately 340 submissions made reference to technology alternatives. A recurring theme raised in submissions was that the applicant has not considered alternatives to the proposal or the consideration of alternatives was inadequate. Many

submissions expressed a preference for the interconnector to be implemented using underground cable. SONI has thoroughly explored the main alternatives to its proposed Tyrone – Cavan Interconnector and has explained its preference for the implementation of the development using 400 kV AC overhead line.

66. A number of submissions contend that public health and safety should be a factor in the consideration of alternatives. One of the criteria considered by SONI in its comparative assessment of the alternatives was that they must comply with all relevant safety standards. In the case of the main technological alternatives SONI found them all to be equally safe from both a public and electricity utility personnel perspective and so safety was not a deciding factor in the choice of the preferred technology.

67. A small number of submissions contend that there have been recent advances in underground cable technology that make the undergrounding of the proposed Tyrone – Cavan Interconnector now feasible and cost effective. SONI's consideration of the underground cable alternative is based on up to date knowledge of the technology and costs.

68. One submission suggests that undergrounding the proposed Tyrone – Cavan Interconnector is feasible because overhead lines are being undergrounded in the New Forest, Peak District and Snowdonia and that National Grid has set aside £500 million for this project. SONI is aware of this project. There are approximately 570 km of existing high voltage overhead lines, supported on pylons, running through 30 National Parks and designated Areas of Outstanding Natural Beauty (AONBs) in England and Wales. These lines were built in the 1950s and 60s when less consideration was given to their visual impact than would now be the case. A national consultation was carried out to determine the public's willingness to pay for the undergrounding of these legacy overhead lines. The outcome of this consultation was that Ofgem, the energy regulator for England and Wales, authorised the spending of £500 million for the undergrounding of the most visually intrusive sections. National Grid the owner of the lines estimates that undergrounding a section of existing line will cost £20 -£22 million per km. This is 10 times more expensive than the cost of building a one km section of equivalent overhead line. The £500 million budget is therefore sufficient to underground approximately 25km, or less than 4.5%, of

the existing 570 km of overhead lines. National Grid has drawn up a shortlist of candidate sections for undergrounding, totalling 25km in length. These are located in the National Parks of Snowdonia, Peak District, New Forest and Brecon Beacons and in the Dorset, Tamar Valley, High Weald and North Wessex Downs AONBs (Areas of Outstanding Natural Beauty). When considering the undergrounding of these existing overhead lines in England and Wales in the context of this proposed Tyrone – Cavan Interconnector development it is important to note that the route of the proposed Interconnector avoids National Parks and designated AONBs.

69. In general the submissions by third parties did not raise any material considerations or any issues that were not dealt with in the Consolidated ES and Addendum. The issues raised by the submissions are examined, analysed and evaluated in Chapter 4 of the Consolidated ES (Volume 2) and in Chapter 10 (Volume 2) of the Consolidated ES Addendum.

2.9 Conclusions

70. The consideration of the main transmission and technology alternatives as outlined in this technical report demonstrates the process undertaken by the parties to inform the available technological alternatives having regard to their likely environmental impact.

71. The process undertaken has shown that there are no non-transmission alternatives (such as the addition of new electricity generation plant in Northern Ireland) that would address the identified needs and drivers for this project.

72. The only option that satisfies all of the identified needs is the development of a second high capacity interconnector between Northern Ireland and Ireland.

73. Implementing such an interconnector using HVDC technology was rejected because it would introduce a significant risk for security of supply across the island of Ireland; it would be significantly more expensive than an HVAC overhead line and would not be in line with good international practice.

74. It is not technically feasible to underground the proposed Interconnector using HVAC underground cable for its entire approximately 135 km length as the distance is too great.

75. Partial undergrounding of the proposed Interconnector using HVAC underground cable may be feasible but only up to a maximum total length of about 10 km; installed in one continuous length or in an accumulation of shorter lengths.

76. No section of the route was identified where partial undergrounding could be justified. This followed a balanced consideration of the environmental, technical and cost issues arising.

77. The preferred option for the proposed Tyrone – Cavan Interconnector is a single circuit 400 kV overhead line for its entire length.

78. The preferred design of the 400 kV overhead line is one based on the use of the lattice steel structure known as the ‘IVI’ tower.

79. SONI has therefore concluded that the examination of the transmission alternatives, as summarised above and described in the Consolidated ES and its Addendum, fully supports the proposal to construct the proposed Interconnector by means of an overhead transmission line using HVAC technology.