The Grid West project - Summary of the report for the Independent Expert Panel

EIRGRID

The current. The future.

Glossary

AC
AC is a type of electrical current, in which the direction of the flow of electrons switches back and forth at regular intervals or cycles.

An Bord Pleanála
Ireland's independent national planning authority.

Assets
All substations and electricity transmission lines that form the transmission network. ESB owns the transmission network, and EirGrid operates it.

Capacity
The amount of electricity that can be safely transferred on the system or a circuit.

CER ('the regulator')
The Commission for Energy Regulation. The CER is Ireland's independent energy regulator with a range of economic, customer and safety functions.

Circuit
The overhead line or underground cable linking two substations. For example, the Moneypoint – Dunstown 400kV circuit.

DC
Direct current (DC) is electrical current which flows consistently in one direction.

Demand
The amount of electrical power that consumers take from the network. This is often expressed as 'peak demand', which is the largest amount of power used in a given period.

Distribution Network
Our high-voltage transmission network supplies power to the distribution network. This lower voltage network delivers power to households and businesses. In Ireland, the ESB owns and ESB Networks Ltd operates the distribution network.

Generator
A facility that produces electricity. Generators use a variety of sources to generate power. This can include coal-fired power plants, gas fired power plants and wind farms.

Kilovolt (kV)
Operating voltage of electricity transmission equipment. One kilovolt is equal to one thousand volts.
The highest voltage on the Irish transmission system is 400kV.

Megavolt-ampere
(MVA) is the unit used for power in an electrical line or cable. In direct current (DC) circuits, this product is equal to the real power in watts.

Megawatt (MW)
A unit of measurement for the amount of power produced by a generator or transported on the transmission grid. The rating of high voltage direct current (HVDC) circuits is generally quoted in MW. For ease of comparison, we use a unity power factor and displayed the rating in MVA. This allows for a better comparison with the high voltage alternating current (HVAC) options.

Present Value
All lifecycle costs including construction, maintenance and electrical losses etc. over the assumed 50 year life of the asset are shown as a single equivalent value today.

Reinforcement
Increasing the capacity of the existing electricity transmission network. We do this by building new lines or cables, or by uprating existing ones.

Renewable generation
The generation of electricity using renewable energy, such as wind, solar, tidal and biomass.

Substation
A set of electrical equipment used to step high-voltage electricity down to a lower voltage. We use substations to create lower voltages to safely deliver power to small businesses and homes.

Transmission line
A high-voltage power line running at 400kV, 220kV or 110kV on the Irish transmission system. The high-voltage allows delivery of bulk power over long distances with minimal power loss.

Transmission Network or Grid
This is a network of around 6,500 km high-voltage power lines, cables and substations. It links generators of electricity to the distribution network. EirGrid operates Ireland's transmission network.

Voltage
Voltage is a measure of 'electric potential'. It is like 'pressure' in a water system.

The Grid West project
Report for the Independent Expert Panel

Foreword

It is EirGrid's responsibility to ensure Ireland has the electricity transmission infrastructure it needs. We develop the grid to help Ireland remain competitive. Our work also fosters economic growth, attracts new investment and supports indigenous jobs. We must do this without placing too great a burden on communities, or too high a cost on industry. Our goal is to always find a fair balance between these factors.

We recently published "Your Grid, Your Views, Your Tomorrow". This draft document outlines our strategy for the development of the transmission grid, which is shaped by three key pillars:

- open engagement with communities;
- making the most of new technologies;
- getting more capability from the existing grid before we build new transmission infrastructure.

We have sought your feedback on our draft strategy. We will reflect the themes and issues you provide in our final strategy which we will publish later this year.

In the case of the Grid West project, we outlined the need to add capacity for high-voltage transmission in the west of Ireland. We must now consider the best solution to meet this need. As part of this process, we undertook a detailed analysis of underground and overhead options. We submitted these studies to a Government-appointed Independent Expert Panel (IEP) earlier this year. The Panel responded to the Minister for Communications, Energy and Natural Resources with a positive opinion. They assessed that our report was complete and fair. We are now publishing this report – the Grid West report for the Independent Expert Panel.

This summary is designed to sit side-by-side with the report as an overview of the key points. We have presented our work in a neutral way which is easy to assess. We will be consulting with the public later this year on all options for the Grid West project. This will help us select a preferred solution for the project.

Fintan Slye
Chief Executive
EirGrid Plc.

July 2015

About this document

The full report for the Independent Expert Panel is a detailed, technical document.

This summary follows the same outline as the full report, including an overview and analysis of each option.

This summary is a shortened version of the report. The chapters listed from page six onwards, directly correspond to the chapters of the Report for the IEP and should be read as a synopsis of each of the chapters.

The main report contains a detailed overview of each option:

- a HVDC underground cable;
- a 400kV overhead line;
- a 220kV overhead line with partial use of underground alternating current cable.

Each chapter outlines the route-specific solution that EirGrid and our consultants considered.

Chapter 1 - an introduction that explains EirGrid's role, the Grid West project and the role of the Independent Expert Panel;

Chapter 2 - a summary that contains a full synopsis of each chapter and the main comparison points for each of the options;

Chapter 3 - an outline of the need for the Grid West project. This explains why new transmission infrastructure is required in the west of Ireland;

Chapter 4 - this chapter details three options, and explains how they compare to national, European and international best practice. First, we describe how each option meets

the need. We then explain how we can integrate each option into the network. Finally, we detail the infrastructure required for each option;

Chapter 5 – this chapter covers the first option, which is a direct current fully underground cable;

Chapter 6 – this chapter covers the second option, which is a 400kV fully overhead line including 8km of underground cable. The underground section is part of an existing lower voltage circuit, close to Flagford;

Chapter 7 – this chapter covers the third option, which is a 220kV overhead line with partial use of underground cable. This includes the 8km close to Flagford and a potential for a further 22km underground. The maximum amount of 220kV cable that can be undergrounded in the region is 30km;

Chapter 8 – is a a side-by-side summary of the analysis for each of the options, in table format;

Chapter 9 – outlines the next steps.

Chapter 1- About EirGrid

This chapter gives an overview of the role of EirGrid, the need for the Grid West project and the role of the Independent Expert Panel.

It is EirGrid's responsibility to ensure Ireland has the electricity transmission infrastructure it needs. We work to ensure there is enough electricity for industry to prosper, and for employment to grow. We also keep the electricity transmission grid secure and reliable. The grid carries high-voltage electricity from where it is generated, to where it is needed. Industrial or high-tech companies connect directly to the transmission grid, as they use large amounts of electricity. Homes and small businesses get their electricity from the lower-voltage distribution network.

Why are we developing the Grid West project?

In 2008, the Commission for Energy Regulation (CER) established a process to regulate how renewable energy generators can connect to the grid. This process, called "Gate 3" also determines how EirGrid must respond to these applications to connect to the grid.

In the north Mayo region, renewable generation companies asked for connections of 647MW in total. At this stage, 400MW of connection agreements are signed. For the balance, approximately 200MW of connection offers are outstanding and 47MW have lapsed.

We assessed the existing network in north Mayo to see if it could carry the power from these extra connections. We determined that the existing 110kV network, even if upgraded, could not do so. The network even when upgraded can only accommodate approximately 200MW of generation. Anything beyond this will need a high voltage transmission circuit, either overhead or underground. Grid West is our name for this new circuit. This project will connect more renewable energy to the national grid, which will help meet our 2020 targets. It will also reinforce the transmission network in the west, and support economic development in the region.

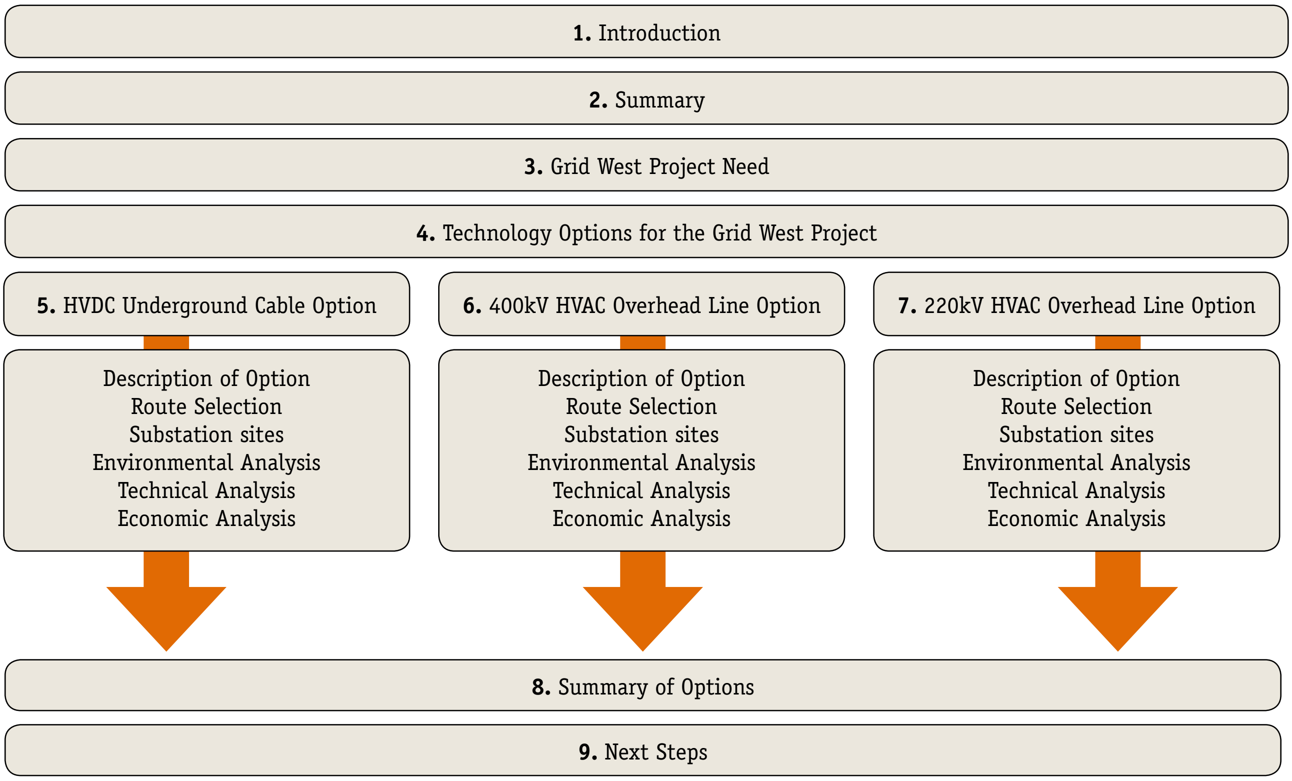
Background to the Independent Expert Panel

In January 2014, the then Minister for Communications, Energy and Natural Resources – Mr Pat Rabbitte TD – established an Independent Expert Panel. The IEP ensured that information we submitted on overhead and underground options was neutral and easy to compare. They also checked that our analysis covered the environmental, technical and economic factors they asked us to consider.

Chapter 2 - Summary & Layout of the Report for the Independent Expert Panel

This chapter contains a summary of the entire report and the main analysis criteria for each of the options under the headings: technical, environmental and economic.

The report is presented in three parts: the background and consideration of the need and technology options (chapter 1-4); chapters 5, 6 and 7 are stand-alone assessments of the underground and overhead options and a summary of options. The next steps are outlined in chapters 8 & 9.



Chapter 3 - Grid West project need

Having explained the background to the Grid West project in Chapter 1, in this chapter we explain why the project is needed.

Introduction

New energy generation proposed in north Mayo will drive the need for a new high-voltage transmission circuit. This is because the existing grid cannot accommodate the proposed volume of extra power.

What factors were considered?

When developing the grid, we engage closely with the Department of Communications, Energy and Natural Resources to ensure we are aligned with its energy strategy, and that our plans deliver for the entire country now and in the years ahead.

In developing solutions for Grid West we considered our statutory obligations as Transmission System Operator (TSO), the upcoming Government policy on energy and the "Gate" process - the CER's approach to the connection of generators. We also considered the capacity of the existing transmission network and the quantity of generation seeking to connect.

Future needs were also considered in terms of additional generation that might seek to connect to the transmission grid and additional demand growth in the region.

Chapter 4 - Technology options for the Grid West project

In this chapter we outline the three technology options we considered, how a Transmission System Operator goes about selecting the various technology options and the factors that determine this.

The specific nature, extent and location of any project determines the most appropriate technology. No single technology or mix of technologies is appropriate for every transmission infrastructure project. Also, transmission technology develops over time. Because of this, we continually review new developments to identify their potential.

When developing any new transmission project, we have three main technology decisions to make:

- whether to use Alternating Current (AC) or Direct Current (DC);
- what transmission voltage to use;
- the appropriate use of overhead or underground technology.

Using AC and DC technology

Ireland's transmission grid uses high voltage alternating current (AC). This is comparable to other European and international grids.

Where we need to transfer power over long distances, we also use high voltage direct current (HVDC). To integrate a HVDC solution with the electricity grid requires converting HVAC to HVDC, or the other way round. We do this in converter substations at each end of a circuit.

Transmission voltage

The decision as to what transmission voltage is used is based on two factors. The first of these is the required power capacity for the new circuit which we measure in Megavolt amperes (MVA). The second factor is the specification of the transmission network at the point of connection.

How did we determine the suitability of underground cables for the Grid West project?

We carried out technical studies for the Grid West project. These confirmed that a fully underground solution is only possible using HVDC.

We developed an underground solution that uses HVDC along the route and connects back into the AC transmission grid via converter stations at either end.

In another study, we confirmed it was possible to use an AC underground cable for a maximum of 30km, if we use a lower voltage of 220kV, rather than 400kV.

This study allowed us to develop Option 3 - the partial underground option. This uses 8km of the possible 30km underground cable near Flagford. This minimises extra wires in the approach to the Flagford substation. No location was selected for the remaining 22 km of AC cable available.

We developed three comprehensive, detailed and route-specific studies to analyse the fully underground and the overhead technology options.

Chapter 5 - A fully underground HVDC option

In chapter 5 we discuss the HVDC underground option in further detail and outline the environmental, technical and economic analysis of this option.

This option has the capacity to carry of 500MVA of power. To investigate this solution, we first identified thirty-one potential underground routes in conjunction with the relevant local authority departments and the National Roads Authority. Then, we selected a preferred route from north Mayo to Flagford.

This option needs a new 110kV substation, and a 500MVA converter station in north Mayo. It requires a second converter station at the Flagford end and new equipment at the existing Flagford substation.

A fully underground high voltage direct current (HVDC) solution

Environment

We assessed that the main environmental impact from the cable route would be during the construction phase. We also considered the visual impact of the two converter stations required for this option.

Technical

This technology, whilst proven internationally, is more common in installations requiring long distances or underwater connections. An underground HVDC cable solution has limited flexibility in providing for future connections and higher capacity.

Present Value Cost

€476.8 million.

Underground Option	
Meets the Need	✔
Present Value	€476.8m
Construction	3 years
Longevity and Flexibility	Limited
Amount of Undergrounding	Full

Chapter 6 - A fully overhead 400kV option

In chapter 6 we discuss the fully overhead 400kV option in further detail and outline the environmental, technical and economic analysis of this option.

This option has the capacity to carry 1,580MVA of HVAC electricity. This solution includes replacing 8km of an existing 220kV overhead line with 220kV underground cable. This would take place on the approach to the existing Flagford substation. This option also needs a new 110kV substation in north Mayo and some new equipment at the existing Flagford substation.

A fully overhead 400kV high voltage alternating current (HVAC) solution

Environment

The most significant impact of this option is the visual impact on landscape due to overhead wires and substations.

Technical

This is a flexible option, and offers the most potential for future expansion and reinforcement.

Present Value Cost

€222.1 million.

Overhead Option	
Meets the Need	✔
Present Value	€222.1m
Construction	3.5 years
Longevity and Flexibility	Good
Amount of Undergrounding	8km*

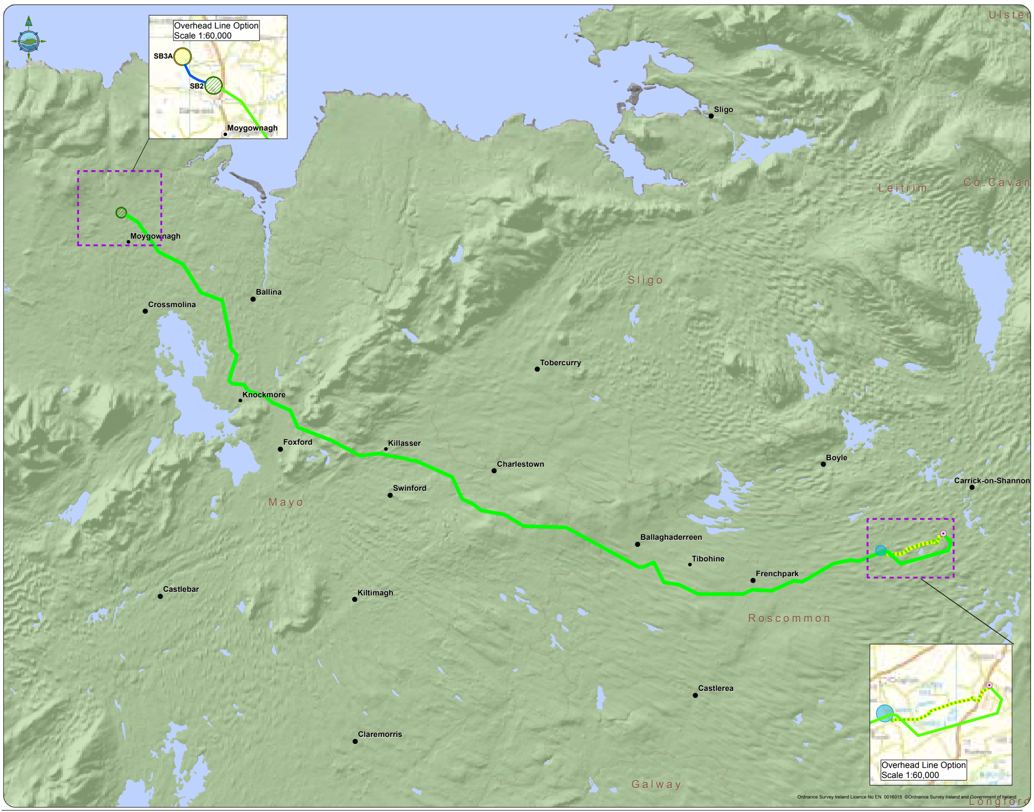
* 8km undergrounding of an existing lower voltage circuit.

Chapter 7 - a 220kV overhead line with partial undergrounding

In chapter 7 we discuss the 220kV overhead line option with partial undergrounding in further detail and outline the environmental, technical and economic analysis of this option.

This option has the capacity to carry 600MVA of HVAC electricity. For comparison, we assessed this option using the proposed overhead 400kV route. This option includes 8km of 220kV underground cable into the existing Flagford substation. It also allows for up to 22km of 220kV underground cable on the proposed overhead route, which is the maximum of underground AC cable available in the region. This option requires a new 110kV gas insulated substation in north Mayo, and new equipment at the existing Flagford substation.

A 220kV alternating current overhead line with partial use of underground AC cable



Environment

We assessed what the main environmental impact from the cable route would be during the construction phase. We also considered the visual impact of the two converter stations required for this option.

Technical

The technology is well proven in Ireland and is in line with international best practice. An underground HVAC cable solution has some flexibility, and can provide for future reinforcement.

Partial Underground Option	
Meets the Need	✔
Present Value	€207.4M – €249M
Construction	3.5 years
Longevity and Flexibility	Moderate
Amount of Undergrounding	Maximum of 30km for the region

Present Value Cost

€207.4M – €249M*

*These values are a range of costs, the ultimate cost of which will be determined by the extent of partial undergrounding on this option.

Chapter 8 - Analysis of options

In this chapter, we compare the work conducted in each of the three previous chapters. We present this work in tables, side-by-side.

The tables show the environmental, technical and economic considerations for each option. The darker the colour, the more significant the impact, difficult to reduce effects of impact, greater the risk of occurrence or more likely to occur. The lighter the colour the less significant the impact, easier to reduce the effects of impact, lower the risk of occurrence or less likely it is to occur.

Example of how to review the table.

The following tables give more detail on the analysis of each option. They show how the options rate under the headings of Environmental, Technical and Cost.

SUMMARY OF ENVIRONMENTAL ASSESSMENTS

CRITERIA	Option 1 – High Voltage Direct Current (HVDC) Underground Cable: Significance of Impact/Effect	Option 1: Ease of Mitigation	Option 1: Likelihood of Residual Effect (following mitigation)	Option 2 – 400kV High Voltage Alternative Current (HVAC) Overhead Line: Significance of Impact/Effect	Option 2: Ease of Mitigation	Option 2: Likelihood of Residual Effect (following mitigation)
Biodiversity, flora and fauna	Blue	Green	Light green	Green	Green	Green
Soil	Green	Light green	Light green	Light green	Light green	Pale yellow
Landscape and Visual	Light green	Green	Light green	Blue	Dark blue	Blue
Cultural Heritage	Green	Light green	Light green	Green	Blue	Green
Settlements and Communities	Light green	Green	Light green	Blue	Dark blue	Blue
Climatic Factors	Pale yellow	Pale yellow	Pale yellow	Pale yellow	Pale yellow	Pale yellow
Material Assets	Light green	Light green	Pale yellow	Light green	Light green	Pale yellow
Recreation and Tourism	Pale yellow	Pale yellow	Pale yellow	Light green	Dark blue	Light green
Noise [1]	Light green	Light green	Pale yellow	Light green	Green	Light green
Water[2]	Blue	Green	Light green	Green	Light green	Light green
Air Quality[2]	Green	Green	Light green	Light green	Light green	Pale yellow
Traffic and Noise [2]	Blue	Green	Green	Light green	Light green	Pale yellow

Notes:
1. During operation
2. During construction

More significant impact **Difficult to reduce effects of impact** **Greater risk of lower but sustained effects after reduction** **More Likely**				**Less significant impact** **Greater potential to reduce effects of impact** **Less risk of lower but sustained effects after reduction** **Less Likely**
Dark blue	Blue	Green	Light green	Pale yellow

Option 3						
220kV Overhead Line with 8km of Underground Cable			220kV HVAC Overhead Line with a maximum of 30km of Underground Cable			
Significance of Impact/Effect	Ease of Mitigation	Likelihood of Residual Effect (following mitigation)	Significance of Impact/Effect	Ease of Mitigation	Likelihood of Residual Effect (following mitigation)	CRITERIA
						Biodiversity, flora and fauna
						Soil
						Landscape and Visual
						Cultural Heritage
						Settlements and Communities
						Climatic Factors
						Material Assets
						Recreation and Tourism
						Noise [1]
						Water [2]
						Air Quality [2]
						Traffic and Noise [2]

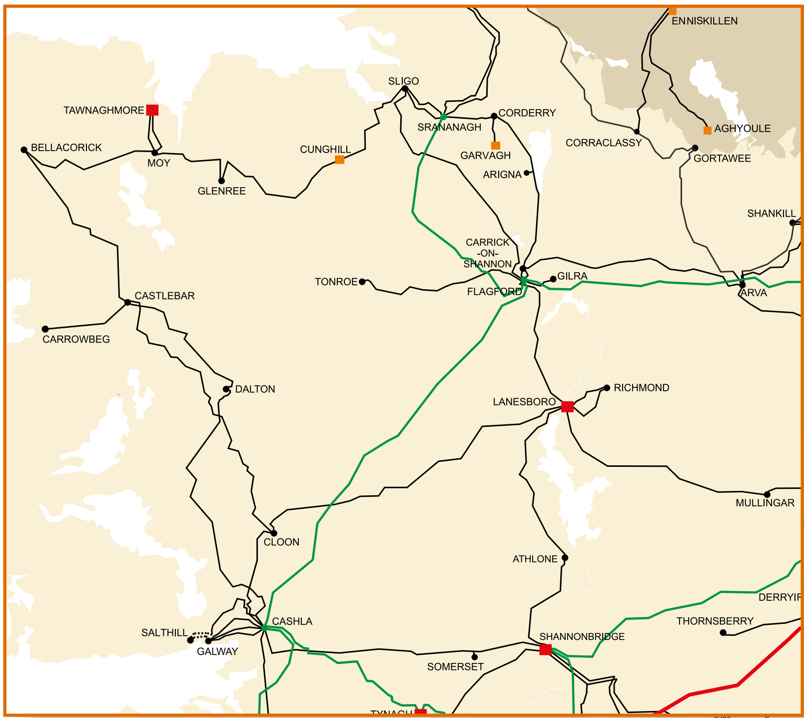
SUMMARY OF TECHNICAL ASSESSMENTS

Table 2 Technical Analysis of Options

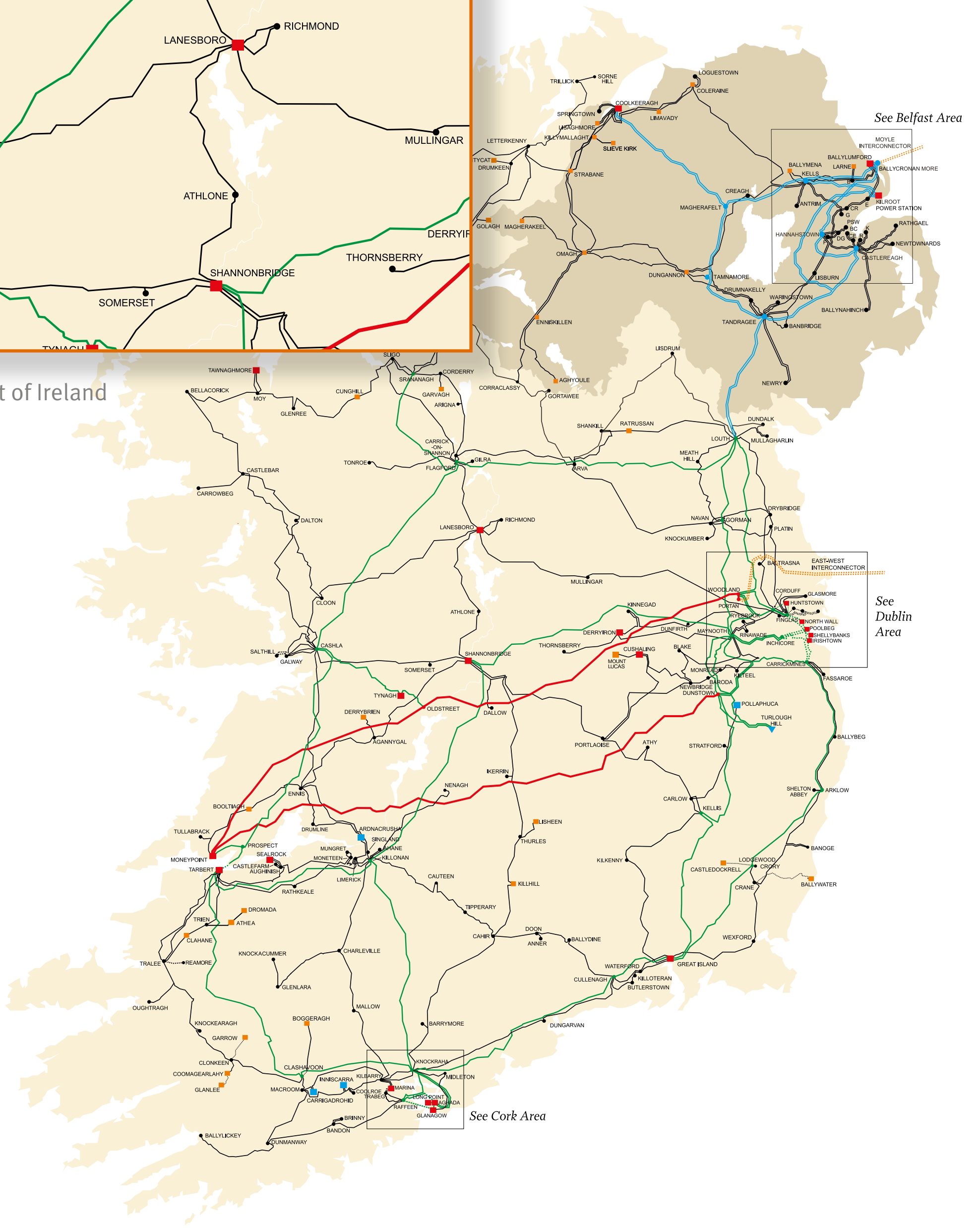
* Note: The rating of HVDC circuits is generally quoted in MW, however for ease of comparison we have assumed unity power factor and displayed the rating in MVA, to enable a better comparison with the HVAC options.

SUMMARY OF COST ASSESSMENTS

ITEM	OPTION 1: High Voltage Direct Current (HVDC) Underground Cable — Present Value (€ M)	OPTION 2: 400kV High Voltage Alternative Current (HVAC) Overhead Line — Present Value (€ M)	OPTION 3: 220kV HVAC Overhead Line with 8km of Underground Cable — Present Value (€ M)	OPTION 3: 220kV HVAC Overhead Line with a maximum of 30km of Underground Cable — Present Value (€ M)
Pre-Engineering Costs	16.1	16.1	16.1	16.1
Project Implementation Costs				
Overhead Line	7.5	100.2	84.5	62.8
Stations	120.9	38.5	33.4	33.4
Underground Cable	145.6	15.5	15.5	58.3
Reactive Compensation	0.0	3.6	3.6	13.4
Other	47.0	17.6	15.9	14.4
Project Life-Cycle Costs				
Cost of Losses	9.0	6.1	16.0	14.5
O&M	65.2	2.1	2.2	2.9
Decommissioning & Replacement	3.9	0.0	0.0	0.0
Cost to SEM from Development Unavailability (Reliability)				
Cost of Unplanned Outages	11.0	0.1	0.1	3.8
Cost of Planned Outages	11.6	4.2	4.2	10.5
Contingency Cost Provisions				
Pre-Engineering Costs	0.4	0.4	0.4	0.4
Project Implementation Costs	32.1	17.5	15.3	18.2
O&M	6.5	0.2	0.2	0.3
Decommissioning & Replacement	0.0	0.0	0.0	0.0
TOTAL	**476.8**	**222.1**	**207.4**	**249.0**



Transmission system in the west of Ireland



TRANSMISSION SYSTEM
400, 275, 220 AND 110kV
JANUARY 2015

- 400kV Lines
- 275kV Lines
- 220kV Lines
- 110kV Lines
- 220kV Cables
- 110kV Cables
- HVDC Cables
- 400kV Stations
- 275kV Stations
- 220kV Stations
- 110kV Stations

Transmission Connected Generation

- Hydro Generation
- Thermal Generation
- Pumped Storage Generation
- Wind Generation

Over time, patterns of power-flow across the transmission network will change. This can happen when there is significant growth in demand, or when new generators request a connection to the grid. As is the case with other infrastructure, electricity transmission assets have a finite lifespan. Our grid - like road, water or telecommunication networks - requires on going upgrades and refurbishment.

What will happen next?

We are publishing the Report for the Independent Expert Panel for people to consider the work we have done.

Separately, we are finalising our other consultation commitments including our new approach to consultation.

This work will be complete in the autumn.

We will then consult with people on the options and how we propose to select one that is preferred.

The report is available online at www.eirgridprojects.com/projects/gridwest/ and can be viewed at our information offices:

- The Square, Ballaghaderreen, Co. Roscommon
- Bury Central, Bury Street, Ballina, Co. Mayo
- Unit 2, Mercantile Plaza block C, Carrick-on-Shannon, Co. Leitrim

You can contact the project team for more information through any of the following channels:
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