MAIN AUTHOR

The main author of the ASKON report is world renowned in his chosen field of research. Up to 2003, Professor Friedhelm Noack was Director of the Institute of Electrical Power and High Voltage Engineering at the University of Technology, Ilmenau, Germany.

He is the author of two celebrated books: 'Stresses of circuit breakers in high voltage networks', 1980 and 'Introduction to electrical power engineering', 2003. Professor Noack has written more than sixty scientific papers in national and international journals and presented over sixty papers for international conferences. He is the author of more than eighty research reports on fundamental and industrial research projects as well as over sixty expert reports.

As a figure of international stature, Professor Noack has been a member of CIGRE – the International Council on Large Electrical Systems and is involved in working groups of IEC – the International Electrotechnical Commission and CENELEC – the European Committee for Electrotechnical Standardisation.

Produced by
NORTH EAST PYLON PRESSURE
PO Box 106, Navan, Co.Meath, Ireland
www.pylonpressure.ie
email: info@pylonpressure.ie

THE ASKON REPORT ON UNDERGROUNDING

Summary and Recommendations

October 2008

ASKON CONSULTINGGROUP

NORTH EAST PYLON PRESSURE

Underground makes sense

CONTENTS

NORTH EAST
PYLON PRESSURE

INTRODUCTION

EirGrid, in collaboration with Northern Ireland Electricity, is proposing to build a North-South electricity interconnector through counties Meath, Cavan, Monaghan, Armagh and Tyrone using 400 kV extra high voltage Overhead Transmission Lines, at an estimated cost of €280 Million. Three route corridor options have been chosen. All three route options are based on Overhead Transmission Lines only. Despite the scale and significance of the North-South interconnector project, EirGrid have not performed a detailed analysis of the feasibility and cost of an Underground Cable alternative system.

North East Pylon Pressure (NEPP) is the overall representative group for the people of the North East who advocate that high power electric cables should go underground. The group was formed in November 2007,in response to the EirGrid announcement of its plans for a North-South interconnector from Meath to Tyrone. The strong consensus is that the interconnector should be established using Underground Cables instead of Overhead Transmission Lines.

In April 2008 NEPP commissioned ASKON to carry out a study, with the following objectives:

1. Determine the feasibility of using a 400kV Underground Cable transmission line for the North-South interconnector project, that could be integrated into the existing grid network managed by EirGrid.

2. Assess the feasibility of such an underground cable option to meet the EirGrid benchmark criteria of affordability, reliability, safety, efficiency and security.

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

In the course of their study ASKON carried out aerial and land analysis of the project area, in order to achieve a detailed, accurate and realistic set of conclusions. The report was issued in October 2008. *('Study on the Comparative Merits of Overhead Lines and Underground Cables as 400 kV Transmission Lines for the North-South Interconnector Project').*

NORTH EAST
PYLON PRESSURE

Underground makes sense

MAIN FINDINGS

1. The Askon report is **the first project specific analysis** of determining the feasibility of undergrounding the North-South interconnector. Askon examined the feasibility of undergrounding using EirGrid's benchmark criteria of affordability, reliability, safety, efficiency and security.

2. **A design consisting of two groups of Underground Cables running in parallel is recommended** for the transmission system, as an alternative to the planned Overhead Lines single system. The design consists of using two groups of aluminium cables entrenched in parallel to each other. The two trenches are 1.4 metres in width and in depth and situated 5 metres apart.

3. The Underground Cable solution **is better suited to integrating with the existing grid network** than the proposed Overhead Line system, as defined by a well established International Standard for evaluating operational security and power disturbances ("N-1 criterion"). Undergrounding enhances national grid security and reliability, compared with Overhead Lines, and gives improved performance in the grid.

4. The Underground Cable solution is significantly **more reliable** than its equivalent Overhead Line option, whether in conditions of either planned or forced outages. Failures in Underground Cables are significantly lower than in Overhead Lines. **The probability of both parallel cables being unavailable is once in every 100,000 years.** The second parallel cable system can immediately be brought into operation should any issues arise with the first cable system. This is not feasible with a single Overhead Line.

5. The Underground Cable system is significantly **more efficient** than the equivalent proposed Overhead Line system. Transmission losses over the lifetime of the Underground Cable system are significantly lower than for a single Overhead Line system. This translates to a significantly better carbon footprint profile than the Overhead Line system. It is also a major component in cost comparisons between the two systems.

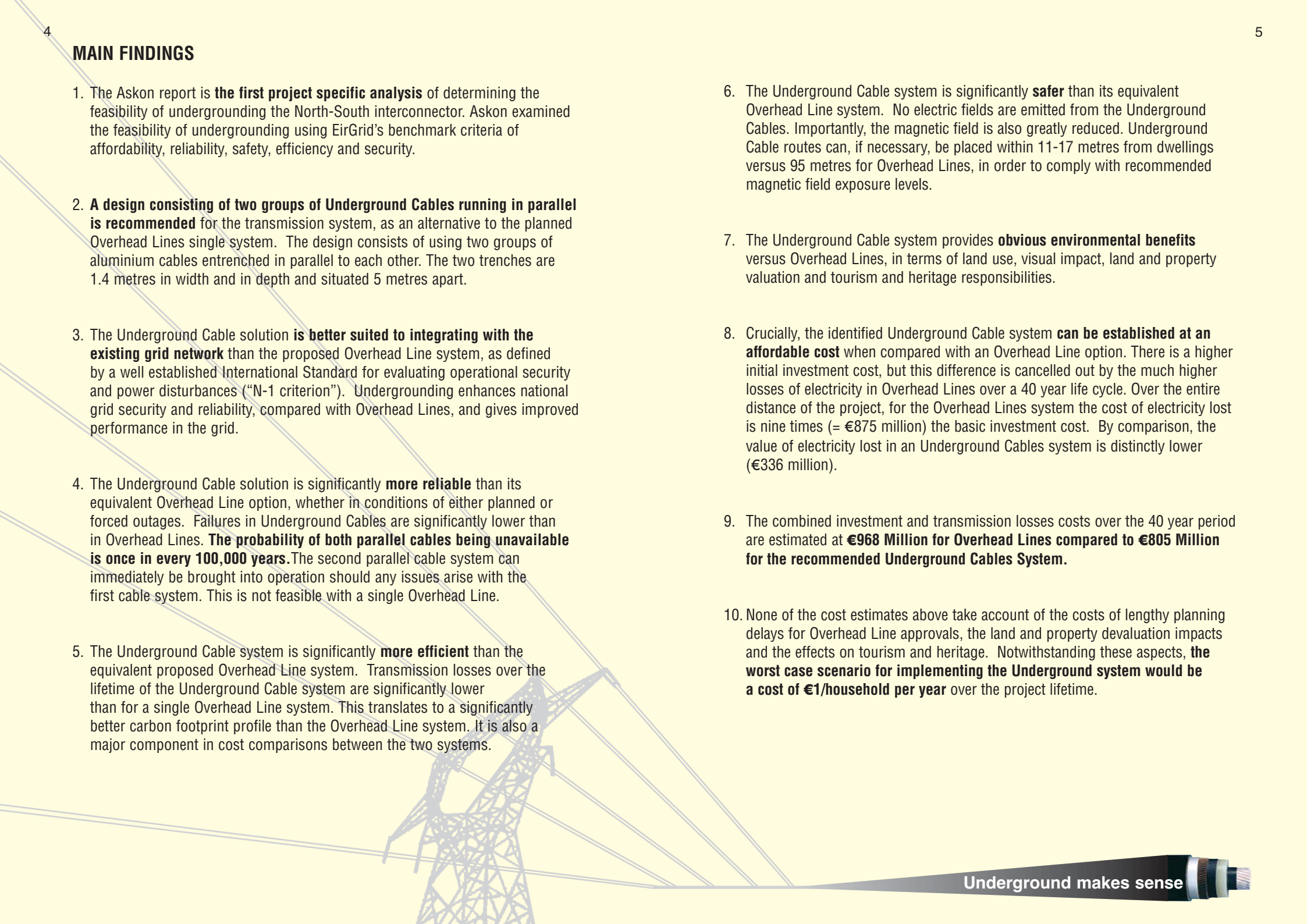
6. The Underground Cable system is significantly **safer** than its equivalent Overhead Line system. No electric fields are emitted from the Underground Cables. Importantly, the magnetic field is also greatly reduced. Underground Cable routes can, if necessary, be placed within 11-17 metres from dwellings versus 95 metres for Overhead Lines, in order to comply with recommended magnetic field exposure levels.

7. The Underground Cable system provides **obvious environmental benefits** versus Overhead Lines, in terms of land use, visual impact, land and property valuation and tourism and heritage responsibilities.

8. Crucially, the identified Underground Cable system **can be established at an affordable cost** when compared with an Overhead Line option. There is a higher initial investment cost, but this difference is cancelled out by the much higher losses of electricity in Overhead Lines over a 40 year life cycle. Over the entire distance of the project, for the Overhead Lines system the cost of electricity lost is nine times (= €875 million) the basic investment cost. By comparison, the value of electricity lost in an Underground Cables system is distinctly lower (€336 million).

9. The combined investment and transmission losses costs over the 40 year period are estimated at **€968 Million for Overhead Lines compared to €805 Million for the recommended Underground Cables System.**

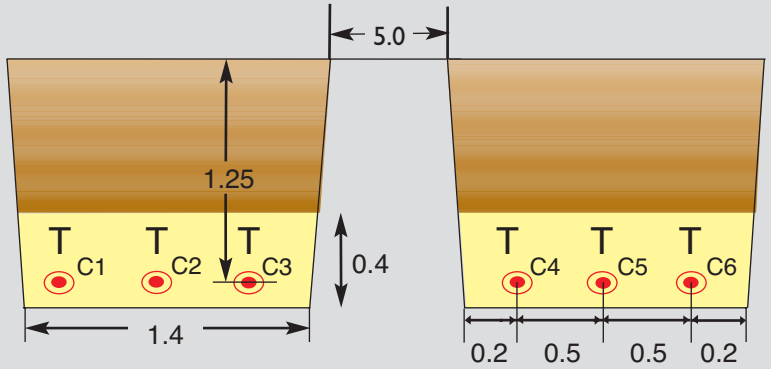
10. None of the cost estimates above take account of the costs of lengthy planning delays for Overhead Line approvals, the land and property devaluation impacts and the effects on tourism and heritage. Notwithstanding these aspects, **the worst case scenario for implementing the Underground system would be a cost of €1/household per year** over the project lifetime.



SYSTEM DESIGN

A design consisting of two groups of Underground Cables running in parallel is recommended for the transmission system, as an alternative to the planned Overhead Lines single system. The design consists of using 2 groups of aluminium cables entrenched in parallel to each other. The 2 trenches are 1.4 metres in width and in depth and situated 5 metres apart.

The 2 groups of cables are placed in trenches that are 1.4 metres in width and in depth and situated 5 metres apart.



Two separate cable trenches: each cable system in flat arrangement

Modern Underground Cables with cross-linked polyethylene insulation (XLPE) are an alternative to the historically well proven technology of Overhead Lines. These Underground Cables are easy to install, easy to maintain and easy to repair. **Several Underground projects with lengths up to 210 km are under consideration in Europe at present.**

GRID SECURITY

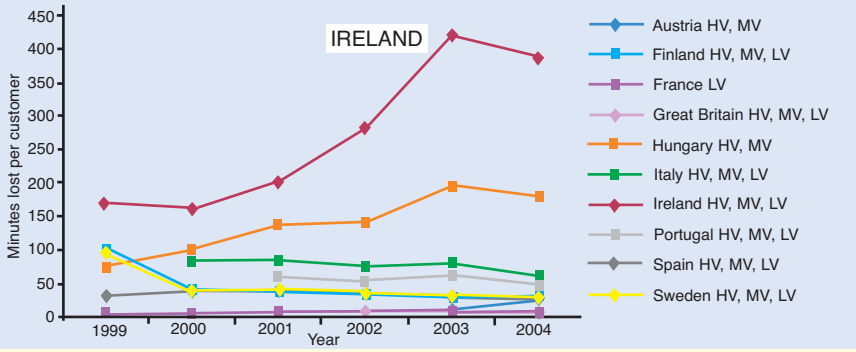
This Underground Cables system solution is better suited to integrating with the existing grid network than the proposed Overhead Lines system, as defined by a well established International Standard for evaluating smooth operation and security of interconnected power systems ("N-1 Criterion"). The "N-1 Criterion" is of major importance to prevent disturbances. The "N-1" Criterion is not fulfilled within the proposed expanded Irish 400 kV grid itself, when single system Overhead Lines are planned to be used in this project. Undergrounding enhances national grid security and reliability, compared with Overhead Lines, and gives improved performance in the grid.

RELIABILITY

The Underground Cable solution is significantly more reliable than its equivalent Overhead Line option, whether in conditions of either planned or forced outages. Failures in Underground Cables are significantly lower than in Overhead Lines, which are permanently affected by the climate and environmental conditions (sun, wind, rain, fog, snow, ice, pollution, and lightning strikes) and thus the components age.

When a failure occurs in Overhead Lines, the transmissible power of the system is zero. Statistical data and statistical reliability analysis, however, shows that the probability of an Underground Cable failure is very low. The longer time it may take to repair an Underground Cable is eliminated by having two cables in parallel, as is the current practice around the world. The probability of both parallel cables being unavailable is once in every 100,000 years. The decisive advantage of the two parallel Underground Cable systems is the redundancy of one cable system, which has, together with the overloading performance of the cables, remarkably favourable advantages over the Overhead Lines system regarding availability and security.

Unavailability in European grids caused by planned interruptions. Minutes lost per customer per year (1999-2004)



Third Benchmark Report on Quality of Electricity Supply, CEER, 2005

Currently, the Irish grid, in comparison to the other European grids, has a remarkably high factor of unavailability, which is caused by planned interruptions. Undergrounding would reduce this level of interruptions.

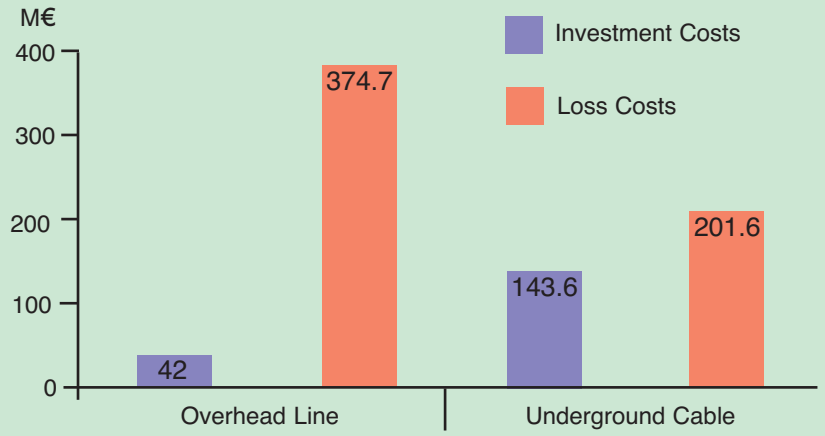
EFFICIENCY

The Underground Cable system is significantly more efficient than the equivalent proposed Overhead Line system. Transmission losses over the lifetime of the Underground Cable system are significantly lower than for a single Overhead Line system. This translates to a significantly better carbon footprint profile than the Overhead Line system, through reduced greenhouse gas emissions.

Transmission losses represent a loss in value and an increase in fuel burn and environmental impact. In Europe, transmission line losses alone represent the waste of around 20 million tonnes of coal, 3.1 million tonnes of gas and 1.7 million tonnes of oil. The annual loss in value is around €12 billion. The annual increase in greenhouse gas emissions is around 60 million tonnes of CO2 per year. In some countries, older transformer infrastructure and lines can yield losses as high as 21%. Ireland's grid losses are above the European average.

Transmission losses are, therefore, a major component in analysing life-cycle cost comparisons between Underground and Overhead alternatives. Underground Cables in the grid have lower voltage drops, higher voltage stability for the consumers and improved transmission stability compared with Overhead Lines. Importantly, the Underground Cables do not have any unfavourable influence on the load flow in the Irish Grid.

Loss costs of transmission systems over 40 years in comparison to the investment costs, for the 60 km Woodland-Kingscourt route.



ENVIRONMENTAL IMPACT

The Underground Cables system provides obvious environmental benefits versus Overhead Lines, in terms of land use, visual impact, land and property valuation, tourism and heritage responsibilities.

Preparing for trenching

Regeneration after trenching

Studies have been carried out over the last fifty years to assess the impact of overhead power lines on the value of residential property and land in close proximity to pylon towers.

A study carried out in Britain in 2007 showed the value of detached properties at a distance of less than 100m from overhead transmission lines was 38 percent lower than comparable properties. The effect of devaluation has been seen up to two-and-a-half kilometres from such lines.

In relation to non-residential holdings a rigorous and comprehensive study in Canada over 20 years ago found that the per acre values from more than 1,000 agricultural property sales were 16-29 percent lower for properties with easements for transmission lines than for similar properties without easements.

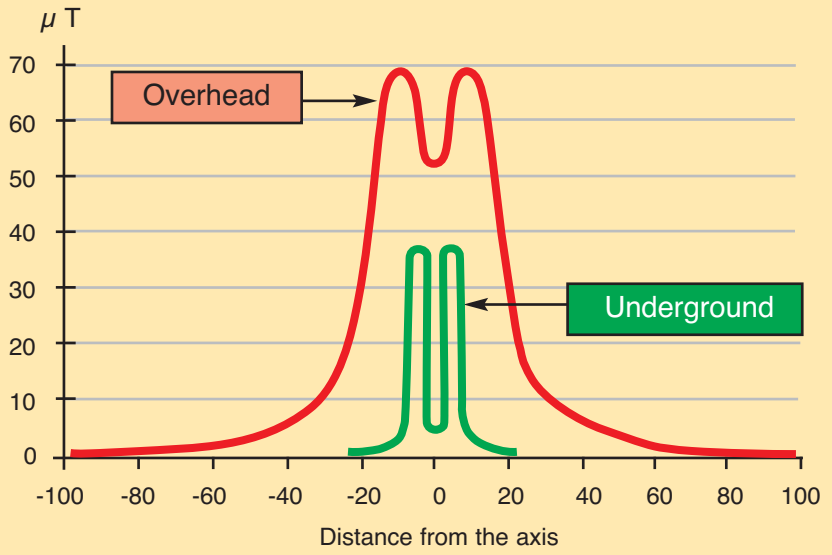
NEPP have commissioned a study to quantify in particular the potential land and property devaluation effects in the North-East, based on proximity of existing dwellings and land-holdings to the proposed route corridors.

SAFETY

For some decades many human and epidemiological studies have been undertaken to investigate the influence of electric and magnetic fields on human and animal health. The International Commission on Non-Ionising Radiation Protection (ICNIRP) in 1998 issued guidelines for exposure to time varying electromagnetic fields (EMF). These guidelines were adopted by the European Union in 1999. A limit level of 100 µT (micro Tesla, the international scientific unit of EMF measurement) was set for permanent exposure of humans at this time. However more recent findings suggest that childhood leukaemia may be caused by permanent exposure to low magnetic fields. As a result of these studies, some countries and regions in Europe and America have reduced the magnetic field exposure limits (e.g. Italy 3 µT, Switzerland 1 µT, Netherlands 0.4 µT, Tuscany 0.2 µT). For new installations the precautionary level for permanent exposure as adopted in Switzerland of 1µT should be applied as best practice.

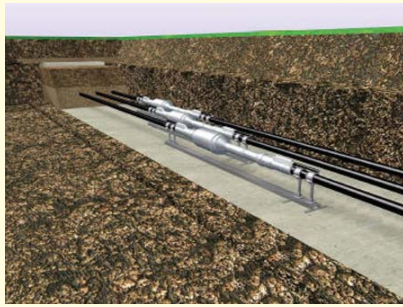
The Underground Cables system is significantly safer than its equivalent Overhead Line system. No electric fields are emitted from the Underground Cables. Importantly, the magnetic field is also greatly reduced. Underground Cable routes can, if necessary, be placed within 11-17 metres from dwellings versus 95 metres for Overhead Lines, in order to comply with exposures below the 1 µ Tesla level. The EMF field from an overhead electricity line cannot be shielded and humans need to be more than 90 metres from the line to meet the precautionary safe reading of 1 µ T. In contrast, even during peak loads, the EMF density above underground cables reduces to 1 µ Tesla after only 11 metres distance. Short term exposure by walking or working above cables is harmless.

Comparison of EMF Levels for Overhead Lines versus Underground Cables



Magnetic field Single Overhead Lines System compared to two parallel Underground Cable systems in flat arrangement at full loads in lateral distance (in metres) from axis.

There are some uncertainties about the magnitude of the loads of the planned transmission systems. Taking into account that existing Overhead Lines can be up-rated or replaced by multi-system lines, as usually happens in other countries, this corridor should have a width of at least 100 metres on both sides of the axis.



AFFORDABILITY

Two components are important in determining overall costs for the 40 year lifetime of this project, namely capital costs in establishing the system, and losses in electricity during the 40 year lifetime of the system.

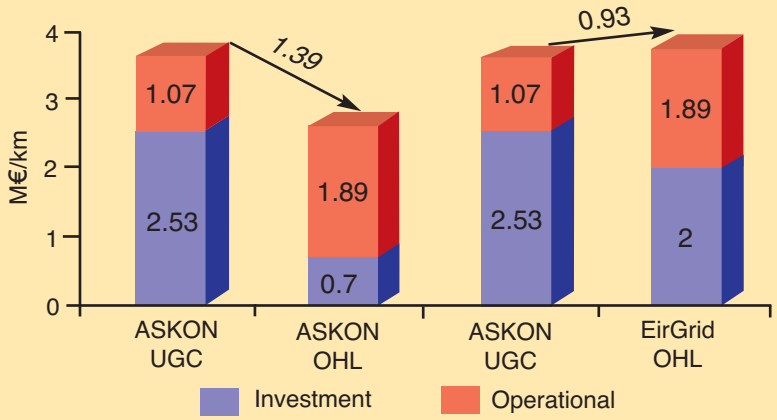
For the North-South interconnector project, the capital costs for an Overhead Lines system are smaller than for a parallel Underground Cables system. Power transmission losses, however, in Overhead Lines are distinctly higher than for Underground Cables. Therefore, the financial losses incurred through wasted electricity are much higher. Over the entire distance of the project, for the Overhead Lines system the cost of electricity lost is nine times (= €875 million) the basic capital investment cost. By comparison, the value of electricity lost in an Underground Cables system is distinctly lower (€336 million).

The efficiency of Underground Cables is equivalent to eliminating a power station with a capacity of 6 to 11 Mega Watts, which represents a considerable saving on the carbon footprint of Undergrounding.

The combined investment and transmission losses costs over the 40 year period are estimated at €968 Million for Overhead Lines compared to €805 Million for the recommended Underground Cables System.

For an assessment of the financial aspects of this project standard appraisal methods involving "Net Present Value method" (NPV) and Weighted Average Cost of Capital (WACC) were used. The capitalised costs, which are the sum of the capital cost and the net present value of the operational costs, were determined for a 40 year lifespan. The life-cycle costs of the Underground Cable options were found to be higher than those of the Overhead Lines, with a lifetime cost factor of 1.39:1 for the recommended Underground Cables system compared with the single Overhead Lines system. Interestingly, however, this factor reduces to 0.93:1, when EirGrid's actual projected Overhead Lines system costs of €2 Million/Kilometre for this project are factored into the analysis.

Capitalised Cost Comparisons for Underground Cables (UGC) versus Overhead Lines (OHL) over a 40 year life-cycle.



None of the cost estimates above take account of the costs of lengthy planning delays for overhead line approvals, the land and property devaluation impacts and the effects on tourism and heritage. **Notwithstanding these aspects, the worst case scenario for implementing the Underground Cables system would be a cost of €1 Euro per household per year over the project lifetime.**

NEPP RECOMMENDATIONS

1. ***EirGrid need to review their strategy in relation to the feasibility and affordability of undergrounding the North-South interconnector.***
2. ***The Minister for Communications, Energy and Natural Resources must revise the Statutory Instrument establishing EirGrid to direct the company to put this project and all future extra high voltage power lines underground.***
3. ***NEPP requests the Joint Oireachtas Committee on Communications, Energy and Natural Resources to institute public hearings based on this report.***
4. ***NEPP requests the Department of Environment, Heritage and Local Government to implement the key recommended actions from the March 2007 report by the Expert Group on health effects of Electromagnetic Fields.***
5. ***A coordinated approach to examining practical options for an Underground Cable route corridor needs to be adopted, involving the relevant State bodies, including the Departments of Communications, Energy and Natural Resources; Transport; and Environment, Heritage and Local Government, with inputs from all relevant stakeholders in the North East region.***

ASKON CONSULTING GROUP

ASKON Consulting Group GmbH is a leading international technology consultancy, specialising in energy, automotive sector and aerospace. ASKON employs more than 350 people. ASKON operates from offices in Hamburg, Munich, Dusseldorf, Bremen, Leipzig, Gummersbach and Lippstadt. **www.askon.de**

ASKON has been part of the ALTRAN Group since 1996. ALTRAN is the European market leader in innovation consulting. In 2007, the Group's turnover reached €1.6 billion with over 17,500 employees in twenty countries. Group headquarters is in Frankfurt, Germany. In its energy division, ALTRAN focuses on support for major utilities, especially on power transmission and distribution, and on renewable energies such as wind power and solar energy. **www.altran.com**

Unlike the Government's Ecofys report – which was a desktop, theoretical exercise – the ASKON Consulting experts made an extended site visit to Ireland and their report is specific to viable routes and to the conditions in the North East of Ireland. They visited the historic Bective Abbey which is threatened by giant pylons nearby.

(L to R) Dr Hans Pleuger, Intelligent Energy, Gisbert Weber BE, Consultant, ASKON, Dr Udo Hass, Managing Consultant, ASKON, and Professor Friedhelm Noack, Faculty of Electrical Engineering, University of Technology, Illmenau, Germany. The ASKON study is the first and only project-specific analysis of the comparative merits of underground cables and overhead lines for the proposed North / South interconnector.

ASKON CONSULTINGGROUP