EirGrid Position on NEPP ASKON Study

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List of Abbreviations

TSO	Transmission System Operator
OHL	Overhead line
NEPP	North East Pylon Pressure
UGC	Underground Cable
EIS	Environmental Impact Statement
EHV	Extra High Voltage
AC	Alternating Current
HVAC	High Voltage Alternating Current
EMF	Electric and Magnetic Field
WHO	World Health Organisation
ELF	Extremely Low Frequency
ICNIRP	International Commission on Non Ionising Radiation
km	Kilometre
€m	Million Euro
DC	Direct Current
HVDC	High Voltage Direct Current
kV	Kilovolt
ESB	Electricity Supply Board
ESBI	ESB International
NPV	Net Present Value
LV	Low Voltage
MV	Medium Voltage
SONI	System Operator Northern Ireland
NIE	Northern Ireland Electricity
EIA	Environmental Impact Assessment

1 Background

EirGrid, as the Irish Transmission System Operator (TSO), is proposing to develop two new transmission projects in Ireland. The first project, the Cavan-Tyrone Project, consists of a new overhead line (OHL) between Ireland and Northern Ireland that will result in an increased interconnection capacity between both jurisdictions and will facilitate the reinforcement of the All-Island Single Electricity Market. This project will terminate at a new station near Kingscourt, Co. Cavan and will loop into the existing Flagford-Louth 220kV line. This project is being developed in cooperation with Northern Ireland Electricity (NIE), who is responsible for the section of the project from the border crossing point, near Clontibret, Co. Monaghan to a new station near Turleenan, Co. Tyrone.

The second project, the Meath-Cavan Project, consists of an overhead line to reinforce the transmission system in the North-East region of Ireland. This is required to meet the increase in electricity demand which has arisen from growth and development in the area. This growth and development will continue in the future notwithstanding the temporary abatement as a result of the current economic situation. This project will also allow for increased interconnection capacity between Ireland and Northern Ireland since the project will connect to the new station near Kingscourt, Co. Cavan and ultimately to the Cavan-Tyrone Interconnector. Both projects are being proposed as 400kV OHL solutions.

EirGrid has a statutory mandate to develop and operate a safe, secure, reliable, efficient and economical transmission system with due regard for the environment, as set out in Statutory Instrument No. 445 of 2000, Part 3, Section 8(1) (a). EirGrid must take cognisance of this mandate when developing new transmission infrastructure. In line with this mandate, the two above mentioned projects are being proposed as OHL, since this technology will provide the most feasible technical, reliable and economic solution[1].

As part of the development of the two projects EirGrid is undertaking an extensive engagement programme with stakeholders on all aspects of the project development. All issues, questions, and concerns raised by stakeholders are given every consideration by the EirGrid Project Team.

[1] EirGrid's Position on the use of Overhead Line / Underground Cable (2008) is available to download from www.EirGrid.com.

In April 2008 North East Pylon Pressure (NEPP) commissioned Askon to carry out a study on the feasibility and cost of an underground cable (UGC) alternative for the projects. NEPP is one of the representative groups for the people of the North East and contends that transmission projects should go underground. While acknowledging the need for both projects, NEPP has concerns in relation to the projects' impacts on issues relating to health, the environment, local heritage and property valuation. Part One of the resultant analysis prepared by Askon, entitled *'Study on the Comparative Merits of Overhead Lines and Underground Cables as 400kV Transmission Lines for the North-South Interconnector Project'*, was published in early October 2008. Part Two was later received by EirGrid in February 2009.

ASKON Consulting Group GmbH is an international technology consultant specialising in the energy, automotive and aerospace sectors. ASKON is part of the ALTRAN Group which states that through its energy division it provides support for major utilities, especially on power transmission and distribution and on renewable energies. The following information is taken from the Askon website[2]:

ASKON Consulting Group GmbH 2007

Sector: *Technology Consulting*
Employees: *over 350*
Turnover: *36 million €*
Customer sectors: *Automotive, Aerospace and Energy*
Division of turnover: *50% Aerospace, 40% Automotive, 10% Energy & other*
Locations: *Frankfurt, Hamburg, Munich, Düsseldorf, Bremen, Leipzig, Gummersbach and Lippstadt*
Parent company: *ALTRAN Group (17,500 employees)*

The main author of the report is Prof. Dr.-Ing. Habil. Friedhelm Noack, who works in the Ilmenau University of Technology in Germany. EirGrid and its transmission consultants for these projects, PB Power, ESB International (ESBI), Socoin, TEPCO and TransGrid, have not, prior to the publication of the ASKON report, encountered either Askon or Prof. Noack in the electricity transmission business.

[2] The Askon website can be found at http://www.askon.de

The purpose of this EirGrid document is to briefly review the Askon Study and particularly to examine those understandings that may or may not correlate with EirGrid's and EirGrid's consultants own understandings. It should be noted, however, that the fact that various aspects of the Askon study have not been commented on, does not imply EirGrid's agreement or acceptance of the content. Having said that, EirGrid has reviewed the report and facilitated two days of meetings with the authors in order ensure that all appropriate options are thoroughly examined in EirGrid's development of the best possible solution to the power needs of the North East.

2 Executive Summary

EirGrid welcomes all input into the consultation process associated with the 400kV projects in the North East.

The Askon Study proposes that the infrastructural requirements of the North East can be met using an HVAC underground technical solution.

Some assertions made in the Askon Study are aligned with EirGrid's own such assertions. Key among these are:

- There have been significant developments in high-voltage cable technology in the last 10 to 20 years;
- HVDC technologies are not appropriate for the 400kV projects in the North East;
- Two parallel UGC systems are proposed by Askon. In this regard the Askon Study has identified the security and reliability problems associated with such UGC;
- The capital costs associated with UGC are significantly higher as compared to OHL;
- UGC systems of the size and type required to meet the transmission infrastructural needs of the North East have never been installed;
- UGC does not emit electric fields; and
- It can be agreed that (as the Askon Study authors states) ***"****There are some uncertainties about investment costs of OVERHEAD LINES, being caused by different transmission capacities, different designs, different labour costs and right-of-way costs, and different geographical conditions".*

However, some fundamental assertions made in the study are either flawed, without basis, or are not supported by evidence. Problems identified in the report in relation to the application of an UGC solution include:

- Incorrect assumptions made with regard to transmission circuit loads. The Askon Report incorrectly assumes a high load on the proposed line when, in fact, the line will be loaded at a much lower level than that upon which Askon bases its conclusions. In reality, losses will be much lower than Askon calculates;
- A lack of clarity in relation to losses calculations including errors made in the application of loss factor values;

- Misleading application of financial analyses. Askon do not provide a full explanation on where their consumer costing data was derived from and their installation estimates are significantly lower than costs prepared by EirGrid's consultants
- As a consequence of the previous three points, incorrect assertions made with regard to transmission efficiencies, line losses and investment costs;
- There is no basis for the assertions that UGCs are safer than OHLs. Both technologies are used by EirGrid and both are designed and implemented so as to meet all relevant national and international safety criteria. UGCs and OHLs are equally safe;
- A lack of understanding of the fundamental principles that underlie long-term planning of an integrated transmission system and the application of reliability criteria to an integrated transmission system;
- A failure to assess the proposed 400 kV line projects in their true context as part of the all-island integrated power system which supports and facilitates the single electricity market. Askon reviewed the 400kV power line circuits in isolation, rather than looking at the system as whole. This, as a result, provides for an incomplete analysis;
- A lack of balance in relation to the discussion on the environmental impacts. EirGrid acknowledges that both OHLs and UGCs result in environmental impacts. These impacts are however different for the different technologies and in most cases mitigation measures are available. It is obvious that OHLs have a visual impact but this is not the only criteria that must be considered. In fact, comparing OHLs with UGCs across the full range of environmental criteria shows overhead lines perform better under many of the categories;
- Errors in assumptions in relation to the calculations of likelihood of cable system outages. Askon ignore potential impacts by third parties on the UGC, which results in lower outage figures. This is misleading, as the outage likelihood figures typically include those both planned and accidental. Further, Askon are incorrect when stating that only joints fail, as cables do as well. As a result, their analysis of failure rates is incorrect;
- Inconsistencies even within the report itself in relation to the case history of the reliability of 400kV UGC. Askon state that no cable failures are known but then go on to detail other failures that have occurred (i.e. Berlin), a direct contradiction;
- The Askon Study was commissioned in April 2008 and it implies that it was commissioned by NEPP because EirGrid was neglecting to carry out such a study. EirGrid would like to point out that in November 2007, EirGrid together with NIE, commissioned PB Power to carry out a comparative and site specific study into the use of

OHL versus UGC for these projects. PB Power's 'Preliminary Briefing Note' on the subject was published in February 2008 and clearly indicates that it is the precursor to a more comprehensive report;

- Substantial evidence has been put forward to show that undergrounding does not represent an appropriate technology for the proposed 400kV projects in the North East or for the general development of the transmission system, and EirGrid believes that this applies a the rail bed routing proposal or even generally to other underground (be it along roads or otherwise) proposals;

- There is an incomplete assessment of the impact of resonance frequencies particularly in relation to parallel resonance leading to incorrect conclusions and

- There is an inappropriate application of the N-1 criteria leading to incorrect conclusions.

Some of the flaws outlined above are fundamental in nature and undermine and invalidate most of Askon's conclusions. It is <u>not</u> correct to conclude that the use of underground cable, instead of the proposed overhead line, for these projects would provide –

- A higher availability

- A higher 'N-1' contingency

- Lower electrical losses resulting in lower operating costs which "*could well work out the lower cost option over the whole life cycle*".

- A Carbon-footprint saving.

It must therefore be concluded firstly that Askon has not made a valid case in favour of the use of underground cable and secondly that for these 400kV projects an overhead line solution is appropriate and consistent with EirGrid's mandate to provide Ireland with a 'safe, reliable, secure and cost effective transmission system while having due regard for the environment'.

3 Introduction

The ASKON study, entitled *'Study on the Comparative Merits of Overhead Lines and Underground Cables as 400kV Transmission Lines for the North-South Interconnector Project'*, hereafter referred to as 'the Askon Study' consists of two separate reports. NEPP supplied a copy of Report One – Main Findings to EirGrid in early October 2008 and subsequently provided EirGrid with permission to use, reproduce or transmit the report, in whole or in part, for any purpose related to the proposed North South Interconnector project. EirGrid circulated this report among its team of consultants. Part Two was later received by EirGrid in February 2009. EirGrid also circulated this report among the team of consultants

Since the release of the Askon Study NEPP has produced short summaries of certain aspects of the study, which are presented in a PowerPoint presentation[3] and a brochure[4]. In addition NEPP and Askon presented to the Joint Oireachtas Committee on Communications, Energy and Natural Resources[5] in December 2008.

The objectives of the Askon Study, according to their report, are as follows:

- Determine the feasibility of using a 400kV underground cable for the projects that could be integrated into the existing grid managed by EirGrid.
- Assess the feasibility of such an underground cable option to meet the following criteria:
    a) Reliability and Security
    b) Efficiency
    c) Safety

[3] The PowerPoint presentation was initially available to download on http://www.pylonpressure.ie; however it is no longer available. The presentation is included in Appendix A.

[4] The NEPP/Askon brochure is available to download at http://www.pylonpressure.ie

[5] A copy of this presentation is included in Appendix B, while the official transcript can be found at http://debates.oireachtas.ie/

d) Affordability

- Explore possible route options and methodologies for minimising road traffic disruptions.

4 General Comments on Askon Report Outputs

The Askon Study proposes the use of a double circuit XLPE UGC solution as a feasible alternative to a single circuit OHL. The study states that the UGC provides a feasible alternative to the OHL solution, as proposed by EirGrid. The Askon Study, however, contains numerous assertions which are incorrect or indicate an incomplete understanding. In this review EirGrid has commented on these issues to help provide a clearer understanding and correct any misinformation that maybe contained. The comments are split into two distinct sections as follows:

- **Section 4.1** deals with the Askon Report 1 – Main Findings
- **Section 4.2** deals with the Askon Report 2 – Technical Analysis an Cable Route Options
- **Section 4.3** deals with NEPP's presentation of the study findings after release of the Askon Report.

4.1 Askon Report 1 – Main Findings

EirGrid's comments and observations in relation to the Askon Report are presented in this section, under the same headings as used in the Askon Study.

4.1.1 EirGrid comments on Summary and Recommendations

Paragraph 1[6] states that "*This report by ASKON is the first project specific analysis of determining the feasibility of undergrounding the North-South interconnector*". In February 2008, EirGrid issued a preliminary briefing note document[7] which investigated the technical and cost issues

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[7] This document entitled "ISLAND OF IRELAND CAVAN-TYRONE AND MEATH-CAVAN 400KV PROJECTS; PRELIMINARY BRIEFING NOTE OVERHEAD AND UNDERGROUND ENERGY TRANSMISSION OPTIONS" is available at www.EirGrid.com

associated with overhead and underground energy transmission options. It was stated in this document that the *"note is prepared in advance of the finalisation of the planning applications for each scheme and in advance also of a more detailed report on undergrounding".* This detailed report[8] prepared by PB Power on behalf of EirGrid and NIE has since been issued and is henceforth referred to as 'the PB Power Study'.

Paragraph 2[9] makes comments in relation to developments in UGC. EirGrid is well aware of such developments and indeed has projects either completed or underway which avail of these recent developments. It is important to note that (given the importance of providing secure and reliable transmission) EirGrid only installs proven technologies in line with EirGrid's mandate. Reference is also made that an UGC is easy to install, maintain and to repair. The statement does not, however, refer to what this is in comparison to. If it is referring to an OHL then this statement is incorrect.

Paragraph 3[10] of this section dismisses the use of a high voltage direct current (HVDC) solution since the projects are required to integrate with the synchronous high voltage alternating current (HVAC) system. EirGrid can see that there are possible applications for HVDC in specific circumstances, as outlined in GRID 25[11]; however EirGrid agrees that the 400kV projects in the North East should be developed using HVAC technologies. This statement also concurs with the conclusion of the Ecofys Study[12] in this regard. EirGrid has ongoing studies in place to review the possibilities of appropriate implementation of HVDC transmission technologies on the Irish transmission system.

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[8] This document entitled "CAVAN-TYRONE AND MEATH-CAVAN 400KV TRANSMISSION CIRCUITS; A COMPARISON OF HIGH VOLTAGE TRANSMISSION OPTIONS: ALTERNATING CURRENT OVERHEAD AND UNDERGROUND, WITH DIRECT CURRENT OPTIONS" is available at www.EirGrid.com

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[11] GRID 25 recently set out a strategy for the development of Ireland's electricity grid for a sustainable and competitive future and sets out the developments needed by 2025 to implement these requirements. The document can be found at www.Eirgrid.com

[12] The Ecofys study is an independent study published by the Department of Communications, Energy and Natural Resources in 2008 and is available at www.dcenr.gov.ie

In Paragraph 4[13] Askon proposes the use of a double circuit UGC as an alternative for EirGrid's proposed single circuit OHL. There is an implicit acknowledgment that a single circuit UGC does not compare favourably with a single circuit OHL of the same rating with respect to reliability.

A statement is made in paragraph 7[14] that in the case of a line outage the '*transmissible power of this system is zero*'. Such a statement demonstrates that the N-1 criterion, as applicable to the Irish and international transmission systems is misunderstood by the Askon Study author. It is true to say that if a single-circuit line is out of service then the transmissible power of the *"system"*, meaning the line, is zero. However if two appropriately sized UGC circuits are in parallel and one trips out (planned or forced) the other will pick up and carry the entire load. But the same applies to OHLs. The proposed 400kV OHL will operate in parallel with other OHLs and if it trips they will carry the load. This is what is meant by the N-1 contingency. This statement shows the failure to approach the issue from the point of view of the integrated transmission system and to apply the Transmission Planning Criteria[15] correctly. This misunderstanding of N-1 criteria by Askon is covered in more detail in Section 3.2.5 of this review.

The following statement is made by Askon in 9th paragraph[16] "*no failures in 400 kV cables are known".* When reviewing this statement following should be noted:

1) 400kV UGC, especially 400kV XLPE, is a relatively new technology. Therefore there are only a small number of projects that can be analysed for reliability;

2) Robust reliability statistics are difficult to obtain. There is often a degree of apprehension (on the part of both equipment suppliers and owners) regarding divulging failure statistics;

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[15] Transmission planning Criteria available at www.EirGrid.com

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3) Not withstanding this, a number of cable failures have been well documented, for example figure 4.2[17] which shows warning signs in relation to the Milan: 380-kV-cable Tubigo-Rho. Performance of this cable has been poor with three failures causing four months of outage in total in 1.5 years of operation:

   i) During start-up 2006: Joint defect;

   ii) June 2007: Damage due to construction work - one month out of operation; and

   iii) September 2007: Joint defect (hair line crack) - two months out of operation.

4) Page 33 of the Askon Study itself presents a study of the 380kV Berlin cable failure;

The additional statement in paragraph 9 that failures in XLPE cables would tend to occur in the joints and are thus relatively easy to locate and fix is misleading. To find the fault, excavate the cable, repair the cable and re-commission the cable could take a number of weeks to successfully carry out. This fact is borne out by EirGrid's own experience and also from international experience. The risks associated with the possible unacceptably long outage could not be tolerated in the Irish transmission system for projects such as those proposed for the North East. In comparison an OHL typically takes a few hours to fix in the event of a failure.

An assertion by the authors is made in the 11th paragraph[18] where they contend that intermediate reactive compensation sites are not required along the length of the UGC. The report further states that *"up to now such additional compensation sites were not installed in long cable systems*". This statement is misleading since there are no cable systems of the length and voltage, as required by these projects in service anywhere in the world. It is not clear how the assertion can be made that intermediate compensation will be not be a necessity along such a length of cable to ensure that it could operate as part of the meshed network. Reference to this issue is further mentioned in Section 5.1[19] where the

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[18] Page 10

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Askon Study states that unloaded and uncompensated cables can only generate resonance overvoltages if they are connected to a *"weak"* station. The existing 400kV network in Ireland is not regarded as being highly meshed; therefore, the 400kV stations would be regarded as *"weak"*, when compared to, for example, Central European standards. Previously in the Askon Study reference was made to the fact that no detailed system studies were carried out by Askon. Therefore the conclusions derived by the Askon Study in this regard should be addressed with a large element of caution and scepticism. For example the 100 km 150 kV cable connecting the Horns Rev 2 wind farm in Denmark has an intermediate compensation station.(75 MVAR in the middle and 120 MVAR at one end). The Askon Study assertion would suggest that the performance of such long cables was not adequately studied to sufficiently support the far-reaching conclusions reached. The wider issues that have to be considered are not detailed sufficiently in the Askon Report.

Broad statements in relation to safety benefits of UGC are presented in paragraph 15[20]. Nowhere in the Askon Study is there an acknowledgement of the fact that the proposed 400kV lines in the North East meet all national and international safety criteria. The perceived safety issue of OHL solutions is covered in more detail in Section 3.2.7.

In paragraph 16[21] Askon refers to "*the obvious environmental benefits"* that an UGC has over an OHL solution. Little attempt has, however, been made to describe how both an UGC and OHL will have an impact on the environment in their respective vicinities. It is necessary when comparing the environmental impacts of the different technologies to compare each of them against the recognised environmental categories and assess their respective impacts using a common benchmark to arrive at a balanced view.

The Askon Study recognises in paragraph 17[22] that the capital cost of an UGC solution is many times that of an OHL solution. Their estimates indicate a cost ratio of between 3.4 and 4.1 to 1. The difference in cost

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equates to several hundred millions of Euro, which is a considerable outlay of money. The PB Power Study indicated that the cost of the UGC would cost seven times that of an OHL. This cost does not take into consideration the additional costs that would arise in modifying the wider system and its operation to try and attempt to accommodate an underground reinforcement. If the project was implemented as an UGC then the extra cost would be borne by the electricity consumer. In relation to the Askon costings a statement is made as follows: "*These values were determined in detail for the 60 km route WOODLAND - KINGSCOURT, but also approximately for the 80 km route from KINGSCOURT to TURLEENAN".* It is not clear what Askon mean by *'detailed'* or *'approximately'* in this regard. From the labelling of many of the tables and graphs throughout the Askon Study, it appears that many aspects of the report are not project specific as far as the Cavan – Tyrone 400kV project is concerned. The PB Power Study costings considered detailed cost analysis for both the Meath-Cavan and Cavan-Tyrone sections of the line.

In paragraph 18[23] a statement is made that the "*sum of the loss costs is approximately 9 times larger than the investment costs… These costs (375 M€) represent a very high absolute value".* These figures for "*the sum of the loss costs*" over the lifetime of the projects are calculated by multiplying the annual losses cost by 40 years. While in another section of the report a more realistic net present value (NPV) calculation is carried out, the "*sum of the loss costs*", is the figure that is presented here. This grossly overstates the benefit of lower losses in favour of the UGC. The issue of losses in both UGC and OHL is covered in more detail in Section 3.2.9 of this review.

The Askon Study contends that an UGC solution would have a "*considerable carbon saving"* over an OHL solution in paragraph 19[24]. This statement is incorrect, having been derived using the assumption that the OHL proposed by EirGrid will be very heavily loaded. As stated later in this EirGrid review, the loading on the OHL will in fact be much smaller than that stated by Askon. As a result of this the losses will be lower than originally estimated in the Askon Study. This error leads to fundamentally incorrect conclusions. The fact that the Askon Study is incorrect on this basis renders many of the other assertions made throughout the Askon

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Study invalid. As stated previously the issue regarding the losses in both the UGC and OHL will be presented in more detail in Section 3.2.9. An additional issue not raised in the Askon study is the energy intensive manufacturing process involved with UGC, resulting in increased production of carbon dioxide. The civil works required to construct the UGC would also be much more carbon intensive than they would be for an equivalent OHL.

When the author calculates the average cost of capital, a lifespan of 40 years was applied to the alternative solutions, yet there is a significant difference between UGC and OHL when it comes to extending life beyond 40 years. It is common practice in Ireland to extend the life of OHLs well beyond 40 years by judicious and cost effective refurbishment. The same cannot however be done for UGC. As the UGC approaches the end of its lifecycle it is more likely the fault rate of the cable may increase to such an extent that it becomes no longer cost-effective to repair. At such a stage the cables would need to be decommissioned, removed from the ground and replaced with new cables. Such a process is effectively a *"rebuilding"* and would involve an extensive cost. Many examples of OHL transmission assets over 40 years old can be found still in use on the Irish system and internationally.

4.1.2 EirGrid Comments on Background

Misleading information has been presented into the public domain in relation to certain EU countries being required to install 400kV UGC instead of OHL. A statement is made in the second paragraph[25] that "*In many European countries, such as Denmark, Austria, Germany and Italy, it is required to install 400 kV UNDERGROUND CABLES (UGC) as an alternative to OVERHEAD LINES*". In May 2008 a survey carried out by ESBI[26] entitled *"Cigré Survey of 380kV to 500kV Overhead Transmission Line Projects"* showed that, for extra high voltage (EHV)[27] projects

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[26] ESBI survey "Cigré Survey of 380kV to 500kV Overhead Transmission Line Projects" can be found at www.Eirgrid.com

[27] Extra High Voltage (EHV) consists of the voltage range of 380kV to 500kV

commenced since the year 2000, electrical utilities across Europe have:

Commissioned	1,988 km of OHL
Under construction	448 km of OHL
In the planning process	2,466 km of OHL

Many of the European utilities with EHV OHL projects in the planning phases are, like EirGrid, required by their planning process to consider an UGC solution. That fact that comparative studies regarding UGC and OHL solutions are being carried out across Europe does not indicate that the respective utilities are proposing to implement these projects as UGC solutions.

For information, the Danish government has recently made a decision that it may, if possible, underground future 400kV projects. The Danish government has acknowledged that applications of long distance 400kV underground technology is in its infancy and is untested over long distances. Currently some 400kV OHLs are being upgraded in Denmark and most notably the single circuit 400kV backbone to Jutland is being replaced with a larger double circuit 400kV construction. Other 400kV projects in Denmark have recently been earmarked for implementation using overhead technology[28].

The objectives of the Askon study are presented in this section. Again it should be noted that the EirGrid project specific study commenced before this time. The author states that the objectives are based on EirGrid’s criteria of:

1. Reliability and Security
2. Efficiency
3. Safety
4. Affordability.

[28] More information can be found at http://www.energinet.dk

No dialogue had taken place between the Askon Study authors and EirGrid in relation to the appropriate parameters that apply in relation to the above named objectives prior to publication of the Askon reports. No mention has been made in the Askon Study of the EirGrid Transmission Planning Criteria which is a key guidance document for these purposes.

An omission of significance by Askon in relation to objectives is the fact that EirGrid must take "*due regard for the environment*" as outlined in Statutory Instrument No. 445. In the course of carrying out the Environmental Impact Assessment (EIA) significant resources are being applied to ensure that every reasonable measure will be taken to assess, minimise and/or mitigate the impact of the proposed projects on the environment, as is required by legislation.

Another main objective of the Askon Study was to explore routes that would minimise road traffic disruptions. If the proposed project was to be implemented as an UGC solution then, in EirGrid's and its consultant's PB Power's view, the cables would likely need to be predominately laid cross country as the existing roads or rail bed reservation would not be appropriate or sufficiently large enough for the required space during construction. At road crossings directional drilling would be utilised to install the cables under the road, thus mitigating any traffic disruption. No mention has been made in the Askon Study of the special measures that may be required in terms of cable adequacy, costs, or performances required in circumstances where UGC may have to be buried deeper than normal.

Options to use larger cable, enamelled stranding, or Milliken (segmental) conductor design of the same cross-sectional area would need to be considered to meet the rating at greater depths of burial, should this be required. Alternate cable types have not been listed in the Askon Study on Tables 8.1.1 or 8.1.2.

4.1.3 EirGrid Comments on Electrical Power Transmission in Ireland

On a point of clarity, the Askon Study refers to both the Meath-Cavan and Cavan-Tyrone 400kV projects as being the collective North South Interconnector Project. As outlined in Section 1 of this review they are two distinct projects that fulfil different requirements but complimentary aspects apply. In some documents the Cavan-Tyrone project maybe referred to as the North-South Interconnector or the Kingscourt-Turleenan 400kV Interconnector, while the Meath-Cavan project maybe referred to as the Kingscourt-Woodland 400kV development. On some occasions the projects are also collectively referred to as the North-East projects.

In paragraph 2[29] the author displays confusion in relation to use of *"Interconnector"* terminology. The North – South Interconnector, which is referred to as the Cavan - Tyrone project in this review, is a cross-border power line, which will provide a further connection between the Irish transmission system and the Northern Ireland transmission system. This will further reinforce the connections between the two transmission systems and further assist in ensuring the effective operation of the Single Electricity Market (SEM) that came into effect in November 2007. This project will also meet the requirement of having to reinforce to the transmission grid by connecting into the Flagford-Louth 220kV line in the Republic of Ireland and to the NIE connection point in Co. Tyrone, thus helping to deliver high quality bulk power to these areas. The EirGrid document entitled *"Strategic Planning Context Report"*[30] should be referenced for more information. The Askon Study author implies that if the project were to be regarded as an 'Interconnector' that this *"would allow consideration of the use of High Voltage Direct Current (HVDC) technology".* This is untrue since the term 'Interconnector' in no way means that the project can be realised using a HVDC connection. The power systems in Ireland and Northern Ireland are a single synchronous network. Therefore a further connection within that network should be AC. The suggestion in the report that if the line is called an "interconnector" it could be DC and if it is called something else it could be AC is unfounded. For any given link the use of AC or DC is determined by technical and economic considerations. In this case both show very clearly that DC is not an appropriate solution. For example there are numerous examples of HVAC OHL interconnectors in Central Europe. HVAC and HVDC connections can be used where appropriate and for the proposed EirGrid projects HVAC OHL will provide the most feasible solution.

The Askon Study refers to three of the longest land cables in service, yet it fails to mention that two of these, the London and Tokyo cables, are

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[30] MEATH – CAVAN 400kV TRANSMISSION LINE CAVAN – TYRONE 400kV TRANSMISSION LINE STRATEGIC PLANNING CONTEXT REPORT can be found at www.EirGrid.com

installed in tunnels deep underground. These tunnels provide ideal situations for the cable as they are forced ventilated and are easily accessible for maintenance and cable repairs. This does not provide a like-for-like comparison of a direct buried UGC nor indeed are the Askon costings consistent with the use of such tunnels. The project in Copenhagen is not 22km as presented in the report. It is two separate projects consisting of 14km and 8km lengths. There is an element of confusion regarding present and future projects in the Askon Study. Reference is made to several long UGC cable projects presently under consideration in Europe, with the author claiming some of up to 210km in length. While it is entirely plausible that there may be projects of up to 210km in length under consideration using lower power transfers or HVDC technology, it is not likely that these are of comparable size, length and type to the projects proposed for the North East. As indicated earlier in this report there are many such projects under consideration and many studies are underway to determine the appropriate technology to apply. No TSO in Europe is installing 400kV AC cables at the long lengths mentioned by Askon in relation to the transmission projects in the North East.

The authors of the Askon Study recognise that the lengths of 400kV cable which they propose for the Cavan-Tyrone and Meath-Cavan projects have not been installed anywhere in the world to date and therefore they recommend a thorough investigation of their operational performance. Evidence of having Askon having carried out such studies on operational performance has not been presented to EirGrid to date. EirGrid and NIE have however commissioned a study to investigate the feasibility and technical impact of significant lengths of 400kV and 275kV AC UGC on the transmission system for the island of Ireland. The “all-island transmission system” refers to the entire collection of transmission equipment managed by both system operators. The aim of the investigation is to determine to what degree there is a genuine alternative to HVAC OHL. This study is expected to be completed in 2009.

The following paragraphs present a number of statements, which the authors of the Askon Study have misunderstood, taken from documents issued over the last number of years in relation to the Cavan-Tyrone Project. EirGrid would therefore like to clarify these misunderstandings.

Section 2.2[31] in the Askon Study makes reference to the transcript of EirGrid's presentation to the Joint Oireachtas Committee on Communications, Energy and Natural Resources in February 2008, on the capacity benefit of the additional interconnection with Northern Ireland. The authors misunderstood the significance of the term "Capacity Benefit". One of the benefits of additional interconnection between Northern Ireland and the Republic of Ireland is that the total generation capacity required to achieve the generation adequacy standard (Loss of load expectation of 8 hours per annum is reduced. This reduction has been found to amount to between 200 MW and 300 MW. This is not an indication of the level of power transfer that might occur between the two jurisdictions. Such power flows are generally driven not by power flows required not by the need to meet a potential capacity shortage in one jurisdiction, but by the actions of generation participants in the single electricity market. Furthermore, the single market coupled with greater integration between North and South (and indeed the European electricity market) will permit generation capacity required to meet the demands of customers in one jurisdiction to be located in another jurisdiction. This would mean that power flows between Northern Ireland and the Republic of Ireland could be much greater than the value of the capacity benefit.

Two load conditions are presented by the authors[32], a 'low-load phase' and a 'high-load phase'. In relation to the high-load phase a statement referring to increasing international power exchange over the lifetime of the project is discussed. The author also argues that an alternative expansion approach is possible, such as a 220kV solution. A number of alternative options were investigated for both projects, but they were eventually dismissed for a number of different reasons and a 400kV solution selected[33].

This is where the authors fail to display an understanding of the wide range of issues that need to be addressed in planning transmission system development. It also supports the suspicion that no analysis beyond reading the Transmission Forecast Statement has taken place. Once a need for transmission development is identified, determining the

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[31] Page 19

[32] Page 19

[33] MEATH – CAVAN 400kV TRANSMISSION LINE CAVAN – TYRONE 400kV TRANSMISSION LINE STRATEGIC PLANNING CONTEXT REPORT can be found at www.EirGrid.com

appropriate development requires consideration of a wide range of technical, strategic, economic, environmental and other issues. Some points that must be considered are:

- An investment may be required to satisfy an immediate need, but in planning longitudinal investments such as transmission lines in particular consideration must be given to evolving needs over the lifetime of the asset, which is likely to be 50 years or more;

- Even in a centrally-planned environment, and especially in the absence of indigenous primary fuel resources, there is considerable uncertainty with regard to the location of future electricity production and consumption. As a consequence there is uncertainty with regard to transmission system power flows. This uncertainty is further exacerbated in both the short term and long term by open electricity markets. It is to be expected that the development of open markets such as the SEM and the further integration with the British and European electricity markets, together with the development of new energy resources including renewables will lead to increased volatility in transmission line power flows;

- The cost of transmission, if effectively implemented, is a relatively small component in the electricity supply value chain. The benefits to the economy from a well-functioning electricity market and the potential benefits to society globally from ambitious programmes to develop renewable and sustainable sources of electricity support a strategy based on the provision of electricity transmission capacity to support a wide range of future scenarios. The proposed 400 kV developments will form part of the strong transmission grid envisaged in EirGrid's Grid Development Strategy Grid25 which is essential for Ireland to attract and retain high-tech industrial investment, for the country to have competitive energy supplies and balanced regional development and in order to reduce our dependence on fossil fuels in light of the major issue of climate change;

- The Irish system is a rapidly evolving system, with sustained demand growth over recent decades and with major interest in investment in generation, both renewable and conventional. It is important to deliver a transmission system with sufficient capacity so as not to unduly constrain generation development, choice of location, and effective market operation;

- Transmission system planning and development needs to cater for, and facilitate future potential growth, as well as meeting Ireland's known objectives including the renewable targets;

- In particular, it is known that the North West area of the island (Donegal/Derry/Fermanagh/Tyrone) is rich in renewable resources and the system needs to be sized to deal with the future development there. This will come on stream over a number of years. This will mean, for example, that the flows on circuits running North-South will be higher at times (e.g. high wind in the North, lower elsewhere) and it is also likely to mean that the average loading will rise too, but high loads will only occur for limited durations;

- EirGrid studies suggest that development of a capacity in the region of 1500MW is prudent and appropriate. Based on OHL development, this can easily be accommodated from the outset by building a 400kV single circuit line, which has the added immediate benefit of reducing losses as against a 275kV or 220kV line and maximising use of the line route;

- Development of an interim lower capacity development would not meet the development requirements of Grid 25 nor would it meet the system requirements for the market driven loading scenarios possible in the all Ireland market;

- All of the fundamental issues remain: it is still several times more expensive than an overhead solution, less reliable and technically complex. Some of theses issues may be mitigated by adopting a lower voltage; however, it would be difficult to achieve the required rating and losses would be higher.

- The losses would be higher than for the 400kV OHL solution, particularly if a cable of lower voltage is used.

- It would be necessary to go back and install a further circuit in the near future.

- The confidence of generation/renewable developers in the capability of the system would be compromised as the transmission capacity necessary for their developments would not be readily available and would be dependent on future developments.

A further consideration in relation to the strategy in developing the project to provide additional transmission capacity was to match the total capacity of the existing Louth – Tandragee 275 kV double-circuit interconnector, which depending on ambient conditions, is about 1500 MVA. Comprehensive technical, economic and strategic analysis led to the choice of a 400 kV rather than a 275 kV solution to achieve this. The

Meath-Cavan project complements the Cavan-Tyrone project and ensures adequacy of transmission capacity to supply the North East of Ireland. Building at 400 kV is more efficient and is consistent with the Grid Development Strategy Grid25, it makes best use of the available route corridors, and it provides a strong link to the renewable and non-renewable electricity generation centres in the West, South West, South, South East, Dublin and Northern Ireland and to the interconnectors with Great Britain. It is clearly consistent with the pattern of network development in Europe, North America and indeed throughout the world.

4.1.4 EirGrid comments on Transmission Capacity and Underground Options

Section 3.3[34] makes assertions based on studies of the overloading capability of the proposed UGC. It is not clear if the studies have been done for appropriate scenarios, such as what would occur when the cable needs to buried deeper than normal, e.g. under roads or waterways or encased above ground.

Information relating to the overloading capability of UGCs as is applicable to the Irish transmission system is presented in EirGrid's Transmission Planning Criteria.

This section includes comments relating to the repair time of a 400kV UGC[35]. The author deduces that the time to repair one phase of the cable is 100 hours. EirGrid and international experience suggests that the actual time to repair such a fault would typically be much longer. For the 220kV UGC network in Ireland the average forced outage duration has been 6 weeks. The Ecofys study states "*Due to the limited experience, reliable figures for maintenance costs for UGC transmission are not available. Regular UGC maintenance may be slightly less labour intensive than that of OHL. Work related to UGC repair, however, is substantial".* The PB Power Study refers to the *'coyness'* prevailing in relation to the availability (from TSO's and manufacturers) of these figures.

[34] Page 23

[35] Page 24

There are further inconsistencies in the Askon Study when they concede that the repair time might last up to one month[36]. Certainty of infrastructural capabilities is critical where applications in meshed transmission systems are concerned.

4.1.5 EirGrid comments on Reliability and Security of Transmission Lines

The Askon Study states that from the EirGrid Transmission System Performance Reports there were no forced outages in the grid in 2005 and 2006[37]. This is only in relation to 400kV OHL and does not refer to 110kV and 220kV OHL and UGC.

The Askon Study makes a statement that the damage caused by external impacts (such as an excavator) on an UGC is a failure of the Transmission Company[38]. However, this damage would still result in a failure of the cable and result in the cable being switched out of service until the damage is repaired. This cannot be ignored as a factor to be considered. The figures quoted for failures in OHL in the Askon Study presumably incorporate damage caused by third parties and for proper comparative purposes so should the figures for UGC. It should be noted that the Electricity Supply Board (ESB) has put in place extensive procedures and safeguards for protection of damage to its UGC by third parties, but even these measures do not fully prevent damage to cables by third parties, as is the case for UGC internationally,

The probability calculated in the Askon Study, on the issue of cable failures, is incorrect. In this section[39] they calculate the expected failure rate of a 56.7km cable connection consisting of and 174 joints (and therefore by implication 348 joints for two off 56.7km cable connections). This would mean there was only a joint every one km of cable for the Meath-Cavan project. The PB Power Study suggests that lengths between joints should be less than 700m, requiring approximately 500 joints for

[36] Page 40

[37] Page 35

[38] Page 39

[39] Page 39

the Meath-Cavan project. Also there is a statement made "*it can be assumed that failures only occur within the joints*". The likelihood of failures in cables cannot reasonably be assumed to be zero. Cables do fail. Also the statement *"failures in cable terminals occur in substations and as such do not need civil work"* is not valid as such failures would result in an outage to the associated cable system and would therefore have to be considered in any outage calculation.

Interestingly, included in the presentation given by Askon and distributed at the Joint Oireachtas Committee on Communications, Energy and Natural Resources held in December 2008 is a photograph of 356 drums of 0.96km length of cable suggesting a requirement for approximately 356 joints in total.

None of the above discussions deal with the impact that the compensation equipment would have on the reliability figures.

An assumption is made by the Askon Study referring to outages of the existing 400kV line in Ireland. A number of outages were needed in recent times to facilitate diversions of the line as a result of a new motorway being constructed. They state that these historical outages are expected to be needed for any future line[40]. This is not the case since these outages should be regarded as once-off outages. The transmission availability information is presented in a misleading manner. The extrapolation of two years of data is unjustified and inappropriate. Even from the data presented it is obvious that one line, over 200 km in length, had no outage in 2005. The most significant fact is that there were no forced outages of a 400 kV line in either year. This line has been operating since mid 1985 with a very good operational history. Since 1988 there have only been five sustained faults on the 400kV network in Ireland, resulting in outages to the affected circuit.

Figure 4.8[41] displays the unavailability in European grids caused by planned interruptions. This figure is misleading as the data presented on the graph represents customer minutes lost on the high voltage (HV),

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[40] Page 44

[41] Page 45

medium voltage (MV) and low voltage (LV) networks. This comparison is not relevant to the matters being discussed in this report since it does not compare like with like. It further shows the author's lack of understanding of integrated power systems. It is well known that customer minutes lost are dominated by losses due to distribution interruptions. The Irish customer minutes lost are being reduced by ESB Networks through increased use of live working to reduce planned outages and increased automation and remote switching to reduce restoration times. This has absolutely nothing to do with the high voltage transmission system. By including this comparison the authors demonstrate their lack of understanding of the relevant issues in transmission system development and the impact of transmission reliability.

The Askon Study carried out further calculations seeking to determine the probability of the second circuit of the UGC failing if the other circuit is being repaired for one month[42]. The resultant figure is very small. This probability analysis did not consider the scenario that could lead to the failure of both circuits, such as third party interference, failure at either of the substations, or type failures of equipment associated with the UGC infrastructure. The figures derived from the Askon Study present figures for unavailability. These figures may be (indirectly) compared with figures available in the Ecofys Study and in the PB Power Study. The calculations are performed using differing techniques and yield quite different results.

EirGrid's own statistics are at variance with the Askon Study assertion that failures in OHL are significantly higher than in UGC. EirGrid's statistics show that the number of faults per km of OHL (sustained faults[43] as opposed to transient faults[44]) is only marginally higher than the comparable figure for UGC; however, more significantly such faults have minimum impact on the operation of the transmission system as they are quickly repaired, which is not the case for underground cables.

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[42] Page 47

[43] Sustained faults that last for more than a number of seconds

[44] Transient faults are temporary faults, such as lightening striking the OHL. This fault is cleared by automatic reclosing, which restores power to the line in a matter of seconds.

The N-1 criterion, as applied on the Irish transmission system, and to transmission systems in general, is misunderstood throughout the Askon Study. The N-1 criteria should be applied to the system as a whole and not to a circuit. In Section 4.5, the Askon Study asserts: *"The "N-1" CRITERION is not fulfilled within the planned expanded Irish 400 kV grid itself, when single system OVERHEAD LINES are planned to be used in this project."* This once again demonstrates the failure to take account of the nature of the integrated 400/275/220/110 kV transmission system on the island of Ireland. The transmission system is planned in accordance with the 'Transmission Planning Criteria'[45] and the corresponding standards in Northern Ireland. These criteria are based on the single-contingency principle that says that the system should be able to withstand the loss of a single element. This means the system as a whole. There is no need for the loss of a 400 kV element to be catered for entirely within the 400 kV part of the system. This is most clearly shown in the case of the lines linking Ireland and Northern Ireland where loss of the 400 kV line would lead to increased flows in the 275 kV lines, and loss of one or both 275 kV circuits would lead to increased flows on the 400 kV line. The first paragraph on page 50 completely ignores the integrated nature of the transmission system. It asserts that for loss of the Meath-Cavan line, the power flow would be diverted to specific 220 kV lines, ignoring the fact that power flows throughout the system would change. Indeed some very relevant lines in the North East are not mentioned in this discussion. Furthermore, in discussing the impact of the loss of the Cavan-Tyrone line the Askon Study assumes that the pre-fault power flow must still be delivered to Kingscourt, ignoring completely the integrated nature of the transmission system.

[45] Transmission planning Criteria available at www.EirGrid.com

4.1.6 EirGrid Comments on Efficiency of Transmission lines

The title of this section in the Askon Report is somewhat misleading and perhaps should refer to the performance characteristics of the UGC.

The Askon Study states that additional compensation stations are not typically installed in long cable systems[46]. Given that there are no long 400kV UGC in the world of the length and type proposed for the North East, this statement is irrelevant. Askon elsewhere acknowledges previously in the report that no projects of the length required have been implemented to date and, therefore, a thorough investigation of their operational performance is needed.

In Section 5.1.1[47] the Askon Study states that unloaded and uncompensated cables can only generate resonance overvoltages if they are connected to a *"weak"* station. The existing 400kV network in Ireland is not regarded as being well-meshed; therefore, the 400kV stations would be regarded as *"weak"*, by comparison with heavily meshed, denser transmission systems such as those found in Central Europe. TEPCO are presently carrying out detailed studies on this issue on behalf of EirGrid.

The nominal voltage level on the Irish Transmission system is 400kV. In the Askon Study a number of allusions are made to a reference voltage level of 380kV[48] (the German reference voltage level pages 46 and 104 for example). It is seems likely that calculations used in the Askon Study may be based on an incorrect voltage levels. This would lead to errors in the system performance calculations, the magnetic field levels and to the losses quantifications and costings.

[46] Page 53

[47] Page 53

[48] 380kV is the nominal voltage as used in Germany. Further examples of the use if this nominal voltage can be found for example on pages 46 & 104

4.1.7 EirGrid Comments on Safety Comparisons of Transmission Lines

The Askon Report asserts that UGC is "safer" than OHL. OHLs in Ireland including the proposed 400kV lines in the North East meet all national and international safety criteria. There is no basis for the assertion in the Askon Study since both OHL and UGC solutions can be designed to meet all standards, so there is no basis for saying either is "safer". EirGrid is satisfied from the totality of studies and the views of international authoritative agencies that the balance of evidence is that Electric and Magnetic Field (EMF) do not have any adverse effect on public health. Despite extensive worldwide research no conclusive evidence has been found to date proving that EMF from power lines is harmful. A study carried out by the World Health Organisation (WHO) EMF Task Group concluded in 2007 that there are no substantive health issues related to extremely low frequency (ELF) EMFs at levels generally encountered by members of the public. This study took into account all research conducted up to that point on EMF and possible health impacts.

The Irish Department of Communications, Marine and Natural Resources reported independently on this issue last year and their document is available on the website (www.environ.ie). All Irish power lines comply with the EU and the International Commission of Non-Ionising Radiation Protection (ICNIRP) standard guidelines for EMF exposure levels. In fact, the levels of EMF from power lines in Ireland are generally much lower than ICNIRP levels and are lower than levels from appliances commonly used in homes throughout the country.

EirGrid recognises that there is much public concern about issues regarding EMF and health. EirGrid is committed to addressing these concerns by continuing to:

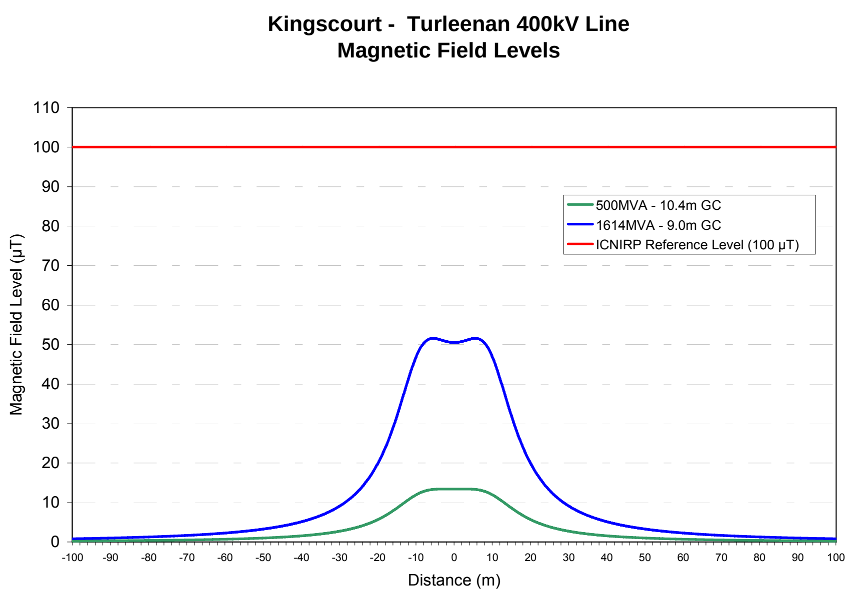
- Design and operate the transmission system in accordance with the most up-to-date recommendations and guidelines of the various expert and independent international bodies;
- Closely monitor engineering and scientific research in this area; and
- Provide advice and information to staff and the general public on the issue.

With regard to EMF effects on animals, extensive studies have been carried out on animals both in-vivo (in live state) and in-vitro (studies of cell and tissue cultures in the laboratory). These studies of animal reproductive performance, behaviour, melatonin production, immune function and navigation have found minimal or no effects of EMF from high voltage powerlines.

A significant statement is made in the Askon Study as they declare that short term exposure, above an UGC, is '*harmless*'[49]. The basis for making this statement is unclear. For comparable loads at comparable voltages the magnetic field at ground level directly over an UGC is generally higher than directly under an OHL. In any case, as far as the Irish transmission system is concerned, this is not an issue since EirGrid design and operate the network in compliance with all relevant national and international guidelines

The following figure presents a graph of magnetic field for both an OHL and UGC. Loadings of 50% and 100% are assumed by the Askon Study to represent this 'permanent exposure'. As discussed in Section 3.2.9 of this review the loadings on the line are typically much less than those utilised by the authors of ASKON. EirGrid's consultants have carried out simulations of the expected magnetic field level under the proposed OHL project for loadings of 33% and 100% (of 1500MVA). The 33% loading would represent a good indication for the expected line loadings over its lifetime. These calculations are much lower than those calculated in the Askon Study and they are presented below:

Figure 1: Kingscourt-Turleenan 400kV Line Magnetic Field Levels



49 Page 62

The Askon Study proposes a corridor 100m on both sides of the OHL equating to a corridor 200m wide. No explanation is provided at how they arrived at this figure[50].

Reference is made to a draft German law[51] which defines a precautionary distance of 400m between OHL and dwellings. The major aim of this new law is to accelerate the erection of new or the reinforcement of existing 380 kV power lines. It will also cover the possibility to underground lines if the distance between dwellings and the line is less than 400m. In no way is it intended to represent a precautionary distance between an OHL and dwellings.

4.1.8 EirGrid Comments on Environmental Impacts

Both an UGC and OHL will have an impact on the environment in their respective vicinities but these impacts can be very different. It is necessary to compare each of them against the recognised environmental categories and assess their respective impacts using a common benchmark to arrive at a balanced view. This has not been presented here to back up the statement regarding the environmental benefits of an UGC solution. The Ecofys Study, prepared on behalf of the Department of Communications, Energy and Natural Resources, carried out the comparative environmental implications of OHL and UGC. Under some environmental categories the OHL had a greater impact when compared to an equivalent UGC solution, such as the visual impact. The UGC solution however is described as having a more significant negative environmental impact, when compared to an equivalent OHL solution under a large proportion of the environmental headings.

The Askon Study states that more temporary access roads are required for an OHL[52], which is not true, as they will only be necessary to access the tower locations and where crossings over existing lines and/or other infrastructure are required. Additionally, when planning the construction stage, the access roads/tracks will be carefully studied in order to

[50] Page 60

[51] Page 61

[52] Page 64

minimise the need for their construction, trying to use and improve the existing farm lanes or access routes already in place where possible. The Askon Study makes only minor reference to the temporary haulage road needed for an UGC solution. This would be part of a working swathe approximately 20-22m wide along the entire length of the project[53].

The PB Power Study indicates that if the proposed projects were implemented as UGC then they would be placed predominately cross-country. Such an UGC would require a parallel temporary access road for nearly the entire route length. This would result in the following disadvantages:

- Running the UGC route along existing roads could result in traffic closures/disturbances; and
- Running the UGC route cross-country will result in an impact corridor of significant width.

The Askon Study further states that forestry development should be restricted along an OHL route. EirGrid would like to note that the route selection has been carefully studied and the potential route corridors refined to avoid forestry as best as possible (subject to other environmental and community constraints also being applied) and to minimise any impacts on this. In the event of forestry having to be removed, full compensation is available to the landowner.

For an UGC a permanent corridor is needed, which would depend on such variables as:

- the voltage and capacity of the cable;
- whether the cable is laid cross county or in urban areas;
- whether the cable is a single or double circuit construction; and
- the layout of the cables.

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[53] Page 23, This document entitled "CAVAN-TYRONE AND MEATH-CAVAN 400KV TRANSMISSION CIRCUITS; A COMPARISON OF HIGH VOLTAGE TRANSMISSION OPTIONS: ALTERNATING CURRENT OVERHEAD AND UNDERGROUND, WITH DIRECT CURRENT OPTIONS" is available at www.EirGrid.com

Traditionally, the majority of UGCs in Ireland have been placed in urban congested areas, under the existing road network, or on lands owned by the ESB. Therefore the issue of easements for UGC did not typically exist. Occasionally there was a need to cross private lands, where the need for an easement arose.

The Askon Study also asserts that the joint bays are back filled with soil and need no sterilisation[54]. This is untrue as typically the joints are housed in joint bays whose environs need to be protected. These joint bays, like the cable itself (but to a greater extent), require large swathes of land where no construction can take place.

Finally, reference is made to an NEPP document that lists the ecological impacts of an OHL solution[55], most of which are unsubstantiated. No reference is made to the impacts that an UGC solution would have. EirGrid will submit an Environmental Impact Statement (EIS) to An Bord Pleanála when applying for planning permission for these projects and this will cover ecological impacts of the proposed line and mitigation measures to overcome these.

4.1.9 EirGrid Comments on Comparative Costs and Affordability

The first sentence in this section[56] states that ***"****There are some uncertainties about investment costs of OVERHEAD LINES, being caused by different transmission capacities, different designs, different labour costs and right-of-way costs, and different geographical conditions".* EirGrid would concur with this statement and would add the following:

Further uncertainties arise from -:

- Differing methods of calculations of such costs by different organisations;
- Differing assumptions made in relation to these calculations;

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[54] Page 65

[55] Page 67

[56] Page 68

- Current market conditions (how busy are the suppliers, availability of materials);

- International exchange rates;

- Changes to estimates in unit prices; and

- Movement of the prices of copper, aluminium, zinc (for galvanising) and lead.

Similar uncertainties would arise in relation to the investment costs of UGC.

The PB Power Study has completed a substantial analysis of investment costs for these two projects and this can be reviewed for comparison with the Askon Study. The following comments apply to the Askon Study analysis of costs:

- The source and reliability of the costs are not apparent in most instances;

- An assertion is made based on EirGrid documentation that an UGC solution would take four years while the OHL solution would take 7.5 years. These figures were extracted from EirGrid's Transmission Forecast Statement. However, the vast majority of UGC projects to date (110kV and 220kV) consist of relatively short lengths of cable laid almost exclusively under city streets or through ESB land. The standard duration for these types of projects could therefore not be replicated on the proposed 400kV project. To date, no underground cable of this length and voltage has ever been installed anywhere in the world and, as a result, there is no benchmark to base an estimation of the possible construction time (especially not in Ireland). The PB Power Study indicates that the delivery time of the required amount of cable is four years (even then assuming use of multiple suppliers and this may not be feasible). Delivery lead times and construction times would need to be added to this figure. Errors may have been introduced into the Askon Study costings as a result of the misjudgement in relation to the project times;

- When the author calculates the average cost of capital, a lifespan of 40 years was applied to the alternative solutions. There, is however, a significant difference between UGC and OHL, when it comes to extending life beyond 40 years. It is common practice in Ireland to extend the life of overhead transmission lines well beyond 40 years by judicious and cost effective refurbishment. The same cannot, however, be done for UGC. As the UGC approaches the end of its lifecycle the fault rate of the cable will increase to such an extent that it becomes no longer cost effective to repair. At such a stage the cables would need to be decommissioned, removed from the ground and replaced with new cables. Such a process would involve an extensive cost. Many examples of OHL transmission assets over 40 years old can be found still in use on the Irish system and internationally. This omission results in errors to the costs calculations in the Askon Study;

- In relation to loss costs two considerations apply resulting in gross cost calculation errors:
  - An unrealistic value for average line loadings is settled upon; and
  - Incorrect numbers used in K_A loss factor calculations

- Accompanying Figure and Table 8.3.2[57] states that the "*sum of the loss costs over 40 years is approximately 9 times larger than the investment costs....... These costs (375 M€) represent a very high absolute value".* These figures for "*the sum of the loss costs*" over the lifetime of the projects are calculated by multiplying the annual losses cost by 40 years. While in another section of the Askon Study a more realistic NPV calculation is done, it is the "*sum of the loss costs*", a meaningless figure[58]. This grossly further overstates the benefit of lower losses in favour of the UGC;

- The Askon Study contends that an UGC solution would have a "*considerable saving*" on its carbon footprint over an OHL solution. As stated elsewhere in this EirGrid review the loading on the OHL will in fact be much smaller than stated by Askon. As a result of this the losses will be lower than originally estimated in the Askon Study thereby (on the basis of the losses argument) resulting in the OHL option having a lower carbon footprint. An additional (related) issue not raised in the Askon Study is the energy intensive manufacturing process involved with UGC, resulting in increased production of carbon dioxide. The civil works required to construct the UGC would also be much more carbon dioxide intensive than they would be for an equivalent OHL.

[57] Page 75 & 76

[58] http://www.pylonpressure.ie/pdf/41166545.pdf, page 8

A major error in the Askon Study relates to the assumption of the loadings in the lines over their lifetime. Section 8.3[59] in the Askon Study explains how the authors arrived at their assumptions. In general lightly loaded UGC have higher losses than lightly loaded OHL, while heavily loaded OHL have higher losses than heavily loaded UGC. The Askon Study authors assume that over its 40 year lifetime, the loading on the line will be approximately 55% (Loss Factor of K_A = 0.3) of its capacity. This estimated loading for the proposed projects is too high, with a more realistic average loading for these lines being approximately 35% (K_A = 0.12). This loading of 35% could even be considered an upper range for the proposed projects. If 55% of 1,500MW is considered to be a realistic average load then an appropriate solution would be to use quad overhead line conductors instead of the proposed twin conductors per phase. This would almost double the capacity of the line at a marginal increase in capital cost and would result in approximately halving the losses.

EirGrid and its international consultants (PB Power) have carried out the losses calculations, using the Askon assumption of 55% loading, based on information available in Report 1, but have failed to reproduce the results obtained by Askon by doing this. This initially suggested that not only was a mistake made in assuming a loading of 55%, but in addition that a mistake was also made in carrying out the calculation itself. On receipt of Report 2, the source of the second mistake became apparent. The K_A used by Askon was based on 1800MW (based on turn on the proposed cable rating) instead of the K_A value based in 1500MW used by EirGrid.

4.1.10 EirGrid Comments on Project Conclusions

In this section a commentary is provided on the conclusions as presented in the Askon Study.

- *"The "N-1" CRITERION is NOT fulfilled within the planned expanded Irish 400 kV grid itself, if single system OVERHEAD LINES are planned to be used in this project. A twin UNDERGROUND CABLES system more than adequately fulfils the "N-1" CRITERION".*

[59] Page 73

The Askon Study seems to misunderstand the N-1 criteria as it applied to the Irish transmission system and to transmission systems in general. The Askon Study completely ignores the fact that the transmission system in Ireland is an integrated system with 400 kV, 220 kV and 110 kV elements (275 kV and 110 kV in Northern Ireland). The network, as planned, will comply with the Transmission Planning Criteria. This compliance is reviewed regularly as part of the normal planning cycle to take account of changing circumstances. Therefore the statement that the N-1 criterion is not fulfilled within the Irish 400 kV grid is incorrect. The projects proposed by EirGrid will in fact reinforce application of the N-1 criterion to the North East region of Ireland. The Askon Study also concludes that a double circuit UGC is needed to match EirGrid's proposal of a single circuit OHL.

- *"There are remarkably favourable advantages of UNDERGROUND CABLES over OVERHEAD LINES regarding operational security, contingency and availability".*

These 'favourable advantages' are not supported by the report or by fact. EirGrid has proposed the use of a single circuit OHL for the projects in the North East, since it provides the most technical and cost-effective solution[60]. Of course there are certain types of high voltages projects where UGC offer 'favourable advantages' over OHL.

- *"UNDERGROUND CABLES offers improved performance within the grid and enhances grid security and reliability over OVERHEAD LINES".*

This statement above is not true for the projects in the North East. There is no evidence throughout the Askon Study that an assessment of grid security and reliability was carried out. An UGC will not provide the same level of performance as an OHL. OHLs are proven technology and even though they have a marginally higher

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[60] This document entitled "CAVAN-TYRONE 400kV TRANSMISSION LINE; MEATH-CAVAN 400kV TRANSMISSION LINE; EirGrid's Position on the use of Overhead Line and/or Underground Cable for these projects" is available to download at http:www.EirGrid.com.

forced outage rate when compared to an UGC, the outage time is much smaller for an OHL. The majority of failures in OHLs are transient in nature (e.g. lightening striking the line) and automatic reclosing will usually allow the line to go back into service in less than a second. A larger failure in an OHL could take at worst a number of days to fix where a failure in an UGC could take a number of weeks or months to rectify.

- *"The occurrence of failures in OVERHEAD LINES is significantly higher than in UNDERGROUND CABLES".*

As previously stated the number of outages of an OHL may be higher when compared to an UGC, however the outage time of an UGC is typically much higher than an OHL.

- *"Unavailability of the parallel cable system tends towards zero".*

The Askon Study proposes the use of a double circuit UGC to match EirGrid's proposed single circuit OHL in order to match the reliability offered by the OHL. EirGrid is satisfied that the proposed single circuit OHL offers the reliability and security performance required. The Askon proposal of the double circuit is needed to match EirGrid's proposed single circuit solution in terms of reliability and security performance. There are oversights in the implementation of the reliability calculations in the Askon report.

- *"There are technical advantages of an UNDERGROUND CABLES system over an OVERHEAD LINES, as higher availability, higher "N-1" contingency, smaller electrical stresses of the devices and loss savings must be taken in account".*

A major source of error in the Askon Study is in relation to the loss calculations. In general, a lightly loaded OHL will have smaller losses than a lightly loaded UGC, whereas a heavily loaded OHL will have higher losses than a heavily loaded UGC. Askon has incorrectly assumed a high load flow in the proposed line; however the load will be much smaller than that proposed by Askon. This will result in significantly lower loss costs than that calculated by Askon. An additional source of error in the Askon Study appears to be in the actual loss calculations that are carried out. Even utilising the high loading assumed by Askon, EirGrid and our international consultants have been unable to replicate the results obtained in the Askon Study.

- *"The installation of an UNDERGROUND CABLES system instead of the OVERHEAD LINES allows the saving of a generator with the power of 5.7 - 8.1 MW (for the 60 km route) and 7 -10.7 MW (for the 80 km route), which is needed for decades solely to cover the higher losses of an OVERHEAD LINES".*

As previously stated there are fundamental flaws in the loadings assumed by Askon and in the loss calculations carried out in the Askon Study.

- *"Substantial carbon-footprint saving with the use of UNDERGROUND CABLES".*

In addition to the incorrect loading assumptions and loss calculations the Askon Study fails to quantify the large carbon footprint associated with manufacturing the UGC, installing the cable and decommissioning the cable.

- *"Lifetime cost factors of 1.39 (for cable option 1) and 1.46 (for cable option 2) are to be expected but trend to smaller factors when future increasing commodity and energy costs are included".*

These figures are incorrect. In the PB Power Study the whole of life cost of OHL connections between Meath-Cavan, and between Cavan-Tyrone is estimated to be €129M, whilst for an UGC that cost would rise to about €695M.

- *"The tremendous impacts of massive high-voltage towers to landscape and visual resources and therefore to the value reduction* *of properties, to the tourism and recreation industries may be difficult to assess in monetary terms".*

While it is acknowledged that there are impacts associated with both the UGC and the OHL solutions, the monetary loss to the industries in the North East (including tourism and recreation industries) associated with an inadequate transmission system is potentially substantial. Both an OHL and UGC solution will have an environmental impact in their respective areas; however the type of impact will vary depending on the chosen technology. EirGrid will carry out an extensive Environmental Impact Assessment (EIA) that will investigate the environmental impacts of the project and mitigation measures necessary to minimise these impacts.

- *"Taking these potential liabilities into consideration would mean that the UNDERGROUND CABLES option could well work out the lower cost option over the whole life cycle".*

As a result of the fundamental flaws relating to loading assumptions and in the loss calculations themselves this statement should be dismissed.

- *"Completion of UNDERGROUND CABLES shorter at 4 years rather than 7.5 years for OVERHEAD LINES".*

These completion figures were extracted from EirGrid's Transmission Forecast Statement. It should, however, be understood that the vast majority of UGC projects completed to date in Ireland (110kV and 220kV) consist of relatively short lengths of cable laid almost exclusively under city streets or through ESB land. The standard duration for these types of projects could therefore not be replicated on the proposed 400kV project. To date no UGC of this length and voltage has ever been installed anywhere in the world, thus, there is no benchmark to base an estimation of the possible construction time. The PB Power Study indicates that the lead times associated with obtaining the required length of 400kV cable would take four years to deliver – assuming multiple suppliers. The Askon Study author indicated at the Joint Oireachtas Committee Meeting that the required length of cable would take less than one year to deliver. This time frame is viewed by EirGrid as being extremely ambitious.

- *“The cost of undergrounding is likely to be less than 1 Euro per household per year. The question is this too greater price to protect the environment is the remit of politicians”.*

No apparent explanation is provided to explain the basis from where the author deduced that the UGC solution would cost less than €1/per household per year. Other considerations of note are the prohibitive cost, technical, reliability and environmental issues associated with the undergrounding of all future and existing transmission infrastructure.

4.2 Askon Report 2 – Technical Analyses and Cable Route Options

4.2.1 Routing Issues

Substantial evidence has been put forward in the relevant PB Power reports to show that undergrounding does not represent an appropriate technology for the proposed 400kV projects in the North East or for the general development of the transmission system, and EirGrid believes that this applies to the current rail bed proposal or even generally to other underground (be it along roads or otherwise) proposals. Nevertheless, EirGrid has considered this proposed rail bed alternative and has examined the considerations that would arise in relation to the use of the rail beds involved and regards;

- the 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;
- the selection of this option would direct a cable route at a series of obstacles, such as narrow, steep sided embankments and cuts;
- legacy structures of the old railway would also have to be modified, removed or avoided; and
- such a routing would not have the advantages of a route selected to minimise community and environmental impacts.

4.2.2 Cost Estimates

In preparing their cost estimates PB Power obtained expert assistance from a Project Director from Cable Consulting International Ltd (CCI). CCI is based in England and has extensive design, installation and project management experience on high voltage underground cable projects throughout the world. Assistance with local knowledge of civil engineering costs was obtained from an engineer, from RPS, who worked on the recently completed North-South gas pipeline.

The Askon estimates were prepared by a team with no apparent local knowledge or practical experience of installing HV underground cables. The civil engineering estimates were based on information received from a "German power supplier".

A comparison of the estimates is shown in Table 1. The following issues arise :

- Askon's provision for trenching is a considerable under-estimation resulting in a cost difference of €25.6 million between the two estimates.
- Askon do not appear to have made any provision for preliminaries, cable pulling or river crossings which are estimated to cost, in total, €31 million.
- Askon has only provided €720,000, out of a total estimate of €140 million, for Project Management. This is so low that it must surely be an arithmetic error. The typical provision for a project such as this should be between 5% and 8% of the project cost. This error results in an underestimation of €10.2 million.

Table 1:

Description	PB Power (€M)	Askon (€M)	Difference (€M)
Civil preliminary works and general charges (note 2)	6.09	0.00	6.09
Trenching (including shuttering, backfilling and reinstating)	44.04	18.40	25.64
Joint bays (note 3)	0.00	0.54	-0.54
Cable pulling	14.40	0.00	14.40
Trenchless Crossings - Major Roads (note 4)	0.80	0.29	0.51
Trenchless Crossings - Other roads (note 5)	1.14	0.18	0.96
Trenchless Crossings - Major Rivers (note 6)	1.71	0.00	1.71
Trenchless Crossings - Minor Rivers (note 6)	8.76	0.00	8.76
sub-Total	**76.94**	**19.41**	**57.53**
Cable and accessories - supply, install and commission (note 7)	116.62	110.68	5.94
Reactive compensation (note 8)	25.21	9.76	15.45
sub-Total	**141.83**	**120.44**	**21.39**
Project management (note 9)	10.94	0.72	10.22
Grand Total	**229.70**	**140.57**	**89.14**

Notes on Table 1

1 The Askon estimate is based on a route length of 56.7km while that of PB is based on 55.4km.

2 Preliminaries include, among other things, plant and equipment, insurance, mobilisation, supervision of suppliers, survey, photographic and engineering records, security, storage, communications, welfare and demobilisation. Provision is also made here for archaeological monitoring, reporting and excavating, and to put this in context, it should be noted that over €30 million was spent on the archaeological monitoring for the M3 motorway scheme that is currently under construction in the same vicinity.

3 In the PB estimate provision for joint bays is included in the general trenching estimate.

4 Askon provided for one major road crossing while PB provided for two.

5 Askon provided for the trenchless crossing of 27 roads (other than motorways). PB however only provided for five such crossings as they considered most of the roads to be so 'minor' that crossing by means of an open trench would be feasible and therefore more cost effective. Crossing these roads using the horizontal directional drilling method proposed by Askon would require the drilling of seven boreholes per crossing, one for each power cable and one for the communications cable. The Askon estimate is based on a cost of €6,670 per such road crossing. This is not credible and must surely be an arithmetic error.

6 PB made provision for the crossing of the Rivers Boyne and Blackwater and 22 'minor' river crossings. The Askon estimates make no mention of river crossings.

7 The Askon estimate is based on 2 X 3 X 1600 mm^2 aluminium UGC with joints at 1km intervals. The PB estimate is based on 2 X 3 X 1,200 mm^2 aluminium cable, with lead sheath, and with joints at intervals of 625 - 690 metres.

8 The Askon estimate is based on reactive compensation at Woodland and Kingscourt substations only. The PB estimate provides for

compensation at these substations as well as at one intermediate point.

9 Project management costs for a project of this kind should be in the region of 5% to 10%. The PB estimate is based on a provision of 5%. The Askon estimate is based on a provision of only 0.51%.

4.3 NEPP's Presentation of the Askon Report

When Report One was published by Askon, NEPP prepared a short summary presentation of some of the aspects covered in the main body of the report[61]. In reading the presentation, it is often unclear the extent to which the content relies on the Askon Study. To varying degrees the presentation:

- Quotes directly from the Askon Study;
- Interprets the Askon Study; and
- Presents the presentation's author's own assertions in relation to the two 400kV projects.

In this presentation it shows that EirGrid estimate the OHL project to cost €2m per km. It appears that this figure was deduced by dividing the combined project total estimate of €280m by the combined project length of 140km. This is erroneous since this cost includes a multiplicity of costs such as project management, way leave costs, compensation costs, substation costs, which were not incorporated in the Askon Study costs studies. The true figure is much smaller than that presented above and is covered in more detail in the PB Power Study.

[61] This presentation is available at http://www.pylonpressure.ie

5 BIBLIOGRAPHY

[1] Study on the comparative merits of Overhead Lines and Underground Cables as 400 kV Transmission Lines for the North-South Interconnector Project. OCT 2008. ASKON Consulting Group.

[2] Ireland North-South Transmission Interconnector. Sept 2008. PB Power