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3 Alternatives – Transmission and Technology

3.1 Executive Summary

1. Alternatives to the proposed Tyrone – Cavan Interconnector, including the use of underground cabling, have been thoroughly explored by SONI. The consideration of alternative technologies 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. In the SONI Statement of Case and in particular in 'Technical Report 2: Alternatives – Transmission and Technology' it was noted that a recurring theme arising in letters of objection to the proposed Tyrone – Cavan Interconnector was that SONI had not considered alternatives to the proposal or that the consideration of alternatives was inadequate. SONI's consideration of alternatives was set out in some detail in its Statement of Case and this clearly demonstrates that SONI has undertaken a proper consideration of the alternatives.

3. In the SEAT Statement of Case the assertion that SONI has not undertaken a "*proper consideration*" of alternatives is once again made. Similar assertions are made in the Statements of Case by Boyd Eagleson, Liz Drew and James McNally. That assertion is firmly rebutted in this Rebuttal Report.

4. Most of SEAT's criticism of the consideration of the alternatives is aimed at EirGrid, and EirGrid's application for planning consent for that part of the proposed Interconnector located in Ireland rather that at SONI and SONI's application for the Tyrone – Cavan Interconnector in Northern Ireland.

5. It is the case however that the consideration of alternatives for the proposed Interconnector was undertaken jointly by the respective applicants, first EirGrid and NIE and subsequently EirGrid and SONI. The consideration of alternatives in the two jurisdictions is therefore effectively the same, and only diverges where specifics which are related to each respective jurisdiction occur. An example of this would in relation to consideration of the alternatives with regard to the both Northern Irish and Irish government

national and local policies. Criticism of EirGrid's consideration of the alternatives is therefore considered equally to be criticism of SONI's consideration of the alternatives. Similarly statements by independent and authoritative persons and bodies supporting EirGrid's position that a full and proper consideration of the main alternatives to the proposed Interconnector have been carried out must be considered to apply equally to SONI's consideration of the alternatives.

6. In its rebuttal of the assertions that it has not undertaken a proper consideration of the alternatives SONI therefore references the work by the Independent Expert Panel (IEP) appointed by Ireland's Minister for Energy. The IEP reported to the Minister that the way EirGrid has compared the transmission options, specifically the overhead and underground options, is fair, transparent and comprehensive. This finding applies equally to SONI's consideration of the transmission options.

7. In Ireland An Bord Pleanála has granted consent for EirGrid's application. In doing so the Board was unanimous in accepting the recommendation of its Inspector that consent should be granted. That Inspector presided over the public oral hearing at which many objectors to EirGrid's application made the very same arguments that are now being made against this application in regard to the consideration of alternatives. On page 180 of her report to the Board the Inspector concluded on the issue of transmission and technology alternatives to the proposed Interconnector -

> *"having taken into considerations all of the arguments made, the strategic importance of the proposed interconnector as part of the all-island transmission network, the lack of existing strong interconnection between Ireland and Northern Ireland and the overwhelming need for reliability and security of supply, on balance it would appear that the technology currently best suited to satisfy the requirements of the proposed North-South Interconnector development is an overhead high voltage alternating current power line".*

8. This is a strong statement of support from an independent, authoritative and well informed person for SONI's contention that it has also undertaken a thorough and proper consideration of the alternatives.

9. The only new information raised in objector's Statements of Case that it is claimed supports the assertion that the proposed Interconnector could be

implemented using High Voltage Direct Current (HVDC) underground cable rather than the proposed High Voltage Alternating Current (HVAC) overhead line is the recently proposed Aachen to Liege project, also known as the ALEGrO project, a HVDC interconnector between Germany and Belgium. This project was not discussed in SONI's Consolidated ES Addendum or Statement of Case nor was it discussed at the oral hearing in Ireland. It is however addressed here in Section 3.10 where it is found to fall within the same category as the previously discussed France-Spain and Norway-Sweden HVDC interconnectors and that therefore its proposal, does not change SONI's conclusion that implementing the proposed interconnector using HVDC technology on the island of Ireland would not be considered as complying with 'good utility practice' or complying with 'good international practice'.

10. The Armstrong Family in their Statement of Case call for the implementation of the findings of the Askon Report (2008). That Report concluded that it would be technically feasible to underground the proposed Interconnector using HVAC underground cable. An International Expert Commission (IEC) appointed by Ireland's Minister for Energy reviewed that report and concluded that it was flawed and wrong in its conclusions. The IEC went on to recommend against undergrounding the proposed Interconnector using HVAC underground cable. SONI concurs with that recommendation.

3.2 About the Authors

11. 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).

12. 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).

13. 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.

3.3 Policy

14. No Policy issues have been raised in relation to technical alternatives.

3.4 Guidance

15. No Guidance issues have been raised in relation to technical alternatives.

3.5 Further Environmental Information for the Purposes of the Inquiry

16. It is not necessary to introduce new information to address any point made by third parties or the Department and its consultees in relation to technical alternatives.

3.6 Reliability of Overhead Lines and Underground Cables

17. In the SEAT Statement of Case at paragraph 46 it is stated that:

> *"adding a further OHTL only exposes the system to the same climatic conditions as already exists and thus the identical dangers such as wind, haw-frosts and other causes of conductor and pylon failure as already exists. To increase security of supply a different form of transmission is required such as UGC's".*

Response:

18. In their consideration of the technical alternatives the respective applicants undertook a comparative analysis of the reliability of high voltage overhead lines (OHL) versus high voltage underground cables (UGC) for electricity transmission. From a security of supply perspective it is the availability for service, or more correctly the lack of availability for service, of a transmission circuit that is a more important measure of reliability than simple 'failure rate'. A circuit's 'availability' is derived from the expected failure rate and the average time it takes to repair a fault.

19. The results of the comparative analysis (as set out below) show that in the case of electricity transmission OHLs have a much better level of availability for service than UGCs. Inserting a UGC into a transmission network rather than an OHL is therefore likely to have a negative impact on overall security of supply.

20. The vast majority of faults on transmission OHLs are **transient** in nature. Most of these are caused by lightning; the lightning does not cause any damage[1]; the fault only exists as long as the lightning exists. The protection systems for the OHLs are designed to trip the line when a fault occurs and, based on the assumption that the fault is transient, will automatically switch the line back into service typically within one second. If the fault is not transient but a 'permanent' fault then the OHL will re-trip and the line will remain out of service until repair crews can find and repair the fault.

[1] Overhead transmission lines are designed and built to withstand lightning strikes and are therefore rarely damaged by lightning.

21. In the case of transmission UGCs however almost every failure can be assumed to be a **permanent** fault as usually the very act of failing results in an explosion at the point of failure which destroys a section of the cable.

22. As the time it takes to repair a 400 kV UGC is much greater than the time to repair a 400 kV OHL, it can be expected that such an OHL will have a much better level of availability for service than an equivalent UGC and this is supported by system statistics (as set out below).

23. In April 2009, Cigré published[2] the results of the most comprehensive study of UGC reliability carried out to date (refer to Table 1). This study was based on the results of a survey of 73 utilities from around the world. Of interest is the information received on the performance of 1,388km of XLPE cable with a voltage rating in the range 220 kV to 500 kV. Applying the calculated fault rates of this 1,388km of installed cable, to the length of cable[3] (2 x 135 km) that would be required for the proposed interconnector, gives a projected fault rate of 'one fault per annum'.

24. Compare this 'fault rate' and the 'average time to repair' of UGC with that of an equivalent OHL. There are 439km of existing 400 kV OHLs in Ireland. This length of 400 kV OHL is too small a sample for determining meaningful performance statistics. Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity (approximately 2,245km) of 400 kV, 275 kV and 220 kV OHLs under EirGrid's control[4]. Taking the fault statistics of this existing 2,245km of OHL for the period 2004 to 2012, gives a projected fault rate for the proposed (approximately 140 km long) 400 kV OHL of one permanent fault (that is a fault that requires repairs before the OHL can be returned to service) every 20 years.

25. The statistics also show that the average duration that a high voltage OHL circuit will be out of service for repair after a fault is considerably less than that of an equivalent UGC circuit - less than two days in the case of OHLs, and 25 days in the case of a 400 kV UGC. This is summarised in Table 1.

[2] Cigré Technical Brochure 379 - Update of Service Experience of HV Underground and Submarine Cable Systems, ISBN 978 -2-85873-066-7 (April 2009). The technical brochure is available from Cigré. Cigré is an acronym in the French language for The International Council on Large Electric Systems'.
[3] The distance of 135km is derived from the length of the route identified by PB Power in its 2009 report. The requirement for two cables per phase is also identified by PB Power in that report.
[4] This is reasonable compromise because the existing 220 kV and 275 kV OHLs are of similar design and experience similar operating conditions to that of the existing 400 kV OHLs.

Table 1: Summary of Comparative OHL and UGC Statistics

UGC and OHL	Projected Fault Rate for N-S Interconnector	Average Time to Repair
UGC – directly buried cable (statistics based on 1,388 km of XLPE cable with a voltage rating in the range 220 kV to 500 kV) **Source:** Cigré Technical Brochure 379	1 fault per annum	25 days
OHL (statistics based on 2,245km of 220 kV, 275 kV and 400 kV OHL in Ireland) **Source:** EirGrid & SONI (2004 – 2012)	1 fault (permanent fault requiring repairs) every 20 years	Less than 2 days

26. The comparative analysis indicates that OHLs have a substantially better level of availability for service than UGCs. This result is consistent with the findings of the independent Ecofys Report[5] in which the 'availability' (the term Forced Outage Rate is used in the report) of OHLs was found to be at least ten times (at least one order of magnitude) better than that of UGCs. This comparative performance must always be an important factor when a TSO is considering UGC particularly when the circuit in question is to be a backbone circuit of the transmission network and therefore of the highest strategic importance.

27. In order to mitigate the risk of critical overhead transmission lines being affected simultaneously by a single weather event, it is prudent to maximise as much as possible the geographic distance between them. This was one of the criteria applied by the respective applicants in the routeing of the proposed interconnector in relation to maintain good geographic separation from the existing Louth – Tandragee Interconnector.

28. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application made the same assertions regarding the

[5] Study on the Comparative Merits of Overhead Electricity Transmission Lines Versus Underground Cables, carried out by Ecofys on behalf of the Irish Department of Communications, Energy and Natural Resources and available at www.dcenr.gov.ie.

comparative reliability of OHL and UGC and in that case the Board's Inspector concluded in her report at Section 5.4.5.4, page 180 that -

"having taken into considerations all of the arguments made, the strategic importance of the proposed interconnector as part of the all-island transmission network, the lack of existing strong interconnection between Ireland and Northern Ireland and the overwhelming need for reliability and security of supply, on balance it would appear that the technology currently best suited to satisfy the requirements of the proposed North-South Interconnector development is an overhead high voltage alternating current power line.'

29. When accepting that the proposed Interconnector should be a high voltage alternating current power-line the Inspector also accepted that there should be geographic separation or "*physical separation*" between the existing Interconnector and the proposed second Interconnector. In Section 5.4.5.4.on page 183 of her Report she states

"*Following the consideration of alternative transmission and technology alternatives, I accept that it has been comprehensively demonstrated that the only way to meet the strategic and technical need for the proposed development is to provide a new and physically separate high capacity interconnector".*

3.7 Partial Undergrounding Report and Selection of Sections of Route in Northern Ireland for Consideration

30. In the SEAT Statement of Case at paragraph 50 it is stated that:

> *"The applicant considers alternatives at Section 4 of the Consolidated ES and Section 10 of the ES Addendum. Appendix 10.2 of the Addendum also contains a 'Partial Undergrounding Report', which details the applicant's consideration of a section around Benburb in Northern Ireland, beginning with a compound at Tower 29 and ending with another at Tower 34. Two other sections are considered in RoI. No other NI section of the route has been considered."*

Response:

31. SEAT's comment is not an accurate reflection of the approach SONI has undertaken to the assessment of undergrounding. As outlined in Chapter 4 of the Consolidated ES, Chapter 10 and Appendix 10.1 of the Consolidated ES Addendum, an assessment has been undertaken of the full undergrounding of the proposed overhead line. In addition to that, an assessment of partial undergrounding was undertaken following a request of by the competent authority for PCI, An Bord Pleanála in Ireland, who requested:

> *"Where significant impacts on landscapes/demesne landscapes are identified, the EIS should address the potential for partial undergrounding of the line to mitigate those impacts".*

32. As explained in Section 10.2.10.4 of the Consolidated ES Addendum a key constraint to the use of partial undergrounding of the overall HVAC circuit, is that the length of HVAC underground cable which is technically feasible for the entire proposed interconnector, both in Ireland and Northern Ireland, is approximately 10km.

33. The methodology for the consideration sought to identify the locations where undergrounding might have the most effective mitigating effect on identified significant and sensitive landscapes impact. The use of this approximate 10km length could have been suitable in one location, or the use of shorter lengths of partial undergrounding could have been considered in more than one location, while bearing in mind the absolute need for, and consequent potential impact of, the above-ground transition stations required at each end of that partially undergrounded portion of the alignment.

34. The process started with a listing of locations where significant landscape and visual impact had been identified. Following this, the impacts that can feasibly be mitigated by partial undergrounding were identified. Some impacts are so dispersed that partial undergrounding of 10km can be excluded as having no potential to mitigate landscape impacts due to the amount of transition stations required.

35. As outlined in Appendix 10.2 of the Consolidated ES Addendum, the entire length of the overhead line in Northern Ireland was assessed for suitability for partial undergrounding where potentially significant landscape effects and potentially significant visual effects occurred. As identified on pages 29 and 30 of Appendix 10.2, the areas assessed included:

"Registered Historic Parks, Gardens and Demesnes

- *The Manor House, Benburb*

Locations of potentially significant landscape and visual effects (Northern Ireland)

Landscape Areas

- *LCA 47 Loughgall Orchard Belt*
- *LCA 66 Armagh Drumlins*
- *LCA 6 Mullyash Uplands*

Viewpoints

- *22 no. viewpoints of the 34 evaluated in the Consolidated ES*

o Clonteevy Bridge over River Rhone on Trewmount Road (B106) - View towards

substation

o Derrygally Way to east of Turleenan Substation - View towards substation

o Derrygally Way to south of Turleenan Substation – View towards substation

o Trewmount Road (B106) near site access road

o Moy Road (A29) crossing

o Culkeeran Road

o Gorestown Road

o Benburb Road

o Benburb Road south of Ninewell Bridge

o Benburb Priory

o Artasooly Road at Tullymore Bridge

o Battleford Road (B115) crossing

o Killylea settlement (Fellows Grange Court)

o Monaghan Road (A3) east of Norton's Cross Roads

o Monaghan Road (A3) crossing

o Maddan Road south of Norton's Cross Roads

- *Drumhillery Road crossing*
- *Fergort Road (B3) crossing*
- *East of Derrynoose*
- *Derrynoose Road at Curragh Lane looking north*
- *Derrynoose Road at Curragh Lane looking south*
- *Crossaghy Road*

Visual impacts upon settlements

- *Moy*
- *Blackwatertown*
- *Benburb*
- *Killylea*
- *Derrynoose*

Properties

- *322 properties that experience a major adverse - moderate adverse impact"*

36. As further outlined in Appendix 10.2, the technical restriction of approximately 10km for partial undergrounding required a further refinement of the areas to determine suitable areas for more detailed assessment. The further shortlisted areas are identified on Pages 33 and 35 of Appendix 10.2. This included a 10km section of partial undergrounding from the proposed substation to the Benburb area (see paragraph 19, page 35 of Appendix 10.2). Additional assessment, as outlined on page 36 – 41, shortlisted the Benburb Area for further and detailed assessment for partial undergrounding.

37. Therefore, it is clear that SONI and its consultants have assessed the entire overhead line for full and partial undergrounding.

3.8 Proper Consideration of Alternatives

38. In the SEAT Statement of Case at paragraph 51 it is stated that:

> "N*o proper consideration is given to possible and viable alternatives to OHL as a means of providing the proposed project. Other alternatives, in particular,*

underground cabling are viable but the ES fails to properly examine this alternative".

39. Third parties Messrs McNally, J. Woods and George and ABC Council have questioned the assessment of alternatives. On page 1 (fourth bullet point) and in the first paragraph of page 2 of the Statement of Case by Mr. Boyd Eagleson and the Statement of Case by Ms. Liz Drew it is stated that:

"concerns regarding the submitted proposal include:

Lack of real consideration of best practice, long-term cost benefit, or of other technologies such as underground cable as a viable alternative"

"Whilst a safe, reliable, economic and efficient electricity supply is undoubtedly required, I continue to believe that this overhead line should be under-grounded as the underground cable will remove the long term negative impact on our environment. Under-grounding the cable is more reliable and also more cost effective over the life of the project."

Response:

40. Alternatives to the proposed Tyrone – Cavan Interconnector, including the use of underground cabling, have been thoroughly explored by SONI. The consideration of alternative technologies 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).

41. The consideration of the alternatives was carried out jointly over many years, first by NIE and EirGrid and subsequently by SONI and EirGrid. The outcome of the consideration of alternatives is summarised later in this Section.

42. In 2013 in Ireland EirGrid was consulting the public on two other 400 kV projects namely the Grid West project and the Grid Link project. During the course of this consultation stakeholders questioned how EirGrid could carry out a fair and transparent comparative analysis of the technology options for those two projects. As a result, in January 2014 Ireland's Minister for Communications, Energy and Natural Resources appointed an Independent Expert Panel (IEP) to:

"decide terms of reference for comprehensive, route-specific studies of fully undergrounded options for both Grid Link and Grid West. The panel will be required to ensure that the studies are complete, objective, and comparable to

similar studies of overhead options for the two projects, and will report to the Minister in that regard"[6]*.*

In addition, the IEP was tasked with providing an opinion to the Minister on -

"the compatibility of the methodologies to be employed on the GW and GL projects with what has already been done (i.e. up to 2 May 2014, being the date the Panel decided to examine the N/S project) on the North South Transmission Line project"[7]*.*

43. In May and June 2014 EirGrid, at the request of the IEP, prepared and submitted reports[8] to the IEP describing the extent of, and the methodology applied to, the comparative analysis of the UGC and OHL options for the North South Interconnector project. In July 2014 the Panel (IEP) announced that in its opinion the work completed to date on the North-South 400 kV Interconnection Development is compatible with the Terms of Reference to be employed on the Grid West and Grid Link projects:

"Having considered and discussed all of the material, the Panel is unanimously of the opinion that, in all material respects, what has already been done on the N/S project is compatible with the methodologies now being employed on the GW and GL projects. While the Panel acknowledges that no two grid infrastructure projects are identical, and that some non-comparabilities are likely to arise when assessing the potential environmental impacts, technical efficacy and cost factors, the Panel is of the opinion that no material differences in the methodologies arise.[9]*"*

44. It is clear therefore that the Independent Expert Panel is of the opinion that EirGrid has applied a "*proper*" methodology for the carrying out of a fair and transparent comparative analysis of the transmission options (see paragraph 51 of the SEAT Statement of Case). As this consideration of alternatives was carried out jointly with NIE/SONI and applies to the overall proposed Interconnector including that part located in Northern Ireland it must follow therefore that the IEP is also of the opinion that SONI has applied a "*proper*" methodology for the consideration of transmissions alternatives including the UGC alternative.

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[6] http://www.dccae.gov.ie/news-and-media/en-ie/Pages/PressRelease/Minister-Rabbitte-responds-to-Grid-Link-public-consultation.aspx
[7] http://www.dccae.gov.ie/news-and-media/en-ie/Pages/PressRelease/Statement-by-the-Independent-Expert-Panel.aspx
[8] Report to the Independent Expert Panel Date: 29/05/2014 & Addendum Date: 19/06/2014 available at http://www.eirgridnorthsouthinterconnector.ie/media/Appendix%203%20Report%20to%20the%20Independent%20Expert%20Panel%2029-5-2014%20Add%2019-6-2014.pdf.
[9] http://www.dccae.gov.ie/news-and-media/en-ie/Pages/PressRelease/Statement-by-the-Independent-Expert-Panel.aspx

45. In addition to the UGC alternative SONI considered the 'Do Nothing' alternative. 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 and more critical as time progresses, will not be addressed. For this reason the 'Do Nothing' alternative was rejected.

46. 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 also considered as described in Section 4.2.3 of the Consolidated ES and updated in Section 10.2.3 of the Addendum to the Consolidated ES. It was found that there was no single or combination of such alternatives that would address the identified needs and objectives.

47. 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.

48. 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.

49. 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.

50. 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 proposed 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.

51. 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.

52. 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.

53. Building further Interconnection to other electricity markets, such as that on the island of Great Britain or Iceland or continental Europe, 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.

54. 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 the SONI Statement of Case: Technical Report 1: Need, satisfying the objectives of improving competition on the all-island electricity market and supporting the development of renewable generation.

55. In conclusion therefore the development of a second high capacity interconnector will adequately address all of the identified needs and objectives, and was therefore identified by the respective applicants as forming the basis of a preferred option.

56. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application contested this conclusion and claimed that it was based on an inadequate consideration of non-transmission options and transmission options other than the development of a new high capacity interconnector. However having considered all of the evidence presented to the hearing the Board's Inspector concluded in her report at Section 5.4.5.4, page 173 that :

> *""the provision of new generating plant or upgrading of existing plant north of the border does not address transmission constraints across the border or the integration of the electricity systems. I accept that it has been comprehensively demonstrated that the only way to meet the strategic and technical need for the proposed development is to provide with [sic] a new and physically separate high capacity interconnector."*

57. 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). A comparative assessment of these was carried out by comparing them against a number of key performance objectives. These are objectives which must be

achieved regardless of the particular technological alternative that is actually employed.

58. 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 (EirGrid only criterion);

f) Facilitate future grid connections and reinforcements; and

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

59. Criteria a), b) and c) derive from SONI's statutory and regulatory obligations to facilitate the planning, development, maintenance and operation of the transmission system in Northern Ireland as part of an efficient, economical, co-ordinated, safe, secure and reliable All-Island Transmission Networks while having due regard for the environment. Criterion d) is a specific objective of this development. The need for a 1,500 MW capacity was set out in 'Technical Report No. 1 – Need' attached to the SONI Statement of Case and in order to make best use of that capacity it is necessary to connect between appropriately robust points on the transmission networks north and south of the border. Criterion e) is an EirGrid-only criterion and is therefore not relevant to the application in Northern Ireland. Criteria f) and g) are general objectives that would apply to all transmission projects. The specific nature and extent of the proposed Interconnector must be considered as part of the ongoing and future strategic development of the all-island electricity transmission network. It must also be considered in the context of international experience and best practice.

60. The outcome of the comparative analysis is summarised in Table 2.

Table 2: Overview AC versus DC – Strategic Constraints of Potential AC and DC Transmission Alternatives (Copied from Table 10.5 of Consolidated ES Addendum)

Points	Description	AC OHL	DC (UGC or OHL)
	Comply with SONI's Statutory and Regulatory Obligations		
a)	Safety	***	***
b)	Reliability and security	***	**
c)	Cost effectiveness	***	*
	Due regard to the environment	**	**
	Meet the Specific Needs of the Project		
d)	1,500 MW capacity and appropriately strong points of interconnection	***	***
e)	Reinforce the North-East transmission network	***	***
	Meet the General Objectives for All Projects of this Type		
f)	Facilitate future grid connections and reinforcements	***	*
g)	Good Technical Solution – Be 'best international practice' with proven technology	***	*

***	Preferred, limited impact, acceptable
**	Some impact, some difficulty
*	Least preferred, major impact, unacceptable

61. From Table 2 it can be seen that the standard HVAC OHL option scored equally with the HVDC option (whether implemented using UGC or OHL) against a number of criteria. However the HVDC option received a lower rating than HVAC OHL when compared against 'Comply with all system reliability and security standards' and rated unacceptable when compared against 'Provide a cost effective solution', 'Facilitate future grid connections and reinforcements' and 'Comply with 'Good Utility Practice' or best international practice'. These ratings are explained below.

<u>Comply with all system reliability and security standards</u>

62. The proposed interconnector as part of the 400 kV network will form a necessary extension of the backbone of the 'all-island' transmission network, and is required in order to enable the two networks, north and south, to operate as if they were one network. It will be an integral part of the 'all-island' meshed network, and as such the power flow (quantity and direction)

in the circuit may be required to react instantaneously to dynamic system changes such as rises and falls in system demand, and sudden and unplanned changes in system configuration due to unplanned outages of other circuits or generators. If the proposed interconnector is a standard AC circuit then the power flow will react naturally and instantaneously, without any input from a control system or human operator, to such dynamic changes to the system.

63. The power flow on a DC circuit on the other hand will not react naturally to such changes. The DC circuit will only react if prompted to do so by a controller. However, a human operator would not be able to react quickly enough, so the control would have to be by means of a computerised control system. Such a control system would be bespoke and very complex, and would therefore introduce the very real risk of mal-operation. Analysis of the risk of mal-operation of the computerised system controlling the operation of a HVDC north-south interconnector has shown that this could (due to its relatively high capacity and strategic location within the network) result in the collapse of the entire 'all-island' electricity system. Taking such a risk is unnecessary when there is a technically superior (for this type of application) and less risky option readily available. Therefore it is SONI's opinion that under the heading of 'comply with all system reliability and security standards', a standard AC circuit is preferable to a DC circuit for the specific characteristics of the proposed interconnector.

Provide a cost effective solution

64. In the PB Power Technology and Costs Update Report (July 2013) it is estimated that in the case of the overall proposed Interconnector the standard HVAC OHL will cost €140 million whereas the HVDC UGC option will cost €810 million (refer to Section 3.15 for more information on the veracity of the costs estimate prepared by PB Power). That is a difference of €670 million. In SONI's opinion this cost differential renders the HVDC option plainly unacceptable when gauged against this criterion.

Facilitate future grid connections and reinforcements

65. All circuits forming a meshed transmission network have the potential to be 'tapped' into at an intermediate point to provide a new grid connection or reinforcement sometime in the future. It is envisaged for example by EirGrid that the circuit that forms the proposed Interconnector will require an intermediate substation in the vicinity of Kingscourt at some future point in time (although not now expected to be required for at least a decade), and others (where and when they will be required cannot be predicted at this juncture) are probable, including in Northern Ireland. The facilitation of future grid connections and reinforcements is therefore an important consideration of the technology choice.

66. As stated previously, a DC circuit does not naturally integrate within an AC network and a consequence of this is that a DC circuit embedded in an AC network would not facilitate future grid connections and reinforcements. If the north-south interconnector were to be developed using HVDC technology, then the cost of the planned 'tap in' to the circuit near Kingscourt for example, based on the estimates of the International Expert Commission (refer to Section 3.15 for more information on the International Expert Commission (IEC) appointed by Ireland's Minister for Energy), would be in of the region of €150 million more than the cost of tapping into an equivalent AC circuit. This would in all likelihood make the plan, ultimately to reinforce the north-east area of the Republic of Ireland by developing a new substation near Kingscourt, uneconomic. Consequently that reinforcement would have to be achieved by some other means, such as the building of new AC transmission lines into the area.

67. In addition to the excessive cost of tapping into a DC circuit, the only practical way of tapping into such a circuit would result in the creation of a 'multi-terminal' DC circuit (i.e. a DC circuit with more than two terminals). A multi-terminal DC circuit would require an even more complex control system than a two terminal circuit, thus increasing the already unacceptable risk of mal-operation.

68. The poor facilitation of future grid connections and reinforcements presented by the DC option makes the use of HVDC technology less preferred than a

standard AC circuit when compared against this criterion for the implementation of the proposed interconnector.

Comply with 'Good Utility Practice' or best international practice

69. There are no working examples in the world of a DC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland. The examples of planned DC interconnectors in Europe that were identified in the IEC[10] Report[11] (that is the proposed France-Spain Interconnector and the proposed Norway–Sweden Interconnector) are not comparable with the proposed interconnector. The electricity networks in those four countries are much larger (six times larger in the case of Norway-Sweden and almost 20 times larger in the case of France-Spain) and stronger than those on the island of Ireland and they already have multiple AC interconnections with each other.

70. The risk of failure, and the consequence of failure, is an important factor in deciding whether the embedding of a DC circuit in an interconnected network is, or is not, good practice. There is currently only one interconnector between Ireland and Northern Ireland and these two networks are required to merge into each other and to operate as if they were one network. The proposed interconnector, with a power carrying capacity of 1,500 MW, will become the 'backbone' of this 'all-island' network.

71. By contrast the proposed France / Spain and Norway / Sweden DC Interconnectors are upgrades in cross border power transfer capacity between networks that are already highly interconnected[12] with each other. Also unlike the network on the island of Ireland the Norway / Sweden and France / Spain networks form part of a wider continental network and have multiple interconnections (both synchronous and non-synchronous) with other third party countries. In addition Table 3 illustrates that the power carrying capacity of the proposed north south interconnector relative to the

[10] International Expert Commission (IEC) appointed by Ireland's Minister for Energy – see Section 3.15 for more information on the appointment of the IEC
[11] Available at - http://www.eirgridnorthsouthinterconnector.ie/media/3B_29)%20IEC%20(2012)%20International%20Expert%20Commission%20%20Meath%20Tyrone%20Report.pdf
[12] There are five existing AC transmission interconnectors between Norway / Sweden, four between France / Spain and one between Ireland / Northern Ireland.

combined 'all-island' system demand is far greater than the comparable figure in the case of the proposed France / Spain and Norway / Sweden Interconnectors. The North South Interconnector would have the capacity to carry 23.8% of the 'all-island' peak demand whereas the comparable figures for the France / Spain and Norway / Sweden Interconnectors are 2.9% and 1.4% respectively and that this in turn results in the proposed interconnector (i.e. between NI and ROI) having a far greater level of strategic importance than those other proposed interconnectors.

Table 3: Comparison of Interconnected Networks and the Relative Importance of Proposed Interconnectors (Copied from Table 10.4 of Consolidated ES Addendum)

Interconnected Countries	Power Carrying Capacity of Proposed Interconnectors	Combined System Peak Demand[13]	Capacity of Proposed Interconnectors as a % of Peak Demand
Ireland - Northern Ireland	1,500 MW	6,311 MW	23.8%
Norway - Sweden	2 X 720 MW	49,643 MW	2.9%
France - Spain	2 X 1,000 MW	145,625 MW	1.4%

72. The capacity of the proposed North-South Interconnector relative to the 'all-island' system peak demand together with the relatively limited level of interconnection with each other and with third party networks means that the North-South Interconnector will have a far greater level of strategic importance to Northern Ireland.

73. The strategic importance of the proposed new France /Spain and Norway / Sweden DC interconnectors will be far less critical to the overall system security of their combined networks than the proposed north south interconnector will be to the 'all-island' network. These proposed DC

[13] The annual instantaneous peak loads were obtained from the ENTSO-E website. The instantaneous peak loads for the respective pairs of networks did not occur at the same time (although they were within days of each other). The combined figures are therefore a slight over statement of the actual combined instantaneous system peak demand.

interconnectors are therefore not representative of a DC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland.

74. Therefore it is essential to ensure that such a strategically important line to Northern Ireland, which has the potential to supply at times most of either jurisdiction's power requirements, should be designed with best practice proven technology. It is on this basis that implementing the proposed interconnector using HVDC technology would not be considered as complying with 'good utility practice' or complying with 'best international practice'.

75. The overall conclusion of the comparative analysis is that the HVDC option is **not preferred.** It does not rate as superior to HVAC under any of the criteria and is rated least preferred on the basis of cost effectiveness, its poor ability to facilitate future grid connections, and because it would not be considered as complying with 'best international practice'.

76. Having eliminated all HVDC options the next step in the analysis was to compare an entirely undergrounded 400kV AC option with a 400kV AC OHL. The respective applicants found in this regard that due to the electrical characteristics of high voltage AC underground cable it would not be technically feasible to underground the entire approximately 135 km length of the proposed Interconnector. This is due to the high capacitance of such a cable – meaning the ability of the cable to collect and store a charge of electricity. This is the unavoidable outcome of a cable's design compared to an overhead line as they use different materials to protect, or insulate, from electrical discharge to the ground. This stored electrical energy following a disturbance in the network, for example from the failure of equipment in the surrounding network, will be released into the network causing much higher than normal voltages for temporary periods. The scale of these temporary over voltages can be such that they exceed the available design rating of equipment, risking wide-spread equipment failure and operational difficulties that cannot be overcome. This conclusion is supported by the IEC who found that there are no 400 kV underground cable circuits in the world that approach the length required for the North-South Interconnector and that this

is because of sound technical reasons. **The IEC Report[14] goes on to make only one recommendation and that is that the proposed North-South Interconnection Development should not be implemented using the entirely undergrounded AC cable option**. SONI concurs with this recommendation.

77. An AC overhead line with a power carrying capacity of 1,500 MW and operating voltage of 400 kV was therefore identified as the preferred option. The partial undergrounding of such an AC overhead line may[15] be feasible.

78. When considering the feasibility, and if feasible the appropriateness, of partial undergrounding for a 400 kV project, it is essential to understand the environmental, technical and cost implications. These are considered in Section 10.2 of the Consolidated Environmental Statement Addendum. The issues arising are summarised below.

79. **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

[14] Available at - http://www.eirgridnorthsouthinterconnector.ie/media/3B_29)%20IEC%20(2012)%20International%20Expert%20Commission%20%20Meath%20Tyrone%20Report.pdf

[15] The feasibility of partially undergrounding a 400kV OHL circuit is network and location dependent and can only be determined by undertaking a technical study. A study was carried out in this case and it concluded that only about 10km of the overall circuit could be undergrounded. If a similar study was to be carried out elsewhere on a different network or a different part of the all-island system the result would likely be different.

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.

80. **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.

81. **Cost Issues**: 400kV AC underground cable would cost on average €5.4 million per km[16] more to install than the proposed AC overhead line. In

[16] €6.3m per km for UGC less €0.9m per km for OHL, PB Power Technology and Cost Update (July 2013).

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.

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

83. 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

84. 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.

85. 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.

62. The respective applicants' conclusions following their consideration of the technical alternatives is supported by the Bord Pleanála Inspector who presided over the oral hearing conducted in respect of the part of the proposed Interconnector located in Ireland. In Section 5.4.5.4 on page 187 of her report she states –

> *"it is my opinion that as a critical element of the transmission system between Ireland and Northern Ireland, it has been demonstrated that an overhead line option presents less risk for system security, reliability and availability than a DC option".*

86. The Inspector concludes on page 180

> *"having taken into considerations all of the arguments made, the strategic importance of the proposed interconnector as part of the all-island transmission network, the lack of existing strong interconnection between Ireland and Northern Ireland and the overwhelming need for reliability and security of supply, on balance it would appear that the technology currently best suited to satisfy the requirements of the proposed North-South Interconnector development is an overhead high voltage alternating current power line".*

87. She further concluded on the issue of partial undergrounding at page 185 that:

> *"The option was discounted on the basis of environmental and cost grounds, which is considered reasonable."*

3.9 HVDC Underground Cable along Public Roads

88. In the SEAT Statement of Case at paragraph 51 it is stated that:

> *"SONI to this day has refused to carry out the relevant analysis and costing of a site-specific underground HVDC cable solution along public roads. It follows from this fact that the planning application has failed to include an objective consideration of alternatives, and this fact alone should render the entire application invalid".*

Response:

89. SONI and EirGrid have jointly carried out an evaluation of HVDC technology as an alternative to the standard HVAC technology. The methodology applied and the outcome of the comparative analysis is described in Section 3.8 above and a summary of the outcome in tabular form is shown in Table 2 in same section.

90. In summary the respective applicants concluded that any option using HVDC 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[17]; 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.

91. In coming to the above conclusions the respective applicants were informed by the PB Power Study. This study comprises three reports as follows -

- The PB Power Preliminary Briefing Note (PB Power, 2008). A short report, published at an early stage in the project development process, drawing upon generic information to summarise in general terms the technical and cost issues associated with implementing the proposed transmission circuit.
- The PB Power Study (PB Power, 2009). A thorough report describing the conclusions drawn from a detailed study by PB Power following the publication of the Preliminary Briefing Note. The study was specific to the proposed project, and compared a high voltage OHL transmission option with UGC options utilising either HVAC or HVDC technologies.
- The PB Power Technology and Costs Update (PB Power, April 2013 and Supplementary Note July 2013). A report summarising the results of a further study carried out to update the information provided in the PB Power Study of 2009. This report includes a review of up to date technology and application developments worldwide. It also draws upon information and conclusions published within a number of recent relevant studies (including the IEC Report (2012), a report by the International Expert Commission setup by the Government of Ireland) into the subject of transmission technology alternatives. A key output from the updated

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

study has been to provide up to date comparative costs for the identified alternatives.

92. As part of its study PB Power (now Parsons Brinckerhoff) was contracted to identify potential route corridors for UGC. Its terms of reference in this regard was to apply "*a set of environmentally based routing principles to identify at least one corridor within which the use of UGC could be technically and environmentally feasible as an alternative to the proposed OHL*[18]".

93. The methodology applied by PB Power is described in detail in chapter 7 of the ***PB Power Report*** (2009). The routing team consisted of:

- An electricity transmission specialist
- A landscape architect
- Environmental consultants responsible for the constraints reports and maps that were used to identify the preferred OHL route corridor
- A UGC installation specialist
- A civil engineer who had worked on the North South Gas Pipeline Project and therefore had local knowledge of issues involved in linear excavations.

94. All members of the team visited and toured the study area. This was done in small groups, at different times, over a combined duration of about six days. The outcome of the route search exercise was:

- Routeing criteria for identifying UGC corridors were developed to accommodate the landscape characteristics of the terrain encountered in the study area.
- A continuous technically feasible "*viable strategic UGC search corridor*" that satisfied these routing criteria was identified from Woodland in County Meath to Turleenan in County Tyrone.

[18] PB Power Report – Executive Summary (2009). The "*environmentally based routing principles"* are described in Section 7.3 of the Report and were "*developed from the team's previous UGC routeing experience, from information contained by the constraints reports and maps, and from general knowledge of the landscape character*".

- The 'most suited' or preferred UGC route corridor passes principally through agricultural land, and avoids routing constraints presented by identified natural, cultural heritage, and landscape features.
- The identification and classification of the different landscapes types encountered along the route corridor was found to be a useful approach to managing routing considerations, assessing UGC route options and estimating cable drum lengths to assist with the subsequent estimating of the civil and overall undergrounding costs.

95. Before undertaking its search for a technically feasible UGC route corridor PB Power was required to establish the layout (spatial and configuration requirements) for the underground cable option. This was derived from the specified technical and operational requirements and from the access requirements during construction and subsequent operation. The resultant layout design by PB Power for the 400kV AC underground cable option is shown in Figure 1.

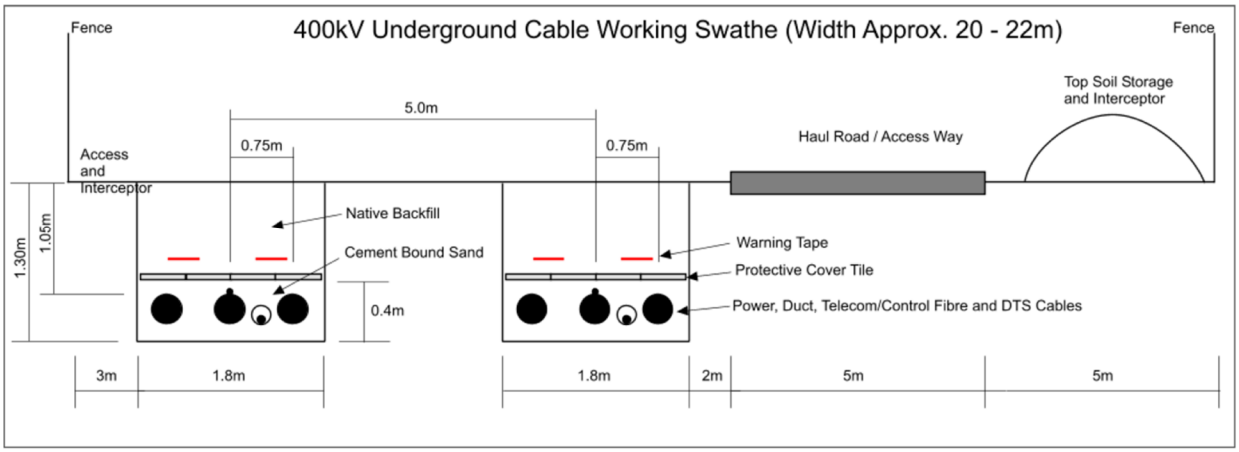

Figure 1 – Extracted from 2009 PB Power Report

96. The HVAC layout consists of six individual cables, installed in two 1.8m wide trenches, each with three cables and with the trenches spaced 5m apart from centre to centre. The equivalent HVDC layout consists of four individual cables, installed in two 0.8m wide trenches, each with two cables and with the trenches spaced 5m apart from centre to centre. The overall

width of the HVDC working swathe would therefore be 18 - 20m as opposed to the 20 – 22m shown in Figure 1 for the HVAC layout.

97. The extent of both the HVAC and HVDC layouts is such that it was immediately apparent that the local and regional roads between the Woodland Substation in County Meath and the proposed substation in Turleenan in County Tyrone are not sufficiently wide to accommodate such a development. That led PB Power to conclude that the "most suited" or preferred UGC route would be one that follows a more direct cross-country route through agricultural land.

98. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application contested this conclusion claiming that EirGrid had never properly considered routeing the UGC option along public roads. However having considered all of the evidence presented to the hearing the Board's Inspector concluded in her report at the page 183 in Section 5.4.5.4:

> *"I consider that it has been demonstrated that due to technical and operational considerations, the local road network in the vicinity of the development would not be suitable to accommodate the underground option."*

99. Identifying a viable route corridor for the UGC option allowed PB Power to develop detailed and robust 'bottom up' cost estimates for the UGC options that are project-specific and site-specific.

100. It is clear from the foregoing that SONI undertook an objective consideration of HVDC as an alternative to the proposed HVAC overhead line, that PB Power undertook a project-specific and site-specific study that identified a route corridor for the UGC option and that in the case of this project the preferred route for any UGC option would be one that follows a more direct cross-country route rather than one that follows a route along public roads.

3.10 Europacable Briefing Note on HV Underground Cables

101. In the SEAT Statement of Case at paragraph 52 it is stated that:

"The latest publication from the European underground cable manufacturer's representative body – Europacable – highlights that an appropriate HVDC cable can easily be accommodated along existing public roads. The publication also clearly states that some of the existing EU designated Projects of Common Interest (PCI), of which the North-South Interconnector Project is a designated PCI project, include establishing HVDC underground cable interconnectors as part of a meshed AC grid system. The Aachen to Liege project is given as an example. This debunks the SONI myth that embedding a HVDC interconnector into the existing AC meshed Grid is not possible (Appendix SEAT9)"

Response:

102. The Europacable publication 'Briefing Note on Cables – August 2015' attached as Appendix 9 of the SEAT Statement of Case does not state that a "*HVDC cable can easily be accommodated along existing public roads".* In fact the Briefing Note is supportive of SONI's conclusion that the existing public roads are not sufficiently wide. This is because in the case of this project a double circuit HVDC scheme would be required in order to meet the required power carrying capacity. As a double circuit each circuit would operate independently of each other and would consist of two cables installed in a trench approximately one metre wide. The two trenches, one for each circuit, would be spaced 5 m apart. As explained in Section 3.9 above the public roads between Woodland Substation in County Meath and the proposed substation in Turleenan in County Tyrone are not sufficiently wide to accommodate such a development.

103. SONI did not say "*that embedding a HVDC interconnector into the existing AC meshed Grid is not possible".* Instead in Section 10.2.8.2 of the Consolidated Environmental Statement Addendum SONI explains why implementing the proposed Interconnector using HVDC technology would not be considered as complying with 'good utility practice' or 'good international practice', notwithstanding that there are existing HVDC interconnectors installed, or being installed, between France and Spain and between Norway and Sweden.

104. It is explained at paragraph 65 in Section 10.2.8.2 of the Consolidated ES Addendum that there are no working examples in the world of a DC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland, and that the France/Spain and Norway/Sweden

interconnectors are not comparable with the proposed Interconnector. This is because the electricity networks in those four countries are much larger (six times larger in the case of Norway-Sweden and almost 20 times larger in the case of France-Spain) and stronger than those on the island of Ireland and they already have multiple AC interconnections with each other. The same situation applies in the case of the "*Aachen to Liege project*", also known as the ALEGrO project, which will be an interconnector between Belgium and Germany.

105. The risk of failure, and the consequence of failure, is an important factor in deciding whether the embedding of a DC circuit in an interconnected network is, or is not, good practice. There is currently only one interconnector between Ireland and Northern Ireland and these two networks are required to merge into each other and to operate as if they were one network. The proposed interconnector, with a power carrying capacity of 1,500 MW, will become the 'backbone' of this 'all-island' network.

106. By contrast, the proposed France / Spain and Norway / Sweden DC Interconnectors are upgrades in cross border power transfer capacity between networks that are already highly interconnected[19] with each other. Also unlike the network on the island of Ireland the Norway / Sweden and France / Spain networks form part of a wider continental network and have multiple interconnections (both synchronous and non-synchronous) with other third party countries. In addition Table 4 illustrates that the power carrying capacity of the proposed north south interconnector relative to the combined 'all-island' system demand is far greater than the comparable figure in the case of the proposed France / Spain and Norway / Sweden Interconnectors. The North South Interconnector would have the capacity to carry 23.8% of the 'all-island' peak demand whereas the comparable figures for the France / Spain and Norway / Sweden Interconnectors are 2.9% and 1.4% respectively and that this in turn results in the proposed interconnector (i.e. between NI and ROI) having a far greater level of strategic importance than those other proposed interconnectors.

[19] There are five existing AC transmission interconnectors between Norway / Sweden, four between France / Spain and one between Ireland / Northern Ireland.

Table 4: Comparison of Interconnected Networks and the Relative Importance of Proposed Interconnectors

Interconnected Countries	Power Carrying Capacity of Proposed Interconnectors	Combined System Peak Demand[20]	Capacity of Proposed Interconnectors as a % of Peak Demand
Ireland - Northern Ireland	1,500 MW	6,311 MW	23.8%
Norway - Sweden	2 X 720 MW	49,643 MW	2.9%
France - Spain	2 X 1,000 MW	145,625 MW	1.4%

107. The capacity of the proposed North-South Interconnector relative to the 'all-island' system peak demand together with the relatively limited level of interconnection with each other and with third party networks means that the North-South Interconnector will have a far greater level of strategic importance to Ireland.

108. As explained above the strategic importance of the France /Spain and Norway / Sweden DC interconnectors and the recently proposed Belgium / Germany interconnector will be far less critical to the overall system security of their combined networks than the proposed north south interconnector will be to the 'all-island' network. These DC interconnectors are therefore not representative of a DC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland.

109. It is on this basis that SONI can say that implementing the proposed interconnector using HVDC technology on the island of Ireland would not be considered as complying with 'good utility practice' or complying with 'good international practice'. As explained above the recently proposed *Aachen to Liege project*", also known as the ALEGrO project, which will be an interconnector between Belgium and Germany, does not change that conclusion.

[20] The annual instantaneous peak loads were obtained from the ENTSO-E website. The instantaneous peak loads for the respective pairs of networks did not occur at the same time (although they were within days of each other). The combined figures are therefore a slight over statement of the actual combined instantaneous system peak demand.

110. SONI's conclusion in this regard is supported by the Bord Pleanála Inspector who presided over the oral hearing conducted in respect of the part of the proposed Interconnector located in Ireland. In Section 5.4.5.4 on page 180 of her report she states:

> *"I accept that different projects require different solutions. EirGrid accepts that the DC option is feasible, but rejects it on the grounds of technical and cost considerations. Having regard to the significant technological advances made and which continue to be made in technology, the Board may wish to seek specific expert opinion on the current feasibility of integrating a HVDC system into the existing AC meshed network. However, having taken into considerations all of the arguments made, the strategic importance of the proposed interconnector as part of the all-island transmission network, the lack of existing strong interconnection between Ireland and Northern Ireland and the overwhelming need for reliability and security of supply, on balance it would appear that the technology currently best suited to satisfy the requirements of the proposed North-South Interconnector development is an overhead high voltage alternating current power line".*

It should be noted that there is no record or reference of the 'Board' seeking expert opinion as part of its decision.

3.11 Suitability of Embedding a HVDC Circuit in a Small and Isolated Transmission Network

111. In the SEAT Statement of Case at paragraphs 53 and 54 it is stated that:

> *"The substantive conclusion from examining all expert opinion is that SONI/Eirgrid is out of step with the received wisdom of major commercial and technical expertise around the world. The very arguments Eirgrid makes concerning the fragility of our grid are in fact arguments in favour rather than against VSC HVDC underground technology.*
>
> *EirGrid stated that there is grid instability and reinforcement risk by adopting HVDC technology, because the current system is 'thin' and 'fragile': "Therefore, we have a thin system in Ireland. It is electrically much lighter and inherently less robust by comparison with those of other European countries" (JOC, 2012)".*

Response:

112. The HVAC transmission network on the island of Ireland is relatively small. It is also isolated electrically from its larger neighbours as any interconnectors (existing and future) with those neighbours must be submarine HVDC schemes and therefore non-synchronous. Embedding a

1,500 MW HVDC scheme in such a small and isolated network cannot be considered as being in compliance with best international practice. As explained in Section 3.10 above the France/Spain, Sweden/Norway and Belgium/Germany HVDC Interconnectors are not comparable as those combined networks are much larger and have greater levels of existing HVAC interconnection than the Northern Ireland/Ireland network.

113. However when undertaking the multi-criteria analysis of HVDC and HVAC as technology options for implementing the proposed Interconnector (described in detail in Section 3.8 above), the fact that using HVDC would not comply with best international practice - whereas HVAC would - was not the only criterion which led to the conclusion that HVDC technology would be inappropriate. The respective applicants also found that:

- 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; and
- It would be significantly more expensive to implement than a standard AC overhead line, €670 million more expensive[21].

3.12 ABB's Statement on the Advantages of Using its HVDC Technology

114. In the SEAT Statement of Case at paragraphs 55 it is stated that:

> *"ABB, the undisputed world leader in power technologies, notes that installation of a VSC is ideal in a weak system:*
>
> - *'VSC-HVDC technology is now emerging as a robust and economical alternative for future transmission grid expansion. In particular, embedded VSC-HVDC applications, together with the wide area measurement system, in meshed AC grids could significantly improve overall system performance, enabling smart operation of transmission grids with improved security and efficiency. VSC-HVDC transmission also offers a superior solution for many challenging technical issues associated with integration of large-scale*

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

renewable energy sources such as offshore wind power. The technology is under continuous development rapidly into higher voltage, higher power and more flexibility'.

Response:

115. It should be noted that in the ABB promotional brochure there is no mention of the suitability, "*ideal*" or otherwise, of installing a HVDC VSC scheme *"in a weak system*". Instead ABB is saying that embedding a VSC-HVDC scheme in a transmission system "*could significantly improve overall system performance"*. The important word here is "could", as that clearly indicates that ABB is not presenting its VSC HVDC technology as a panacea for all transmission grid expansion projects. Rather it indicates that ABB is aware that the suitability of VSC HVDC depends on the circumstances, the particular application and the transmission network in question. As explained in Section 3.9 above if the proposed Interconnector was implemented using HVDC then:

- 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[22]; 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.

116. When ABB says in its brochure that its HVDC technology offers a superior solution for the integration of offshore wind power into the transmission grid that benefit of HVDC, specifically its ability to accommodate long submarine

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

cables, does not apply in this case as the proposed Interconnector will not connect to an offshore wind farm.

117. When considering HVDC as an alternative to the proposed HVAC solution the respective applicants considered the use of ABB's VSC-HVDC technology and concluded that it, along with the other variants of HVDC technology, is not an appropriate option for the intended nature and purpose of the proposed Interconnector.

3.13 Cost Arguments against Undergrounding

118. In the SEAT Statement of Case at paragraph 55 in the second and third bullet point it is stated that:

> *"The whole life cost assessment needs a thorough examination, as required by the policy, of all elements including affordability, security/safety, reliability, losses, efficiency and environment. A circuit of 1500MW has a potential to transmit up to 4.3 Million GBP worth of energy daily (based on the assumed cost of energy of 1MWh = 120GBP). This also supports the statement that the Applicant has to carry out a more detailed techno-economic feasibility assessment which will address the topics below.*
>
> *It should be remembered that the applicant has never produced an economic fully costed financial model even for the overhead preferred solution and no cost-benefit analysis undertaken of the various alternatives. Such a model should contain details of pre- construction development costs, capital costs, land access costs (in terms of compensatory payments), lifetime operating costs in terms of conductor replacement and maintenance, electrical losses in transmission, expected revenues, servicing if debt (at the CER required discount rate of 5.63%) and all other costs. This has never been provided. Equally other than sweeping generalities the costs and financial models of underground cable solutions have never been made available and the applicant have relied on using simple multiples of cost against their preferred solution".*

Response:

119. The factors of "*affordability, security/safety, reliability, losses, efficiency and environment*" were all part of the multi-criteria analysis of the technology alternatives that was undertaken by the respective applicants and which is described in Section 3.8 above.

120. It is unclear what point is being made when claiming that a potential £4.3 million worth of energy will pass through the circuit daily.

121. A detailed techno-economic feasibility assessment can be found in the PB Power Report (2009) and the PB Power Technology and Costs Update Report (2013).

122. The objective of the PB Power studies was to establish an estimate of the *difference* in costs between the options as opposed to the *overall* cost of each option because when carrying out a comparative assessment of project options it is the difference between the options that is at issue. The capital cost estimates produced by PB Power are therefore not 'whole of project' cost estimates. Those elements that are common to all options, such as AC substations and third party payments (refer to Section 3.2 of the Addendum to the Report[23] to Independent Expert Panel of June 2014 for more detail) were specifically excluded from the cost estimates. "[*E]xpected revenues*" are not included in the cost estimates as they do not arise.

123. Other than the above all of the other elements identified in the third bullet point of paragraph 55 are considered in the PB Power cost estimate. Refer to Section 3.2 of the Addendum to the Report to Independent Expert Panel of June 2014 which is discussed further below for more detail on the methodology applied by PB Power in the preparation of its cost estimate.

124. In 2014 Ireland's Minister for Energy set up the Independent Expert Panel (IEP) chaired by Mrs Justice Catherine McGuinness. The IEP was tasked with drawing up Terms of Reference for the carrying out of a fair comparison of underground and overhead options for electricity transmission projects. Include in the Terms of reference were a number of economic criteria (including pre-engineering costs, project implementation costs and project life cycle costs) against which the technical alternatives shall be compared. At that time the respective applicants had completed their consideration of the technical alternatives for the proposed Interconnector and the Minister asked the IEP to review this and compare it against the methodologies set out in its terms of reference.

[23] Report to the Independent Expert Panel Date: 29/05/2014 & Addendum Date: 19/06/2014 available at http://www.eirgridnorthsouthinterconnector.ie/media/Appendix%203%20Report%20to%20the%20Independent%20Expert%20Panel%2029-5-2014%20Add%2019-6-2014.pdf.

125. In July 2014 the IEP reported to the Minister that it was of the opinion that the work completed by EirGrid on the North-South 400 kV Interconnection Development was compatible with their terms of reference. It follows therefore that the IEP is of the opinion that the methodology applied by the respective applicants in their joint comparative assessment, including the economic comparison of the OHL and UGC options will result in a full, fair and transparent economic comparison.

3.14 EirGrid's Opinion of the Underground Cable Option as Being "Sub-Optimal"

126. In the SEAT Statement of Case at paragraph 55 in the third and fourth bullet points it is stated that:

> *"Given that the cost multiple is now generally accepted by international agencies as being less than 2, the cost argument no longer holds valid credibility. EirGrid's (and thus SONI's) sole remaining argument is that UGC's are feasible and reliable and cost effect represent (in their words) "a sub-optimal solution".*
>
> *At the public inquiry in the Republic, EirGrid has accepted that UG HVDC is as reliable as OHTL's, are as safe, are not prohibitively expensive and their sole remaining argument to support their inherent opposition to UGC's has been the quote that "the HVDC solution is sub-optimal".*

Response:

127. We are not aware of any reputable and knowledgeable international agencies that estimate that the cost of underground cable transmission is less than twice the cost of equivalent overhead line transmission, let alone that there is any consensus among such agencies on the point.

128. The respective applicants' preference for 400kV AC overhead line is much more broadly based than the simple position that UGC represents "*a sub-optimal solution*", such that OHL is preferred.

129. In their joint comparative assessment of HVDC as an alternative to HVAC, (described above in Section 3.8) the respective applicants 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[24]; 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.

130. In their careful and detailed consideration of alternative AC technology solutions (described above in Section 3.8) the respective applicants concluded:

- A 400 kV AC overhead line is the best technical solution for the proposed Interconnector;
- 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;
- 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[25].

131. "*At the public inquiry in the Republic, EirGrid*" explained that:

- An AC OHL can be expected to have a much superior level of availability for service than a HVDC UGC;
- An AC OHL and a HVDC UGC can be considered to be equally safe;

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

- In the case of the proposed Interconnector the HVDC UGC option would cost €670 million more than the proposed AC OHL:
- Despite costing significantly more than the proposed AC OHL the HVDC UGC option would not do the job as well as the AC OHL and can therefore be considered to be sub-optimal.

132. The Inspector at that "*public inquiry in the Republic*" was also of the opinion that there are more reasons for discounting the HVDC UGC option than it is considered by EirGrid to be a "*sub-optimal solution*". This is evident on page 180 of her report where she concludes that -

> *"I accept that different projects require different solutions. EirGrid accepts that the DC option is feasible, but rejects it on the grounds of technical and cost considerations. Having regard to the significant technological advances made and which continue to be made in technology, the Board may wish to seek specific expert opinion on the current feasibility of integrating a HVDC system into the existing AC meshed network. However, having taken into considerations all of the arguments made, the strategic importance of the proposed interconnector as part of the all-island transmission network, the lack of existing strong interconnection between Ireland and Northern Ireland and the overwhelming need for reliability and security of supply, on balance it would appear that the technology currently best suited to satisfy the requirements of the proposed North-South Interconnector development is an overhead high voltage alternating current power line".*

It should be noted that there is no record or reference of the 'Board' seeking expert opinion as part of its decision.

3.15 EirGrid's Position on the Cost of UGC

133. In the SEAT Statement of Case at paragraph 55 in the fifth and sixth bullet points it is stated that:

> *"The statements and claims by EirGrid on cost of underground cable technology have varied wildly over the last 7 years. Notwithstanding its refusal to carry out a*

site specific underground route and cost analysis for the NSIP EirGrid has not been shy in making apparently authoritative statements on the cost of same;

In 2007 EirGrid estimated the cost of underground cable technology to be 25 times that of overhead lines and pylons. In 2009 this figure was reduced to 7 times the overhead line cost. The most recent statements by EirGrid and by Minister Rabbitte refer to 3.5 times the cost. All of these cost claims are based on hypothetical estimates from various reports".

Response:

134. EirGrid's position on the comparative cost of UGC and OHL for the proposed Interconnector has not "varied wildly over the last 7 years" and since the publication of the PB Power Report (2009). In 2009 EirGrid was saying that HVAC UGC would cost €565 million, or 5.4 times more than HVAC OHL. While HVDC UGC would cost €685 million, or 6.3 times more than the equivalent HVAC OHL. Today EirGrid says that HVAC UGC would cost €740 million, or 6.3 times more than HVAC OHL. While HVDC UGC would cost €670 million, or 5.8 times more than the equivalent HVAC OHL.

135. While the **least cost** UGC option in 2009 was estimated to be HVAC UGC at 5.4 times the cost of HVAC OHL the **least cost** UGC option is now estimated to be HVDC UGC at 5.8 times the cost of HVAC OHL. So in cost ratio terms there has not been a significant change in the last seven years in EirGrid's cost comparison between the standard AC OHL and the least cost UGC option. In monetary terms however the cost difference between the least cost UGC option and the standard HVAC OHL option remains significant and now stands at €670 million.

136. In 2007 when this project was first launched, and prior to the completion of the PB Power Report in 2009, the best available information on the comparative cost of 400 kV UGC and 400 kV OHL was received from the National Grid Company, the owner of the transmission system in England and Wales. National Grid had direct experience of installing 400 kV UGC and constructing 400 kV OHL and was reporting that the cost differential could be up to 25 times. This was however based on the installation of a 400 KV UGC in London which was installed in an expensive air-conditioned tunnel.

137. In December 2007 following feedback received during public consultation EirGrid and NIE jointly commissioned the PB Power study. One of the objectives of the PB Power study was that detailed project specific and site specific cost estimates for the UGC options be prepared which could then be compared with the OHL costs estimates. In 2009 the PB Power report was published and it found that the least cost UGC option would cost €565 million, or 5.4 times more than the OHL option.

138. In July 2011 Ireland's Minister for Energy appointed an International Expert Commission (IEC) to examine the case for, and cost of, undergrounding all or part of the Meath – Tyrone 400 kV line. As part of this study the IEC[26] reviewed expert literature already available both in Ireland and internationally in relation to undergrounding high voltage power lines. The IEC report was published in January 2012 and included in its review of the expert literature was a review of the PB Power Report (2009). The IEC concluded in respect of the PB Power Report that within its terms of reference its "*analysis is very robust*" and "*the results are correct,*" however if the study was to be repeated today the results may be different due to advances in HVDC technology and changes in costs since 2008.

139. Following the publication of the IEC report NIE and EirGrid therefore re-engaged PB Power and requested that a Technology and Costs Update be prepared which would form an Addendum to their 2009 report. The Addendum was published in April 2013, with a Supplementary Note in July 2013.

140. The IEC estimated that the standard AC OHL circuit would cost €167 million whereas the DC UGC alternative would cost €500 million. That is a difference of €333 million or 3 times more than the cost of AC OHL. The PB Power Technology and Costs Update Report (July 2013),[27] on the other hand, found that the standard AC OHL circuit would cost €140 million whereas the DC UGC alternative would cost €810 million (see Table 3-2,

[26] Available at - http://www.eirgridnorthsouthinterconnector.ie/media/3B_29)%20IEC%20(2012)%20International%20Expert%20Commission%20%20Meath%20Tyrone%20Report.pdf

[27] The *Supplementary Note* of July 2013 to the *PB Power Technology and Costs Update Report* of April 2013 revise the comparative cost estimates by excluding any provision for the intermediate substation near Kingscourt (refer to summary details of report in Table 4.2). This results in the PB estimates being directly comparable with those of the IEC as the IEC also excluded any provision for the intermediate substation.

page 3 of the Supplementary Note). That is a difference of €670 million or 5.8 times more than the cost of AC OHL.

141. This significant variation between the cost estimates in the IEC Report and the PB Power Update Report for the DC alternative is explained as follows. Both reports agree that the converter stations will cost approximately €300 million (that is €150 million each). The cost difference arises in the difference in cost per km for the DC UGC connecting between the two converter stations.

142. The IEC assumes optimum conditions are available for the installation of the DC cables. By 'optimum conditions' they mean that the cables will be installed in the wide soft margin of a major road for almost the entire length and that the cables will be installed side by side in a single 3 metre wide trench (**Figures 2** and **3** are extracted from the IEC Report and were included in that report for the purpose of illustrating the assumptions that formed the basis for the UGC cost estimate). This results in a cost per km of €1.36 million for 140km[28] giving a total cable cost of €190 million.

Figure 2: Wide Soft Margin of a Major Road

[28] The IEC assumed that the route for UGC would be 140km in length whereas PB Power identified a route for UGC and measured it at 135km in length.

(Source: IEC Report p. 46)

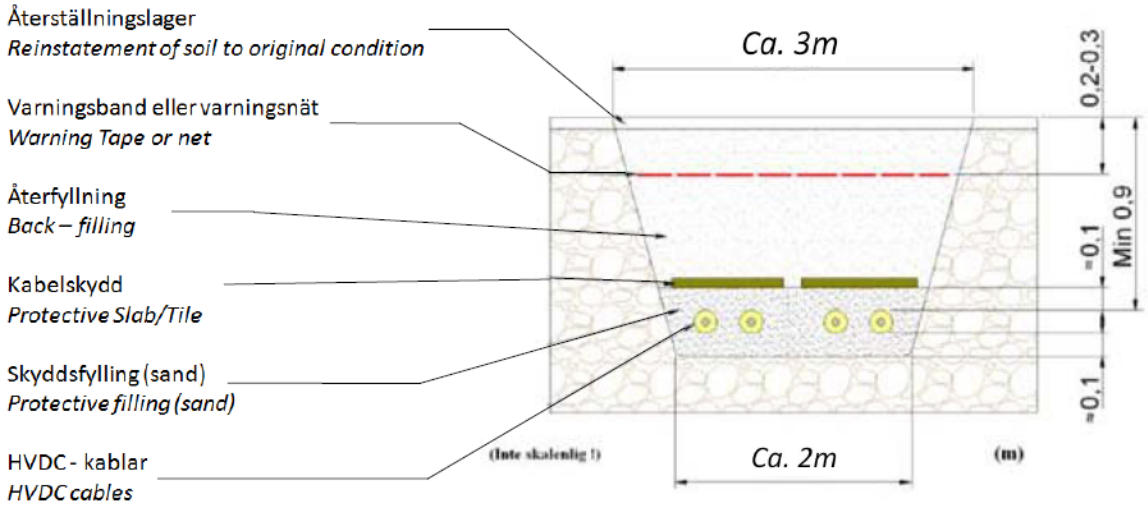

Figure 3: Section through cable trench for two parallel HVDC circuits

(Source: IEC Report (p. 46) with translation to English by EirGrid)

143. The PB Power estimate is based on the assumption that the DC cables will be installed along a route across country through farmland in the corridor identified in the PB Power Report of 2009. This results in a cost per km of €3.76 million for 135km giving a total cable cost of €508 million.

144. In SONI's and EirGrid's view, the IEC estimate is understated. A long major road, with a wide soft margin, linking Batterstown in County Meath to Turleenan in County Tyrone does not exist. Instead the roads in the five counties to be traversed are generally narrow and winding. The IEC itself recognises that installing cables under such roads would result in a higher cost per km than the €1.36 million previously indicated. Consequently without a contiguous suitable soft margin, the works and their cost will extend to not only the road network but the adjacent hedging, buildings, gateways, culverts, ditches, etc. It is also the case that due to the winding nature of the roads that any route that follows the public roads will be longer than a more direct cross country route. The scale of this works and costs will be exasperated by this longer route length compared to a cross country route.

145. In their consideration of the DC option, the respective applicants follow the costing approach adopted by PB Power for the following reasons:

- It will allow the two pairs of DC cables that would be required for such a scheme to be installed in two separate trenches that are sufficiently far apart (> 5 metres) that it reduces the likelihood, to a level that can be considered to be negligible, of a single event causing damage to both sets of cables at the same time. This will result in a significantly better level of service availability and as a result improved security of supply were they not laid with this level of physical separation.
- It will result in a shorter more direct route.
- It will avoid extensive road closures and the considerable disruption to local communities that that entails.

146. The UGC cost estimate by PB Power is a 'bottom up' estimate based on a site-specific and route-specific study. This is the most robust method for preparing a cost estimate. The IEC estimate is a desk top 'top down' estimate based on tender prices for similar type projects in Europe with an assumption as to the UGC routeing conditions. Within the context of its report the IEC estimate is also a robust estimate. The difference between the two has been explained above and neither of them should be considered as "hypothetical".

3.16 EirGrid's Knowledge of the Cost of UGC and OHL

147. In the SEAT Statement of Case at paragraph 55 in the seventh and eighth bullet points it is stated that:

> *"The reality, however, is very different. EirGrid has direct knowledge of the construction costs of overhead transmission lines. EirGrid recently completed the construction and installation of the underground and undersea 256 km East-West interconnector from Wales to Woodland in Meath, and therefore has direct knowledge of the construction costs for undergrounding, especially HVDC cable systems. This is exactly the same system that the Independent Expert Commission report is recommending as suitable for the North-South interconnector.*

All of this information is now in the public domain. The average cost for EirGrid's planned overhead lines - Grid West, Grid Link and North-South interconnector is €2.1M per kilometre. The construction cost for the East-West HVDC underground and undersea cable is €2.2M per kilometre. Hence, based solely on EirGrid's own cost figures the construction cost of overhead lines and underground cables is similar."

Response:

148. In the case of the proposed Interconnector EirGrid and SONI rely on the cost estimates prepared by PB Power.

149. EirGrid's East West Interconnector has a capacity of 500 MW. The proposed North South Interconnector requires a capacity of 1,500 MW, three times the capacity of the East West Interconnector. The cost of the East West Interconnector is not therefore directly comparable with that of the proposed Interconnector.

150. It is assumed that the figure in the SEAT Statement of Case of "€2.2M per kilometre" for the East West Interconnector was calculated by dividing the overall project cost by 256, based on the 256 km length of the cables connecting the two ends of the East West Interconnector. This is not an appropriate way of calculating the cost per km of a HVDC UGC scheme as the converter stations at the ends of the cable are such a large component of the overall cost and their cost would be incurred equally whether the length of the connecting cables was 50 km, 100 km, 256 km or 500 km. It is assumed that a similar approach was applied by SEAT in arriving at the average cost of €2.1 million per km for EirGrid's three 400 kV AC OHL projects. This is also not an appropriate method for calculating the cost per km of 400 kV AC OHL because again it does not allow for the cost of the substations at the ends of the overhead lines which can be significant, although not as significant as the cost of converter stations is in the case of HVDC.

151. The methodology applied by PB Power is described in Section 3.13 above. This is a much better methodology for undertaking a fair and transparent cost comparison of OHL and UGC options for a transmission project than that presented by SEAT. The objective of the PB Power cost comparison

was to establish the difference in monetary terms between the options, not the overall project cost, because in a comparative assessment it is the difference that matters. When comparing the cost of two options therefore it is not necessary to include in the cost estimates items that are common to both as they have no material influence on the cost differential.

3.17 Construction Costs are Not the Only Factor to be Considered in a Comparative Assessment of Technical Alternatives

152. In the SEAT Statement of Case at paragraph 55 in the ninth bullet point it is stated that:

> *"These costs refer to construction costs only. EirGrid has refused to accept or factor in any devaluation of property or land caused by extra high voltage overhead lines. It also refuses to accept any tourism or landscape impact. EirGrid refuses to accept any health risks associated with these overhead lines."*

153. In last paragraph on page 2 and continuing on page 3 in the Statement of Case by James McNally it is stated that:

*"There has never been a thorough **and transparent transboundary Cost Benefit Analysis** completed on the proposed inland route for this project, the long term ecological and environmental costs will far outweigh the expected economic benefits over the proposed life cycle economic benefits assumed by the developer. Technological feasible developments such as **HVDC (High Voltage Direct Current) undergrounding technology along existing state owned assets such as road and rail networks at a fraction of the cost have not been independently assessed or considered as a viable and less contentious alternative in planning this project".***

Response:

154. The multi-criteria analysis that was applied to the comparative assessment of technical alternatives is described in Section 3.8 above. It can be seen there that 'impact on the environment' was one of the criteria considered when comparing options.

155. The Consolidated ES and its Addendum presents a full and robust assessment of all likely significant environment effects including impacts to

tourism, landscape and EMF. Additional information is also presented in SONI's Statement of Case and supporting documentation for the project. All likely significant effects have been assessed and, where required, mitigation proposed to eliminate or remove the impacts.

156. Impacts to tourism will not be direct as no tourist sites will be physically impacted by the Proposed Development. The key sites within the study area (the Argory, Navan Fort and Benburb Priory) will have views of the construction and operational phases but it is considered that these impacts will not be significant. It has been determined that there will be no likely direct or indirect significant effect on tourism (Consolidated ES, Volume 2, Chapter 15).

157. The Proposed Development will fully comply with the Government policy on exposure of the general public to EMFs, which is based on numerical exposure guidelines. The exposure guidelines in place in the UK as a result of Government policy, formulated in 2004 and reiterated in 2009, are those published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), applied in the terms of the 1999 European Union Recommendation. These guidelines take account of all the relevant scientific evidence. The proposed overhead line complies with the public exposure limits at all places underneath it, not just beyond some specified minimum distance. A person standing directly under the overhead line would be within the exposure guidelines (Consolidated ES, Volume 2, Chapter 7 and Consolidated ES Addendum, Volume 2, Chapter 1).

158. The landscape assessment indicates that there would be significant adverse impacts upon the landscape of some parts of the study area. There would also be significant adverse effects on the visual amenity afforded from many locations from within the immediate area following the line route. However it is considered that the landscape and visual resource of the wider study area would not deteriorate to a significant degree and the overall impact upon landscape and visual amenity in general is therefore restricted to those receptors/areas within close proximity to the towers and overhead line (Consolidated ES, Volume 2, Chapter 13).

159. Any residual impacts to these environmental topics have been minimised as far as possible or there are no likely significant effects. SONI and its experts are not aware of any methodology that would allow the monetisation of the residual impacts.

160. The issue of land devaluation is dealt with in the Main Rebuttal Document.

161. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application also made the same assertion that is made in the SEAT Statement of Case at paragraph 55, ninth bullet point. However in that case the Board's Inspector, having considered all of the evidence presented to the hearing, concluded in her report at page 134 -

"'I accept that a cost/benefit analysis has been carried out in accordance with industry norms and has been accepted by the CER [Commission for Energy Regulation in Ireland]*. I accept that this falls short of the observers' requirements in terms of assessing the wider costs and benefits associated with the proposed development and other alternatives. However, I consider that this is a matter which is clearly outside the scope of the Board, which is limited to the consideration of planning matters. I accept that it would be difficult to quantify in monetary terms the wider costs and benefits associated with the proposed development, but that the positive and negative effects associated with the development are identified and assessed in the EIS."*

162. It is also the case that "*that the positive and negative effects associated with the development are identified and assessed*" in the SONI Consolidated ES.

3.18 Impact of Project Delays

163. In the SEAT Statement of Case at paragraph 55 in the eleventh and twelfth bullet points it is stated that:

"The delays incurred in upgrading the grid also carry a significant cost element. EirGrid and Chambers of Commerce Ireland, estimates this at circa €30Million per year. Planning delays on the North-South interconnector, self-inflicted by EirGrid, are now running at a minimum of 7 years behind schedule at best, totalling €210 Million. Undergrounding of cabling, however, does not require planning and so provides an immediate solution to this problem.

EirGrid has never included lifetime cost elements, such as project delays and valuation impacts, in its transmission investment decisions."

Response:

164. In the case of this proposed Interconnector any underground cable option would require statutory planning approval in both Northern Ireland and in Ireland.

165. It is not the practice to include costs associated with historical *"project delays"* or future potential *"valuation impacts"* in investment decisions.

166. The methodology applied by the respective applicants is in line with the terms of reference set out by the IEP for undertaking a fair and transparent comparative analysis of the UGC and OHL options (see Section 3.8 above).

167. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application also made the same assertions regarding the absence of the impact of *"project delays"* and *"valuation impacts"* in investment decisions However having considered all of the evidence presented to the hearing the Board's Inspector concluded in her report in Section 5.2.4.7, page 134:

"'I accept that a cost/benefit analysis has been carried out in accordance with industry norms and has been accepted by the CER [Commission for Energy Regulation in Ireland]*. I accept that this falls short of the observers' requirements in terms of assessing the wider costs and benefits associated with the proposed development and other alternatives. However, I consider that this is a matter which is clearly outside the scope of the Board, which is limited to the consideration of planning matters. I accept that it would be difficult to quantify in monetary terms the wider costs and benefits associated with the proposed development, but that the positive and negative effects associated with the development are identified and assessed in the EIS."*

3.19 Impact of "the compensation scheme" on the Comparative Cost Estimates of Alternatives

168. In the SEAT Statement of Case at paragraph 56 it is stated that:

> *"Given the opposition and uncertainty as to who is to be funding the compensation scheme, neither the inquiry or the Department could possibly know the cost of the proposal to make a fair and objective comparison with undergrounding; an alternative most likely to be supported by those communities directly adversely affected by this proposal."*

Response:

169. In the context of this application it is unclear what "compensation scheme" is being referred to here; however it should be noted that SONI's assessment of undergrounding as an alternative to the proposed overhead line is the same as EirGrid's as it was a joint effort.

170. For the comparative costs estimates SONI and EirGrid rely on the cost estimates prepared by PB Power. The methodology applied by PB Power is described in Section 3.13 above and is an appropriate methodology for undertaking a fair and transparent cost comparison of OHL and UGC options for a transmission project. The objective of the PB Power cost comparison is to establish the difference in monetary terms between the options, not the overall project cost, because in a comparative assessment it is the difference that matters. When comparing the cost of two options therefore it is not necessary to include in the cost estimates items that are common to both as they have no material influence on the cost differential.

171. In Section 3.8 above it is mentioned that an Independent Expert Panel (IEP) was appointed by Ireland's Minister for Energy to draw up terms of reference for undertaking *"a fair and objective comparison"* of OHL and UGC options for transmission projects. The IEP was further tasked with providing the Minister with an opinion on -

"what has already been done (i.e. up to 2 May 2014, being the date the Panel decided to examine the N/S project) on the North South Transmission Line project"[29].

172. EirGrid submitted a report[30] to the IEP describing what has already been done in the case of the proposed Interconnector. The work carried out by PB Power was described in the Report and in the case of the economic comparison of options it was explained on page 15 of the Addendum –

"In the case of both the OHL and UGC options the most suited route is a route across private lands. This means that "third party payments" would arise in the case of both options. As the UGC option would place a greater burden on private lands than would the OHL option it is likely that these costs would be greater in the case of UGC than in the case of OHL. It was considered however that this difference would not have a significant impact on the overall difference in cost between the options and as a result they were excluded from the PB Power cost estimates."

173. In Ireland a Community Gain scheme is proposed and in the Report to the IEP it was explained, again on page 15 of the Addendum that:

> *"Community Gain costs would arise in the case of the OHL option but not in the case of the UGC option. Provision has not been made for these in the OHL cost estimates however they would not have a significant impact on the overall difference in cost of the options."*

174. The IEP reviewed EirGrid's comparative analysis of UGC and OHL and concluded that: "*in all material respects, what has already been done on the N/S project is compatible with the methodologies"* set out in its specified terms of reference.

175. It follows therefore that IEP is of the opinion that the cost of any Community Gain scheme or any landowner compensation scheme would not have a material impact on the difference in cost between the UGC and the OHL options for the proposed Interconnector.

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[29] http://www.dccae.gov.ie/news-and-media/en-ie/Pages/PressRelease/Statement-by-the-Independent-Expert-Panel.aspx
[30] Report to the Independent Expert Panel Date: 29/05/2014 & Addendum Date: 19/06/2014 available at http://www.eirgridnorthsouthinterconnector.ie/media/Appendix%203%20Report%20to%20the%20Independent%20Expert%20Panel%2029-5-2014%20Add%2019-6-2014.pdf.

3.20 Combinations of Alternatives

176. In the SEAT Statement of Case at paragraphs 57 to 59 it is stated that

> *"The applicant has failed to examine realistic combined options for achieving the desired capacity and security of supply objectives for the North-South interconnector."[para 57]*
>
> *Specifically:*
>
> *• The use of High Tension Low Sag (HTLS) conductors on existing lines,*
>
> *• The use of 'Series Compensation' technology, currently being considered for Grid Link*
>
> *• The use of 400kV 500MW underground cable technology along public roads." [para 58]*
>
> *"The combination of 2 or all 3 of above would achieve the desired objectives of the applicant, but the company has always only examined the simplest, but most destructive, option of 400kv OHL."[para 59]*

Response:

177. In the course of their consideration of the alternatives SONI and EirGrid has examined the use of both individual and a mixture of alternatives to resolve the issue of the need for a second North South interconnector.

178. As has been discussed in Section 3.8 above there is a need for a second interconnector to be an alternative path for power to flow in case of the failure of the existing interconnector.

179. Consequently, the nominal electrical capacity required for the second North South interconnector is 1500MW[31], as:

a. The proposed interconnector will form a link between the 400 kV network in Ireland and the double circuit 275 kV network in Northern Ireland. The nominal capacity of the circuits that form these 400 kV and 275 kV networks is 1,500MW;

b. The nominal capacity of the existing north-south interconnector is 1,500MW[32]. The proposed interconnector will form a second north-

[31] MVA (megavolt-amperes) is the technically correct unit of measurement for describing the capacity of transmission circuits and power transformers, and is the product of voltage (V) and current (A for amperes / amps). It has however become customary in non-technical documents to use MW for this purpose; therefore in this context, MW shall be interchangeable with MVA for the purpose in this rebuttal.

[32] Although the existing 275 kV double circuit OHL has a nominal capacity of 1,500MW the transformers at the Louth Substation end have a combined capacity of 1,200MW.

south interconnector and operate in parallel with the existing interconnector. A nominal capacity of 1,500MW will therefore match that of the existing interconnector;

c. Studies also show that a rating in excess of 1,100 MW would be required to avoid continued limitations on the Total Transfer Capacity (TTC) being imposed. It is therefore prudent to design for 1,500 MW accounting for point a, and b and a margin for future growth.

180. The first two elements of the combined option proposed in the SEAT Statement of Case, the use of HTLS and series compensation would increase the capacity of the existing interconnector (see Section 3.21 below for further discussion on this option). This however will not help the situation because:

- The existing interconnector already has a nominal capacity of 1,500 MW,
- A cross border power transfer of 1,500 MW would meet current identified requirements,
- A cross border power transfer of 1,500 MW would only be permitted if, along with the existing 1,500 MW interconnector, there was one or more additional interconnectors in place with a combined capacity of 1,500 MW or greater.

181. The final element, the 500MW rated cable, would provide a second interconnector. However it would only be of medium capacity and to provide that capacity it would have to be connected to suitably strong connection points north and south of the border and be independently terminated at different locations to the existing Louth – Tandragee 275kV double circuit line.

182. With a 1,500 MW interconnector and a 500 MW interconnector in place applying standard operating procedures[33] would limit the maximum cross border power transfer to 500 MW, the capacity of the smaller interconnector.

[33] This refers to the 'N – 1' criterion where in a case such as this, where two circuits are operating in parallel, should one of them unexpectedly trip the remaining circuit should at all times be able to pick up all of the load lost by the tripped circuit and continue to operate within its safety limits and the system remain within operational limits. To satisfy the 'N – 1' criterion therefore the combined load on the two parallel circuits can never be allowed to exceed the capacity of the smaller circuit.

However a need for a cross border power transfer in the region of 1,500 MW has been identified.

183. In conclusion therefore any combination of these three 'options' will not provide a cross border transfer capacity of 1500MW and therefore this proposal does not meet the identified needs of the project and is not an acceptable solution.

184. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application contested this conclusion.

185. The objectors claimed that the capacity of 1500MW specified as need for this project was not justified and that the project proposal to develop a new high capacity interconnector was based on an inadequate consideration of non-transmission options and other transmission options. However having considered all of the evidence presented to the hearing the Board's Inspector concluded in her report at the end of Section 5.4.5.2 –

"I accept that it has been adequately and comprehensively demonstrated by EirGrid why the proposed new interconnector needs to be rated 1500MW."

186. And at the end of section 5.4.5.4 the Inspector concluded:

> *"I accept that it has been comprehensively demonstrated that the only way to meet the strategic and technical need for the proposed development is to provide with [sic] a new and physically separate high capacity interconnector."*

3.21 Reinforcement of the Existing Interconnector as an Alternative

187. In the SEAT Statement of Case at paragraph 60 it is stated that:

> *"if the existing Louth-Tandragee interconnector was restrung with HTLS conductors the theoretical Total Transfer Capacity ("TTC") would increase by approximately 65 to 100% (estimated 75-80%) (EirGrid Figures)"*

Response:

188. The TTC[34] is defined by the power that can be transferred without impacting on security of supply.

189. In the case of the Louth-Tandragee 275kV double circuit interconnector this is defined by the impact of the loss of this circuit, and is not the rated capacity of the line, which is the maximum power level that the circuit can transmit which is 1500MW.

190. Replacing the standard conductors on the existing interconnector with HTLS[35] will increase the rated capacity of the line. However as the TTC of the existing line is not limited by its capacity uprating the line will not increase the TTC. Only a second high capacity interconnector will increase the TTC and thereby address the need for the project and provide the benefits that result.

191. The use of HTLS, or any other technology to increase the capacity of the existing interconnector, is not an acceptable solution.

3.22 Route Specific Studies of Alternatives

192. In the SEAT Statement of Case at paragraph 62 it is stated that:

> *"In simple terms alternatives that require meaningful and route specific studies should have been conducted on:*
>
> *1. HVAC cables for partial undergrounding along the indicative route of the alignment.*
>
> *2. HVDC underground cables along public roads or other corridors*
>
> *3. HVDC underground cables along existing railbeds*
>
> *4. Retrofitting of HTLS conductors on extant interconnector(s)*
>
> *5. Retrofitting of HTLS conductors and Arago insulating arms on the existing interconnector*

[34] The TTC will vary with system conditions, for example electricity demand and the location of the generation providing power to this demand, but is defined in Appendix 3.1 of the Consolidated Environmental Statement as at present having a maximum limit of 450MW.

[35] .High Temperature Low Sag (HTLS) conductors are special conductors that have a much greater capacity than an equivalent sized (cross sectional area and weight) standard conductor and are therefore typically used for uprating existing overhead lines where the existing standard conductors are replaced with HTLS conductors and no alterations to the existing support structures are required. If the existing overhead line was to be up-rated using standard conductor then a larger and heavier conductor would be required which may require that the existing support structures to be reinforced or even replaced.

6. Use of alternative routes using offshore routing using sub-marine HVDC cables.

Response:

193. Partial undergrounding using HVAC cable was considered and discounted: see Sections 1.6.2 and 1.6.3 above for further details.

194. HVDC underground cables along public roads was considered and discounted: see Sections 1.6.3 and 1.6.4 above for further details.

195. EirGrid undertook a study[36] that considered disused rail beds as a routeing option for underground cables. It concluded in Section 3.1. *'Executive Summary'* that:

"EirGrid finds that co-location of transmission cables and rail to be unfavourable in this instance, in terms of ongoing security of the system and the arrangements necessary in the event of major accidents or faults. Secondly, the selection of a rail bed selection would only serve to direct a cable route at a series of obstacles, such as bridge abutments and narrow, steep sided embankments and cuts which would have to be severely modified. Legacy structures of the old railway would also have to be modified, removed or avoided. Such a routing would not have the advantages of a route corridor selected to minimise community and environmental impacts, such as was done in the report produced"

196. In addition to the aforementioned significant works required to widen the existing rail bed to the width of 18-20m required for a HVDC double circuit scheme, there is no rail bed that provides a direct and unbroken route between the existing station at Woodland and the proposed station at Turleenan. The report concludes in section 3.1 and 3.3. respectively:

"No rail bed exists between the Woodlands 400kV substation and the Dunboyne to Fairy House Bridge"

"There is no rail bed between Kingscourt and Carrickmacross;"

197. The report concludes in section 5.3.3 on the *"Conclusions in Relation to the Kingscourt to Armagh Section":*

[36] "Locating 400kV Cables in or Adjacent to Rail Beds" Reference Chapter 3B of the EirGrid application in Appendix 1.1 of the SONI consolidated ES Addendum

"An independently determined cable route corridor chosen to mitigate the environmental constraints, taking into account the technical requirements for a 400kV cable, would be shorter and more secure, could more easily mitigate its environmental impacts, and be more cost effective."

198. As discussed in Sections 1.6.15 and 1.6.16 above there is only one existing interconnector between Northern Ireland and Ireland and uprating that existing interconnector by *"[r]etrofitting of HTLS conductors"* will not address the identified needs of this project.

199. Similarly uprating the existing interconnector using a combination "*of HTLS conductors and Arago insulating arms"* will not address the identified needs of this project.

200. An "*offshore routing using sub-marine HVDC cables*" was considered in Section 10.2.8.3 of the Consolidated ES Addendum. As explained in Section 3.8 above the HVDC cable option was discounted for technical and cost reasons. This conclusion applies regardless of whether that HVDC cable is installed on land or under the sea. Notwithstanding this conclusion it was also concluded in Section 10.2.8.3 of the Consolidated ES Addendum that a HVDC sub-marine cable scheme would be even less preferred than an on-land HVDC cable scheme for the following reasons:

201. For any on-land cable option there is a concern about the relatively long time it takes to find and repair faults. These durations would be even longer for a sub-marine cable.

202. The circuits required for the proposed development must connect into the existing transmission grid at appropriately strong points north and south of the border. In the case of the undersea option long on land cables are required to reach the coast (e.g. in excess of 40km from Woodland to the coast). An entirely on-land cabled option can take a more direct cross country route and as a result be considerably shorter and by implication less expensive than its undersea equivalent. For this reason a DC submarine cable, is considered to be even less preferred when rated against the criterion of 'provide a cost effective solution' than an on-land DC cable.

203. In summary therefore SONI has considered all six of the proposals identified by SEAT and concluded that they are not acceptable solutions for the nature, purpose, and extent of this project whether implemented individually or in combination.

3.23 The Partial Undergrounding Report and PRSNI Policy

204. In the SEAT Statement of Case at paragraphs 63, 64 and 65 it is stated that:

> *"The report fails to recognise the more onerous requirements of the PSRNI policies, which do not limit the scope of alternatives to specific sections of the proposed transmission route and require a thorough exploration of alternatives and the minimisation of visual impact of the entire proposal. The applicant's ES concedes that there will be many significant adverse visual impacts as a result of the proposed OHL. To that extent the applicant's own case corroborates the concerns expressed by members of the public who object to the significant adverse impact on amenity.*
>
> *Undergrounding as an alternative to all sections along the entire transmission route should therefore have been given due consideration.*
>
> *The applicant's failure to consider any other section of the transmission route for undergrounding is thus a failure to satisfy the requirements of the PSRNI policies."*

Response:

205. The approach taken to the assessment of alternatives (technology, routeing and siting) is fully outlined in Chapter 4 of the Consolidated ES and Chapter 10 of the Consolidated ES Addendum. These chapters outline in detail the process that was undertaken to determine the best available design, route and location of the proposed Tyrone – Cavan Interconnector taking into account all factors. In its thorough exploration of alternatives, SONI and its consultants have assessed a full undergrounding and partial undergrounding of the proposed Tyrone – Cavan Interconnector. These assessments are detailed in Chapter 10 of the Consolidated ES Addendum along with detailed technical appendices 10.1 and 10.2. Therefore, the applicant has fully considered the issue of undergrounding and it has been ruled out for a combination of environmental, economic and engineering reasons. In doing so the applicant has been aware of the policy requirements and has

demonstrated that alternative technology and routes are not suitable and is thus compliant with PSRNI PSU policies 2 and 8.

206. As stated in the Consolidated ES (Volume 2, Chapter 13, page 525, paragraph 844), the landscape assessment indicates that there would be significant adverse impacts upon the landscape of some parts of the study area. There would also be significant adverse effects on the visual amenity afforded from many locations from within the immediate area following the line route. However it is considered that the landscape and visual resource of the wider study area would not deteriorate to a significant degree and the overall impact upon landscape and visual amenity in general is therefore restricted to those receptors/areas within close proximity to the towers and overhead line. As also stated in the Statement of Case for the project (December 2016):

> *"When considering the site specific circumstances of the proposed Tyrone-Cavan Interconnector it is accepted that the proposed Tyrone-Cavan Interconnector produces some environmental impacts that are unavoidable. However, none are of such significance that they would either individually or cumulatively outweigh the overriding national and regional need for the proposed Tyrone-Cavan Interconnector and the benefits to be gained."*

3.24 Impact of the Removal of Kingscourt Substation from the EirGrid Application

207. In the SEAT Statement of Case at paragraph 75 it is stated that –

> *"In this application EirGrid has taken out the originally planned substation at Kingscourt in Cavan, due to the lack of demand for at least a decade. This also removes the requirement for a convertor station at Kingscourt and makes the project a true point to point interconnector – Woodlands to Turleenan – unlike the original application. This further supports the concept of an underground HVDC cable approach."*

Response:

208. The removal of the substation at Kingscourt from the EirGrid application does not alter the balance in favour of AC overhead line, as opposed to HVDC underground cable, for the proposed Interconnector. Prior to

EirGrid's decision to defer the planned substation at Kingscourt the proposed Interconnector was a "*true point to point interconnector*" from Turleenan to Kingscourt now it is a "*true point to point interconnector*" from Turleenan to Woodland. This change has no material impact on the application in Northern Ireland.

3.25 The Benefits of HVDC Technology

209. In the SEAT Statement of Case at paragraphs 78 and 79 it is stated that –

> *"Modern HVDC systems combine the good experience of the old installations with recently developed technologies and materials. The result is a very competitive, flexible and efficient way of transmitting electrical energy with a very low environmental impact.*
>
> *Furthermore it is material that:*
>
> *(a) The need for ROW (Right Of Way) is much smaller for HVDC than for HVAC, for the same transmitted power. The environmental impact is smaller with HVDC.*
>
> *(b) VSC technology gives a good opportunity to alternative energy sources to be economically and technically efficient.*
>
> *(c) HVDC transmissions have a high availability and reliability rate, shown by more than 30 years of operation.*
>
> *(d) If the existing Louth-Tandragee interconnector was restrung with HTLS conductors the theoretical TTC would increase by approximately 65 to 100% (estimated 75-80%)"*

Response:

210. The respective applicants are aware of the benefits provided by modern HVDC systems and these benefits were considered in the comparative analysis of HVDC technology and HVAC technology described in Section 10.2.8 of the Consolidated ES Addendum.

211. In the case of point (a) SONI is aware that the ROW for a HVDC UGC is not as wide as the ROW for a HVAC UGC. This is reflected in Section 3.9 above where it states that in the case of this project the working swathe for a HVDC UGC scheme would be 18 – 20m wide whereas the comparable working swathe for a HVAC UGC would be 20 – 22m wide.

212. Point (b) is not relevant to this application. The subject matter of this application is a point to point interconnector between two networks. It is not a connection to an "*alternative energy source*".

213. In the case of point (c) the respective applicants are aware of the "*availability and reliability rates"* of HVDC transmission schemes. As explained in Section 3.6 above the statistics show that a high voltage UGC will not have anywhere as near as a good a level of availability for service as a high voltage overhead line.

214. In addition it is worth noting that the Moyle Interconnector, a HVDC scheme connecting Northern Ireland to Scotland, has in its 15 years of service suffered a number of cable faults resulting in long duration outages. As a result of one of these the overall scheme was reduced to 50% of its capacity for four years from 2012 until 2016. Also the East West Interconnector, a HVDC scheme connecting Ireland to Wales, which was commissioned in 2012, was out of service due to a fault for over three months from September 2016 until December 2016.

215. HVDC schemes are very complex, much can go wrong, and when it does they can be expected to be out of service for a relatively long time. In comparison HVAC overhead lines are a relatively simple technology that when built to a high standard will give a very high level of reliability and in the rare event of a permanent fault can be quickly repaired and returned to service, typically in less than two days. For example the existing 429 km of 400 kV overhead lines connecting from Moneypoint in County Clare to the greater Dublin area have been in service for 30 years and during that time have only experienced one permanent fault that required a repair crew to find and repair the fault and on that occasion the line was returned to service within two days.

216. During the course of the oral hearing conducted by An Bord Pleanála in respect of the part of the proposed Interconnector located in Ireland objectors to that application also proposed that HVDC was competitive, flexible and efficient with a very low environmental impact. However having considered all of the evidence presented on the attributes of both HVDC and

HVAC alternatives to the hearing the Board's Inspector concluded in her report at the end of Section 5.4.6 *"Conclusion"*:

> *"I accept, having regard to the strategic importance of the proposed interconnector as part of the all-island transmission network, the lack of strong interconnection between Ireland and Northern Ireland and the overwhelming need for reliability and security of supply in terms of the all-island electricity market, that notwithstanding the alternatives considered and the advancements in technology, on balance it would appear that the most appropriate and cost effective technology to satisfy the requirements of the proposed North-South Interconnector development is an overhead high voltage alternating current power line."*

217. Point (d) of the SEAT Statement of Case is not related to the issue of the benefits HVDC and seems to have been inserted here in error. It is a repeat of paragraph 60 of the SEAT Statement of Case which is addressed in Section 3.22 above.

3.26 Consideration of the Askon Report

218. On page 2 of the Armstrong Family Statement of Case it is stated that –

> *"The only acceptable solution is to refuse permission for the applications and implement the recommendations of the Askon report (2008) and remove the health risks by undergrounding the cables."*

Response:

219. Implementing "*the recommendations of the Askon report (2008)"* is not an *"acceptable solution"* as explained below.

220. The Askon Report (Study on the Comparative Merits of Overhead Lines and Underground Cables as 400 kV transmission Lines for the North-South Interconnector project was commissioned by North East Pylon Pressure and published in 2008. The study was carried out by the Askon Consulting Group, Germany and the lead author was Professor Friedhelm Noack.

221. The Study concluded that from an environmental, technical and economic perspective the best option for implementing the proposed Interconnector was a double circuit HVAC cable development.

222. The International Expert Commission (setup by the Government of Ireland and discussed above in Section 3.15) reviewed the Askon Report as part of

its review of the proposed North–South Interconnection Development. The International Expert Commission (IEC) Report was published in January 2012 and stated that, while the author of the Askon Report, Professor Noack *"is well known in the industry for his work on lightning protection and overvoltages"* the "*Commission, is however, not aware of his expertise in grid development, grid operation, economic aspects and undergrounding*". The IEC then went on to state that it had found "*several questionable statements*" in the Askon Report. The more significant of these were:

- The IEC does not agree with the Askon Report when it states that long 400 kV AC underground cables "*are not really a problem and that experience is there".* The IEC found that there are no 400 kV underground cable circuits in the world that approach the length required for the North-South Interconnector and that this is because of sound technical reasons.
- The analysis by Askon of the reliability of AC underground cable circuits is not valid as it "*is not backed up by actual data".*
- The costs estimates for AC underground cable in the Askon Report are significantly understated as insufficient provision is made for the cost of installation.

223. Overall, the IEC concluded that the findings of the Askon Report "*are not consistent with industrial practice for other projects in Europe"* that are similar in size and form to the North-South Interconnection Development and which "*have been executed, are under construction or are in planning".* **The IEC Report goes on to make only one recommendation and that is that the proposed North-South Interconnection Development should not be implemented using the entirely undergrounded AC cable option.**

224. The position of the IEC regarding the Askon Report is consistent with SONI's position on that report. SONI concurs with the recommendation of the International Expert Commission that the proposed Interconnector should not be implemented using the entirely undergrounded HVAC cable option

3.27 Conclusions

225. In conclusion, nothing in the objectors' Statements of Case and representations serves to undermine the conclusions set out in the SONI Statement of Case and supporting Technical Reports. As stated in SONI's Main Rebuttal Document, the proposed Tyrone - Cavan Interconnector remains clearly acceptable in planning terms.