APPENDIX 6

Your Grid, Your Views, Your Tomorrow - A Discussion Paper on Ireland's Grid Development Strategy (EirGrid 2015) and associated appendices

Your Grid, Your Views, Your Tomorrow.

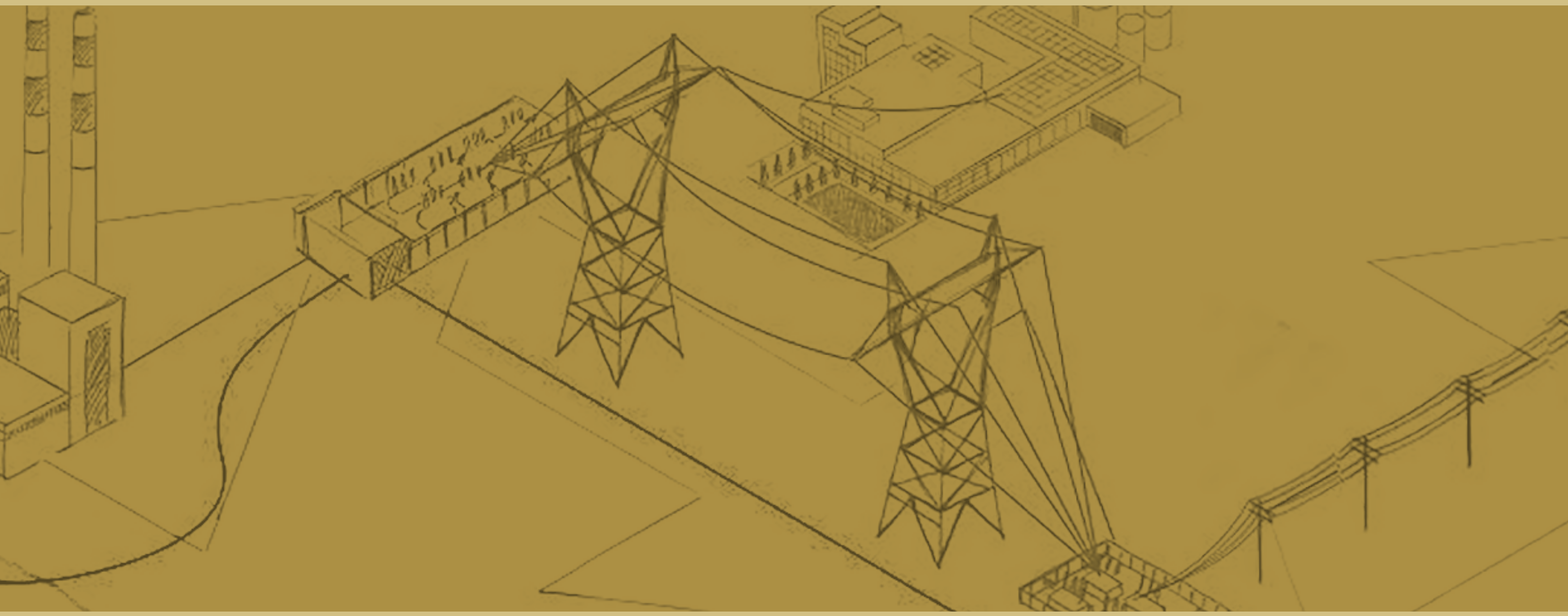
A Discussion Paper on Ireland's Grid Development Strategy

EIRGRID

eirgrid.com/yourgridyourviews

A Discussion Paper on Ireland's Grid Development Strategy

EIRGRID



Electricity: Powering Ireland

Electricity is essential to our economy and way of life. It powers everything from our household appliances to complex, multi-million euro industries. It is one of the core infrastructures that keeps our society functioning and our economy operating.

The electricity industry directly employs thousands of Irish people. At its core is the high-voltage transmission grid, a state-owned asset that is operated by EirGrid.

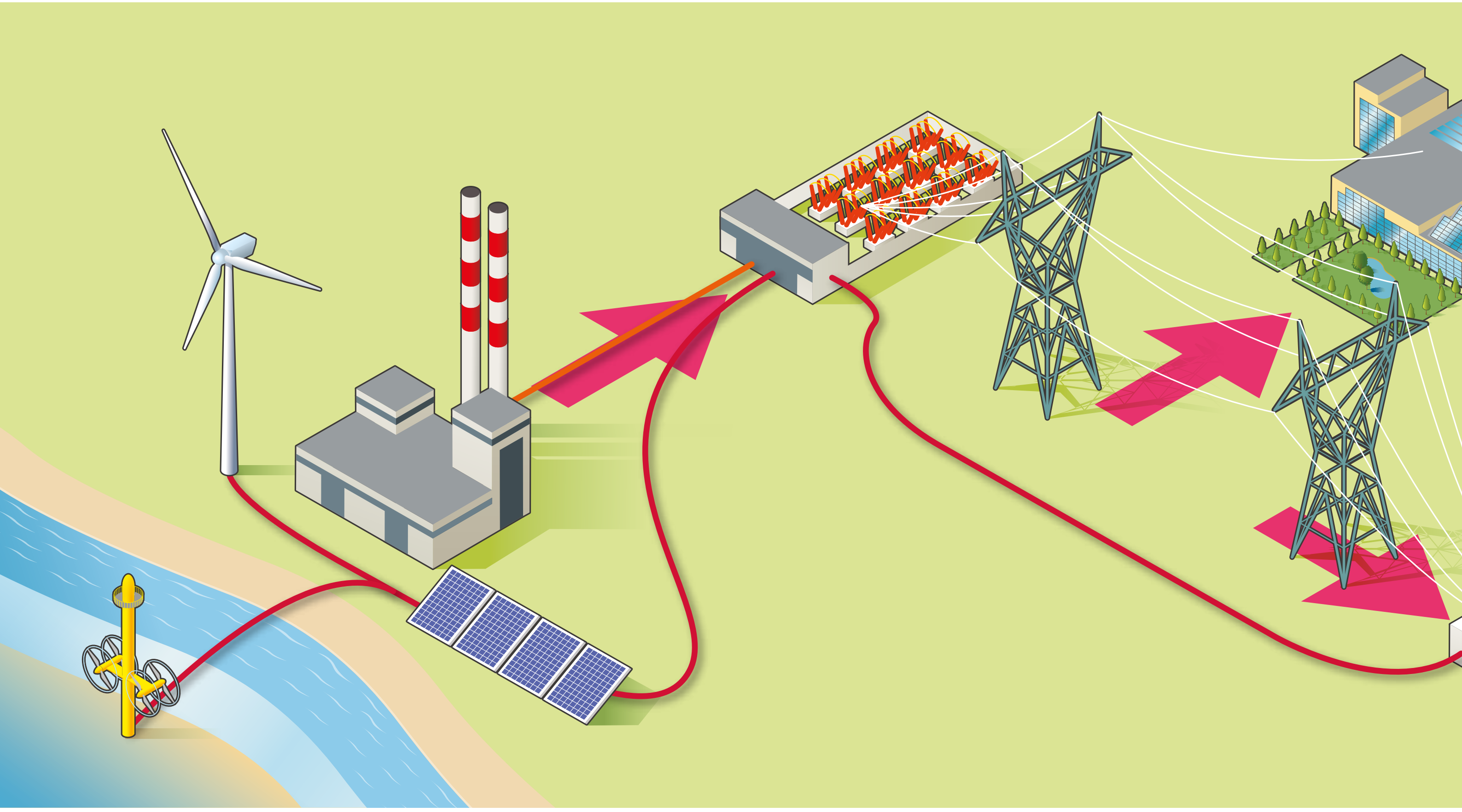
Our primary responsibility is the consistent and reliable transmission of electricity. EirGrid is the independent guardian of the grid: We are charged with operating a world-class system that homes and businesses can rely on.

We also make sure the system is planned and developed to meet Ireland's future needs. The European energy market is evolving, with the ultimate aim of establishing a single market for electricity. At EirGrid, we are transforming our operations to best meet this changing environment. In tandem, we are also developing the physical infrastructure of the grid. We want to make sure your views on your electricity transmission grid are at the core of our thinking.

This document aims to explain the need for and drivers of grid development. These factors are the context for a broader discussion about how we should respond to these needs.

We want to know what you think - this is your grid.

EirGrid's core responsibility is the consistent and reliable transmission of electricity.



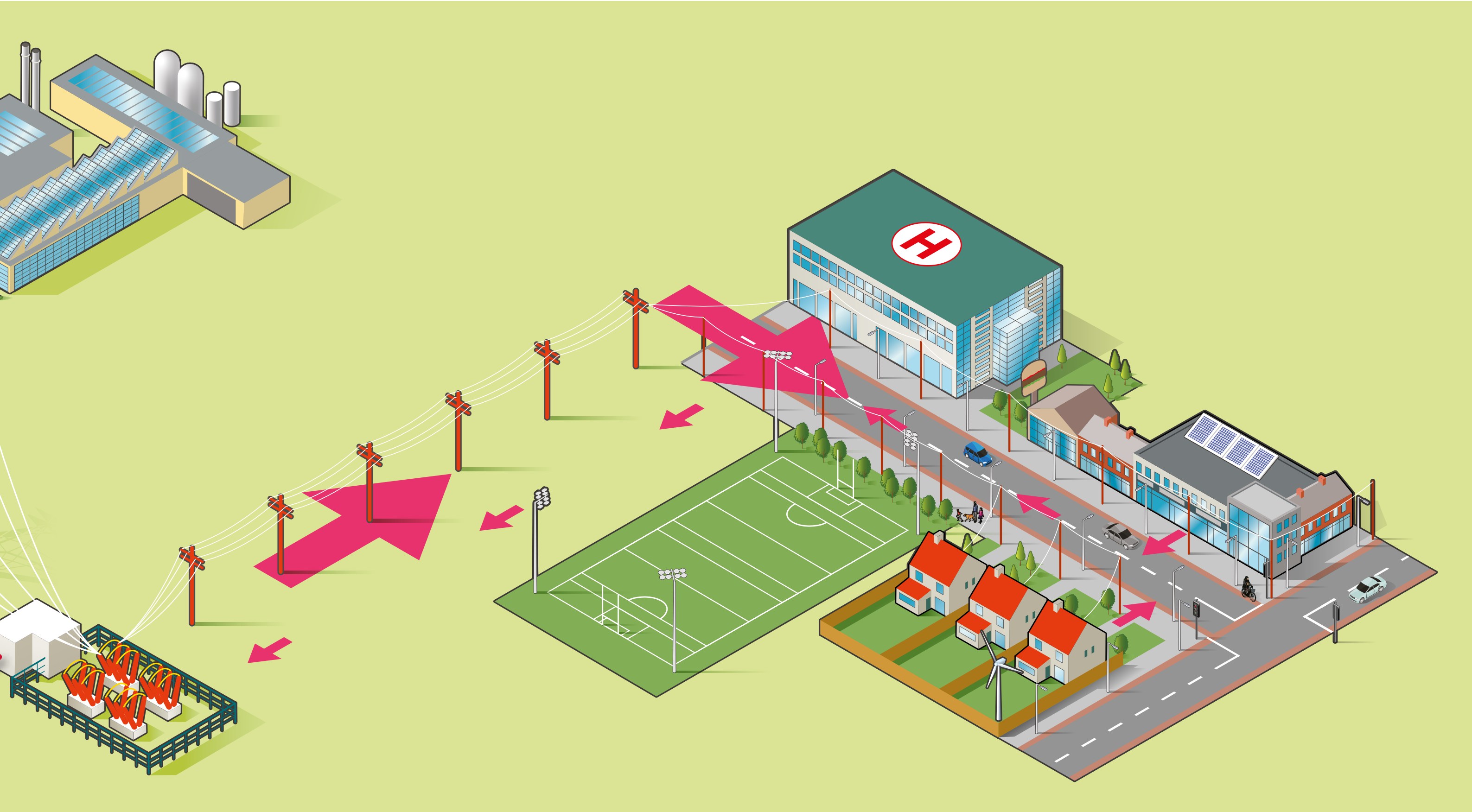
It is our responsibility to manage the need for power across the electricity transmission grid. We forecast when and where electricity is needed; hour-to-hour, day-to-day, and year-to-year.

We work closely with government to make sure there is sufficient electricity for industry to prosper and employment to grow.

We also keep the grid secure and reliable. Homes and small businesses connect to the lower-power distribution network; large industry and enterprise needs high-power, high-quality electricity that is supplied via the transmission grid.

We review our grid development plans regularly. Our last major review reflected the economic and energy demand forecasts of the time, and the objectives of local, national and European policy.

Generators supply the energy into key transmission stations around the country. We move this energy around the country via the transmission grid. The lower voltage distribution network, operated by ESB Networks, then supplies electricity to homes and businesses.



It is time once again to review the grid development strategy outlined in Grid25, our long-term approach to develop the transmission grid published in 2008. This review reflects the changes that have occurred in the intervening period. Our draft strategy reflects a changed economic context and, importantly, opportunities offered by advanced transmission technologies.

With this, our aim is to start a dialogue about the need for grid development, and to seek opinions and suggestions from anyone impacted by our plans.

Throughout this paper, certain topics are highlighted for your specific consideration. Your responses are valuable in helping develop the final strategy.

We will reflect the themes and issues you raise in our final strategy, which will be published later this year.

Ireland's Draft Grid Development Strategy

Executive Summary

EirGrid is a state-owned company, responsible for managing and operating Ireland's transmission grid. We work to ensure a safe, secure supply of electricity to homes, businesses and industry across the island of Ireland. We need to develop the transmission grid to guarantee a secure supply of electricity now and for future generations, and to facilitate local, national and European policies.

In 2008 we published Grid25, our long-term strategy to develop the grid. The strategy outlined the investment required to develop the transmission network in order to future-proof Ireland's electricity needs. We are now reappraising the need and the drivers for these investments.

This draft strategy responds to feedback received from the public, as a key part of our renewed efforts to encourage greater participation in our decision-making process. It also reflects an updated view of the economic context, and incorporates our growing experience of promising new transmission technologies.

The final strategy, to be published later this year, will support Ireland's wider policy objectives; economic, environmental and social – including the Government's Action Plan for Jobs and the IDA's Regional Development Strategy.

In addition, it will take into account the views of communities and representative groups, whilst also ensuring sufficient capacity is available for regional economic development.

In managing the overall cost, we will do our part to ensure that Ireland remains competitive – fostering economic growth, attracting new investments, and supporting indigenous jobs.

As we considered the options for our new strategy we faced a key question: How do we balance all these considerations? We have to ensure that our plans meet Ireland's electricity needs, without placing too great a burden on communities, or too high a cost on industry. How much investment is needed to adequately future-proof the grid? Too little investment now may have negative economic impacts in the future.

We want to deliver best value for the Irish people. We will build new infrastructure only when this is the right solution. We will select appropriate technology to get more from existing grid infrastructure, depending on the needs and circumstances in each case.

In summary: We will do more with the existing grid and make it work harder – before we build new transmission infrastructure.

Executive Summary

In 2015, we are nearly half of the way through the time period originally covered by the Grid25 Strategy. Since 2008, EirGrid has completed the construction of over 330 km of new circuits. We have also uprated over 1,200 km of circuits – adding capacity without building new infrastructure.

We previously reviewed this strategy in 2011. At that stage, the cost of Grid25 was reduced from €4bn to €3.2bn. This was possible because of revised future demand forecasts and through to the use of new technologies.

The need remains to reinforce the transmission grid. How this reinforcement is technically achieved may change in certain circumstances.

On the North South project[1], a new 400kV AC overhead line is still the most effective and appropriate solution.

However, for Grid West and Grid Link projects, alternatives to building 400kV overhead lines are being carefully considered. These are described in more detail in Chapter 5.

Grid25 delivered significant direct economic benefits[2], and the proposed revision to our grid development strategy will continue this trend.

Electricity transmission infrastructure has two additional long-term benefits for the overall economy:

- the availability of power capacity to support new investment and jobs;
- ensuring competitiveness by having cost-effective power capacity.

We confirm that our revised strategy will provide enough transmission capacity in all regions to meet demand forecasts.

We also highlight the connections and interdependencies that exist between national and European policies, and the balance that must be achieved between social, environmental and economic factors. These are the key drivers of our grid development strategy.

For example, the IDA has in recent years been extraordinarily successful in attracting high-tech foreign direct investment to Ireland.

One impact of these high-demand customers is potentially a need for additional capacity in Dublin, where a significant portion have chosen to locate.

An independent economic analysis carried out by Indecon has considered a number of scenarios and the impact these will have on the grid.

This publication sets out our view on the major investment projects necessary to meet Ireland's needs. This draft strategy relates only to Ireland, but is cognisant of the all-island energy market, and of the urgent need to secure electricity supply in Northern Ireland.

We want to start a discussion about the options open to us all. Some grid development is essential, as this document shows, but in certain cases it may be appropriate to reconsider how we deliver this.

1 The North-South 400kV Interconnection Development

2 Indecon Report, 2013

For particular projects, we consider in more detail the decisions that must be made to support energy policy objectives. These decisions will impact on local communities, and on the national economy, so they need careful consideration.

We are eager to hear your views on our draft strategy – and we have identified a number of specific questions throughout this document where we are particularly looking for your feedback. We have set up an online feedback service for this purpose at eirgrid.com/yourgridyourviews

We are publishing some supporting material to this document which provides more detailed information. These are found attached as appendices.

We will closely engage with the Department of Communications, Energy and Natural Resources and the Commission for Energy Regulation to ensure that our final strategy is consistent with their forthcoming Energy White Paper, and with wider government, regulatory, economic, and energy policies.

When responding to this draft strategy, we ask you to be aware of the trade-offs between technical, economic and social considerations. We want to work together to find an acceptable and effective outcome for Ireland. We encourage the participation of all stakeholders. This is your opportunity to influence our thinking as we develop our strategy for grid development across Ireland.

How this draft strategy document works

There are five main sections in this draft strategy.

Chapter 1 explains the need to develop the grid.

Chapter 2 outlines the work we've done to meet this need since 2008.

Chapter 3 sets out the broader context - looking at how the economy, the environment, government policy and other external factors affect what we do, and how we have responded.

Chapter 4 details the technical developments that have the potential to affect our future strategy.

Chapter 5 talks about the implications for our current projects.

Chapter 6 puts forward a summary and some overall conclusions. We've also provided a glossary at the back to help with some of the technical terms

Throughout this document, we ask for your views on particular topics. Please use our website to tell us what you think.

1 The Need to Develop the Electricity Grid

Patterns of power-flow across the transmission grid can change over time, such as when there is significant growth in demand, or following requests to connect to the grid from new electricity generators. Like other major infrastructure - road, water or telecommunications - electricity transmission assets have a finite lifespan and need to be upgraded and refurbished.

A secure supply of electricity is the lifeblood of any economy. Our transmission system must remain stable and secure under a broad range of possible circumstances.

These include:

- Changes to expected demand for electricity
- The closure of generators
- Changes to generation sources and their effect on operations

Demand for Electricity

There is a relationship between economic growth and electricity consumption. Due to more efficient energy use, this relationship is changing – meaning proportionately less energy is required as the economy grows. EirGrid's demand forecasts are based on the Economic and Social Research Institute's (ESRI) long-term forecast of moderate growth in economic activity. These forecasts are updated annually in the *All Island Generation Capacity Statement*[3].

Around the world, 2008 saw the most severe recession in decades. This resulted in significant variation between demand forecasts from 2008 to those from 2015. The graph in Figure 1-1 on page 10 illustrates the 2008 and 2015 peak demand forecasts up to 2025.

The 2015 peak demand forecast for 2025 has been scaled back considerably. It is now approximately 5,100 MW, compared to the 2008 peak demand forecast of approximately 8,000 MW.

In 2011 our population was 4.57 million, up 17% from 2002. The CSO projects that this will grow – up to an average of 1% a year from 2011 to 2026. This is an increase of 734,000 people in this period. This is a key consideration when planning the development of the transmission system.

3 www.eirgrid.com

1 The Need to Develop the Electricity Grid

Regional Demand Growth

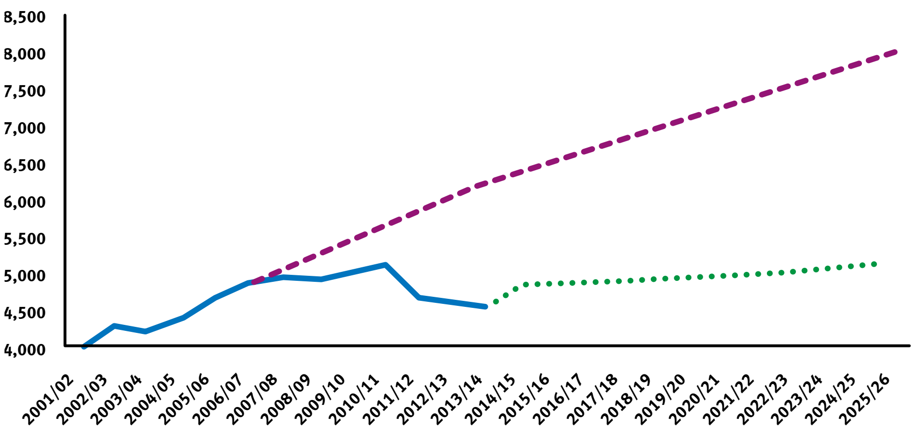
Our economy is returning to growth. This means renewal and expansion of the electricity transmission system becomes even more critical. This work will support job creation, economic development and economic competitiveness. Developing a 21st century transmission system will deliver real social, economic and environmental benefits for every person in Ireland.

By investing in a secure transmission grid we can create a balanced playing-field across the regions, and open the entire country to investment opportunities. Currently the majority of foreign direct investments are clustered around our larger cities. That's why developing the transmission grid is an important element in supporting the Government's drive to create jobs in the regions of Ireland.

A number of data centre operators have expressed interest in connecting large-scale facilities in the Dublin area.

Figure 1.1

Ireland Transmission Peak Demand (MW)



Recorded Peak Demand

2008 Forecast
based on Median Peak Forecast, Generation Adequacy Report 2007-13

2015 Forecast
based on Median Peak Forecast, Generation Capacity Statement 2015-24

These proposals would see substantial power loads connecting in this region by 2020 – this would represent a significant increase on current and forecast demand. Depending on the number and scale of projects that materialise, this may require new transmission solutions. EirGrid is working to ensure that all reasonable requests for demand can be facilitated.

Changing Generation Patterns

Ireland is on course to meet the Government's renewable energy target of 40% of electricity demand from renewable energy by 2020. A large proportion of this renewable electricity will come from wind power.

In Ireland, the Commission for Energy Regulation has directed that all generator applications for grid connections are processed using the Group Processing Approach - or 'Gate' Process. To date, there have been three 'Gates'. In Gate 1 and 2 (2004/5 and 2006/7 respectively) a total of approximately 1,700 MW of connection offers were made and accepted. In Gate 3, approximately 4,000 MW of renewable generation capacity received connection offers.

The uptake of Gate 3 offers is particularly high. As of January 2015 82% of offers had been accepted, 7% were under consideration and only 11% have been declined by applicants.

This high rate of acceptance of connection offers is in line with our original Grid25 assumptions. These additional connections indicate generation growth in areas that are distant from the urban centres where we typically have greater demand.

As peak demand and energy forecasts have been scaled back since 2008, there will be between 3,200 and 3,800 MW of renewable energy sources required to deliver the 40% target.

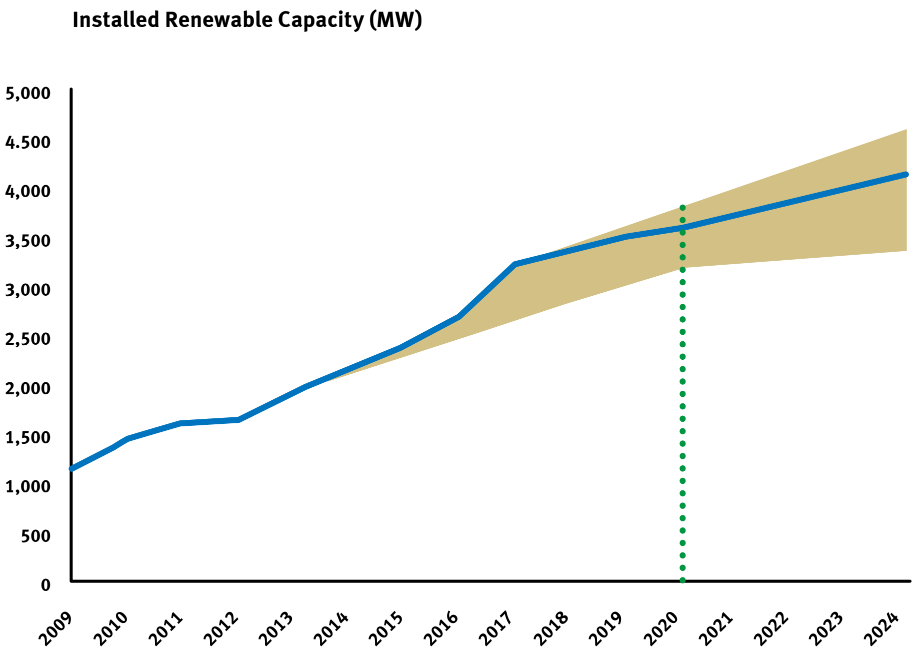


Figure 1-2
Band of Possible Renewable Requirements to meet the 2020 Renewable Target

This graph shows how much additional capacity from renewable sources will be required to meet EU targets by 2020. Whilst Ireland is on target to meet this goal, doing so will add almost 4000MW of generative capacity, which is simply not possible on the current grid. We must add additional transmission capacity to meet this need.

This draft strategy suggests how EirGrid can meet contractual obligations to offer connections to new generators – without overbuilding the grid. Crucially, we need to achieve this balance whilst also meeting national energy policy objectives and increasing Irish competitiveness.

Conventional Generation

Grid25 considered how a range of conventional generation scenarios would affect electricity transmission. These included connecting new generation capacity and the closure of existing plants. Developments including new generation capacity in east Cork and in the south east, were predicted and planned for.

Peak demand and energy forecasts have been scaled back – so the additional required capacity from conventional thermal generators is reduced. Grid25 assumed that capacity would be constructed at brownfield sites closer to traditional load centres along the east coast.

Based on analysis carried out for this draft strategy, we now consider that this construction is unlikely to happen in the timeframe originally envisaged. Instead, new generation is now expected to be located in the west, southwest and southeast. The location of these new generators will only serve to increase the main power flows from these remote locations.

Historically, Ireland benefited from electricity imports from Northern Ireland in order to balance supply and demand and maintain security of supply. In recent times the generation portfolio has changed, with the commissioning of new and more efficient plant in Ireland. This will change further as a result of anticipated plant retirements in Northern Ireland. It is therefore likely that Northern Ireland will need more generation imports from Ireland at times of high demand in the next decade, in order to balance supply and demand and maintain security of supply. For more details and analysis, please see the All Island Generation Capacity Statement.

East West Interconnector

High-voltage direct current cable
Runs undersea & underground
Links grids in Ireland & Great Britain

Completed **2012**

264km Long

187km undersea

500 Mw Capacity

Powers **300,000** homes

Interconnection

In addition to investing in the electricity grid within Ireland, the transition to a competitive, low-carbon, energy system requires us to explore opportunities for increased interconnection to other countries.

The current level of interconnection capacity linking Ireland to other markets is in line with the current EU objective of 10%.

The European Commission is now considering 2030 targets, one of which is a possible increase in interconnection targets to 15%.

In 2007, EirGrid commenced work on an interconnector between Ireland and the UK. This project was delivered on time and in budget, and has been operational since 2012.

EirGrid is now working in co-operation with our French counterparts - Réseau de Transport d'Électricité (RTE) - to explore the possibility of an Ireland-France interconnector.

Who pays for these improvements to the grid?

EirGrid is state-owned, public limited company. We are funded by the "Transmission Use of System" charge, which is levied to users of the transmission network. These charges are approved by the Commission for Energy Regulation. For the most part, this funding system is designed to ensure that heavier users pay more for the grid.

Development Needs

1. What are your views on our proposals to develop the electricity grid to support Government plans for new investment and jobs?
2. What are your views on our other reasons for continuing to develop the electricity grid?

Tell us your views
eirgrid.com/yourgridyourviews

2 Grid Development Since 2008

Our Grid25 strategy was published in 2008. Electricity demand had grown by an average of 4% per year over the previous decade and forecasts up to that point had predicted this trend would continue. A driver of our 2008 strategy was to promote efficient and cost-effective development and, importantly, to avoid multiple projects in an area if a single solution was viable. These factors combined to favour overhead solutions as opposed to underground alternatives.

Grid25 identified the need for several projects of varying scope. We planned to upgrade existing lines to allow for increased capacity transfer; we planned to build new lines and stations; and we planned significant new regional connections, such as the Grid West and Grid Link projects. Progress on these projects is shown in the tables on the following page.

Given the scale of the Grid25 Strategy, EirGrid prepared and implemented policies concerning planning and environmental issues, including landowner engagement, wayleaving and project communications - to ensure a consistent approach for all Grid25 projects.

In comparison to previous electricity transmission investment strategies, the scale of Grid25 was much greater. Delivering this strategy presented challenges.

Since then, EirGrid has gained considerable experience in areas such as project delivery, risk management, project lead-times, landowner engagement and access agreements. We also learned greatly from our engagements with the public and with communities.

Project Delivery

For the minor projects - such as line uprates - the estimated lead-times have been broadly accurate. This is also the case for new substation builds. However, for new and large-scale linear projects, our original estimates for lead-times have proven to be overly optimistic.

A number of factors contributed to this - including time required to select a route and time for public consultation and evaluation.

EirGrid and ESB Networks are now jointly reassessing project lead-times based on our joint experience of grid delivery since 2008. We have created a joint programme management office to improve the efficiency of our project delivery process.

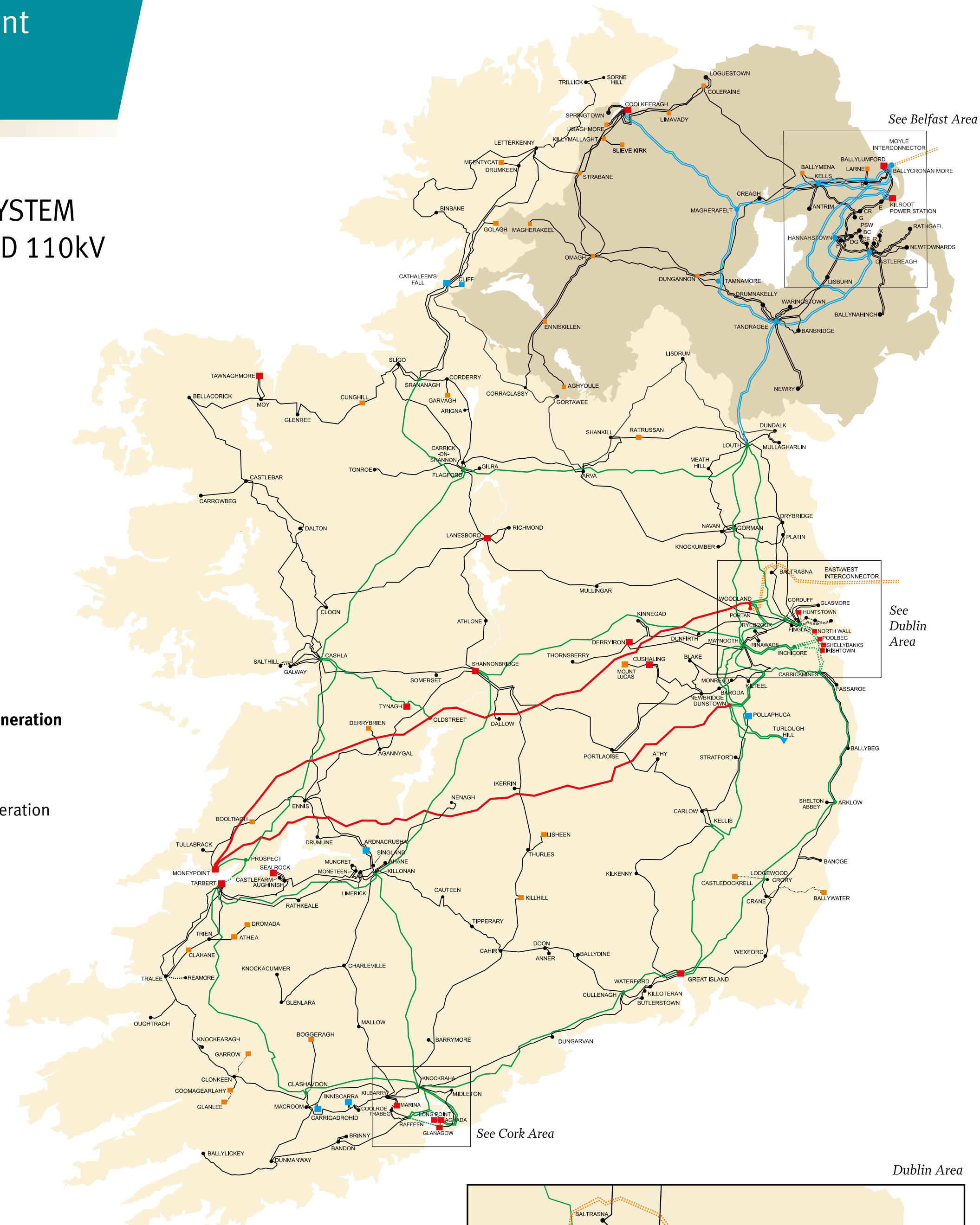
Over the last seven years a considerable number of grid development projects have been delivered. A summary of the transmission projects that were delivered is described in Tables 2-1 and 2-2 on the following page.

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

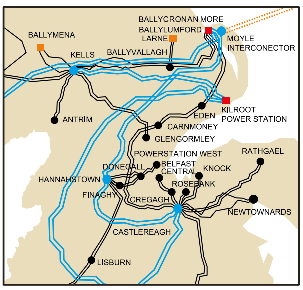
- 400kV Lines
- 275kV Lines
- 220kV Lines
- 110kV Lines
- 220kV Cables
- 110kV Cables
- HVDC Cables
- 400kV Stations
- 275kV Stations
- 220kV Stations
- 110kV Stations

Transmission Connected Generation

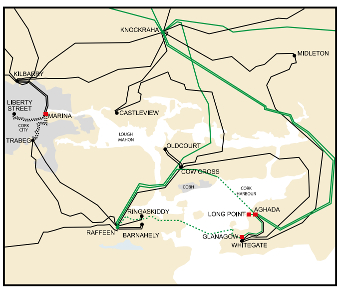
- Hydro Generation
- Thermal Generation
- Pumped Storage Generation
- Wind Generation



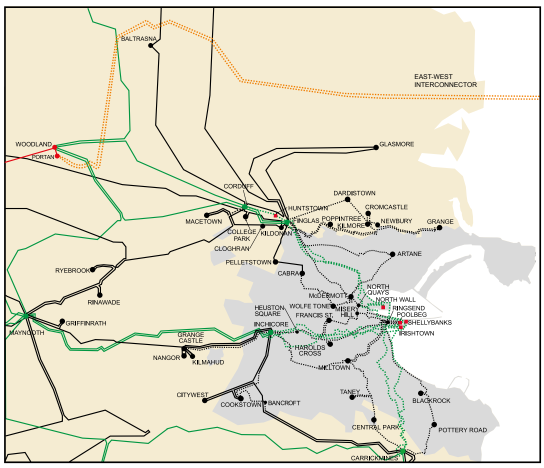
Belfast Area



Cork Area



Dublin Area



	Submitted	Granted [1]	Application Withdrawn
An Bord Pleanála	13	12	1[2]
Local Planning Authority	20	17	0

Table 2-1 – Summary of Planning Consents

1 The “Granted” figures include those projects granted with conditions.

2 The North-South 400kV Interconnection Development Project planning application, submitted to An Bord Pleanála in December 2009, was withdrawn in June 2010 on account of an error in the public notice of the planning application.

Planning Consents

Most electricity transmission projects are classed as Strategic Infrastructure Development, which means EirGrid makes a direct application to An Bord Pleanála for planning consent.

Table 2-1 summarises applications that we have submitted since 2008. These include projects classed as strategic electricity transmission infrastructure development, where we applied to An Bord Pleanála, and projects that were not deemed to meet this classification, where we applied to the relevant planning authorities.

Capital Expenditure

€938 million was spent between 2009 and 2013 on transmission projects. The figure does not include the cost of the East West Interconnector or the circuits required to connect new generation stations to the grid.

Projects Completed

Table 2-2 summarises line uprates and new build projects since 2008. EirGrid has completed over 330 km of new lines and over 1,200 km of line uprating. Of this 1,200 km, approximately 510 km were uprated using high-temperature low-sag (HTLS) conductors. This technology allows for significant increase in capacity to the grid at a much lower cost. The remainder were uprated using more conventional conductors. As these figures demonstrate, we maximised existing network capacity by upgrading the infrastructure already in place.

In addition, a number of new 220kV and 110kV substations that have progressed through planning are currently in the construction and energisation phase. All projects are detailed in the annual Transmission Development Plan, and are available on the EirGrid website.

Project Completions (km)*		
Voltage	New Circuit	Line Uprating
110kV	244	956
220kV	93	325
400kV	0	0
Total	**337**	**1281**

Table 2-2 – Summary of New and Uprated Circuits

* The project completion figures do not include the East West Interconnector or the circuits required to connect new generation stations to the grid.

3 The Wider Context

Delivering an efficient transmission grid requires long-term planning and must be consistent with wider national social, economic and energy policies. The Department of Communications, Energy and Natural Resources is currently carrying out a review of Ireland's energy policy for an Energy White Paper, which it will publish later this year. Our draft strategy will be submitted for the Department to consider. EirGrid will then assess the implications of any significant changes in energy policy before we publish our final grid development strategy.

EU Policy Trends

Emerging EU policies aim for smart, low-carbon, economies centred on energy efficiency. To achieve this, the EU encourages the use of low or zero carbon generation technologies, and the deployment of smart grid technologies. To deliver these policies, Ireland's electricity grid must be developed.

EirGrid is committed to maintaining a reliable grid, providing high-quality, affordable electricity supplies to all consumers.

Our final strategy will deliver a transmission grid that can support potential economic opportunities, whilst also enabling continued recovery, and facilitating balanced regional development.

Energy Policy

In common with many other EU member states, Ireland faces three crucial and inter-related energy challenges: energy security, sustainability and competitiveness. We are heavily reliant on energy imports, leaving us particularly vulnerable to the fluctuations of international energy prices.

In 2013, 89% of Ireland's total energy use was imported, costing an estimated €6.7 billion[4]. That same year, almost 50% of Ireland's electricity generation came from imported natural gas.

4 Source: SEAI

3 The Wider Context

Ireland has a target to increase its share of renewable energy in the electricity sector to 40% by 2020. This is a step towards reducing our dependence on imported energy. The development of a sustainable energy power system requires the modernisation and strengthening of the electricity transmission grid.

In addition to increasing capacity, EirGrid is also investing in operational technology – including advanced information and communication systems.

These will allow us to operate the grid securely, while increasing our ability to take variable generation from renewable sources like wind. New technology will also empower consumers to have more say on how and when they consume electricity.

The central role of the transmission grid to Irish society and the economy was confirmed in the 2012 Government policy statement on the strategic importance of transmission energy infrastructure.

It reaffirmed "the imperative need for development and renewal of our energy networks, in order to meet both economic and social policy goals". It also recognised "the need for social acceptance and the appropriateness of building community gain considerations into project planning and budgeting."

In addition to investing in the transmission grid within Ireland, the transition to a competitive, low-carbon, energy system requires us to explore opportunities for increased interconnection to other countries.

The Economic Context

As outlined in Chapter 1, EirGrid bases our demand forecasts on technical, economic and environmental analyses - and changes to these factors will impact on our forecasts. In 2008, we anticipated that the grid would need to carry 60% more power by 2025. This estimate was based on a predicted average yearly growth in Gross Domestic Product (GDP) of 4% over the same period[5].

However - between 2008 to 2012, Ireland's Gross National Product (GNP) actually declined by 10%[6].

Electricity demand in Ireland has closely matched recent economic volatility. Following a 7.1% fall in demand between 2008 and 2012, electricity demand grew once again in 2013 by 1.1%. This was in line with an increase of 3.4% of Ireland's Gross National Product. The demand for electricity is now expected to grow on average by 1.3% per annum from now to 2025.

Thus, while the economic downturn reduced electricity demand, recent trends now point to steady growth in the economy – and in electricity use – out to 2025. Although this is now at lower levels than previously predicted.

The total scope of Grid25 was revised down by almost 20% in the 2011 review. This was possible because of new transmission technologies, and a reduction in projects. We are now closely examining, once again, all of the information available to us – to ensure that our grid development strategy meets the needs of all users.

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5 Previously, the economic parameters of GDP were employed in the forecast model as advanced by ESRI. In 2014, the ESRI recommended the use of a modified GNP parameter, which has led to a more robust model.

6 Percentage figures for Gross National Product (GNP) adjusted for re-domiciled public limited companies (historic and future) was provided by the ESRI in October 2014.

Region	€ Million	
	1 Hour Outage	24 Hour Outage
Republic of Ireland	24.2	579.6
Border	2.6	63.4
Midland	1.5	36.5
West	2.3	55.0
Dublin	6.7	160.3
Mid-West	2.0	47.6
South-East	2.6	63.5
South-West	3.5	84.7
Mid-East	2.9	68.8

Table 3-1 – Economic cost of an electricity disruption for residential users, by region. Note: Based on applying London Economics' estimates. Source: Indecon analysis

Contributing to the Local Economy

The economic benefits of developing grid infrastructure are spread throughout the economy. A modern grid can help reduce energy costs and provide a secure basis upon which businesses can invest and expand.

As Ireland returns to economic growth, the renewal and expansion of the electricity transmission system is important to support job creation, economic development and regional competitiveness. Developing a 21st century transmission system will deliver concrete social, economic and environmental benefits for every person in Ireland. In particular, only by investing in a secure transmission grid will we open up large areas of the country to investment from the types of high-tech industries currently clustered around our larger cities. Economics consultancy Indecon has proposed a number of possible measures to increase the attractiveness of regional locations for investment. In this way, developing the transmission grid is an important element in supporting the Government's drive to create jobs in the regions of Ireland.

The Action Plan for Jobs and IDA's Regional Development Strategy

Ireland is a small, open economy with over 1,000 international companies operating across a wide range of business activities. Indeed, Ireland is ranked as one of the most attractive business locations in the world and continues to attract world-class investments. The IDA has cited access to a high quality electricity grid as critically important for attracting new investment[7].

It highlights the ICT and high-tech manufacturing sectors in particular as requiring a high-quality power supply. This is supported by the Indecon Report, published as an appendix to this document.

The second progress report on the Government's first Action Plan for Jobs emphasised the importance of access to a secure and affordable supply of electricity – for new and future investment. The importance of energy costs to Ireland's overall economic competitiveness is further emphasised in the Government's 2015 Action Plan for Jobs.

7 "Winning: Foreign Direct Investment 2015-2019" www.idaireland.com

Public Engagement

In 2014, the Department of Communications, Energy and Natural Resources issued a public consultation on Energy Policy in Ireland – the Green Paper. This paper highlighted the challenge of seeking acceptance from communities of electricity transmission infrastructure. This means that when designing future energy policy, we must consider how to build social support for energy initiatives.

For EirGrid, it was clear towards the end of 2013 that we needed to review how we consulted on our projects. Throughout 2014 we carried out a comprehensive review of our approach to public consultation. This concluded with a detailed report, supported by analysis from independent experts the Institute of Arbitrators and SLR Consulting.

This review reaffirmed the importance of engagement with people and communities directly impacted by planned development to the transmission grid, and by current grid projects. The review highlighted where we did not meet people's expectations and where changes would improve future engagement.

EirGrid has obligations under the Aarhus Convention in relation to early public participation in environmental decision making. We have ensured, and will continue to ensure, that the principles in the Aarhus Convention are integrated into our processes. This will be done through public consultation and feedback during all stages of transmission projects.

Public consultation also forms part of any application by EirGrid for statutory planning consent on our projects.

EirGrid is committed to engaging with communities to provide clearer information on the work that we are doing - and most importantly, why we are doing it. We are in the process of creating a tool-kit to enable people to participate more effectively in the project development process. We will also locate more EirGrid staff around the country to support our consultation process.

In addition, we will hold a series of Regional Discussion Forums in the coming months. These will be independently chaired, and will facilitate more detailed and technical discussions on our grid development strategy.

Community Gain Fund

We have committed to implementing a Community Gain Fund made up of two elements:

Community Payments

An EirGrid funded payment of €40,000 per kilometre to communities in proximity either to new 400kV pylons or to new outdoor rural stations.

We will pilot a number of implementation methods before we roll this out on a national basis.

Proximity Payments

A once-off payment to owners of occupied residential properties (or those with full planning permission) within 200 metres from the closest point of the property to the new transmission pylons, or within 200 metres from a new outdoor rural station.

We always seek to locate overhead transmission lines and stations at least 50m from homes. In exceptional cases where this is not achievable, EirGrid will engage with the affected property owners on an individual basis.

Protecting our Environment

It is an essential part of EirGrid's work to understand how the development of the transmission system has potential to affect the environment. Consideration of the environment is central to how we work – whether we are looking at a review of our overall grid strategy, or simply the progress of a particular project. We ensure that we comply with all national and EU guidelines.

A full SEA was applied to the original Grid25 implementation plan (IP) 2011-2016, with both documents published in April 2012. The results of this SEA are available on www.eirgrid.com. It was intended that following adoption, the IP and associated SEA would have a 5–year lifespan, with the review and drafting process for the subsequent IP and SEA commencing within the final year of that lifespan. Therefore when this grid development strategy is finalised, it will form a fundamental element of the next implementation plan and associated SEA, the preparation of which will commence in the second half of 2015.

Health & Safety

EirGrid regards the protection of the health, safety and welfare of its staff and the general public as a core company value.

We design and operate the transmission network to the highest relevant safety standards and to comply with the most up to date international guidelines.

4 New Transmission Technologies

EirGrid continually reviews technological developments to assess their potential use on the Irish transmission system. New transmission technologies can offer a number of advantages. These include: reduced capital and operational costs, reduced social and environmental impacts, improved system reliability.

New Technology at Research and Development Stage
Complex DC Networks
New Voltage Uprate strategies

New Technology Ready for Trial Use
Power Line Guardian
Voltage Uprating
Next Generation HTLS
New Tower Designs

Technology Available Now
HTLS
AC Lines
AC Cables
Linear HVDC
Series Compensation
Dynamic Line Rating

The possible advantages of new technologies will always be balanced with the need to ensure a reliable, secure electricity supply. EirGrid characterises new technologies in three broad categories, as shown above. We work with industry partners, technology innovators and with other transmission service operators to identify, research and trial possible innovations. The following section describes many of the most promising technologies in each of these categories.

EirGrid is assisting industry in identifying, developing and trialling new technologies, new products and new services. To manage the operation of the power system over the coming years, we have a world-leading initiative called “Delivering a Secure, Sustainable Electricity System DS3”.

4 New Transmission Technologies

Technology Available Now

AC Overhead Lines

AC overhead transmission lines have been in operation for many years, and they represent a highly efficient and reliable means of transmitting electricity. They comprise the vast majority of transmission infrastructure in use across the world today. In Europe, approximately 98% of transmission circuits are overhead AC lines.

High-Temperature Low-Sag (HTLS) overhead line conductors

HTLS technology was introduced to the Irish transmission system in 2011. These higher capacity conductors can operate at higher temperatures with lower sag characteristics, ensuring we can maintain critical clearances from trees and other obstacles.

These first generation HTLS conductors have been used successfully by EirGrid and ESB Networks as part of the Grid25 strategy, achieving approximately a 60% increase in capacity on over 500km of our existing 110 and 220kV overhead lines.

AC underground cable technology

Underground cable technology has been used in Ireland for many decades. Traditionally it was used in limited cases, where a route for an overhead line could not be found. However, the capacity of underground cables continues to increase. Similarly, there is also growing international expertise in determining how greater amounts of underground cable can be reliably incorporated onto a transmission system.

Our most recent analysis has identified that Ireland, due to its smaller size compared to other networks, is at greater risk of issues arising through the use of AC underground cables. We have concluded that a number of techniques existed which could reduce - but not avoid - these issues.

Investigations into the use of longer lengths of underground AC cable on the Irish transmission network have typically found that for 220kV cable, the maximum feasible length is up to 30km – depending on the specific situation. For 400kV, it is considerably shorter – approximately 5 to 10km.

HVDC and DC transmission

The transmission grid in Ireland, like other European and international grids, uses High Voltage Alternating Current (HVAC). Where power is transferred from point to point over long distances it may be cost-effective and technically possible to use High Voltage Direct Current (HVDC) instead.

One advantage of HVDC is that a full circuit can be placed underground. HVDC is a mature technology that is available for integration on the Irish transmission system. This technology is considered, where appropriate, on each project. EirGrid has included this technology in a number of recent project evaluations. In 2012, we developed a HVDC interconnection between Ireland and Wales.

Series Compensation

Series compensation has been used to boost flows on very long transmission lines in some parts of the world - such as Russia and the US - for several years. It has traditionally not been used on smaller systems such as some of those found in Europe. Recent advances in technology and control systems allow greater flexibility in and benefits from the application of series compensation.

Dynamic Line Rating

The capacity of an overhead line is influenced by conditions such as temperature, wind speed, wind direction and other factors. Dynamic line rating involves the installation of devices to monitor these conditions and allow higher power flows when conditions permit.

However, as long-term variations in meteorological conditions are difficult to predict, these enhanced ratings are not generally used for system development. Instead, the technology can be used in the short-term to reduce potential network bottle-necks while awaiting delivery of grid development projects. EirGrid has trialled Dynamic Line Rating on several lines, and will continue to evaluate whether additional use is appropriate in specific circumstances.

New Technology Ready for Trial Use

Power Line Guardian

Power management technologies have been increasingly used in recent years to make better use of existing grid infrastructure. We are investigating technologies to consider their use on the Irish grid. A pilot trial using new technology known as *Power Line Guardian*[8] is underway. These devices can be rapidly deployed onto existing overhead lines. They allow power flows to be diverted from heavily loaded overhead lines or cables to more lightly loaded ones. This allows the existing grid to be used more effectively.

Voltage Uprating

It is possible to increase the capacity of a line by increasing its operating voltage. This generally requires considerable modifications within substations and a complete rebuild of the overhead line. In many cases, the length of time the line must remain off makes this prohibitive.

EirGrid is actively supporting research and development efforts into new voltage uprating technologies that would involve less structural modifications. This makes the uprating quicker to complete and lowers the overall cost of this approach. This technology may become a technically and economically viable option for the grid before 2025.

Second Generation High Temperature Low Sag (HTLS) overhead line conductors

New HTLS conductors that could potentially double line capacity are undergoing field trials. Should they prove successful, they may become available – although their application is likely to be restricted to voltage levels greater than 110kV.

New overhead line structures / new tower designs

EirGrid is actively considering new tower designs and other measures to minimise the visual impact on the landscape. These measures were outlined in a 2008 Government-sponsored report issued by Ecofys on *The Comparative Merits of Overhead Electricity Transmission Lines Verses Underground Cables*. In addition, EirGrid will also take account of the National Landscape Strategy when this is published.

New Technology at Research and Development Stage

For details of these technologies, see Appendix 1. (EirGrid Technical Report)

New tower designs currently under consideration

8 Developed by Smart Wires

5 Proposed Strategy for Grid Development

In this chapter we put forward various solutions to upgrade the transmission network. These reflect the evolving national, economic and social requirements detailed in previous chapters. We outline our updated assumptions for the overall strategy, and describe how these assumptions could impact current projects.

Factors that Influence our Strategy

Three main factors have influenced our strategy to develop the national transmission grid:

- Feedback received during the consultation process on major projects
- Advances in technology
- Changes in the external economic environment

These factors are the basis for EirGrid's three new strategy statements, which we describe below:

Strategy Statement 1

Open engagement and inclusive consultation with local communities and stakeholders will be central to EirGrid's approach to network development

We acknowledge the sensitivities associated with major transmission infrastructure development.

In response to major project consultation feedback, and to follow through on the Grid25 initiatives announced in 2014, EirGrid undertook to carry out thorough internal and external reviews of our consultation process. This task of reviewing and improving the consultation process[9] is now complete. One of the outputs of this is a review of our current *Project Development and Consultation Roadmap*.

We are committed to enhancing public participation and community engagement as part of this process.

9 http://www.eirgrid.com/aboutus/publications/gridinitiatives/

Strategy Statement 2

All practical technology options will be considered for network development

One of the themes raised during recent consultations was the need to conduct a comprehensive underground analysis for Grid Link and Grid West. While underground technology has always been considered during initial project scoping and technical analysis, in future, we will always publish underground options for public consultation.

We also commit to engaging with the public before we identify a preferred technology. This consultation will explain the transmission technology options, and then seek feedback from stakeholders.

This will assist us in determining the best transmission technology for future projects. We are committed to looking for alternative options that may avoid or reduce the necessity for new overhead lines.

Strategy Statement 3

The network will be optimised to minimise requirements for new infrastructure

EirGrid will continue to maximise the use of the existing transmission network. Where we can increase the capacity of existing infrastructure, or use new technologies, this can remove the need to construct new lines. This strategy lowers costs and ensures that there will be potentially less impact on the environment and on local communities.

Impact on Strategy

To provide greater transparency and a clearer understanding of the impact of this review of Grid25, the strategy is now broken up into seven individual regions across Ireland as shown in the pie chart in Figure 5-1 below.

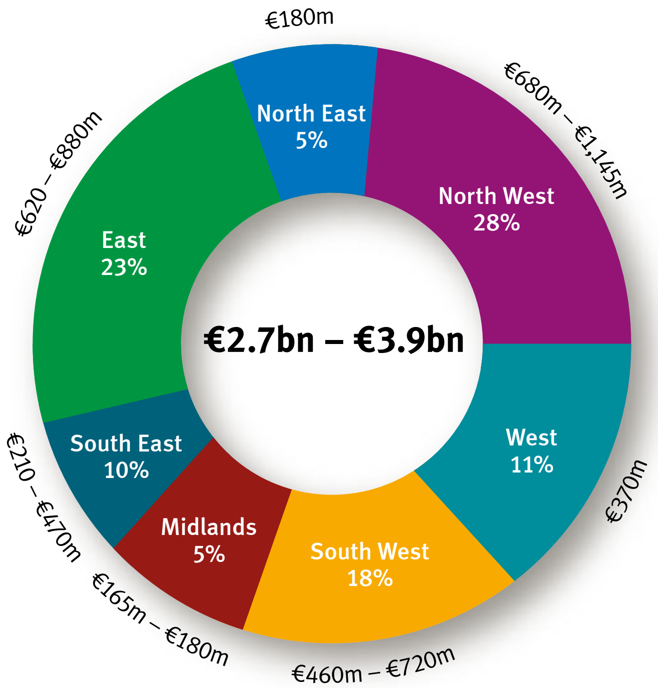


Figure 5.1
Regional breakdown of investment.

For detail on these regions, please consult the supporting appendices.

Major Projects

North South Interconnector

Background

EirGrid and the System Operator for Northern Ireland (SONI) are jointly proposing a new high-capacity electricity interconnector between the electricity networks of Ireland and Northern Ireland.

The proposed development is a 400kV overhead line linking a substation in Woodland, County Meath with a planned substation in Turleenan, County Tyrone.

It will provide a second high-capacity electricity transmission line between the two jurisdictions.

Why is this being proposed?

The interconnector is critical to ensuring a safe, secure supply of electricity throughout the island of Ireland.

It will bring about major cost savings and address significant issues around security of electricity supply, particularly in Northern Ireland.

A key benefit will be the removal of bottlenecks between the two systems. This will enable them to operate together as if they were one network benefiting residents and businesses in both jurisdictions.

This will bring cost savings for electricity consumers, as larger electricity systems operate more efficiently than smaller ones.

Interconnection will also facilitate greater connection of wind generation which will help achieve Ireland's renewable energy targets.

Has EirGrid evaluated an underground option for the project?

There have been numerous studies of underground options.

Most recently, in July 2014, a Government-appointed Independent Expert Panel provided its opinion on whether EirGrid had adequately examined an underground option for this project.

The panel compared the work to date on this project with its recently formulated terms of reference for EirGrid's Grid West and Grid Link projects. It found that, in all material respects, the studies and work undertaken on the interconnector project was compatible with the methodologies now being employed on the Grid West and Grid Link projects.

What has happened recently?

The project was designated a Project of Common Interest (PCI) by the European Commission in October 2013. PCIs are energy projects deemed by the European Commission to be of strategic, trans-boundary importance. This will be the first PCI in Ireland to be submitted for planning approval.

In November 2014, as part of the PCI process, EirGrid submitted a draft planning application file to An Bord Pleanála for review.

What is happening now?

In December 2014, An Bord Pleanála informed EirGrid that it had reviewed the draft planning application file and asked for certain specified missing information to be submitted.

In March 2015, EirGrid submitted the requested information to An Bord Pleanála. It will advise on the timing of the various steps in the statutory planning process.

What happens next?

Our review of Grid25 found there remained a compelling and clear need for the project. We expect to submit a planning application for the North South 400kV Interconnection Development in the coming weeks.

We remain committed to our new standards of consultation to ensure that all interested parties have an opportunity to voice their views. To that end, we have recently opened local offices in Carrickmacross, Navan and Kingscourt.

Grid West

Background

In 2008, as part of its "Gate 3" process, the Commission for Energy Regulation set out the process for EirGrid's consideration of applications from companies that wished to connect to the distribution and transmission networks. In the west of Ireland, 647MW of renewable generation projects have entered into a contract and are awaiting a connection – in areas around the existing Bellacorick 110kV substation in north Mayo.

An assessment of the network capability in north Mayo showed that the existing 110kV network, even if upgraded, could not handle this amount of additional generation.

Therefore, we need to add an additional transmission line or cable. Plans to develop a solution were included as part of our Grid25 Strategy.

Is this still needed?

Yes. The current grid cannot accommodate the volume of power that is proposed in the west.

What was originally proposed?

To meet these connection needs, EirGrid originally looked at a number of factors, including; demand forecasts, available technology, cost, and environmental considerations.

The conclusion of all of these studies was that the best option to meet the needs of the project was a 400kV High-Voltage Alternating Current (HVAC) overhead line.

Are there other solutions?

Yes. The most appropriate solution for any project is determined by the details of that project – its location, scale and purpose. In 2008, EirGrid considered these factors for Grid West, taking into account cost-effectiveness, long-term forecasts, and the known reliability proven transmission technologies.

In 2014 EirGrid agreed with feedback from the public that we had ruled out underground alternatives too soon in the process. We then reassessed underground cables to see if they could meet the needs of the project and to determine how they performed in environmental, economic and technical terms. We also investigated if the capacity needs of the generation companies could be met using a lower voltage solution.

Strategy Statements

3 Strategy Statement 1
Optimise the current network in order to minimise requirements for new infrastructure.

4 Strategy Statement 2
Consider all practical technology options for network development.

5 Strategy Statement 3
Foster open engagement and inclusive consultation with local communities and stakeholders as a central principle to developing the grid

Tell us your views
eirgrid.com/yourgridyourviews

Based on this review, we found that there are three possible solutions:

- A High Voltage Direct Current underground cable - which allows for a fully underground solution. Capital Investment: €475m
- a 400kV High Voltage Alternating Current overhead line with 8km of undergrounding. Capital Investment: €220m
- A 220kV High Voltage Alternating Current overhead line with partial use of underground cable to the maximum possible extent – up to 30km. Capital Investment: €205-250m, depending on length of underground sections.

Which solution will be chosen?

A detailed analysis of the economic, technical and environment impacts of the three solutions has been presented to the Government-appointed Independent Expert Panel (IEP).

It is expected that the panel will publish its opinion on the report shortly. The report will then be published and we will be asking you for your feedback, we expect this will occur in May 2015.

We will then balance the wider economic environment, technical developments and, most importantly, the views of industry, policymakers and the people of the west to find the best outcome.

Grid Link

In 2008, studies indicated that, if left as is, the existing transmission system in the south and east of Ireland would not meet either Ireland's or the region's future electricity requirements.

There are three main drivers for this project:

Security of supply

Despite the recent drop in electricity demand, there remains a risk to the security of supply in the south and east of the country. This is largely caused by heavy power flows through the network.

Integrating renewable energy

To achieve Ireland's target of providing 40% of our electricity from renewables by 2020, significant levels of renewable generation will be connected in the south and east of the country. The transmission system must be able to facilitate the flow of this power from where it is generated to where it is needed.

Future interconnection

EirGrid, with its French counterpart, is currently exploring the feasibility of an interconnector with France. This would give Ireland direct access to a mainland European electricity market, strengthening our security of supply and creating opportunities to import and export electricity. It is important to stress that no decision on a French interconnector will be made for some time. Private developers are also exploring interconnection to Great Britain.

Is this project still needed?

Yes. However, changing demand forecasts, a slower rate of growth, upgrade works on existing lines and advances in technology means it is now possible to consider alternative solutions.

What was originally proposed?

The original Grid Link Project was designed to maximise the long-term benefit of new infrastructure by using the most secure and cost-effective technology. This resulted in a proposal to build a fully overhead 400kV HVAC overhead line at a capital investment of €500-550m.

Are there other solutions?

Yes – we have researched a number of options, and in this discussion paper we are proposing two additional solutions.

Firstly, it is possible to put the line underground using HVDC technology – but at a significantly higher cost. The capital investment of this option would be €800-850m.

Secondly, we can introduce a technology known as 'series compensation' onto the Irish transmission grid for the first time.

This advanced smart grid technology would allow us to put more power on existing lines so that we could address the current weaknesses of the system.

Although it would require no significant new overhead infrastructure in the southeast, an underwater cable would be needed across the Shannon estuary. This will allow electricity generated in the southwest to cross the Shannon and be transferred from there on the existing 400kV line from Moneypoint.

Although series compensation technology has been used mainly on long distance lines for example in the US, this would be one of the first times it has been used in a network the size of Ireland's.

The capital investment for all the elements in this solution is €200-€250m.

Which solution will be chosen?

EirGrid will engage with stakeholders to discuss the possible options as we continue our evaluation of the three potential solutions outlined here, with a view to making a submission to the Independent Expert Panel in Autumn 2015.

Following its review it is expected that there will be public consultation towards the latter part of this year.

Other Projects:

Moneypoint - North Kerry project

This project will facilitate the connection of wind generation in the south west.

The project was initially conceived as a 400kV part overhead and part submarine circuit connecting Moneypoint generation station in Co. Clare and a new 220kV substation in North Kerry.

The project is now a 220kV cable solution using a new type of high-capacity cable. Cost benefit analysis identified that the higher cost of utilising a cable solution would be compensated by the benefits of earlier delivery. This resulted in the land portion of the project being changed from overhead line to underground cable.

The North West project

As part of the overall need to increase capacity for renewable generation across the island of Ireland, we need to strengthen the grid in the North West. We will be consulting with the public on the need for this project, and on a range of possible solutions later this year.

The West Dublin project

This project is at the earliest point in the development cycle. The project will increase the strength of the link between two 400kV stations at Dunstown and Woodland. EirGrid is examining the full range of practical technologies including maximising existing infrastructure.

Scale of our proposed new Grid Development Strategy

The original estimated cost of Grid25 was €4bn; in 2011 the overall scale of the Grid25 strategy was revised down to €3.2bn. This was made possible by falling forecasts for future demands, and through the use of new technologies. For new transmission circuits, the final costs will vary depending on the different technologies that are used on individual projects, but we anticipate that the final cost will be in a range from €2.7bn to €3.9bn.

Proposed Strategy

6 What are your views on EirGrid's proposal to meet project needs but with reduced power capacity in the long-term?

Tell us your views
eirgrid.com/yourgridyourviews

6 Summary & Conclusions

Ireland needs a long-term strategy to develop the electricity grid in a safe and secure manner. This will help us to meet projected demand levels, to meet government policy objectives, and to ensure a long-term, sustainable, and competitive energy future for Ireland. We are now conducting an assessment of the 2008 Strategy, based on the long-term electricity needs of our economy, and of Irish society.

EirGrid's final grid development strategy will provide a comprehensive development strategy for our electricity infrastructure. The main findings and impacts that inform this draft strategy are:

Overall Assessment

- Developments in technology now allows us to achieve improved performance from existing transmission infrastructure.
- The economic downturn has resulted in reduced demand forecasts for 2025 and beyond; however, the need for continuing development to our infrastructure remains.
- The expected level of generation connections remains valid, looking forward from 2015.
- The end-of-life for certain grid assets is now being reached, so maintenance and/or replacements are necessary. More than 60% transmission lines on our system are over 35 years old.
- The overall estimated costs for our proposed new Grid Development Strategy have been revised, and will fall within the range of €2.7 to €3.9 billion.[10]
- Grid investment will have a widespread positive impact on the Irish economy and can help reduce overall energy costs in the market.
- Investing in a modern transmission grid will put Ireland in a strong position to continue to attract foreign investment.

Your Grid, Your Views

We have listened. We have assessed advances in technology, and we have reviewed the forecasted changes in the economic and energy landscape. While these factors will influence how we develop the grid, the basic need for investment remains. We need to invest in a stronger, flexible and future-focused electricity grid.

In some cases, it will be possible to maximise the infrastructure we currently have. However, the consequences of this approach need to be carefully considered.

We are committed to working more closely with local communities to respect their concerns, and to do all we can to help communities and homeowners in response to their concerns about the visual intrusion of new infrastructure on the landscape.

We now need your views. Let us know your thoughts – and we will reflect these in a final strategy. While all submitted feedback will be recorded and analysed, we will not be responding to individual submissions. We will address all themes and issues raised in a feedback report, to be published later this year.

Other Comments

7 Do you have any other comments on this draft Grid Development Strategy?

Tell us your views
eirgrid.com/yourgridyourviews

10 This also includes the cost for the southern portion of the North South Interconnector. In the original Grid25, this cost was not included.

Glossary

AC

Alternating current is a type of electric power and is used on transmission systems around the world. It is the form in which electricity is delivered to homes and businesses.

An Bord Pleanála

Ireland's independent national planning authority.

Assets

All substations and electricity transmission lines that form the transmission network. Operated by EirGrid, the transmission network is owned by ESB.

Capacity

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

CER ('the regulator')

The Commission for Energy Regulation.

Circuit

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

Conductors

An object or material that can transfer electricity, for example, found in underground power cables and overhead lines.

Conventional generation

The generation of electricity using fossil fuels, such as natural gas, coal or peat.

DC

Direct current is a type of electric power particularly suited to underground cables or interconnectors.

Demand

The amount of electrical power that is drawn from the network by consumers. This may be talked about in terms of 'peak demand' (the maximum amount of power drawn throughout a given period).

Distribution Network

This is the lower voltage network that delivers power from the transmission network to households and businesses. The distribution network in Ireland is owned and operated by the ESB.

EMF

Electric and magnetic fields. These occur naturally – the earth itself has natural electric and magnetic fields – or from man-made sources, the most common of which is electricity. They can induce electrical currents in materials capable of conducting electricity.

EWIC

The East West Interconnector, which links the Irish and UK transmission systems. It is owned and operated by EirGrid. It is used both to import and export electricity.

Generation Adequacy Report

EirGrid produced an annual Generation Adequacy Report. The final Generation Adequacy Report was GAR 2010-2016. This was replaced by the All Island Generation Capacity Statement

Generation Capacity Statement

Replacing the Generation Adequacy Report, the first All Island Generation Capacity Statement covered the period 2011-2020.

Generator

A facility that produces electricity. Power can be generated from various sources, for example, coal fired power plants, gas fired power plants and wind farms.

Generation Dispatch

The amount of electricity being produced for the grid by a number of generators at any one time. This will vary as demand for electricity and the amount of renewable energy on the system fluctuates.

Grid25

EirGrid's national strategy for the development of the transmission grid, published in 2008.

HTLS conductors

High-Temperate, Low-Sag conductors were first introduced to the Irish transmission system in 2011. They carry substantially more electricity than the conductors normally used in Ireland.

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.

Megawatt (MW)

A unit of measurement for the amount of power produced by a generator or transported on the transmission grid.

Outage

An outage is when part of the network is switched off. This can be either planned (i.e. when work needs to be done on the line) or unplanned (i.e. a system fault caused by storms).

Reinforcement

Increasing the capacity of the existing electricity transmission network by building new lines or uprating existing ones.

Renewable generation

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

Strategic Environmental Assessments (SEA)

SEA is a strategic assessment process for plans and programmes only.

Individual projects are subject to their own assessments outside of the SEA process. If projects fall under a class of development requiring Environmental Impact Assessment (EIA)then an EIA is submitted to the relevant planning authority.

Series Compensation

Series compensation is a technology that would allow us to safely and securely put more power on an existing transmission line. It is used to optimise the power flows on the system. In effect, series compensation allows us to get the most out of the existing transmission grid.

Substation

A set of electrical equipment used to step high-voltage electricity down to a lower voltage. Lower voltages are used to deliver power safely to small businesses and residential consumers.

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

The network of around 6,500 km high-voltage power lines, cables and substations linking generators of electricity to the distribution network. It is operated by EirGrid.

Voltage

Voltage is a measure of ‘electric potential’, which is similar to ‘pressure’ in a water system.

EIRGRID

Your Grid, Your Views, Your Tomorrow.

A Discussion Paper on Ireland's Grid Development Strategy

Appendix 1

EIRGRID

eirgrid.com/yourgridyourviews

Appendix 1
EirGrid Technical Analysis

Grid 25 review

EirGrid Technical Analysis

3/27/2015

Table of Contents

Chapter 1: Introduction

EirGrid's role, as a state-owned company, is to manage and operate Ireland's national grid to ensure a safe, secure supply of electricity to homes, businesses and industry across the island. In order to implement Government energy policy, we need to develop the Irish electricity transmission system to guarantee a secure supply of electricity for today and for future generations.

In 2008 we published our long-term strategy to develop the grid – Grid25 – which set out how we would seek to meet these responsibilities. The Grid25 Strategy outlined the investment required to develop the transmission network in order to future proof Ireland's electricity needs. It would facilitate more sustainable, competitive, and secure power supplies in support of economic and social development, and reaching Irish renewable energy targets.

We have now published a review of our strategy for developing the grid in light of feedback received from the public, an updated view of the broader economic context and growing experience of promising new technologies. In particular, we are committed to ensuring that our strategy for developing infrastructure supports Ireland's broader policy objectives including the Government's Action Plan for Jobs and the IDA's regional development strategy.

We are conscious of the need to ensure that we have full regard for the views of communities, ensure sufficient capacity is available for regional economic development and that the overall cost of the strategy ensures Ireland remains a competitive location for new investment. This review of the Grid25 Strategy is also part of our efforts to facilitate greater participation in the decision making process.

This document provides more information on some of the technical matters underpinning the review. Chapter 2 provides background to the drivers for grid development. The various technologies currently available for use on the transmission system, and others in earlier stages of research and development, are explored in Chapter 3. The revised strategy is described in Chapter 4 with a regional breakdown of the main projects outlined in Chapter 5.

EirGrid commissioned London Power Associates to carry out a technical peer review of our updated strategy.

Indecon economic consultants have carried out an economic review of the revised strategy and its ability to support Ireland's economic recovery.

These reports are available online at www.eirgrid.com/yourgridyourviews.

Chapter 2: Drivers of Grid Investment

Where there is significant growth in demand for electricity, changes in generation or new interconnectors, this tends to alter the power flows across the transmission grid. In addition, transmission assets have a finite lifespan.

The transmission system must meet certain standards, identified in the Transmission Planning Criteria, which set out what the grid needs to be able to do.[1] Where the system is not capable of meeting those standards, reinforcement is often necessary.

In the case of asset condition, investment is primarily driven by factors such as the age of the asset, obsolescence and its condition.

The main drivers of grid investment are:

- Changes in demand for electricity;
- Changing generation patterns;
- Interconnection development; and
- Asset condition.

Changes in Demand for Electricity

There is a relationship between economic growth and electricity consumption. However this relationship is changing and many new industries, such as data centres, have disproportionately high power demands.

EirGrid's demand forecasts are based on the Economic and Social Research Institute's (ESRI) long-term forecast of moderate growth in economic activity and are updated annually in the All Island Generation Capacity Statement.[2]

Since 2008 Ireland and the global economy have been through the worst recession in many decades. There have been considerable changes in future demand forecasts.

Figure 2-1 illustrates the 2008 and 2015 base year peak demand forecasts up to 2025. The 2015 base year peak demand forecast for 2025 has been scaled back considerably to approximately 5,100 MW compared to the 2008 peak demand forecast of approximately 8,000 MW.

[1] http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf
[2] Latest version: http://www.eirgrid.com/media/Eirgrid_Generation_Capacity_Statement_2015.-2024.pdf

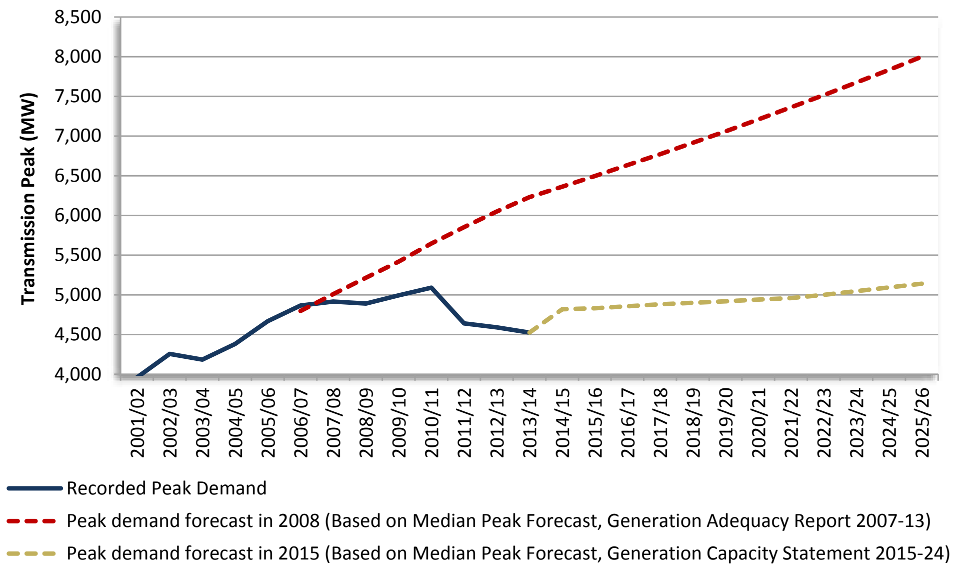


Figure 2-1 Actual Demand and Forecast Demand to 2025

One of the government's main priorities for creating a sustainable energy future is the area of energy efficiency. A successful energy efficiency campaign will improve performance across all energy sectors, including in electrification of transport and smart metering, details of which are in the National Energy Efficiency Action Plan (NEEAP) and the National Renewable Energy Action Plan (NREAP).[3] These measures have been factored into the 2015 forecasts out to 2025.

The previously anticipated increase in the use of electric vehicles by 2020 looks unlikely to be achieved within the anticipated timeframe, although government policies and improvements in battery technology may change this over the next decade and beyond 2025.

The roll out of smart meters through the National Smart Metering Plan is expected to deliver a fundamental change to demand side usage patterns.[4] This technology is in the development phase and a number of meter trials have taken place.

Micro generation, including solar photovoltaic and small-scale wind, will also have an influence on demand patterns to some degree. EirGrid will continue to monitor progress and technology developments in these key areas.

Taken together, the consequence of all these developments is that the traditional link between GDP and electricity demand will become weaker.

[3] http://www.dcenr.gov.ie/energy/energy+efficiency+and+affordability+division/national+energy+efficiency+action+plan.htm and http://www.dcenr.gov.ie/NR/rdonlyres/03DBA6CF-AD04-4ED3-B443-B9F63DF7FC07/0/IrelandNREAPv11Oct2010.pdf

[4] http://www.dcenr.gov.ie/Press+Releases/2010/Important+Milestone+in+National+Smart+Metering+Plan.htm

It is not anticipated that the outcome of the current review of the National Spatial Strategy being carried out by the Department of the Environment, Community and Local Government (DECLG) will significantly alter these forecasts in terms of strategic demand for electricity.

Regional Demand Growth

As our economy returns to growth, the renewal and expansion of the electricity transmission system becomes even more critical to supporting job creation, regional economic development and economic competitiveness. Developing a 21st century transmission system will deliver concrete social, economic and environmental benefits to every person in Ireland.

In particular, only by investing in a secure transmission grid can we open up large areas of the country to investment from the types of high-tech industries currently clustered, by necessity, around our larger cities. In this way, developing the transmission grid is an important part of supporting the Government's drive to create jobs in the regions.[5]

Ireland is a premium destination to host digital assets for a variety of reasons including:

- Fast transcontinental fibre links;
- A secure, reliable power supply;
- Favourable financial arrangements including taxation;
- Economic stability and a pro-business legislative environment;
- Strong support from the Government and associated bodies;
- Availability of a skilled local workforce.

A number of data centre operators have expressed interest in locating large-scale data centres in the Dublin area, in close proximity to the fibre network. These proposals envisage substantial demand connecting in the region by 2020 which would represent a significant increase on current and forecast demand.

Depending on the number and scale of projects that are developed this may require new transmission solutions additional to those in the proposed grid development strategy.

Forecasting Demand

As noted above there are significant changes expected over the short to medium term (e.g. demand side response, electric vehicles, new large demand sites e.g. data centres) which is leading to increased difficulty in forecasting short, medium and long-term demand. However, EirGrid is actively and prudently monitoring these changes to ensure only efficient and economic investments in the transmission network take place.

Population Change

Population growth must also be considered when planning the transmission system. As the population of Ireland grows, demand for electricity can also increase.

According to the CSO, Ireland's population has grown strongly over the past decade. In 2011 it was 4.57 million, up 17% from 2002.

[5] See the Government's *Action Plan for Jobs 2015* at http://www.djei.ie/publications/2015APJ.pdf

Recent CSO projections suggest the population will grow by up to an average of 1% a year from 2011 to 2026. This is a total increase of 734,000 people over the same period.[6]

In considering how to approach the development of the transmission system, EirGrid must ensure that the growing demand for electricity from our increasing population can be securely met.

Changing Generation Patterns

Renewable Generation

Ireland is on course to meet the Government's renewable energy target of meeting 40% of electricity demand from renewable energy by 2020.[7] A large proportion of this renewable electricity will come from wind power.

In Ireland, the Group Processing Approach or 'Gate' Process is the means by which all generation, including renewable generation, is currently contracted to connect to the grid. To date there have been three 'Gates' in which applications for connections were processed in batches rather than sequentially.

In the Gate 1 and 2 connection offer processes in 2004/5 and 2006/7 respectively a total of around 1,700 MW of connection offers were made and accepted by renewable generators.

Approximately 4,000 MW of renewable generation capacity received connection offers in the Gate 3 process. The uptake of Gate 3 offers is particularly high with 82% of offers accepted, 7% under consideration and only 11% have been declined.[8]

This high rate of acceptance is in line with the original Grid25 assumptions in 2008. This means we expect a greater number of smaller, intermittent, generators connecting in dispersed areas, remote from traditional load centres.

As peak demand and energy forecasts have been scaled back, this suggests that the required wind power capacity to deliver the 40% target will be between approximately 3,200 and 3,800 MW.

This band of possible wind capacity requirements to meet the 2020 renewable target is illustrated in Figure 2-2 below.

[6] CSO population and labour force projection to 2016-2046. July 2013 http://www.cso.ie/en/media/csoie/releasespublications/documents/population/2013/poplabfor2016_2046.pdf

[7] In December 2008 the Government increased the target from 33% to 40%. http://www.dcenr.gov.ie/NR/rdonlyres/C71495BB-DB3C-4FE9-A725-0C094FE19BCA/0/2010NREAP.pdf

[8] As at the date of publication.

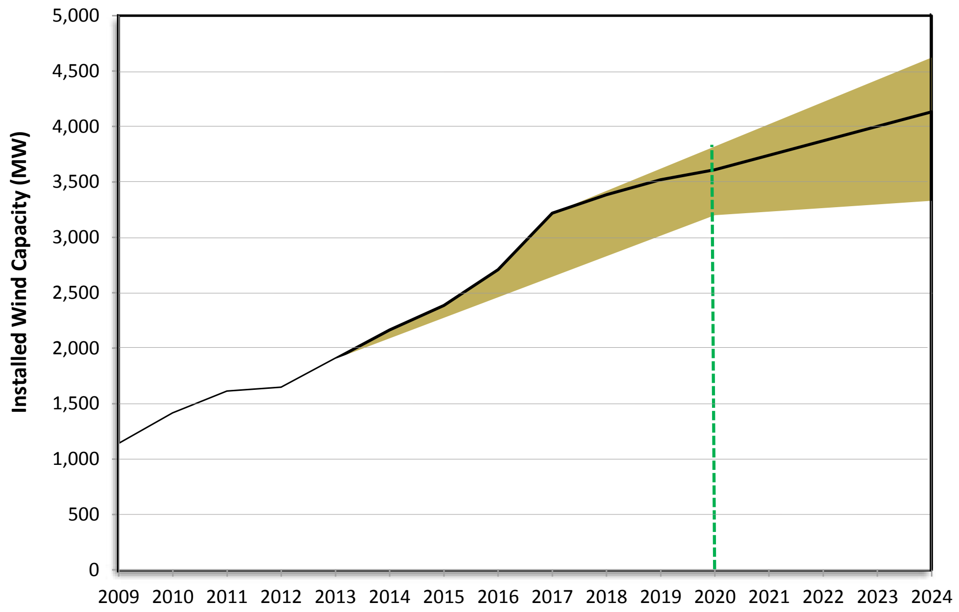


Figure 2-2 Band of Possible Wind Capacity Requirements to meet the 2020 Renewable Target[9]

EirGrid believes, considering government policy, regulatory mechanisms and the outcome of the Gate 3 connection offer process, that the original renewable generation connection assumptions from 2008 broadly remain valid today. This remains true even though, in terms of mega-watts of power, the 40% target will now be lower.

EirGrid will continue to monitor the progress of individual generation connection projects as they advance to the connection and energisation phase, and will bring forward timely reinforcements to facilitate connection of these projects in accordance with its statutory and license obligations.

Planning of network development needs to account for both the changes in investment decisions by individual generators and the consequences of policy changes. Network development is balanced between the timely development of the necessary reinforcements to permit connection and operation of generators, with the risk of overinvestment if the connection of generators are delayed or even cancelled.

[9] Drawn from EirGrid and SONI's Generation Capacity Statement 2015

Conventional Generation

In 2008 EirGrid considered a range of conventional generation dispatch scenarios, including the connection of new generation capacity and the closures of existing plants. Developments since 2008, including new generation capacity in East Cork and in the southeast, are in line with the original Grid25 scenarios.

Peak demand and energy forecasts have been scaled back since 2008 and the implication is that the required capacity from conventional thermal generators will be less than anticipated. The original Grid25 assumption was that this capacity would be constructed at brownfield sites closer to traditional load centres along the east coast.

This analysis concludes that this is unlikely to happen as planned and that generation will come from conventional and renewable generation located in the west, southwest and southeast. This will only serve to increase the main power flows from these locations. Therefore, the power flow assumptions in 2008 are still valid.

In the past Ireland benefited from electricity imports from Northern Ireland to balance supply and demand and to maintain security of supply. In recent times the generation portfolio has changed with the commissioning of new, more efficient, plant. This is expected to change further because of anticipated plant retirements in Northern Ireland.

It is therefore likely that in the next decade Northern Ireland will need to import more power at times of high demand to ensure a secure supply of electricity as detailed in the All Island Generation Capacity Statement.

Interconnection

Interconnection between jurisdictions is heavily supported by both national and European legislation and policies. Interconnection contributes to market integration and furthers competition, enhances security of supply and facilitates the increased penetration of renewable energy sources, thereby reducing carbon emissions.

There is also a greater focus on interconnection projects following EU Regulation 347/2013 Guidelines for trans-European Energy Infrastructure, finalised in 2013, which identifies European Projects of Common Interest (PCIs).

These are projects which have significant benefits for at least two Member States, including contributing to market integration, enhanced security of supply and the integration of renewable energy.

Wholesale energy prices on the island of Ireland remain above those in Great Britain and continental Europe. In 2008 EirGrid envisaged at least one additional interconnector, between the transmission networks of Ireland and Great Britain or France, by 2025. [10] This potential interconnection capacity will provide access to wider electricity markets. These interconnector assumptions remain valid in 2015.

[10] In addition to the East West Interconnector (EWIC) which was completed in 2012.

EirGrid and the French transmission system operator (TSO), Reseau de Transport d'Électricité (RTÉ), are undertaking a joint project to investigate the development of a High Voltage Direct Current (HVDC) interconnector between Ireland and France, known as the "Celtic Interconnector".

The results of preliminary feasibility studies show there are benefits for electricity customers in Ireland and France in terms of both electricity costs and security of supply.

In March 2014, the two TSOs signed an agreement to proceed to the next stage of the project. This includes carrying out a marine survey. The proposed survey route is over 500 km long and extends from the south coast of Ireland to northwest Brittany.

In addition there are currently other third party developers considering interconnection projects between Ireland and Great Britain.

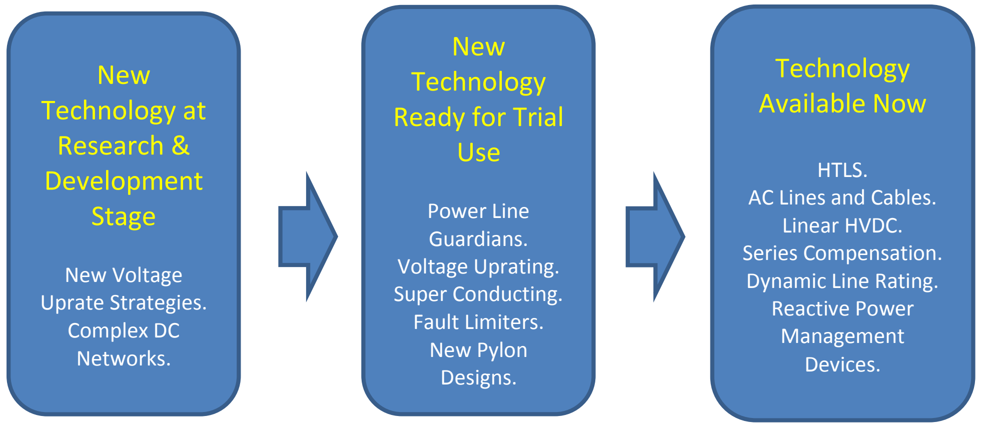
Chapter 3: Technology

New technologies can impact on network development in two main ways; the impact on users of the transmission network, and the range of options that may be used in the development of the transmission grid. Each of these are discussed the relevant sections below.

Technologies used across the world to transmit bulk electrical power are well established and have stood the test of time. However, improvements continue to be made in these technologies, and this is an important driver for carrying out this review.

EirGrid is playing a leading role in the introduction of new technologies to the Irish transmission system for the benefit of consumers. The use of new technologies can bring a number of advantages, including enhanced operational performance, improved system reliability, shortened construction times and reduced impact on the environment. All of these have the potential to reduce system costs.

EirGrid places new technologies in three broad categories as shown below.



EirGrid is assisting industry to identify, develop and trial new technologies by encouraging innovative solutions though the Smart Grid Innovation Hub and demonstration projects (Figure 3-1 show examples of battery and energy storage projects that EirGrid is currently actively engaged with).[11] As part of this commitment EirGrid is working in research and development with academia, nationally and internationally, by providing support and expertise.

[11] http://www.smartgridinnovate.com/ and http://www.eirgrid.com/operations/demonstrationprojects/

Figure 3-1: Images of EirGrid partnership projects for Battery and Energy Storage (left ENERNET storage heater technology and right high voltage battery[12] technology)

EirGrid also participates in international organisations such as the Electric Power Research Institute (EPRI), the International Council of Large Electric Systems (CIGRÉ) and the European Network of Transmission System Operators for Electricity (ENTSO-E). EPRI and CIGRE are international organisations that promote the collaboration of experts from all around the world by sharing knowledge to improve electricity power systems. ENTSO-E represents all electricity TSOs in the EU and promotes research and development.

The range of technologies available for the transmission system is constantly assessed, and in some cases developed, by both EirGrid, in its role as TSO, and ESB, in its role as Transmission Asset Owner.

Since 2008, a number of technologies have been collectively assessed by EirGrid and ESB. Some are in the research and development phase and may mature before 2025. Others have advanced sufficiently to be added to the list of technologies that are now available for use on the Irish grid.

Each of these technologies and the expected impact on grid development is discussed below.

Technological changes

It is important to consider the impact that customers connected to transmission system have on the grid. The proliferation of smaller, intermittent, generation distant from traditional, larger, load centres is of particular importance. Besides the principal need to reinforce key corridors to transfer this power, these generators present other technological challenges.

These issues include:

[12] Image supplied of Tait Energy Storage courtesy of AES

Reactive Power

Reactive power is the portion of electricity that is used to control voltage on the transmission system. As conventional thermal generation is displaced by renewable generators, it is important that sufficient reactive power reserves are available from renewable generators and the transmission system to replace that previously provided by conventional thermal generators. This is particularly important to maintain transmission system voltage stability and comply with transmission planning standards.

In addition, EirGrid has been working with ESB as the Distribution Network Operator to ensure renewable generation connected to the distribution network provides reactive power. This reduces the potential for reactive power to be drained from the transmission system to the distribution system.

This work is extremely important to optimise capital expenditure on reactive power devices to maintain voltage stability on the Irish transmission system. EirGrid is developing a strategy to ensure transmission system voltage stability up to and beyond 2025.

System Inertia

System inertia mostly comes from the stored rotating energy on the transmission power system. Conventional thermal generation normally consists of large rotating masses with high inertia. This is in contrast to renewable generation, which possesses little or no inertia and is increasingly connected via power electronic devices.

Considerable technological changes have also occurred on the demand side. New industrial, and large commercial, demand connections tend to be connected using power electronic devices, which provide flexible control. Demand characteristics have also changed. For example, traditional filament light bulbs are being replaced with low energy alternatives and there are increasing amounts of personal electronic devices in households.

At times, these generation and demand changes have led to a lower inertia system with different demand characteristics. This can lead to a number of challenges for the operation of the system including less dampening of changes in system frequency, less suppression of harmonic distortion and short-term voltage fluctuations. The risk of frequency instability is recognised and addressed by the EirGrid DS3 process and often mitigated by operational measures.[13]

Harmonic Distortion

Harmonic distortion on the transmission grid can result in the distortion of both the current and voltage waveforms. This can lead to poor power quality for consumers. Harmonic distortion tends to be introduced onto the power system by modern electronic devices, such as motor starters, variable speed drives, computers and other devices. This has led EirGrid to invest considerable in carrying out detailed harmonic modelling and analysis during the connection and planning process.

[13] http://www.eirgrid.com/operations/ds3/

The harmonic distortion issue has been exacerbated by greater than expected use of underground cables to connect generators to the transmission system. Harmonic distortion is often magnified by the introduction of high voltage cable onto transmission networks and this must be carefully modelled and assessed.

EirGrid has investigated network devices capable of reducing harmonic distortion to acceptable international standards and will continue to monitor the progress of individual generation projects as they advance to the connection stage.

Technology – Available now

New High Temperature Low Sag (HTLS) overhead line conductors

The capacity of transmission circuits can be increased by replacing the existing conductors with higher capacity conductors. This generally requires reinforcing the pylons which support the lines.

The higher capacity conductors can operate at higher temperatures with lower sag characteristics; ensuring critical clearances from trees etc. are maintained. HTLS technology has been approved for use on the Irish system since 2008. These first generation HTLS conductors have been used successfully by EirGrid and ESBN, achieving a 60% increase in capacity on approximately 500km of 110 and 220 kV overhead lines.

EirGrid is constantly looking at ways of further increasing conductor capacity. Recently developed second generation HTLS conductors using newer materials, for example composite rather than metallic cores, could double line capacity. These are currently undergoing field trials. Should they prove successful, they may become available in advance of 2025, although their application is likely to be restricted to voltage levels greater than 110 kV (except in very limited circumstances) where the increased system losses are not prohibitive.

AC underground cable technology and its use

EirGrid has used underground cable technology for many decades, for example:

- in urban areas;
- on the approach into substations where there is a multiplicity of existing overhead lines, and;
- under deep and wide expanses of water.

The capacity of underground cables continues to increase, which creates greater opportunities for considering cables as alternatives to overhead lines.

The obvious advantage of underground cable circuits is the potential for reduced visual impact compared to overhead line technologies. This must be balanced against the potential impacts on sensitive environmental and ecological areas from what can be significant civil engineering works. This is addressed in considerable detail in the report commissioned by the Department of Communications, Energy and Natural Resources (DCENR) on the Study on the Comparative Merits of Overhead Electricity Transmission Lines Versus Underground Cables.[14]

In addition, the capital cost of installing a cable is more than the cost of the equivalent overhead line and, on average, cable suffers from a higher period of unavailability due to faults and maintenance requirements.

EirGrid commissioned a report in 2009 by Tokyo Electric Power Company (TEPCO) which has considerable experience of transmission cable networks.[15] This study, together with further EirGrid technical analysis, has shown that long lengths of 400 kV AC cables present significant technological problems and operational risks. This greatly restricts their use on individual circuits and on the Irish network as a whole.

Consequently, 400 kV AC cables may only be used sparingly, for example, when considering the partial undergrounding of a transmission project.

EirGrid has continued to examine the performance of cables and their technical impact on the network.

Recent research identified that, due to its relative size to other networks, Ireland is at greater risk of issues arising from the use of AC underground cables. It concluded that a number of techniques existed that would mitigate these issues, but not fully avoid them.

EirGrid will continue to assess technological developments in this area to ensure the full capability of this technology is available for use on the Irish grid.

Linear HVDC and DC transmission

The transmission grid in Ireland, similar to other European and international grids, uses high voltage alternating current (HVAC). Where power is to be transferred over long distances it may be cost effective and technically possible to do so using high voltage direct current (HVDC). This requires the conversion of HVAC to HVDC, and vice versa, in large converter substations at each end of a circuit.

HVDC is a mature technology that is available for integration on the Irish transmission system. EirGrid has included this technology in a number of recent project evaluations and considers its use, where appropriate.

In 2009, EirGrid commissioned a separate investigation into the use of HVDC circuits in the Irish transmission network.[16] This work was completed by TransGrid, a Canadian consultancy specialising in HVDC. It concluded that HVDC is used mainly in specialist applications. These include, for example, long transmission circuits or subsea links. In these cases the electrical properties of HVDC make it a more suitable, or even the only, choice and offset the much greater cost of the conversion between Direct Current (DC) and Alternating Current (AC).

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14 http://www.dcenr.gov.ie/NR/rdonlyres/4F49D5FA-0386-409A-8E72-6F28FD89EC7C/0/FinalReport_StudyonOHLversusUGC_June2008.pdf

15 http://www.eirgrid.com/media/Tepco%20Report%20North%20South.pdf

16 http://www.eirgridprojects.com/media/TransGrid%20Report.pdf

EirGrid selected HVDC as the best technology for the East West Interconnector (EWIC) currently operating between Ireland and Wales for these very reasons. The conclusions of the TransGrid study are consistent with those of the International Expert Commission (IEC) review in respect of the use of HVDC in transmission networks.[17]

Following on from this work EirGrid has continued to examine the performance of HVDC and its technical impact on the network.

The most recent report commissioned by EirGrid was an external investigation by Power Systems Consultants into the use of HVDC for the Grid West Project, discussed in Chapter 5.

This report identified a number of different applications to provide suitable HVDC circuits to meet the needs of the project. It concluded that a HVDC solution was possible and that a Voltage Source Converter (VSC) rather than a Line Commutated Converter (LCC) technology was more appropriate.

At present the maturity of multi-terminal HVDC technology is such that this review has only considered point to point links.

Series Compensation

As the use of the existing network is maximised, power transfers and their associated losses will rise and become more frequent. Overhead lines and pylons in Ireland are physically designed and constructed to accommodate the typical power transfer that would be expected over the life of that line. However, if due to changes in the network the power transfer on the line becomes much higher the electrical performance will be impacted.

Consequently although the lines are in principle rated for much higher power transfers, in practice, where these power transfers occur, the system cannot supply the necessary reactive power.

EirGrid has investigated series compensation which is a mature technology that has been extensively used internationally in similar situations. Series compensation changes the electrical performance of a circuit on which it is installed. It compensates the need for the system to provide reactive power. Their use in Ireland would be a new application with the related challenges to a network of its size and strength.

The need and benefit of this technology varies with each application but it can provide significant benefit by increasing the practical transfer capability of the system. To increase the transfer capacity further additional series compensation can be added to meet future needs.

Dynamic Line Rating

The rating of an overhead line is influenced by meteorological conditions such as ambient temperature, wind speed and wind direction etc. Dynamic Line Rating involves the installation of monitoring devices to examine meteorological conditions.

By combining this local information with line design data, it is possible to derive a rating that varies in real time.

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17 http://www.oireachtas.ie/parliament/media/Published-Report-on-Meath-Tyrone-Interconnector-14-June-2012.pdf

Under certain conditions, it may then be possible to increase the line rating and to transfer additional power on the line. This technology can now be integrated onto the grid where conditions are suitable.

However, as the variation in meteorological conditions is difficult to predict many years ahead, the enhanced ratings are not used for long-term system development. Instead, it is expected that the technology will be used in shorter operational timeframes to reduce potential network constraints while awaiting delivery of grid development projects. EirGrid will continue to monitor technological developments in this area.

Reactive Power Management Devices

Reactive power management technologies have been increasingly used in recent years to make better use of existing assets.

However, as previously discussed, new sources of reactive power provision and management are required to support the increased use of renewable energy. These sources must not only provide the necessary scale of reactive power but must also be able to adjust this power provision adequately to maintain voltages within their limits.

Many parts of the network are expected to simultaneously handle higher power transfers. Higher transfers increase losses and voltage drop along circuits. This creates new challenges in voltage and operational management. Due to the intermittent nature of power production and consumption, rapid changes to these power transfers can be expected and this will increase real-time operational management issues.

Together, these needs require a new generation of fast acting flexible reactive power management devices for use in Ireland. The manner of their application will, in some instances, be unique internationally.

Consequently, besides the use of fixed permanent reactive power compensation typical in long-term network development, the need for temporary devices to defer longer term reinforcement (mainly new circuits) is expected to increase.

A new need is also envisaged for very short-term devices (covering a period of a few weeks to months) to assist maintenance and construction activities, as the scale of network development increases and outages become more difficult to schedule.

Fixed Reactive Power Management Devices

EirGrid is currently considering the introduction of statcom devices, but with new technological characteristics providing higher short-term operational voltage ranges. These devices will be necessary to cover the greater volatility in system voltage from high levels of renewables in weaker parts of the network.

Technology – Ready for Trial Use

Power Line Guardians

A pilot trial is currently underway into another reactive power management device technology. Power Line Guardians can be rapidly deployed onto existing overhead line conductors. Individually, they provide a small change to the reactive power of a line. By increasing their number along individual spans of the line, adequate levels of reactive power management can be provided.

These devices can easily be fitted or removed to change the degree of reactive power management. This provides a high level of flexibility. They can also be individually controlled, allowing for a range of responses which would enhance both voltage and power flow control.

They offer a rapid, low cost, replacement for both fixed and temporary reactive compensation or power flow control for long-term network reinforcement.

Their speed of deployment also makes them an option to assist in reactive power management in facilitating network outages for development and maintenance.

If the trial is successful it may be adopted as a mature technology.

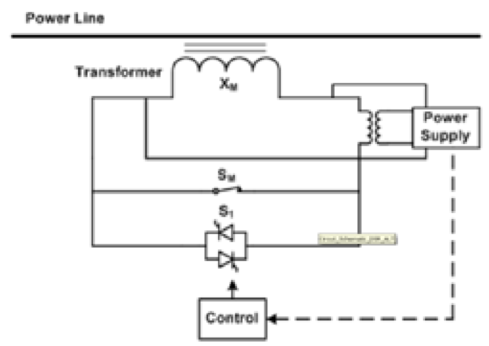


Figure 3-2: Power Line Guardians

Voltage Uprating

Voltage uprating offers a rapid increase of power transfer capacity, whilst simultaneously reducing associated losses by using the existing overhead line route.

The scale of the increase is approximately proportional to the increase in voltage and a conversion from 220 kV to 400 kV can increase capacity by over 80%.

The standard approach to upgrading an existing 220 kV line to 400 kV involves the complete dismantling of the 220 kV line and rebuilding it as a 400 kV line, generally on the same alignment.

In 2008, the lengthy outages of key transmission circuits and the negative impact on system security that would be required for uprating, was considered to make this technique impractical and unfeasible.

Since then, new developments in electrical composite insulators have introduced the possibility of converting some existing 220 kV pylons to 400 kV pylons. This is achieved by replacing the head of the 220 kV pylon with that of a 400 kV design. It would incorporate specialised composite insulators, but retain the existing foundations and base of the pylon.

Consequently, this would permit a lower cost and faster conversion of an existing 220 kV circuit to 400 kV while retaining the existing infrastructure.

Voltage uprating may allow higher capacities on existing routes and provide a solution if there is a need to increase a circuit's capacity. However, if there is a requirement for an additional circuit to allow for circuit outages this approach would not be a solution.

This technology is currently in the development phase and has passed initial modelling tests for the latest generation of pylons. It now requires rigorous physical examination and trials to refine and test performance, before adopting it as a mature technology option.

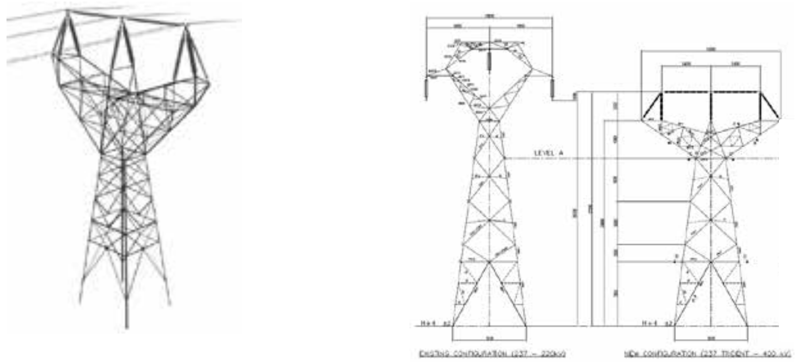


Figure 3-3: Prototype voltage uprate technology using composite insulators (left, new example 400 kV design; right, comparison to existing 220 kV line)

Super-Conducting Fault Current Limiters

When a fault occurs on the transmission system, extremely high currents can flow for short periods of time. It is very important that all transmission equipment is rated to withstand these currents. New developments in super-conducting devices have resulted in the

successful trials of super-conducting switches that can be used to limit the increase in current during faults.

There could be economic benefits from reduced capital expenditure and system losses, as well as the operational benefits of increased flexibility and reliability.

EirGrid plans to carry out trials of this technology on the Irish transmission system in the near future. If the trial is successful, it may be adopted as a mature technology and could reduce the cost of developing infrastructure.

New Overhead Line Structures/New Pylon Design

In most cases overhead line technology remains the most reliable and least expensive option for developing new circuits. EirGrid is actively considering new pylon designs and other mitigation measures in order to minimise adverse landscape and visual impacts, see Figure 3-4 for some examples. The goal is to use less visually intrusive overhead line pylons, particularly in sensitive areas. These mitigation measures were outlined in a 2008 Government sponsored report issued by Ecofys on The Comparative Merits of Overhead Electricity Transmission Lines Verses Underground Cables.

EirGrid plans to carry out a public consultation on a number of 400 kV pylon designs and subsequently in individual projects. In addition, EirGrid will also take account of the National Landscape Strategy when it is published.

Figure 3-4: Examples of new pylon designs

Technology – Research & Design Stage

Complex DC Networks

HVDC is an established technology for transmitting power from point to point.

However, large scale meshed use of HVDC requires significant advances in technology to enable more advanced control strategies and the effective isolation of faults before it can become commonplace in network development.

As power electronic devices become more cost effective and more devices utilise power electronics the need to understand these interactions increases.

EirGrid will continue to monitor developments in this area, which is attracting significant international interest.

New Voltage Uprating Strategies

The technologies available to uprate overhead lines and equipment are constantly developing.

EirGrid has investigated and identified technological solutions which may avoid the need for complete replacement of the existing structures for the higher voltage 220 kV and 400 kV overhead lines. These technologies are progressing towards trials.

However, for the lower voltage 110 kV lines, due to the existing non-metallic support structures these technologies are not likely to prove successful. EirGrid therefore is continuing to investigate other techniques and more conceptual technologies that may provide a more viable solution for these circuits.

Other Smart Grid Concepts

A revolutionary development in information, communication and telecommunication (ICT) has occurred in recent years. Transmission and distribution equipment has become progressively more intelligent and responsive.

As ICT development continues, and more data can be communicated on the status and needs of the network and its users, the influence Smart Grids will have on both market and network operation and development will increase.

The move to a Smart Grid is driven by the changing needs of network users. The Smart Grid is the network that enables such changes to happen. From a user perspective, the continued introduction of renewable generation, and the uncertainty in the location and size of these individual generators, will be mitigated by advances in Smart Grid to some degree. Increasing ICT will make the control of these smaller generators more practical and cost effective.

Chapter 4: Proposed Strategy for Grid Development

To ensure transmission system reliability and security, the performance of the network is compared with the requirements of the Transmission Planning Criteria (TPC).[18] EirGrid's license specifically requires EirGrid to ensure the maintenance of the transmission system and, if necessary, to develop it.

The transmission system is required to remain stable and secure for a variety of critical contingencies (including outages as a result of faults or maintenance). The network is assessed for a wide variety of network conditions, such as: diverse demand levels and generation dispatches, different interconnection power transfers, generation closures, network stability and asset condition. Projects are regularly reviewed as network conditions change part of the on-going process of project development and delivery.

The drivers for network investment result in a series of projects to reinforce the system. The need for these projects can result from inter-regional power flow, local constraints, connection of demand or generation, interconnection, and asset condition.

Historically the primary grid reinforcement needs were the need to handle rising demand for electricity and to facilitate generation connections to the transmission grid or the aggregate effect of multiple connections to the distribution system.

In the past Ireland has been particularly successful in attracting many high-tech industries centred around our larger cities. As our economy returns to growth it is essential that transmission grid investment continues to support economic growth and job creation, and to encourage more balanced regional development.

As well as the larger urban areas on the eastern seaboard, EirGrid's development plans cover many less populated areas to the west, south and southwest. This grid investment is essential if broader regional economic growth is to be enjoyed throughout Ireland.

The proposed new strategy statements are:

Strategy 1

Open engagement and inclusive consultation with local communities and stakeholders will be central to EirGrid's approach to network development.

We acknowledge the sensitivities associated with major transmission infrastructure development.

In response to major project consultation feedback, and to follow through on the Grid25 Initiatives announced in 2014, EirGrid undertook to carry out a thorough internal and external review of our consultation process. This task of reviewing and improving the consultation

[18] http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf

process is now complete.[19] One of the outputs of this is a review of our current *Project Development and Consultation Roadmap*.

We are committed to enhancing public participation and community engagement as part of this process.

Strategy 2
All practical technology options will be considered for network development.

One of the themes raised in submissions during recent consultations was the need to conduct a comprehensive underground analysis for Grid Link and Grid West. While underground technology has always been considered during initial project scoping and technical analysis, in future, we will always publish underground options for public consultation.

We also commit to engaging with the public before we identify a preferred technology. This consultation will explain the transmission technology options, and then seek feedback from stakeholders.

This will assist us in determining the best transmission technology for future projects. We are committed to looking for alternative options that may avoid, or reduce, the necessity for new overhead lines.

Strategy 3
The network will be optimised to minimise requirements for new infrastructure

EirGrid will continue to maximise the use of the existing transmission network. Where we can increase the capacity of existing infrastructure, or use new technologies, this can remove the need to construct new lines. This strategy lowers costs and ensures that there will be potentially less impact on the environment and on local communities.

Impact of technological choice

Transmission development projects can use a range of technologies that deliver a variety of benefits to the system. As the assumptions in demand and generation change, the benefits may increase or decrease for each investment option under consideration.

For example, in an environment of rapidly increasing demand and associated generation development, the optimum solution may be a clear cut need for additional circuit capacity to serve the medium to long-term network reinforcement needs.

On the other hand, if demand growth was more moderate, this could mean future reinforcement needs may be better served by optimising the existing network.

This could be achieved by uprating existing circuits or installing equipment to optimise power flows on the network.

These reinforcement measures may provide sufficient network capacity to negate the need for the construction of new transmission circuits.

[19] http://www.eirgrid.com/aboutus/publications/gridinitiatives/

Proposed Grid Development Strategy

The new proposed grid development strategy has been developed in light of the new strategy statements and the updated drivers and available technologies described in this document.

The original 2008 estimated cost of the delivery of Grid25 was €4bn; this estimate was scaled back in 2011 to a new estimated cost of €3.2 billion. This was made possible by falling expectations of future demand and through the use of new technologies.

For many of the projects – such as line uprates and new substations – the available technologies fall within a relatively narrow cost range.

However, for new transmission circuits, there are a wide range of costs among the different technologies that may be used and this makes it difficult to estimate costs until final decisions are made.

The overall estimated costs for our proposed new Grid Development Strategy have been revised, and will fall within the range of €2.7 to €3.9 billion. This also includes the cost for the southern portion of the North South Interconnector. In the original Grid25, this cost was not included.

The potential reduction can be explained by a number of factors, including:

- The cost of circuit uprates is lower than anticipated in 2008. At the time of the launch of Grid25, it was standard practice to achieve higher ratings on overhead lines by using heavier conductors. This often requires a complete re-build of the line. As outlined in Chapter 3, EirGrid adopted the HTLS conductor for uprating lines wherever feasible. This conductor provides an increase in capacity of about 60%, without excessive increases in conductor weight. This negates the requirement to change the support structures, thus significantly reducing the cost of uprates.
- A reduction in the scope, or in some cases a deferral, of a number of projects due to the lower forecast demand described in Chapter 2 and shown in Figure 4-1. This has had a significant impact, particularly evident in networks supplying major towns and cities.

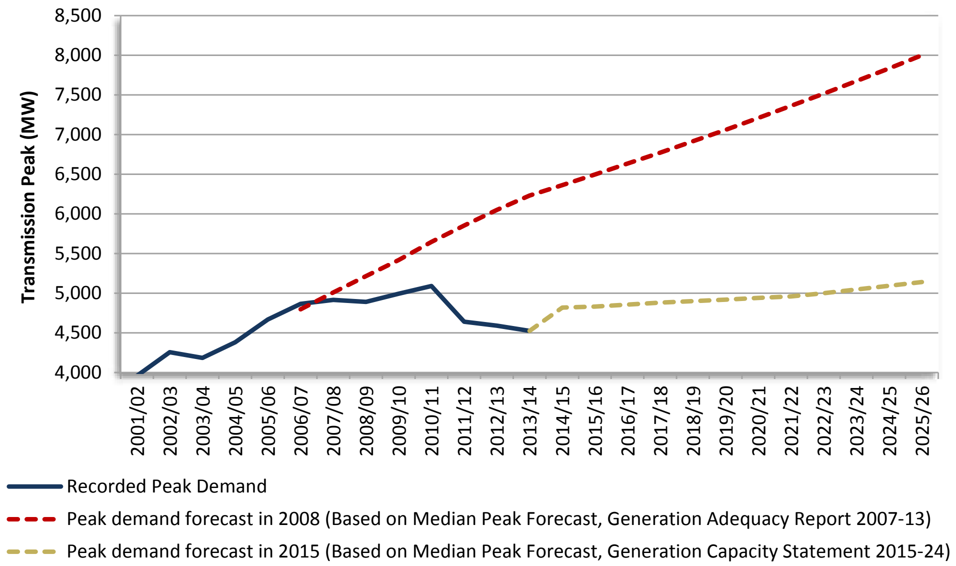


Figure 4-1 Actual Demand and Forecast Demand to 2025

- One of the key strategies for the future is to optimise the use of the transmission network. This would minimise the requirement for new infrastructure. The extensive use of various uprating and compensating technologies to maximise the capacity of existing circuits and substations has proven successful in reducing the need for grid development.

Figure 4-2 below compares the quantity of transmission circuits proposed in the Grid25 Strategy and what is now proposed in this updated grid development strategy.

The impact of the successful implementation of new technologies can be seen as the proportion of circuits to be uprated or modified, as opposed to building new lines, has increased from 50% to 66%. Simultaneously the amount of new infrastructure has dramatically reduced due to the greater use of network optimisation. This equates to around a 33% reduction in the total length of new build. The high level of circuit uprating will be maintained, considerably reducing the need for new infrastructure.

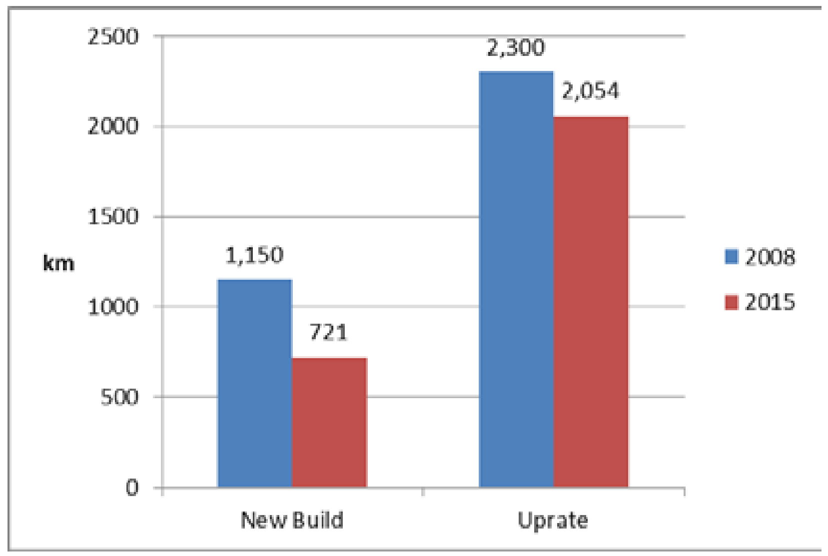


Figure 4-2 Comparison of uprates/modified circuits compared with new build

Chapter 5: Regional Development and Major Projects

Having reviewed the many assumptions and drivers for major grid investment there is a significant difference in the capital investment requirements between the original grid development strategy, estimated at €4 billion, and the new proposed strategy, ranging between €2.7 and €3.9 billion.

It is necessary to provide a cost range to allow for the increasing variety of technologies which may be selected for a project. In Figure 5-1 below the broad distribution of this capital investment across all seven regions is illustrated.

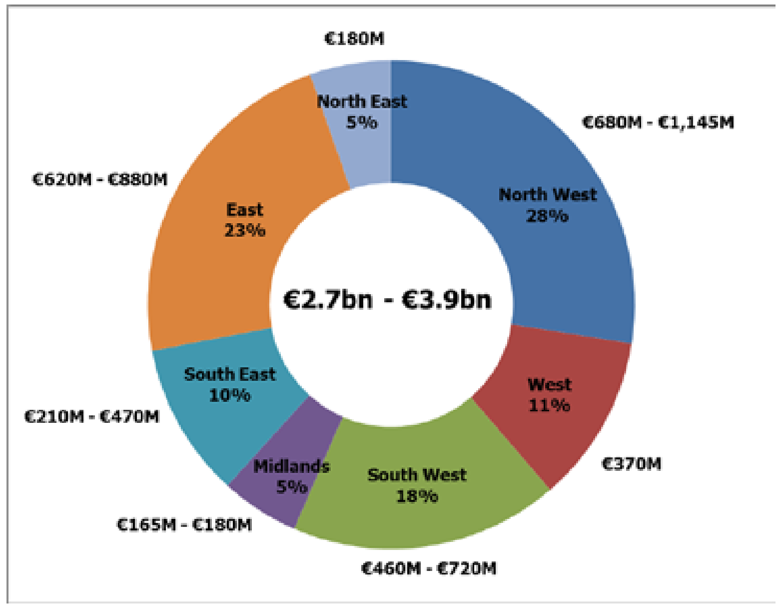


Figure 5-1 Regional breakdown of investment

To provide greater transparency and a clearer understanding of the impact of this review on the Grid25 Strategy, the plan is now broken up into seven individual regions across Ireland as shown on the map in Figure 5-2.

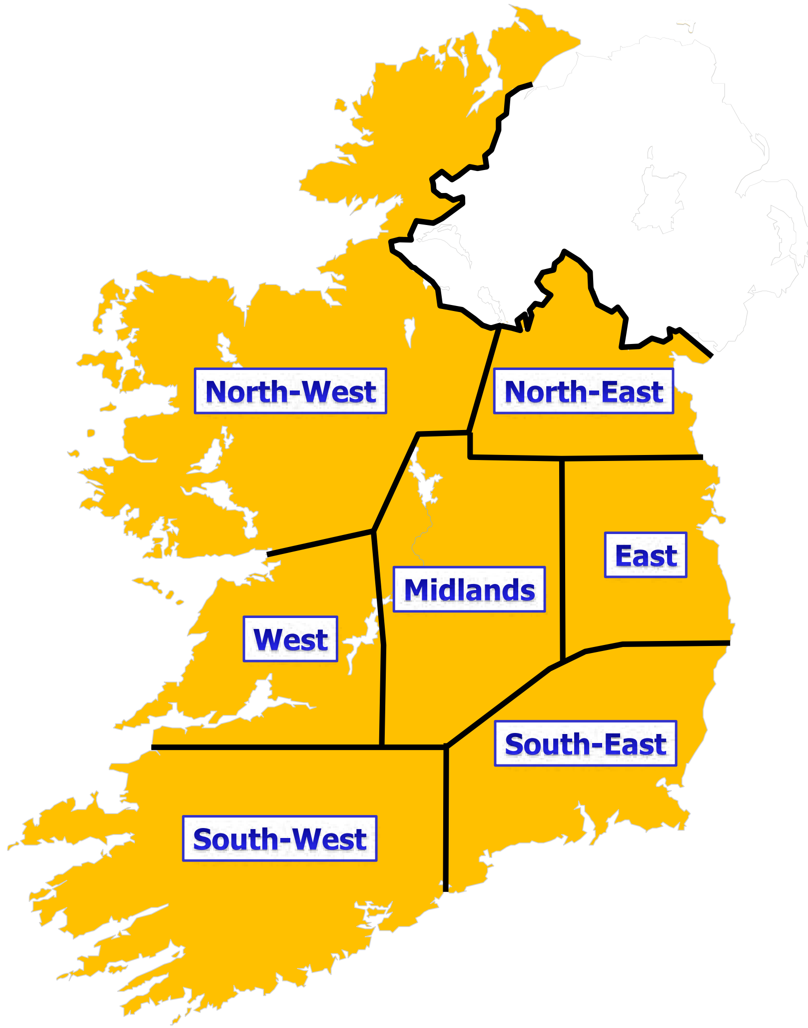


Figure 5-2 Regional Map

In each region a detailed map is provided showing all transmission circuits and substations, their operating voltages and generation sources.

It is important to note that Wind Farm Power Station (WFPS) location symbols are *only indicative* and their purpose is to highlight possible wind resources in the area. Major grid developments are highlighted and categorised as new assets, uprated or modified assets, or areas of continuing investigation.

Each region is accompanied by a regional summary table. This table describes:

- the regional generation and demand balance;
- main regional demand centres and capacity[20];
- the number of projects;
- circuit lengths, and;
- total projected regional development cost[21].

The major new regional developments are listed and a high-level description of the regional development plan is provided and summarised nationally in Figure 5-3.

When discussing a particular region, where there are major projects within that region, a more detailed description of these key projects is provided.

It should be understood that this is a high level grid development strategy. However, it is noted that certain elements of the original strategy have already been shaped into projects - for e.g. Grid West and Grid Link, which are at various stages of progression.

While certain projects are identified in this strategy, these will all be subject to project level screening for Environmental Impact Assessment and Appropriate Assessment, in accordance with the governing legislation.

[20] Note although capacity is shown at the demand centre, it is indicative of the available capacity for the surrounding general area
[21] For projects within the proposed new grid development strategy only, for example new assets that physically connect generation to the transmission network are excluded

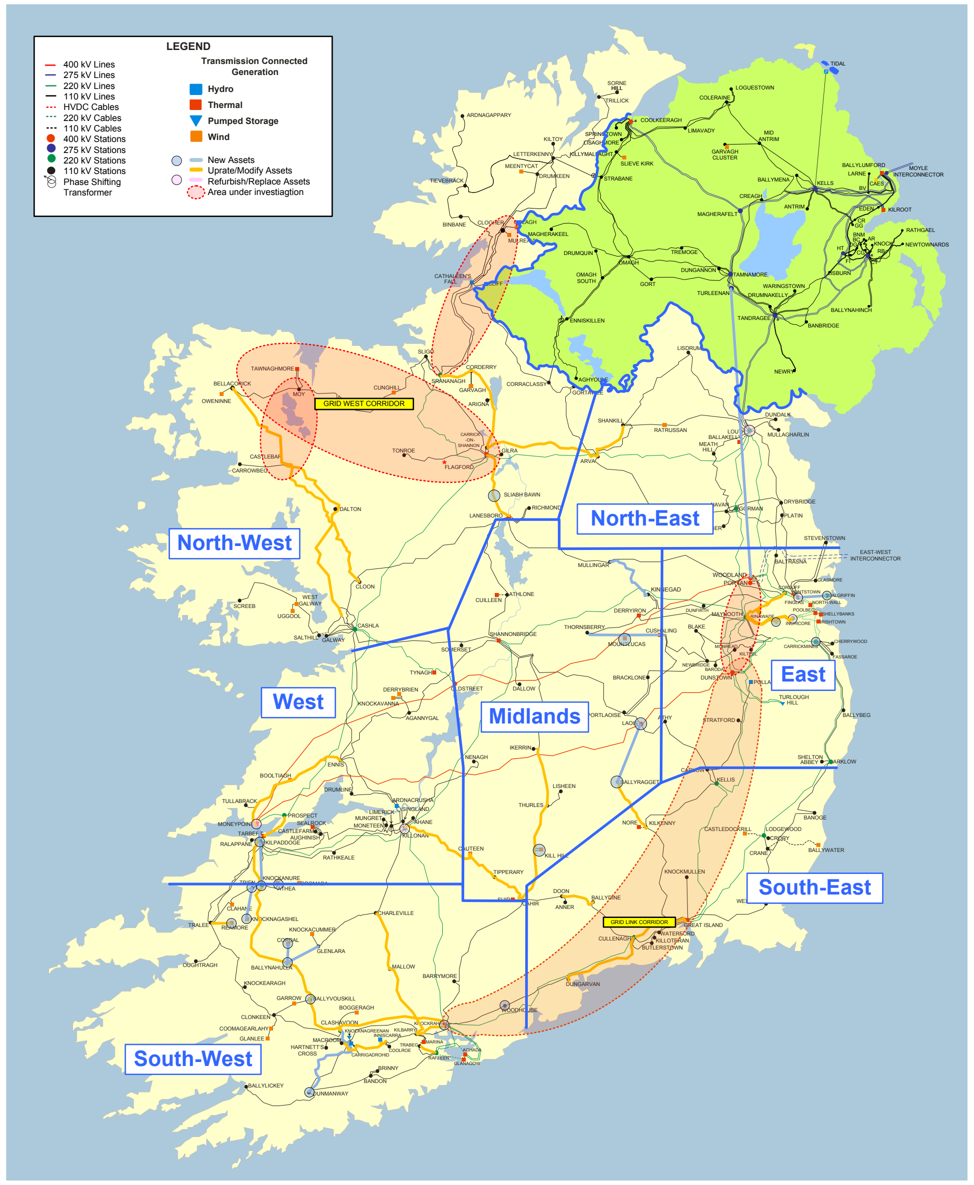
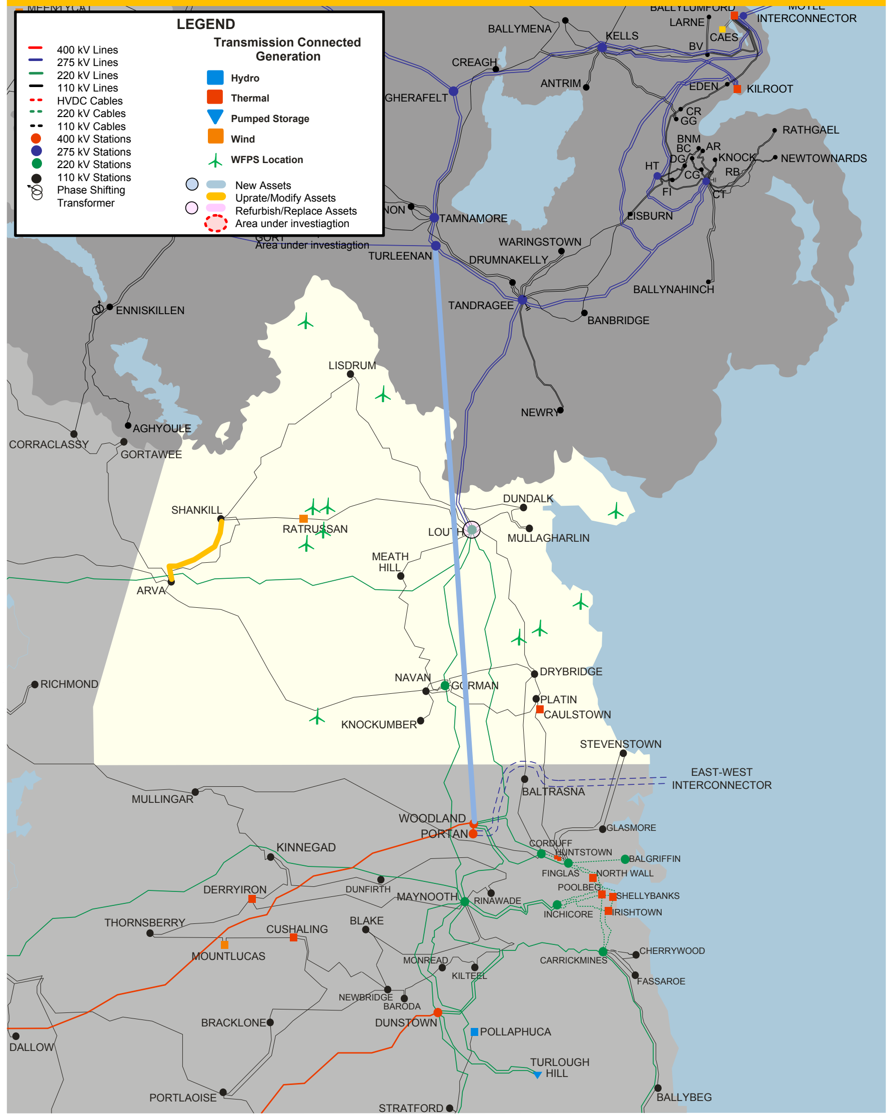


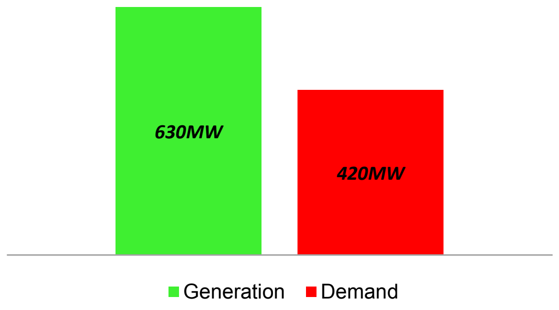
Figure 5-3 National Map Regional Projects

NORTHEASTREGION



NORTHEASTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

Location	*Forecast Demand (MW)*	*Additional Demand Capacity[22] (MW)*
Drogheda (Drybridge)	*82*	*110*
Dundalk	*80*	*40*

Summary of Development Projects

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*1*	*53*	€180m
Uprate circuits	*4*	*117*	
New substations	*0*	*N/A*	

Major Regional Projects

- Second North South Interconnector between Turleenan, Co. Tyrone, and Woodland, Co. Meath, substations

Other Regional Projects

- Refurbishment of the 220/110 kV substation at Louth
- Uprate of Arva – Shankill 110 kV circuit

Regional Description

[22] Available capacity in the network for increased demand

The northeast region has renewable energy resources and conventional generation sources. There is an excess of generation in the area.

Demand in the region, including the main urban centres of Dundalk and Drogheda, is expected to grow up to 2025 and beyond. The existing transmission network is composed of both 110 kV and 220 kV circuits. The existing local transmission network facilitates limited inter area power flows between Northern Ireland and Ireland via the existing 275 kV Tandragee – Louth interconnector.

The major project in this region is the proposed North South Interconnector project between Turleenan and Woodland substations.

The North-South Interconnector Project

As part of the Grid25 Strategy, EirGrid carried out an assessment of the northeast region. The report highlighted the need for grid reinforcement and identifies costs, benefits and the consequences of non-action. One of the key reinforcements assumed was the North – South Interconnector.

In the re-examination of generation assumptions carried out in chapter 2 of this update, the requirement for increased power to flow between Ireland and Northern Ireland in future years was confirmed. This is mainly driven by changes to the future all-island generation portfolio, plant retirements and the relative operational costs of generation plants in each jurisdiction.

The capacity for power flows between Ireland and Northern Ireland is limited by the existing infrastructure. In particular, there is a risk that a single event could take the existing interconnector out of service leading to a system separation of Ireland and Northern Ireland, requiring each system to instantly adjust to achieve a new demand-supply balance. The North South Interconnector Project will remove this risk of system separation and significantly increase cross-border transmission capacity.

The combined value of these benefits has been assessed collectively to deliver a range of benefits of the order of €20m per annum in 2020 rising to between €40m - €60m per annum from 2030, by:

- Improving competition and economic operation of generators by removing constraints on power flows across the border;
- Improving security of supply by allowing greater sharing of generation across the island. Due to the existing limited transmission capacity available from North to South, generation sources in Ireland cannot be fully utilised to help alleviate anticipated shortfalls in Northern Ireland until the second North-South Interconnector is constructed; and
- Providing the required flexibility for renewable generation.

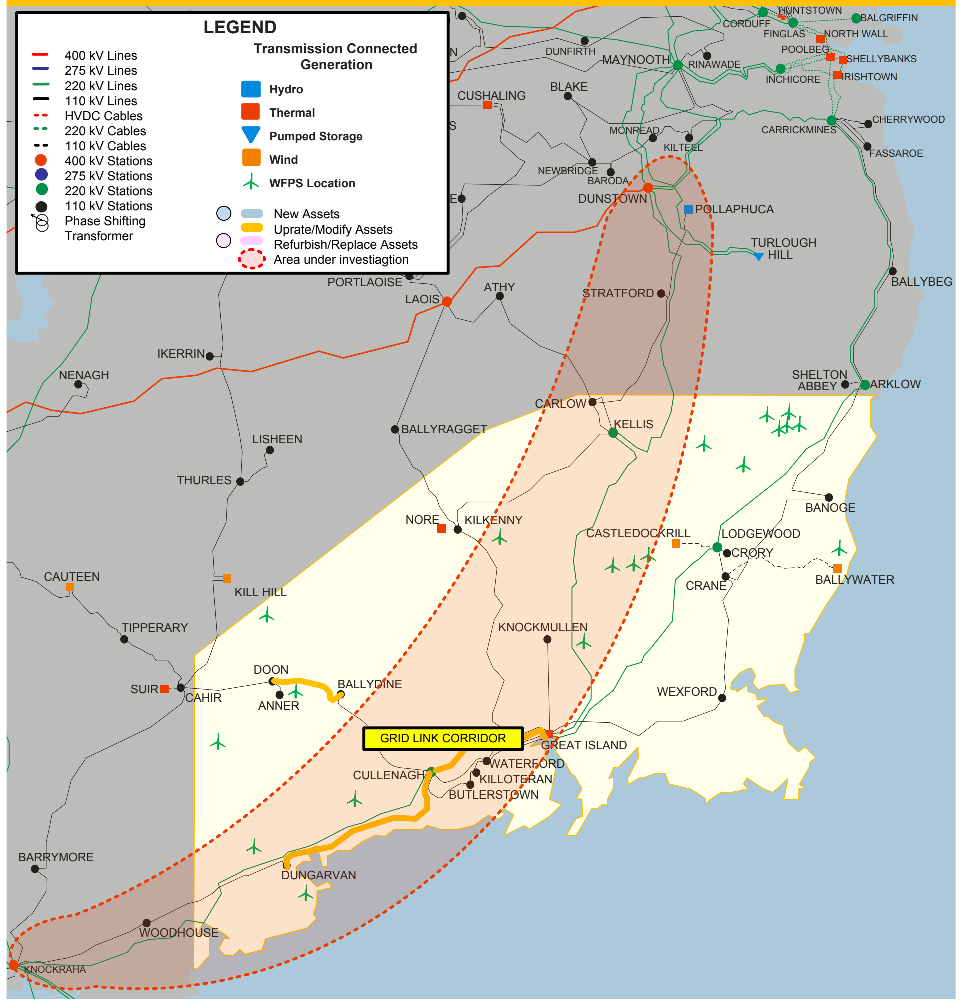
The North South Interconnector Project will additionally ensure the long-term security of supply for the North East part of the network in Ireland.

Because of the length and capacity of the interconnector circuit, it is not possible to use AC underground cables for the entire length nor, were it possible, would this technology provide an efficient and reliable option for the operation of the infrastructure into the future.

In addition, while underground cables using HVDC technology would be feasible, their use on this project would introduce higher costs to the consumer, would not facilitate future grid connections and reinforcements along the route, and does not comply with best utility practice.

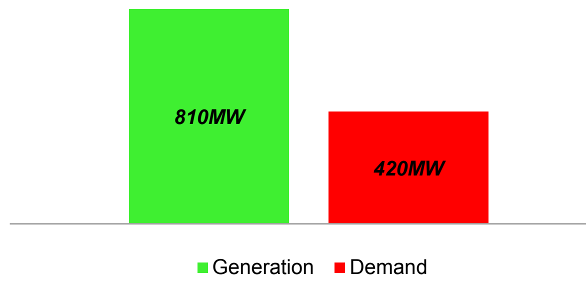
For these reasons, the new interconnector circuit will be shortly submitted into the statuary consenting process.

SOUTHEASTREGION



SOUTHEASTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

Location	Forecast Demand (MW)	Additional Demand Capacity[23] (MW)
Carlow	56	50
Waterford	51	100
Wexford	56	30

Summary of Development Projects

Type of Projects	No. of Projects	Project kilometres	Total Regional Cost
New build circuits	1	77	€210m-€470m
Uprate circuits	11	232	
New substations	1	N/A	

Major Regional Projects

- The Grid Link Project[24]: Increased transfer capacity from the southwest to the Dublin region, either with a regional solution or a new circuit from Knockraha to Dunstown

Other Projects

- Uprating of Ballydine – Doon 110 kV circuit

[23] Available capacity in the network for increased demand .
[24] The cost of the Grid Link Project will vary depending on the technology chosen. The range of costs have been spread out across the costs for the different regions within which the project is located.

Regional Description

The southeast region has both renewable energy resources and conventional generation located at Great Island substation. As a result, the region has a surplus of generation. The southeast also contains a number of possible landing locations for interconnectors.

The main urban demand centres are Carlow, Waterford and Wexford. These are composed of a mix of residential, commercial and industrial demand, which is expected to grow up to 2025 and beyond. The existing transmission network is composed of 110 kV and 220 kV infrastructure. The region has considerably more generation than demand and the existing infrastructure also facilitates high inter-regional power flows from the southwest.

EirGrid are currently investigating a number of options to increase network capacity between the southwest and southeast to the larger demand centres located on the eastern seaboard. This will enable the transmission system in this region to safely accommodate more diverse power flows from local generation, inter-regional power flows and also to facilitate future growth in demand across the region.

The Grid Link Project

As part of the Grid25 Strategy, EirGrid carried out an assessment of the southeast and southwest. The report identifies the need to strengthen the grid in these regions and particularly between Cork and Dublin. New, large, conventional generators have recently connected along the south coast. Substantial amounts of renewable generation are contracted to connect in Kerry and Cork.

As a result, the main flow of electricity in the southern half of the Irish network is from the south and southwest towards the highest concentration of demand in the east and north.

Generators close to large load centres such as Dublin or Belfast may not always be available, nor economical to run, and hence may not operate at times, further increasing the levels of power flows towards the east.

The existing network cannot manage such large power flows. These flows could cause significant problems, especially following a system fault. These problems include very low voltages throughout the system and in some circumstances, the potential for widespread voltage collapse (local blackouts).

Large changes in system voltage can also prevent automatic reclosing of lines. This has a serious impact on circuit availability and system reliability, hence reducing security of supply.

Furthermore, the large transfer power from the southwest to the north and east of the country exceeds the capabilities of some circuits.

Underground option

This review has confirmed that an underground cable option using HVDC technology would address the needs identified for the Grid Link Project, if combined with some enhancement of existing plant and equipment.

The estimated capital cost for this option would be €800-850m.

400 kV AC option

The use of 400 kV HVAC overhead line has been identified as a possible solution and this review has confirmed it would also address the needs identified, if combined with some enhancement of existing plant and equipment.

The estimated capital cost for this option would be €500-550m.

Regional Solution

This review has also identified a regional solution. This would comprise a new underwater circuit across the Shannon Estuary; the introduction of a new technology to Ireland called series compensation; and a series of line uprates.

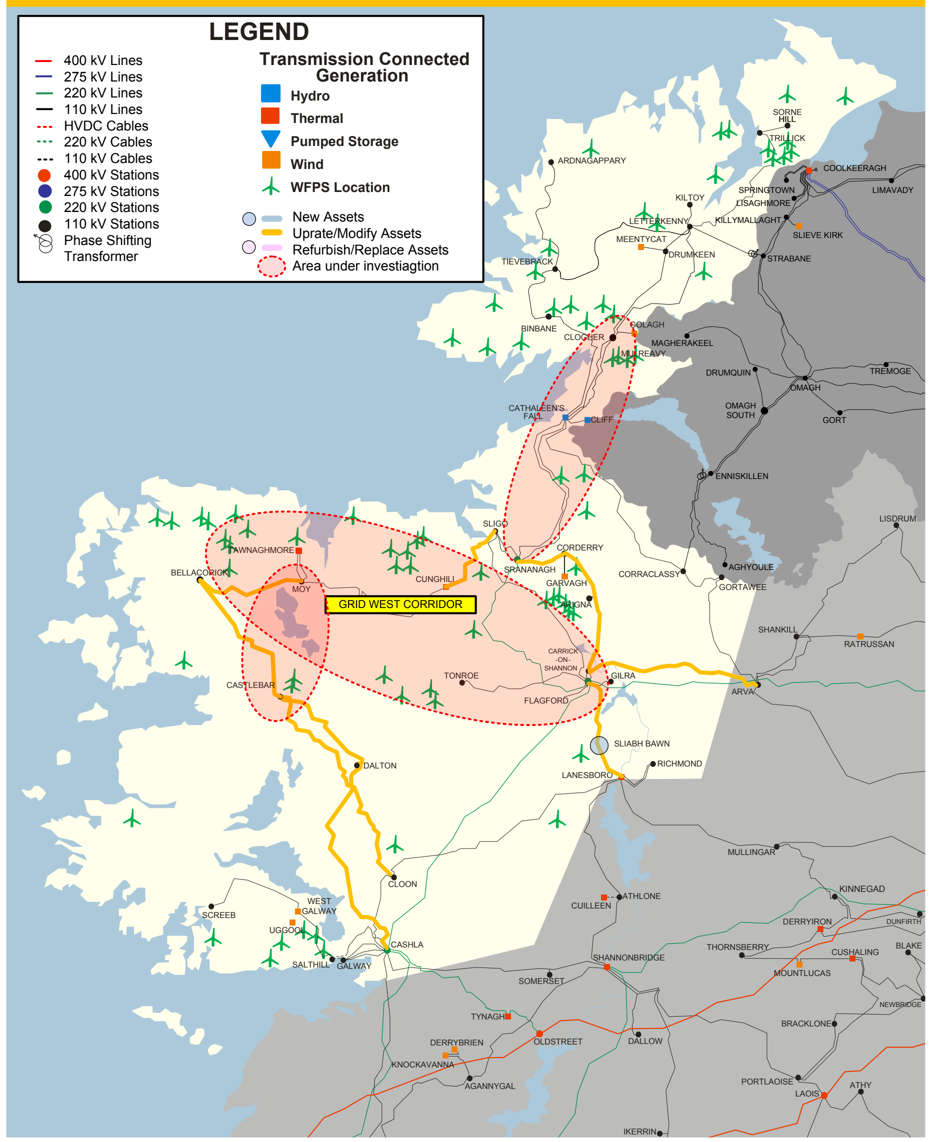
This option is built around installing series compensation technology which would change the characteristics of the existing 400 kV circuits (from Moneypoint in Co. Clare, to the 400 kV substations Woodland and Dunstown that supply Dublin) to make them suitable for a much higher power transfer capability.

In conjunction with a new underwater cable under the Shannon from Moneypoint into the newly constructed Kilpaddogue substation in Co. Kerry, the power transfer out of the southeast would be rebalanced.

Additional uprating of existing transmission lines in the midlands would avoid the need for any new circuits. Additional enhancement of existing plant and equipment to supplement this approach would also be needed.

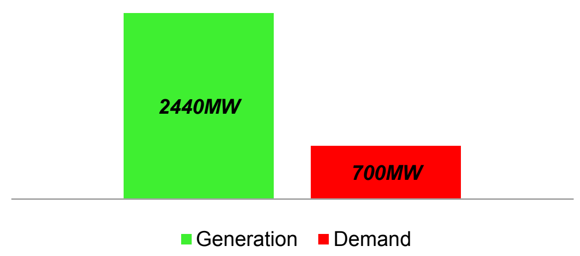
The estimated capital cost for this option would be €200-250m.

NORTHWESTREGION



NORTHWESTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

Location	Forecast Demand (MW)	Additional Demand Capacity[25] (MW)
Galway	77	60
Letterkenny	66	30

Summary of Development Projects

Type of Projects	No. of Projects	Project kilometres	Total Regional Cost
New build circuits	6	273	€680m-€1,145m
Uprate circuits	22	808	
New substations	3	N/A	

Major Regional Projects

- The Grid West Project: New circuit from the Bellacorick area to Flagford Transmission substation
- The Northwest Project – reinforcement of the corridor between South Donegal and the main backbone transmission system at Srananagh substation, currently under investigation

Other Regional Projects

- Reinforcement of the transmission network in the vicinity of Mayo and Sligo comprising the North Connacht 110 kV project
- Uprating of 110 kV circuits between Castlebar – Dalton – Cashla and Castlebar – Cloon
- Uprating of 110 kV circuits between Srananagh – Carrick on Shannon – Arva and Flagford – Lanesboro
- Reactive power support required to strengthen system voltage

[25] Available capacity in the network for increased demand

Regional Description
The northwest region is particularly rich in renewable energy resources, including ocean and wind energy. These generation sources are dispersed across the region, but particularly concentrated along the western coastline. The main demand centres are Castlebar, Letterkenny and Galway. These are composed of a mix of residential, commercial and industrial demand, which is expected to grow up to 2025 and beyond. The existing transmission network is predominantly lower capacity 110 kV with very little higher capacity 220 kV and no 400 kV transmission infrastructure. Developing the grid will enable the transmission system to safely accommodate more diverse power flows from surplus regional generation and also to facilitate future growth in electricity demand. These developments will strengthen the network for all electricity users, and in doing so will improve the security and quantity of supply. This is particularly important if the region is to attract high technology industries that depend on a reliable, high quality, electricity supply.

The Grid West Project

The amount of renewable generation seeking to connect in the northwest of Mayo is significantly in excess of the local demand and therefore needs to be transferred out of the area. The local 110 kV network is not capable of carrying these levels of power flow.

A new high capacity circuit is required to carry this power from northwest Mayo to the backbone transmission system at Flagford substation in Co. Roscommon. This new circuit will also provide long-term capacity benefits, facilitating economic growth in Mayo.

EirGrid has conducted a comprehensive analysis on the underground and overhead solutions for the Grid West Project and has submitted its report on this analysis to the Government-appointed Independent Expert Panel.

The report, based on this detailed analysis, considers three options: a HVDC underground option, a 400 kV overhead line option, and a 220 kV overhead option which may incorporate substantial amounts of underground AC cable.

HVDC Cable Option

This option can be summarised as a single, fully underground, HVDC cable, 113km in length. The cable connects a new HVDC converter station from the existing Flagford 220 kV substation to a new HVDC converter station near Moygownagh to 'collect' the power produced by the wind energy in the local area.

The estimated capital cost for this option would be €426m[26].

400 kV Overhead Option

This option can be summarised as a single 400 kV AC fully overhead line, 103km in length. The line connects from the existing Flagford 220 kV substation to a new substation near Moygownagh to 'collect' the power produced by the wind energy in the local area.

The estimated capital cost for this option would be €235m[27].

220 kV Overhead Option

This option can be summarised as a single 220 kV AC overhead line, up to 103km in length. This option allows for approximately 20km of this overhead line to be undergrounded, with the remainder constructed as overhead line. The circuit connects from the existing Flagford 220 kV substation to a new substation near Moygownagh to 'collect' the power produced by the wind energy in the local area.

The estimated capital cost for this option would be €205-245m[28] (dependant on total cable length).

The Northwest Project

EirGrid has carried out, in association with SONI, an assessment of the northwest region and western Northern Ireland. This investigation has resulted in a submission to the European Commission (EC) requesting Project of Common Interest (PCI) status for a project titled the Renewable Integration Development Project [RIDP]. The EC has since accepted that application.

The need for this project is predicated on the level of renewable generation in both Donegal and western Northern Ireland. Once certainty on the level and staged development of generation is achieved, the project, or a subset of it will be progressed.

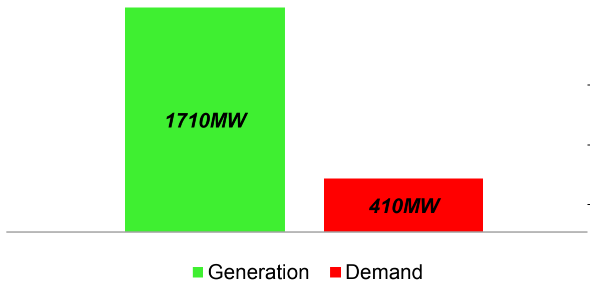
A range of technological options will be considered and consulted upon for any such projects in line with EirGrid's commitments in this new grid development strategy and out new approach to public consultation.

[26] Rounded to nearest million
[27] Rounded to nearest million
[28] Rounded to nearest million

WESTREGION

WESTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

Location	*Forecast Demand (MW)*	*Additional Demand Capacity[29] (MW)*
Limerick	*84*	*100*
Ennis	*63*	*110*

Summary of Development Projects

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	2	17	€370m
Uprate circuits	7	163	
New substations	2	N/A	

Major Regional Projects

- The Moneypoint – North Kerry Project: New 220 kV cable from Moneypoint to Knockanure via Kilpaddoge
- New Moneypoint 400/220/110 kV substation
- New Kilpaddoge 220/110 kV substation

Other Regional Projects

- Uprating of Ennis – Moneypoint 110 kV circuit
- Uprating of Knockanure – Kilpaddoge 220 kV (part of Clashavoon – Tarbert 220 kV circuit)
- Uprating of Tarbert – Prospect 220 kV circuit
- Uprating of Cauteen to Killonan 110 kV circuit
- Major refurbishment of Killonan 220 kV substation
- Reactive power support required to strengthen system voltage

[29] Available capacity in the network for increased demand

Regional Description

The western region is particularly rich in renewable energy resources including ocean, wind energy and hydro generation on the Shannon Estuary. In addition, the area has considerable conventional generation located at Tarbert, Moneypoint and Tynagh substations. The main urban demand centres are Limerick and Ennis. These are composed of a mix of residential, commercial and industrial demand, which is expected to grow up to 2025 and beyond. The existing transmission network is composed of 110 kV, 220 kV and 400 kV infrastructure.

The region has considerably more generation than demand, and the existing infrastructure also facilitates high inter-regional power flows from the southwest. These proposed Moneypoint – North Kerry investments will enable better use of the existing 400 kV circuits from Moneypoint to Dublin, circuits which originally were designed to facilitate the connection of large conventional generation at Moneypoint.

These 400 kV circuits will therefore become a more integral part of the backbone transmission network and may become yet more so depending on the final option selected for the Grid Link Project.

These new projects will enable the transmission system to safely accommodate more diverse power flows from surplus regional generation and also to facilitate growth in electricity demand across the region.

These developments will strengthen the network for all electricity users, and in doing so will improve the security and quality of supply. This is particularly important if the region is to continue to attract high technology industries that depend on a reliable, high quality, electricity supply.

The Moneypoint – North Kerry Project

The need for network reinforcement arises due to the large amounts of wind generation connecting to transmission and distribution networks in Co. Kerry, Co. Cork and west Co. Limerick. This gives rise to a risk of overloads on the existing transmission system.

The project was initially conceived as a 400 kV, part overhead and part underwater, circuit connecting Moneypoint generation station in Co. Clare and a new 220 kV substation in North Kerry.

Subsequently, higher capacity underground cable technology became available. This led to a re-evaluation of the potential options. For this particular project a 220 kV cable solution is

technically feasible as the circuit is of a relatively short length and the required capacity can be met with extra high thermal capacity cables.

Cost benefit analysis identified that the higher cost of utilising a cable solution would be compensated by the benefits of earlier delivery. This resulted in the land portion of the project being changed from overhead line to underground cable.

In other circumstances where the circuit distances are longer, this technology may not be appropriate. Building the circuit at 220 kV rather than 400 kV reduces the project cost and at the same time the use of cable technology reduces the visual impact of the project.

Moneypoint 400/220/110 kV substation

This project combines the replacement of 400 kV equipment in the existing Moneypoint substation with the need to alleviate a local constraint on the 110 kV network following the connection of renewable generation.

The new, reconfigured, Moneypoint 400 kV substation will replace the existing 400 kV substation equipment. It will also alleviate the local constraint with a new 110 kV supply into the existing network from a new 220/110 kV transformer.

This project is currently under construction.

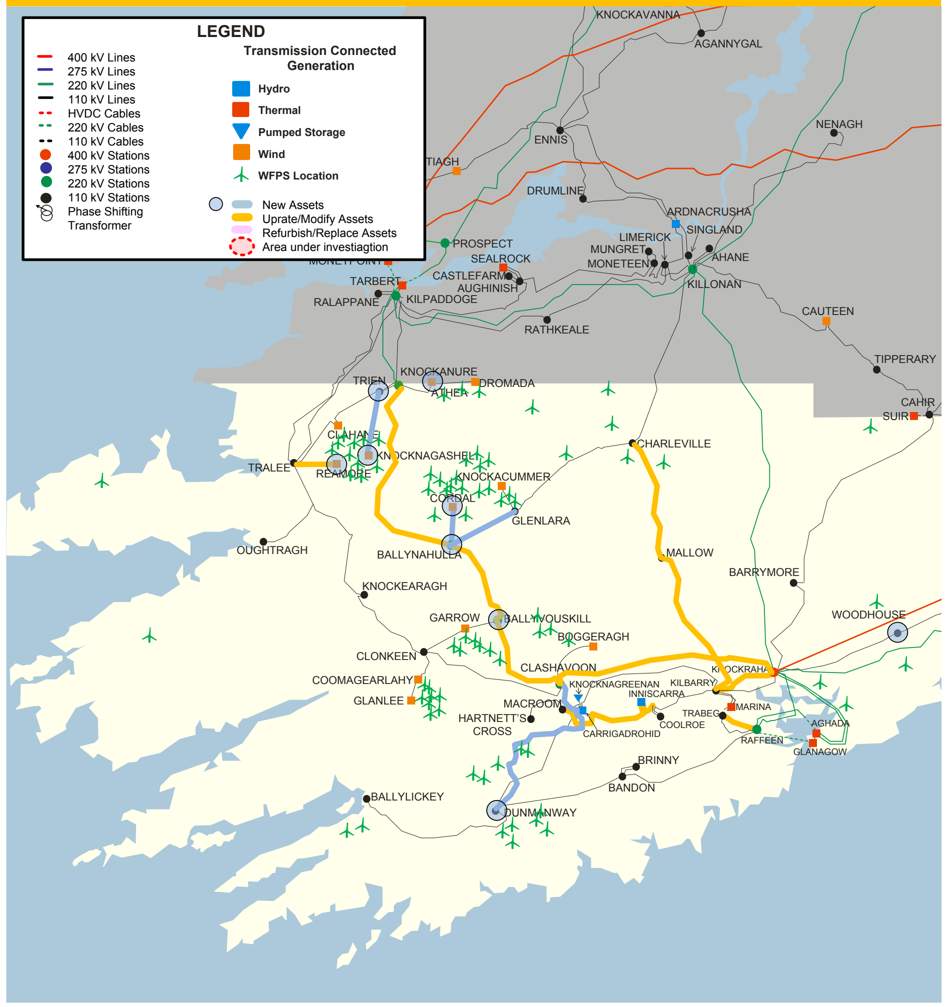
Kilpaddoge 220/110 kV substation

The driver for this project is security of supply. The need for reinforcement arises due to local constraints on the transmission network, i.e. the physical capacity of Tarbert 220/110 kV substation is close to being reached.

The new Kilpaddoge substation is necessary to allow for the essential expansion of transmission connections in north Kerry and will replace some of the functionality of the existing Tarbert 220 kV substation.

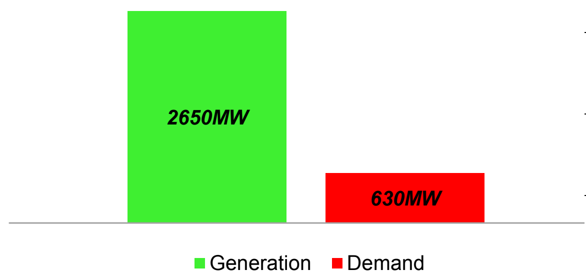
This project is currently under construction.

SOUTHWESTREGION



SOUTHWESTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

Location	***Forecast Demand (MW)***	***Additional Demand Capacity[30] (MW)***
Cork (Kilbarry)	***93***	***30***
Cork (Trabeg)	***77***	***110***

Summary of Development Projects

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*2*	*93*	€460m-€720m
Uprate circuits	*17*	*387*	
New substations	*3*	*N/A*	

Major Regional Projects

- New 220/110 kV substations at Knockanure, Ballyvouskill and Ballynahulla
- New Clashavoon – Dunmanway 110 kV circuit

Other Regional Projects

- New 110 kV substations at Cordal, Knocknagashel, Reamore and Woodhouse
- Uprating of Clashavoon – Knockanure 220 kV circuit
- Uprating of Clashavoon – Knockraha 220 kV circuit
- Uprating of Raffeen – Trabeg 110 kV circuit
- Uprating of Knockraha – Kilbarry 110 kV circuit
- Uprating of Inniscarra – Macroom 110 kV circuit
- Uprating of Charleville – Mallow – Kilbarry 110 kV circuit
- Reactive power support required to strengthen system voltage
- Reconfiguration and extension of Knockraha 220 kV substation

[30] Available capacity in the network for increased demand

Regional Description

The development of the transmission system in the southwest is characterised by the connection of high levels of renewable energy in Co. Cork and Co. Kerry. This results in transmission network constraints as power is transferred out of the region towards the Moneypoint and Knockraha transmission substations.

The region also has considerable amounts of conventional thermal generation around Cork with plants at Marina, Aghada and Whitegate. There is also hydro generation on the River Lee. The combined effect is that this region has a considerable surplus of generation. In addition, EirGrid and the French transmission system operator, RTÉ, are undertaking a joint project to investigate the development of a 700 MW HVDC interconnector between Ireland and France that would potentially connect in the southwest region.

The existing regional transmission network is comprised of 220 kV and 110 kV infrastructure.

The projects described above are required to safely and securely integrate large quantities of renewable energy onto the Irish transmission network. This is achieved by upgrading existing transmission circuits and substation equipment, and building new substations and circuits where necessary.

The main load centre in the region is Cork, which has attracted a number of pharmaceutical companies as well as other high technology industries. These projects will enable the network to safely and securely accommodate more diverse power flows from local and remote generation and also facilitate future growth in electricity demand across this region.

Knockanure, Ballynahulla, and Ballyvouskill substation Projects

Knockanure, Ballynahulla and Ballyvouskill 220 kV substations are collecting points for wind generation in their localities.

Each of these 220 kV substations will collect local renewable generation via the 110 kV transmission circuits.

The ‘collector’ transmission network will be operated separately to the rest of the 110 kV existing transmission network in the area which mainly supplies demand centres. This ensures that this existing network is not overloaded.

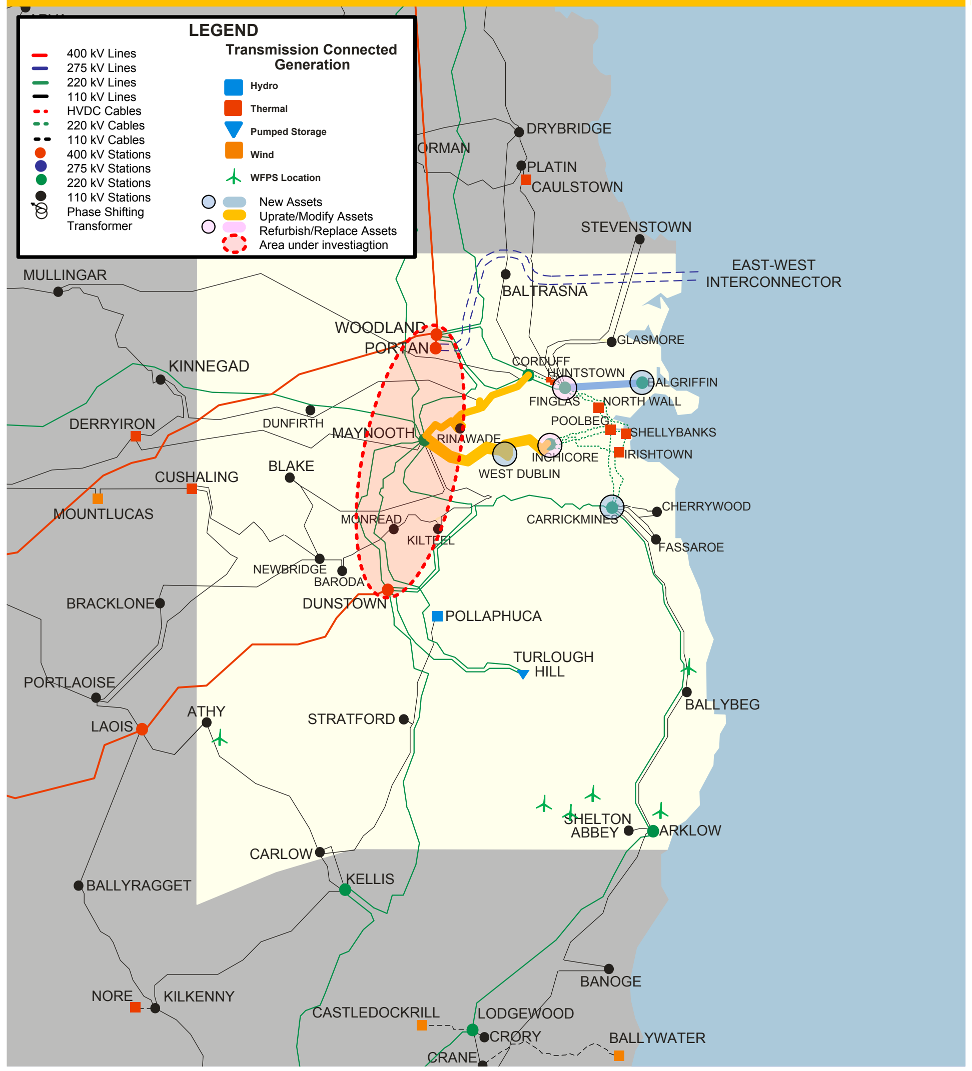
Clashavoon Dunmanway 110 kV Circuit

The need for the circuit arises due to local constraints which are close to exceeding the rating of the existing infrastructure. The circuit will maintain security of supply and permit the integration of new renewable generation.

The circuit will provide a third 110 kV circuit into west Cork, thus securing supply to the area and enabling transmission of surplus generated renewable power from the area to other demand users.

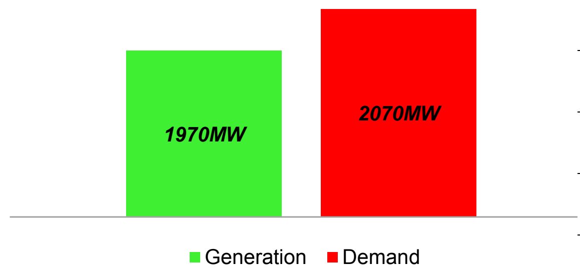
This project is currently in the construction phase.

EASTREGION



EASTREGION Summary Table

Grid25 Regional Generation/Demand Balance



Main Regional Demand Centres

Location	Forecast Demand (MW)	Additional Demand Capacity[31] (MW)
Carrickmines	380	90
Finglas	498	90
Inchicore	368	90

Summary of Development Projects

Type of Projects	No. of Projects	Project kilometres	Total Regional Cost
New build circuits	1	131	€620m-€880m
Uprate circuits	6	126	
New substations	2	N/A	

Major Regional Projects

- Reinforcement of the Greater Dublin Area between Dunstown and Woodland 400 kV substations
- Balgriffin 220/110 kV substation and 220 kV cable to Finglas
- New 220/110 kV GIS substation in West Dublin

Other Regional Projects

- Uprating of Inchicore – Maynooth 220 kV overhead line double circuit
- Uprating of Maynooth – Ryebrook – Corduff 110 kV circuit
- Reconfiguration and major refurbishment of Inchicore, Finglas and Carrickmines 220 kV substations
- Reactive power support required to strengthen system voltage

[31] Available capacity in the network for increased demand

Regional Description

The eastern region, which comprises Dublin and the greater Dublin area, is the major load centre on the Irish transmission system. Approximately one third of the total Irish demand is located here. There are also considerable quantities of conventional generation connected to the transmission network in close proximity to the gas network and Dublin port area.

The EWIC 500 MW interconnector is connected to the transmission system at Woodland via the new 400 kV substation at Portane and a pump storage facility is located at Turlough Hill in Wicklow. The existing regional transmission network is comprised of 400 kV, 220 kV and 110 kV infrastructure.

The transmission network has to meet a number of diverse power flows that can vary depending on the generation dispatch, network demand, interconnector flows and network topology. As well as meeting the high density demand in the area and local generation exports, the network can be subject to high inter-regional power transfers from both north to south and south to north.

EirGrid is currently investigating grid development options between Woodland and Dunstown to the West of Dublin, to increase the capacity of the often congested and highly loaded Dublin transmission network. This will enable the transmission system to safely accommodate more diverse power flows from both local and remote generation, and also facilitate future load growth in the Dublin area.

Under high renewable generation scenarios, where power is generated in remote locations and transferred across the transmission system over long distances to Dublin, there will be little local generation that, has in the past, supported and maintained the voltage level in the Dublin area. EirGrid is investigating a number of development options to resolve this issue.

To meet Dublin demand growth it is necessary to install additional transformer capacity and increase circuit capacity to the north and south of the city, and into the city itself.

These projects will strengthen the network for all electricity users, and in doing so will improve the security and quality of supply.

This is particularly important if the region is to continue to develop as an ICT hub and attract high technology industries that depend on a reliable, high quality, electricity supply.

Reinforcement of the Greater Dublin Area

As part of the grid development strategy, EirGrid carried out an assessment of the Dublin region. The report identified the need for a strengthening of the grid in this region between Woodland, Co. Meath, and Dunstown, Co. Kildare, 400 kV substations.

The assumptions concerning the connection of renewable generation described in chapter 2 of this report have a significant impact on transmission system power flows into this region.

Simultaneously, interest from a number of large-scale industrial customers in the area is almost certainly going to drive the need for further reinforcement in and around Dublin and this will require strengthening the links between these substations.

The project will require a 400 kV link, which may be developed by re-using existing assets converted to 400 kV, thus maximising the existing assets in line with the new strategic statements.

EirGrid is currently refining the need and assessing the range of available technologies in preparation for consultation with local communities and stakeholders.

Belcamp 220/110 kV Substation Project

The new Belcamp substation will provide a new high voltage supply point in north Dublin that will supply existing and new load, thereby alleviating the loading on constrained substations and circuits within the area.

Consequently, this substation will enhance the security of supply for existing customers and facilitate the connection of new customers.

The project incorporates the configuration of Finglas 220 kV substation and a new 220 kV cable circuit from Finglas to a new 220/110 kV substation is permitted and known as Belcamp.

The existing local 110 kV circuits will also be diverted into this new substation to supply the local area.

New West Dublin 220/110 kV Substation Projects

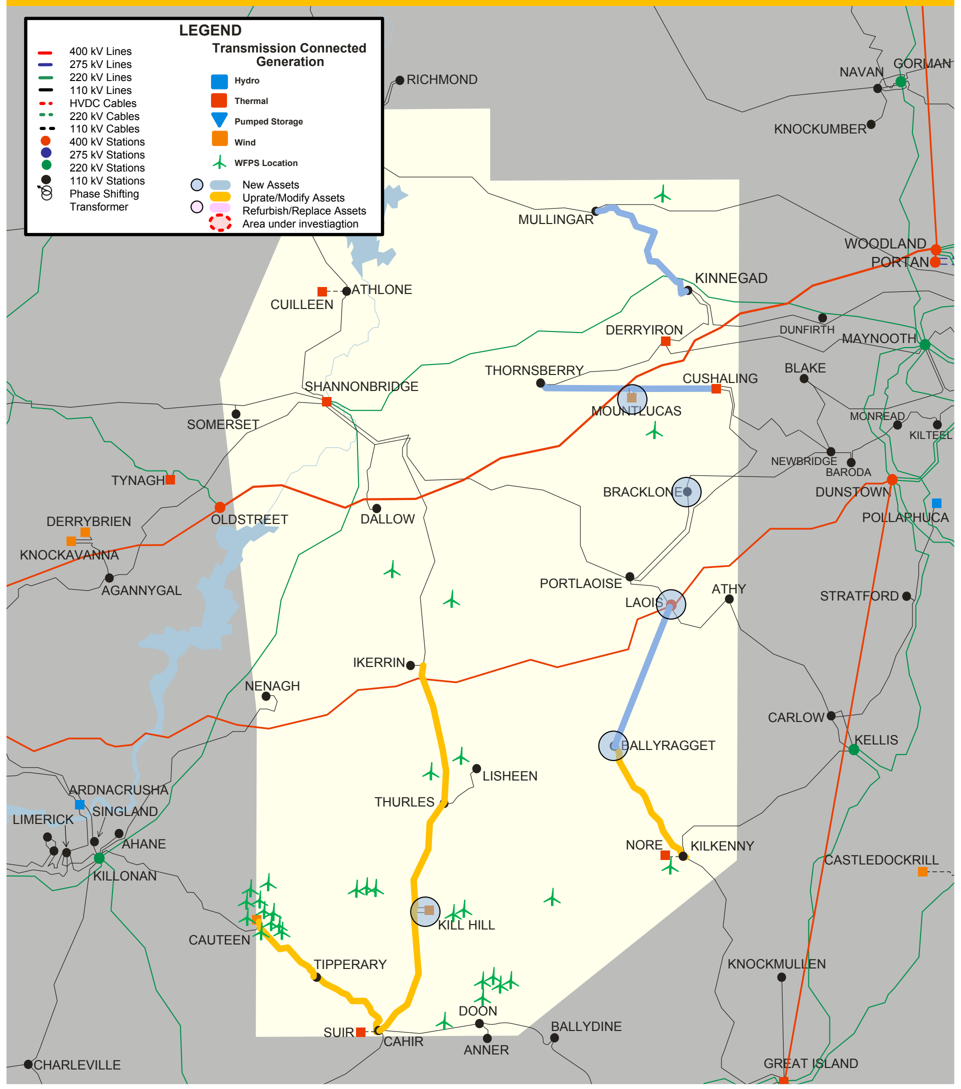
The new West Dublin substation will provide a new high voltage supply point that will supply existing and new load, thereby alleviating the loading on constrained substations and circuits within the area.

Consequently, this substation will enhance the security of supply of existing customers and facilitate the connection of new customers.

The project incorporates the diversion of the existing Inchicore – Maynooth circuits into a new 220/110 kV substation in the area of Grange Castle business-park.

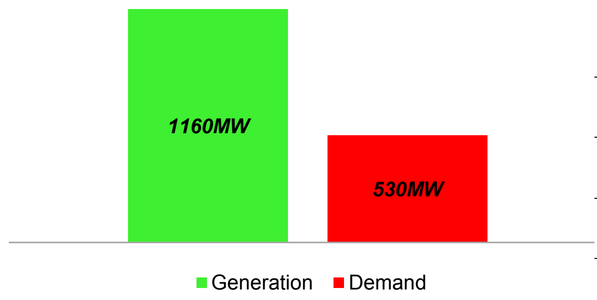
New 110 kV circuits will be installed to connect the existing 110 kV network and new large-scale demand customers into this new substation.

MIDLANDSREGION



MIDLANDS REGION Summary Table

Grid25 Regional Generation/Demand Balance



Main Regional Demand Centres

Location	*Forecast Demand (MW)*	*Additional Demand Capacity[32] (MW)*
Athlone	65	20
Mullingar	52	60
Kilkenny	63	10

Summary of Development Projects

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*2*	*77*	€165m-€180m
Uprate circuits	*7*	*221*	
New substations	*1*	*N/A*	

Major Regional Projects

- New Laois Kilkenny Reinforcement Project: New 400/110 kV substation in Laois, with part new and uprated substation/circuit to create 110 kV new circuit from Laois – Kilkenny 110 kV substation

Other Regional Projects

- New 110 kV circuit from Cushaling to Thornsberry
- New 110 kV circuit from Kinnegad to Mullingar
- New 110 kV substation at Bracklone
- Uprating of Cahir – Cauteen 110 kV circuit
- Uprating of Cahir – Ikerrin 110 kV circuit
- Reactive power support required to strengthen system voltage

[32] Available capacity in the network for increased demand

Regional Description

The midlands regional transmission network is required to transport power over considerable distances to a widely dispersed range of demand centres, the largest of which are Mullingar, Athlone and Kilkenny.

The region has dispersed generation, mainly composed of peat-burning power stations at Lanesboro, Shannonbridge and Cushaling stations, and renewable energy located mainly to the south of the region.

The existing Midlands transmission network is comprised of 400 kV, 220 kV and 110 kV infrastructure. The regional demand centres and generation sources are mainly served by the widely dispersed 110 kV meshed network, with the high capacity 400 kV and 220 kV circuits mainly transferring power through the region.

The Laois-Kilkenny Reinforcement Project is a major reinforcement to tap into an existing 400 kV circuit and create a new 400/110 kV substation and new 110 kV circuit capacity. This will strengthen the network in large parts of midlands and provide additional capacity for potential demand growth in the wider region, and in particular in Kildare and Laois.

It is proposed to construct a number of new 110 kV circuits (Cushaling – Thornsberry and Kinnegad – Mullingar) and uprate others across the region in Westmeath, Offaly, Laois and Kilkenny.

These projects will strengthen the region's transmission network by improving security and quality of supply and ensuring there is the potential for demand growth in a number of gateway towns including Athlone, Mullingar and Tullamore.

In the south of the region, the uprating of circuits and the installation of reactive support will facilitate the connection of renewable energy and accommodate more diverse network power flows.

Laois-Kilkenny Reinforcement Project

This Laois 400 kV substation will provide a new high voltage supply point in Laois that will alleviate the voltage and loading on constrained substations and circuits within the area. Diversions of the existing 400 kV circuit and a local 110 kV circuit into the station are also required.

To support the Kilkenny area, a circuit into the existing 110 kV Kilkenny station is also part of the project.

This is achieved with by building a circuit from the Laois 400 kV substation to the existing Ballyragget 38 kV station, combined with the conversion from 38 kV to 110 kV of both the Ballyragget 38 kV station and the line supplying it from Kilkenny 110 kV substation.

EIRGRID

Your Grid, Your Views, Your Tomorrow.

A Discussion Paper on Ireland's Grid Development Strategy

Appendix 2

EIRGRID

eirgrid.com/yourgridyourviews

Appendix 2

London Power Associates
External Peer Review
of Grid 25 Review
(2015) for EirGrid

LONDON POWER ASSOCIATES LTD

EirGrid

EXTERNAL PEER REVIEW OF GRID25 REVIEW (2015)

Consultancy Services

FINAL PEER REVIEW REPORT

V 1.0

27 March 2015

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REPORT AUTHORISATION SHEET

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1.0	24/03/15	Final Report	ASJ/HG/ EY	ML	JS

Contents

1 INTRODUCTION

London Power Associates Ltd has been asked to carry out an external peer review of the following documents:

Grid 25 review (2015) – Main report

Grid 25 review (2015) – Technical report

1.1 Background – Grid25 Strategy (2008):

The publication of Grid25 was a major initiative in 2008, in taking a long-term strategic view of transmission infrastructure investment. The aim of the strategy was to avoid a less efficient incremental approach to grid development, thereby minimising unnecessary expenditure whilst ensuring compatibility with wider national and European policies and directives. Grid25 provides a **Strategic Overview** for anticipated grid development up to 2025 and beyond, based on a strategic **Vision**, identifying strategic **Future Grid Requirements** and, in this context, setting out a **Grid Development Strategy**. The Vision of Grid25 was to deliver a strong cost-effective transmission grid, which is essential for Ireland to facilitate regional economic growth by attracting high-tech industrial investment. Grid25 intends to deliver high quality, secure and competitive electricity supplies to customers and, by connecting new renewable and sustainable energy sources, reduce Ireland's over dependence on fossil fuels. Grid25 will also support further interconnections to the UK and mainland Europe, which improves security of supply and encourages competitive energy prices in the All Island Single Electricity Market.

1.2 Purpose of 2015 Grid25 Review:

EirGrid drafted a Grid25 review which assessed changes since 2008 and the impact of those changes on the strategies and on the major projects progressing as part of the strategy implementation.

The Technical Report provides more detail on the Technical Issues.

The main topics covered are:-

- Progress since 2008
- The Evolving Context
- Drivers of Grid Investment
- Technology
- Revised Strategies
- Regional Development and Major Grid Development Projects

Following a tendering process EirGrid invited London Power Associates to fulfil the role of Independent Peer Reviewer and to carry out an assessment of the Grid25 review (2015) documents (Main report and Technical report).

The main tasks included:

- **Part 1: Review the Grid Development Strategies**

Consideration was given to:

  - Changes to assumptions and drivers
  - Changes to available technology options
  - Changes to public planning and the environmental requirements
  - Updates to Strategies

- **Part 2: Review the five Grid Development Major Projects**

For each Grid Development Major Project LPA was asked to:

  - Evaluate the impact of the changes on the projects
  - Comment on the need case

- **Part 3: Compare Processes with good utility practice**

LPA was asked to**:**

- Review EirGrid's Standards, Strategies and processes
- Compare with good utility best practice
- Advise whether robust grid planning procedures have been applied

1.3 Main focus of review:

The main focus of the review is on the following areas:

- To note the changes to assumptions and drivers, impact of new technology and of new approaches to public planning and environment.
- Review the overall strategy for Grid development and the three main Strategy Statements
- Evaluate the impact of the background changes (assumptions, drivers etc.) on Grid Development Major Projects.
- Review of the case of need for the Grid Development Major Projects
  - North- South Interconnector
  - Grid Link Project
  - Grid West Project
  - Moneypoint – North Kerry project
  - North West Project

1.4 LPA Company Profile:

Established in 2001, LPA is one of the UK's leading power consultants, with offices in Manchester and Staines. LPA provides a highly responsive and flexible service on all aspects of power engineering projects that allow our clients to make investment decisions with confidence at any time during the project's life cycle.

LPA provides services to large international organisations around the world. Our experience is wide-ranging and we are particularly active in transmission, distribution and generation projects.

1.4.1 LPA Recent Experience:

LPA has extensive experience in electricity transmission planning and studies, in power system studies and in major transmission projects. Some examples are given below:

1.4.1.1 Power System studies and planning:

LPA has the capability to analyse power systems covering the complete time frame from microsecond's phenomenon to many years ahead. This capability arises from the vast experience of our engineers and the capabilities of the array of modern study tools we use. Power systems are typically analysed in the time domain as well as in the frequency domain. Some of the studies we undertake include:

- Transmission & Distribution system planning including optioneering
- Power flows
- Short circuit fault levels
- Motor starts
- Harmonic penetration & filter design
- Transient and dynamic stability
- Design optimisation
- Lightning and switching transients
- Insulation co-ordination
- Flicker & voltage fluctuations
- Reactive compensation & static var compensation (SVC)
- EMC and interference investigation and mitigation
- Reliability, risk analysis and system security
- Site measurements and analysis
- Loss reduction

Our engineers have many years of experience in analysing networks, covering highly complicated and interconnected national grid systems, sub-transmission and distribution systems to local low voltage networks. Other projects include; large conventional thermal power stations to small-scale renewable generation, analysing their effects on the distribution and transmission systems and presenting the findings in the form of a comprehensive report.

LPA consultants have extensive knowledge of network analysis study tools including; PSS/e, DigSilent, ELLA, Neplan, CDEGS, GROND, DINIS, CAPTOR, PTW, ETAP, CYME, ERACS, PSCAD & IPSA, together with the relevant standards, including Grid Code, Security and Quality of Supply Standards (SQSS) and Customer Use of System Code (CUSC).

Some example cases of the services we are currently providing in studying and planning power systems are:

- Planning, power flow, fault level studies & system security assessments for UK's leading

distribution network operators.

- System planning work for UK's National Grid involving 400/275 kV transmission system power flow, short circuit fault studies and transient stability studies.
- System planning, harmonic distortion, flicker, reliability and system security studies for a major National Railway and London Underground operators. Developed network reinforcement options, including the addition of reactive compensation plant and harmonic filters.
- Advising a global energy company on grid connection issues for large power plants in the UK including CCGT and wind power.
- Power quality studies for several expansion projects in South East UK.
- Protection Studies – application, setting and coordination

2 CHANGES IN ASSUMPTIONS AND DRIVERS

2.1 Demand forecasts

The Grid25 (2008) demand forecasts and the corresponding economic growth scenarios were taken from the Generation Adequacy Report 2007-2013. The demand forecasts are based on information prepared by the Economic and Social Research Institute (ESRI), which models the Irish Economy and prepares estimates for Gross Domestic Product (GDP) and Personal Consumption of Goods and Services (PCGS). ESRI prepares forecasts for high, median and low economic scenarios. The median scenario was used in the Grid25 report. For the period, 2007 – 2013 the average annual forecast economic values were:

Median Scenario:

GDP growth:	5.0% per annum
PCGS growth:	4.3% per annum

Appendix 1 of the Generation Adequacy Report, 2007-13, provides forecasts for the high, median and low economic growth scenarios. Under the median scenario the annual peak demand (for Ireland) was expected to grow from 5,200 MW in 2008, to 6,400 MW in 2014 to around 8,000 MW in 2025.

In 2015 The Grid25 review Technical Report uses the demand forecasts and the corresponding growth scenarios in the All Island Generation Capacity Statement 2015-2024. In July 2013, ESRI published its Medium Term Review (MTR). Then in October 2014, the short term economic data was updated in the ESRI Quarterly Economic Commentary. The median scenario (described as the "Recovery scenario") has been adopted as the Base Case for the demand forecasts for 2015 to 2025.

The economic inputs to the "median" scenario are as follows:

	GDP	PCGS
2016 – 2020	3.6% p.a.	2.8% p.a.
2021 – 2025	2.2% p.a.	2.7% p.a.

The updated forecasts for annual peak demands in the Grid25 review technical report show the peak demand growing from around 4,800 MW in 2014 to around 5,100 MW in 2025.

EirGrid produced a high and a low scenario. The high scenario considers a severe weather winter peak. Although the peak demand is shown to be higher than the average winter peak it is just an extreme version of the ACS (Average Cold Spell) conditions that should be provided for every winter. There would be little impact on annual energy GWh, as the severe weather conditions are not expected to last all year. In the low scenario, based on the economic data from ESRI, the Irish economy stagnates, there is very little economic growth and the annual peak demand hardly grows. By 2025 it is around 4,900 MW.

As per the Grid25 Review Technical Report, the difference between the 2008 and 2015 forecasts is as follows:

- For the 2008 forecast – annual growth in peak demand is higher (higher GDP and PCGS).
- The starting point for the 2015 forecast is 4,800 MW for 2014
- For the 2008 forecast the peak demand in 2025 is 8,000 MW.
- For the 2015 forecast the peak demand in 2025 is 5,100 MW.

2.1.1 LPA Comments on Demand Forecasts and Demand Drivers

For projects that have peak demand as a driver, the rate of growth of annual peak demand and the forecast peak demands to be expected by 2025 are lower.

The "All Island Generation Capacity Statement 2015-2024" seeks to "bracket" the median forecast by using a high and a low forecast. The intention is to capture the uncertainty around the median forecast. For 2025:

- The high forecast is 5300 MW
- The low forecast is 4900 MW

LPA notes that there is a relatively small variation between the median forecast and the related high and low scenario forecasts.

LPA endorses the selection of the "recovery scenario" as the basis for the "median" electricity demand and energy forecasts.

Also LPA notes that whilst trends in Regional demand growth may be based on economic parameters, attention needs to be paid to other developments which might have a direct impact on rates of growth in demand on parts of the network. These include:

- The National Energy Efficiency action Plan
- Demand Side Response – facilitated through the installation of Smart metering
- Individual additions of large block loads related to prospective new Data centres, mainly in the Dublin area.

EirGrid's demand forecasts take into account the above initiatives.

LPA has considered EirGrid's forecasting methodology (including the econometric approach and temperature correction techniques) and believes that these are robust and are in line with international best practice.

2.2 Renewable Generation

In Ireland a group processing or gate process has been used to aggregate applications to connect renewable (mainly wind) generation

2.2.1 Gates 1 & 2:

The offer processes for Gates 1 and 2 took place in 2004/5 and 2006/7 respectively, resulting in connection offers being made and accepted for 330 MW of renewable generation under Gate 1 and for 1400 MW under Gate 2.

- Gate 1: - the 330 MW of generation has been connected
- Gate 2: - 1,400 MW of offers have been made and accepted. However, some connections are awaiting construction of connecting substations and related grid reinforcements (mostly 220 kV circuits).

2.2.2 Gate 3:

Under Gate 3, connection offers have been made for around 4,000 MW of generation. The current status of the Gate 3 connection offers is as follows:

- 82% of offers accepted
- 7% of offers still under consideration.
- 11% of offers declined.

The final outcome lies in the range 82% to 89% (3280 MW to 3560 MW).

It is assumed that some of the Gate 3 projects will be waiting for associated grid reinforcements to be completed.

2.2.3 Renewable generation 40% Target

Ireland has a 2020 target of 40% for renewable generation. Future demand growth forecasts have moderated so it is estimated that the 40% target will be met with around 3,200 MW to 3,800 MW of renewable generation. It is anticipated that following completion of the renewable generation projects under Gates 1, 2 and 3, the 40% target will have been met or exceeded.

2.2.3.1 LPA Comments

- It is the planned connection of renewable generation under Gates 2 and 3, together with connection of new conventional generation (mainly CCGT in the south and south east) that is a driver for many of the Grid25 major projects.
- The reinforcements related to the Grid25 major projects, will provide increased transmission capacity to accommodate connection of new generation, future demand growth and support increased power transfers across the transmission network.
- Future Gates – after Gate 3 there are more generation projects in the pipeline. Subject to approval by the regulator, it is possible that there will be a further round of applications to connect renewable and conventional generation projects.
- EirGrid continually updates and monitors the progress of planned generator connections and keeps their assumptions and drivers up to date

2.3 Conventional Generation

2.3.1 New conventional generation at East Cork and in the South East

Since 2010 the following generation has been commissioned:

- Near Cork, Aghada CCGT
  - Aghada AD2 431 MW
- Near Cork, Whitegate CCGT
  - Whitegate 444 MW

The following plant commissioning is expected

- At Great Island, County Wexford – a new CCGT plant
  - 431 MW

Conventional Plant potential de-commissioning includes:

- Great Island Units 1 – 3 212 MW expected 2015
- Tarbert Units 1 – 4 592 MW expected 2023

Northern Ireland:

- Ballylumford ST4 – ST6 510 MW expected by 2016

Since 2008, new generation projects using conventional designs have emerged at East Cork and in the South East. Peak demand forecasts have been scaled back so the increases in renewable generation and in conventional plant at locations remote from the Dublin and Belfast load centres will lead to lower generation load factors on conventional plant and possible early closure of older inefficient plant. These factors will support the need cases for network reinforcements to support higher power transfers between the relatively remote areas of Ireland to the demand centres in Dublin and in Belfast.

2.3.2 Changes from Grid25 (2008)

Grid25 (2008) made assumptions about the connection sites for new conventional generation:

- Higher demand growth was assumed
- To meet the higher demand new conventional generation would be constructed on brown-field sites closer to the main load centres around Dublin and on the east coast.
- Higher power transfers across the network are partially mitigated by new conventional generation close to load centres.

For Grid25 Review EirGrid does not expect a major uptake of new conventional generation to be constructed on the brown-field sites, close to load centres.

- Overall, higher power transfers are expected as the known new generation projects are sited in more remote areas and this will more than make up for the lower power transfers arising from lower demand forecasts. The transmission network needs the capability to deal with the diverse portfolio of conventional and renewable generation leading to larger variations in power transfers across the transmission network.

2.3.2.1 LPA Comments

LPA agrees that high power transfers remain the main characteristic, even though there have been changes in the demand growth and in the quantity and location of new conventional generation.

LPA notes that a modern transmission network must cater for a wide diversity of generation and large variations in power transfers across the network. Also current and future International

Interconnectors contribute further to diversity as scheduled power transfers can be varied from maximum export to maximum import.

2.4 Interconnections

2.4.1 Changes in Assumptions

The East West Interconnector (EWIC) (from Portan, near Woodland, to Deeside) was completed in 2012.

Support for future Interconnections between Ireland and Great Britain and between Ireland and France is coming from both National Institutions and from the European Union.

The new EU regulation 373/2013 Guidelines for trans-European Energy Infrastructure (2013) identifies Interconnection Projects of Common Interest (PCIs).

The "Celtic Interconnector" is a possible interconnection between southern Ireland and Brittany in France. Preliminary feasibility studies indicate a benefit to customers in Ireland and France. In March 2014 Eirgrid and the French TSO (RTE) agreed to carry out a marine survey. Route length is around 500 km.

2.4.1.1 LPA Comments

Currently the provision of a connection point for a future Interconnector is not a direct driver for the Major Grid Projects.

However, the following Interconnections remain possible:

- HVDC Interconnector between Ireland and France
  - Currently a marine survey has been authorised
  - The EU has identified it as a Project of Common Interest.
  - Note that a possible connection point is along the south coast of Ireland
- A second HVDC Link between Ireland and England/ Wales

3 IMPACT OF NEW TECHNOLOGIES ON GRID DEVELOPMENT

3.1 Changes in Grid25 Review technical report (2015)

EirGrid has made the following statement in the Grid25 review technical report (2015):

"All practical technology options will be considered for network development"

Reference: Strategy 2 in Grid25 Review technical report (2015).

The following paragraphs give examples of where new technologies have been considered/ adopted:

3.1.1 AC Underground Cable

Recent developments in cable technology have resulted in increased use of XLPE at transmission voltage 220 kV. Also 220 kV cables are available at higher ratings and they can now match the rating of 220 kV overhead lines. Where technically viable, this has led to the consideration of 220 kV cable. EirGrid have used 220kV underground cables in Ireland.

3.1.2 High Temperature Low Sag (HTLS)

Since 2008, HTLS conductor has been used extensively by EirGrid to uprate existing overhead line routes. Under Grid25 some 1280km of OHL uprates have already been carried out. In some cases ACSR conductor is replaced by ACSR with higher current rating (larger cross- sectional area. In other cases HTLS conductor is used. It has lower sag characteristics and enables higher conductor temperatures. Ratings are increased by 50 – 60% when compared to existing conductor. Some 510kms of HTLS conductor has been installed.

This is an example of cost effective application of new technology to increase the rating of existing assets.

3.1.3 Dynamic Line rating (DLR)

By monitoring local meteorological conditions, it is possible to combine this with the line design data to derive a rating that varies in real time. Where local conditions allow an increased rating it may be possible to transfer increased power. The technology is only useful in operational timescales, where there is a system constraint and a short term increase in rating is desirable to relieve the constraint pending medium term reinforcements.

3.1.4 Voltage Uprating

This technology is under development and will enable uprating of 220 kV lines and towers to 400 kV without a full rebuild of the towers. This technology is still in the R & D phase.

3.1.5 Tower Design

New tower designs are being considered as a replacement for the existing lattice type towers.

Objectives include:

- Reduced visual impact
- Lower tower heights

- Less steel work
- Monopole designs

EirGrid is exploring the available options for tower design.

3.1.6 Power Line Guardians

A Power Line Guardian (PLG) is a reactive power management device that can be deployed on existing overhead line conductors. Each device is individually controlled and can provide reactive compensation and/ or power flow control.

Currently a pilot trial is ongoing to identify the benefits of installing Power Line Guardians on selected overhead lines.

3.1.7 Superconducting Fault Limiters

SFLs will limit fault currents and in some cases will remove the need to uprate/ replace existing switchgear. Trials are planned for the Irish Transmission System.

3.1.8 Smart Grid Innovation

EirGrid is committed to introducing SmartGrid technologies. The main benefit is the transmission of information to enable transmission and distribution user equipment to become more intelligent and responsive.

3.1.9 User Technology

Changes to the characteristics of user equipment may have an impact on the grid. The main issues that EirGrid has identified are:

- Changes in reactive power demands
- Reduction in system inertia
- Increased harmonic distortion

These changes are largely caused by wind farms, Solar PV farms and cable networks. In future harmonic distortion issues are likely to worsen due to charging of electric vehicles.

3.1.10 Series Compensation

Series Compensation Benefits

Series Compensation is a well-established technology that is primarily used to reduce transfer reactance on circuits in bulk transmission corridors.

Series Compensation allows higher active power transfer and improved sharing between parallel circuits whilst improving the transmission system transient and voltage stability.

The use of Thyristor Controlled Series Compensators may reduce the risk of local sub-synchronous resonance issues and provide damping of active power oscillations, although not for low frequency inter-area power oscillations. This controllable solution whilst still cost effective requires additional equipment and hence cost compared to a fixed solution.

EXTERNAL PEER REVIEW OF GRID25 REVIEW (2015)
FINAL PEER REVIEW REPORT

Series Compensation Issues

The introduction of Series Compensation on the transmission system may cause sub-synchronous issues with generation plant and may introduce control interaction issues with other power electronic controlled equipment such as HVDC and large windfarms, however mitigation is possible.

High levels of compensation (up to 100%) are not unusual; however, over-compensation can lead to issues with ferro-resonance.

3.1.11 LPA Comments

LPA notes that EirGrid is proactive and seeks to introduce new technologies as soon as they become viable. Since 2008 substantial savings and benefits have been made from;

- Use of high capacity ACSR and HTLS overhead line conductor and other measures to increase the rating of existing assets.
- Adoption of high capacity 220 kV cable designs in order to meet specific needs of a project.
- As part of EirGrid's commitment to consultation and engagement with the public and other stakeholders it intends to bring forward technically feasible solutions and to evaluate all practical technologies.

4 LPA COMMENTS ON THE UPDATED GRID DEVELOPMENT STRATEGIES

4.1 Introduction

In light of changes since 2008 and with experience of implementing the smaller Grid25 Projects during the period 2009 – 2015, EirGrid has updated and modified its key strategies as follows:

- Open engagement and inclusive consultation with local communities and stakeholders will be central to EirGrid's approach to network development.
- All practical technology options will be considered for network development.
- The existing network will be optimised to minimise requirements for new infrastructure.

4.2 Strategies

4.2.1 Strategy 1: Open engagement and inclusive consultation with local communities and stake-holders will be central to EirGrid's approach to network development

EirGrid has published 12 commitments that are related to three themes, with the intention of improving the public consultation process. The themes are:

Theme 1: Develop a participative approach.

Theme 2: Change our Cultures and Processes.

Theme 3; Encourage Leadership and Advocacy.

The related commitments are:

1. Clear communications
2. Process for Consultation in Project Development
3. Consultation toolkit
4. Improved Community Relationships
5. Demonstrate Consideration of Social Impact
6. Consultation handbook
7. Consistency of information
8. Complaints process
9. Support of policy makers
10. Input from representative groups into EirGrid's approach to grid development
11. Regional discussion forums
12. Independent EMF monitoring and compliance

LPA notes that whilst the previous consultation and engagement process was in line with international best practice, EirGrid had identified that the consultation process could be further improved and decided to conduct a thorough review. In January 2014 EirGrid initiated an independent review of the public consultation process in order to enhance future public engagement in the Major Grid reinforcement projects.

The three themes above and the twelve commitments are an outcome of the review process.

LPA considers that EirGrid has been proactive in initiating the review of the process and then by making improvements to the public consultation process.

4.2.2 Strategy 2: All practical technology options will be considered for network development

In Grid25 (2008 version) there was a prescriptive statement: "New transmission lines will be built at 400 kV and at 110 kV". This approach has evolved and EirGrid now recognises that in building strategically, it is important to consider the full range of technologies, and consider the advantages and disadvantages of each.

LPA agrees that, initially all practical technology options should be considered at the outset in order to determine the most effective solutions. Also there is a need to bring alternative options into the public domain (during consultation and public inquiries) to demonstrate to Local Communities and Stakeholders that the best solution has been identified.

One of the themes raised during discussion of the public consultation process was the need to conduct comprehensive overhead line and undergrounding analysis for selected Major Grid development projects. For the Grid Link and the Grid West major projects, it has been decided that overhead line and underground options shall be brought forward into the public consultation phase. For each project, three feasible options shall be prepared. The proposals shall then be submitted to an Independent Expert Panel, to consider the three options and to give feedback to EirGrid on the relative merits of the options for the selected project.

LPA considers that new processes that ensure extensive consultation with Local Communities and Stakeholders are commendable. However it is noted that this procedure may result in longer lead times for major projects, which will need to be factored in to project timescales.

LPA notes technological developments bring forward new technical solutions that help to increase the capability and reduce the cost of new assets. Appropriate new technologies should be adopted, following rigorous testing in R& D and successful trials on the network. Where possible, designs should be standardised in order to minimise cost and maximise the benefit to the network. Following rigorous testing leading utilities are quick to adopt any new technologies that help to improve power networks.

4.2.3 Strategy 3: The network will be optimised to minimise requirements for new infrastructure

LPA supports this strategy.

It is good practice to aim to maximise the capability of existing networks. Also there are some relatively inexpensive enhancements that lead to increased circuit ratings and help to delay major investments for a few years. Also it maximises the utilisation of existing line or cable routes. Many western utilities have a version of this policy.

4.2.3.1 Maximise use of the existing network

Tools for optimising the existing network include: Dynamic Line Rating, Series Compensation, reactive compensation, fault limiters, voltage uprating and re-conductoring using ACSR or HTLS conductor.

The above measures are seen as incremental and serve as a means of maximising the capacity of the existing network, thereby ensuring that major investments are postponed. However, as power transfers increase the loading of existing circuits continues to increase and may then approach the limits of the new ratings.

4.3 LPA comments

- LPA notes that the three draft strategy statements have been presented for comment. They embrace the high level principles that EirGrid intends to follow when developing the grid. In summary the strategies are:
    - Commitment to open engagement and inclusive consultation with public and stakeholders
    - Consider all practical technology options for network development
    - Optimise the existing Network

LPA supports the three high level strategies. Optimising the existing network is a priority strategy for many utilities. It helps to improve the utilisation of existing assets and helps to postpone network reinforcements. Using all practical technology options will ensure that new technologies will be considered as soon as they have been developed and tested and may help to improve network performance and/ or reduce the capital cost of new schemes. Updating the public consultation process with twelve new commitments is the outcome of an initiative to further improve the public consultation. Once implemented, this should help the consent/ implementation phases of the major grid development projects.

5 IMPACT OF THE CHANGES TO MAJOR PROJECTS AND THEIR NEED CASES

5.1 Changes Common to all the Major Projects

5.1.1 Changes to Drivers

Most of the major projects are driven by prospective connection of Gate 2 and Gate 3 renewable Generation projects and connection of known new conventional generation projects. In both cases connecting sites are some distance away from the major demand centres (Dublin and Belfast) and various power corridors need to be strengthened in order to carry the increased power transfers.

The lower demand forecasts reduce future requirements for conventional generation. The new conventional generation projects originally identified in Grid25 (2008) have located in the south and south east, this new generation will tend to displace older, low merit generation sited near to Dublin and to Belfast. The net effect is that power transfers across the network will be high as was anticipated in Grid25 (2008).

5.1.2 Amendments to Strategies

When projects were taken into the public domain for consultation with stakeholders and with communities, considerable feedback was received. One common theme that was identified was to expand on the technology options in the public consultation phase.

In response, new public planning and environmental policies and procedures are being developed in order to ensure that there is full consultation with communities and stakeholders ensuring that their needs are taken into account and that as far as possible there is consensus and the outcomes for each project are consistent and fair.

5.2 The North- South Interconnector Project

5.2.1 The Project

400 kV OHL linking Woodland in County Meath to Turleenan, County Tyrone, in Northern Ireland

5.2.2 Status and Drivers

Joint Proposal between EirGrid and SONI (System Operator Northern Ireland)

Reviewed by International Expert Commission in 2012 – on case for and cost of undergrounding.

Project Re-evaluation report published in April 2013

Project is part funded by EU-Ten-E initiative.

Past planning submissions:

- Dec 2009 – NIE applied to NIPS for the northern part of the project
    - Aug 2010 – referred for public inquiry

  - Public Inquiry commenced Mar 2012 – now adjourned
- Dec 2009 – EirGrid application to An Bord Pleanála (ABP)
  - Jan – Mar 2010 ABP invited submissions from stakeholders and public
  - May 2010 oral hearing commenced
  - June 2010 application withdrawn due to error in public notices
  - As a result no determination was given by ABP

Submission of revised planning application to ABP is scheduled for 2015.

Drivers:

- Improve **Security of Supply** by adding a reliable high capacity link between Ireland and Northern Ireland.
- Improving **Competition** in the All Ireland Single Electricity by removing transmission constraints that have been restricting efficient performance of the Single Electricity Market.
- Support the integration of new renewable generation by facilitating increased power flows across the interface with Northern Ireland and across the entire transmission network
- Alignment with the latest EU regulation – "Guidelines for trans- European energy infrastructure"

5.2.3 Impact of changes on the project

- Local demand growth is no longer, a significant driver for this project
- Following feedback from stakeholders and others the selection of AC OHL as the preferred technology has been challenged. EirGrid has devised a robust consultation process and has sought expert advice on the potential impact of undergrounding for the entire route.
- 400 kV OHL is the preferred option.

5.2.4 LPA View of need Case

- The need case remains sound and unchanged
- **Security of Supply** will be improved.
- **Competition** will be facilitated in the All Ireland Single Electricity Market (SEM) by removing transmission constraints that have been restricting efficient performance of the Single Electricity Market.
- Removal of constraints will reduce the overall cost of generation dispatch.

- Completion of the project by 2020 will assist with the connection of Gate 3 renewable generation in Ireland and assist in meeting the 40% target for renewables (for Ireland and for Northern Ireland) by 2020.
- Larger power transfers will be possible on the internal links between Ireland and Northern Ireland and on the external links between Ireland/ Northern Ireland and Great Britain.

LPA considers that there is a strong need case for this project and that significant benefits will accrue.

5.3 The Grid Link Project

A total of 3 technically complaint solutions have been proposed as a result of 'The Grid Link Project'. These are summarised as follow:

1. A new HVDC link from Knockraha – Dunstown.

This scheme consists of a fully underground HVDC solution from Knockraha to Dunstown. It will offer the advantage of creating a new corridor to bring up the generation from the south west to serve the heavy demand centre of Dublin.

2. A new HVAC circuit from Knockraha - Dunstown.

This scheme is a full HVAC solution from Knockraha to Dunstown. The solution will help to reduce the loadings on the existing 400 kV network by creating a new transmission corridor from the south west to Dublin.

3. Series compensation on existing 400 kV circuits.

This scheme is concerned with the installation of series capacitors on the three (3) existing 400 kV lines to a maximum of 70%. The series compensation will encourage more power flows across the existing 400 kV circuits and thus provide an increase in utilisation. This solution meets the forecast in generation and demand make-up for the foreseeable future. However, it may have less of a contributory nature when compared with the other solutions proposed if new interconnectors across southern Ireland were to materialise. However at this point in time there is no such evidence to cater for additional interconnectors and should the need arise then the investments requirements will be considered.

5.3.1 Status and Drivers

The project is currently in progress and a selection of overhead and underground cable routes are being assessed.

Drivers:

- Government white papers in 2007 and 2008, setting a target of 33% then 40% of electrical energy consumption to be supplied from renewable sources by 2020.
- The Gate 3 process (4,000 MW total for Ireland), when added to Gates 1 and 2 (330 MW and 1400 MW) will ensure that the 40% target is either met or exceeded.
- Connection of 1630 MW (40.7%) of Gate 3 new renewable generators in the south west.

- Beyond Gate 3 there are more generator connection applications in the pipeline – renewable and thermal.
- Actual and planned connection of new thermal generators (CCGTs), near Cork City and at Great Island: – three CCGTs have been connected already.
- Regional demand growth – note the strength of this driver is greatly reduced, as demand forecasts in 2015 are much lower than the forecasts in the original Grid25 (2008) Strategy.

5.3.2 Impact of Changes on Project

- Demand growth is no longer considered a significant driver, however, it is noted that the present demand estimate for Ireland is significantly lower than the original 2011 figure.
- Connection of Gate 3 Generation in the area remains a strong driver and is unchanged
- Most, if not all, of the Gate 3 generation will most likely connect and most connections will be made by 2020
- All technologies remain under consideration at this time and will go before an expert panel for review.
- In January 2014, The Independent Expert Panel (IEP) was appointed by the Irish government to oversee a comparative analysis of OHL / UGC technology for both the Grid Link and for the Grid West Projects. Findings for Grid Link go to IEP during 2015.

5.3.3 LPA View of Need Case

- LPA agrees that the main drivers for the project are the Gate 3 renewable generation and over 1200 MW of conventional generation, that has connected since 2008.
- The 1630 MW of new renewable generation (Gate 3) will lead to increased power transfers that exceed the capabilities of the existing 220 kV/ 110 kV networks.
- Transmission reinforcements with new circuits are required between Cork (Knockraha) and SE Dublin for two of the options. For the series compensation option, only series compensation is installed on the existing 400 kV circuits with a Shannon subsea crossing and new linear reinforcement between Knockraha and SE Dublin is not required.
- It is noted that building a HVAC 400 kV line route from Dublin to Cork fulfils part of a longer term strategy to create a southern route at 400 kV that links Dublin and Cork (Knockraha); then runs northwards to create a strong mesh with the existing 400 kV network at Moneypoint. Note that this is a conceptual plan and is a long term option, it is not a current project and at present no driver for the "project" has been identified.
- HVDC Underground cable route is an alternative solution to the construction of an HVAC 400 kV overhead line.
- In conjunction with the need to reinforce, using any solution there are parts of the south midlands network that need separate reinforcement. It is understood that separate schemes will be developed to address these issues.
- Series compensation offers an alternative to installing and building new infrastructure, however its effects should be studied in detail to get a greater understanding of the technical

and practical issues of the installation, refer to section 3.1.10 on Series Compensation technology.

LPA agrees that there is a strong need case for this project. The take-up of Gate 3 renewable generation offers should be monitored as the timing and amount of new generation (under Gate 3), will dictate the timing and need for this reinforcement project.

5.4 The Grid West Project

A total of 3 technically complaint solutions have been proposed as a result of 'The Grid West Project'. These are summarised as follow:

1. A new single fully HVDC underground cable, 113 km in length and with two new HVDC converter stations, one near the existing Flagford 220 kV station and one near to Moygownah. The HVDC underground cable will run from near Moygownah to Flagford and will collect the output of the wind farms in the vicinity of Moygownah.
2. A new single HVAC 400 kV overhead line circuit, 103 km in length, running from the existing Flagford 220 kV substation to a new station near Moygownah. The final 8 km of the existing Flagford-Srananagh 220 kV circuit will be utilised. It will collect the output of the wind farms in the vicinity of Moygownah.
3. A new single HVAC 220 kV overhead line circuit, up to 103 km in length, running from the existing Flagford 220 kV substation to a new station near Moygownah. The final 8 km of the existing Flagford-Srananagh 220 kV circuit will be utilised. It will collect the output of the wind farms in the vicinity of Moygownah. This option allows for up to around 20 km of the overhead line to be undergrounded.

5.4.1 Status and Drivers

A report was recently submitted to the Independent Expert Panel (IEP). The panel will consider the three options described above.

Drivers:

- Government white papers in 2007 and 2008, setting a target of 33% then 40% of electrical energy consumption to be supplied from renewable sources by 2020.
- The Gate 3 process (4,000 MW), when added to Gates 1 and 2 (330 MW and 1400 MW) will ensure that the 40% target is either met or exceeded.
- Around 650 MW (16.2%) of Gate 3 new renewable generation is in the vicinity of Bellacorick, County Mayo. Note that some of the Gate 3 generation can be absorbed on the 110 kV network (assuming a number of 110 kV reinforcements are completed), leaving around 400 - 500 MW to be met by the new Grid West reinforcement.
    - It is noted that after Gate 3 there are applications in the pipeline for:
        - Further wind generation
        - Biomass plants

- Pumped storage plant
- Potential wave and tidal generation projects – the Marine Renewables Industry Association (MRIA) advises that North Mayo coastline is a priority zone for such projects

5.4.2 Impact of Changes on Project

- Demand growth is not a significant driver
- Connection of Gate 3 Generation in the area remains a strong driver and is unchanged
- Three options have been submitted to the IEP for consideration. They may be described as;
  - HVDC single cable option
  - HVAC single 400 kV overhead line – 100% overhead line
  - HVAC single 220 kV overhead line – 70% to 100% overhead line (up to 30% undergrounded).
- In January 2014, The Independent Expert Panel was appointed by the Irish government to oversee a comparative analysis of OHL / UGC technology for both the Grid Link and for the Grid West Projects. Findings for Grid West Options have been submitted.

5.4.3 LPA View of Need Case

- LPA agrees that the main driver for the project is the Gate 3 renewable generation
- The existing 110 kV network at Bellacorick is unable to support an export greater than circa 100 MVA at present or 180 MVA when uprated. Any development at 110 kV alone would require construction of multiple 110 kV circuits.
- Therefore reinforcement is required – HVDC link or HVAV at either 220 kV or 400 kV.
- It is noted that the largest single infeed is 500 MW, so not more than 500 MW of generation should be lost following the trip of a single circuit.
- In conjunction with the reinforcement (at 220 kV or 400 kV HVAC or HVDC) there is a need to reinforce the 110 kV network around Bellacorick to increase its export capability from around 100 MVA to around 180 MVA. This would allow some of the Gate 3 generation to be connected at 110 kV to Bellacorick 110 kV substation. The need for this element of the project depends on a 100% take-up of connection offers in the vicinity of Bellacorick.

LPA confirms that there is a strong need case for this project. The take-up of Gate 3 renewable generation offers should be monitored as it is the amount of new renewable generation that drives the need to reinforce this group.

5.5 The Moneypoint – North Kerry Project

Build a 220 kV high capacity underground cable running under the Shannon to connect Moneypoint to Kilpaddoge.

EXTERNAL PEER REVIEW OF GRID25 REVIEW (2015)
FINAL PEER REVIEW REPORT

Build a 220 kV cable from Kilpaddoge to Knockanure.

5.5.1 Status and Drivers

The original scheme had initial approval in March 2011 and was a 400 kV circuit running from Moneypoint to Knockanure that comprised:

- A 400 kV cable from Moneypoint running under the Shannon
- Then a 400 kV line running to Knockanure

During Phase 2:

- During consultation with stakeholders/ local representatives it was noted that:
  - The OHL corridor (between Tarbert and Listowel) is already congested with 2 x 220 kV OHLs and 4 x 110 kV OHLs.
  - The route runs close to Manveanlagh bog
  - A fully consented wind-farm (at Moyvane village) lies close to the route
  - There would be significant local opposition to the 400 kV OHL proposal.
- A review of the original options was carried out and three new Options identified. Option C was selected (that was based on the original Option 1). This was for a 220 kV cable from Moneypoint to Kilpaddoge and a 220 kV cable from Kilpaddoge to Knockanure. This project is deliverable before 2020.

Revised Status:

- Revised project was submitted for internal approval.
- Construction has commenced on the 220 kV (high capacity) cable running from Moneypoint to Kilpaddoge
- The project for the 220 kV cable from Kilpaddoge to Knockanure has a target completion date of 2019.

Drivers:

- Meet the 40% target for renewable generation by 2020.
- Connect the Gate 3 renewable generation located in the south west.
  - It is noted that after Gate 3 there are applications in the pipeline for:
    - Further wind generation

5.5.2 Impact of Changes on the project,

- The project has changed from an AC 400 kV submarine cable plus AC 400 kV OHL project to an AC 220 kV submarine cable plus AC 220 kV cable project.

- The project was reviewed in 2013 after consultation on route options.
- When AC 220 kV cable was re-considered it was noted that through technology development high capacity 220 kV XLPE cable was available with a $2500mm^2$ cross- section and with segmented copper construction. The cable rating exceeds 700 MVA and matches a 220 kV OHL using HTLS conductor.
- Due to the fact that there is a change in the technical specification of the project the costs are now lower than the original proposal.

5.5.3 LPA View of Need Case

- LPA agrees that the main driver for the project is the Gate 3 renewable generation.
- The proposed scheme connects the Gate 3 generation, in the south west to the 400 kV grid at Moneypoint.
- The availability of high capacity 220 kV cables has facilitated the selection of a 220 kV connection option that costs less than the original 400 kV option and can be completed earlier (by 2020).
- LPA notes that this scheme is not immediately compatible with the conceptual plan to complete a 400 kV ring running from Dunstown (SE Dublin), to Cork (Knockraha), then on to Moneypoint 400 kV substation. Also it is noted that this is a long term conceptual project and that currently there is no driver to complete this project.
- LPA agrees that the 220 kV solution is still compatible with the conceptual plan, but notes that additional expenditure would be incurred in 2040 (or later) in order to upgrade the existing 220 kV OHL to 400 kV and to lay new 400 kV submarine cables under the Shannon.

LPA notes that there is a strong need case for the project.

5.6 The North West Project

The **North West Project** comprises one of the elements of the Renewable Integration Development Project (RIDP) that lie in County Donegal and the north-west of Ireland and that EirGrid needs to take forward for approval. Whilst full benefit is only obtained when all proposed reinforcements are completed in both Ireland and Northern Ireland, the construction of a reinforcement from Srananagh to Donegal will facilitate the export of the Gate 3 renewable generation in north-west Donegal to Srananagh, and on to Flagford station, at present the only need in the area.

The Renewable Integration Development Project is a joint project established (in December 2007) by the all- island planning licensees to address network limitations in the north-west of Ireland and in the north and north-west of Northern Ireland and to identify the reinforcements needed to connect onshore renewable generation expected in both jurisdictions by 2020. Note that the North – South 400 kV Interconnection project is included in the base case study background for the above project.

North West Project:

First phase of RIDP scheme

It has been submitted as a Project of Common Interest (PCI) as a 220 kV line from Srananagh 220 kV substation to a new 220 kV substation near Clogher 110 kV substation. However, as per Strategy 2 and the approach being undertaken for the Grid West and Grid Link projects, all practical technology options will be considered.

Reinforcement at 110 kV is also required.

5.6.1 Status and Drivers

5.6.1.1 North West Project

North West Project is being progressed and all practical technology options will be considered, as per Strategy 2 and in line with the approach being undertaken for the Grid West and Grid Link projects.

Updated Scheme drivers:

- Gate 1 and Gate 2 Renewable Generation projects (381 MW), have used up the spare capacity on the existing 110 kV Networks
- Gate 3 renewable generation, (261 MW + 19 MW non GPA) brings the total wind generation capacity to 661 MW in county Donegal and triggers the need to reinforce the network.
- The proposed technology options will address a reinforcement between Srananagh and Donegal.
- The project is consistent with RIDP that addresses network deficiencies in both County Donegal and in the north and west of Northern Ireland.

5.6.2 The impact of changes on the North West Project

- The reduced demand forecast has an adverse affect. Lower demands in Donegal serve to increase the amount of generation exported from the group.
- The main driver remains the integration of Gate 3 Renewable generation in Donegal.
- A secondary driver is to be able to further reinforce to provide the mutual support to the NI Network as determined by the RIDP scheme.
- All practical technology solution options will be considered.
- Consulation on the need and options will be undertaken in future months.

5.6.3 LPA Comments on the Need Case for the North West project

- LPA notes that the main driver is the Gate 3 Renewable generation in County Donegal. The 280 MW under Gate 3 is a similar order to the 381 MW that has already been connected under Gates 1 and 2.
- The status and progress of the relevant Gate 3 projects needs to be closely monitored as a poor take-up of connection offers will have an adverse impact on the need case.
- LPA notes that after Gate 3, the amount of renewable generation in the queue is 1500 MW, which is considerably greater than the renewable generation (661 MW) that is to be connected under Gates 1, 2 and 3. Whilst there is no obligation to formally consider connections post Gate 3, LPA suggests that EirGrid considers the scale of network

reinforcement that would be required and whether the additional reinforcements would be compatible with those planned for the North West Project and under RIDP.

LPA confirms that, even as a standalone project, there is a need case for the proposed reinforcement. However, it is sensitive to the final connection outcome of the Gate 3 generation in Donegal. The North West Project is consistent with the RIDP Scheme.

6 COMMENTARY ON EIRGRID PRACTICES STANDARDS AND PROCEDURES

LPA makes the following comments on various aspects of EirGrid's practices in relation to presentation in the Grid25 Review technical (2015) of its revised strategies and its major project development proposals.

6.1 Transmission system security and planning standards (TSSPS)

EirGrid has developed rigorous Transmission System Security and Planning Standards that bear comparison with other (larger) utilities in Western Europe.

To determine whether current and planned future networks will meet the planning criteria, system models are prepared and power system studies are carried out that always include:

- AC loadflow studies
- Short circuit studies
- Stability studies

Winter peak, Summer Peak and Summer valley conditions are studied. Normal and outage contingencies are studied including: N-1, N-G-1, and N-1-1 Trip maintenance. Where appropriate, operational mitigation measures are considered. These include: re-dispatch of active and reactive power, transformer tap- changing, power-flow controller dispatch and busbar sectionalising.

The Transmission System Security and Planning Standards (Transmission Planning Criteria) were used to determine the transmission reinforcements required for each of the five major Projects for Grid25. Naturally the study backgrounds included expectations for demand growth, new thermal generation plus the Gate 3 renewable generation. Also a typical generation dispatch would be used for each of the seasonal demand scenarios (winter peak, summer peak and summer valley).

LPA has compared the TSSPS with the security standards used by National Grid in the UK and considers that whilst there are differences, the TSSPS matches the UK standards and in some aspects is superior. In operational timescales a 450 MW equates to 10% of system demand. The probability of generator loss incidents is similar to UK, but the initial severity of the frequency excursion (rate of fall) is greater.

6.2 Grid Development Strategies

6.2.1 Strategy 1: Open engagement and inclusive consultation with local communities and stakeholders will be central to EirGrid's approach to network development.

LPA notes that whilst the previous consultation and engagement process was in line with international best practice, EirGrid had identified that the consultation process could be further improved and decided to conduct a thorough review. In January 2014 EirGrid initiated an independent review of the public consultation process in order to enhance future public engagement in the Major Grid reinforcement projects.

LPA considers that EirGrid has been proactive both by initiating a review of the public consultation and engagement process and then by implementing measures to enhance the process.

6.2.2 *Strategy 2: All practical technology options will be considered for network development*

LPA agrees that, initially all practical technology options should be considered at the outset in order to determine the most effective solutions. Also there is a need to bring alternative options into the public domain (during consultation) to demonstrate to Local Communities and Stakeholders that the best solution has been identified.

One of the themes raised during discussion of the public consultation process was the need to conduct comprehensive overhead line and undergrounding analysis for selected Major Grid development projects. For the Grid Link and the Grid West major projects, it has been decided that overhead line and underground options shall be brought forward into the public consultation phase. For each project, three feasible options shall be prepared. The proposals shall then be submitted to an Independent Expert Panel, to consider the three options and to give feedback to EirGrid on the relative merits of the options for the selected project.

LPA notes that many west European utilities follow the principle that the AC overhead lines are the default choice for medium length circuits, but that provision is made for undergrounding for environmentally sensitive areas, river crossings etc.

6.2.3 *Strategy 3: The existing network will be optimised to minimise requirements for new infrastructure.*

It is good practice to aim to maximise the capability of existing networks. Also there are some relatively inexpensive enhancements that lead to increased circuit ratings and help to delay major investments for a few years. Also it maximises the utilisation of existing line or cable routes. Many western utilities have a version of this policy.

Tools for optimising the existing network include: Dynamic Line Rating, Series Compensation, reactive compensation, Fault Limiters, voltage uprating and re-conductoring using ACSR or HTLS conductor.

LPA approves of these strategies because they involve making better use of existing equipment, lines and line routes.

6.3 Major Project Development Proposals

The need cases for the five major projects have been re-confirmed in the Grid25 Review Technical Report (2015).

EirGrid follows a rigorous process for establishing the need case and for evaluating the alternative options.

- Papers are then submitted to ABP (An Bord Pleanăla)
- Public participation is invited (oral hearings)

- ABP gives a decision

LPA is happy with the process, but notes that it can take some time before all the issues raised have been resolved to everyone's satisfaction.

NOTES:

EIRGRID

Your Grid, Your Views, Your Tomorrow.

A Discussion Paper on Ireland's Grid Development Strategy

Appendix 3

EIRGRID

eirgrid.com/yourgridyourviews

Appendix 3

National and Regional Evaluation of the Economic Benefits of Investment in Ireland's Elecricity Transmission Network

Indecon

National and Regional Evaluation of the Economic Benefits of Investment in Ireland's Electricity Transmission Network

Report for EirGrid

Prepared by

Indecon

www.indecon.ie

26th March 2015

Contents

Indecon *Indecon International Economic Consultants*
National and Regional Evaluation of the Economic Benefits of Investment in Ireland's Electricity Transmission Network

Executive summary

Introduction

This independent report is undertaken by Indecon International Economists for EirGrid. The report concerns a research assessment of the economic benefits associated with the expenditure impacts of investment in Ireland's electricity transmission network. The report also considers the scenarios available to achieve the key objective of providing adequate high-voltage electricity transmission grid infrastructure. Indecon recognises there are broader community and environmental issues which are relevant and this report is confined to economic aspects.

The context for the study is that EirGrid has identified a number of new scenarios to meet the future electricity transmission grid requirements of the Irish economy. Indecon fully supports the validity of EirGrid reviewing the scale of investment and the specific scenarios to meet requirements in the light of changes in economic need and revised policy priorities. This is particularly important given the fundamental revisions to Ireland's economic growth forecasts. There have also been changes in technological developments and in energy efficiency.

From an economic perspective Indecon believes the key challenges for EirGrid are to ensure sufficient high-voltage grid infrastructure to meet the requirements of the economy and to plan this infrastructure spending in the most cost effective manner.

Indecon believes that if there is over-investment in the electricity transmission network, beyond the needs of the economy then this would represent a clear waste of scarce economic resources and would result in higher electricity costs than necessary. This could result in uncompetitive electricity prices and would damage the ability of firms in Ireland to succeed in export markets and the attractiveness of Ireland as a location for overseas investment. As a result, excessive infrastructural spending would damage economic and employment prospects. However, insufficient electricity infrastructure would have very negative economic impacts and would stunt economic growth.

Reflecting policy priorities and the changes in the structure and prospects of the Irish economy, EirGrid has appropriately identified a number of new scenarios for electricity transmission network investment, which on a like-for-like basis relative to previous plans, show significant cost savings.

Indecon would also highlight that in addition to ensuring the lowest cost effective solution to Ireland's electricity transmission network requirements, it is essential that EirGrid's investment programme meets the policy requirement to spread economic growth on a regional basis.

In this report we consider some of the economic and regional aspects of grid investment and also assess the direct economic benefit of expenditure on the grid. We also outline some issues for consideration designed to ensure sufficient infrastructure at the lowest cost to the economy.

Background, Context and Policy Objectives

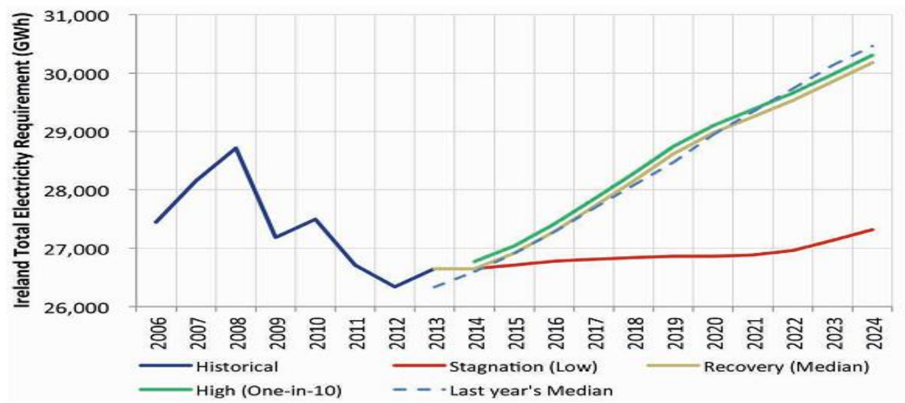
EirGrid began planning for the next generation of transmission grid investment over seven years ago. The original grid investment programme cost estimate was scaled back from €4 billion to €3.2 billion in 2011. The final cost of the programme will depend on the technologies selected for individual projects but it is anticipated that it will be in the range of €2.7 billion to €3.9 billion. All of these programme scenarios, however, involve cost adjustments due to a number of reasons including:

- Expected reduction in demand-related expenditure;
- Better use of new technologies;
- Lower than anticipated costs for some technologies such as circuit upgrading technologies;

- Scaling back and optimisation of some intended projects to be aligned with a rigorous assessment of future requirements over the relevant period; and
- Technology selected for individual projects.

Transmission capacity needs are fundamentally linked to electricity demand growth. The chart below provides a range of likely future electricity demand scenarios. The median scenario indicates the most likely growth in electricity demand between 2014 and 2024. By 2024, the likely total annual electricity consumption is forecast to be just above 30,000 TER (GWh), which represents around a 14% increase on the 2013 value. This represents annual average growth of around 1.3% which is considerably lower than the average growth rates prior to 2007.

Republic of Ireland annual electricity demand forecast- 2013-2024



Source: EirGrid/SONI "All Island Generation Capacity Statement 2015-2024"

Three scenarios have been developed to meet Ireland's high-voltage grid infrastructure requirements and involve costs of between €2.7 billion to €3.9 billion. Scenario A costs are estimated to be €2.9 billion, Scenario B €3.9 billion and Scenario C €2.7 billion. The key variables are discussed in EirGrid reports but from an economic perspective we examine the expenditure impacts of all three. We refer to Scenario A as mid-cost scenario, Scenario B as high-cost and Scenario C as low-cost. Some general elements of these scenarios are presented below. In addition to the economic issues the impact on visual amenity and other factors should be considered.

Summary of proposed for Grid Development – Other Economic Impacts

	Scenario A – Mid Cost	Scenario B – High Cost	Scenario C – Low Cost
Supports Regional Development	✓	✓	✓
Provides adequate capacity	✓	✓	✓
Minimises Cost to Electricity Users	-	×	✓

Source: Indecon analysis

Assessment of the Direct Impact of Grid Investment Programme

In our analysis we consider both the direct and indirect economic impacts of the expenditure and we firstly consider the direct impacts. A number of key points with regard to the direct economic impacts of the grid investment are as follows:

- Grid investment will generate significant levels of spend in the domestic economy through the expenditure on Irish labour and Irish-produced materials and services.
- Estimating the expenditure impacts of this investment requires a quantitative model of the programme of investment expenditure. This model developed by Indecon is designed as one input to the assessment of how grid investment expenditure will contribute to national output/GDP and employment.
- We estimate that undertaking grid investment as per Scenario A contributes around €1.97 billion to national output in gross expenditure impacts. In present value terms, this equates to around €1.5 billion. This gross expenditure benefit should be considered in evaluating the overall costs of the investment and the key user and other benefits.
- In terms of employment, this investment would lead to significant direct employment benefits of around 22,234 FTE man years which equals around 1,482 annual jobs supported.
- In all of the scenarios identified by EirGrid the expenditure benefits need to be weighed against the opportunity costs of the resources and the wider benefits for the Irish economy of the provision of sufficient grid infrastructure.

Direct contribution of each grid investment scenario total expenditure to national output/GDP and Employment – Scenario A	
Total National Spending – €million (undiscounted)	1,968
Total National Spending – €million (discounted)	1,498
Total National Employment– FTE Man Years	22,234
Total National Employment– Average annual jobs	1,482
Source: Indecon analysis of EirGrid Expenditure data	

- In present value terms, we estimate that the expenditure in Scenario B contributes around €3.0 billion to national output in gross expenditure impacts. This equals €2.15 billion in present value terms.
- This level of expenditure on electricity grid investment supports an estimated 1,982 annual jobs.

Direct contribution of each grid investment scenario total expenditure to national output/GDP and Employment – Scenario B	
Total National Spending – €million (undiscounted)	2,994
Total National Spending – €million (discounted)	2,146
Total National Employment– FTE Man Years	29,734
Total National Employment– Average annual jobs	1,982
Source: Indecon analysis of EirGrid Expenditure data	

- An analysis of the expenditure impacts of Scenario C leads to an expenditure related contribution of around €1.81 billion to national output.
- The employment supported by this investment expenditure is estimated to be around 1,365 per annum.

Direct contribution of each grid investment scenario total expenditure to national output/GDP and Employment – Scenario C	
Total National Spending – €million (undiscounted)	1,814
Total National Spending – €million (discounted)	1,407
Total National Employment– FTE Man Years	20,476
Total National Employment– Average annual jobs	1,365
Source: Indecon analysis of EirGrid Expenditure data	

Assessment of Economy-wide impacts of grid investment

- When account is taken of indirect impacts as well as the direct impacts referred to above, grid investment is likely to have significant impacts in terms of national expenditure and employment.
- We estimate that grid investment in the proposed Scenario A would contribute a gross €1.62 billion to the wider Irish economy over the lifetime of the project. In present value terms, this translates to €1.2 billion.
- This level and type of investment is estimated using input-output analysis to support around 2,825 in average annual jobs when account is taken of the direct, indirect and induced impacts.

Gross economy-wide impacts of grid investment expenditures on Irish economy – Contributions to National Output and Employment – Scenario A	
	Total
Total Direct, indirect and induced benefits less labour spending – discounted (€million)	1,226.4
Direct, Indirect and induced FTE Man years	42,371
Average Annual jobs equivalent	2,825
Source: Indecon analysis	

- Scenario B is estimated to contribute around €1.94 billion in present value terms to the economy in gross expenditure impacts.
- Including direct, indirect and induced employment impacts gives an annual average of jobs supported of 3,774.

Gross economy-wide impacts of grid investment expenditures on Irish economy – Contributions to National Output and Employment – Scenario B	
	Total
Total Direct, Indirect and induced Benefits less labour spending – discounted (€million)	1,939.6
Direct, Indirect and induced FTE Man years	56,603
Average Annual jobs equivalent	3,774
Source: Indecon analysis	

- Scenario C grid investment would lead to around €1.15 billion in gross expenditure related economic benefits (less labour spending) to the economy.
- In terms of wider economy benefits, this investment is likely to support around 2,603 jobs on an annual basis.

Gross economy-wide impacts of grid investment expenditures on Irish economy – Contributions to National Output and Employment – Scenario C	
	Total
Total Direct, Indirect and induced Benefits less labour spending – discounted (€million)	1,147.7
Direct, Indirect and induced FTE Man years	39,046
Average Annual jobs equivalent	2,603
Source: Indecon analysis	

In the next table we compare the key economic impacts across the different scenarios. The estimates in the table demonstrate that while all of the scenarios have significant cost as well as expenditure and employment benefits on the Irish economy, a key issue is the impact of these investments regarding the direct benefits of infrastructure provision.

All of the scenarios will have positive gross employment impacts arising from the expenditures. The gross employment impacts of the expenditures should not, however, be misinterpreted as suggesting that this equates to net employment impacts. The latter would need an adjustment to take account of the opportunity cost of labour. We estimate the opportunity cost of labour to be between 80 – 100%, indicating the percentage of persons who would be employed as a result of the investment expenditure that would have been employed otherwise in other activity. The more significant employment impacts would depend on how the provision, or lack of provision, of adequate electricity grid infrastructure impacts on jobs in the traded sector of the economy. Some indication of this can be seen by considering the costs of disruption in electricity supply but this is only a short-term impact. The effect on the ability of enterprises to expand and to facilitate new investment is a more significant impact. These factors represent the most important potential long-term benefits of grid investment. Research on the views of enterprises in Ireland on the importance of an adequate electricity grid on investment represents one indication of the significance of this issue. Also relevant are the implications of the proposed investment for cost competitiveness and electricity prices. This demonstrates the economic importance of ensuring infrastructure needs are met at the lowest feasible cost.

Summary of proposed scenarios for grid development			
	Scenario A	**Scenario B -**	**Scenario C**
NPV (Net Present Value) of the Gross Expenditure Benefits	2,229	2,864	2,097
NPV of the Costs	1,229	1,942	1,150
Difference	1,000	922	947
Economy-wide Employment (Man Years) supported	42,371	56,603	39,046
Economic Benefits of Infrastructure provision	(See below)	(See below)	(See below)
Source: Indecon analysis			

Economic Benefits of Grid Infrastructure on Investment and Economic Output

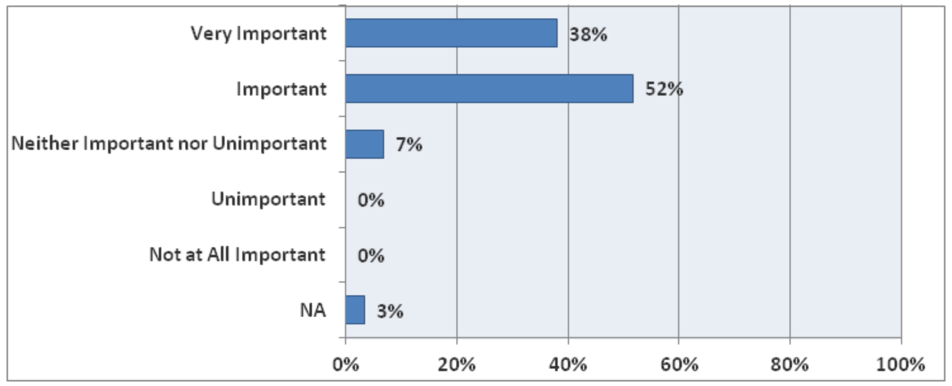
The economic benefits of providing grid infrastructure can also be considered in the context of the economic cost of an electricity outage to users. Indecon estimates that this is likely to be significant. We estimate that for a one hour outage, a conservative estimate of the economic cost is likely to be over €24 million and if wider economy costs are included is estimated to be around €45 million.

In addition to the economic costs of an electricity outage, of more fundamental significance is the impact on investment if sufficient infrastructure were not available. Such a scenario would impact on the ability of existing firms to expand and the ability to attract new investment into Ireland.

Grid investment is an essential component in meeting the requirements of industry connection to the transmission system. This is particularly relevant for firms in the internationally traded sector.

Indecon's analysis shows that 90% of firms surveyed believe that investment in the electricity transmission network is important or very important for Ireland's ability to attract additional foreign direct investment (FDI).

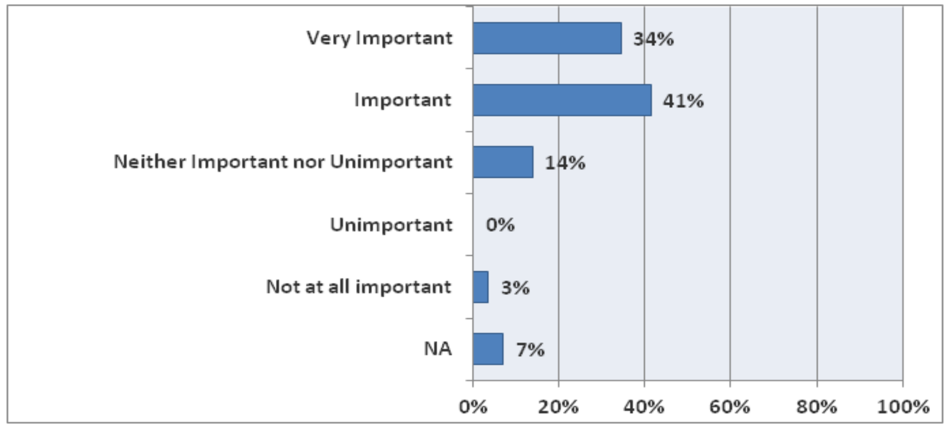
Views on importance of electricity transmission network on ability to attract additional foreign investment to Ireland



Source: Indecon survey of multinationals and indigenous companies in Ireland

- 75% of companies indicated it was 'important' or 'very important' to decisions to locate new operations or functions in Ireland.

Views on the importance of access to a high quality electricity supply on decisions to locate new operations or functions in Ireland



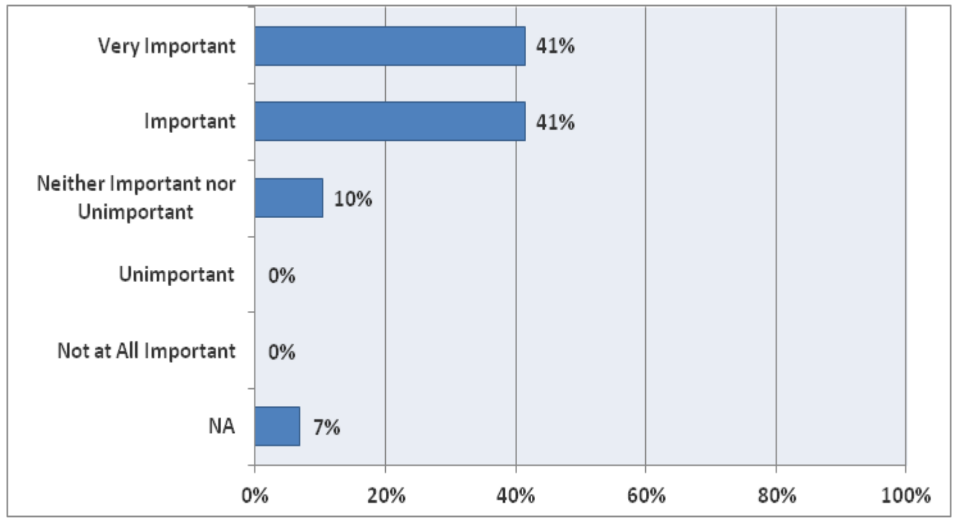
Source: Indecon survey of multinationals and indigenous companies in Ireland

Assessment on the Regional impact of grid investment

Grid investment will lead to different regional impacts in terms of local spending and employment. Of even more importance is whether the scenarios being considered have the potential to facilitate an expansion of economic output in each of the regions. Some of our key findings are as follows:

- It is estimated that grid investment will lead to significant local expenditure. This grid investment will have different regional impacts.
- It is essential there is sufficient grid infrastructure to support regions to attract new investment and to facilitate growth in jobs in existing industry. The importance of regional infrastructure is a crucial factor to achieving the potential of regional development in Ireland.
- National policy is focused on expanding economic output and employment in each of the regions. This will require an expansion of tourism, agriculture and indigenous and foreign-owned firms. While it would be a mistake to see this only in terms of foreign industry, the focus on winning investment for the regions is reflected in the new IDA (Ireland) strategy which is targeting a minimum of 30% - 40% increase in the number of investments for each region outside of Dublin over the period 2015 – 2019.
- Opinions of businesses surveyed on the importance of grid investment in facilitating regional economic development indicate that 82% of respondents believe that investment in the transmission grid is 'important' or 'very important' to facilitate regional development.

Views on the importance of investment in the electricity transmission network to facilitate regional economic development



Source: Indecon survey of multinationals and indigenous companies in Ireland

Adequacy to Meet Regional Needs

In evaluating the scenarios being considered by EirGrid it is critical to consider the ability of each scenario to accommodate the likely future demand in each region. In the table below we outline the capability of the proposed investment programme to accommodate additional demand and compare this to estimated demand in each of the regions. This suggests that there will be available capacity in all of the regions to accommodate significant expansion of demand. There are a number of caveats regarding the table below regarding differences within regions and the interaction between nodes/stations and regions. However, the evidence suggests that all of the plans for regional expansion outside of the Dublin/East region could be accommodated under the various scenarios identified by EirGrid.

Projected Demand by Region and Additional Capacity available

	East	Midlands	West	North East	North West	South East	South West
2014 Demand (MW)	1830	480	370	380	630	380	560
2025 Demand (MW)	2070	530	410	420	700	420	630
Additional Capacity (MW) – High	870	657	658	700	441	378	775
Additional Capacity (MW) - Median	735	469	433	425	295	284	532
Additional Capacity (MW) – Low	600	280	210	150	150	190	290

Source: EirGrid

Issues for Consideration

A number of issues have been identified by Indecon during our research which Indecon believes merit consideration in order to maximise the use of scarce resources at the lowest cost to the economy. These are summarised as follows and discussed later in the report and include possible measures to increase the attractiveness of regional locations for investment.

- Examine regional economic outlook and map against infrastructure gaps
- Consider adjustments to transmission pricing policy to facilitate lower pricing in regions
- Evaluate the current and likely future economic costs and benefits of energy policy concerning renewables and wind and its impact on grid infrastructure requirements

Overall Conclusions

This independent report suggests that grid investment will lead to significant benefits for the Irish economy in terms of increased output and employment arising from the expenditures in Ireland from the grid development strategy. It will also support regional development. The development strategies will also involve significant costs which must be evaluated against the benefits of facilitating an expansion of the Irish economy both nationally and at a regional level. Ensuring this is achieved at the lowest cost taking into account all relevant factors is a key challenge.

Acknowledgements

Indecon would like to thank a number of individuals and organisations for their inputs and assistance in completing this assessment. We are very grateful for inputs from our survey work with indigenous and overseas firms in Ireland on their views on the benefits of grid infrastructure. We would also particularly like to acknowledge the valuable inputs and assistance of management and staff at EirGrid, including Michael Walsh, Rosemary Steen, Timothy Hurley, Mark Norton and Fintan Slye. In addition, we would like to thank the Board of EirGrid for their insightful comments. The usual disclaimer applies, and responsibility for the analysis and findings in this independent research remain the sole responsibility of Indecon.

1 Introduction

This independent report is undertaken by Indecon International Economists for EirGrid. The report concerns a research assessment of the economic benefits associated with the expenditure impacts of investment in Ireland's electricity development strategy. The report also considers the economic impact of the transmission scenarios available to achieve the key objective of providing adequate electricity grid infrastructure.

The context for the study is that EirGrid has identified a number of scenarios to meet Ireland's future transmission grid requirements. Indecon fully supports the validity of EirGrid reviewing the scale of investment and the specific scenarios to meet requirements in the light of changes in economic need and revised policy priorities. This is particularly important given the fundamental revisions to Ireland's economic growth forecasts. There have also been changes in technological developments and in energy efficiency.

From an economic perspective Indecon believes the key challenges for EirGrid are to ensure sufficient grid infrastructure to meet the requirements of the economy, and how to ensure this is delivered in the most cost effective manner.

Indecon would also highlight that in addition to ensuring the most cost effective solution to Ireland's electricity grid requirements, it is essential that the infrastructural strategy meets the policy requirement to spread economic growth on a regional basis.

In this report we consider some of the economic and regional aspects of grid investment and also assess the direct economic benefit of expenditure on the grid. We also outline some issues for consideration designed to ensure sufficient infrastructure is provided but at a lower cost to the economy.

1.1 Background, Context and Policy Objectives

The original 2008 grid development strategy cost estimate was scaled back from €4 billion to €3.2 billion in 2011. The final cost of the programme will depend on the technologies selected for individual projects but it is anticipated that it will be in the range of €2.7 billion to €3.9 billion. All of these programme scenarios, however, involve cost adjustments.

Based on the technology options for projects described in EirGrid's reports three scenarios have been developed that cover the potential investment requirements to meet Ireland's grid infrastructure requirements. We examine the expenditure impacts of all three Scenarios from an economic perspective. We refer to Scenario A as mid-cost which involves costs of €2.9 billion which is most closely aligned with the technology assumptions in the original Grid 25 strategy. Scenario B involves costs of €3.9 billion which we refer to as high cost scenario and Scenario C has estimated capital costs of €2.7 billion which we refer to as the low cost scenario.

1.2 Objectives of study

The primary objective of this study is to examine the gross expenditure benefits associated with the grid strategy. This study also examines the importance of grid infrastructure in terms of regional development and the attraction of foreign investment along with the creation of employment. We also undertake a preliminary assessment of the three investment scenarios and review whether these are likely to meet regional demand requirements. A number of recommendations designed to ensure grid requirements are met at lowest cost to the economy is presented.

1.3 Methodological approach

The methodology applied in this report involves application of international best practice regarding estimating economic impacts of large-scale investments. It should be noted that this analysis is not a cost-benefit analysis and focuses on the expenditure benefits of each investment scenario. The direct user benefits and the impact of ensuring adequate grid infrastructure as well as the costs of the investment are separately considered on a project by project basis by EirGrid.

1.4 Structure of report

The remainder of the report is structured as follows:

- Section 2 outlines EirGrid's scenarios for grid investments;
- Section 3 evaluates the direct expenditure of the grid investment scenarios and the economic benefits from such expenditure;
- Section 4 considers the economy-wide indirect and induced benefits from grid investment expenditure including an analysis of the various scenarios that could be chosen to meet the objectives of grid development;
- Section 5 examines the regional impacts of grid investment on local expenditures and employment. This section also considers regional development and how grid development is important in sustaining regional job creation;
- Section 6 considers the impact of grid development on attracting foreign direct investment; and
- Section 7 summarises the key conclusions.

2 EirGrid's Scenarios for Grid Investment

2.1 Introduction

Grid investment will impact the economy in two primary ways: by improving the capacity and efficiency of the national electricity transmission network, and by the investment expenditure impact on the economy that is required to implement such upgrades. This report focuses on the economic impacts of this investment expenditure and how it relates to national expenditure and employment.

2.2 Changing context of the Grid Investment Programme

The original grid investment programme had an initial estimated capital cost of around €4 billion and was scaled back to €3.2 billion in 2011. The final cost of the programme will depend on the technologies selected for individual projects but is anticipated it will be in the range of €2.7 billion to €3.9 billion. All of these scenarios however involve cost adjustments due to the following reasons:

- Expected reduction in demand-related expenditure;
- Better use of new technologies;
- Lower than anticipated costs for some technologies such as circuit upgrading technologies;
- Scaling back and optimisation of some intended projects; and
- Technology selected for individual project.

The key considerations underlying the revised scenarios for grid investment include the following:

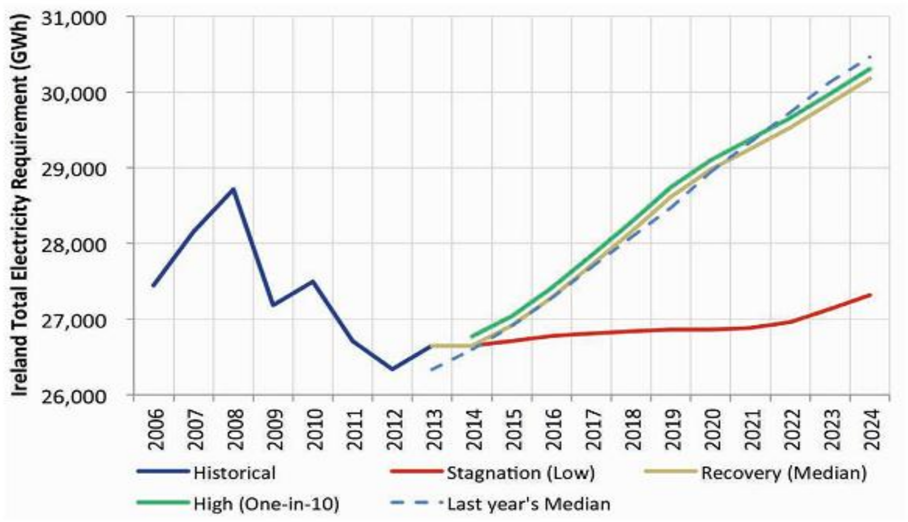
- Fundamental revision of forecasts for future economic growth;
- Technological developments and improvements in energy efficiency; and
- Changes in Policy including the New 5 Year Regional Government Strategy.

It is important to note that forecasted electricity demand has changed considerably since 2008. This is related to developments in the Irish economy but also relates to an improvement in the energy efficiency of the Irish economy.

2.3 Demand Projections

An important aspect of any investment project is to establish the need or the demand for the proposed infrastructure. The most recent projections for electricity demand in Ireland are shown in Figure 2.1. This chart provides a range of likely future electricity demand scenarios with the median scenario indicating the likely growth in electricity demand between 2014 and 2024. By 2024, the likely electricity demand is forecast to be just over 30,000 TER (GWh) which represents around a 14% increase on the 2013 value. It must be noted that the link between economic growth and electricity demand has decreased in recent years due to changes in the energy efficiency / intensity of the economy. This is related to an improvement in the energy efficiency and also structural changes in the composition of the economy.

Figure 2.1 : Forecasted electricity demand in Ireland- 2013-2024

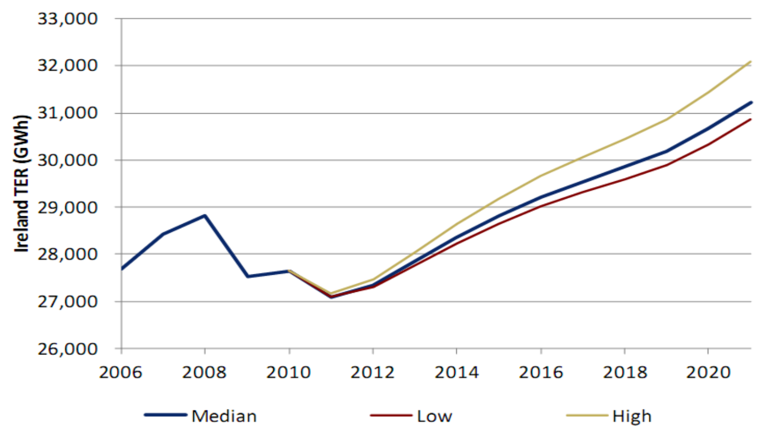


Source: EirGrid/SONI "All Island Generation Capacity Statement 2015-2024"

The figure above also highlights that electricity demand may be lower if the Irish economy grows more slowly than anticipated. Under this scenario, electricity demand will be 8% lower by 2023 compared to the median growth scenario.

In the context of the original plans for the Grid Transmission Development Strategy, forecasts of future electricity demand have reduced significantly since 2011. The extent of change in demand is evident in Figure 2.2. The median demand forecast is now around 29,000 TER (GWh) by 2020. This compares with the previous comparable estimate of 30,500 TER (GWh).

Figure 2.2 : Previous Forecasted electricity demand in Ireland- 2006-2021



Source: EirGrid/SONI "All Island Generation Capacity Statement 2012-2021"

Peak Demand

It is also necessary to consider peak demand when forecasting electricity demand. The most recent analysis of peak demand in Ireland is shown in Table 2.1 and shows the likely future growth in peak demand over the next ten years. This highlights expected growth in demand and it is of critical national importance that further investment is made in the electricity capacity in order to be able to accommodate peak demand requirements.

Table 2.1: Peak Demand Projections (2014-2024) – Transmission Peak (MW)

Year	Ireland (Peak Demand)	% change	NI (Peak demand)	% change	All Island Peak Demand	% change
2014	4,818		1,694		6,492	
2015	4,831	0.3%	1,694	0.0%	6,505	0.2%
2016	4,856	0.5%	1,696	0.1%	6,532	0.4%
2017	4,881	0.5%	1,700	0.2%	6,561	0.4%
2018	4,898	0.3%	1,707	0.4%	6,585	0.4%
2019	4,919	0.4%	1,716	0.5%	6,614	0.4%
2020	4,939	0.4%	1,727	0.6%	6,646	0.5%
2021	4,959	0.4%	1,739	0.7%	6,678	0.5%
2022	4,999	0.8%	1,750	0.6%	6,729	0.8%
2023	5,045	0.9%	1,762	0.7%	6,788	0.9%
2024	5,093	1.0%	1,774	0.7%	6,847	0.9%

Source: EirGrid/SONI "All Island Generation Capacity Statement 2015-2024"

2.4 Description of scenarios under consideration to achieve the objectives of the Grid Development Strategy

The estimated capital costs of the three scenarios for addressing grid requirements of the Irish economy are summarised in Table 2.2.

Table 2.2: Key statistics with the proposed Grid Investment Scenarios

	Scenario A	Scenario B	Scenario C
Capital Cost (€Billion)	2.9	3.9	2.7

Source: EirGrid

A summary of some of the other characteristics of the scenarios are presented below.

This highlights the fact that the costs of the investment needs to be compared to the likely benefits and reinforces the importance of ensuring cost effective solutions. It is also important to consider other issues such as visual amenity which are outside the scope of this economic report.

Table 2.3: Summary of proposed for Grid Development – Other Economic Impacts

	Scenario A	Scenario B	Scenario
Supports Regional Development	✓	✓	✓
Provides adequate capacity	✓	✓	✓
Minimises Cost to Electricity Users	-	×	✓

Source: Indecon analysis

2.5 Summary of findings

In this section, we reviewed the changing context on which the update of the grid development strategy is based. The key findings of this section can be summarised as follows:

- The final cost of the programme will depend on the technologies selected for individual projects but it is anticipated that it will be in the range of €2.7 billion to €3.9 billion. All of these scenarios however involve cost adjustments.

  This reduction in the capital costs is related to a reduction in demand-related expenditure, better use of new technologies, lower than anticipated costs for some technologies and scaling back of some intended projects.
- The key considerations underlying the revised scenarios for grid investment include the following: fundamental revision of forecasts for future economic growth; technological developments and improvements in energy efficiency; and changes in policy including the new Five-Year Regional Government Strategy.
- The main driver of the investment programme is to meet the electricity demand requirements of the economy. By 2024, the likely electricity demand is forecast to be just

above 30,000 TER (GWh) which represents around a 14% increase on the 2013 value. This represents annual average growth of around 1.3% which is considerably lower than the average growth rates prior to 2007. It must be noted that the link between economic growth and electricity demand has decreased in recent years due to a decrease in the energy intensity of the economy. This is related to an improvement in energy efficiency and also structural changes in the composition of the economy.

- All of the three scenarios identified by EirGrid are seen as providing sufficient capacity to meet both national and regional needs. However, they have different capital costs and have other differing characteristics which need to be evaluated.

3 Assessment of direct impacts of Transmission Grid Development Strategy

3.1 Introduction

In this section, we examine the direct expenditure impacts of the different grid investment expenditure scenarios. The analysis is based on a quantified economic impact model which examines different economic impacts at a national and regional level associated with different levels and types of expenditure.

The analysis examines the direct impacts of the expenditure of the different grid investment scenarios from 2011-2025. Each scenario consists of a large number of individual projects that will develop and upgrade the electricity transmission network.

3.2 Economic model used to assess expenditure benefits

Estimating the expenditure benefits of grid investment requires a quantitative model of the programme of investment. This model, developed by Indecon, is designed to assess the amount of grid investment expenditure that will contribute to national output/GDP and employment.

The model maps the spending breakdowns of the grid investment undertaken by EirGrid by project type, type of expenditure, class of expenditure to locations, and discounted future cash flows, which will occur over the period to 2025. The model can be used to assess the division of spending by county across grid investments; this allows estimation of the regional impacts. In addition, the model has been designed to identify labour spending both at regional and national levels in order to analyse the employment impacts of grid investment.

The model has been used to estimate different variants of grid investment (Scenarios A, B, C) which have different compositions of project types.

The model inputs make use of four sets of key parameters:

1. Time parameters: timeline of project types, cash flow schedule of project types; this is important to establish the net present value of the investment. It is also important in terms of identifying when additional infrastructure is completed.
2. Project and expenditure location parameters: distance-split of projects spanning more than one area, percentage of spending that occurs in the same area as project location and split by project type; this allows us to estimate the regional impacts of the different grid investments. It must also be noted that a number of grid investments span multiple regions and thus it is important to isolate the individual regional impacts.
3. Project expenditure type breakdown parameters[1]: labour spending by project type, material spending by project type, 'other[2]' spending by project type, overhead spending by project type and labour spending by project stage.
4. Discount parameters: the discount rate used (5% discount rate used). This is consistent with the Department of Public Expenditure recommended 5% discount rate which replaces the previous advised discount rate of 4%.

[1] These parameters are important in isolating the different impacts associated with the different types of projects.

[2] Other spend is further broken down into civil works, labour and other

3 | Assessment of direct impacts of Transmission Grid Development Strategy

The model calculates the present value of national spending undertaken as part of the grid development strategy. In addition, the model offers the present value of total local expenditure.

This expenditure is classified as spending that involves the purchase of Irish and non-Irish goods and services. For example, the construction of a new substation in Tarbert will require a certain proportion of local goods and services, national goods and services, and imported goods and services. Finally, the model gives the present value of labour expenditure under the proposed grid investment and maps this spending to regional level. Therefore, both total expenditure and labour expenditure are mapped to regions. It should be noted that these results represent gross expenditure and do not take account of the opportunity costs of resources. All resources have opportunity costs and these need to be taken into account in the cost-benefit appraisal of individual projects. The purpose of this section of our research is, however, confined to examining the impact on the economy of the expenditures incurred.

3.3 Methodological approach

The key economic impacts that we examine in the model are the gross effect of the investment on national output/GDP and the impact of the national expenditure on national and local employment.

3.3.1 The direct contribution of grid investment expenditure to national output/GDP

To estimate the contribution of grid investment expenditure to national output/GDP, the following methodology was used:

- Each spending project was classified by five types (uprate, substation, overhead line, cable and miscellaneous).
- For each project type, proportions of spending on Time, Materials, Other and Overheads were assumed based on prior research.[3]
- For each project type, the percentage of the spending on imports was calculated.
- The total amount of grid investment expenditure that will contribute to GDP/national output is the sum over all projects of the total national (non-imported) expenditure.

Total national spending by year for electricity grid investment for Scenario A is shown in Table 3.1. These figures represent the sum of expenditure for the individual projects for each year, discounted to the present.

Table 3.1: National grid investment discounted spending for each scenario by year – Scenario A (€ million)

2011-2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
722.9	115.8	104.6	98.2	105.5	114.8	90.6	73.7	63.9	4.2	4.1

Source: Indecon analysis of EirGrid data

[3] Station, Overhead Line and Cable are based on the CER decision document published in 2009 (Standard Transmission Charges & Timelines, CER/09/077; assumptions on uprate and misc. projects were developed by EirGrid

Scenario B involves a different profile of national spending post 2016. This spending is shown on an annual basis in Table 3.2. After 2015, the spending peaks in 2021.

Table 3.2: National grid investment discounted spending for each scenario by year – Scenario B (€ million)

2011-2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
722.9	115.8	125.3	133.8	142.8	197.1	347.8	152.1	130.9	18.2	9.7

Source: Indecon analysis of EirGrid data

Finally, we examine the national spending profile of Scenario C. The annual national spending profile associated with this scenario is shown in the table below. It is important to note that this national spending excludes spending on imports.

Table 3.3: National grid investment discounted spending for each scenario by year – Scenario C (€ million)

2011-2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
722.9	115.8	104.6	98.2	105.5	95.0	65.5	49.8	41.1	4.2	4.1

Source: Indecon analysis of EirGrid data

3.3.2 The direct contribution of grid investment expenditure to national employment

The methodology employed to estimate the direct contribution of grid investment expenditure to employment is similar to the methodology outlined for estimating the contribution to national output, with the following changes:

- Instead of using proportions of spend on time, materials, etc., the model isolates spending on labour.
- Using the assumption made on the percentage of labour that is imported, the model produces a figure on the amount spent on national labour from grid investments.
- The estimated domestic labour spend is then used to estimate the number of FTE (Full Time Equivalent) jobs due to grid investment.
- The estimates of labour expenditure are typically driven by the assumption of the share of time of total expenditure. All time costs directly translate into labour costs.
- We also include the labour portion included in the 'other' category. This varies considerably by project type. A significant portion of the 'other' category relates to civil works. Using Indecon's model of the Irish economy, we are able to estimate the labour expenditure associated with each €1 million of civil works.
- This is particularly important for Scenario B where a significant portion of the 'other' category is likely to be accounted by civil works.

In the table, U relates to uprate projects; S relates to station projects; C equals cable projects; L refers to line projects; and O refers to other miscellaneous projects.

The breakdown of labour expenditure for Scenario A by the different project types is shown in the table below.

Table 3.4: National grid investment Discounted labour spending by year and project type – Scenario A

€Million	2011-2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
U Labour spend	63.2	7.9	4.3	3.1	2.4	0.9	0.1	0.1	0.0	0.0	0.0
O Labour spend	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C Labour spend	14.5	1.1	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
L labour spend	139.4	31.9	32.2	31.9	42.5	50.0	37.6	31.8	28.0	1.9	1.8
S labour spend	97.9	13.2	13.0	10.5	4.1	0.6	0.5	0.5	0.1	0.0	0.0

Source: Indecon analysis of EirGrid data

The number of FTE jobs for one year for Scenario A is given in Table 3.5. The direct contribution of this expenditure to national employment is 20,147 man years i.e. with one year tenure.

Table 3.5: Direct contribution of grid investment total expenditure to national employment – undiscounted values – Scenario A

	€Million	FTE Man Years	Average annual jobs equivalent
Stage 1 National Spending	160.5	2,749	183
Stage 2 National Spending	749.0	19,485	1,299
Total National	**909.5**	**22,234**	**1,482**

Source: Indecon analysis of EirGrid Expenditure data

We also examine the profile of the present value of labour expenditure by type of project for Scenario B. This analysis is shown in Table 3.6 and highlights the significant difference in labour expenditure.

Table 3.6: National grid investment discounted labour spending – Scenario B

€Million	2011-2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
U Labour spend	63.2	7.9	4.3	3.1	2.4	0.9	0.1	0.1	0.0	0.0	0.0
O Labour spend	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C Labour spend	14.5	5.9	13.3	16.8	19.2	16.5	63.1	9.1	5.9	4.2	1.5
L labour spend	139.4	27.1	21.3	19.2	25.4	56.0	54.4	49.8	46.8	0.6	1.8
S labour spend	97.9	13.2	13.0	10.5	4.1	0.6	0.5	0.5	0.1	0.0	0.0

Source: Indecon analysis of EirGrid data

The implications of this level of investment in terms of employment are shown in Table 3.7. In terms of FTE man years, this level and type of investment is estimated to lead a direct impact of 29,734 jobs. Assuming that each jobs lasts for the full investment period (i.e. 15 years) indicates that this level of investment supports around 1,982 jobs on an annual basis.

Table 3.7: Direct contribution of grid investment total expenditure to national employment – undiscounted values – Scenario B

	€Million	FTE Man Years	Average annual jobs equivalent
Stage 1 National Spending	184.8	3,166	211
Stage 2 National Spending	1,021.3	26,568	1,771
Total National	**1,206.2**	**29,734**	**1,982**

Source: Indecon analysis of EirGrid Expenditure data

The labour expenditure profile of Scenario C is shown in the table below.

Table 3.8: National grid investment discounted labour spending – Scenario C

€Million	2011-2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
U Labour spend	63.2	7.9	4.3	3.1	2.4	0.9	0.1	0.1	0.0	0.0	0.0
O Labour spend	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C Labour spend	14.5	1.1	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
L labour spend	139.4	31.9	32.2	31.9	42.5	41.3	26.6	21.2	18.0	1.9	1.8
S labour spend	97.9	13.2	13.0	10.5	4.1	0.6	0.5	0.5	0.1	0.0	0.0

Source: Indecon analysis of EirGrid data

The employment impacts of this investment are shown in Table 3.9 and indicate this investment supports around 20,476 jobs in terms of FTE man years. In terms of annual jobs equivalent we estimate this represents approximately 1,365 jobs. This equates to a position if the jobs lasted the full 15 years.

Table 3.9: Direct contribution of grid investment total expenditure to national employment – undiscounted values – Scenario C

	€Million	FTE Man Years	Average annual jobs equivalent
Stage 1 National Spending	160.5	2,749	183
Stage 2 National Spending	681.4	17,727	1,182
Total National	**842.0**	**20,476**	**1,365**

Source: Indecon analysis of EirGrid Expenditure data

3.4 Contribution of Grid investment expenditure to output and employment

In this section, the direct expenditure contribution in terms of national output and employment of the various grid investment expenditure scenarios are shown.

The key direct contributions of electricity grid investment as per Scenario A are shown in Table 3.10 and indicate that Scenario A will contribute around €1.97 billion to national output. In present value terms, we estimate that this investment contributes around €1.5 billion to national output. The employment supported by this scenario is very significant and our analysis indicates that around 1,482 jobs are directly supported on an annual basis.

Table 3.10: Direct contribution of each grid investment scenario total expenditure to national output/GDP and Employment – Scenario A

Total National Spending – €million (undiscounted)	1,968
Total National Spending – €million (discounted)	1,498
Total National Employment– FTE Man Years	22,234
Total National Employment– Average annual jobs	1,482

Source: Indecon analysis of EirGrid Expenditure data

The key direct contributions of the grid investment as per Scenario B are summarised in Table 3.11.

In present value terms, we estimate that undertaking grid investment as per Scenario B contributes around €3.0 billion to national output. This equals €2.15 billion in present value terms. This level and type of electricity grid investment supports an estimated 1,982 annual jobs.

Table 3.11: Direct contribution of expenditure to GDP and Employment – Scenario B

Total National Spending – €million (undiscounted)	2,994
Total National Spending – €million (discounted)	2,146
Total National Employment– FTE Man Years	29,734
Total National Employment– Average annual jobs	1,982

Source: Indecon analysis of EirGrid Expenditure data

Scenario C leads to an expenditure contribution of around €1.81 billion to national output. The employment supported by this investment is estimated around 20,476 FTE man years. This equates to around 1,365 annual jobs. These results are shown in Table 3.12.

Table 3.12: Direct contribution of total expenditure to national output/GDP and Employment – Scenario C	
Total National Spending – €million (undiscounted)	1,814
Total National Spending – €million (discounted)	1,407
Total National Employment– FTE Man Years	20,476
Total National Employment– Average annual jobs	1,365

Source: Indecon analysis of EirGrid Expenditure data

3.5 Conclusions on direct impact of grid investment

In this section, we have examined one impact of the benefits namely the direct economic impact of the grid development strategy. This has been assessed in terms of the different scenarios that are being considered to achieve these objectives. A number of key findings are as follows:

- Grid investment is likely to lead to significant levels of investment in the domestic economy through labour and Irish purchased materials;
- We estimate that undertaking grid investment as per Scenario A represents a gross expenditure of around €1.97 billion to national output. In present value terms, this equates to around €1.5 billion;
- In terms of employment, this investment leads to significant direct employment benefits of around 22,234 FTE man years which translates to 1,482 annual jobs supported;
- In present value terms, Scenario B contributes to around €3.0 billion to national output. This equals €2.15 billion in present value terms;
- This scenario supports an estimated 1,982 annual jobs;
- Scenario C leads to a gross contribution of around €1.81 billion to national output; and
- The employment supported by this investment is estimated to be around 20,476 FTE man years equivalent to approximately 1,365 jobs per annum.

These benefits, as well as the indirect benefits discussed in Chapter 4 need to be compared to the costs involved and the objectives of the investment, namely, to meet the requirements of the economy in particular the importance of ensuring competitive electricity prices.

4 Assessment of indirect and economy-wide impacts

4.1 Introduction

This section considers the gross economy-wide impacts arising from the direct economic impacts of each grid investment scenario considered in the preceding section. These wider impacts can be categorised as such:

- Economy-wide value added/GDP impacts and
- Economy-wide employment impacts.

These multipliers have been updated based on the latest CSO publically available data which was released in 2013.

4.2 Explanation and derivation of multipliers

Type I multipliers enable an estimate of the economy-wide impacts arising from the *direct plus indirect impacts* associated with changes in activity that occur in industries that have no direct links to expenditure due to an increase in demand from the directly affected industry. For example, the employment of 80 people (direct effects) on grid investment may lead to additional employment in the local services sector (indirect effect). The relationship between the direct effects and the indirect effects is determined by the size of the Type I multiplier.

Type II multipliers are an expansion of the Type I multiplier by including *direct, indirect and also induced impacts*. Induced impacts arise through the additional consumption that takes place as a result of the additional employment and incomes created, through the indirect impacts. In other words, Type II multipliers include the household as an additional sector in the economic relationships that make up the input-output framework.

Interpretation of multipliers

We would urge caution in the interpretation and usage of the output and employment multiplier estimates presented in this section, for the following reasons:

These multipliers are derived through input-output analysis and this, by definition, reflects the structure of the economy at a particular point in time. Multipliers are subject to change as the economy develops. We currently use multipliers based on the structure of the economy in 2010. These are based on CSO data published in 2013 and replace the pervious multipliers which were based on the structure of the economy in 2005. Also of relevance is that all expenditures and all sectors of the economy have an impact through multipliers on other parts of the Irish economy.

4.3 Economy-wide expenditure impacts

As previously described in the national impact estimates section, expenditure is split into four categories (by EirGrid/CER) in order to estimate, as accurately as possible, the indirect benefits from grid investment. They are:

- Labour
- Materials
- Other expenditures
- Overheads

In our analysis we consider labour spending in terms of full-time equivalent jobs (FTE). Therefore some of the multiplier impacts below do not include the multiplier impacts of expenditure on labour. Such expenditure of course has an expenditure benefit to the economy. It is therefore also useful to consider multiplier impacts taking into account the overall spend including labour. However it is important not to view the expenditure impacts on labour as an addition to the employment impact estimates and for that reason it is useful to consider the multiplier impacts with, and without, the labour spend.

The multipliers used in this report are summarised in Table 4.1 and are based on the multiplier impacts associated with the electricity and gas sector derived from the input-output tables. We present the output and Gross Value Added (GVA) multipliers in this table.

Table 4.1: Economy-wide impacts of grid investment expenditure in the Irish economy using Input-output analysis

		Type I		Type II	
Category of spending	Multiplier classification	Output Multiplier	GVA Multiplier	Output Multiplier	GVA Multiplier
Labour	Electricity and Gas	1.30	1.29	1.47	1.46
Materials	Electricity and Gas	1.30	1.29	1.47	1.46
Other	Construction/Electricity and Gas	1.36	1.81	1.58	2.39
Overheads	Electricity and Gas	1.30	1.29	1.47	1.46

Source: Indecon analysis of EirGrid Expenditure data, and CSO Input-output tables.

We present the direct, indirect and induced spending for Scenario A in Table 4.2. These estimates are in undiscounted terms and indicate that total economy-wide impact of grid expenditure is likely to be around €1.62 billion. As noted previously, this excludes the labour expenditure as this will be translated directly into employment.

Table 4.2: Undiscounted gross value of economy-wide impacts of grid investment expenditures on Irish economy - Scenario A

	€Million				
Category of spending	Labour	Materials	Other	Overheads	Total
Direct Spending	909.5	83.0	634.9	340.3	1,967.7
Indirect Benefits	270.9	24.7	225.7	101.3	622.7
Induced Benefits	154.0	14.0	140.5	57.6	366.2
Direct and Indirect	1,180.4	107.7	860.7	441.7	2,590.4
Direct, Indirect and induced Benefits	1,334.4	121.7	1,001.2	499.3	2,956.6
Direct, Indirect and induced Benefits less labour spending		121.7	1,001.2	499.3	1,622.2

Source: Indecon analysis of EirGrid Expenditure data and CSO, Input-output tables.

We present a similar analysis for Scenario B in Table 4.3. The key difference between Scenario A and Scenario B is in terms of the 'other' category. Around 59% of the expenditure under Scenario B is classified as other expenditure. This is made up primarily of civil works. The labour component

of this civil works expenditure is removed from the other category and included in the labour category.

Our analysis indicates that the total economy-wide gross impact of the expenditure needed to complete Scenario B on the Irish economy is likely to be around €2.75 billion.

Table 4.3: Undiscounted gross value of economy-wide impacts of grid investment expenditures on Irish economy - Scenario B

	€Million				
Category of spending	Labour	Materials	Other	Overheads	Total
Direct Spending	1,206.2	120.3	1,145.4	522.4	2,994.2
Indirect Benefits	359.2	35.8	407.2	155.6	957.8
Induced Benefits	204.2	20.4	253.5	88.4	566.5
Direct and Indirect	1,565.4	156.1	1,552.6	677.9	3,952.0
Direct, Indirect and induced Benefits	1,769.6	176.4	1,806.1	766.4	4,518.5
Direct, Indirect and induced Benefits less labour spending		176.4	1,806.1	766.4	2,748.9

Source: Indecon analysis of EirGrid Expenditure data and CSO, Input-output tables.

The final scenario that we consider is Scenario C which has the lowest levels of capital investment. The key undiscounted impacts are shown in Table 4.4. The direct, indirect and induced impact of the investment (less the labour spending) is estimated to be around €1.5 billion.

Table 4.4: Undiscounted gross value of economy-wide impacts of grid investment expenditures on Irish economy - Scenario C

	€Million				
Category of spending	Labour	Materials	Other	Overheads	Total
Direct Spending	842.0	77.2	582.8	312.4	1,814.3
Indirect Benefits	250.8	23.0	207.2	93.0	574.0
Induced Benefits	142.5	13.1	129.0	52.9	337.5
Direct and Indirect	1,092.7	100.2	789.9	405.4	2,388.2
Direct, Indirect and induced Benefits	1,235.2	113.3	918.9	458.3	2,725.7
Direct, Indirect and induced Benefits less labour spending		113.3	918.9	458.3	1,490.4

Source: Indecon analysis of EirGrid Expenditure data and CSO, Input-output tables.

The discount net present value (NPV) analysis of the economy-wide impacts of Scenario A expenditure is shown in Table 4.5.

Table 4.5: Discounted NPV of gross economy-wide impacts of grid investment expenditures on Irish economy – Scenario A

	€Million				
Category of spending	Labour	Materials	Other	Overheads	Total
Direct Spending	695.9	63.9	478.9	257.2	1,496.0
Indirect Benefits	207.3	19.0	170.3	76.6	473.2
Induced Benefits	117.8	10.8	106.0	43.5	278.2
Direct and Indirect	903.2	83.0	649.2	333.8	1,969.2
Direct, Indirect and induced Benefits	1,021.0	93.8	755.2	377.4	2,247.4
Direct, Indirect and induced Benefits less labour spending		270.5	2,159.7	1,088.6	1,226.4

Source: Indecon analysis of EirGrid Expenditure data and CSO, Input-output tables

Using a 5% discount rate, the present value economy-wide impacts of undertaking investment as per Scenario B are shown in Table 4.6. The 5% discount rates is the recommended Department of Public Expenditure and Reform guideline rate to be used to adjust future values into current net present values.

Table 4.6: Discounted NPV of gross economy-wide impacts of grid investment expenditures on Irish economy – Scenario B

	€Million				
Category of spending	Labour	Materials	Other	Overheads	Total
Direct Spending	882.0	87.8	801.7	372.6	2,144.1
Indirect Benefits	262.7	26.2	285.0	111.0	684.8
Induced Benefits	149.3	14.9	177.4	63.1	404.7
Direct and Indirect	1,144.7	114.0	1,086.7	483.6	2,829.0
Direct, Indirect and induced Benefits	1,294.0	128.8	1,264.1	546.7	3,233.6
Direct, Indirect and induced Benefits less labour spending		371.6	3,614.9	1,577.0	1,939.6

Source: Indecon analysis of EirGrid Expenditure data and CSO, Input-output tables

The direct, indirect and induced expenditure impacts of electricity grid investment as outlined in Scenario C are shown in Table 4.7. These values are shown in present value terms using a 5% discount rate.

Table 4.7: Discounted NPV of gross economy-wide impacts of grid investment expenditures on Irish economy – Scenario C

	€Million				
Category of spending	Labour	Materials	Other	Overheads	Total
Direct Spending	655.6	60.5	447.8	240.5	1,404.4
Indirect Benefits	195.2	18.0	159.2	71.6	444.1
Induced Benefits	111.0	10.2	99.1	40.7	261.0
Direct and Indirect	850.8	78.5	607.0	312.2	1,848.5
Direct, Indirect and induced Benefits	961.8	88.7	706.1	352.9	2,109.5
Direct, Indirect and induced Benefits less labour spending		255.9	2,019.1	1,018.0	1,147.7

Source: Indecon analysis of EirGrid Expenditure data and CSO, Input-output tables

4.4 Direct and indirect labour benefits

In order to estimate the indirect labour benefits of grid investment projects, we convert the euro amount spent on Labour into a number of FTE (Full Time Equivalent) jobs.

The labour expenditure for Scenario A for each stage is shown in Table 4.8 and indicates that this investment is likely to support around 2,825 jobs in each year of the project. We note that the levels of employment supported may vary on a year to year basis but we have examined the jobs supported on an average annual basis. As discussed previously, the first step of the methodology applied in the table below is to convert the total national labour expenditure into the number of full-time equivalents (FTEs) supported. Multiplier analysis is then applied to these FTEs to estimate the economy-wide employment impacts.

Table 4.8: Value of undiscounted direct, indirect and induced impact on employment from grid investment expenditure – Scenario A

	Stage 1	Stage 2	Total
Labour Spending (€million)	160.5	749.0	909.5
Direct FTE Man Years of Employment	2,749	19,485	22,234
Direct & Indirect Man Years	3,974	30,124	34,098
Direct, Indirect & Induced Man Years	5,523	36,849	42,371
Average Annual Jobs	368	2,457	2,825

Source: Indecon analysis

The breakdown of employment impacts for the different stages under Scenario B is shown in Table 4.9 and shows the total number of direct, indirect and induced annual jobs supported is around 3,774.

Table 4.9: Value of undiscounted direct, indirect and induced impact on employment from grid investment expenditure – Scenario B

Scenario B:	Stage 1	Stage 2	Total
Labour Spending (€million)	184.8	1,021.3	1,206.2
Direct FTE Man Years of Employment	3,166	26,568	29,734
Direct & Indirect Man Years	4,576	41,074	45,650
Direct, Indirect & Induced Man Years	6,360	50,244	56,603
Average Annual Jobs	424	3,350	3,774

Source: Indecon analysis

The employment supported, based on discounted labour expenditure, for Scenario C is shown in Table 4.10 and this indicates that this level of investment is likely to support around 2,603 jobs on an annual basis.

Table 4.10: Value of undiscounted direct, indirect and induced impact on employment from grid investment expenditure – Scenario C

Scenario C:	Stage 1	Stage 2	Total
Labour Spending (€million)	160.5	681.4	842.0
Direct FTE Man Years of Employment	2,749	17,727	20,476
Direct & Indirect Man Years	3,974	27,406	31,380
Direct, Indirect & Induced Man Years	5,523	33,524	39,046
Average Annual Jobs	368	2,235	2,603

Source: Indecon analysis

It is also useful to examine the employment impacts based on the undiscounted national labour expenditure for each scenario. Our estimates of full-time equivalent employees is based on a standard approach using official CSO data and a number of assumptions as outlined above.

The analysis below shows that the number of direct and the number of indirect jobs arising from undiscounted expenditure for the different scenarios. The gross employment impacts of the expenditures should not however be misinterpreted as suggesting that this equates to net

employment impacts. The latter would need an adjustment to take account of the opportunity cost of labour and this is likely to be somewhere between 80 – 100%. The more significant employment impacts would depend on how the provision or lack of provision of adequate electricity grid infrastructure impacts on jobs in the traded sector of the economy. Some indication of this can be seen by considering the costs of disruption in electricity supply but this is only a short-term impact and the much more significant impact is likely to result from the impact on the ability of enterprises to expand and the facilitation of new investment. These factors represent the most significant potential long term benefits of the grid investment. Research on the views of enterprises in Ireland on the impact of an adequate electricity grid on investment represents one indication of the significance of this issue. Also relevant are the implications of the proposed investment for reliability, flexibility, cost competitiveness and electricity prices. This demonstrates the importance of ensuring infrastructure needs are met at the lowest feasible cost.

We estimate that grid investment in terms of the proposed Scenario A will contribute €1.6 billion to the wider Irish economy over the lifetime of the project. In present value terms, this translates to €1.2 billion. This analysis removes the expenditure on labour as this is examined in terms of actual employment supported. This level and type of investment under Scenario A is estimated using input-output analysis to support around 2,825 in average annual jobs.

Table 4.11: Gross economy-wide impacts of grid investment expenditures on Irish economy – Contributions to National Output and Employment – Scenario A

	Total
Total Direct, Indirect and induced Benefits less labour spending – discounted (€million)	1,226.4
Direct, Indirect and induced FTE Man years	42,371
Average Annual jobs equivalent	2,825

Source: Indecon analysis

Scenario B includes a significant investment and it is estimated that this investment would be worth around €1.94 billion to the economy in gross benefits. Including direct, indirect and induced employment impacts gives an annual average of jobs supported of 3,774. These economic contributions of Scenario B to the wider economy are summarised in Table 4.12.

Table 4.12: Gross economy-wide impacts of grid investment expenditures on Irish economy – Contributions to National Output and Employment – Scenario B

	Total
Total Direct, Indirect and induced Benefits less labour spending – discounted (€million)	1,939.6
Direct, Indirect and induced FTE Man years	56,603
Average Annual jobs equivalent	3,774

Source: Indecon analysis

The key expenditure and employment related benefits of grid investment as per Scenario C are shown in Table 4.13 and would lead to around €1.15 in gross economic benefits (less labour spending) to the economy. In terms of wider economy benefits, this investment is likely to support around 39,046 in FTE man years or 2,603 jobs on an annual basis.

Table 4.13: Gross economy-wide impacts of grid investment expenditures on Irish economy – Contributions to National Output and Employment – Scenario C

	Total
Total Direct, Indirect and induced Benefits less labour spending – discounted (€million)	1,147.7
Direct, Indirect and induced FTE Man years	39,046
Average Annual jobs equivalent	2,603

Source: Indecon analysis

The key gross expenditure and employment related benefits of the different scenarios for electricity grid investment are summarised in Table 4.14. This table shows that electricity grid investment is likely to lead to significant expenditure impacts, but require significant costs. These costs need to be compared to the wider benefits of the provision of the infrastructure.

Table 4.14: Summary of proposed Scenarios for Grid Development

	Scenario A	Scenario B	Scenario C
NPV (Net Present Value) of the Costs	2,229	2,864	2,097
NPV of the Gross Benefits	1,229	1,942	1,150
Difference	1,000	922	947
Economy-wide Employment (Man Years) supported	42,371	56,603	39,046
Economic Benefits of Infrastructure provision	(See below)	(See below)	(See below)

Source: Indecon analysis

4.5 Economic Cost of a Disruption

As one of the benefits of the proposed investment programme is to ensure the avoidance of electricity disruption as well as the wider benefits of being able to accommodate new and expanded projects, it is useful to consider estimates of the economic cost of an electricity disruption. This can be done using econometric techniques or detailed survey research. Previous research in other countries (including Ireland) have shown that there is likely to be a significant cost to society in terms of a loss in economic welfare due to an electricity outage. This research has also shown a range of estimates for the likely economic cost of an electricity disruption. The sources of these estimates are summarised in Table 4.15. It must be noted that there is likely to be a range of factors that are driving the different estimates in this table including weather, energy use and other socio-economic characteristics.

Table 4.15: Research on the economic cost of electricity disruption – residential consumers

Study
Carlsson and Martinsson (2008), WTP
Kariuki and Allan (1996)
Bertazzi et al. (2005), WTP
Sullivan et al. (2009)
Accent (2008), All DNOs except LPN
Bertazzi et al. (2005), WTA
Bliem (2009)
Accent (2004)
Accent (2008): LPN
Leahy and Tol (2011) – Ireland
London Economics (2013), WTA

Source: Indecon analysis based on London Economics report

Stated preference techniques are in our view probably more appropriate to the estimation of the economic cost of an electricity outage for residential consumers, and this is also the position of the Council of European Energy Regulators (CEER).[4] Stated preference techniques are able to give a comprehensive measure of the economic cost of a disruption even when intangible costs such as inconvenience and discomfort are some of the main costs associated with an outage.

Many recent studies use the production function approach to estimate the economic cost of an electricity disruption for household and industrial sectors. This is a more simplistic methodological approach based on aggregate data which is widely available. There are a number of drawbacks associated with this methodology. This is particularly true with relation to the household sector where this methodological approach typically focuses on the assumption regarding households' valuation of leisure time. Thus, there is a significant justification for using a survey based approach for estimating the economic cost of an electricity disruption in the residential sector. To consider estimates of disruption costs of electricity in Ireland, we make use of best-practice research undertaken internationally by London Economics[5] in the UK and previous research undertaken in Ireland[6] using the production function approach to provide a range of estimates of the likely economic cost associated with an electricity disruption. The economic cost of an electricity disruption is likely to vary significantly depending on a number of factors including the duration of the outage, the time of the outage, the time of the year of the outage and the day of the week of the outage. For this reason, we take an average estimate of the various disruption costs. The highest economic costs associated with a disruption are likely to be during winter at peak-times.

We show estimates of economic costs of an electricity outage in Ireland in Table 4.16 for residential users and the entire economy. These estimates show the very significant costs associated with an outage. More conservative estimates of the cost of a one hour outage for residential users suggest a figure of €24.2 million. These and the likely regional distribution are discussed in section 5.

[4] CERR Guidelines on Estimation of Costs due to electricity interruptions and voltage disruptions.
[5] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224028/value_lost_load_electricty_gb.pdf
[6] Leahy, Eimear & Tol, Richard S.J., 2011. "An estimate of the value of lost load for Ireland," Energy Policy, Elsevier, vol. 39(3), pages 1514-1520, March.

Table 4.16: Economic cost of electricity disruption in Ireland – (€ 2014 prices)	
	€ million
	1 hour outage
Leahy & Tol (2012) (residential sector)	41.9
London Economics (2013) (Full Economy)	45.4
Source: Indecon elaboration using costs per user from the studies	

4.6 Conclusions on economy-wide and other impacts of grid investment

The key conclusions from this section can be summarised as follows:

- Grid investment is likely to have significant impacts in terms of national expenditure and employment.
- We estimate that grid investment in the proposed Scenario A would contribute a gross €1.62 billion to the wider Irish economy over the lifetime of the project. In present value terms, this translates to €1.2 billion.
- This level and type of investment is estimated using input-output analysis to support around 2,825 in average annual jobs when account is taken of the direct, indirect and induced impacts.
- The investment as per Scenario B is estimated to contribute around €1.94 billion in present value terms to the economy in gross expenditure impacts.
- Including direct, indirect and induced employment impacts gives an annual average of jobs supported of 3,774.
- The final scenario for grid investment would lead to around €1.15 billion in gross expenditure related economic benefits (less labour spending) to the economy.
- In terms of wider economy benefits, this investment is likely to support around 39,046 in FTE man years or 2,603 jobs on an annual basis.
- The economic cost associated with an electricity outage is likely to be significant and we estimate that for a one-hour outage the economic cost to the entire economy is likely to be around €45 million. A one-day outage is likely to have a considerably higher economic cost and would impact on the attractiveness both nationally and regionally of Ireland as a location for foreign investment.

5 Impact on Regional Development

5.1 Introduction

In this section, we examine the regional profile of the various grid investment expenditures and how these national expenditures translate into local employment and expenditure. This is particularly important as some the largest grid investments are likely to cross a number of regions.

One of the aims of grid investment is to assist in achieving balanced regional development in Ireland. The grid will be developed in all regions of the country. Without such infrastructural investment, some regions would find difficulty in supporting economic expansion. Grid investment will help regions operate on a level playing field to attract new industries which will create jobs and boost existing industry. However, it must be noted that there is a large number of reasons, aside from grid development, that will promote and sustain regional development.

Indecon has grouped counties into regions in line with CSO regions and the regions promoted by the development authorities.

5.2 Socio-Economic characteristics of different regions

In this section, we present some important data on the socio-economic profile of the various regions. This is important in examining the possible future need for future reliable electricity supplies. One of the drivers of electricity demand will be population growth. Historically, there has been a strong link between population growth and electricity demand. Many electricity forecasting models[7] have used housing stock as a driver of electricity demand and this shows the importance of population change in projecting electricity demand. The most recent data on population by region is shown in Table 5.1 and show a considerable increase in the population for the Mid-East over this short time period. Overall, the data presented below indicates that the population has increased by around 0.8% per year since 2011.

Table 5.1: Recent Population Changes, by Region				
	2011	2012	2013	2014
State[8]	4574.9	4585.4	4593.1	4609.6
Border	515.5	510.9	509.6	503.9
Midland	283.8	287	288.7	290.6
West	440.8	437.4	437.9	437.1
Dublin	1261.5	1262.9	1262.4	1274.6
Mid-West	377.8	380.1	378	378.2
South-East	499.3	500.8	505.1	504.8
South-West	662.3	666.2	670.6	673.4
Mid-East	533.8	540.1	540.8	546.9
Source: CSO				

[7] See Hennessy and FitzGerald (2011) "The HERMES model of the Irish Energy Sector" ESRI Working Paper 396

[8] The regions used in the section are based CSO regions aligned with the National Spatial Strategy. The regions used by EirGrid reports differ slightly

In terms of infrastructure planning, it is important to examine demographic pressures in the long term. The CSO has produced detailed regional projections of population out to 2031. These are based on different assumptions regarding mortality, fertility, immigration and internal migration.

The CSO uses the same assumption regarding the fertility rate for the three main population scenarios. This assumption (F2) is based on the total fertility rate (TFR) decreasing from its 2010 level of 2.1 to 1.8 by 2026 and remaining at the 2026 rate for the remaining years.

Another key assumption is the level of net migration between 2011-2031. Prior to 2007, there were significant levels of immigration with the peak of 151,100 coming into Ireland in 2007. This was offset by 46,300 people leaving Ireland in the same year but the total net migration was nearly 105,000. Between 2010 and 2014, the annual average total net emigration was around 29,000. The total gross emigration was around 81,000 in each of these years. The key migration assumptions that underpin the population projections are shown in Table 5.2 and these show the annual migration assumptions. Post 2016, it is assumed that the level of net migration will be positive and this will increase further after 2021. However, these levels of net migration are significantly lower than those observed in Ireland between 2000 and 2008.

Table 5.2: Assumptions regarding Net Migration used in Population Projections

	2016-2021	2021-2031
M2	+4,700	+10,000

Source: CSO Regional Population Projections

The final assumption that will drive regional population growth is internal migration. This has no impact on the overall Irish population but has very significant impacts on the regional distribution of the population.

The first assumption is called 'traditional' which assumes a gradual reversal to the 1996 pattern of inter-regional flows by 2021 and stays at this pattern for the remaining years. The implications of these assumptions are shown in Table 5.3 which shows that it is projected the total population of Ireland will be around 13% higher by 2031 which represents an annual growth rate of around 0.7%. It is projected that the largest percentage population increases are likely to be in the GDA with Dublin projected to grow by 1% per annum and the Mid-East projected to grow by 1.3% per annum. This is in stark contrast to the Border and West regions which are projected to have very low population growth.

Table 5.3: Actual and projected population of Regional Authority areas, 2011 and 2031 (M2F2 Traditional)

Regional Authority area	Population 2011	Population 2016	Population 2021	Population 2026	Population 2031	Average annual increase	Total % Increase
	Thousands					%	
Border	516	518	526	531	533	0.2%	3.4%
GDA:	1,795	1,858	1,973	2,087	2,197	1.1%	22.4%
Dublin	1,262	1,297	1,373	1,448	1,519	1.0%	20.3%
Mid-East	534	561	600	639	678	1.3%	27.0%
Midland	284	293	302	307	309	0.4%	8.8%
Mid-West	378	383	393	403	410	0.4%	8.4%
South-East	499	514	531	542	550	0.5%	10.2%
South-West	662	678	701	719	733	0.5%	10.7%
West	441	443	451	455	456	0.2%	3.4%
State	4,575	4,687	4,876	5,044	5,188	0.7%	13.4%

Source: CSO

A second assumption on internal migration is to examine the implications of using inter-regional flows as observed in the 2011 Census. This 2011 observation is applied to each year out to 2031. Using the same assumptions on fertility and immigration, the population projections under this scenario are shown in Table 5.4. This assumption considerably reduces the projected population in the GDA and this scenario projects an 18% increase compared to a 22% increase under the previous assumption.

Using the 2011 observed regional flows as the most likely scenario would indicate a much regionally balanced population growth albeit the east of the country will grow faster than other parts. It also be noted that the West and the Mid-West have the lowest levels of population growth with projected future population only around 5% above the current level.

Table 5.4: Actual and projected population of Regional Authority areas, 2011 and 2031 (M2F2 Recent							
Regional Authority area	Population 2011	Population 2016	Population 2021	Population 2026	Population 2031	Average annual increase	Total % Increase
	Thousands					%	%
Border	516	520	532	544	555	0.4%	7.6%
GDA:	1,795	1,851	1,949	2,038	2,115	0.9%	17.8%
Dublin	1,262	1,293	1,360	1,421	1,472	0.8%	16.6%
Mid-East	534	558	589	617	644	1.0%	20.5%
Midland	284	296	311	326	341	1.0%	20.0%
Mid-West	378	382	389	394	397	0.3%	5.1%
South-East	499	515	534	551	566	0.7%	13.4%
South-West	662	679	706	730	751	0.7%	13.5%
West	441	443	453	459	462	0.2%	4.8%
State	4,575	4,687	4,875	5,043	5,188	0.7%	13.4%
Source: CSO							

The final scenario considered is where there is an increased pattern of internal migration towards Dublin at the expense of all regional (except the Mid-East). This was achieved by increasing the number of movers into Dublin on the 2011 levels by 2.5% per annum up to 2016 and holding the level steady thereafter. This increase in movers into Dublin was balanced by increasing the number of movers out of the other regions by the same amount. The key different between this scenario and the 'traditional' scenario is that the Mid-East does not grow by the same amount. The difference in the overall GDA of the two scenarios is negligible. These projections are shown in Table 5.5.

Table 5.5: Actual and projected population of Regional Authority areas, 2011 and 2031 (M2F2 Modified)							
Regional Authority area	Population 2011	Population 2016	Population 2021	Population 2026	Population 2031	Average annual increase	Total % Increase
	Thousands					%	
Border	516	518	527	534	540	0.2%	4.7%
GDA:	1,795	1,861	1,978	2,089	2,192	1.1%	22.1%
Dublin	1,262	1,303	1,389	1,472	1,548	1.1%	22.6%
Mid-East	534	558	589	617	644	1.0%	20.6%
Midland	284	295	308	319	331	0.8%	16.4%
Mid-West	378	381	386	389	389	0.1%	2.8%
South-East	499	514	529	541	552	0.5%	10.5%
South-West	662	678	701	721	737	0.6%	11.4%
West	441	442	447	450	448	0.1%	1.6%
State	4,575	4,687	4,875	5,043	5,188	0.7%	13.4%
Source: CSO							

In addition to population growth a core objective of the grid investment is to meet the needs of the enterprise sector. In this context it is useful to review trends in employment across the various regions. The latest available data shows that the numbers in employment have grown in recent years in all regions in Ireland. However, it is clear that the Southern and Eastern regions have had a higher percentage increase in employment compared to the Border, Midland and Western regions. The latest figures suggest even in years where overall national employment grew, the numbers in employment decreased in certain regions. For example, the South-West had around 5,000 fewer working in 2014 compared to 2013.

Table 5.6: Number in Employment by Region (000s)					
	2010	2011	2012	2013	2014
State	1857.3	1847.7	1848.9	1909.8	1938.9
Border	187.4	180.8	171.5	185.8	185.8
Midland	103.4	102.8	105.7	111.1	113.7
West	181.5	178.8	180.9	185.9	181.1
Dublin	552.6	548.8	556.3	572.1	587.5
Mid-West	151	154.6	150.1	151.3	152.8
South-East	185.8	182.9	181.8	197.1	204.5
South-West	269.3	269.1	277	280.6	275.6
Mid-East	226.3	229.9	225.5	225.9	237.9
Source: CSO QHNS					

The most recent (and most reliable) estimates on the level of unemployment by region are shown in Table 5.7. The data shows that the level of unemployment is significantly higher in certain regions such as the South-East and Midland when compared to Mid-East or the National position.

Table 5.7: Unemployment Rate by Region (%)					
	2010	2011	2012	2013	2014
State	14.3	14.5	13.7	11.7	9.9
Border	13.5	13.9	16.5	13.5	10
Midland	16.4	18.7	16.9	13.7	13.1
West	15.4	15.4	14.4	11.9	10.2
Dublin	13	13	11.1	10	8.6
Mid-West	17.1	15.9	15.4	10.7	10.2
South-East	18.3	19.2	18.8	15.5	11.9
South-West	13	13.5	11.9	10.2	10.6
Mid-East	12.8	12.4	12.4	12.5	8.5
Source: CSO QHNS					

One of the key drivers of future demand for energy and electricity will be the levels of output growth in the economy. The most recent forecasts for the Irish economy indicate steady growth out until 2020. However, from an infrastructural planning point of view, it is important to examine the growth potential of the economy over a longer time period. Although any forecast of economic output is characterised by significant degrees of uncertainty, it is useful to consider the potential growth across the different sectors in the economy. These sectors often have very different electricity demand profiles and this will have considerable implications for future levels of electricity demand by the non-residential sector. This assumes a recovery in Ireland's growth prospects. Given the uncertainties for the international and European economies and the volatility of Irish economic growth, caution is required in interpreting this scenario. Particular uncertainty surrounds sectoral movements. Some of these forecasts are based on ESRI previously published estimates based on an economic recovery scenario. The ESRI data does not provide forecasts at this detailed sectoral level shown below and so the forecasts are the responsibility of Indecon.

Table 5.8: Scenario for Sectoral Output–Average Percentage Output Growth

	2014-2018	2019-2026	2027-2034	2035-2042	2043-2050
Agriculture, fishing, forestry	2.8%	1.9%	1.5%	1.5%	1.5%
Coal, peat, petroleum, metal ores, quarrying	4.1%	3.5%	1.4%	1.5%	1.5%
Food, beverage, tobacco	4.1%	3.5%	1.4%	1.5%	1.5%
Textiles Clothing Leather & Footwear	4.1%	3.5%	1.4%	1.5%	1.5%
Wood & wood products	4.1%	3.5%	1.4%	1.5%	1.5%
Pulp, paper & print production	4.1%	3.5%	1.4%	1.5%	1.5%
Chemical production	4.2%	3.5%	1.7%	1.8%	1.8%
Rubber & plastic production	4.1%	3.5%	1.4%	1.5%	1.5%
Non-metallic mineral production	6.4%	3.1%	3.4%	3.4%	3.4%
Manufacture of Basic Metals	6.4%	3.1%	3.4%	3.4%	3.4%
Manufacture of Fabricated Metal Products	4.2%	3.5%	1.7%	1.8%	1.8%
Agriculture & industrial machinery	4.2%	3.5%	1.7%	1.8%	1.8%
Electrical goods	4.2%	3.5%	1.7%	1.8%	1.8%
Transport equipment	4.2%	3.5%	1.7%	1.8%	1.8%
Other manufacturing	4.1%	3.5%	1.4%	1.5%	1.5%
Fuel, power, water	3.4%	3.9%	2.4%	2.3%	2.3%
Construction	6.4%	3.1%	3.4%	3.4%	3.4%
Transport	3.9%	2.1%	1.8%	1.8%	1.8%
Services*	3.3%	3.4%	4.0%	4.1%	4.1%
Health & Education	0.3%	2.0%	2.0%	2.0%	2.0%
Public Administration	-0.7%	2.0%	2.0%	2.0%	2.0%

Note: Forecasts beyond 2030 assume sectors continue to grow at 2030 rate for each year between 2030 and 2050.
*Wholesale & retail of vehicles, wholesale & retail excl. motor vehicles, accommodation, food services.
Source: Indecon analysis

It is likely that each of these sectors will have different electricity demand profiles. The most recent data on industrial electricity use is shown in Table 5.9 and this highlights the large electricity usage by the food and beverage sector, the chemicals sector and the electrical equipment sector. In the output scenario shown previously, the food sector is likely to grow considerably over this period. The chemical sector is also estimated to grow significantly with annual growth rates of around 2% projected. This growth rate would lead to an outcome where the level of output in the chemical sector will be nearly double its current level by 2050.

Table 5.9: Electricity Consumption by Industrial Sector (Ktoe) 2008-2013

	2008	2009	2010	2011	2012	2013	% change 08-13
Final energy consumption	2294	2173	2186	2139	2078	2081	-9.3%
Sum of all industry sub-sectors	686	740	783	816	788	799	16.5%
Industry- non energy mining	51	55	56	59	56	57	11.8%
Industry- food, beverages and tobacco	133	145	167	174	168	170	27.8%
Industry- textiles and textile products	6	7	10	10	10	10	66.7%
Industry- wood and wood products	26	28	34	35	34	34	30.8%
Industry- pulp, paper, publishing and printing	15	17	18	19	18	19	26.7%
Industry- chemicals and man-made fibres	119	130	142	148	143	145	21.8%
Industry- rubber and plastic products	30	32	34	36	35	35	16.7%
Industry- other non-metallic mineral products	70	77	50	52	50	51	-27.1%
Industry- basic metals and fabricated metal products	50	44	63	64	64	64	28.0%
Industry- machinery and equipment n.e.c	15	16	20	21	20	20	33.3%
Industry- electrical and optical equipment	101	110	97	101	97	99	-2.0%
Industry- transport equipment manufacture	8	9	17	17	17	17	112.5%
Industry- other manufacturing	63	68	76	79	76	78	23.8%

Source: SEAI Energy Balances

It must be noted that long-term projections of the future of the economy or the population are very uncertain and they should be used accordingly. The electricity intensity of different sector may reduce considerably overtime due to energy efficiency and different processes. In this context, it is particularly important to consider the electricity required by data centres. The electricity requirements of these centres can be very large. For this reason, it is also important to look at shorter-term regional targets.

5.3 Overall regional expenditure

As described previously, it is estimated that the total capital expenditure needed to complete Scenario A is around €2.9 billion. The regional breakdown of this expenditure is shown in Table 5.10.

Table 5.10: Benefits of grid investment by Region – Scenario A

	Discounted direct benefits (€m)	Share of Total Investment (%)	Total Spending €millions
Border	154.5	19.3%	564.4
West	87.8	11.0%	320.9
Mid-West	64.4	8.6%	249.3
South-West	174.3	21.2%	620.8
South-East	112.6	15.6%	455.1
Midlands	41.2	4.6%	136.0
Eastern	95.2	12.3%	359.6
Dublin	53.9	7.3%	211.5
Total Local Benefits	783.8	100.0%	2,917.6

Source: Indecon analysis

The same analysis is presented for Scenario B in Table 5.11 which highlights a slightly difference regional share of total expenditure.

Table 5.11: Benefits of grid investment by Region – Scenario B

	Discounted direct benefits (€m)	Share of Total Investment (%)	Total Spending €millions
Border	166.4	16.5%	646.3
West	145.3	15.4%	603.2
Mid-West	70.2	6.9%	272.1
South-West	207.9	19.8%	777.3
South-East	20.4	12.0%	446.3
Midlands	105.8	3.5%	154.0
Eastern	132.3	20.4%	782.9
Dublin	53.9	5.5%	215.9
Total Local Benefits	902.1	100.0%	3,897.9

Source: Indecon analysis

The regional analysis for Scenario C is shown in Table 5.12 which indicates the largest proportions of total spend will take place in the South-West.

Table 5.12: Benefits of grid investment by Region – Scenario C

	Discounted direct benefits (€m)	Share of Total Investment (%)	Total Spending €millions
Border	154.5	21.0%	566.2
West	87.8	11.9%	321.9
Mid-West	64.4	9.3%	250.0
South-West	166.2	21.8%	588.9
South-East	73.6	10.9%	293.6
Midlands	41.2	5.0%	136.4
Eastern	87.0	12.1%	326.7
Dublin	53.9	7.9%	212.1
Total Local Benefits	728.5	100.0%	2,695.8

Source: Indecon analysis

5.4 Contribution of grid investment to local employment

In order to examine the local employment that is supported by grid investment expenditures, it is important to establish the local labour expenditure associated with each grid investment scenario.

In the table below, regional estimates of the present value of expenditure on labour for each scenario are presented.

The method used to map the direct contribution of grid investment expenditure to regional employment is similar to that for the contribution to output. However, some changes are described below:

- Following on from the step where there are assumptions over how much of each spending category will be spent nationally; there are similar assumptions that have been described already that decide the percentage of national spending on a specific spending type (e.g., materials) that will accrue to the locality of the individual project.
- The locations of the projects will determine the region into which the local expenditure will be attributed. Where projects occur in two or more regions, the local expenditure is divided according to the geographic proportion of the project that is located in each region. For example, if there is a new overhead line planned for construction that is 10km long and passes through Mid-East (4km) and Dublin (6km) then 40% of the local expenditure is allocated to the Mid-East and 60% to Dublin.

In order to estimate the direct contribution of grid investment expenditure to employment at both national and regional levels, the direct spending amount must be converted to a number of jobs. The methodology used to estimate the number of full-time equivalent (FTE) jobs for one year, was to divide total labour spend by the annual FTE cost.

The direct contribution of grid investment expenditure to local employment, detailed by region

Table 5.13 below shows the breakdown of labour expenditure that occurs locally to the projects under grid investment by region for Scenario A. All spending is used to estimate the number of FTE jobs by region. Our analysis indicates that the largest numbers of jobs that are supported are in the Border region, the South-West and the South-East.

Table 5.13: Direct contribution of grid investment total expenditure to local employment – Scenario A

Region	Undiscounted €Million	Average annual jobs equivalent	Average annual jobs equivalent (including pro-rata allowance for national labour expenditure)
Border	117	196	282
West	69	115	164
Mid-West	41	68	106
South-West	110	186	280
South-East	98	164	234
Midlands	31	50	71
Eastern	77	128	183
Dublin	75	129	162

Source: Indecon analysis of EirGrid expenditure data

Scenario B supports a higher number of jobs and this is shown in Table 5.14.

Table 5.14: Direct contribution of grid investment total expenditure to local employment – Scenario B

Region	Undiscounted €Million	Average annual jobs equivalent	Average annual jobs equivalent (including pro-rata allowance for national labour expenditure)
Border	108	180	323
West	80	134	269
Mid-West	42	71	131
South-West	141	239	411
South-East	11	18	123
Midlands	91	153	183
Eastern	111	187	364
Dublin	75	129	177

Source: Indecon analysis of EirGrid expenditure data

Scenario C supports the lowest amount of employment but this employment support is quite evenly distributed across the different regions. This is shown in Table 5.15 which shows the impact of including a pro-rate allowance for national labour expenditure which raises the number of jobs supported by around 30% on average. This reflects the levels of overall expenditure but as noted earlier account has to be taken of the opportunity cost of the expenditure.

Table 5.15: Direct contribution of grid investment total expenditure to local employment – Scenario C

Region	Undiscounted €Million	Average annual jobs equivalent	Average annual jobs equivalent (including pro-rata allowance for national labour expenditure)
Border	117	196	283
West	69	115	165
Mid-West	41	68	107
South-West	102	173	264
South-East	62	102	148
Midlands	31	50	71
Eastern	69	115	165
Dublin	75	129	162

Source: Indecon analysis of EirGrid expenditure data

The analysis shown in this section highlights the significant number of jobs that grid investment is likely to support during its implementation and construction phase. This varies somewhat by region and investment scenario. It also be noted that the analysis above does not account for the opportunity cost of resources. Also this only looks at the employment impact of the expenditure and not the employment expansion facilitated by the provision of sufficient grid infrastructure. In many regions this latter factor is likely to be most important.

5.5 Community Gain

In accordance with the Government Policy Statement on Energy Infrastructure July 2012 and as part of the investment programme an explicit community gain package for homes and communities that are near new Overhead lines and new rural transmission station projects has been proposed. However, while this is important, the main community gain relates to the ability of the investment to facilitate an expansion of economic output and employment in each of the regions. This combined with the local employment inputs from the expenditure programme represents the main areas of community gain.

The specific elements of the proposed Community Gain ('CG')[9] include:

- Community Payment
- Proximity Payment

The Community Payment will involve the establishment of a fund for local communities living in the vicinity of new lines and new rural stations. The fund amount is based on the length of the new transmission line. The rates per kilometre are as follows:

- €40,000 per km for 400 kV transmission lines
- €30,000 per km for 220 kV transmission lines
- €15,000 per km for 110 kV transmission lines

[9] Community Gain is only applicable on new infrastructure and is only applicable to projects granted planning permission after 17th July 2012

The proximity payment is a payment for homes that are near new OHL and new rural stations. The payment relates to the distance the new infrastructure is to a home. There is a sliding scale of payments between 50m and 200m with case by case negotiation for closer distances. The scales are shown in Table 5.16.

Table 5.16: Levels of Compensation assoicated with Proximity Allowance

Type	Distance 50m	Distance 200m
400 kV OHL (New)	€30,000	€5,000
400 kV Station (New)	€30,000	€5,000
220 kV OHL (New)	€20,000	€3,500
220 kV Station (New)	€20,000	€3,500
110 kV OHL (New Pylons only)	€10,000	€2,000
110 kV Station (New)	€10,000	€2,000

Note: Distances between 50-200m will be interpolated based on the above figures. All distances closer than 50m will be negotiated on a case-by-case basis.
Source: EirGrid

There may also be multiplier impacts with the direct expenditure on Community Gain (CG). Applying a Type II expenditure multiplier of two would indicate that the economy-wide impact of CG may be around €60 million. The actual amount of Community Gain will depend on a number of factors most importantly the selection of technology on individual projects.

Table 5.17: Direct contribution of grid investment in terms of Community Gain

Region	Community Gain Expenditure €Million (2016-2025)
Border	6.5
West	4.9
Mid-West	0.0
South-West	2.0
South-East	6.1
Midlands	2.1
Eastern	7.7
Dublin	0.4
Total	29.6

Source: EirGrid and Indecon analysis

5.6 Regional economic cost of an electricity disruption

As discussed in Section 4.5, it is very unlikely that the electricity disruptions will occur at the national level and thus the impacts are likely to vary on a regional basis. We present the likely regional impacts to residential users in Table 5.18 of a one hour outage and a 24 hour outage. It must be noted that the 24 hour outage may be an overestimation as residential users may be able to adjust to longer-term outages. Indecon also considered estimates based on applying costs per household which would have indicated lower estimates but as we were keen to attempt to take account of costs outside of direct residential costs, we used per capita estimates. At €24.2m, these

estimates are however much lower than previous estimates used for the residential sector in Ireland which as outlined in section 4 suggested a figure of €41.9 million.

Table 5.18: Economic Cost of an electricity disruption for residential uers, by region

	€Million	
Region	1 hour outage	24 hour outage
State	24.2	579.6
Border	2.6	63.4
Midland	1.5	36.5
West	2.3	55.0
Dublin	6.7	160.3
Mid-West	2.0	47.6
South-East	2.6	63.5
South-West	3.5	84.7
Mid-East	2.9	68.8

Note: Based on applying London Economics' estimates
Source: Indecon analysis

We also used an alternative approach to estimate the likely economic costs for the whole economy associated with electricity outages for the different regions in Table 5.19. These are based on applying the overall national economic cost estimates of a one-hour outage to the various regions according to the gross value added in each region. We would note however that the largest economic cost of a disruption is estimated to be in the Dublin region which reflects the significance of economic activity in Dublin and indeed this may even understate the costs in Dublin. The same caveats that were discussed previously are also important to consider for this regional analysis. This analysis however clearly shows that there are likely to be significant economic costs associated with an electricity supply disruption. This highlights the importance of a reliable electricity transmission system. These represent direct costs and the implications for economic growth and investment are likely to be significantly higher if lack of adequate provision impacts on investment.

Table 5.19: Economic Cost of an electricity disruption for whole economy, by region

	€Million	
Region	1 hour outage	24 hour outage
State	45.4	1,089.6
Border	2.8	67.6
Midland	1.5	36.0
West	3.6	87.2
Dublin	19.0	456.5
Mid-West	3.0	71.9
South-East	3.4	81.7
South-West	8.5	203.8
Mid-East	3.5	83.9

Source: Indecon analysis

5.7 Implications of Regional Targets on Electricity Demand

The employment and output potential of each region will be determined by the performance of the agri-food, tourism, services and manufacturing sectors including both indigenous and foreign firms. It is important that the needs of all of the key sectors can be met. It is useful to consider the key targets outlined by IDA (Ireland) as set out in Table 5.20 as some of coming projects such as data centres may have very high energy requirements. Over the next five years, it is targeted that the IDA will deliver around 900 new investments which contribute to around 35,000 of additional net employment. An increase in the number of investments of between 30 – 40% is targeted for each region outside of Dublin.

Table 5.20: IDA Ireland's Stategy, Winning: Foreign Direct Investment 2015-2019

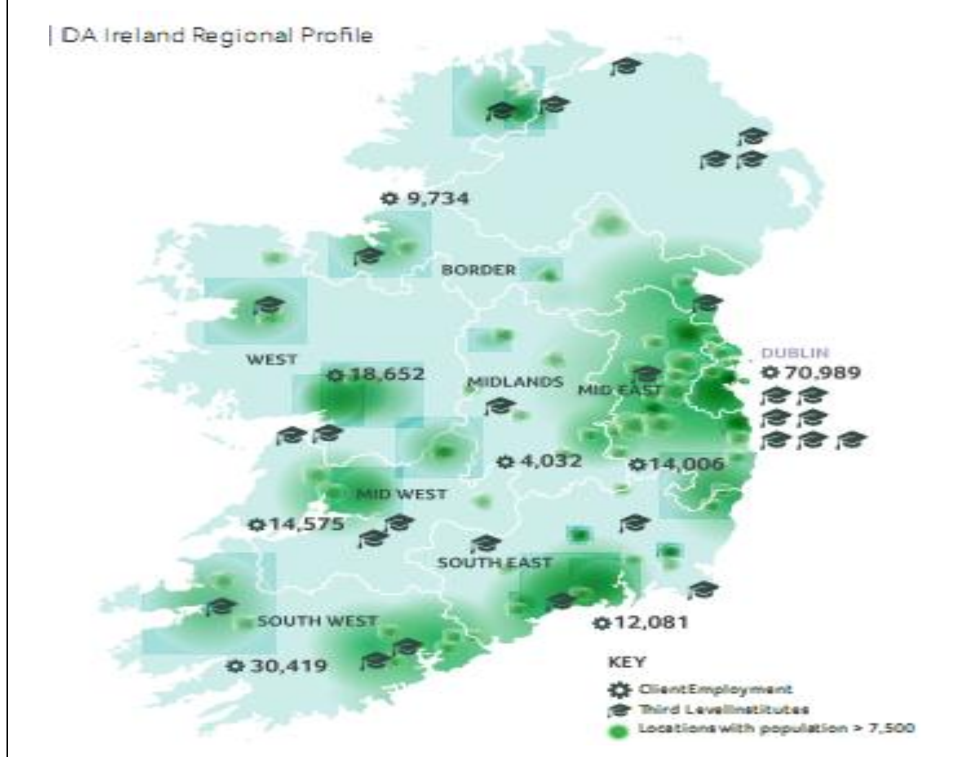
	Targets
No. of new Jobs (Gross)	80,000
No. of new Jobs (Net)	35,000
No. of Investments	900
R&D investment	€3 billion
Balanced Regional Growth	Minimum 30-40% increase in each region outside of Dublin

Source: IDA

The importance of regional infrastructure is critical to achieving these targets and the same issue applies to other traded sectors.

The current regional profile of FDI supported employment is shown in Figure 5.1 which shows FDI supports significant levels of employment in all the regions.

Figure 5.1: Regional Profile for Foreign Direct Investment.



Source: IDA Ireland

The most recent performance of FDI by different regions is summarised in Table 5.21.

Table 5.21: Recent FDI in terms of Regional Development

	Current Employment (IDA Client companies	No. of Investments over the last 5 years	Specialist Areas
Dublin & the Mid-East	84,995	450	Technology and Pharma
South-West	30,419	107	Pharma, Technology and Engineering
Mid-West	14,575	51	ICT and Med Tech
West	18,652	71	ICT, Life Sciences and services sectors
Border area	9,734	47	Engineering, Life Sciences, Financial services
Midlands	4,032	19	ICT, Life Sciences, Engineering
South East	12,081	34	Medical Technology

Source: IDA

In evaluating the ability of the electricity transmission network to accommodate the requirements of indigenous and overseas firms as well as the needs of other traded sectors, it is useful to note that there is significant variation in electricity demand by the different types of users as presented in Table 5.22. It is clear that data centre/farms are the largest users of electricity and it is important that this is considered in regional grid development.

Table 5.22: Typical Electricity Demand by different type of large user

Type	Size typical
New pharmaceutical factory	10-25MVA
New Mine	10-30MVA
New Datafarm small	10-30MVA
New Datafarm mid-sized	30-100MVA
New large Data Centre	100-300 MVA
New Semiconductor company	30-100MVA
New SME	1-10 MVA

Source: EirGrid

The largest users of electricity will typically provide some advance notice regarding expansion plans but are likely to require advance provision of basic infrastructure. The potential increase over the next couple of years from customers currently with a connection agreement was also examined but not included here for confidentiality reasons. This data indicated potential for a substantial growth in new very large demand centres in the Dublin region.

The demand of the current transmission connected customers was also examined and we reviewed the regional demand of the largest users. The data highlighted the significant non-residential electricity demand outside of the Dublin region. Over the 2010-2014 period, the new transmission connected customers were in the Dublin and Mid-East regions.

Aside from customers who connect directly with the TSO (EirGrid), there are also significant non-residential electricity users who connect with the DSO (ESBN). A regional breakdown of this data was considered but is not published here for the reasons outlined above.

In the context of the significant new non-residential demand, it is important to assess the impact of this on the electricity transmission network. The existing and projected level of demand in each of the regions is shown in the next table (see Table 5.23). The analysis below is based on assumptions for ongoing demand growth and do not include any discrete changes such as large once-off users. However, it is clear that in most of the regions significant percentage increases in demand could be accommodated.

This table also outlines the capability of the proposed investment programme to accommodate additional demand and compare this to estimated demand in each of the regions. This is based on EirGrid's median demand forecast.

This evidence suggests that there will be available capacity in all of the regions to accommodate significant expansion of demand. There are a number of technical caveats regarding the table below including:

- There may be local network access issues in the regions;
- Available capacity may vary throughout the region;[10] and
- There is a degree of interaction between the nodes/stations and regions. These are monitored on an ongoing basis.

Overall, the analysis indicates that there is significant capacity to accommodate likely significant increases in demand across all the regions outside of Dublin however there are risks of constraints in the Dublin/East area. It is clear however that the plans for regional expansion outside of Dublin would be capable of being accommodated under the various scenarios identified by EirGrid.

Table 5.23: Projected Demand by Region and Additional Capacity available

	East	Midlands	West	North East	North West	South East	South West
2014 Demand (MW)	1830	480	370	380	630	380	560
2025 Demand (MW)	2070	530	410	420	700	420	630
Additional Capacity (MW) – High	870	657	658	700	441	378	775
Additional Capacity (MW) - Median	735	469	433	425	295	284	532
Additional Capacity (MW) – Low	600	280	210	150	150	190	290

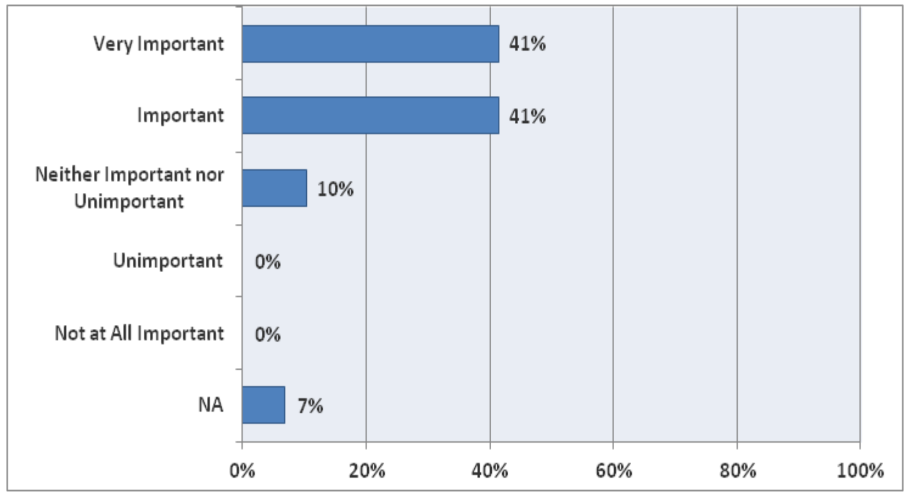
Source: EirGrid

5.8 Impact on regional development

In many ways the most important benefit of the investment programme is to support the expansion of both the national and regional economies. At a regional level the core benefit is therefore likely to be in terms of facilitating economic development in each of the regions. Figure 5.2 presents the assessment of businesses surveyed on the importance of electricity grid investment in facilitating regional economic development. 82% of respondents suggested that investment in the transmission grid is 'important' or 'very important' to facilitate regional development. This and other evidence in Section 6 is based on a survey of leading companies in Ireland which accounted for over 24,000 employees in Ireland and over 950,000 worldwide.

[10] This variation is examined in the Transmission Forecast Statements

Figure 5.2: Views on the importance of investment in the electricity transmission network to facilitate regional economic development



Source: Indecon survey of multinationals and indigenous companies in Ireland

5.9 Conclusions on the regional impacts

In this section, we outlined how the grid investment will lead to different regional impacts. Main findings include:

- It is estimated that grid investment will lead to significant local expenditure. This grid investment will have different regional impacts.
- In terms of gross economy-wide employment, grid investment is likely to support local employment across the different regions.
- It is essential that there is sufficient grid infrastructure to support regions to attract new investment as well as to facilitate expansion of jobs and existing industry. The importance of regional infrastructure is a crucial factor to achieving the potential of regional development in Ireland.
- National policy is focused on expanding economic output and employment in each of the regions. This will require an expansion of tourism, agriculture and indigenous and foreign owned firms. While it would be a mistake to see this only in terms of foreign industry, the focus on winning investment for the regions is reflected in the new IDA (Ireland) strategy which is targeting a minimum of 30% - 40% increase in the number of investments for each region outside of Dublin over the period 2015 – 2019.

6 Impact of Grid investment on attracting investment

6.1 Introduction

A key factor influencing investment decisions is the availability of adequate infrastructure. Ireland has targeted sectors such as Cloud Computing and Clean Technology, Manufacturing, Life Sciences, Internet Data Centres, Software and other sectors. It is therefore important to understand how grid investment may or may not impact on this key area of the Irish economy.

It is useful in examining the role of grid investment in facilitating investments to consider the types of investments that have been achieved in recent years. While differing sectoral investments apply to indigenous and foreign firms it is useful to consider examples of key foreign investment projects as presented in Table 6.1.

Table 6.1: IDA New Investments - 2014

Company Name	Jobs	Sector
Amazon	300	ICT
Bristol Myers Squibb	400	biological medicine
Fidelity	200	Financial services
LinkedIn	600	ICT
Survey Monkey	50	ICT
Air Bnb	100	ICT
PayPal	400	ICT
Ericsson	100	ICT
SAP	260	ICT
Johnson & Johnson	100	ICT
Alexion Pharmaceuticals	200	Pharma
Zendesk	100	Data Centre
Adroll	100	ICT
New Relic	50	ICT

Source: IDA Ireland

As discussed previously, it is important to note that a number of factors influence the location of foreign direct investments. These are summarised in the table below based on the results of a major recent book by Gray, Swinand and Batt on Ireland's Comparative Advantages for Foreign Direct Investment.

Table 6.2: Elements of comparative advantage for mobile foreign investment	
Element	**Importance**
Access to Markets	Essential Requirement
Education, Skills and Research and Development	Fundamental to Being Considered
Productivity and Labour Costs	Key in Evaluation of Locations
Taxation and Cost of Capital	Critical Factor for High Profit Sectors
Intermediate Input Costs	Influences Return on Capital Employed
Ease of Doing Business	Frequently the Deciding Issue
Exchange Rates	Important in Maintaining Cost Competitiveness
Demonstration Effects	Influences Overall Perceptions

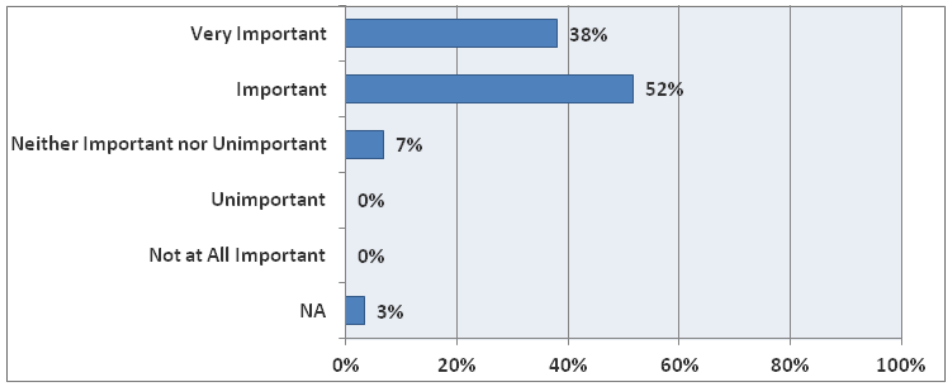
Source: Economic Analysis of Ireland's Comparative Advantages for Foreign Investment. Gray, A.W., Swinand, G.P. and Batt, W.H., ISBN 978-0-9531318-15

These factors are all likely to vary by region and thus it is important the targeting of investment takes a regional view of strengths and weaknesses.

6.2 Evidence of Importance of electricity grid

In this section, we will examine survey evidence of the importance of electricity grid investment in supporting economic development in Ireland. Figure 6.1 shows that 90% of firms surveyed believe that investment in the electricity transmission network to be either 'important' or 'very important' for our ability to attract additional foreign direct investment (FDI) to Ireland.

Figure 6.1: Views on importance of electricity transmission network on ability to attract additional foreign investment to Ireland

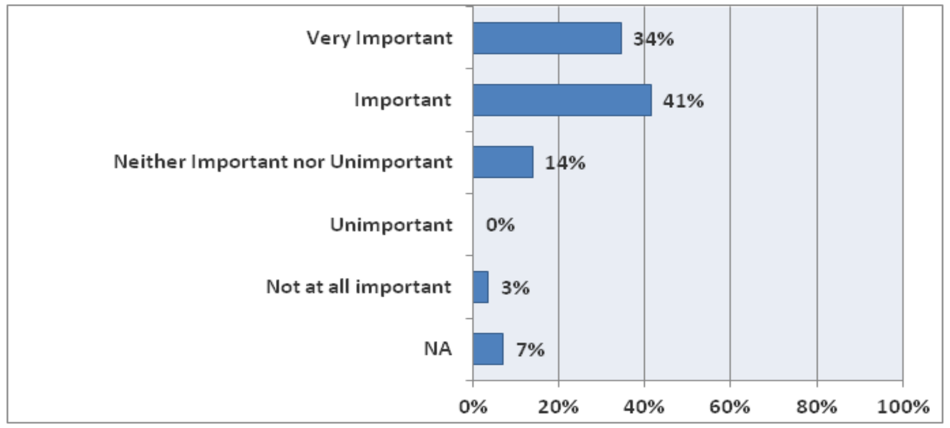


Source: Indecon survey of multinationals and indigenous companies in Ireland

The following figure shows the results of the judgment of firms surveyed on the importance of a high quality electricity supply to decisions to locate new operations or functions in Ireland. A

majority, 75%, of companies indicated it was 'important' or 'very important' to such decisions, while only 17% said high quality electricity supply had no important impact.

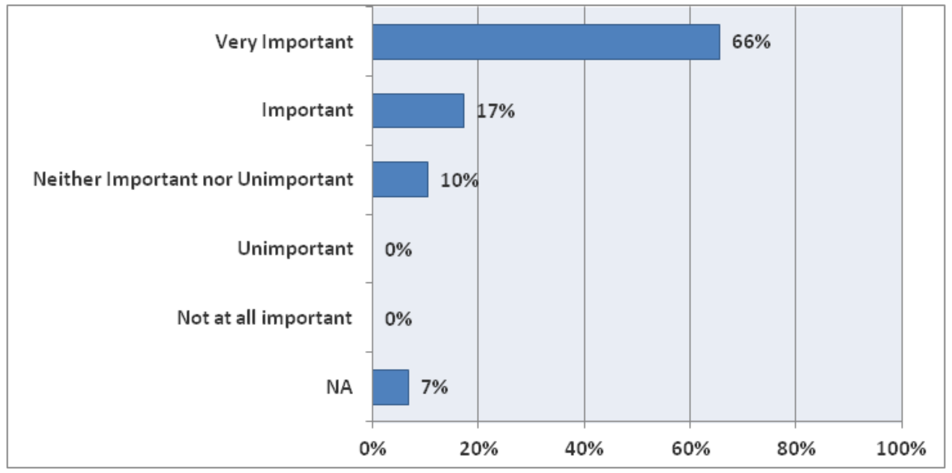
Figure 6.2: Views on the importance of access to a high quality electricity supply on decisions to locate new operations or functions in Ireland



Source: Indecon survey of multinationals and indigenous companies in Ireland

The views on companies surveyed on whether access to a high quality electricity supply would be 'important' to their continuing operations in Ireland are presented in Figure 6.3. A majority, 66%, responded that it was 'very important' while another 17% said it was 'important'.

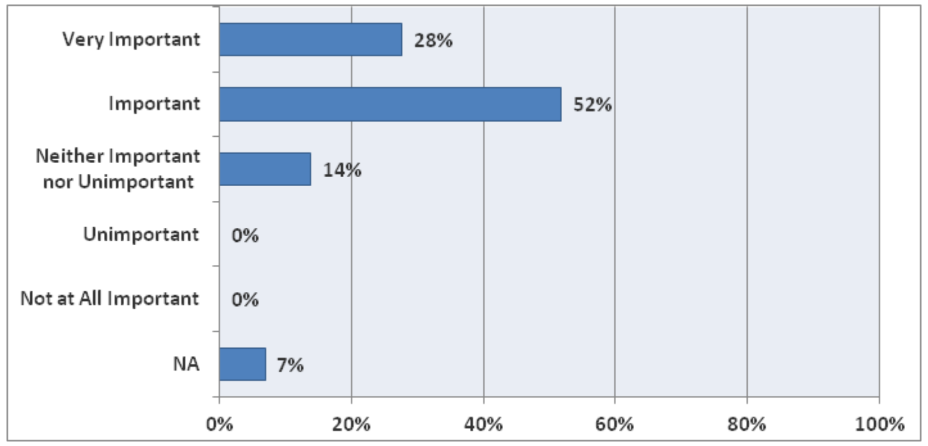
Figure 6.3: Views on the importance of access to a high quality electricity supply on continuing operation in Ireland?



Source: Indecon survey of multinationals and indigenous companies in Ireland

Figure 6.4 shows the views of the surveyed companies on the importance of investment in the electricity transmission network for facilitating companies to remain in Ireland. 52% of respondents felt that investment in the National Grid was 'important' to help facilitate companies to remain in Ireland with a further 28% considering it 'very important'.

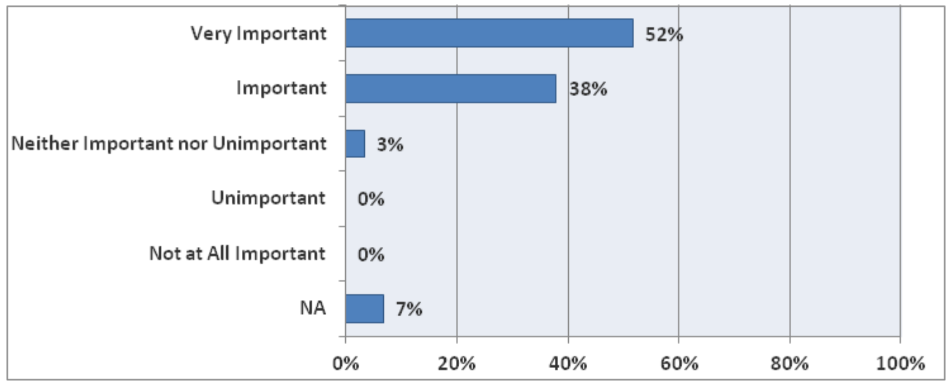
Figure 6.4: Views on the importance of electricity transmission network to facilitate companies to remain in Ireland



Source: Indecon survey of multinationals and indigenous companies in Ireland

Figure 6.5 shows the views of surveyed firms on the importance of investment in the electricity transmission network to facilitate companies in Ireland to expand their operations. 90% suggested that it is either 'important' or 'very important' to companies when making the decision to expand their operations in Ireland.

Figure 6.5: Views on importance of investment in the electricity transmission network to facilitate companies in Ireland to expand

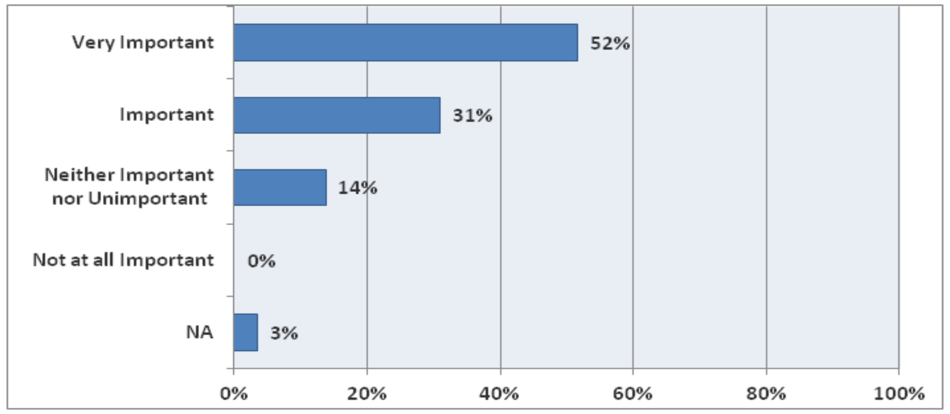


Source: Indecon survey of multinationals and indigenous companies in Ireland

Figure 6.6 reflects the views of the surveyed firms on the importance of available capacity to their decisions to expand their operations. 83% of firms indicated that additional available capacity was

'important' or 'very important' to any expansion plans. The majority of firms (52%) considered it to be 'very important' to any future expansion plans.

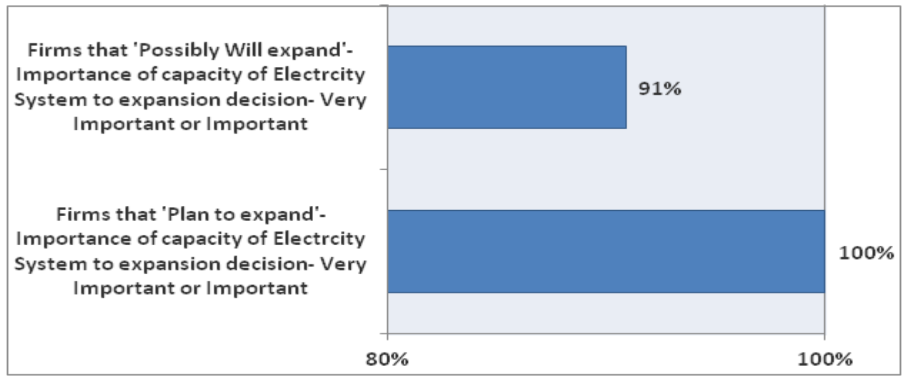
Figure 6.6: Importance of additional available capacity on the electricity system in terms of expansion plans



Source: Indecon survey of multinationals and indigenous companies in Ireland

Figure 6.7 shows the opinions of surveyed firms that indicated they 'Plan to Expand' or that they 'Possibly Will Expand'. Of those firms that planned to expand, 100% of them believed that the additional capacity of the national electricity transmission network was very important or important to the expansion decision. 91% of the firms that indicated a possible plan to expand considered it to be very important or important.

Figure 6.7: Priorities of firms with plans for expansion



Source: Indecon survey of multinationals and indigenous companies in Ireland

6.3 Data Centres

In evaluating the role of the electricity grid infrastructure in meeting the needs of the economy it is useful to consider one area in more detail, namely data centres. The importance of added analysis of data centres is due to the fact that such projects are very large and intensive users of electricity and the scale of individual projects can impact on grid infrastructure requirements. A summary of the key features of Data Centres is provided in Box 6.1. This type of FDI is directly linked to the ability of the grid to provide a reliable source of electricity.

Box 6.1: Case study: Importance of Data Centres

Introduction and Background:

Data Centres are large groups of networked computer servers used for the remote storage, processing and distribution of significant volumes of data. Ireland currently hosts a combined electrical capacity of 224 MVA in 12 commercial co-location Data Centres. These large data centres are predominantly situated in clusters in West Dublin. However as outlined below a major new centre has been proposed for Co. Galway

Locational choice:

Data Centre investment decisions are inter-alia governed by two fundamental criteria; proximity to high-bandwidth fibre and the availability of a reliable power supply.

Recent developments:

A significant recent announcement with relation to data centres has been by Apple. It has announced that it will invest around €850 million in a new data centre in Athenry in forestry land previously owned by Coillte. This is the largest data centre in Ireland to be located outside of the wider Dublin area. It has been announced that the Athenry centre will provide 300 jobs during its multiple phases.

Impact of Data Centres:

There are a number of important impacts of data centres including:

- Transmission system benefits associated with the typically flat loads of data centres.
- Employment created during the operation of the centre.[11]
- Significant employment generated during the construction of the data centre.[12]
- Data Centres may attract corporate headquarters nearby or spin-off industries for cooling, digital rights, software development, data mining and analysis. In other words, Data Centres may attract increasing amounts of FDI.
- Transmission Use of System contributions from Data Centres can reduce the obligations of other users while any network reinforcement costs may be recouped in a reasonable pay-back period.

Source: Indecon and EirGrid

11 EirGrid estimate that Circa 1 high value telecoms or electrical engineering role is created per 1 MW installed
12 EirGrid estimate that Every 10,000 sq. ft. installed creates approximately 150 construction jobs over 1 year

6.4 Conclusions on impact of grid investment on attracting investment

The findings in this chapter highlight the importance of a high quality electricity sector to the expansion of the internationally traded sectors of the Irish economy.

- Analysis shows that 90% of firms surveyed believe that investment in the electricity transmission network to be either important or very important for our ability to attract additional foreign direct investment to Ireland.
- 75% of companies indicated it was 'important' or 'very important' to this decision, while only 17% saying high quality electricity supply had no important impact.

7 Conclusions

7.1 Key Conclusions on overall Economic Impacts

This study has estimated the economic value of the expenditures arising from EirGrid's development strategy for the high-voltage electricity grid in Ireland.

Grid investment will have significant economic benefits for Ireland. The benefits can be grouped into a number of main categories:

- Direct economic benefits (economic impact) from the planned investment expenditure;
- Indirect benefits (the knock-on economic impacts) from the planned investment expenditure;
- Improvements in security of supply, which is highly valued by both households and business;
- Improvements in the attractiveness of Ireland as a location for existing and future direct investment; and
- Improvements in the ability of the electricity system to accommodate new demand and new supply, especially renewables.

Table 7.1: Summary of proposed scenarios for grid development

	Scenario A	Scenario B -	Scenario C
NPV (Net Present Value) of the Gross Expenditure Benefits	2,229	2,864	2,097
NPV of the Costs	1,229	1,942	1,150
Difference	1,000	922	947
Economy-wide Employment (Man Years) supported	42,371	56,603	39,046
Economic Benefits of Infrastructure provision	(See below)	(See below)	(See below)

Source: Indecon analysis

A number of other key factors are important in considering electricity grid investment. These are summarised in Table 7.2. This highlights the fact that the costs of the investment needs to be compared to the likely benefits and reinforces the importance of ensuring cost-effective solutions. It is also important to consider other issues such as visual amenity which are outside the scope of this economic report.

Table 7.2: Summary of proposed Sceanrios for Grid Development – Other Economic Impacts

	Scenario A	Scenario B	Scenario C
Supports Regional Development	✓	✓	✓
Provides adequate capacity	✓	✓	✓
Minimises Cost to Electricity Users	-	×	✓

Source: Indecon analysis

7.2 Conclusions on Economic Benefits and Grid Infrastructure

Economic Benefits of Grid Infrastructure on Investment and Economic Output

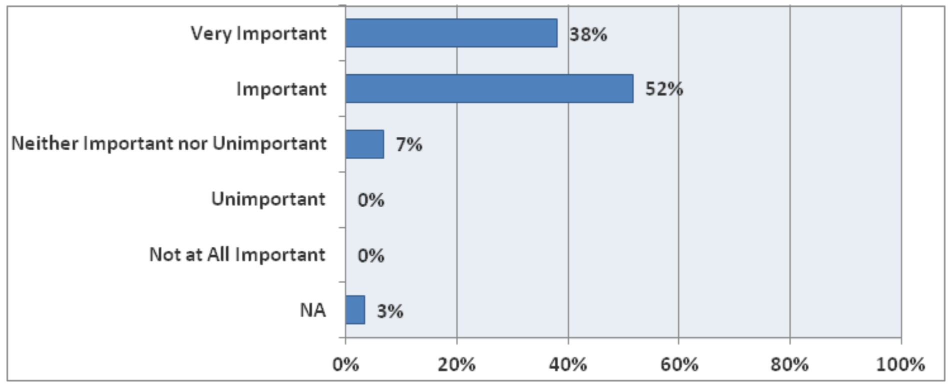
The economic benefits of providing grid infrastructure can also be considered in the context of the economic cost of an electricity outage. Indecon estimates that this is likely to be significant and we estimate that for a 1-hour outage the cost to the Irish economy is likely to be around €45 million.

In addition to the economic costs of an electricity outage, of more fundamental significance is the impact on investment if sufficient infrastructure is not available. Such a scenario would impact on the ability of existing firms to expand and the ability to attract new investments.

Grid investment is an essential component in meeting the requirements of industry connection to the transmission system. This is particularly relevant for firms in the internationally traded sector.

Indecon's analysis shows that 90% of firms surveyed believe that investment in the electricity transmission network is important or very important for Ireland's ability to attract additional foreign direct investment (FDI).

Table 7.3: Views on importance of electricity transmission network on ability to attract additional foreign investment to Ireland



Source: Indecon survey of multinationals and indigenous companies in Ireland

- 75% of companies indicated it was 'important' or 'very important' to decisions to locate new operations or functions in Ireland.

7.3 Adequacy to Meet Regional Needs

Adequacy to Meet Regional Needs

In evaluating the scenarios being considered by EirGrid it is critical to consider the ability of each scenario to accommodate the likely future demand in each region. In the table below we outline the capability of the proposed investment programme to accommodate additional demand and compare this to estimated demand in each of the regions. This suggests that there will be available capacity in all of the regions to accommodate significant expansion of demand. There are a number of caveats regarding the table below regarding differences within regions and the interaction between nodes/stations and regions. However the evidence suggests that all of the plans for regional expansion outside of the Dublin/East region could be accommodated under the various scenarios identified by EirGrid.

Table 7.4: Projected Demand by Region and Additional Capacity available

	East	Midlands	West	North East	North West	South East	South West
2014 Demand (MW)	1830	480	370	380	630	380	560
2025 Demand (MW)	2070	530	410	420	700	420	630
Additional Capacity (MW) – High	870	657	658	700	441	378	775
Additional Capacity (MW) - Median	735	469	433	425	295	284	532
Additional Capacity (MW) – Low	600	280	210	150	150	190	290

Source: EirGrid

7.4 Issues for Consideration

A number of issues have been identified by Indecon during our research which Indecon believes merit consideration in order to maximise the use of scarce resources at the lowest cost to the economy. These are summarised in the table and discussed below and include possible measures to increase the attractiveness of regional locations for investment.

Table 7.5: Issues for Consideration

1. Examine regional economic outlook and map against infrastructure gaps
2. Consider adjustments to transmission pricing policy to facilitate lower pricing in regions
3. Evaluate the current and likely future economic costs and benefits of energy policy concerning renewables and wind and its impact on grid infrastructure requirements

Source: Indecon

Examine Regional Economic Outlook and Map against Infrastructure Gaps

A key focus of policymakers is to strengthen and develop job creation in the regions. While governments cannot create jobs at regional level (as recognised in policy statements), it is essential that infrastructure provision, including electricity transmission network, facilitates realisation of the potential of every region. Research undertaken by Indecon has demonstrated that over 82% of multinationals and indigenous firms rated investment in the electricity

transmission network as important, or very important, to facilitate regional economic development.

Indecon has analysed the existing level of transmission grid capacity and current demand by region and considers this is in the context of the investment plans proposed by EirGrid. Our preliminary research suggests that all of the three scenarios are likely to be sufficient to meet expected demand by each of the main regions outside of Dublin, but this needs careful ongoing evaluation and monitoring.

There is also a challenge to ensure investment takes place quickly enough to meet rapidly growing demand in Dublin and to also meet the needs of other regions. It is therefore essential that EirGrid continues to examine national and regional economic projects and their implications for any electricity infrastructure. Meeting transmission network infrastructural needs on time is critical for economic and regional development. The costs to the economy of any infrastructural deficiencies would be very high.

Consider Adjustments to Transmission Pricing of Infrastructure to Facilitate Lower Pricing in Regions

At present, national policy involves geographically uniform pricing for electricity grid access for demand regardless of the location of the investment. Indecon believes that this does not make economic sense. The cost to EirGrid and to the economy of facilitating grid access varies depending on the location of the investment and the grid's capacity. This economic consequence is not reflected in the costs faced by firms choosing between different locations and in our judgement is not appropriate. A realignment of pricing to reflect the overall system wide costs could enable EirGrid to offer discounted pricing to investors locating in certain regional areas. Such an outcome would enhance economic welfare and would enable EirGrid to meet infrastructure needs at lower costs.

The original geographically uniform pricing was designed to ensure that regional investments did not face higher pricing. However, Indecon believes such a standardised pricing approach is not currently aligned with supporting regional development and the current variance in excess capacity in grid infrastructure means that EirGrid could offer lower pricing to firms locating in certain regional locations compared to investing in Dublin. If geographically non-uniform pricing were aligned with geographic-specific cost elements (such as losses, cost of disruption for installation, etc.) geographical or zonal pricing could reduce overall national costs would improve overall competitiveness of electricity prices, besides enhancing the incentives to invest in certain regions. It could also reduce potential electricity grid infrastructure gaps in certain areas.

Indecon accepts this is not an issue for decision unilaterally by EirGrid but believe that it should be addressed as a priority by EirGrid, CER and the central Government.

Evaluate the Economic Costs and Benefits of Energy Policy concerning renewables and wind and its Impact on Grid Infrastructure Requirements

The net cost to EirGrid of connecting additional wind energy to the network varies by location. Indecon believes it is essential that an ongoing evaluation of the economic costs and benefits of wind policy and of specific wind investments should be undertaken to assess the implications and costs on grid infrastructure requirements.

Indecon understands that there are legal, regulatory and other issues in such decisions but ensuring that policy objectives are met by the lowest cost method is a key challenge for a small open economy such as Ireland's. If there are existing wind projects in planning which would involve significant additional economic costs to EirGrid in terms of providing access and they do not proceed, Indecon supports a very rigorous approach to enforcement of legal requirements in order to minimise national costs. Wider evaluation of the costs and benefits of wind policy is also an issue for national policymakers which merit ongoing review.

7.5 Overall Conclusions

This independent report suggests that grid investment will lead to significant benefits for the Irish economy in terms of increased output and employment arising from the expenditures in Ireland from the grid development strategy. It will also support regional development. The development strategies will however also involve significant costs which must be evaluated against the benefits of facilitating an expansion of the Irish economy both nationally and at a regional level. Ways to ensure this is achieved at the lowest cost taking into account all relevant factors is a key challenge.

EIRGRID