Meath-Tyrone Report

Review by the International Expert Commission

August – November 2011

Meath–Tyrone International Expert Commission, Executive Summary

The Minister for Energy Pat Rabbitte, on July 5, 2011 announced that the Cabinet had agreed on his proposal to establish an international commission of experts to review and report, within six months, on a case for, and cost of, undergrounding (all or part of) Meath-Tyrone 400KV power link.

The appointed members of the Commission have professional background experiences from the Electrical Supply Industry, Transmission System Operations and Academic Knowledge in Power Systems.

There have already been performed several studies on the project by specialists appointed by organizations representing different aspects of and options for the Meath – Tyrone Project. The Commission wishes to build upon and add to the content and knowledge available in the various reports by studying the system from various angles. In this respect, the commission tries to find an answer to the following question:

- How do different stakeholders look at the project? What are their main concerns and their main suggestions?
- How does the Meath–Tyrone Project fit in a European perspective?
- What can we learn from previous reports on the Meath–Tyrone Project?
- What is the present state of the art of technologies already implemented or commercially available?
- What are the development trends in transmission technologies?
- Using a benchmark approach, what can be learned from recent project in Europe under construction or decided? What are the cost elements for different options today?
- What are the implications on cost and technical performance of possible alternatives for the Meath–Tyrone Project?

By looking at the Meath-Tyrone project from a wider perspective, and checking the arguments from the different reports within an international framework, the NIMBY (Not In My BackYard) elements can be overcome, which are a generally found weak element in almost all reports on a project written from a stakeholder specific angle.

The approach to include the examination of on-going projects in Europe is particularly relevant given the fact that there have been significant changes in technology, suppliers and costs the very last years.

The Commission has spent considerable effort on collecting data from five reference projects all relevant for the Meath–Tyrone project. These projects have ended up in different choice of technology, confirming that there is no single “right” solution. Each project must be judged on its own merits and hybrid solutions, i.e. combining different technologies, have been applied in many cases, for instance partially undergrounding a link. A specific technical solution must be derived accounting for local conditions.

Given the fast technological and market developments over the last years, some of the conclusions drawn in reports on the Meath-Tyrone project reflect the technology status as available a couple of years ago, using information available at the time. Therefore, given the project targets and boundary conditions, the conclusions may be different today compared to the results found at the time of writing of the reports.

Examples are the development of VSC HVDC technology and its deployment in transmission projects and the introduction of new tower designs for overhead lines. Given these major changes in the market it appears relevant to look at near-term trends, i.e. systems that can be bought of the shelf.

Detailed studies were made before the final solution was defined in each of these cases and these experiences are of great value for the Meath–Tyrone project. Examples are:

- Overhead lines can be rendered more acceptable by using new tower designs, new conductor types and other measures to reduce the visual impact, and in some cases also reduce EMF. Short distances may also be covered using underground AC cables.

- When considering undergrounding, a.c. cables are not the best choice when longer connections are to be covered. D.C. technology becomes a viable option as the cable itself is comparable in cost to an advanced overhead line, while major steps forward are seen in both costs and losses in the converter stations.

The Commission is not recommending any solution as such. However, it recommends against fully undergrounding using an a.c. cable solution.

If the option is to underground the connection along the whole, or main part of the route, with today's technology the best solution is a VSC HVDC solution combined with XLPE cables. The best cable route is most likely following existing infrastructure such as large freeways or railroads, or through farmland, as the width of the trajectory is far less than that needed for a.c. cables. In difficult terrain for undergrounding d.c. overhead lines can be used.

The commission wants to stress that an overhead line still offers significantly lower investment costs than any underground alternative and could also be made more attractive by investing slightly more in new tower designs, than the classical steel lattice towers now proposed.

For cost estimations, values found in real projects under execution are the most reliable source, although the high market activity and large fluctuations in key cost parameters such as metal prices can have a major influence that may be different given the technical option chosen.

Operational costs for different alternatives e.g. losses, will depend upon the power flowing to the link. This is an assessment outside the scope of this report. All alternatives have different characteristics, but are rather close making the assessments of lowest "life cycle losses" rather irrelevant, certainly when considering that the price of energy is very difficult to estimate over the say 60 years of life of the project.

The commission appreciates the open and constructive approach taken by all stakeholders. This has made it possible to get a good understanding of the specific conditions of the Meath–Tyrone project. The commission is grateful that all organisations involved made themselves available on short notice. This has made it possible to complete the work with-in the limited time available.

The report will not discuss EMF, the potential impact of the line on property value or landscape devaluation, as none of the Commission members have the appropriate knowledge.

The commission hopes that the report makes a valuable contribution to the overall discussion about the Meath Tyrone Project.

For the Commission

Bo Normark Odd-Håkon Hoelsaeter Ronnie Belmans

1 Introduction

1.1 Commission Members

This report is prepared by the Commission composed of:

- Bo Normark, Chairperson Elimark AB
- Odd Håkon Hoelsæter OHH Energy
- Ronnie Belmans 2BEnergy

The Terms of Reference for the work were set by the Department of Communications, Energy and Natural Resources.

1.2 Terms of reference for the review

In preparing its Report the Expert Commission will:

- *review expert literature already available both in Ireland and internationally in relation to undergrounding high voltage power lines*
- *consider the route or routes proposed by EirGrid*
- *examine the case for and cost of undergrounding all or part of the Meath-Tyrone 400KV line*
- *consult with EirGrid, the North East Pylon Pressure Committee and the County Monaghan Anti Pylon Committee, and which ever other bodies or organisations it sees fit*

The case for the actual provision of the Meath-Tyrone power line is not subject to review.

2 Comments on reports

2.1 Transgrid Report, Oct 18, 2009

"Investigating the Impact of HVDC Schemes in the Irish Transmission Network"

Transgrid conducted a comprehensive study in 2009 looking at the technical possibilities to use HVDC in the Irish Grid. The report covers:

1) North-West Wind
2) North-South Interconnector
3) Drawing Power out of the Cork Region
4) System Expansion in Northern Ireland

In the study it has been anticipated that there will be a substation in Cavan. The report gives a very complete and comprehensive description of technologies including AC lines, Line Commutated Converter HVDC (LCC) and Voltage Source Converter HVDC (VSC). The report describes the state of the art VSC technology at that time, including reference projects. The report does not cover the 400 kV AC Cable alternative.

The Commission believes that this report gives an accurate and comprehensive technical comparison of the alternatives. However as described in Section 3.2 of this report, there has been a significant development of the market and technology for VSC HVDC over the last two years. This development, e.g. related to significant reduction of losses, is naturally not covered.

The technical relevance, in particular of an HVDC option, has been questioned but here the report correctly concludes that this alternative is feasible. There are some advantages with the HVDC option and some things to watch. A summary in this respect regarding the "North-South" Interconnector can be given with some quotes:

"The studies show that the AC and HVDC options are all technically feasible and each option could be integrated into the network provided that the relevant protection, control and telecommunication systems for these HVDC technologies and their interactions are sufficiently robust to maintain the safety, reliability and security of the Irish network."

"VSC HVDC is technically feasible and has "improved dynamic voltage performance" compared to the AC alternative. Adding STATCOM to the AC alternative as suggested by Transgrid would add significant costs since the cost of a STATCOM is about half the cost of a complete HVDC convertor. This would only add dynamic capabilities and not the possibilities for load sharing between the parallel lines."

" Based on the selected power flow cases and contingencies that were studied, there are no significant technical advantages identified for the use of HVDC transmission instead of AC transmission for the North-South Interconnector."

"A meshed AC network with embedded HVDC circuits can impose an added complexity to future network planning and expansion".

"In addition, both HVDC options could be designed with a controller to monitor the phase angle difference between the two systems when the double circuit Louth-Tandragee lines are out of service in order to further adjust the HVDC power transfer to minimize the angle difference between the North and South".

2.2 TEPCO report, Nov 2009,

"Assessment of the Technical Issues relating to Significant Amounts of EHV Underground Cable in the All-island Electricity Transmission System"

This report is entirely focussing on the underground AC Cable option. The report addresses a number of technical issues related to large amounts of HV AC Cables. No detailed studies have been conducted, but the conclusion is that technically a fully or partly undergrounded AC solution could be made work. Since the AC Cable option is not considered to be the best underground alternative with today technology, no in-depth study of the TEPCO report has been made.

2.3 THE ASKON REPORT ON UNDERGROUNDING

"Study on the comparative merits of overhead lines and underground cables as 400 kV transmission lines for the North-South interconnector project"

The main author is Prof.Dr.-Ing. Habil. Friedhelm Noack of the Ilmenau University of Technology, Germany. The Commission understands that the task given was to concentrate on a 100% underground AC cable alternative. When reviewing the report the Commission has found several questionable statements. Some of these are discussed below.

First a comment on the main author of the report, Prof.F.Noack. He is well known in the industry for many years for his work on lightning protection and overvoltages. The Commission, is however, not aware of his expertise in grid development, grid operation, economic aspects and undergrounding.

When discussing the Transmission Technology in Section 2, it is stated that cable projects with lengths up to 210 km are under construction in Europe: this is not for AC at the voltage needed here. In the text it is suggested that long distance ac cables at 400 kV are not really a problem and that experience is there. This is not correct.

The discussion on the transmission capacity in Section 3 has limitations. For example, putting the cables next to each other increases the magnetic field and pushes towards the use of shielding (see Tihange-Avernas 150 kV cable connection in Belgium) and requires the uses of transposition (exchanges the place of each single phase cable every kilometre, increasing costs). These elements are key and are not treated in the text.

The reliability data is not backed up by actual data. CIGRE reports are available but not used. The interpretation of the (N-1) criterion, which is the basis of all security assessments in transmission grids (although new systems are under development but this is beyond the discussion here) is not correct. The report discusses (N-1) on a local line, but the criterion has to be used within the overall grid, where if a line is no longer available, it has to be seen whether the system as a whole is still capable to supply the load. In answers during the hearings in the parliament on the report it was claimed that in Europe all lines are double circuit to provide redundancy, this is not a correct statement.

Section 5 deals with "Efficiency of transmission lines". However, the text only deals with transients and overvoltage's that have no relevance to the topic announced in the title of the report.

Section 6 on electric and magnetic fields is very general. Shielding is not looked at. For overhead lines, no alternative designs are considered. For instance, Wintrack from the Netherlands, which reduces the magnetic field of overhead lines.

The costs in Section 8 are based on material costs. Almost no costs (10 % approximately) for civil works are included, this is not consistent with experiences from real projects where these costs typically are of the same order of magnitude of the cable and the connections or more. The cost estimations are not relevant considering today's material prices.

In conclusion, findings in the report are not consistent with industrial practice for other projects in Europe similar to Meath-Tyrone that have been executed, are under construction or are in planning.

2.4 Parsons and Brinkckerhoff report

"Comparison of High Voltage Transmission Options"

In the "Cavan-Tyrone and Meath-Cavan 400 kV Transmission Circuits", Parsons and Brinkckerhoff and associates compare transmission options: AC overhead and underground, and DC underground.

The project is discussed over the whole length both in the Republic of Ireland and in Northern Ireland.

Three elements are studied: technical feasibility, environmental impact and cost differences.

The basic design used is a 1500 MVA, single circuit 400 kV overhead line with classical steel lattice type towers.

The design of the overhead line is very basic, with no attempt to use somewhat more advanced techniques as available these days to tackle some of the problems that are mentioned when dealing with overhead lines like magnetic fields or visual impact.

The cable approach is studied leading to the result that two circuits would be needed. Furthermore, the N-1 criterion is discussed in a very special way, i.e. locally, while this is an overall system approach, not limited to a specific connection. All challenges of the cable approach are discussed in detail, providing the impression that these are far more difficult and that the overhead line is an easy thing to permit and build. All numbers in the report are excerpts of one single report from 2003, with a small number of data: http://ec.europa.eu/energy/gas_electricity/studies/doc/electricity/2003_02_underground_cables_icf.pdf. No CIGRE input is used for instance.

The conclusion is that overhead lines are more flexible over the long term than underground cables. The higher values for instance of the fields are not considered to be a drawback of the OHL.

With regard to DC links, most attention is paid to line commutated HVDC and almost none to the modern Voltage Source Converter (VSC) version. Today the situation is entirely different compared to when the report was written regarding technical data such as commercial availability of higher voltages and significantly lower losses.

In chapter 7 an extremely detailed discussion is given on the choice of the routing. Chapter 8 deals with the costs. The data used in this chapter seem to be irrelevant today especially given the fact that the basic scheme today does not include an intermediate substation in Moyhill and the technical developments of VSC HVDC.

As a conclusion the report draws correct conclusions within the framework that is self imposed, i.e. a very conventional overhead line and AC cables along the overall route. Within this framework the results are correct and the analysis is very robust. However, today the results may be different both in cost and technical performance given the recent technological developments. This Commissions report will later discuss possible solutions including both new OHL designs that reduce visual impact and magnetic fields as well as updated data, particularly for VSC HVDC.

2.5 Ecofys report

Prof.Dr.-Ing.habil. H.BRAKELMANN from the university of Duisburg-Essen, Ecofys Germany GmbH and Golder Associates have written a report in 2008 entitled "Study on the comparative merits of overhead electricity transmission lines versus underground cables.

When looking at the website of the Institute of Power Transmission and Storage (http://www.ets.uni-duisburg-essen.de/), the research topics and publication list (http://www.ets.uni-duisburg-essen.de/~bra/VeroeffentlichungenBrakelmann.pdf) of prof.H.BRAKELMANN can be found. Both clearly indicate the relevance of the knowledge and experience for the subject studied in the report.

The report has a clear structure, starting from the analysis of stakeholders submissions and a study of international practices, a technology comparison in made.

The general conclusion is that a directly buried ac cable comes closest to the overhead line cost (factor of 5 in investment, factor of 3 when looking at the lifecycle cost.

When analysing the stakeholder submissions, most concerns regard the environmental issues like land use and impact on communities and property value.

The overview of underground cable projects in chapter 3 is very extensive. The conclusion is clear that at that moment, no cable project of the magnitude of the Meath-Tyrone project was even considered.

The state of the art of the technology is interesting and quite comprehensive for somewhat 5 years ago. On overhead line design, only the somewhat improved Danish tower design is shown. The discussion on AC cables includes all relevant elements. Superconducting cables are mentioned as long horizon feasibility. The discussion on HVDC and specifically VSC is rather limited, being normal for that time.

Chapter 5 discusses the difficulties in comparing costs between OHL and UGC approach, both in investments and in operation.

Chapter 6 on the "Comparison of Environmental Impacts" contains a large amount of very detailed and very interesting assessments of possibilities to reduce the impact of electric lines. The treatment of the impact on the soil is very clear and the conclusions are very interesting, leading to the fact that also UGC are far from environmentally free of trouble.

Chapter 7 gives a very high level description of "policy implications". The relevance to the specific project is not directly clear. Chapter 8 lists some costs aspects.
Chapter 9 compares a number of technical alternatives for the Meath-Tyrone project. The overall conclusion is that only a UGC double circuit 3000 mm2 aluminium conductor directly buried in the soil is technically viable (status begin 2008) with investment costs 5 times and life cycle costs 3 times higher than OHL.

Overall this report gives a very good overview of most of the relevant elements for assessing the Meath-Tyrone project. It is bounded by the time it has been written (May 2008, so state of the art 2007), but within these boundary conditions, the conclusions are very sound.

Conclusions Chapter 2

When studying the other reports, made available to the Commission, it became clear that their content was technically sound within the boundary conditions set in the reports as such. Sometimes these boundary conditions were not wide enough to get to more advanced solutions based on new developments.

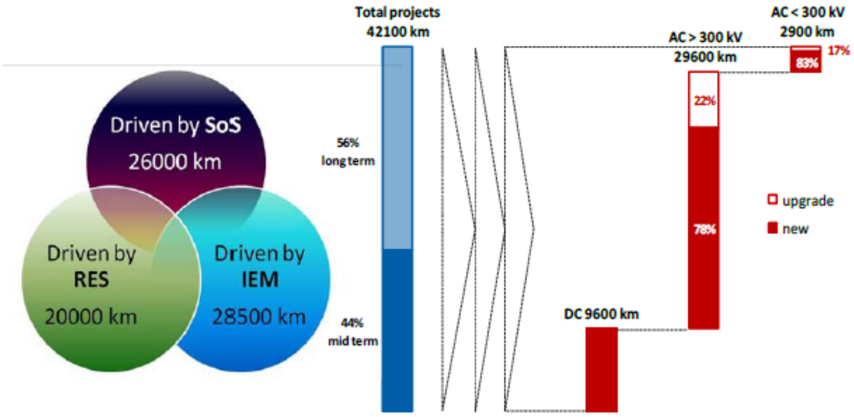
This is particularly relevant given the fast technological and market developments over the last years. Some of the conclusions drawn in reports on the Meath-Tyrone project reflect the technology status as available a couple of years ago, using information available at the time. The chosen technologies for high voltage transmission show a more diverse picture today. Therefore, given the project targets and boundary conditions, the conclusions will be different today compared to the results found at the time of writing of the reports.

3 Meath-Tyrone in a European perspective

The Meath-Tyrone link is a project with rather classic targets when we look at the grid development projects in Europe. As most of them, it wants to serve the community by:

- improving the reliability and the security of supply
- linking the markets to improve competitions
- enabling the integration of renewable energy resources

In Europe the latest report from ENTSO-E suggests the following distribution of grid additions 2011 – 2014



From the current planning it can be seen that the three main drivers are equally responsible for the need to expand the grid and that for new lines above 300 kV HVDC represents about one third of the investments. Many DC lines are subsea or underground.

The Meath-Tyrone project has the same rationale as many European projects:

- sharing reserves and increasing the inertia by coupling the Northern Ireland and Republic of Ireland system increases reliability
- the Meath-Tyrone link will also enable Ireland to better use the present and the future links to the UK both for market and security of supply purposes
- the connection at Moyhill aims to strengthen the grid in the node
- the link to more conventional generation will increase the possibility to tap into renewable resources like wind, wave and tidal

The link has been recognized as being important by Europe for a long time. As can be seen from the maps below, it has always been part of the so-called TEN-E development plan of Europe. We show here the maps as they "evolved" over the years, noticing that most of the priority links that were prioritized in 1997 are still there in 2007. The interconnection within the Irish system as such is no longer present in the 2007 plan.

When looking at the ENTSO-E Ten Years Development Plan, the interconnection has returned.

https://www.entsoe.eu/index.php?id=232

If we look at the table on this website, the project is shown with the following content:

- The full connection is the sum of two projects, being number 462 and number 464 both in the so-called North Sea region of ENTSO-E.

- Project 462 is the link between Moyhill (Ireland) and Turleenan (Nothern Ireland, UK). The project characteristics are "A new 80 km single circuit 400 kV 1500 MVA OHL from a new Moyhill 400/220 kV substation in Ireland to a new Turleenan 400/275 kV substation in Northern Ireland. This project is an integral part of the new interconnection project Moyhill-Wooodland between Ireland and Northern Ireland."

- Project 464 is the link between Moyhill (Ireland) and Woodland (Ireland). The project characteristics are "A new 60 km single circuit 400 kV 1500 MVA OHL from Woodland station north of Dublin up to a new Moyhill 400/220 kV station in Co. Meath. This project together with Moyhill-Turlenaan constitutes the new interconnection project between Ireland and Northern Ireland."

- Both projects thus are clearly combined, which is also seen in the common investment need: "Alleviate low cross border capacity", the common expected benefits "Increase of NTC up to 1000 MW NTC from IE to NI (today <450MW); improved security of supply; improved access for renewable generation."

- The progress status is "design and permitting" and the expected time of commissioning 2012. The TEN-E designation is explicitly mentioned.

- When comparing the map of the projects, the 462 and 464 are indicated for the time span 2010-2014 and have disappeared in the next one (2015-2020).

From this overview we can conclude that the aim of building the connection has been there for almost 15 years, without much progress. The design used has always been a standard 400 kV AC overhead link. The rating is not really a design quantity as such but has to be seen as a rating that follows from the type of link chosen (if you go for a single system, three phase overhead line at 400 kV, you end up with about 1500 MVA for this distance).

It has to be stressed that in the present design, the intermediate Moyhill substation is no longer present.

This approach has been used in many of the TEN-E projects, with a very low rate of success if the projects that are still to be built from the 1997 plan are looked at. Therefore, it should be studied whether there exist techno-economic alternatives for an overhead approach.

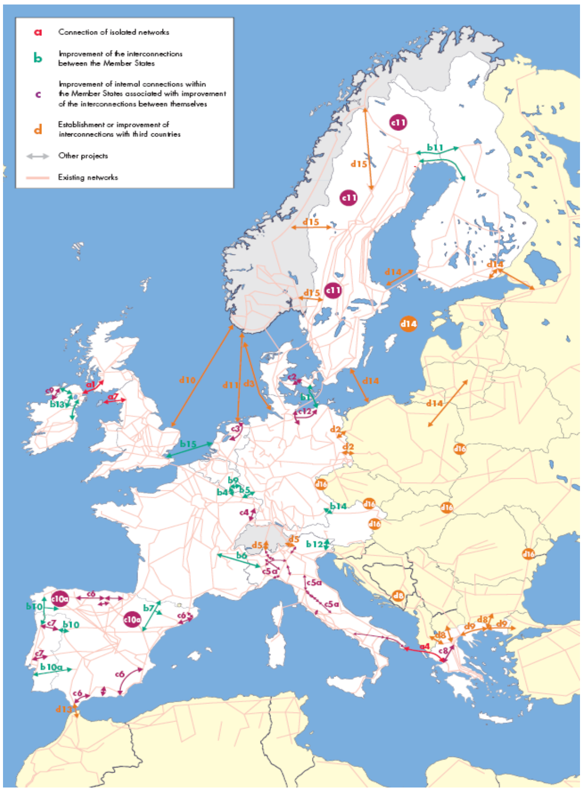
This is particularly relevant given the fact that alternative solutions are increasingly being implemented. For example the PB Power report from 2009 summarises the construction of high voltage lines.

Table 2-2 – World activity on new 380-500kV OHL since 2000

Activity since the year 2000 (route km)	Within the EC	Outside the EC
Constructed/commissioned	1990 km	5450 km
Currently in planning/consent process	2470 km	12,670 km
Currently under construction	450 km	2470 km

This should be compared to the fact that currently there is 1300 km of subsea and 700 km of underground HVDC cable currently under construction in Europe.

Development of EU priority plans



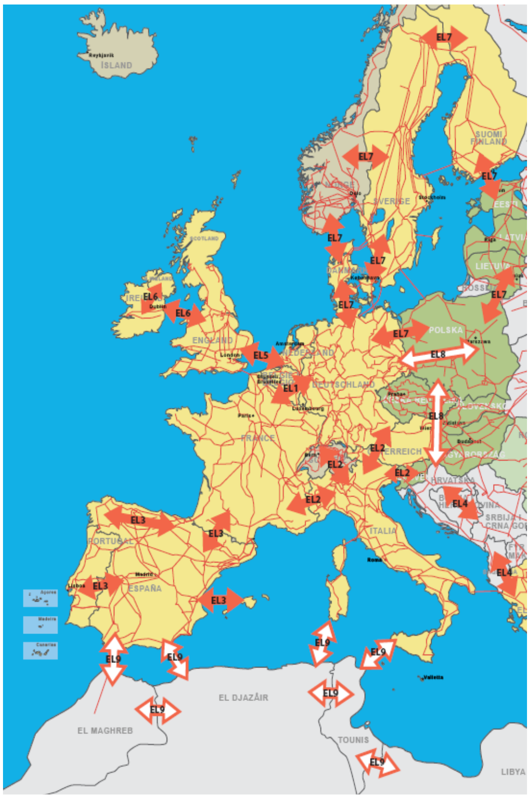


Figure 1. TEN-E Brochure 1997 Figure 2. TEN-E Brochure 2004

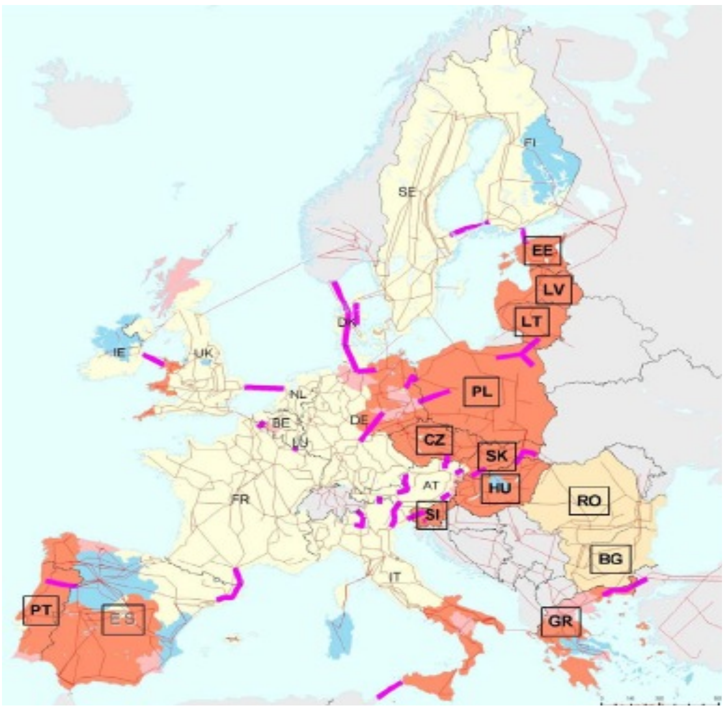
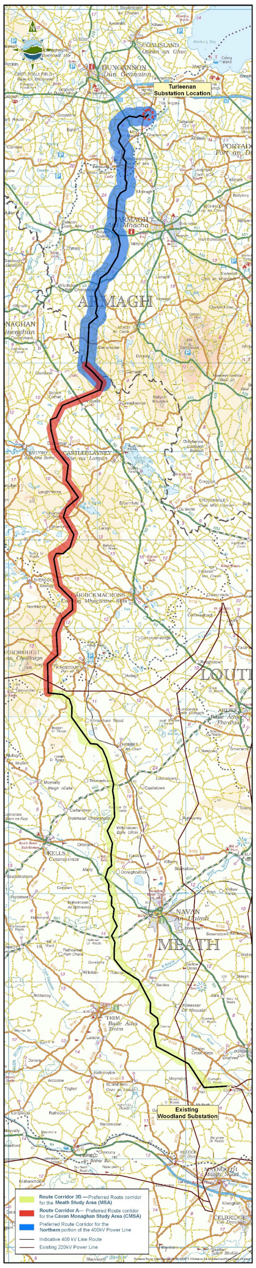


Figure 3 Priority Interconnection Plan 2007

Meath Tyrone Project, overview map and OHL route proposal:



Conclusions Chapter 3

The Meath-Tyrone project has the same rationale as many European projects and has been identified as a priority project for many years:

- Allow integration of renewable energy resources
- Increase security of supply
- Improve the market integration

The project also shares the slow historical progress in implementing priority projects.

4 Technical alternatives

The Meath-Tyrone project has been discussed for many years. The project shares this with many other projects of significant European interest. At the same time, there have been significant technical developments that justify a further review of the technical alternatives.

In theory, 5 alternatives exist to make the connection:

- AC connection as overhead line
- AC connection in a combination overhead line and 0 – 100 % underground cable
- DC connection as overhead line
- DC connection as a combination overhead line and 0 – 100 % underground cable
- underground GIL (Gas Insulated Line)

Based on experiences gained in reference projects in Europe with similar data as the Meath-Tyrone Project, two options appear less attractive. One is the DC Alternative with a 100% overhead line. The reason is that based on data from reference projects undergrounding of a VSC HVDC cable is similar in cost compared to an overhead alternative if "best practice" for cable installation can be used. As will be described in the reference project "South-West Link" in SE/NO, overhead lines are used in difficult terrain or where conditions are particularly favourable for overhead lines e.g. by using an existing right-of-way.

Another alternative that is not discussed further is a 100% underground AC connection. This solution has not been applied, nor seriously considered, for any of the similar projects in Europe. The reasons are costs, technical complexity and difficult installation. AC underground cables are only considered for shorter distances (10 – 20 km) often as part of a hybrid AC solution. In contrast, there are many projects under construction and planned using the VSC HVDC technology. This will be demonstrated when reference projects are presented later in this report.

The AC connection as overhead line is the traditional technical solution for the European transmission grid. The technology is well proven and in principle the cheapest solution in most cases. Many European projects, however, encounter a lot of public opposition and the delays due to this opposition are massive. When looking at all projects finalized or designed during the last decade in Europe, it becomes clear that for "green field" projects, i.e. connecting two nodes that were not connected before in the 400 kV grid, few have been built by using standard steel high voltage towers with standard conductors at the one hand, and no long distance project has chosen to use AC cables.

4.1 Technical development, AC overhead lines

The traditional AC overhead line has undergone significant technical development in recent years.

Some achievements are:

- Reduced visual impact
- Increased capacity per line
- Possibilities to reduce number of pylons
- Possibilities to reduce EMF

One example of technical development is the introduction of new high temperature conductors, using a core out of composite material. Given the temperature increase due to the current passing and the losses involved, the sag is far less. This may also be used to lower the height of the towers and/or reduce the number of towers.

A further increase in capacity for a given high voltage line may be reached by introducing dynamic line rating equipment, in order to monitor the real sag of the line. Given both elements, it is clear that in order to reach the power flow as needed, the line may be designed in a more compact way even when using steel type towers.

In order to make the line even more compact, thus further reducing the visual impact, the towers may be equipped with tower heads out of composite, isolating material. As can be seen on the picture, the tower of a 400 kV line then becomes of the same size as the one of a classical 150 kV line.

When using special design towers, the lines can even be smaller and furthermore the magnetic field is reduced drastically. The Windtrack design by TenneT is very well known for this purpose and will be used in the Randstad project.

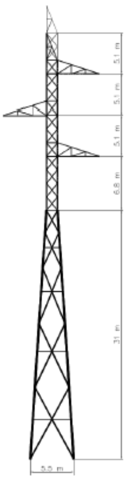
It should be mentioned that when installing FACTS (Flexible Alternating Current Transmission System) devices, the flows in AC grids might be controlled. Given the layout of the grid in the all-island power system after installing the Meath-Tyrone connection, loop flows may exist, as the impedances of both links will be different. Therefore, it may not be excluded that, on top of the investment in the connection as such, power flow devices may be needed. When using a VSC HVDC connection, which will be discussed further, this power flow capability is included in a natural way.

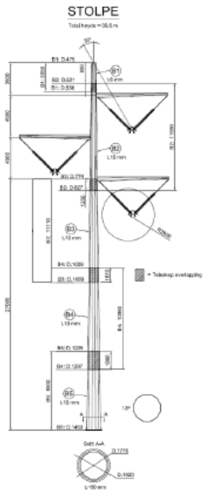
Also in Sweden examples can be found where traditional lattice towers are replaced by compact steel towers:

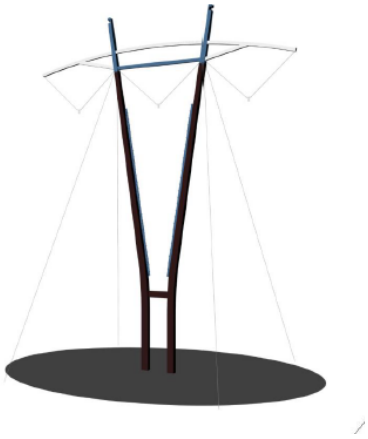
The traditional design is rather wide (picture from Svenska Kraftnat, Stenkullen Project)

A new design is much more compact and exhibits lower EMF impact (picture from Svenska Kraftnat, Stenkullen Project)

Further examples of alternative tower designs, 400 kV lines are found for several applications.







The traditional lattice steel tower will still offer the lowest cost. Alternative designs with reduced EMF and/or less visual impact will offer somewhat higher costs.

Another method to reduce the visual impact of traditional lattice steel towers is painting the steel dark green or another colour somewhat matching the terrain around. This method is efficient to reduce the visibility as most people will see the tower with nature as a background.

In some places it is necessary to paint the tower white and red to make them more visible for aircrafts.

Traditional lattice steel tower painted in different colours in Norway.

4.2 Technical development, AC underground cables

In AC cable technologies, a lot of developments have taken place over the last decades. Some of them may have to be taken into consideration when looking at the Meath-Tyrone project as they may impact the choices made.

In cable technology, a distinction is made between underground and submarine cables. For the purpose of this report, we limit ourselves to underground designs.

Furthermore, a distinction is made between oiled filled, extruded and gas insulated systems.

4.2.1 Oil Filled Cables

The present state of the art technology has the following upper limits:

- Oil filled cables (0.6-20 bar) with PPLP up to 800 kV
- Oil filled cables with Kraft paper (0.6-20 bar): up to 500 kV
- Under oil external pressure: pipe type cables (15-20 bar): up to 345 kV
- Under gas internal or external pressure: Gas filled cables: up to 150 kV (15 bar)

The under oil internal pressure cables (0.6-20) bar with PPLP (polypropylene laminated paper) can be used for the highest voltage levels. Many short distance (up to a several tens of kilometres) have been installed as in-feeds into large urban areas, a lot of them being situated in Asia. When using somewhat lower voltages, Kraft paper (extremely refined, unbleached pulp as basis) is an alternative to PPLP. When using external oil pressure, the voltage that is feasible is somewhat lower (up to 345 kV, pipe type cables).

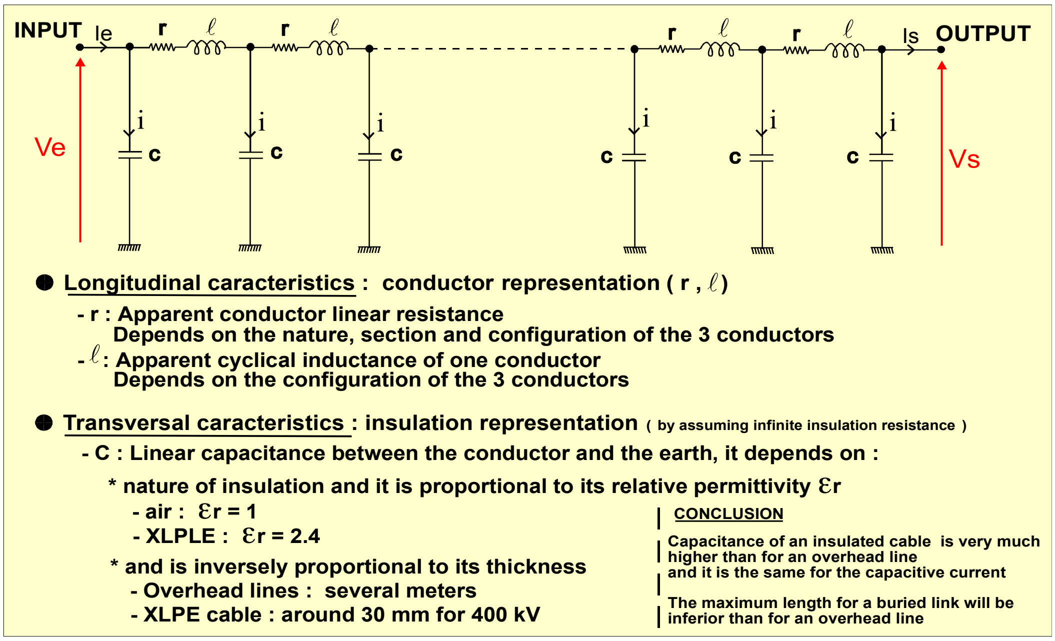
The cable in Guangzou (China) is an oil filled cable with Kraft paper with a rated voltage of 500 kV and a rated power of 1300 MVA. The total produced length is 3.6 km. The cable is in operation since 1992.

Therefore, the conclusion is that oil filled cables can be used for short distances in city in-feed applications. The oil filling makes their use not evident in environmentally vulnerable applications, like Meath-Tyrone. Oil leakage is always possible and very difficult to handle.

4.2.2 XLPE (Cross Linked Poly-Ethylene)

XLPE (Cross Linked Poly-Ethylene) extruded insulation cables can be used up to 500 kV. The BEWAG project in Berlin has 17 km of cable length and was energized in 2000. It is rated 1100 MVA.

The equivalent circuit of the cable is given in the figure. The most relevant parameters are the resistance (losses and thus temperature increase) on the one hand and capacitance on the other. The capacitance has to be electrically charged every period, and this leads to high reactive currents. This has two drawbacks: higher losses further increased by the dielectric losses in the insulating material, and a high voltage drop. Therefore, at regular intervals, coils have to be introduced to compensate for the capacitive reactive current, further increasing the cost of the cable option. Such an inductance for compensation introduces losses and requires a large footprint (i.e. a substation every few tens of kilometres).

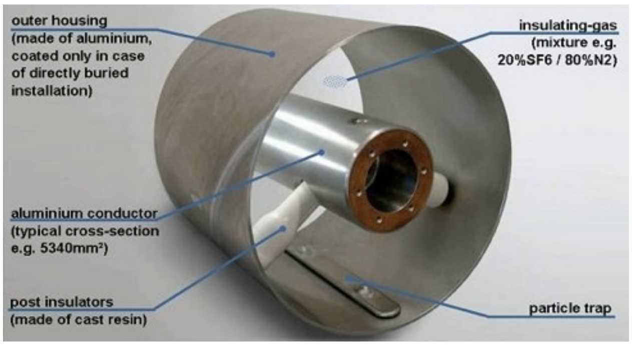


Overall, the use of classical cables for the distances envisaged in an AC supply environment has to be excluded.

4.2.3 Gas Insulated Lines (GIL)

Gas Insulated Lines (GIL) provide technical, environmental and operational features which make them a very good alternative wherever the transmission of extra high voltage (EHV) and extra high currents (EHC) is needed within restricted space, e.g. wherever overhead lines cannot be used. It has to be stressed that the wording is carefully chosen: the system behaves far more as an overhead line, regarding capacitance and reactive currents due to the distance between the conductors amongst each other and the conductors and the ground. Therefore, the problem of the very high capacitive reactive power supply is far less pronounced here. Furthermore, the breakdown at overvoltages is within a gaseous medium, giving a behaviour comparable to that found in overhead lines regarding self-healing and automatic reclosure.

The gaseous insulation material has been for many years SF_6 (sulphur hexafluoride), a very expensive gas with greenhouse gas characteristics. This gas is used in switchgear and in gas insulated substations. There it is well confined and the risk of escape is very low, as sensors are installed that warn when SF_6 would be released. However, this is almost impossible to guarantee in long distance connections.



GIL consist of two concentric aluminium tubes. The inner conductor is resting on cast resin insulators, which centre it within the outer enclosure. This enclosure is formed by a sturdy aluminium tube, which provides a solid mechanical and electrical containment of the system. To meet up-to-date environmental and technical aspects GIL are filled with an insulating gas mixture of mainly nitrogen and a smaller percentage of SF_6 (Typically 80/20%). This reduces the potential environmental risk dramatically and reduces the cost.

Due to their modular design, the elements can be combined to the required length. Typical GIL installations have a length between 100 m and 60 km.

Due to their low electrical capacitance reactive compensation is not needed in general.

The figure below shows the layout of a typical system. The table brings together important key parameters.

Typical Technical Data

Nominal voltage (typical)	220 up to 500 kV
Maximum operation voltage	245 up to 550 kV
Nominal frequency	50 / 60 Hz
Nominal short-time current (rms., 1 - 3 s)	31.5 up to 63 kA
Nominal operation current (typical)	2000 up to 5000 A
Withstand voltage vs. earth:	380 up to 620 kV

AC withstand voltage 1 min	1050 up to 1675 kV_{peak}
Nom. surge-impulse withstand voltage 1.2/50 µs wave	850 up to 1175 kV_{peak}
Nom. switching-impulse withstand voltage 250/2500 µs wave	
Housing and conductor material	Aluminium alloy

The resistive losses of GIL are lower compared to cables and overhead lines. The dielectric losses of GIL are negligible. Due to its low capacitance, GIL do not require phase angle compensation even for a system length of 60 km or more.

The conductor current induces in the enclosure a reverse current of the same size. Consequently the electromagnetic field outside the GIL is negligible.

The high transmission capability of GIL allows to continue overhead lines underground with one GIL tube per phase, which minimizes space consumption. The GIL allow auto-reclosure switching cycles and consequently no major changes in the operation-and-protection schemes of the grid are necessary.

GIL are mostly used for transmission systems with 345 kV to 550 kV rated voltages and 2500 A to 5000 A rated current. There are no reference projects with data similar to the Meath-Tyrone project and this alternative has thus not been subject to further investigations.

4.3 Technical development, HVDC systems

Over the last years, the technical developments in DC technology have been very significant. The classic HVDC technology has been developed towards higher voltage and higher capacity per line. The largest systems under construction today have a voltage of 800 kV and a capacity of 7000 MW per line. This technology has found its market primarily in Asia in conjunction with bringing large amounts of hydro production over large distances (1500 – 2500 km). There are several projects of this type under construction and China alone is planning to install a total transmission capacity of more than 200.000 MW using this upgraded classic HVDC technology.

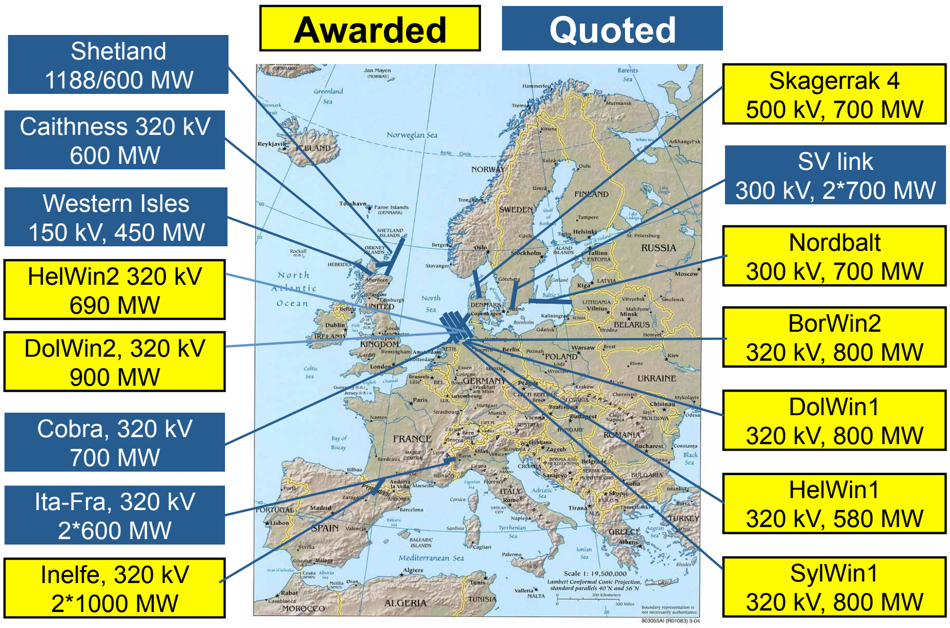
The most recently developed HVDC technology, the VSC-HVDC technology, has in recent years seen a significant technical development and a commercial break-through, particularly in Europe. There are now three European manufacturers offering VSC–HVDC Convertors and three European manufacturers offering extruded HVDC Cable.

The development can be characterised by:

- High capacity, high frequency power electronic components (IGBT, Insulated Gate Bipolar Transistors) enabling full control of both active and reactive power at the ac terminals, i.e. for the ac grid, the dc connection can provide all functions delivered by an ac overhead line equipped with flow control devices (and more)
- Efficiency of the convertors has improved with about 50% (from 1.9 % losses per convertor used in previous studies to less than 1 %)
- New convertor design allows construction of lower buildings
- Increased voltage levels: up to 320 kV are now possible with extruded cables (both subsea and on land); Several VSC-HVDC systems with voltage 320 kV are under construction. Extruded cables lead to cost reduction and reduction in number of joints compared to ac cables and mass impregnated cables
- The first 500 kV system has been contracted with subsea and land cables of classic design (mass impregnated cables)
- DC breakers are under development and are expected to be commercially available on the market in 2013. This allows increased flexibility for construction of DC Grids.

When looking at key projects to develop transmission infrastructure in Europe the technical development has stimulated many of them to use VSC-HVDC technology. During 2010-2011 a large number of VSC-HVDC projects has been awarded and quoted.

VSC HVDC Projects in Europe 2010 - 2011



VSC HVDC Projects Contracted 2010-2011

Project	Country	Appl	Cost M€	MW	Voltage kV	Cable Land km	Cable Tot km	M€/MW
DolWin1	Germany	Off-Shore	525	800	320	90	165	0,66
NorBalt	Sweden/Lithuania	SubSea	435	700	300	50	450	0,62
BorWin2	Germany	Off-Shore	480	800	300	75	200	0,60
HelWin1	Germany	Off-Shore	488	576	250	45	130	0,85
Skagerrak 4	Denmark/Norway	SubSea	263	700	500	104	244	0,38
Spain-France	France-Spain	Land	750	2000	320	65	65	0,38
SylWin1	Holland	Off-Shore	750	864	320	45	194	0,87
DolWin2	Holland	Off-Shore	750	900	320	90	135	0,83
			4440	7340		564	1583	0,62

***Note1**: All information in the table is derived from public sources such as press releases and public web sites. Some deviation is contract prices due to currency fluctuations are possible*
***Note 2**: Yellow marked are projects connecting off-shore wind parks. Cost of off-shore systems are generally significantly higher than land based systems.*
***Note3**: Spain – France is actually 2 x 1000 MW over 65 km*

Clearly, many of the developments include off shore elements with a lot of emphasis on offshore wind parks. However, these projects are driving the technological development to the benefit also for land-based systems. The projects with sub-sea cables normally continue with underground cables on land.

An important element is that in recent years, two European companies can offer the convertor technology (and have built and delivered real life projects) while a third one is capable of quoting. Three European companies can deliver cables. Therefore, the hesitation from TSO's to be locked in by a technology provider is much less relevant today.

The Commission is of the opinion that the HVDC VSC option is a viable one for the Meath-Tyrone connection.

Conclusions Chapter 4

New technical options can offer more attractive overhead and underground solutions.

The traditional AC overhead line has undergone significant technical developments in recent years, some achievements being:

- Reduced visual impact
- Increased capacity per line
- Possibilities to reduce number of pylons
- Possibilities to reduce EMF

AC cables are technically possible, but have never been found attractive for long distance, high power transmission.

GIL transmission is also technically possible, but not found to be an attractive solution for any project with similar length as the Meath-Tyrone Project

VSC HVDC has seen significant developments over the last three years:

- Convertor losses significantly reduced
- Higher voltage and capacity commercially introduced
- Large number of contracts under execution with significant distance of underground cables included
- HVDC breakers under development enabling construction of DC grids.
- Multiple European suppliers can today offer the technology with ratings suitable for the Meath Tyrone Project

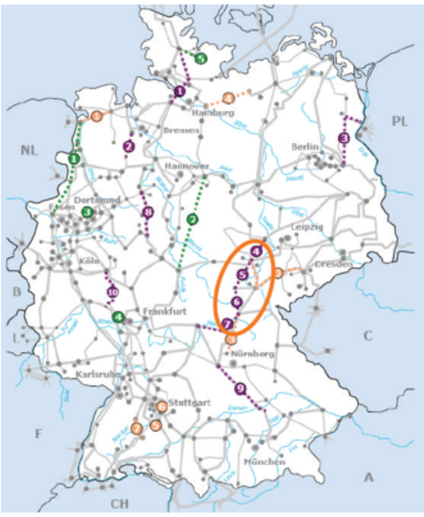
5. International benchmark

In order to show how other projects have dealt with the societal pressure at the one hand and the technical developments that can be used to cope with them, we have documented a number of recent, important projects in Europe. The reason the commission has concentrated on European projects is that these projects have been judged as most relevant for the Meath-Tyrone Project.

All projects are situated in the meshed grid and are driven by the same type of drivers as the Meath-Tyrone project being: secure grid operation, coupling of markets and enabling massive deployment of renewable energy resources. Some of them are national in nature, some are crossing national borders.

5.1. Thuringian Electricity Bridge

In Saxony-Anhalt and Thuringia, 50Hertz (name of TSO in Germany) plans an approx. 210-km extra-high-voltage overhead line. The line will run from Bad Lauchstädt in Saxony-Anhalt (near Halle) via Vieselbach in Thuringia (near Erfurt) and Redwitz near Kronach (Bavaria) on to the region around Schweinfurt. Overall, 50Hertz plans to invest around 248 M€[1] in the "Thuringian electricity bridge". It is designed as a double circuit 400 kV overhead line.

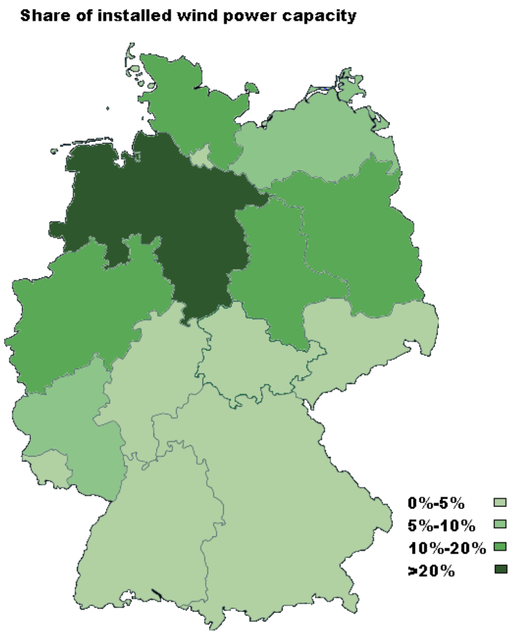


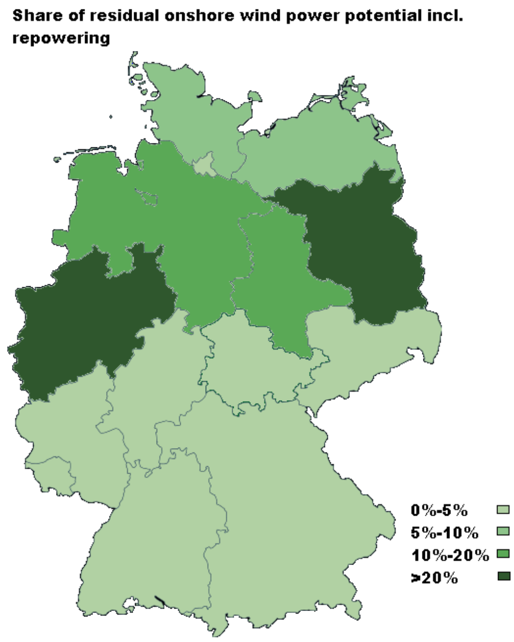
The necessity of the Thuringian electricity bridge has been emphasized in different reports.

TEN-E has issued guidelines to identify the highest priority projects in a "Priority Interconnection Plan". These 'Projects of European Interest' have the objective to support the achievement of the European Energy policy. The overview is given above. Three interconnectors are identified as priority projects in the 50Hertz control area. Two of them are situated in the North. The one in the South (Southwest Interconnector), crossing the regions Sachsen-Anhalt, Thüringen and Bayern, can be subdivided into four different interconnectors of which three are situated in the 50Hertz control area.

[1] This number assumes that only overhead interconnections are built. The figure at the end of this report provides an indication of the surplus cost.

Dena grid studies I and II focus on the need of this grid reinforcement, facilitating the integration of wind energy, since wind power injections are mainly situated in the 50Hertz control area. No overloaded lines will be found in 2015 in this control area because the Thuringian electricity bridge is expected to be operational by then. If that would not be the case, huge overloads in the (N-1) contingency scenario would be found. Additionally, the European Wind Integration Study (EWIS) report concludes that the new 380-kV double overhead line between Halle/Saale and Schweinfurt prevents overloading of existing lines in the 50Hertz control area. Finally, also Consentec and the Regionenmodell, a joint study of the four German transmission system operators made similar suggestions.





Three construction phases have been planned for construction of the "Thuringian electricity bridge" in the 50Hertz control area. They are at different stages of the process of planning and operations.

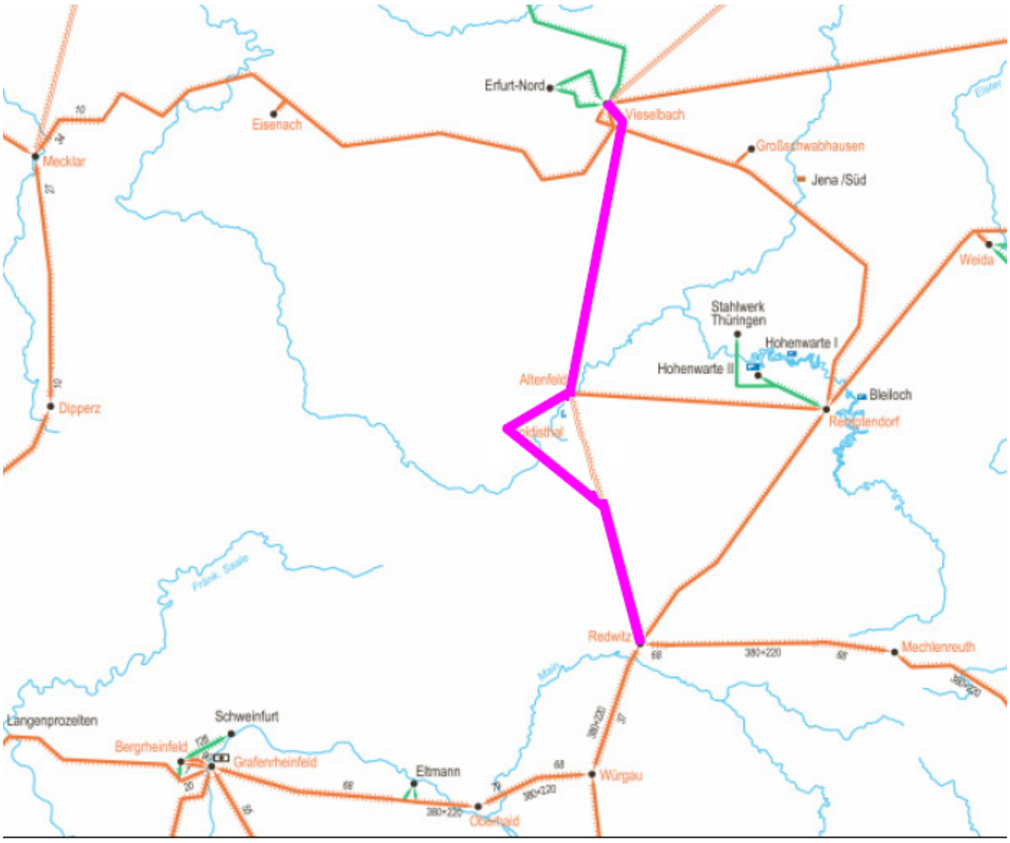
On 18 December 2008, the first section of the European priority project Halle-Schweinfurt, the northern section from Saxony-Anhalt to Erfurt in Thuringia (**Bad Lauchstädt to Vieselbach)**, went into operation. This is an 80 km long, overhead high voltage line. The routing follows to a major extend that of an old 220 kV line.

On 30 March 2007, the Weimar State Administrative office finalized the regional planning procedure by issuing what is called the state regional planning assessment for the second section of 80 km between Vieselbach and Altenfeld. The plan approval procedure is now underway.

The overhead line will run westwards from Vieselbach, i.e. in a northerly direction parallel to the existing Vieselbach-Eisenach/Mecklar overhead line, to Federal motorway A71. It will then turn south, running in an infrastructure bundle with Federal motorway A71 and the Nuremberg-Erfurt ICE railway track until it reaches Altenfeld.

At the end of May 2006, the so-called application conference for the regional planning procedure in respect of the third construction phase from Altenfeld in the direction of the Bavarian border (Altenfeld-Redwitz) was held. The distance covered is 60 km. A supplementary conference was held in February 2007. The regional planning procedure was initiated in January 2010.

In a press release from 14.04.2011, 50Hertz welcomed the conclusion of the regional planning procedure for the third section of the European priority connecting line project Halle – Schweinfurt by the competent administrative department of the Land (federal state) Thuringia. As a result of the regional development assessment procedure, preference was given to the option Goldisthal (transmission route from Altenfeld to the Federal state border via Goldisthal). This implies that the site of the future transformer station will be located in the area Schalkau. In addition, the administrative department of the Land has charged 50Hertz to examine the possibility of cable undergrounding in the south of the Thuringian Forest and near affected settlements. However, for the crossing of the Rennsteig trail, the cable option has been rejected by the administrative department of the Land.



Together with the neighbouring transmission system operator Tennet TSO, 50Hertz will now immediately start the practical preparations of the planning approval process for the section Altenfeld (Thuringia) – Redwitz (Bavaria).

Construction of the section from the Bavarian Federal state border to Redwitz will be managed by the local transmission system operator TenneT. The route from the Federal state border to Redwitz can therefore be found on the website of the responsible transmission system operator TenneT TSO GmbH. No new construction is required for the section from Redwitz to the Schweinfurt region. Instead, transport capacity will be increased by converting the existing overhead lines from 220 kV to 380 kV operation.

In conclusion, this project will result in an AC link, partially in cable construction. The amount of cable length, compared to the overall project of 210 km will probably be around 10 % of the overall length and is due to a specific part that is environmentally critical.

http://www.50hertz-transmission.net/de/file/100101_Infomappe_Thueringer_Strombruecke_neu1.pdf

5.2. Randstad in The Netherlands

With the completion of an initial bore below the Caland canal TenneT managing director Mel Kroon gave on September 8, 2004 the symbolic starting signal for constructing a new high voltage line in the Randstad.

The Dutch government gave the go ahead on 13 October 2006 for the Randstad380 project, which involves the construction of two new 380 kV lines in the Randstad. The decision cleared the way for an investment in the Randstad high voltage grid to build the Wateringen-Bleiswijk and Zoetermeer-Beverwijk lines over the next few years.

In its Key Planning Decision on the Randstad380 line of April 2, 2007, the Dutch government stated that a new high voltage line needed to be built between Wateringen and Zoetermeer to assure a sufficient supply of electricity to the (southern) Randstad region from approximately 2011 onwards.

TenneT signed two agreements with Electrabel for new plants at Lelystad and at the Maasvlakte industrial zone near Rotterdam on June 20, 2007. The recently concluded agreements mean that no more connection capacity is available at the Maasvlakte location. In the coming years, new connections with a total capacity of more than 4000 MW will be realised there. In 2005 TenneT started work on the Randstad380 project. This large-scale project will ensure a structural expansion of the transmission capacity in the Randstad region of the Netherlands. The southern section of this new line was expected to be complete by the end of 2010. "It's of great importance for both market parties and consumers that Randstad380 will not be delayed", says CEO of TenneT Mel Kroon.

TenneT, the operator of the national electricity grid, wants to realise a new 380 kV high-voltage line between Beverwijk and Wateringen near The Hague. For this purpose, the second Electricity Supply Structure Plan (SEV) must be partially revised via a key planning decision. On 28 June 2007, Minister Van der Hoeven of Economic Affairs and Minister Cramer of Housing, Spatial Planning and the Environment submitted parts 2 and 3 of the key planning decision for this “Randstad 380 kV connection” to the Lower House of Dutch Parliament.

The project is divided into a north (between Zoetermeer and Beverwijk) and south (between Wateringen and Zoetermeer) ring. The upcoming time scope for the project is:

North ring	Action
	Permits Beverwijk-Vijfhuizen
Q4 2011	Design Routing
Q1 2012	Final Routing
Q3 2012	Reaction of Supreme Court
Q4 2012	Start construction
	Permits Vijhuizen-Bleiswijk
Q3 2012	Design Routing
Q4 2012	Final Routing
Q3 2013	Reaction of Supreme Court
Q4 2013	Start construction
South ring	Action

Februari 2011	Preparatory measures are done at locations where the high voltage line is constructed as overhead line. These preparations are done between the N223 and the village Tanthof. In between finally 6 towers and a point of transition between cable and overhead will be constructed.
April 2011	TenneT starts with the platforms at each tower locations for construction. The tower are built on concrete poles.
Eind 2012-begin 2013	Line ready

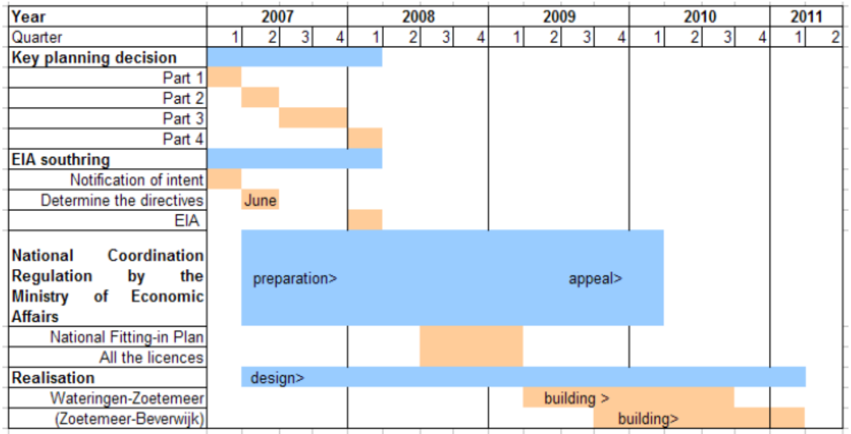
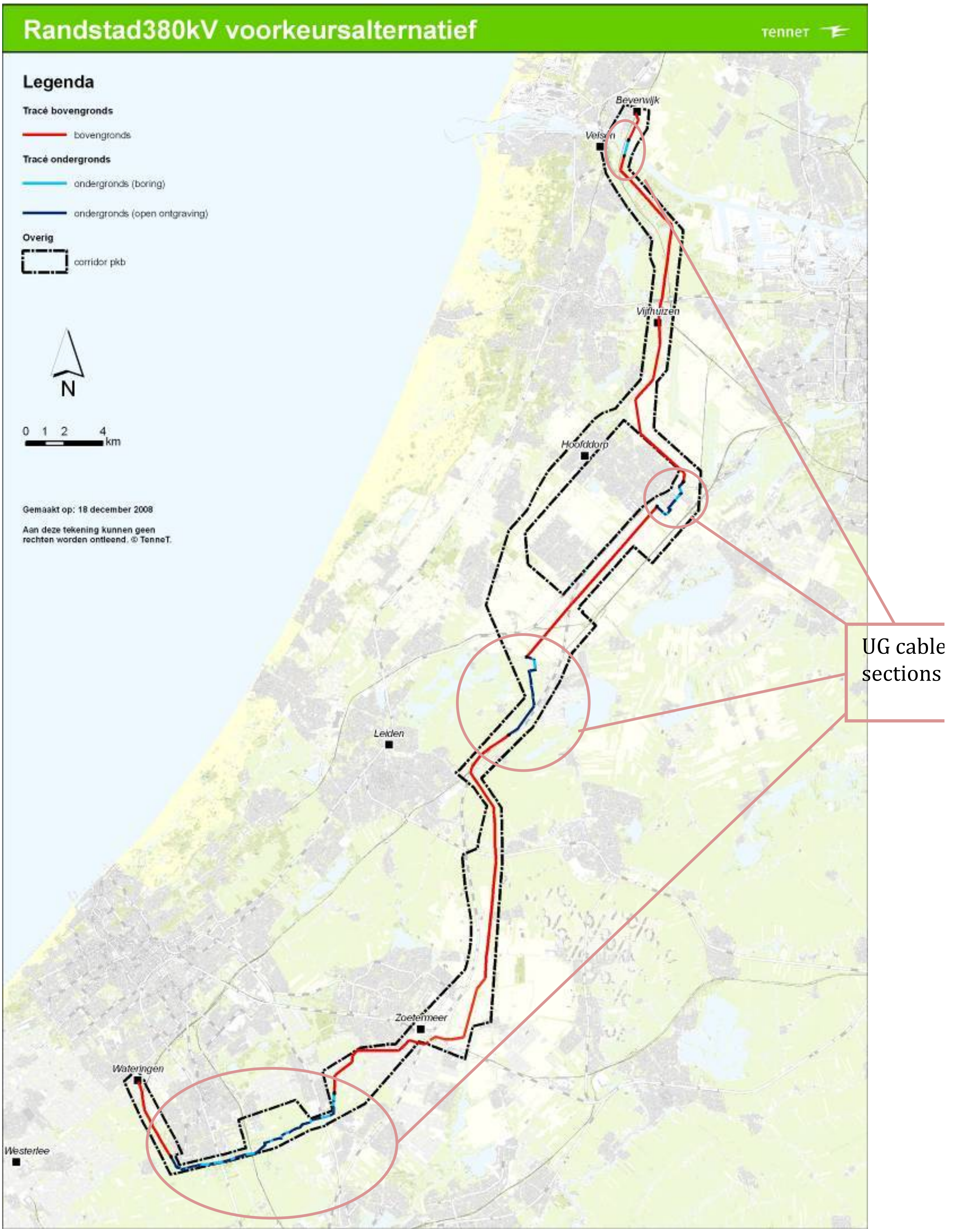


Figure 3-2 Planning for procedures and decisions for the Randstad 380 kV project [9]



The whole route is around 80 km, where around 20 km of it will be realized with 380 kV underground cables. For the overhead lines a new type of pylon has been designed (Windtrack), which produced no magnetic fields beyond 100 m distance from the line corridor centre.

On January 31, 2011, the European Investment Bank has formally agreed to provide a 450 M€ loan to TenneT Holding B.V. to finance construction and operation of an 83 km 380 kV transmission connection. This will close the 'Randstad 380' extra-high voltage electricity transmission ring. The contract for the first tranche of 150 M€ is signed by TenneT Holding B.V. and the European Investment Bank

The total cable length of the connection is 20 km in two sections. The rated current of the cable is 4000 A with 2 cables per phase, i.e. ca. 1000 Mvar at 400 kV. Compensation is foreseen at 380 kV transformers of 11x100 Mvar. 10 km is in Zuidring (ca. 2012 in operation) 10 km in Noordring Bwk-Vhz-Bvw (ca. 2014 in operation).

The cost differences are analysed with results. The cost for a single system overhead AC is 2.3 M€/km and for an AC cable 12.3 €/km, i.e. roughly 10 M€/km difference.

http://www.tennet.org/images/Position_paper_Ondergronds_tcm41-17804.pdf

5.3. Spain-France Interconnection Project

Electrical interconnection between Spain and France currently consists of four lines, the last of which was built in 1982: Arkale-Argia, Hernani-Argia, Biescas-Pragneres y Vic-Baixas. These have a total commercial exchange capacity of 1.400 MW, meaning that they represent only 3% of the current maximum demand in the Iberian Peninsula. This makes the Iberian Peninsula to have one of the lowest interconnection ratios in the European Union, thereby limiting the possibilities of helping or receiving assistance in the event that there is a failure in any of the electrical systems. This new interconnection line will allow double the level of interconnection between France and Spain from its current 3% to 6%, which would still be below the 10% recommended by the European Union.

The owners of all interconnections are and will be Red Eléctrica de España and Réseau de Transport d'Electricité (RTE). For this specific new project a special purpose company has been established, being INELFE (Interconnection Electrical France-Espagna), a joint venture company between RED and RTE, governed by French law. The agreement was signed in 2008 in Zaragoza. The line is expected to be commissioned in 2014. As a final step in permitting, RED Electrica obtained the Environmental Impact Declaration (EID) of the project on December 13, 2010
The overall cost is 700 M€, with the following elements

- The cost for four converters including platforms and connections is about 400 M€.
- The cost of the cable including joints, termination and pulling the cable inside pipes is around 110 M€.
- The civil works and drilling is estimated to 50 M€ and the 8 km of tunnel for 120 M€.

The financing is organized in the following way:

- 225 M€ from the European Union within the framework of the EEPR (European Energy Program for Recovery) programs
- 350 M€ from European Investment Bank (EIB) as a loan
- 125 M€ from the Owners

The project moderator has been Mario Monti.

The key technical characteristics of the connection are the following:

- **Length:** 64,5 km, 33,5 km in France and 31 km in Spain. It connects the towns of Baixàs, in the Roussiollon region (France), and Santa Llogaia, in Alto Ampurdán (Spain).
- **Layout:** The entire layout will be underground and, to the extent possible, it will follow the existing infrastructure, as is the case with the freeway AP-7 and the high-speed train linking Figueras and Perpignan. The central part of the line will cross the Pyrenees at the Albera massif. An 8.5 km tunnel will be built for this section, 1 km in Spain and 7.5 km in France. The rest of the line will be in underground trenches. The layout was made environmentally[2] suitable.
- **Technology:** 320 KV[3], HVDC line and converter stations will use VSC (voltage source converter) with modular multilevel converter technology in Santa Llogaia and

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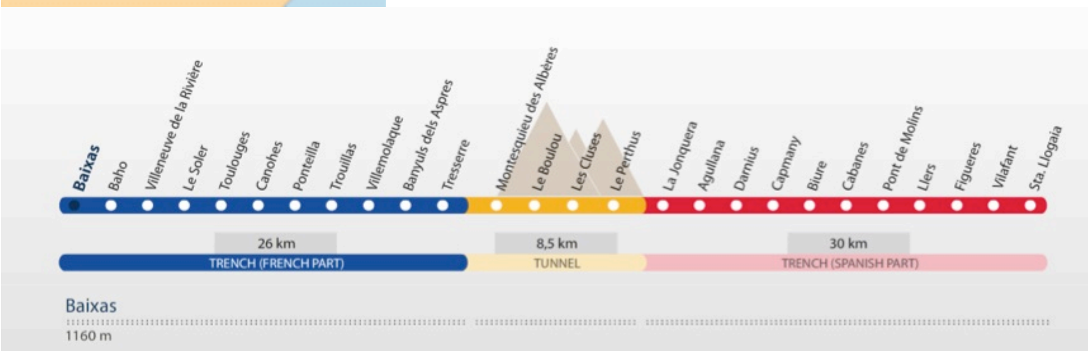
[2] Red Eléctrica obtained the Environmental Impact Declaration (EID) of the project on 13 December 2010.
[3] 400KV on REE website

Baixàs. The provider of the material is Siemens for the converters and Prysmian for the cable. The rated power is 2000 MW (2*1000 MW), with reactive power +/- 300 MVAr.



The need for the line is found in the basic triangle that is key for all projects.

- **Renewable Energy :** Presently, the limited level of interconnection also means the development of wind energy is limited. Only with the support of a sufficiently meshed network, it will be possible to continue incorporating renewable, cheaper energy without CO_2 emissions.

- **Security of Supply:** Increasing the interconnection capacity between France and Spain will allow providing more solidity to the European grid as a whole and, therefore, improving the capacity to resist possible risks and incidents. This would mean a remarkable improvement in the quality and security of supply for both countries, most especially in the Ampurdán and Roussillon areas.

- **Social and Economic Development:** This interconnection assures keeping the level of quality, responding to medium-term supply needs and providing clear support for the social growth of both Gerona and Roussillon regions' municipalities. In addition, it will guarantee feeding the future high-speed train in the Spanish part without burdening the area's stability or supply. If it were a lower voltage line, the loads required for the high-speed train would cause voltage drops and distortions in the network.

- **European Electrical Market:** This new interconnection will facilitate a deeper integration of the electricity markets, which will allow adjusting the electrical energy prices between the Iberian Peninsula and the rest of Europe. In this way energy prices in Spain and France will be harmonized, while the electrical markets will become more competitive and less concentrated,.

References:

- Zaragoza Agreement
- http://www.inelfe.eu
- Project description from REE
- http://www.energy.siemens.com/us/en/power-transmission/hvdc/hvdc-plus/references.htm#content=2013%20INELFE%2C%20France-Spain
- http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2011/power_transmission/ept201101032.htm
- http://www.emtp.com/?q=system/files/introduction%20France%20EspagneV4-SD.pdf

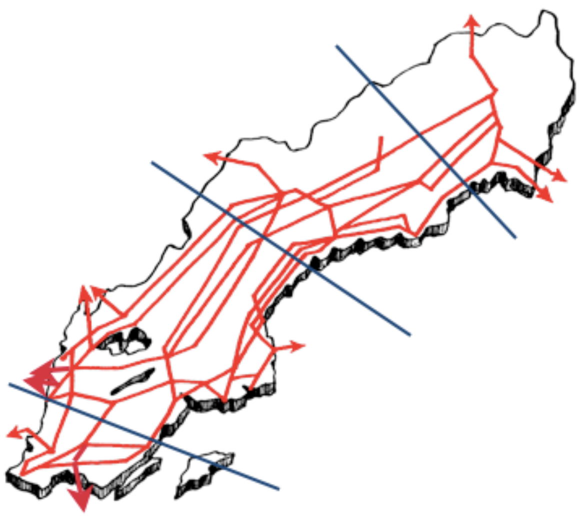
5.4. South–West Link in Sweden / Norway

Reason for project

There has for many years been identified a need to reinforce the North–South interconnection capacity in Sweden has been identified for many years in order to:

- Improve the market
- Allow further integration of renewable energy
- Increase security of supply

Sweden has a number of critical sections in the grid. The most southern section has today a total transmission capacity of 4500 MW. The first priority was to increase the transmission capacity in this section by at least 1000 MW.



4500 MW

Project history

The first idea was to build only a limited project within Sweden, the "South Link", with a capacity of 400 – 600 MW. Different alternatives for the project were investigated, 400 kV OH line or 300 – 400 kV HVDC line OH or UG.

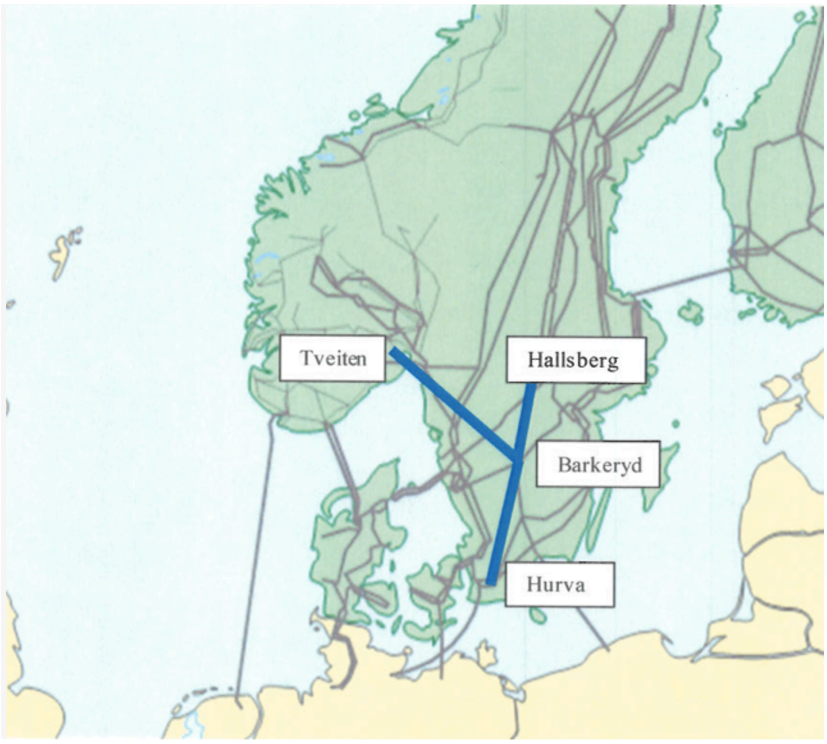
In 2008 a very important step was taken for the project that was transformed accordingly:

- A third leg extended the project from Sweden to Norway. It now consists of four subprojects, three in Sweden and one in Norway.
- Technology was decided to be a combination of 400 kV OH lines and a 300 – 400 kV VSC-HVDC line built with a combination of OH, UG and possibly also sub-sea Cable.
- Locations of the three HVDC convertor sites were decided to maximize the utilisation of the dynamic properties of the convertors.
- Capacity was to be doubled to 1200 MW.

In September 2011 a formal board decision was taken by Svenska Kraftnät to go forward with the investment in the North and the South Part of the South-West Link in Sweden. (Hallsberg – Barkeryd – Hurva).

The capacity has been further upgraded to 2 x 720 MW and the project will use a combination of 400 kV AC OHL, 320 kV DC UG Cables and 320 kV OHL.

Overall Project layout today



Distance:	Hallsberg - Barkeryd – Hurva - Tveiten
Overall length:	810 - 952 km
Technology:	DC, HVDC VSC
No: Convertors	4 x 720 MW (SE) ; 2 x 720 MW (NO)
Transmitted power:	2 x 720 MW
OH DC line:	62 km
UG DC cables:	379 km
OH AC line	176 km
UG, OH or Sea line	85 – 135 km (SE, details to be decided)
UG or OH line	55 – 100 km (NO, details to be decided)
In-Service	Nov 2014 - 2018

Project Summary (Svenska Kraftnät)

The South-West Link is Swedish Kraftnät's largest and single most important network investment. The project aims to enhance the AC network, increase reliability and address the limitations of transmission capacity in southern Sweden and Norway. South-West Link is also important to plan for the large-scale expansion of wind power as part of the Swedish and European climate policy.

The South-West Link will be built in three parts with a junction outside Nässjö. From there the DC link will be built, with new technology to Hörby in southern Sweden and the Oslo area in Norway. For long distances, e.g. following a major road E4 down to Skåne and west to Trollhattan, the focus is on DC links buried as ground cables. From Nässjö and north, a new overhead 400 kV AC to Hallsberg will be built.

Reason for choice of technology (Svenska Kraftnät)

(From press release 2008-04-23)

The decision is a step towards adapting the Swedish and Nordic transmission grids to the European energy and environmental politics of the future. The growth in wind power generation will in particular create a need for increased capacity and flexibility in the electricity transmission grids. The decision means that the optimal combination of HVAC (high voltage alternating current) and new HVDC (high voltage direct current) technology will be applied. There is already a decision to construct the Southern Link (Sydlänken). This will now be part of a larger infrastructure project, the South-West Link. The capacity is doubled compared to previous plans. Thanks to the extended project, bottlenecks in the national grid on the Swedish west coast and on the interconnection with southern Norway will also be alleviated.

-"We have chosen the technology which can both provide maximum capacity and flexibility for the future. By constructing an interconnector to Norway at the same time, we will now solve a number of problems which have inhibited the efficiency and competition in the Nordic electricity market." say Chairman of Svenska Kraftnät's Board Sven Hulterström

Reason for choice of technology (Statnett)

(from Melding SydVestlinken, September 2011, translated text)

"It is possible to construct the SouthWest Link with AC technology. When the conceptual solution was decided in 2009 the cost for a VSC HVDC solution was estimated to be 25% higher than an AC solution. From an operational point of view the HVDC solution offers benefits in terms of possibility to control active and reactive power (allows control of power and voltage). This gives more possibilities to support the connected AC grid. An HVDC solution is judged to offer better solutions for market support. This is valid both for expected capacity for trading and the potential for exchange of system/balancing services. A downside with the choice of VSC technology is a less mature and more complex technology that can lead to increased operational risks. **Based on an overall assessment of the two alternatives Statnett has decided on a preference for a HVDC solution over an AC solution.**

South-West Link, summary of technologies

Blue	Overhead lines AC and DC
Red	Underground DC Cable
Green	Subsea Cable
Violet	National Borders

South-West Link, North part, investment decision Sept 2011. Tenders submitted

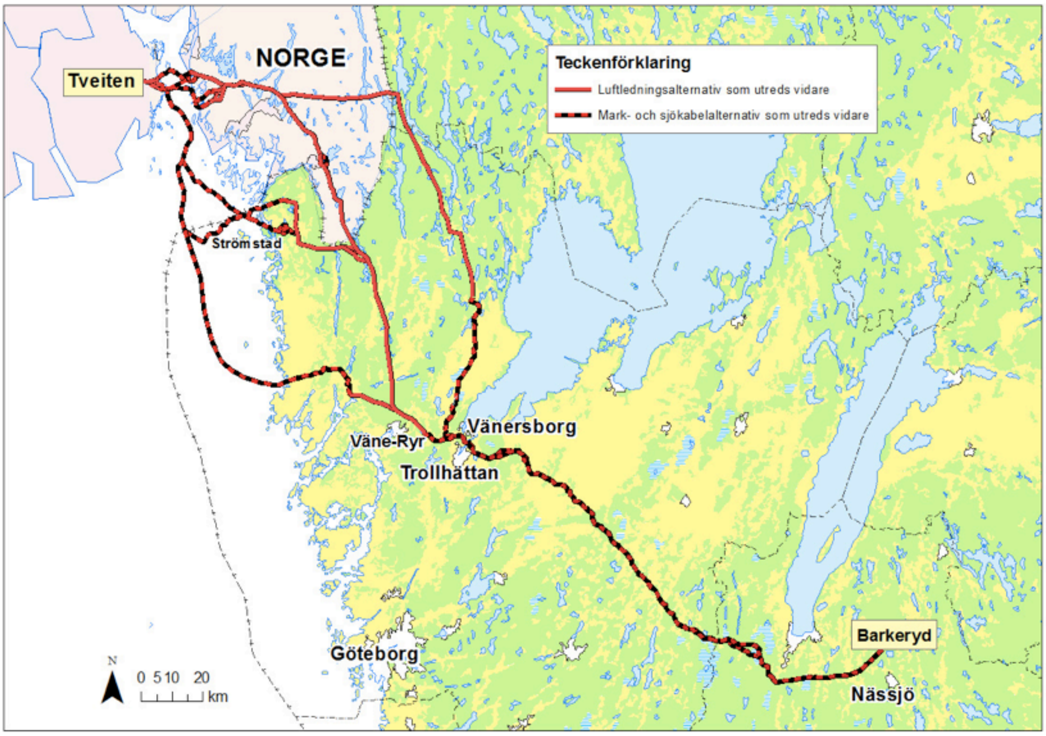
Distance:	Hallsberg - Ostansjo - Barkeryd
Technology:	OH - AC, 400 kV
Route	Mainly replacing existing 220 kV OHL
Transmitted power:	1440 MW
Overall length:	176 km
No: Pylons	App 350
Pole height:	App 30 m
Approx Cost	160 M€
In-Service	Nov 2014

South-West Link, South part, investment decision Sept 2011. Tenders submitted

Distance:	Barkeryd - Hurva
Overall length:	251 km
Technology:	DC, HVDC VSC
No: Convertors	4 x 720 MW
Transmitted power:	2 x 720 MW
OH line:	62 km (on existing 220 kV OHL route)
UG cables:	189 km
Approx cost	570 M€
In-Service	Nov 2014

South-West Link, West part, investment decision pending

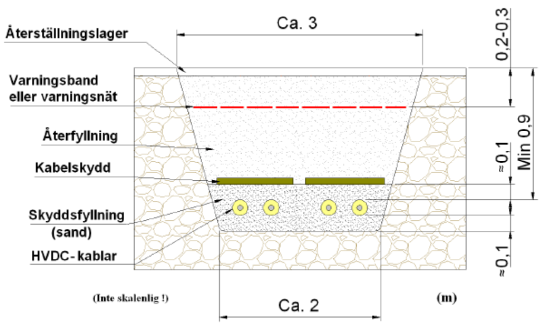
Technology: direct current,	HVDC VSC
Transferred power:	1440 MW
Barkeryd-Grunnebo:	
Overall length:	approx. 190 km UG Cable
Grunnebo-Norwegian border:	
Overall length:	approx. 85-135 km OH, UG or part Subsea
Norwegian border-Tveiten:	
Overall length:	approx. 55-100 km OH or UG
No: Convertors	0 (Sweden), 2 (Norway)
Approx Cost Cost	Depending on route
In-Service	2018



Cable installation

A majority of the land cable installations in the South – West Link will follow major roads. The "South" part of the project will e.g. follow E4 and other major roads for most of the distance. Direct burial of the cable will be used for the whole distance. Directional drilling will be used in some critical parts.

The cable trench will be about 3 m totally for the two cable pairs. The cables for 720 MW will have a diameter of about 105 mm and a weight of about 10 kg/m.



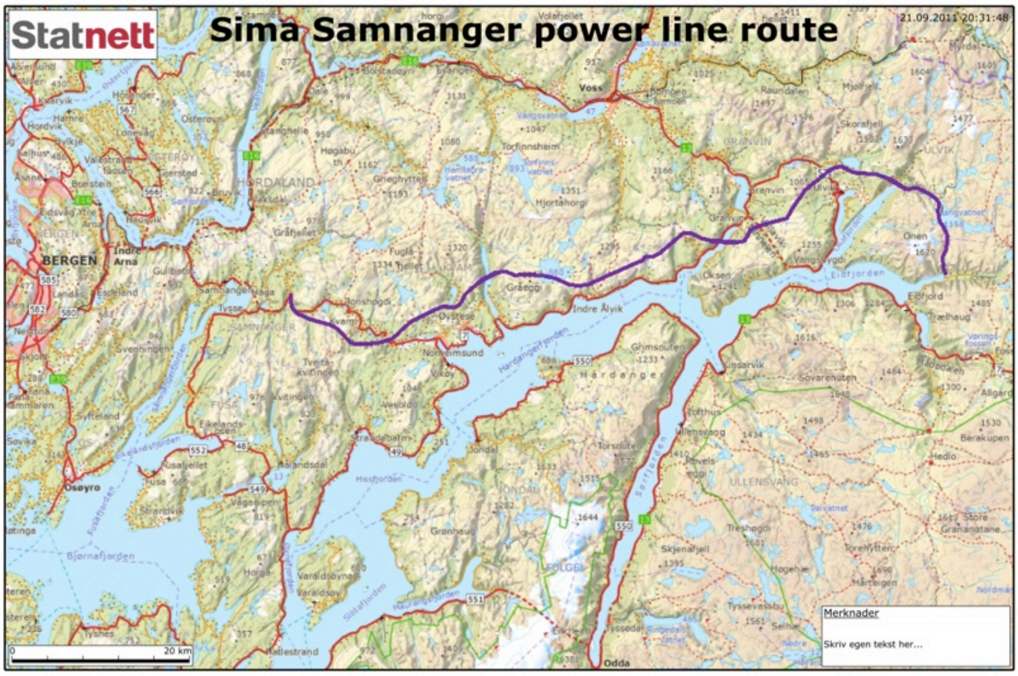
Financing

The project will be completely financed by Svenska Kraftnät and Statnett and the costs will be incorporated in grid tariffs.

5.5. SIMA – SAMNANGER, NORWAY

Geographical location

The power line between Sima and Samnanger will increase the capacity in to the smaller part of the Norwegian grid on the west coast. The route for this connection is in the direction east–west, north of the Hardanger fjord. The power line will, according to plans, have three crossings over arms of the Hardanger fjord.



Background

This connection is necessary to increase the security of supply level in the grid on west coast up to acceptable standards. Norway´s second largest city, Bergen, is located in this area. The congestion in the Norwegian grid, which now and then gives different prices in the wholesale market, will also be reduced.

Technical specification

The line is 92.3 km long, and the route goes through partly hillside, partly mountain terrain. The connection is single circuit overhead line with 420 kV AC, and a capacity on 2000 MW.

The meteorological dimension criteria: wind up to 45 m/s and ice load up to 25 kg/m on each conductor.

A major part of the power line will be constructed by helicopter, where there is no access by road.

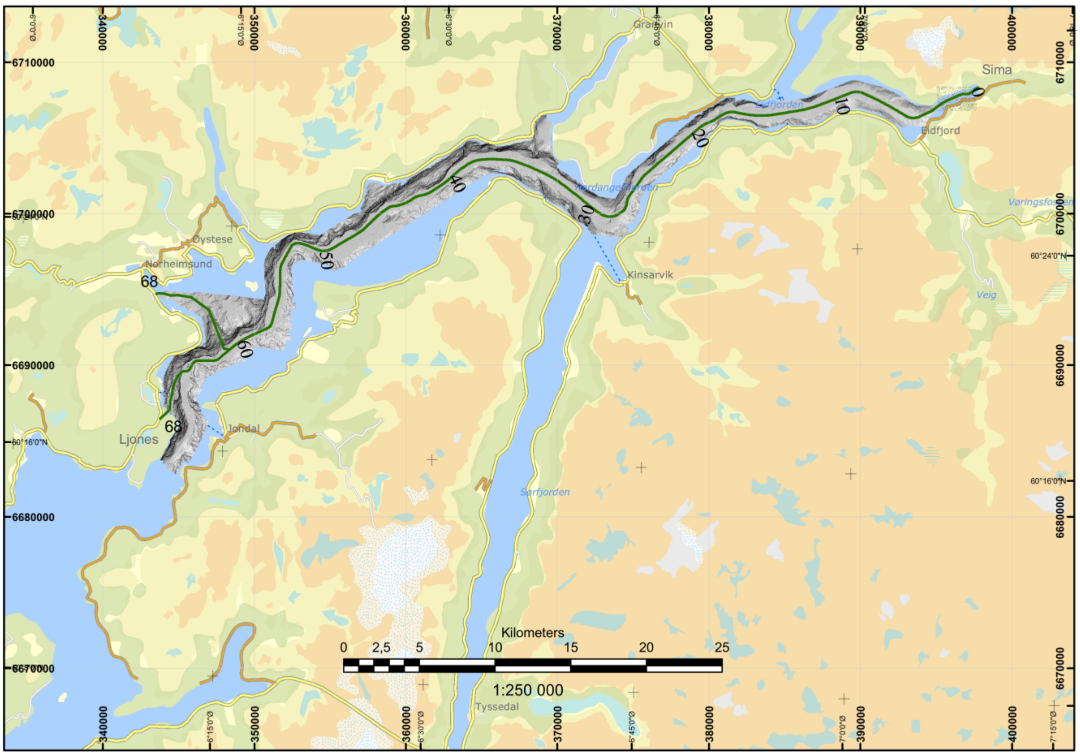
Cost

Calculated cost for AC overhead line is 990 MNOK (€123.8m). This includes 100 MNOK (€12.5m) in compensation to local municipalities. It also includes approximately 80 MNOK (€10m) to a substation and to change the route for an existing 300 kV line.

The licensing process

The first information about the start of the planning process was send to the authorities in June 2005. In May 2006 Statnett sent the formal application for approval to build a 420 kV overhead line between Sima and Samnanger The Norwegian authority NVE gave approval to build the new power line in June 2008, but the decision was appealed to the Ministry of Petroleum and Energy. The Ministry of Petroleum and Energy gave approval to Statnett in July 2010 to build the connection as 420 kV AC overhead line. This decision should have been final, and "case closed".

The local resistance was so strong that the Government was forced to reopen the case for more detailed studies about different alternatives. After reopening the case, the Government appointed four commissions to go through different topics in connection to the approval process. The four commissions presented their reports February 1st 2011, and February 10th 2011 the original approval was confirmed by the Ministry of Petroleum and Energy.



The cable route on the bottom of Hardangerfjorden.

Conflict/disagreement

Both local authorities and local community insisted that the connection Sima–Samnanger should be constructed as cables in the fjord for a major part of the distance. The total length of cables would be approximately 70 km, and the depth of the fjord is down to 800 m.

The argument against the overhead line was the visual impact on especially beautiful scenery and landscape. It was also claimed that a new overhead line would dramatically reduce the potential for the tourist industry in one of the most beautiful parts of Norway.

The alternative of a cable at the bottom of the fjord was presented in the application from Statnett, but one of the commissions appointed by the government had as a special task to evaluate the cable alternative once more. The study should include different technologies, both 420 kV AC and VSC HVDC.

The commission's evaluation of the cable alternative

The conclusions from the studies made by the Commissions appointed by the Government were presented February 1st 2011, with the following summary:

- It is possible to construct a cable connection both with AC and DC in the fjord, but it is necessary, to some extent to qualify the technology, depending on the solution chosen
- The investment cost is between five to six times higher than the investment for an AC overhead line
- The value of the losses accumulated over the lifetime is estimated to be something between 25 – 150 M€ more expensive than an AC overhead line, depending of the technology used
- The environmental impact from the overhead line will obviously be reduced, but new installations as converters or substations for compensation equipment will also have some negative impact on the environment close to the local community

Conclusion

After the presentation of the reports from the four commissions the government confirmed the approval of AC overhead line.

Conclusions Chapter 5

The benchmark projects have been carefully selected to cover projects with similar data as found in the Meath-Tyrone project, and representing different technical solutions including:

- 100 % AC OH line
- Partly UGC, partly OHL, AC technology
- Partly UGC partly OHL , HVDC technology
- 100 % underground HVDC UGC

All projects have one thing in common, the technical solution has very recently been decided and they thus represents the state of the art of industrial practices.

For AC connections, the solution by underground cables is only used for limited distances.

For HVDC lines undergrounding with cables is today a realistic solution. VSC HVDC is used in most subsea projects, although LCC HVDC is still interesting for point-to-point subsea connections. Overhead lines are used also for HVDC in difficult terrain or when an existing right of way is reused.

It is already from the list of projects that there is not one “right” solution. Each project must be decided on its own merits considering specific local conditions.

6. Some observations relevant for the Meath Tyrone Project based on the reference projects

6.1 Choice of technology

An AC connection given the length of the project, being 140 km, using cables would be a very challenging technical project, never been built in the world. As shown in both the "Cavan-Tyrone and Meath-Cavan 400 kV transmission circuits" report of Parsons and Brinckerhoff and associates from February 2009 and the "North South 400 kV Interconnection Development-Preliminary Re-Evaluation Report" of Eirgrid from May 2011, the costs are very high, on the one hand and the grid operation, including the compensation for reactive power of the cable capacity are far from evident on the other. Given the distance that has to be covered in the Meath-Tyrone project, this design is not realistic.

No reference project (or other recent project in Europe) with data similar to Meath-Tyrone has chosen underground AC Cables or Classic HVDC.

The technologies chosen are:

- 100 % AC OHL
- Hybrid AC with OHL and limited distance underground AC Cable
- Hybrid solution with AC OHL + VSC HVDC underground and partly overhead
- 100% underground VSC HVDC

6.2 Overhead or underground

Applying the experiences in the reference projects on the Meath-Tyrone project, it becomes obvious that the choice between underground and overhead is not necessarily either/or it can be a hybrid solution. It is also clear that the costs for both underground and overhead solutions can vary significantly depending e.g. choice of design for towers, routing of overhead lines and underground cables. The reference projects illustrate that the lowest cost for undergrounding HVDC cables will be following major roads or railroads or going through farmland.

The predominant installation method chosen for installation of the underground VSC HVDC cables is direct burial. This method gives the lowest cost and also good cooling of the cable. Typical installation and trenching in farmland is shown below.

The left picture shows installation of 180 km underground cable in Australia and the right picture is from installation in Germany of 75 km underground cable.

Australia (Murraylink) Germany (BorWin1)

Both examples have demonstrated low installation costs and in Germany similar installation will be used to install the on-going projects in Germany where a total of over 300 km of underground cable will be installed. Installation can be done in a width of 8-10 m. This means that roadbeds in major roads are sufficiently wide for installation of HVDC cables. Direct burial technique has been used in many existing projects and will be used for planned projects such as the South-West Link in Sweden and Norway.

For the cable route it has in previous reports been suggested that the cable cannot be installed along roads since the main alternative has been double AC cables and the right of way for the cables will be too wide to be accepted ("Cavan-Tyrone and Meath-Cavan 400 kV Transmission Circuits" Parsons and Brinckerhoff and associates February 2009). If however a HVDC VSC option is chosen, it will be possible to follow along the road.

As explained in the description of reference projects (South-West Link SE/NO and Spain–France) the installation of the cables will mainly be done following existing main infrastructure such as major roads or railroads. Particularly for the South-West link a number of alternatives have been thoroughly studied, such as going through forests or following smaller roads. The "major road" option has, after these investigations, been chosen as the most efficient from both cost and permitting point of view. Experiences from other HVDC projects with underground sections not covered in this report have shown that passing through farmland will offer the best solution, if major roads are not an option.

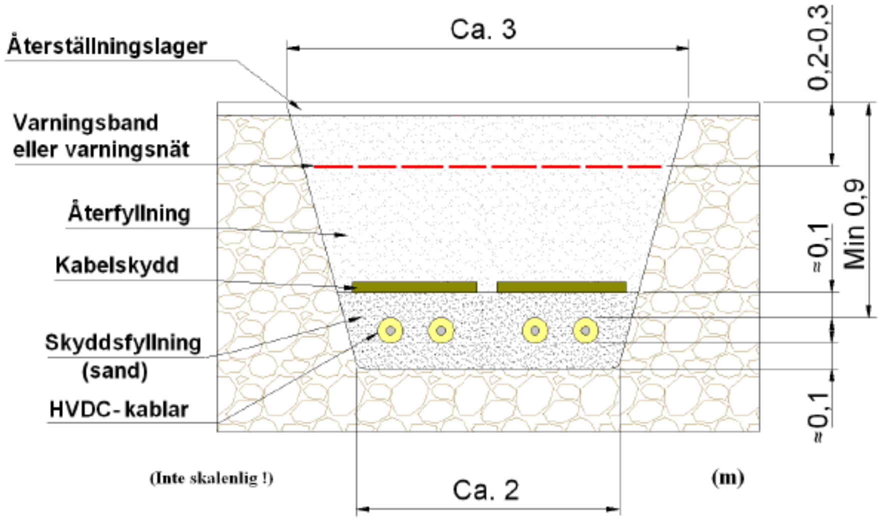
If major roads or farmland not can be used, smaller roads offer an alternative, but are also challenging since roads will be completely blocked at times during installation. This is the case for the now on-going design of the East-West Interconnector on Ireland. The pictures illustrate the installation in this project. The project also uses conduits rather than direct burial to limit the time with open trenches. This will increase the installation costs compared to direct burial.

East-West Interconnector

The example from Norway clearly shows a case where an overhead line at the end of a very thorough review was chosen.

The Commission has not investigated the detailed conditions of the Meath-Tyrone Project, but based on experiences in other projects, it appears that a route following major roads and farmland should be considered. This is based on a general observation that the terrain and existence of major roads is similar e.g. to the conditions in the South-West Link in Sweden. Note that the HVDC alternative compared to AC undergrounding requires a considerably smaller cable trench and thus offers more options for underground routes. The graph below illustrates the planned trench for the 2x720 MW South-West Link in Sweden.

The diagram shows the planned installation for the 2x720 MW South-West Link in Sweden



Conclusions Chapter 6

The reference projects with similar technical data as Meath-Tyrone have demonstrated that an underground AC cable alternative or a classic LCC HVDC solution is not attractive. The solutions chosen are:

- 100 % AC OHL
- Hybrid AC with OHL and limited distance underground AC cable
- Hybrid solution with AC OHL + VSC HVDC underground and partly overhead.
- 100% underground VSC HVDC

The reference cases illustrates that the “best” solution is different in each case.

The AC OHL is a natural choice in difficult terrain whereas partly or fully undergrounding has been chosen in other cases.

From a certain distance onwards, and if full undergrounding is chosen, the best option is a VSC HVDC solution. The distance relevant for Meath Tyrone Project certainly falls within this range. Due to a much more compact cable system, this alternative offers more options to install the cables compared to an AC cable and the installation costs are crucial for the overall project cost. It should be possible to find good reference material in built and planned projects particularly in Germany and Sweden. The terrains studied in these projects appear to be relevant to the conditions found in Ireland.

7 Cost data

Cost data have been collected from a number of sources. The most relevant data can be found in on-going projects. In the description of reference cases cost data have been included. For comparison, also cost data from studies used in previous analysis of the Meath-Tyrone Project, as well as other recent studies in Europe have been included.

7.1 Parsons and Brinckerhoff and associates February 2009 report

The report includes very detailed cost data. It should, however, be noted that they were assembled in 2009 when many conditions on the market (e.g. metal prices) were at extreme values. This may be a reason why the cost estimation for the OHL is significantly lower than the data derived from the reference projects. The costs for AC substations are also not specified in the report.

Another major change, particularly affecting the cost for the HVDC option, is that the substation in Co. Cavan is now excluded in the project.

The cost data particularly for installation of underground cables focused on the AC underground cable alternative. Therefore, other than from a cost perspective, more favourable routes were not studied. As pointed out, the on-going projects including underground HVDC cables, installations along major infrastructure such as freeways and railroads have been found to be the most favourable.

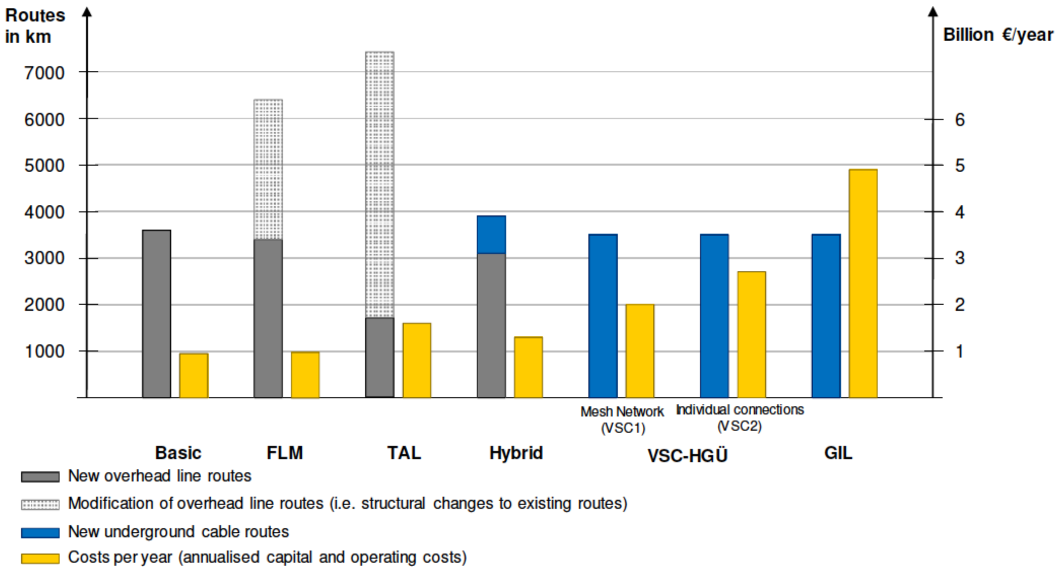
The cost estimations particularly for the underground HVDC alternative appear to be very high in the PB Power report compared to data from the reference projects. This comment would also apply if an option using farmland would be used.

7.2 DENA Study

A very recent and comprehensive cost estimation is found in the DENA Study from November 2010. Here a comprehensive analysis on the costs for building a complete VSC HVDC alternative with a complete OH alternative for Germany has been made.

The conclusions in the report is interesting since the underground VSC HVDC alternative is found to be about 2 x higher than a conventional OHL alternative. Note that this requires a “meshed” network to be built since this saves convertors compared to a solution with individual convertors. This requires that HVDC breakers are available and according to manufacturer information this will be the case in 2013.

The difference in annual costs for different alternatives is:



Basic: Base case with traditional technology
FLM: Temperature monitoring
TAL: High Temperature Lines
Hybrid: AC/DC Hybrid
VSC-HGU Voltage Source HVDC

Based on these numbers the effect on the transmission tariff in Germany for different alternatives has also been calculated. The increase for domestic customers would increase from 5.8 c€/kWh to 6 €/kWh, and in the most expensive case calculated, the tariffs would be 6.3 c€/kWh. This does not include costs for additional expansion measures in the distribution grid if necessary.

Table 10-15: Investment costs for the examined transmission tasks and transmission technologies (in relation to the investment for 380 kV overhead lines)

	1,000MW/100km	1,000MW/400km	4,000MW/100km	4,000MW/400km
380 kV OHL	1,0	1,0	1,0	1,0
750 kV OHL	2,5 - 4,0	2,5 - 3,5	2,5 - 3,5	1,2 - 2,0
380 kV cable	3,0 - 5,0	3,0 - 5,0	10,0 - 13,0	6,0 - 9,0
GIL	3,0 - 5,0	3,0 - 5,0	9,0 - 12,0	5,6 - 7,0
HVDC cl. OHL	1,7 - 3,5	1,1 - 1,4	4,0 - 6,0	0,8 - 1,4
HVDC cl. cable	2,0 - 4,5	1,3 - 2,5	7,0 - 9,0	1,9 - 3,3
VSC-HVDC OHL	1,7 - 3,5	1,1 - 1,4	4,0 - 6,0	0,8 - 1,6
VSC-HVDC cable	2,0 - 4,0	1,2 - 2,0	7,0 - 9,0	2,4 - 4,0

Source: Manufacturer ABB/Siemens

7.3 Summary, cost estimations

Cost estimates have been collected from a number of sources:

- Study reports from PB Power and DENA
- Reference projects
- Manufacturers

It can be noted that there is a wide spread in cost estimates both for overhead lines and underground cables.

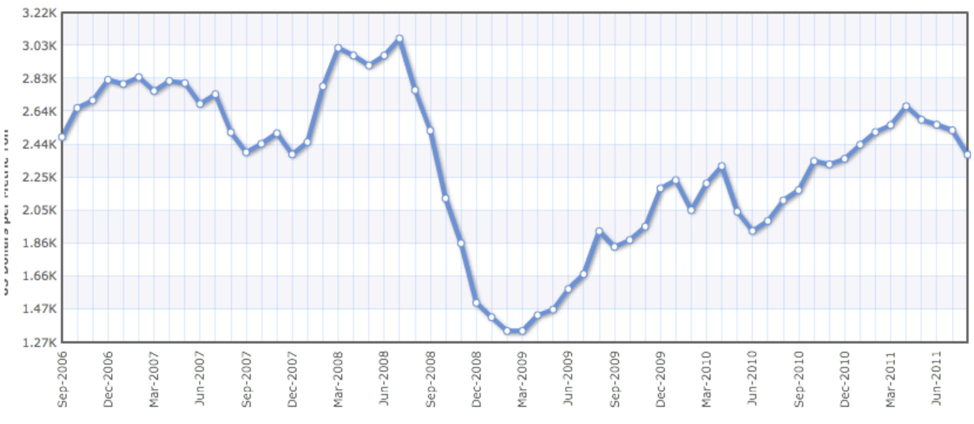
For overhead lines important factors are:

- Existing or new corridor for the line
- Type of terrain
- Type of tower design
- Current metal prices

For VSC underground systems the main uncertainty are found in:

- Installation cost depending on terrain, installations method, soil conditions etc. Examples from previous and current projects suggests that the lowest costs are found by direct burial in farmland or following major existing infrastructure such as major roads or railroads.
- Current metal prices
- For VSC systems, there is also a limited supply base that could affect availability and costs for complete systems.

One example of the difficulty with price estimates is the price curve for Aluminium where the price within a time frame of three years has shown a variation of more than a factor of 2!



Summary Cost Estimations

Source	400 kV AC OHL M€/km	2x400 kV AC terminal M€	2x700 MW VSC Convertor M€	2x700 MW UG DC Cable M€/km	1x1000 MW VSC Convertor M€	1000 MW UG DC Cable M€/km
South-West Link SE	0,8	24	300	1,32		
Spain-France ESP/FR					210	1,38
DENA (note 1100MW)	1,15	16			210	1,4
Randstad NL	2,3					
Sima-Samnager NO	1,1					
Thuringian DE	1,18					
PB Power report	0,6		321	2,7		
Manufacturer data			300	1,47	190	1,05

Comments
1) Spain-France 1 x 1000MW estimated to have a 5 % higher unit cost than two systems
The cost for the dedicated tunnel excluded from cable cost
2) 400 kV AC line in Sweden mainly installed in existing right of way
This reduces costs.
3) Thuringian is double circuit, cost assumes 100% OHL
4) Manufacturer data incresed with 5% to cover project cost for owner/investor
5) The PB Power convertor figure is calculated without the Cavan station
6) The cable cost for DC cables is derived from the PB report following the calculation made in section 8.5
7) South-West Link SE has rating 2x720MW

Conclusions Chapter 7

In the period 1990 to 2007, there has been very low activity in construction of new high voltage lines in Europe. Underground cables were historically not used at all for long distance transmission.

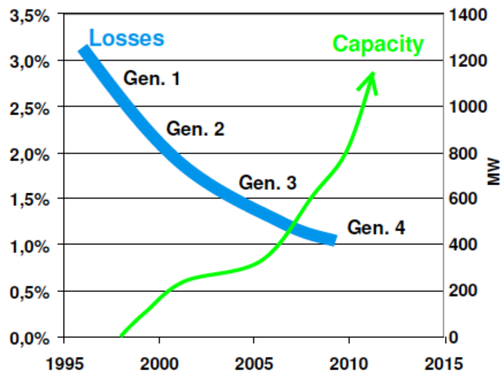
Cost data from previous reports are likely to be less reliable than data from recent projects.

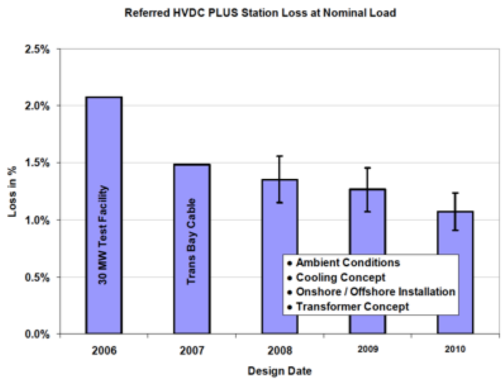
Prices of different alternatives are also changing significantly with technology and other key factors such as metal prices.

Over the last two years a large numbers of projects relevant for the Meath-Tyrone Project have been contracted or decided. Cost data for these projects are thus likely to be relevant for the Meath-Tyrone project.

8 Losses

In previous studies such as the PB Power Report from 2009, it has been assumed that VSC HVDC Convertors have losses of about 1.9% per convertor at full load. These loss figures are historically correct, but over the last years a new generation of voltage source convertors has been brought to the market. The development of convertor losses is illustrated in the following diagrams published by two major manufacturers.



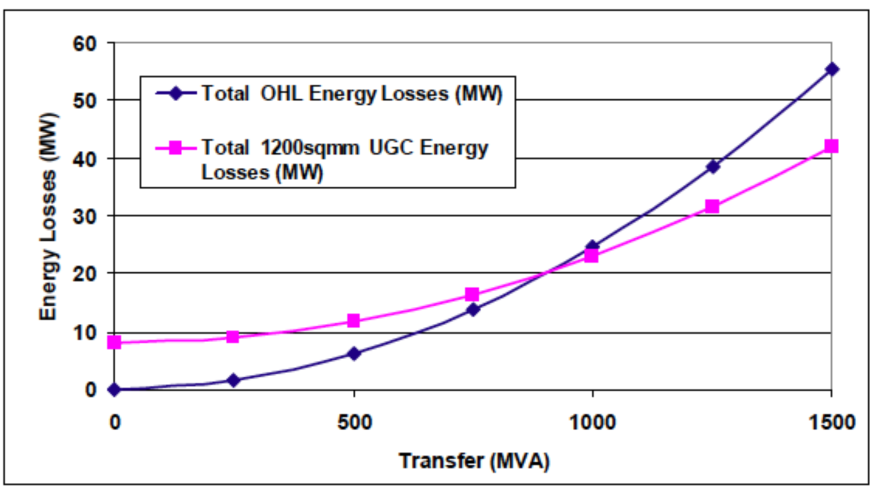


References: ABB North Sea Offshore Conference, K Linden June 6, 2011
Siemens EEI Presentation, M Lindsay 2011

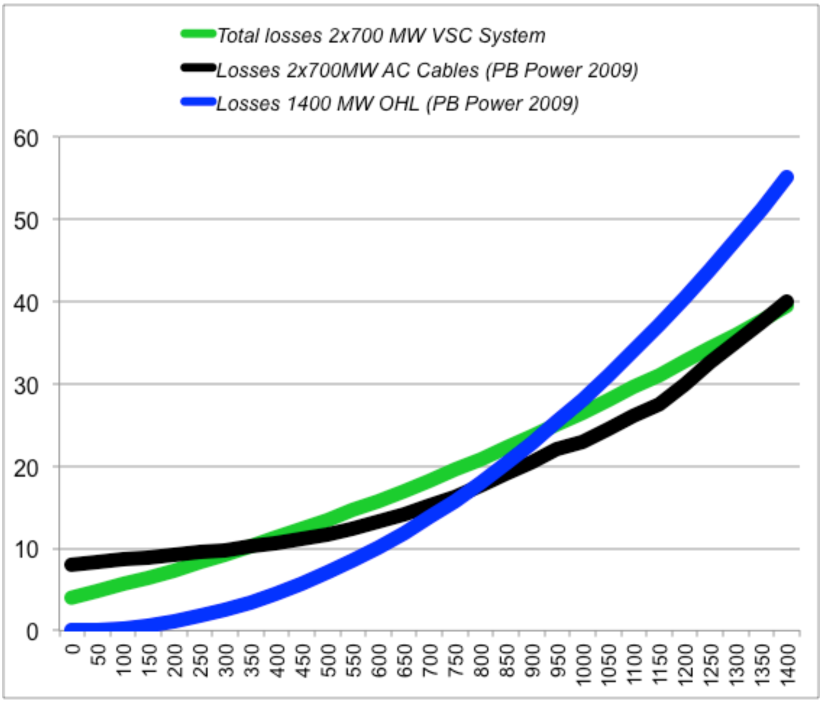
Today, manufacturers state that losses in contracted schemes are "below 1 % per convertor". This means that the losses have been reduced by about 50 % compared to the conditions when the main reports for the projects were written. This has a significant impact when losses for different alternatives are compared.

To refresh the loss data, the data presented for the OHL alternative and the UGC (Underground AC Cable) alternative in the PB Power report has been used as a starting point. This diagram is from this report.

Figure 8-1 – Comparison of Energy Losses for OHL and UGC



For comparison this data has been transferred to a new diagram that also has state of the art data for a 2x700 MW VSC HVDC alternative included.



It can be noted that the OHL offers the lowest losses at low load. Both the VSC and the AC cable have lower losses than the OHL during high load conditions.

The VSC HVDC option offers an opportunity to reduce losses in the connected AC grids in both ends due to better voltage control and the capability to optimise the load flow between the HVDC connection and the parallel AC lines. This opportunity is difficult to quantify without detailed studies. The losses at low load (below 500 MW) in the VSC HVDC system can also be reduced by operating one set of convertors and keeping the second pair in standby. This will reduce the losses with up to 2 MW.

Conclusions Chapter 8

Losses for VSC HVDC have been significantly reduced compared to state of the art when previous studies were made. The AC OHL has the lowest losses at low load whereas the cable alternatives have lower losses at high load.

Operational costs for different alternatives are related to losses. They depend on the power flowing to the link. This is an assessment outside the scope of this report. All alternatives have different characteristics, but are rather close making the assessments of lowest "life cycle losses" rather irrelevant, certainly when considering that the price of energy is very difficult to estimate over the say 60 years of life of the project.

9 Cost estimation alternatives for Meath Tyrone

If the cost data summarized in section 6 are applied in the Meath-Tyrone Project the following summary table could be derived:

Meath Tyrone cost estimation based on reference projects

Concept	Lenght km	Terminals M€	Line/ Cable M€/km	Total M€	Relative Cost
400kV OHL 1x1400MW	140	20	1,05	167	1
2x700 MW VSC HVDC+2x700 MW UG cable	140	310	1,36	500	3,0
Optional alternatives with reduced power rating					
1X700 MW VSC HVDC+1x700MW UG Cable	140	160	0,9	286	1,7
1x700 MW VSC + 2 x 700 MW cables	140	160	1,36	350	2,1
1x1000 MW VSC+1x1000MW UG Cable	140	210	1,2	378	2,3

Optional alternatives with reduced rating have been included since it is technically possible with HVDC and particularly the second alternative with 1x700 MW VSC HVDC and 2x700 MW cables opens possibilities for future upgrading with second set of convertors.

It should be noted that the cost assessments have uncertainties based on:

1) Limited number of reference projects both for the AC and the HVDC alternatives.
2) The cost for installation of the underground cable is based on using favourable installation alternatives such as installation along major roads or in farmland.
3) For the AC overhead alternative the costs can be significantly higher if more advanced tower designs are used for reduced visibility and/or reduced EMF.

If the VSC underground option is considered, we strongly recommend that experiences gained in completed and on-going projects including undergrounding of cables, are studied. There are 670 km of underground Lines under construction and there are also completed installations e.g. in Germany a 70 km underground cable in farmland.

With a VSC HVDC it will in the near future (availability of DC breakers) be possible to expand the system to a multi-terminal system (compare with the South-West Interconnector between Sweden and Norway). This will reduce the number of convertors and make the expansions relatively cheaper. This was also the finding in the DENA II report in Germany that compared a “meshed” system with a system with individual convertors.

Conclusions Chapter 9

Cost estimations for the Meath Tyrone Project can today be based on recent projects in Europe with similar technical data and in terrains and under conditions similar to Ireland. It should still be pointed out that there is a significant uncertainty and experiences in recent projects in Europe could be used to find “best practices”. Recently built and planned projects in Germany and Sweden could offer interesting data relevant for Ireland.

10. Meetings on the project

Meeting with EirGrid July 28

A separate meeting was held between the Commission and EirGrid.

The representatives from Eirgrid were:

Andrew Cooke	Director Grid Development & Commercial
Tomás Mahony	Transmission Projects Mgr
Aidan Geoghegan	Project Manager, Meat-Tyrone Project
Aidan Corcoran	Mgr Grid25

Eirgrid presented the overall energy situation on Ireland and plans for the future. The plan Grid25 was also presented to the Commission as well as the background for the Meath-Tyrone Project. The Commission also got access to the reports and studies done on the project. It was agreed that Aidan Geoghegan should be the point of contact for the Commission should the commission need more information.

Meeting with County Monaghan Anti-Pylon Committee July 28

The group was represented by:

Mr Nigel Hillis,
Mr Owen Bannigan,
Mrs. Margaret Marron.

The representatives presented the activities of the Committee and also their views on the coming task for the commission. They were in general positive to the establishment of the commission but also raised some concerns related to the terms given to the Commission. From the Commission it was made very clear that the Commission was going to work strictly in line with the terms. Clarifications could always be discussed and one clarification asked by the Monaghan group was if the Commission also examined the part of the project outside the Republic of Ireland. After the meeting the Commission has explained that since the Minister gives the task for the Commission from the Republic of Ireland, the review will be restricted to the part of the line within the Republic of Ireland.

The Monaghan group also raised more concerns such as the limited time given to the Commission and they also felt that there was not given enough attention to possible underground routes.

Meeting with Commission for Energy Regulation CER Aug 22

CER were represented by:

Dermot Nolan
Cathy Mannion
Michelle Whelan

The representatives explained the role of CER and the organisation and structure of the electricity market in Ireland. The importance of the Meath-Tyrone Project was highlighted.

Meeting with the Irish Farmers Association IFA Aug 22

The organisation was represented by:

John Moroney
Pat Farrell

The background and role of IFA was explained. The representatives described how a general document, ESB/IFA "Code of Practice", was developed in 1985. This document is still valid and has later been submitted to the Commission. The representatives strongly stressed the importance of potential heath effects from the line, in particular, the EMF issue was mentioned.

Meeting with ESB Networks Aug 22

ESB Networks were represented by:

Jerry O´Sullivan
Marguerite Sayers
Denis O'Leary

A general description of ESB Networks was given with special attention to the relation with EirGrid. The planned investments were described including the Meath-Tyrone project. ESB also shared their experiences from other projects.

Site Tour with EirGrid Aug 23

The tour was organized by Andrew Cooke and Aidan Geoghegan and covered a significant part of the proposed line route. During the tour the Commission had the opportunity to meet with and discuss with several representatives from EirGrid that have been directly involved in the planning of the Meath Tyrone Project.

The Commission had the opportunity to visit the on-going construction work for the East – West Interconnector and a thorough presentation of the cable installation work was given (45 km of underground cable).

The Commission also travelled along the proposed overhead line route and got a good understanding about the type of landscape the new line is planned to pass through.

Meeting with NEPP Aug 23

The Commission was represented by Odd-Hakon Hoelsaeter and Bo Normark.

NEPP were represented by:

Padraig O'Reilly
Aimee Treacy
Bernie Andrew

The representatives gave a good description of the organisation formed in 2007. They stressed that the main concerns they represent. There are genuine concerns related to visual impact/health/safety and noise. The group also felt low level of responsiveness from EirGrid related to their views for all aspects of the project.

The group has besides all voluntary work spent a considerable amount of money to hire a consultant to examine an underground AC cable alternative. A DC Underground alternative was not examined since this alternative, at the time, was deemed by EirGrid to be not feasible.

Meeting with ESB Oct 12

A meeting was held with the CEO of ESB. Mr Padraig McManus. Odd-Hakon Hoelsaeter and Bo Normark represented the Commission.

Mr McManus gave a good background for the Meath-Tyrone project and stressed the importance for ESB to find a solution. ESB has considerable experiences related transmission projects that also were discussed.

Meeting with Public Representatives Oct 13

Odd-Håkon Hoelsaeter and Bo Normark represented the Commission. The participating representatives were:

Regina Doherty (chair)
Shane McEntee
Dominic Hannigan
Peadar Toibin
Damien English
Heather Humphreys
Sean Conlan
Caoimhin O´Caolain
Joe O´Reilly
Thomas Byrne
Diarmuid Wilson

The discussion covered many topics from the process to forming the Commission to the schedule for the review. The meeting was basically based on questions from the Representatives that were answered by the representatives of the Commission.

- The Commission described the chosen process of finding and describing international (European) projects of relevance for the Meath-Tyrone Project. Focus in particular to cover recent development that could be relevant for the Meath-Tyrone Project.
- The report will not give any recommendation but just deliver facts.
- The Commission confirmed they did not see that any information was withheld or missing from Eirgrid.
- The Commission confirmed that they based on recent information including the discussion with the representatives were going to ask for a slight delay
- The Commission stated that the fact that the Askon report has not been made available is not likely to have any effect on the report. The reason is that the underground AC is not seen as realistic alternative and particularly not given the state of art for an HVDC alternative.

Note: Later the Askon report was made available to the Commission but reading the report does not change the position from the Commission.

11. List of abbreviations

MW	Million Watts
kV	Thousand Volts
AC	Alternating Current
HVDC	High Voltage Direct Current
LCC	Line Commutated Convertor
VSC	Voltage Source Convertor
STATCOM	Static Voltage Compensator of VSC type
TEN_E	TransEuropean Networks Electricity
EHV	Extra High Voltage, Transmission Voltage
EMF	Electro Magnetic Fields
OHL	Overhead Line
UGC	Underground Cable
XLPE	Cross Linked Polyethylene