Ireland's Grid Development Strategy

Your Grid, Your Tomorrow

Technical Report

EIRGRID

The current. The future.

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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. 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.

In March 2015 we published "Your Grid, Your Views, Your Tomorrow." A Discussion Paper on Ireland's Grid Development Strategy. That review responded to feedback received from the public over recent years. It was part of our renewed efforts to encourage more participation in our decision-making process. It also reflected an updated economic context and our growing experience of new technologies.

We thank those who provided feedback to Your Grid, Your Views, Your Tomorrow during our public consultation. We have published a separate report on this consultation alongside this document.

In drafting this, our updated grid development strategy, we took account of this feedback. We also took into account the Government's Energy White Paper, published in December 2015.

We were further guided by the Action Plan for Jobs and the IDA's 2015-2019 strategy, which includes ambitious regional targets.

Our grid development strategy is based on available information at the time of publication, and is an informed view of our future needs in the coming years. However, we will continue to review it on a regular basis. This is to ensure that our strategy continues to be up to date, and fit for purpose in a changing Ireland.

The United Kingdom's June 2016 referendum on EU membership has introduced new considerations. However, most issues covered by our grid development strategy relate to the Republic of Ireland only, and so are unaffected.

Regardless of the UK leaving the EU, there will always be many shared benefits of working closely with our nearest neighbours. We aim to maintain a strong relationship between Ireland, Northern Ireland and Great Britain on energy matters.

This includes the North South Interconnector. This project is needed to improve the security of supply across the island of Ireland. It will reduce costs and ultimately save money for the electricity customer.

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

We commissioned London Power Associates to carry out a technical peer review of our draft strategy.

Indecon economic consultants carried out an economic review of the draft strategy.

These reports were published as appendices to our draft strategy document in 2015 and are available online at www.eirgridgroup.com.

Their analysis was reflected in the draft strategy and it is also reflected in the updated strategy.

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 System Security and Planning Standards[1] (TSSPS), which set out what the grid needs to be able to do and are published at www.eirgridgroup.com. 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. Due to more efficient energy use this relationship is changing – proportionally less energy is now required even though the economy is growing. In addition many new industries, such as data centres, have disproportionately high power demands.

Electricity demand in Ireland is linked to recent economic fluctuations. Following a 7.1% fall in demand between 2008 and 2012, electricity demand then grew again. In 2013, 2014 and 2015 it increased by 1.1%, 0.5% and 2.9% respectively. This relates to growth of 3.4%[2], 7.3%[3] and 5.7%[4] in Ireland's Gross National Product (GNP) between 2013 and 2015. The demand for electricity is now expected to grow on average by 2.0% every year until 2025.

In summary, the economic downturn reduced electricity demand. However, recent trends now point to steady growth in the economy and in electricity use up to 2025.

Our demand forecasts are based on the Economic and Social Research Institute's (ESRI) short-term and long-term forecast of economic activity and are updated annually in the All Island Generation Capacity Statement[5] (GCS) which is available on our website.

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, 2015 and 2016 peak demand forecasts up to 2025. Since 2008 we have scaled back our peak demand forecast for 2025. The 2016 forecast for 2025 is approximately 5,500 MW, compared to 8,000 MW that we forecasted in 2008. The current 2016 forecast for 2025 has increased by approximately 400 MW compared to the 2015

[1] Formerly the Transmission Planning Criteria (TPC).
[2] Modified GNP figure provided by the ESRI.
[3] Modified GNP figure provided by the ESRI.
[4] This is the CSO's GNP figure.
[5] Formerly the Generation Adequacy Report (GAR).

forecast published in our draft grid development strategy in 2015. A reason for this increase is the expected connection of additional large data centres.

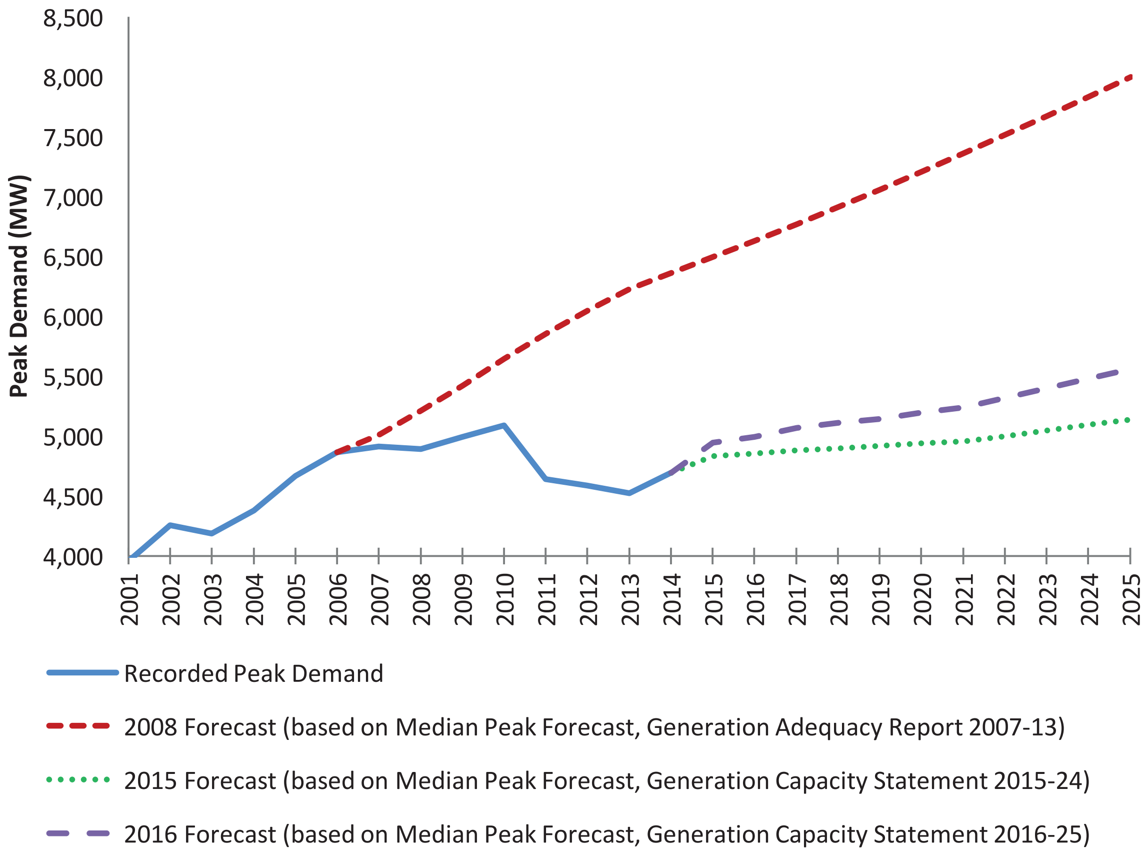

Figure 2-1 Actual Demand and Forecast Demand to 2025

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 heat, and smart metering, details of which are in the National Energy Efficiency Action Plan (NEEAP)[6] and the National Renewable Energy Action Plan (NREAP)[7]. These measures have been factored into the 2016 forecasts out to 2025, and we will continue to factor them into our annual All Island Generation Capacity Statement.

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.[8] This technology is in the development phase and a number of meter trials have taken place.

[6] http://www.dccae.gov.ie/energy/en-ie/Energy-Efficiency/Pages/National-Energy-Efficiency-Action-Plan-(NEEAP).aspx
[7] http://www.dccae.gov.ie/energy/en-ie/Renewable-Energy/Pages/Action-Plan.aspx
[8] http://www.cer.ie/electricity-gas/smart-metering

Micro generation, including solar photovoltaic and small-scale wind, will also have an influence on demand patterns. We 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 economic growth and electricity demand will become weaker.

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.[9]

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; and
- Availability of a skilled local workforce.

Currently a number of data centre operators are either contracted to connect to the grid or are in the process of being issued an offer for connection to the grid in various parts of the country. These proposals represent a substantial increase in demand connecting by 2020 resulting in a significant step increase in demand predictions. In addition there continues to be further expressions of interest in locating large-scale data centres in Ireland. If these current expressions of interest were to materialise further step increases in demand would also occur.

Depending on the final number and scale of these projects that are developed new transmission solutions additional to those in the grid development strategy are likely to be required.

Forecasting Demand

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

[9] See the Government's Action Plan for Jobs at https://www.djei.ie/en/

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 2016 census, our population was 4.76 million, up 3.7% from 2011.

The Central Statistics Office (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.[10]

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

Changing Generation Patterns

Renewable Generation

Ireland is in a strong position to meet the Government's renewable energy target of meeting 40% of electricity demand from renewable energy by 2020.[11] 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 most 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 issued by ESB Networks and EirGrid 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 83% of offers accepted, 1% under consideration and only 16% have been declined.

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 assist in meeting the 40% renewable target will be between approximately 3,800 and 4,100 MW.

This is an increase in the requirement for wind capacity since the forecast in 2015. This is due to the increase in our forecasts of the overall demand for electricity.

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

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[10] CSO Population and Labour Force Projection 2016-2046 (2013)
http://www.cso.ie/en/media/csoie/releasespublications/documents/population/2013/poplabfor2016_2046.pdf

[11] In 2008 the Government increased the target from 33% to 40%. http://www.dccae.gov.ie/

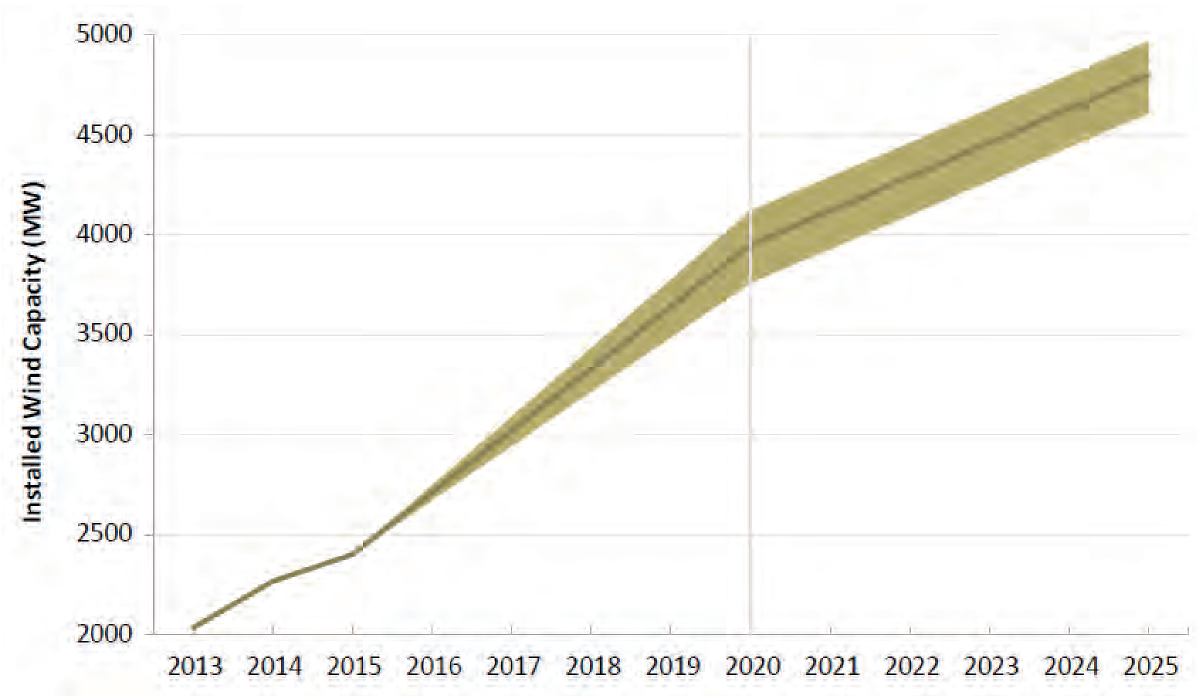


Figure 2-2 Band of Possible Wind Capacity Requirements to meet the 2020 Renewable Target[12]

Another renewable energy resource is solar power. ESB Networks and EirGrid have received a significant number of applications for connection of solar farms. We are currently processing these applications and making connection offers.

We 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 our 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 over-investment if the connection of generators are delayed or even cancelled.

Conventional Generation

In 2008 we 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.

[12] Taken from EirGrid and SONI's All Island Generation Capacity Statement 2016.

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.

Balance with Northern Ireland

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 and more efficient plants in Ireland. 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. For more detailed analysis see the All Island Generation Capacity Statement which is available on our website.

Interconnection to Europe

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 we envisaged at least one additional interconnector, between the transmission networks of Ireland and Great Britain or France, by 2025.[13] This potential interconnection capacity will provide access to wider electricity markets. These interconnector assumptions remain valid.

We are undertaking, with the French transmission system operator (TSO), Reseau de Transport d'Électricité (RTÉ), 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 included carrying out a marine survey. The survey route is over 500 km long and extends from the south coast of Ireland to northwest Brittany.

In July 2016 EirGrid and RTÉ agreed to progress the project to the next phase of its development, Initial Design and Pre-Consultation. This latest phase will take two years and

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

comprises an in-depth economic assessment of the project; technical studies and initial technical design specifications; environmental studies; and pre-consultation in preparation for permit granting procedues in France and Ireland. It will also include the investigation of landing points for a subsea cable and connection points to the electricity transmission grids in France and Ireland. The Initial Design and Pre-Consultation phase is a continuation of previous studies, and does not represent a commitment to construct the interconnector.

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

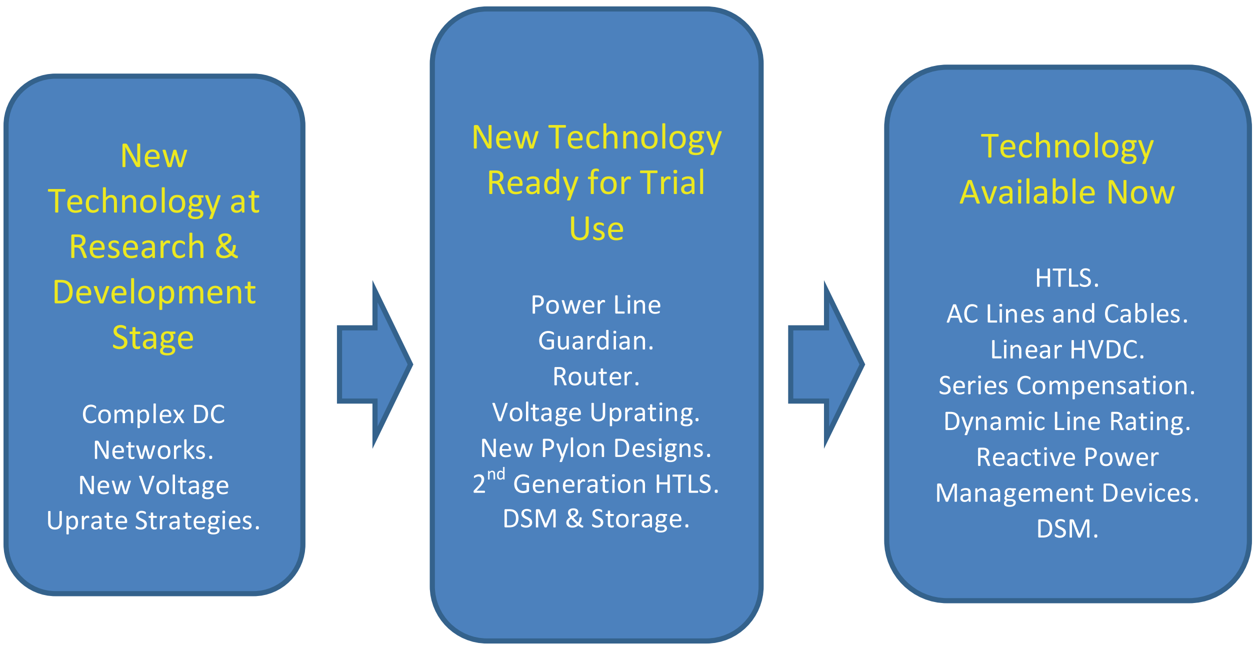
Chapter 3: Technology and Innovation

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 in 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.

We are 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.

We place new technologies in three broad categories as shown below.



We are assisting industry to identify, develop and trial new technologies by encouraging innovative solutions though the Smart Grid Innovation Hub. Figure 3-1 shows examples of battery and energy storage projects that we are currently actively engaged with. As part of this commitment we are working in research and development with academia, nationally and internationally, by providing support and expertise.

Figure 3-1: Images of EirGrid partnership projects for Battery and Energy Storage (left RealValue Project storage heater technology and right high voltage battery[14] technology)

We also participate 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 us, in our 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 the transmission and distribution systems 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:

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

[14] Image supplied of Tait Energy Storage courtesy of AES.

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, we are working with ESB Networks, the Distribution System 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. We are 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 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 our world-leading initiative “Delivering a Secure, Sustainable Electricity System” (DS3 programme) and often mitigated by operational measures. You can find out more about this initiative on our website.

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 us to invest considerable resources in carrying out detailed harmonic modelling and analysis during the connection and planning process.

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.

We have 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

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 structures 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. We introduced HTLS technology to the Irish transmission system in 2011. These first generation HTLS conductors have been used successfully by EirGrid and ESB Networks, achieving a 60% increase in capacity on approximately 600km of existing 110 and 220 kV overhead lines.

We are 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

We have 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 power carrying 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.[15]

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.

We commissioned a report in 2009 by Tokyo Electric Power Company (TEPCO) which has considerable experience of transmission cable networks.[16] This study, together with further

15 http://www.eirgridnorthsouthinterconnector.ie/media/3B_5)Ecofys(2008)ComparativeMeritsofOHElectricityTransmissionLinesvsUGCables.pdf

16 http://www.eirgridnorthsouthinterconnector.ie/media/3B_39)Tokyo%20Electric%20Power%20Co%20TEPCO%202009%20Assessment%20of%20Tech%20Issues%20%20EHV%20UGCs.pdf

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.

We have continued to examine the performance of cables and their technical impact on the network.

Our recent analysis has 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. We have concluded that a number of techniques exist that could reduce, but not avoid, these issues.

We 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. We have included this technology in a number of recent project evaluations and considers its use, where appropriate.

In 2009, we commissioned a separate investigation into the use of HVDC circuits in the Irish transmission network.[17] 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).

We 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.[18]

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

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

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17 http://www.eirgridnorthsouthinterconnector.ie/media/3B_40)%20TransGrid%20Solutions%20Inc%202009%20Investigating%20Impact%20of%20HVDC%20Schemes.pdf

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

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.

We have 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.

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. We 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

We are 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.

Demand Side Management and Response

Demand Side Management and Response has been used in Ireland for many years, primarily at the larger industrial level. It works when customers reduce their electricity consumption on request. This helps us to operate the grid more securely.

In the future it is expected that residential customers will also take part in Demand Side Management and Response, through initiatives such as Power Off and Save, and the RealValue Project. This is expected to help us to maximise the use of the existing grid and potentially delay or avoid investment in the grid. Details on our innovation programme, including the Power Off and Save, and the RealValue projects are available on our website.

Technology – Ready for Trial Use

Power Line Guardian and Router

We are investigating the use of modular power flow control technologies that may enable us to make better use of the existing transmission network. Two types of modular power flow controller are under investigation, the Power Line Guardian and the Router. A pilot trial is currently underway for the Power Line Guardian. Power Line Guardians can be rapidly deployed onto existing overhead line conductors. Individually, they provide a small change to the reactive inductance of a line. By increasing their number along individual spans of heavily loaded lines, it may be possible to divert load on to lines with spare capacity.

These devices can easily be fitted or removed to change the degree of power flow 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.

We started a trial of the Router technology in 2016. This technology builds on the capabilities of the Power Line Guardian, adding further flexibility to make better use of existing network capacity. The Router may also be adopted as a mature technology if the trial is successful.

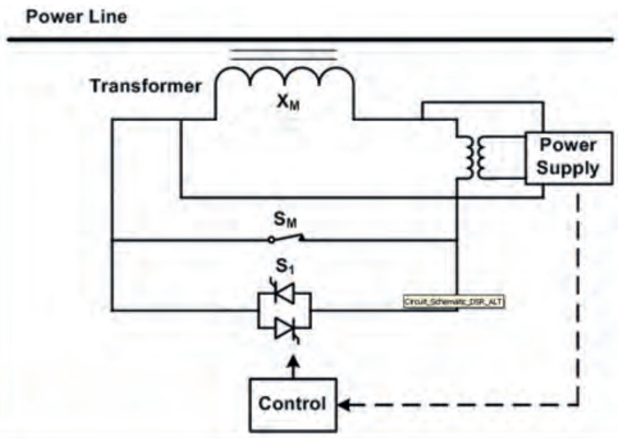


Figure 3-2: Power Line Guardians

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.

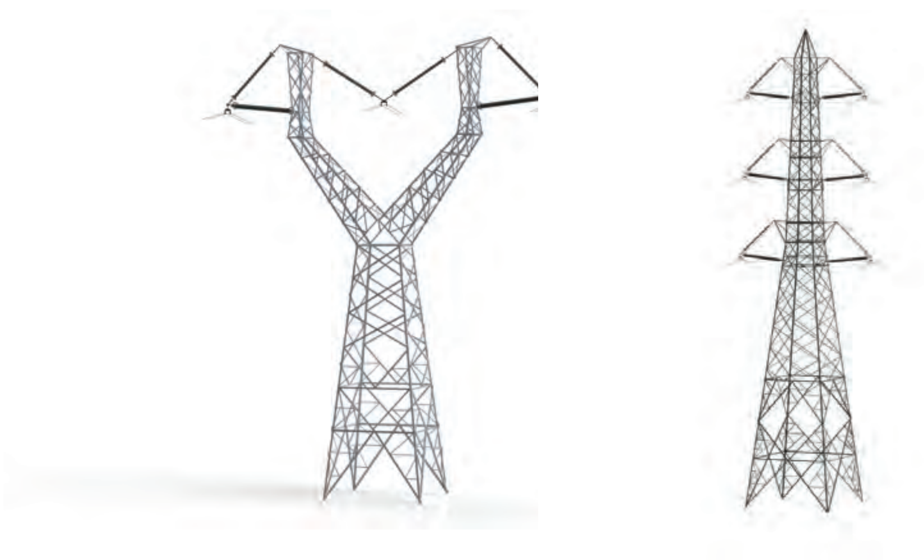


Figure 3-3: Prototype voltage uprate technology using composite insulators
(left, new example 400 kV single circuit design; right, new example 400 kV double circuit design)

New Overhead Line Structures/New Pylon Designs

In most cases overhead line technology remains the most reliable and least expensive option for developing new circuits. We are 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.

We will also take the National Landscape Strategy into account.

Figure 3-4: Examples of new pylon designs

Technology – Research & Development 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.

We 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.

We have 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. Further information is provided in the Voltage Uprating section in Technology Ready for Trial Use.

However, for the lower voltage 110 kV lines, due to the existing non-metallic support structures these technologies are not likely to prove successful. We therefore are 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.

Tomorrow's Energy Scenarios

The majority of grid development projects are driven by changes in how the grid is used. To plan new grid development projects, we first have to understand what the future usage of the grid may look like.

To do this, we think about changes in the way people and businesses use electricity and changes in the way in which electricity is produced. We ask ourselves: "What factors will drive these changes and how will these changes play out over time?".

For example, we know that in response to a global commitment to tackle climate change, the energy industry is moving towards a low carbon energy future.

This will lead to changes in the type, size and location of power stations connecting to the grid.

It may also lead to more community-based power and heating systems being built which would mean greater efficiency in how electricity is used in the home and in business.

It is important that we look at all the factors that influence changes in the usage of the grid in the future. Government and EU policy are key influences but social trends, changes in technology, changes in the economy, changes in agricultural and industrial development all have a role to play.

Over the past ten years, we have learned that the level of uncertainty over the future usage of the grid is increasing.

To cater for this, we are changing how we plan the grid. Our new approach involves developing a range of future scenarios. We will test whether the grid of today can support these future scenarios or if further development of the grid is required.

These future scenarios will reinforce our grid development plans. It is vital that we gather a wider range of stakeholder opinions and views early on in the scenario development process.

Therefore, when we create our scenarios, we will ask key policy makers and industry experts how they see things changing over time. We will then publish our scenarios and invite comments from everyone.

The scenarios will be reviewed every two years in this way and any other new information available to us on trends, changes in the industry, and other relevant factors will be included. This two-year cycle of ‘review and renew’ will be ongoing.

We will use these scenarios throughout our planning analysis to assess the needs of the future electricity system. We will also use them to test the practicality and merits of network reinforcement options, and propose solutions for any problems we uncover.

We already use a version of this approach for individual projects. We ask various ‘what if’ questions when we are looking for a specific development solution. This tests robustness, durability and technical performance. This ensures we choose the most appropriate solution.

Chapter 4: Strategy for Grid Development

To ensure transmission system reliability and security, the performance of the network is compared with the requirements of the Transmission System Security and Planning Standards (TSSPS) which are available at www.eirgridgroup.com. Our license specifically requires us 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 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 such as thermal and voltage issues, 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, our development plans cover all areas of the country. This grid investment is essential if broader regional economic growth is to be enjoyed throughout Ireland.

Our strategy statements are:

Strategy 1

Inclusive consultation with local communities and stakeholders will be central to our approach.

We acknowledge the sensitivities associated with major transmission infrastructure development.
In response to major project consultation feedback, and to follow through on our Grid25 Initiatives announced in 2014, we undertook to carry out a thorough internal and external review of our consultation process. In December 2014 we published "Reviewing and Improving our Consultation Process". The review contained 12 commitments aimed at achieving a more community-focused approach to grid development. We are making significant progress in meeting these commitments. One of the 12 commitments was a review of our Project Development and Consultation Roadmap. As a result of that review,we have developed a new project development framework. This clearly and

transparently outlines the steps we take when developing the grid, and how communities can have their say.

Our new framework replaces the previous Project Development and Consultation Roadmap.

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

Strategy 2
We will consider all practical technology options.

One of the themes raised in submissions during recent consultations was the need to conduct a comprehensive underground analysis for our large linear projects.

We have always considered underground technology during initial project research and technical analysis. We are commited 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
We will optimise the existing grid to minimise the need for new infrastructure.

We 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 may 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.

Grid Development Strategy

Our grid development strategy has been developed in light of the 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 an estimated cost of €3.2bn. 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 cost for our grid development strategy has been revised, we expect it to fall within the range of €2.6 to €2.9 billion. This also includes the cost for the southern portion of the North South Interconnector.This cost was not included in the original Grid25.

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, we 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. This has had a significant impact, particularly evident in networks supplying major towns and cities.
- 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 4-1 below compares the quantity of transmission circuits proposed in the original Grid25 Strategy in 2008 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 66% to 86%. Simultaneously the amount of new infrastructure has dramatically reduced due to the greater use of network optimisation. This equates to around a 73% reduction in the total length of new build. The high level of circuit uprating will be maintained, considerably reducing the need for new infrastructure.

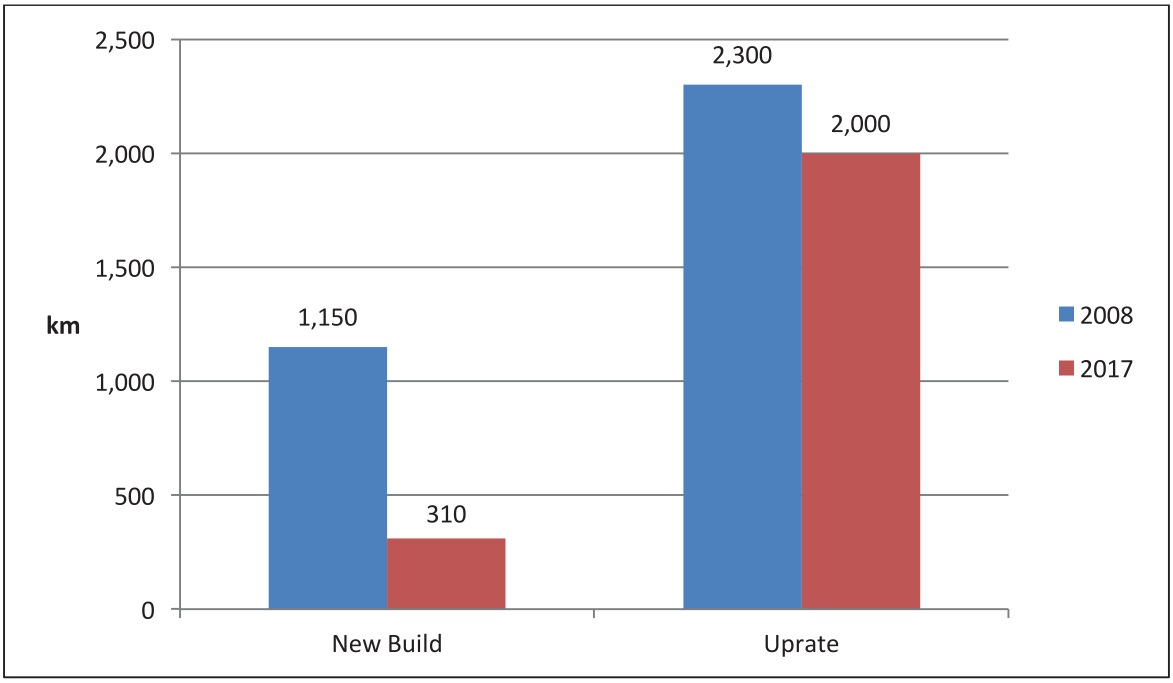


Figure 4-1 Comparison of length of uprate and new build circuits

Chapter 5: Regional Development and Major Projects

We have 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 in 2008, and the estimated cost of the updated strategy, ranging between €2.6 bn and €2.9 bn.

It is necessary to provide a cost range to allow for the increasing variety of technologies which may be selected for a project. To provide greater transparency and a clearer understanding of the consequences of our strategy, the plan is broken up into eight individual regions[19]. Figure 5-1 below illustrates the broad distribution of this capital investment across the eight regions. The map in Figure 5-2 shows the outline of the eight regions. Each region is made up of the following counties:

- Border: Donegal, Sligo, Leitrim, Cavan, Monaghan and Louth;
- West: Mayo, Glaway and Roscommon;
- Mid-West: Clare, Limerick and North Tipperary;
- South-West: Cork and Kerry;
- Midlands: Longford, Weathmeath, Offaly and Laois;
- South-East: South Tipperary, Waterford, Wexford, Kilkenny and Carlow;
- Mid-East: Wicklow, Kildare and Meath; and
- Dublin.

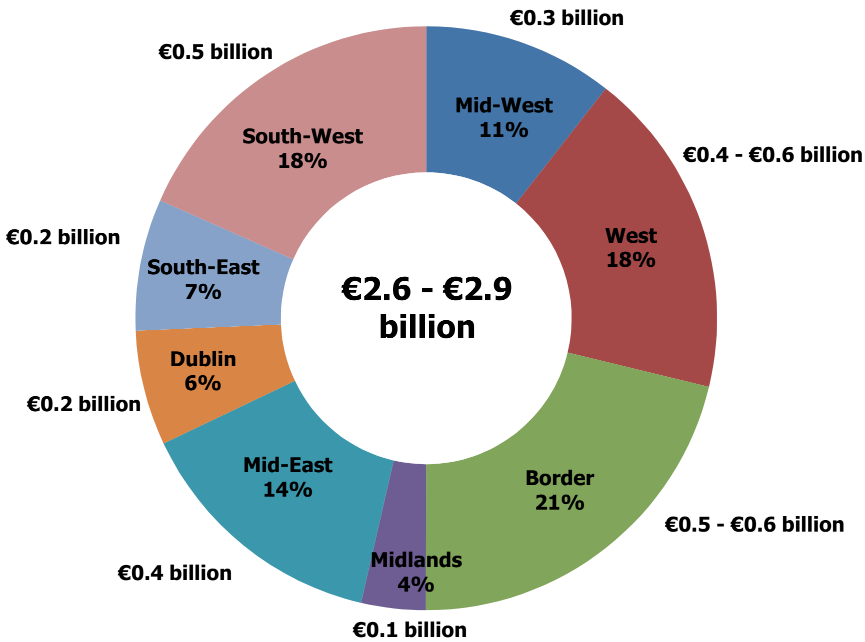


Figure 5-1 Regional breakdown of investment

[19] We have updated the regions to align with those used by Government and Government bodies e.g. the IDA. Previously we used regions we developed ourselves.

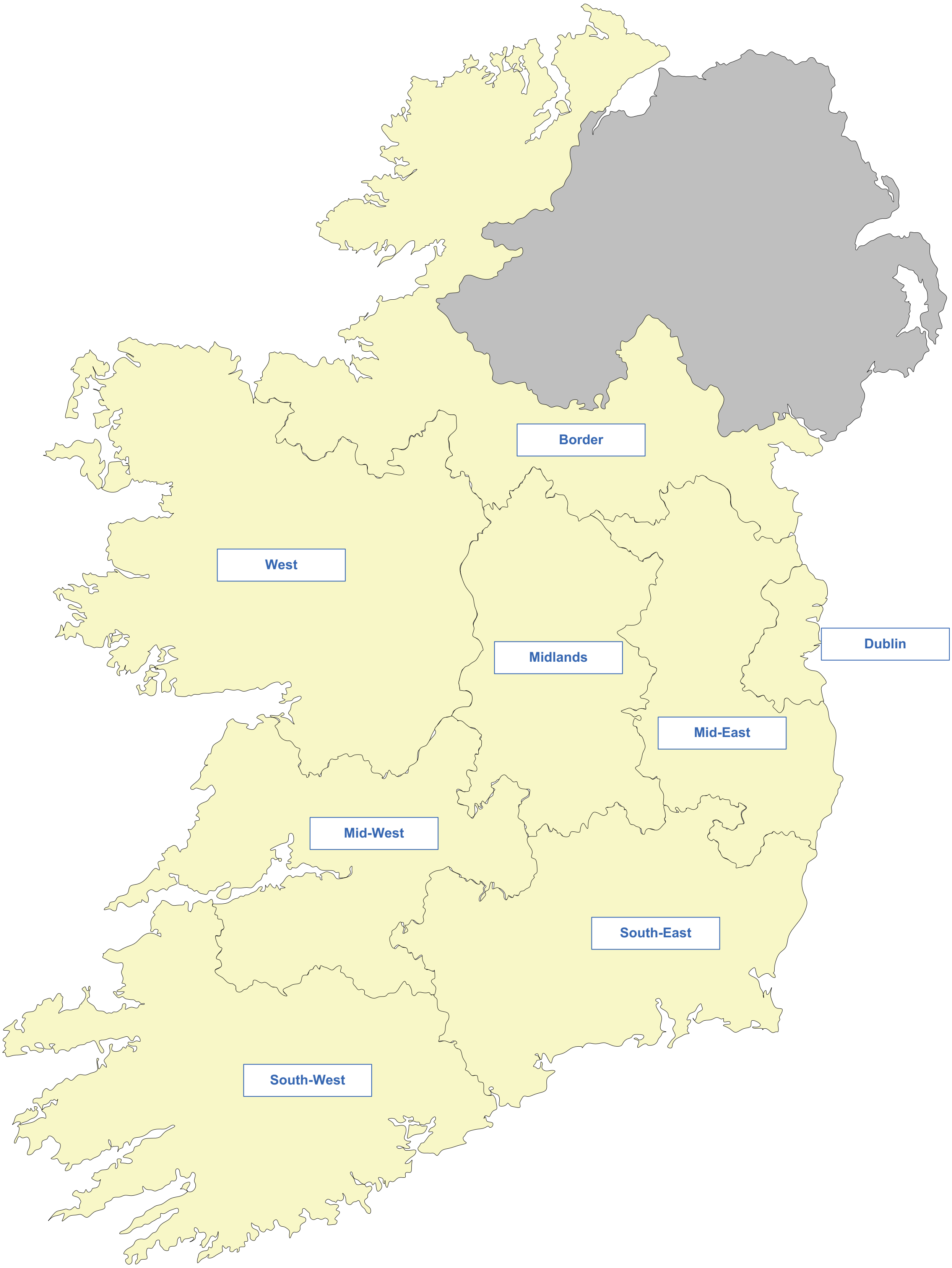


Figure 5-2 Map Showing Outline of Regions

Each region is summarised individually below. In each regional summary a detailed map is provided showing all transmission circuits and substations, their operating voltages and generation sources. Major grid developments are highlighted and categorised as new assets, uprated or modified assets, or areas of continuing investigation.

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

- the forecast regional generation and demand balance;
- the main regional demand centres, and the forecast demand and additional available capacity at the demand centres[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 for each region. Where there are major projects within that region, a more detailed description of these key projects is provided. Figure 5-3 provides a national summary.

For details on projects that have already been completed see the Transmission Development Plan which is available on our website.

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. In addition, our grid development strategy, including this Technical Report, will provide the foundation for our next Implementation Plan and Strategic Environmental Assessment (SEA), the preparation of which has commenced, and which will be published in 2017.

In our grid development strategy we set out our view on the major investment projects necessary to meet Ireland's needs. This strategy relates only to Ireland, but it considers the all-island energy market. In particular, it responds to the urgent need to secure electricity supply in Northern Ireland.

[20] 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 grid development strategy only, for example new assets that physically connect generation to the transmission network are excluded.

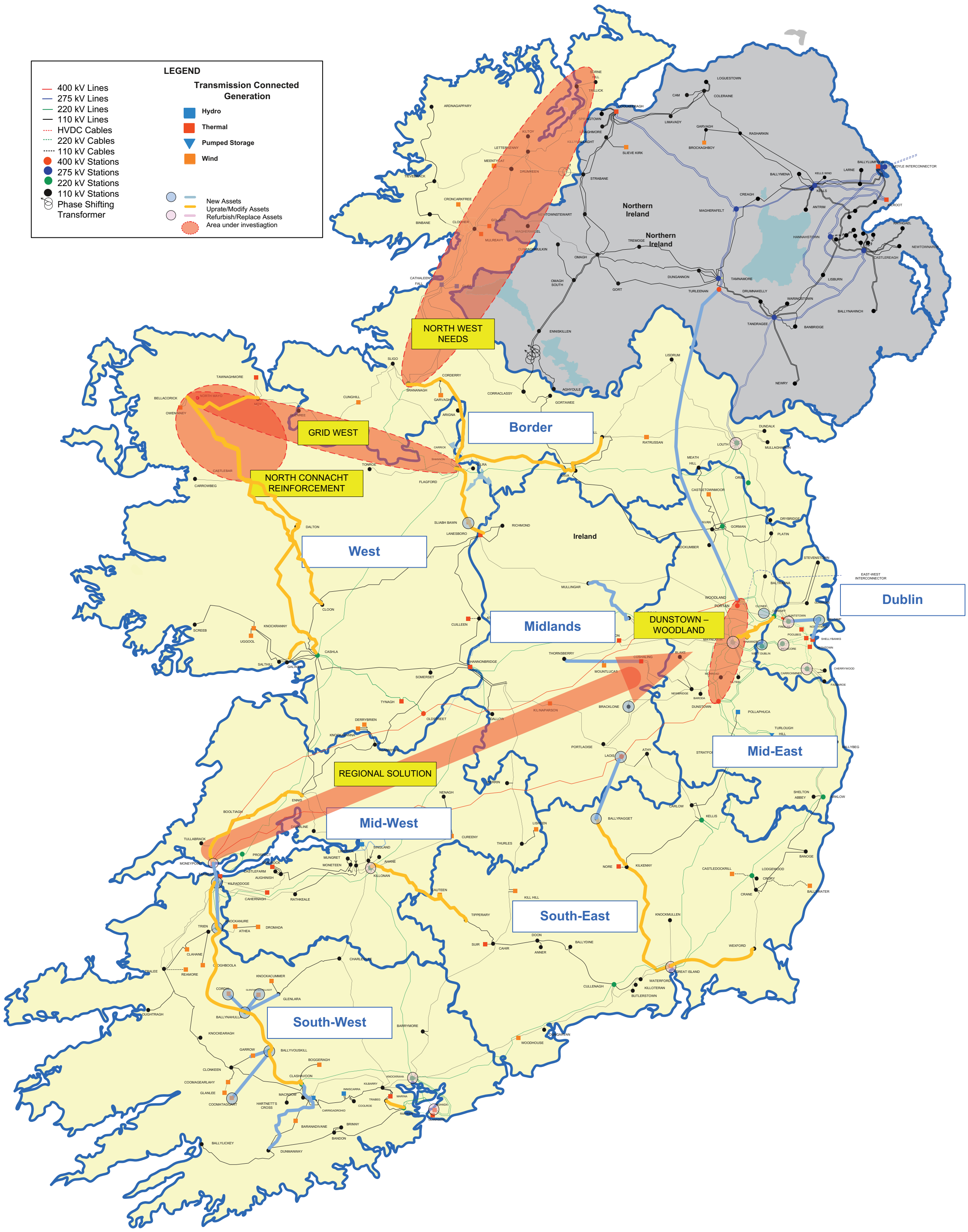
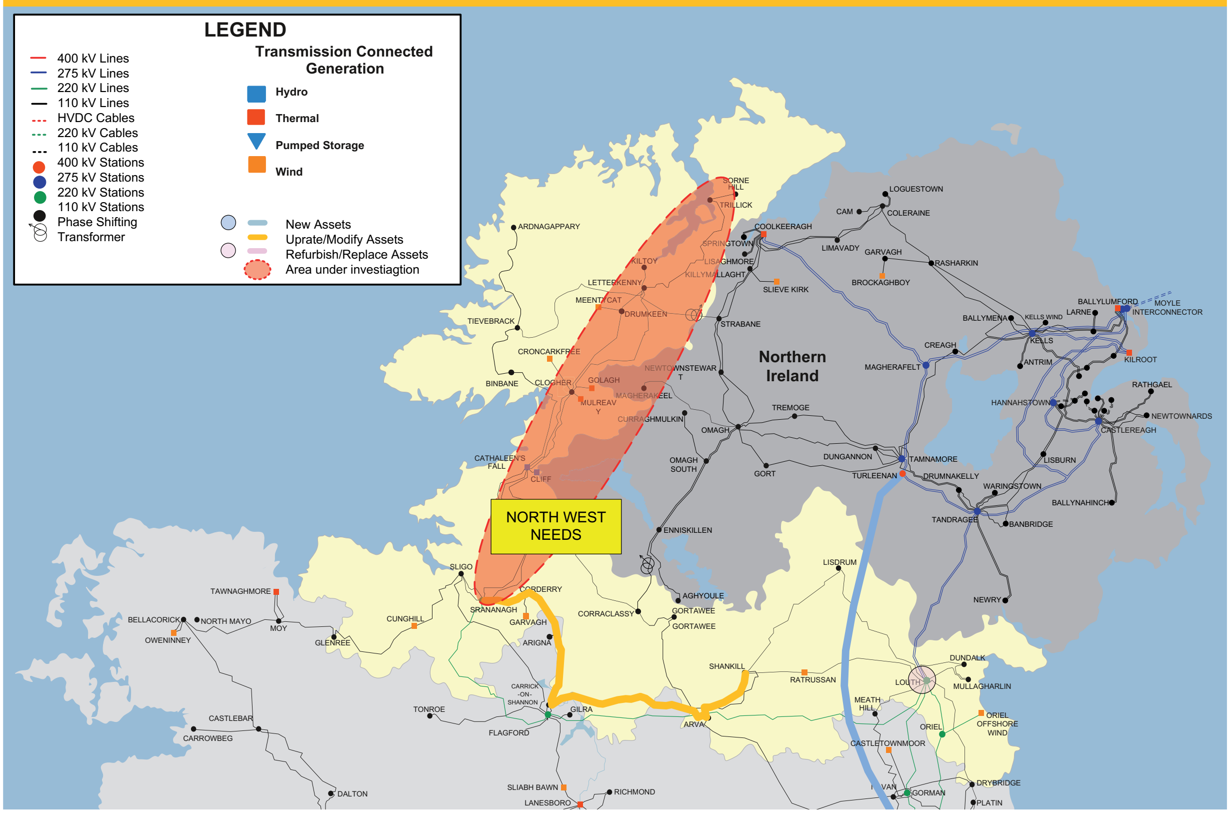


Figure 5-3 Map Showing Regions and Network[22]

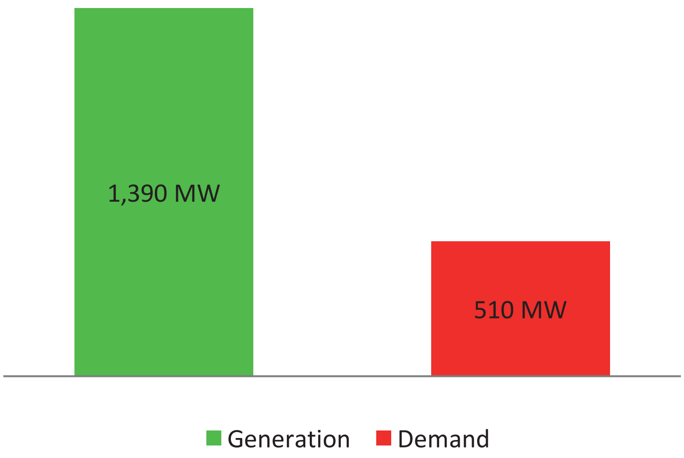
[22] Based on current information and commitments we have identified a need for either Grid West or a North Connacht Reinforcement, however not both.

BORDERREGION



BORDERREGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres[23]

Location	*Forecast Demand (MW)*	*Additional Demand Capacity (MW)*[24]
Drogheda[25]	*75*	*100*
Dundalk[26]	*73*	*40*
Letterkenny	*60*	*40*
Sligo	*54*	*50*

Summary of Development Projects[27]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*2*	*68*	€0.5-€0.6 billion
Uprate circuits	*17*	*565*	
New substations	*0*	*N/A*	

Major Regional Projects

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

Other Notable Regional Projects

- Northwest Needs – reinforcement of the grid in the north-west is required. The solutions, technology and timing of this work are currently being reviewed
- Reconfiguration and refurbishment at Louth 275/220/110 kV substation
- Uprate of Arva – Shankill and Arva - Carrick on Shannon 110 kV circuits
- Uprate of Carrick on Shannon – Arigna T – Corderry and Corderry – Sranangh 110 kV circuits
- Reactive power support required to strengthen system voltage

[23] Source: All Island Transmission Forecast Statement 2015.
[24] Available capacity in the network for increased demand.
[25] Transmission substation is Drybridge.
[26] Transmission substations are Dundalk and Mullagharlin.
[27] Anticipated at the time of publication of this strategy - subject to ongoing review.

Regional Description
The Border region has significant renewable energy resources. There is an excess of generation in the area. Demand in the region, including the main urban centres, 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 between Turleenan and Woodland substations. We are also investigating the need to reinforce the grid in the north-west.

The North-South Interconnector

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

In the re-examination of 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 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 between North and 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 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 as efficient and reliable option, compared to the proposed solution.

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.

The project was designated a Project of Common Interest (PCI) by the European Commission in October 2013. It was reaffirmed as a PCI in the second PCI list, which was published in November 2015.

Projects of Common Interest are energy infrastructure priority projects deemed by the European Commission to be of strategic, trans-boundary importance – in other words, that they are of value and importance to more than one country.

It is also designated as an eHighway 2050 Project by the European Union. This is an initiative to support the development of "electricity highways" as steps towards the creation of an all-Europe transmission network.

An Bord Pleanála (ABP) is the designated authority for PCIs in Ireland. Between June 2014 and April 2015, we engaged with the PCI unit of ABP in a PCI pre-application process. When that was complete, we formally submitted the planning application file to An Bord Pleanála in June 2015.

In September 2015, An Bord Pleanála asked us to respond to submissions made by the public in respect of the planning application. We responded to those public submissions in October 2015.

In March 2016, the North South Interconnector oral hearing started in Carrickmacross, County Monaghan. This is a process which allows further discussion of the planning application before an independent planning inspector. The oral hearing ran for a total of 35 days and ended in May 2016.

In December 2016 An Bord Pleanála granted planning approval for the part of proposed interconnector in Ireland.

There is a separate planning process ongoing in Northern Ireland in relation to the part of the proposed interconnector in Northern Ireland. Most recently, the Planning Appeals Commission held a public inquiry at the end of June 2016 on legal and procedural issues for the planning application. The Planning Appeals Commission is due to advance to the main phase of a public hearing in early 2017.

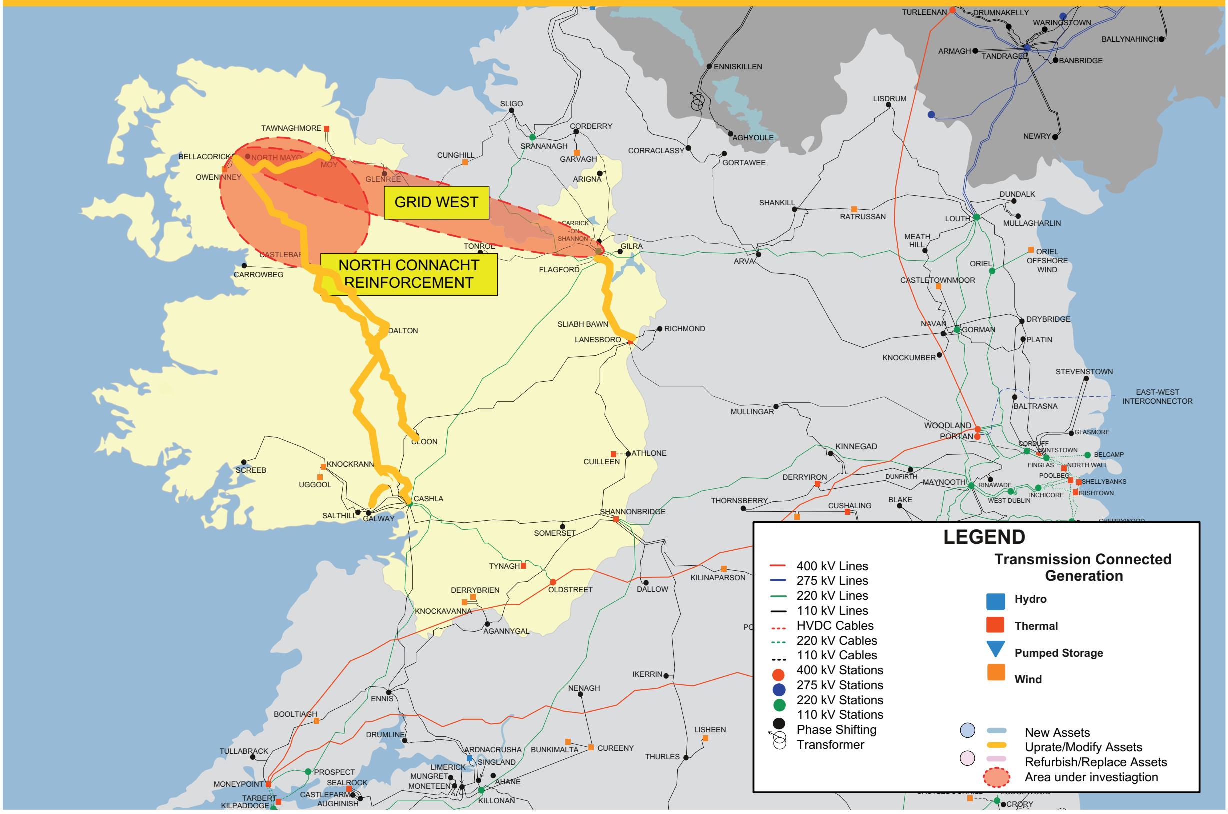
The Northwest

We carried out, in association with SONI, an assessment of the northwest region and western Northern Ireland. This investigation 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 project was designated a Project of

Common Interest (PCI) by the European Commission in October 2013. It was reaffirmed as a PCI in the second PCI list, which was published in November 2015.

The need for reinforcement is predicated on the level of renewable generation in both Donegal and western Northern Ireland. The solutions, technology and timing of this work are currently being reviewed. We will, in time, consult with relevant stakeholders on the needs, and the range of solutions that address these needs.

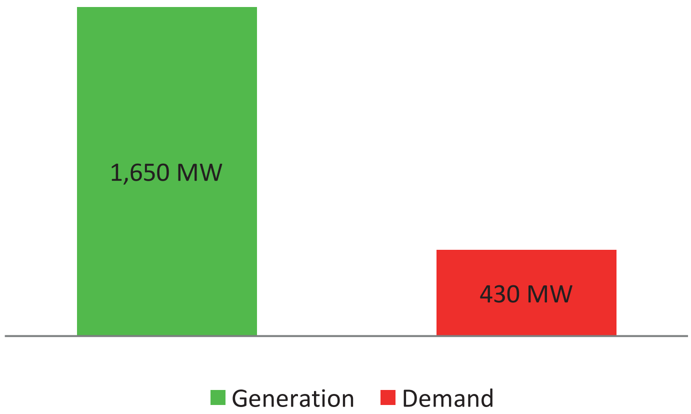
WESTREGION



GRID WEST
NORTH CONNACHT REINFORCEMENT
TAWNAGHMORE
BELLACORICK
NORTH MAYO
MOY
OWENINNEY
GLENREE
CUNGHILL
SLIGO
SRANANAGH
CORDERRY
GARVAGH
ARIGNA
CORRACLASSY
ENNISKILLEN
AGHYOULE
GORTAWEE
LISDRUM
TURLEENAN
DRUMNAKELLY
WARINGSTOWN
BALLYNAHINCH
ARMAGH
TANDRAGEE
BANBRIDGE
NEWRY
DUNDALK
MULLAGHARLIN
LOUTH
SHANKILL
RATRUSSAN
MEATH HILL
ORIEL
ORIEL OFFSHORE WIND
CASTLETOWNMOOR
ARVA
GILRA
TONROE
CASTLEBAR
CARROWBEG
FLAGFORD
SLIABH BAWN
LANESBORO
RICHMOND
DALTON
NAVAN
GORMAN
DRYBRIDGE
PLATIN
KNOCKUMBER
STEVENSTOWN
EAST-WEST INTERCONNECTOR
BALTRASNA
MULLINGAR
WOODLAND
PORTAN
KINNEGAD
CLOON
ATHLONE
CUILLEEN
SCREEB
KNOCKRANNY
UGGOOL
DERRYIRON
MAYNOOTH
CASHLA
SALTHILL
GALWAY
THORNSBERRY
CUSHALING
BLAKE
SHANNONBRIDGE
SOMERSET
TYNAGH
DERRYBRIEN
OLDSTREET
DALLOW
KILINAPARSON
KNOCKAVANNA
AGANNYGAL
IKERRIN
NENAGH
ENNIS
BOOLTIAGH
DRUMLINE
ARDNACRUSHA
BUNKIMALTA
CUREENY
LISHEEN
THURLES
TULLABRACK
PROSPECT
SEALROCK
MONEYPOINT
TARBERT
KILPADDOGE
CASTLEFARM
AUGHINISH
LIMERICK
MUNGRET
MONETEEN
AHANE
SINGLAND
KILLONAN
CRORY
LEGEND
400 kV Lines
275 kV Lines
220 kV Lines
110 kV Lines
HVDC Cables
220 kV Cables
110 kV Cables
400 kV Stations
275 kV Stations
220 kV Stations
110 kV Stations
Phase Shifting Transformer
Transmission Connected Generation
Hydro
Thermal
Pumped Storage
Wind
New Assets
Uprate/Modify Assets
Refurbish/Replace Assets
Area under investiagtion

WESTREGION Summary Table

Forecast Regional Generation/Demand Balance



***Main Regional Demand Centres*[28]**

Location	*Forecast Demand (MW)*	*Additional Demand Capacity (MW)*[29]
Castlebar	***26***	***10***
Galway	***71***	***60***

Summary of Development Projects[30]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*2*	*125*	€0.4-€0.6 billion
Uprate circuits	*8*	*236*	
New substations	*2*	*N/A*	

Major Regional Projects

- The Grid West Project: New circuit from the Bellacorick area to Flagford transmission substation
- Series Compensation on the existing 400 kV overhead line at Oldstreet 400 kV substation (part of the Regional Solution, see the South-East region summary for more information)

Other Notable Regional Projects

- Reinforcement of the transmission network in the vicinity of Mayo and Sligo comprising the North Connacht 110 kV project. The reinforcement potentially includes the uprating of some 110 kV circuits in the area, for example Castlebar – Dalton – Cashla and Castlebar – Cloon 110 kV circuits[31]
- Uprating of Cashla – Salthill 110 kV circuit
- Uprating of Flagford – Lanesboro 110 kV circuit
- Uprating of Bellacorick – Castlebar and Bellacorick Moy 110 kV circuits
- Reactive power support required to strengthen system voltage

[28] Source: All Island Transmission Forecast Statement 2015.
[29] Available capacity in the network for increased demand.
[30] Anticipated at the time of publication of this strategy - subject to ongoing review.
[31] Based on current information and commitments we have identified a need for either Grid West or a North Connacht Reinforcement, however not both.

Regional Description
The West region is particularly rich in renewable energy resources. These generation sources are dispersed across the region, but particularly concentrated along the western coastline. There is also a large conventional thermal generator located at Tynagh substation. The main demand centres 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 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 quality 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 existing local 110 kV network, even if it is uprated, is not capable of carrying these levels of power flow.

Therefore, another transmission circuit is required. We are carefully considering alternatives.

We conducted a comprehensive analysis on the underground and overhead options for the Grid West Project. We presented an analysis of three options to the Government-appointed Independent Expert Panel (IEP). This detailed analysis considered economic, technical and environment factors.

The IEP published its opinion that the report was complete and the options were comparable. Subsequently, we published the report in July 2015.

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 Underground Cable Option

This option can be summarised as a single, fully underground, HVDC cable, approximately 113km in length. The cable connects a new HVDC converter station close to 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. In addition approximately 2km of 220 kV AC underground cable is required to connect the new converter station to the existing Flagford 220 kV substation.

The estimated present value cost for this option is €475m[32].

400 kV Overhead Line 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. In addition approximately 8km of 220 kV AC underground cable would be installed into the first section of the existing Flagford – Srananagh 220 kV line.

The estimated present value cost for this option is €220m[33].

220 kV Overhead Line and Partial Underground Cable Option

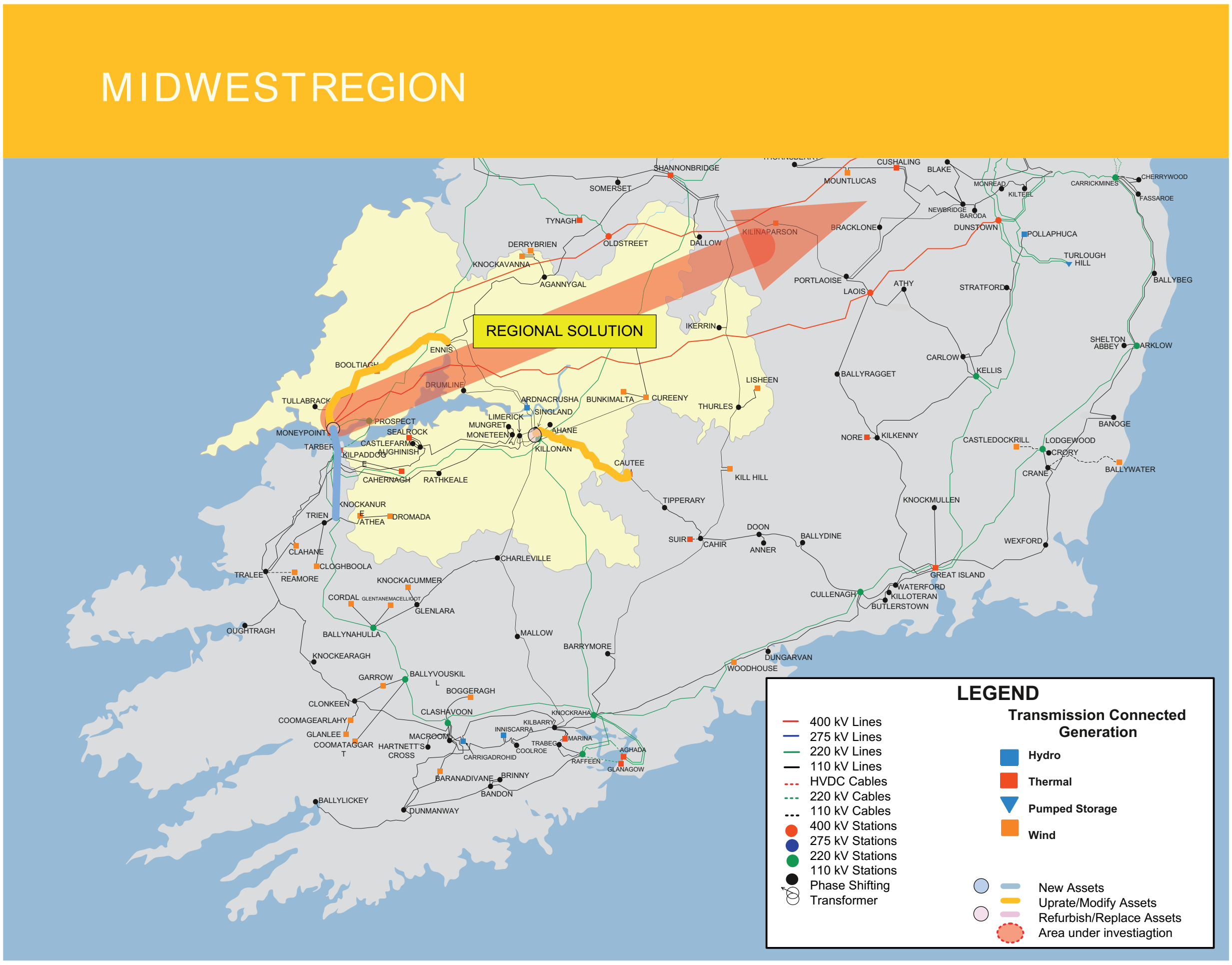
This option can be summarised as a single 220 kV AC overhead line, up to 105km in length. This option allows up to 20km of this overhead line to be undergrounded, with the remainder constructed as overhead line. The circuit connects from the existing Flagford 220 kV substation to a new substation near Moygownagh to 'collect' the power produced by the wind energy in the local area. In addition approximately 8km and 2km of 220 kV AC underground cable would be installed into the first section of the existing Flagford – Srananagh 220 kV line and the approach to a new substation near Moygownagh respectively.
The estimated present value cost for this option is €205-250m[34] (dependent on total cable length).

Is the Grid West project still needed?

There is a sufficient level of committed generation in the area to drive a new circuit, but this may not be the Grid West project.

Depending on the final volume of generation, the solution may be a more local reinforcement. When the need for Grid West is fully confirmed, we will consult on the information contained in the IEP report. We will do this before selecting a preferred technology type.

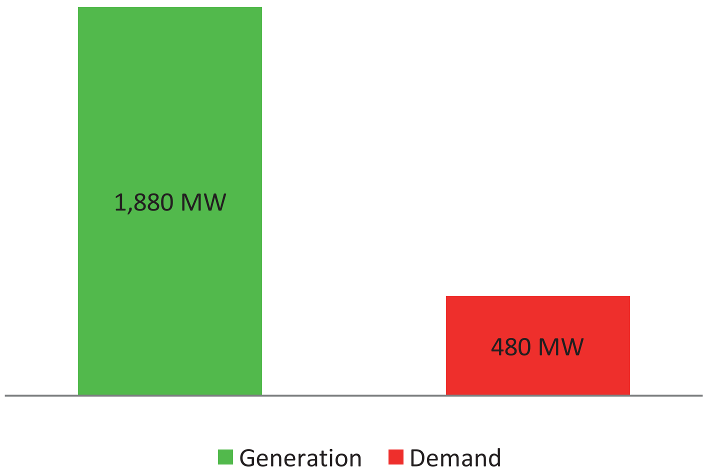
[32] Source: Grid West Report to the IEP. The cost is rounded here.
[33] Source: Grid West Report to the IEP. The cost is rounded here.
[34] Source: Grid West Report to the IEP. The cost is rounded here.



MIDWESTREGION
REGIONAL SOLUTION
LEGEND
Transmission Connected Generation
400 kV Lines
275 kV Lines
220 kV Lines
110 kV Lines
HVDC Cables
220 kV Cables
110 kV Cables
400 kV Stations
275 kV Stations
220 kV Stations
110 kV Stations
Phase Shifting Transformer
Hydro
Thermal
Pumped Storage
Wind
New Assets
Uprate/Modify Assets
Refurbish/Replace Assets
Area under investiagtion

MIDWEST REGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres[35]

Location	*Forecast Demand (MW)*	*Additional Demand Capacity (MW)[36]*
Ennis	***57***	***110***
Limerick	***77***	***100***

Summary of Development Projects[37]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*3*	*9*	€0.3 billion
Uprate circuits	*7*	*176*	
New substations	*0*	*N/A*	

Major Regional Projects

- Moneypoint – North Kerry Project: New 220 kV cable from Moneypoint to Knockanure via Kilpaddoge
- New Kilpaddoge - Moneypoint 220 kV cable
- New Moneypoint 400/220/110 kV substation
- Series compensation on the existing 400 kV overhead line at Moneypoint 400 kV substation (part of the Regional Solution, see the South-East region summary for more information)
- A new 400 kV sub-sea cable, across the Shannon estuary from Moneypoint to Kilpaddoge (part of the Regional Solution, see the South-East region summary for more information)

[35] Source: All Island Transmission Forecast Statement 2015.
[36] Available capacity in the network for increased demand.
[37] Anticipated at the time of publication of this strategy - subject to ongoing review.

Other Notable Regional Projects
• Uprating of Ennis – Booltiagh – Tullabrack T - Moneypoint 110 kV circuit • Uprating of Cauteen - Killonan 110 kV circuit • Redevelopment of Killonan 220/110 kV substation • Reactive power support required to strengthen system voltage

Regional Description
The Mid-West region is particularly rich in renewable energy resources including wind energy and hydro generation on the Shannon. There is also a large conventional thermal generator located at Moneypoint substation. The main urban demand centres 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. The 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 will become more so due to our decision to implement the 'Regional Solution' for Grid Link which involves greater use of the existing 400 kV circuits. 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.

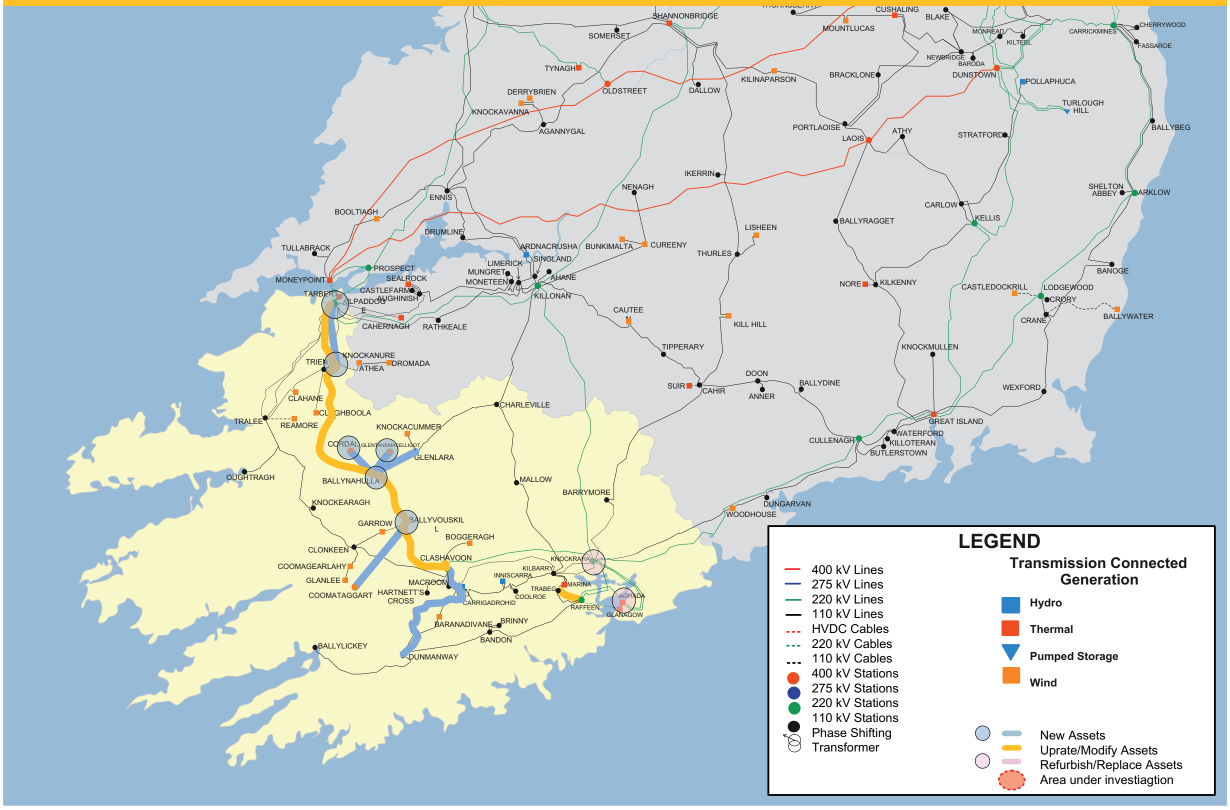
After a cost benefit analysis on this project, it is now a 220 kV underground cable solution using a new type of high-capacity cable for the full length of the circuit. In other circumstances where the circuit distances are longer, this technology may not be appropriate.

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.

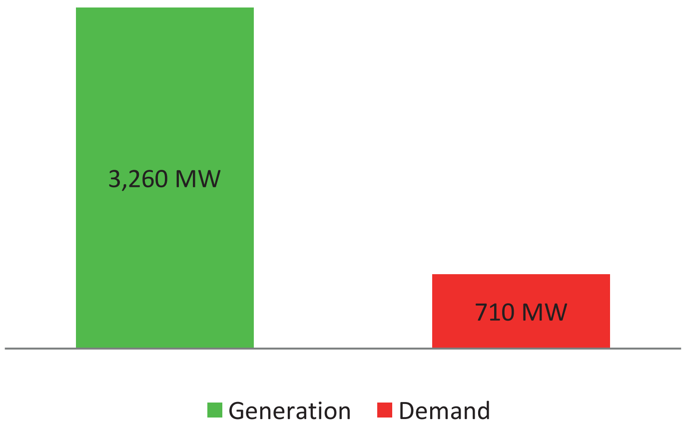
The local constraint will be alleviated by installing a new 220/110 kV transformer which will provide a new 110 kV supply into the existing 110 kV network.

SOUTHWESTREGION



SOUTHWESTREGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres[38]

Location	***Forecast Demand (MW)***	***Additional Demand Capacity (MW)***[39]
Cork (Trabeg)	***77***	***90***
Tralee	***44***	***100***

Summary of Development Projects[40]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*2*	*32*	€0.5 billion
Uprate circuits	*15*	*345*	
New substations	*6*	*N/A*	

Major Regional Projects

- New 220/110 kV substations at Knockanure, Ballyvouskill, Ballynahulla and Kilpaddoge

Other Notable Regional Projects

- Uprating of Clashavoon – Knockanure and Kilpaddoge – Knockanure 220 kV circuits
- New Clashavoon – Dunmanway 110 kV circuit
- New Clashavoon – Macroom 110 kV circuit
- Uprating of Raffeen – Trabeg 110 kV circuit
- Reactive power support required to strengthen system voltage
- Reconfiguration and extension of Knockraha 220 kV substation
- Reconfiguration and refurbishment of Aghada 220 kV substation

[38] Source: All Island Transmission Forecast Statement 2015.
[39] Available capacity in the network for increased demand.
[40] Anticipated at the time of publication of this strategy - subject to ongoing review.

Regional Description
The development of the transmission system in the South-West 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 Moneypoint and Knockraha transmission substations. The region also has considerable amounts of conventional thermal generation at Tarbert substation, and 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 along the south coast. 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 grid development 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.

New Knockanure, Ballynahulla and Ballyvouskill 220/110 kV 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 110 kV transmission circuits.

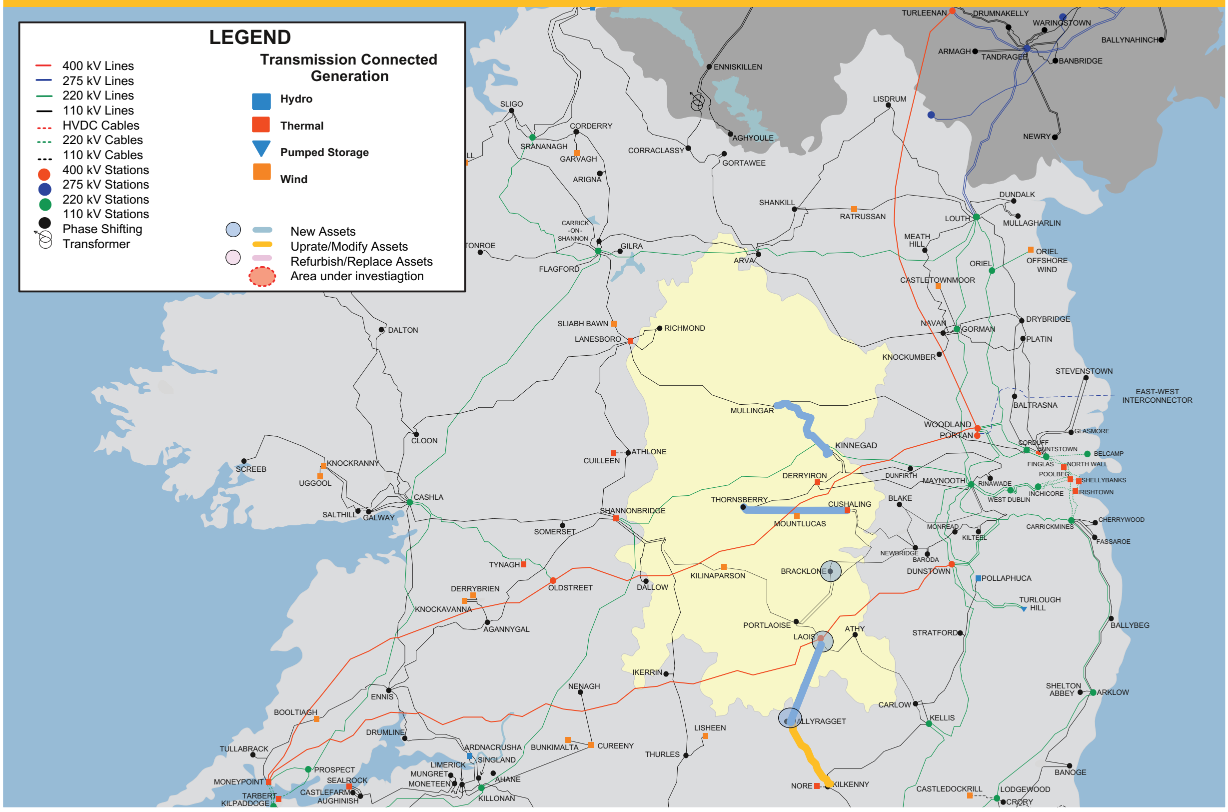
The ‘collector’ transmission network will be operated separately to the rest of the 110 kV existing transmission network in the area which mainly supplies demand centres. This ensures that this existing network is not overloaded.

New Kilpaddoge 220/110 kV Substation Project

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.

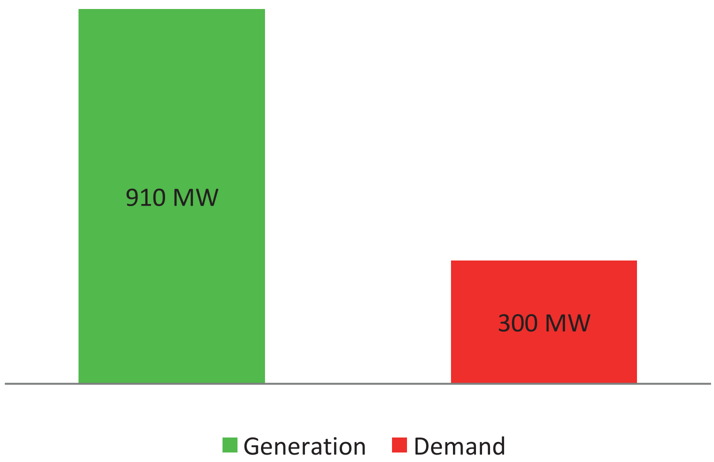
The new Kilpaddoge substation is necessary to allow for the essential expansion of transmission connections in north Kerry and will replace some of the functionality of the existing Tarbert 220 kV substation.

MIDLANDSREGION



MIDLANDS REGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres[41]

Location	Forecast Demand (MW)	Additional Demand Capacity (MW)[42]
Athlone	***59***	***20***
Mullingar	***48***	***50***
Portlaoise	***37***	***80***
Tullamore[43]	***32***	***30***

Summary of Development Projects[44]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*2*	*27*	€0.1 billion
Uprate circuits	*3*	*92*	
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 110 kV substation/circuit to create new 110 kV circuit from Laois to Kilkenny via Ballyragget

Other Notable Regional Projects

- New Cushaling - Thornsberry 110 kV circuit
- New Kinnegad - Mullingar 110 kV circuit

[41] Source: All Island Transmission Forecast Statement 2015.
[42] Available capacity in the network for increased demand.
[43] Transmission substation is Thornsberry.
[44] Anticipated at the time of publication of this strategy - subject to ongoing review.

Regional Description
The Midlands regional transmission network is required to transport power over considerable distances to a widely dispersed range of demand centres. The region has dispersed generation, mainly composed of peat-burning power stations at Lanesboro, Shannonbridge and Cushaling stations, and renewable energy. 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 connect 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 the Midlands and provide additional capacity for potential demand growth in the wider region, and in particular in Kildare, Laois and Kilkenny. We are constructing two new 110 kV circuits in the region, namely Cushaling (Edenderry) – Thornsberry (Tullamore) and Kinnegad – Mullingar. 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 Mullingar and Tullamore.

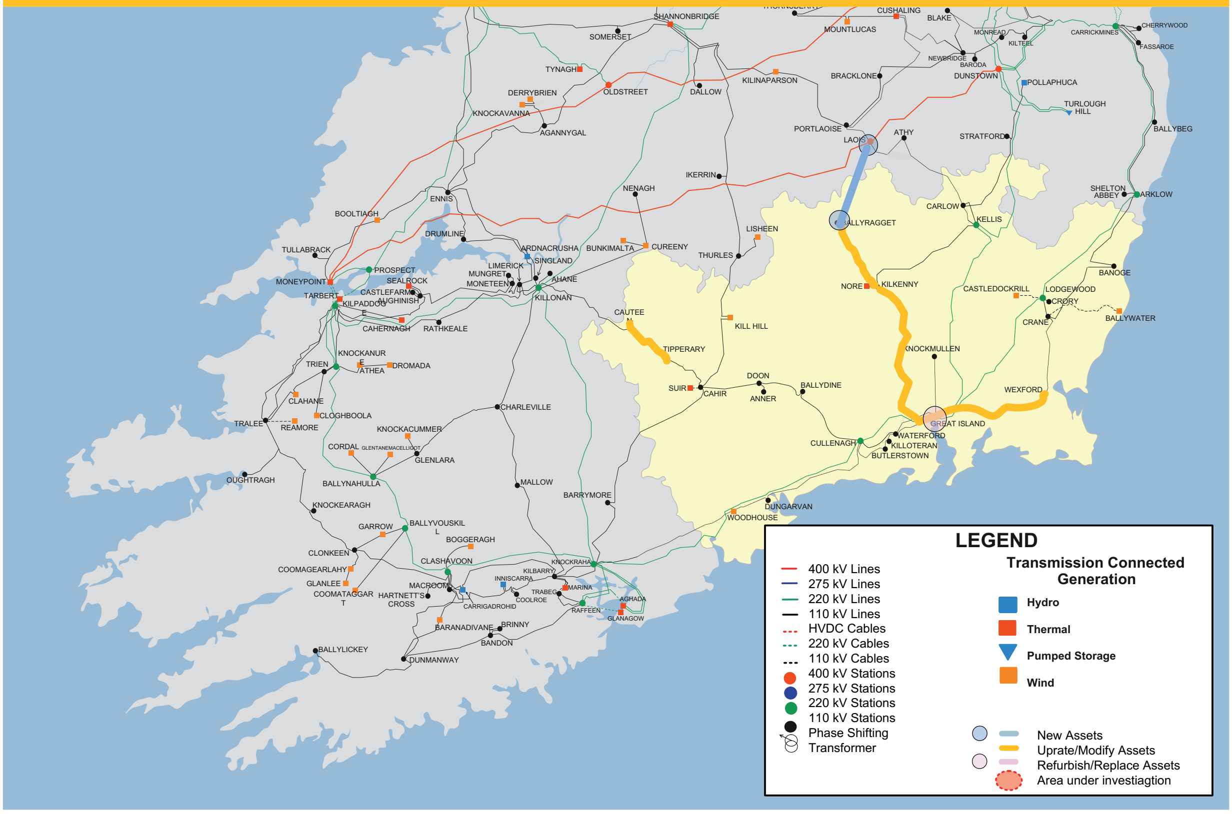
Laois-Kilkenny Reinforcement Project

The new 400 kV substation in Laois will provide a new high voltage supply point in Laois that will support the voltage and alleviate 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.

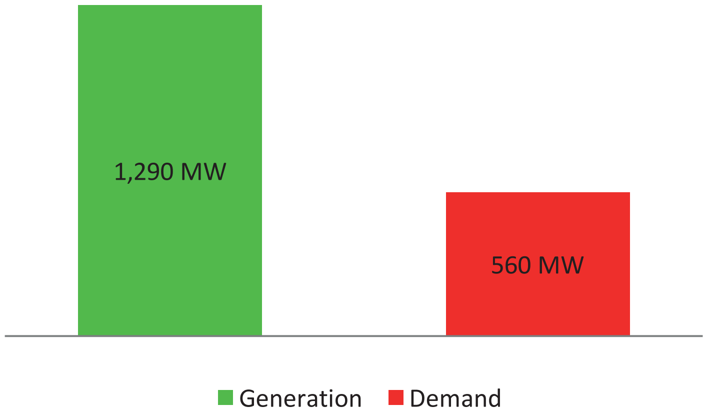
This is achieved by building a circuit from the Laois 400 kV substation to the existing Ballyragget 38 kV station, combined with the conversion from 38 kV to 110 kV of both the Ballyragget 38 kV station and the line supplying it from Kilkenny 110 kV substation.

SOUTHEASTREGION



SOUTHEASTREGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres[45]

Location	Forecast Demand (MW)	Additional Demand Capacity (MW)[46]
Cahir	***23***	***50***
Carlow	***51***	***70***
Kilkenny	***57***	***30***
Waterford	***45***	***110***
Wexford	***51***	***30***

Summary of Development Projects[47]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*0*	*0*	€0.2 billion
Uprate circuits	*17*	*425*	
New substations	*0*	*N/A*	

Major Regional Projects

- The Regional Solution (formerly the Grid Link Project): Increase transfer capacity from the south and southwest to the Dublin region. The Grid Link project has been replaced by the Regional Solution.

Other Notable Regional Projects

- Uprate of Great Island – Wexford and Great Island – Kilkenny 110 kV circuits (part of the Regional Solution)
- Redevelopment of Great Island 220/110 kV substation
- Uprating of Cauteen – Tipperary 110 kV circuit

[45] Source: All Island Transmission Forecast Statement 2015.
[46] Available capacity in the network for increased demand.
[47] Anticipated at the time of publication of this strategy - subject to ongoing review.

Regional Description
The South-East region has renewable energy resources, and conventional generation located at Great Island substation. As a result, the region has a surplus of generation. The South-East also contains a number of possible landing locations for interconnectors. The main urban demand centres 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. 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 along the south coast. We recently investigated a number of options to increase network capacity between the southwest and southeast to the larger demand centres located on the eastern seaboard. The result is the Regional Solution which replaces the project formerly known as Grid Link. 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 Regional Solution (formerly the Grid Link Project)

As part of the original Grid25 Strategy published in 2008, we carried out an assessment of the southeast and southwest. The report identified 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 have connected and 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 of power from the southwest to the north and east of the country exceeds the capabilities of some circuits.

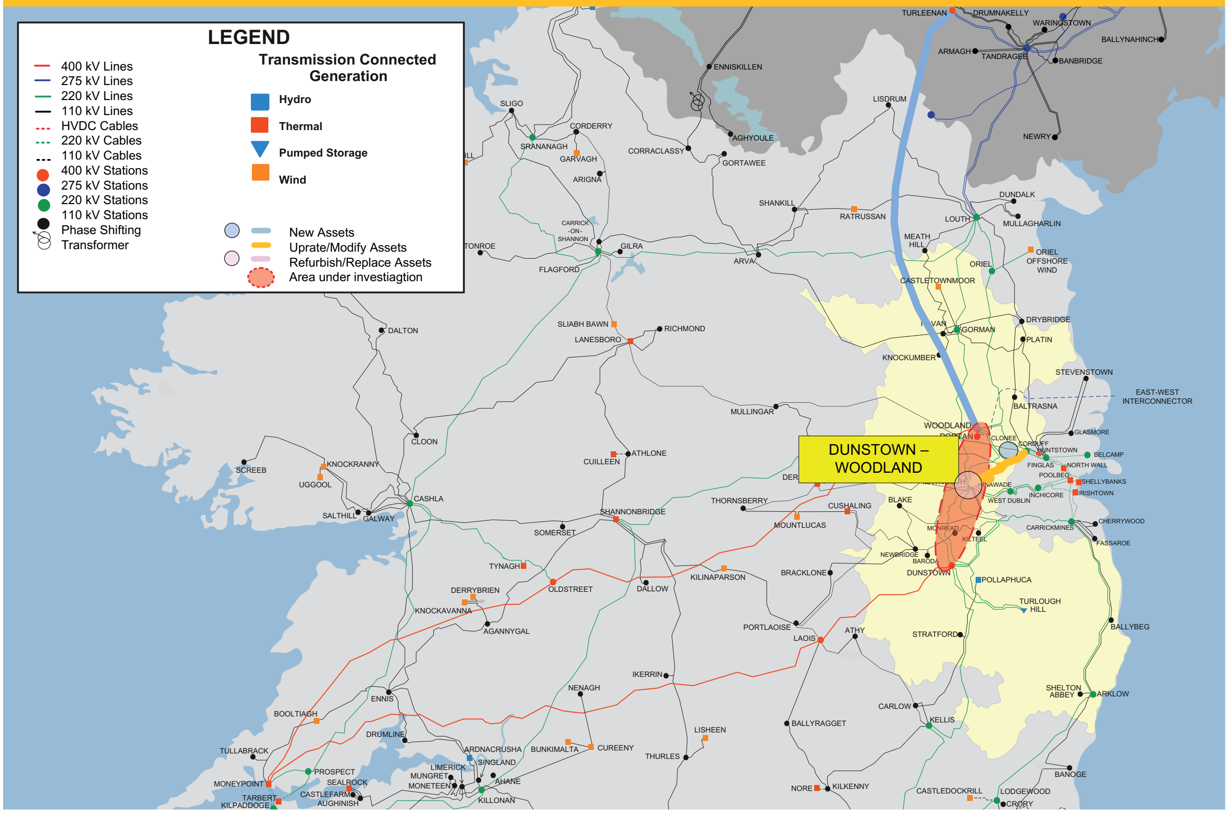
We conducted a comprehensive review of the need and solution options for the Grid Link Project. We presented an analysis of three options to the Government-appointed Independent Expert Panel (IEP). This detailed analysis considered economic, technical and environment factors. The Grid Link report for the IEP is available at www.eirgridgroup.com. The review took into account changing demand forecasts, a slower rate of growth, upgrade works on existing lines and advances in technology.

As part of this analysis we replaced the Grid Link project with what we call the 'Regional Solution'. The Regional Solution is made up of a number of independent projects. These are:

- Series Compensation on the existing 400 kV overhead lines that cross the country from Moneypoint in County Clare to Dunstown in County Kildare and Woodland in County Meath. The series compensation devices are planned for:
  - Moneypoint;
  - Oldstreet in County Galway; and
  - Dunstown 400 kV stations.
- A new 400 kV sub-sea cable across the Shannon estuary. This will run from Moneypoint on the northern bank of the estuary to Kilpaddoge, a new station on the southern bank of the estuary.
- Uprate of Great Island – Wexford and Great Island – Kilkenny 110 kV circuits.
- Uprate of the busbar (conductors) at Wexford 110 kV station.

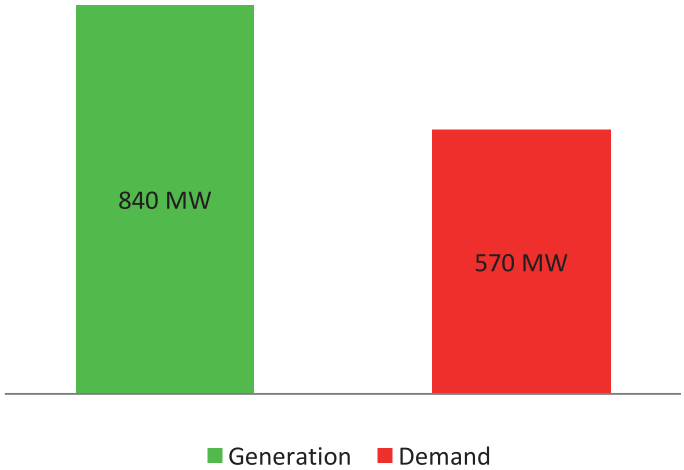
These projects are required to meet the updated needs identified in the reviews of the Grid Link project.

MIDEASTREGION



MIDEASTREGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres[48]

Location	***Forecast Demand (MW)***	***Additional Demand Capacity (MW)***[49]
Arklow	***23***	***60***
Naas[50]	***38***	***30***

The generation figure in the forecast generation/demand balance includes the East West Interconnector (EWIC) as a 500 MW generation source. EWIC can be either a generation or demand source.

Summary of Development Projects[51]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*1*	*53*	€0.4 billion
Uprate circuits	*5*	*123*	
New substations	*1*	*N/A*	

Major Regional Projects

- Series Compensation on the existing 400 kV overhead line at Dunstown 400 kV station (part of the Regional Solution, see the South-East region summary for more information)
- Reinforcement of the Greater Dublin Area between Dunstown and Woodland 400 kV substations
- New 220 kV substation near Clonee, Co. Meath

Other Notable Regional Projects

- Uprating of Maynooth – Ryebrook and Corduff – Ryebrook 110 kV circuits
- New 400/220 kV transformers at Dunstown and Woodland 400 kV substations
- Reconfiguration and major refurbishment of Maynooth 220/110 kV substation

[48] Source: All Island Transmission Forecast Statement 2015.
[49] Available capacity in the network for increased demand.
[50] Transmission substation is Kilteel.
[51] Anticipated at the time of publication of this strategy - subject to ongoing review.

Regional Description
The Mid-East region is part of the Greater Dublin Area and is a major load centre on the Irish transmission system. The main urban demand centres are composed of a mix of residential, commercial and industrial demand, which is expected to grow up to 2025 and beyond. The 500 MW East West Interconnector is connected to the transmission system at Woodland via the 400 kV substation at Portan 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. The network can be subject to high inter-regional power transfers from both north to south and south to north. We are currently investigating grid development options for connecting the Woodland and Dunstown 400 kV substations, 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 and also facilitate future load growth in the area. To facilitate increased and new demand existing 110 kV circuits need to be uprated and a new 220 kV substation is required near Clonee, Co.Meath. 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 between Dunstown and Woodland 400 kV Substations

As part of the grid development strategy, we carried out an assessment of the Greater Dublin Area. The report identified the need for a strengthening of the grid in this area 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 of the links between these substations.

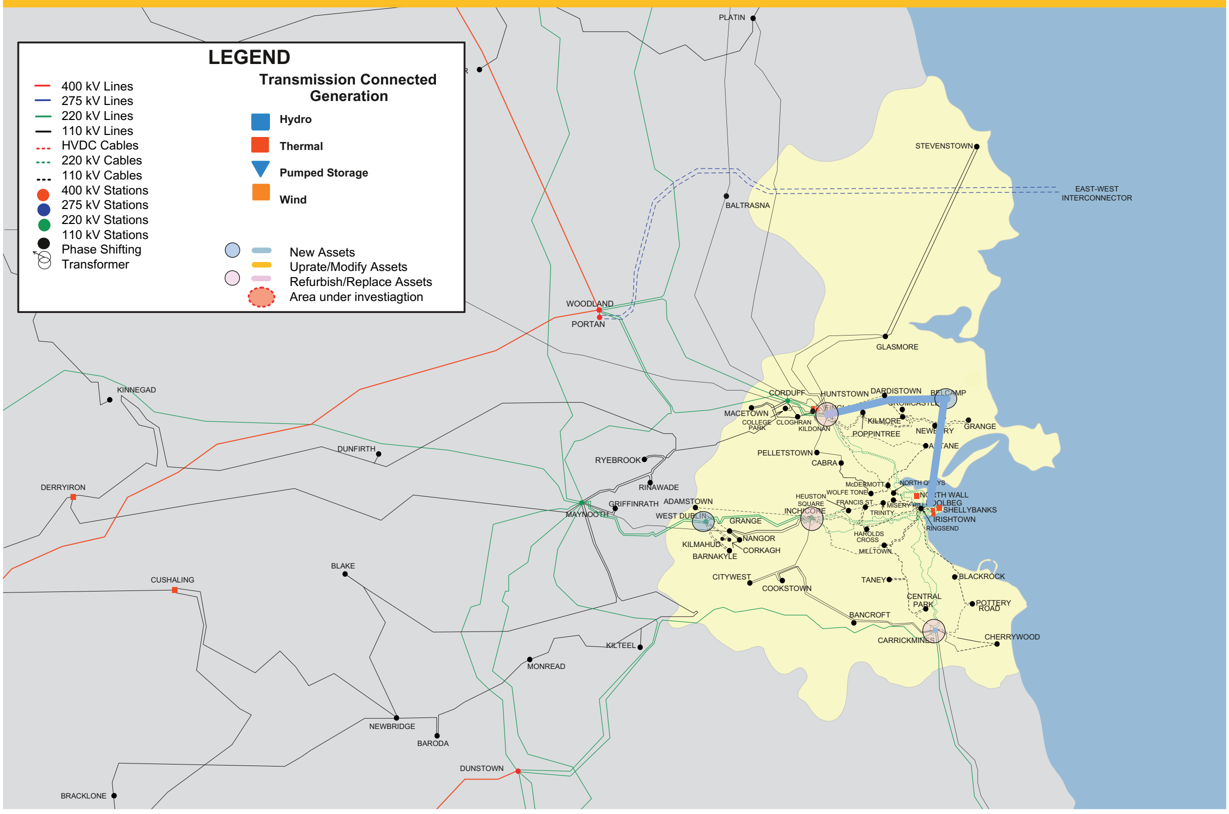
The project may require a 400 kV link, which may be developed by re-using existing assets converted to 400 kV, thus maximising the existing assets in line with the new strategic statements.

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

New 220 kV Substation near Clonee, Co. Meath

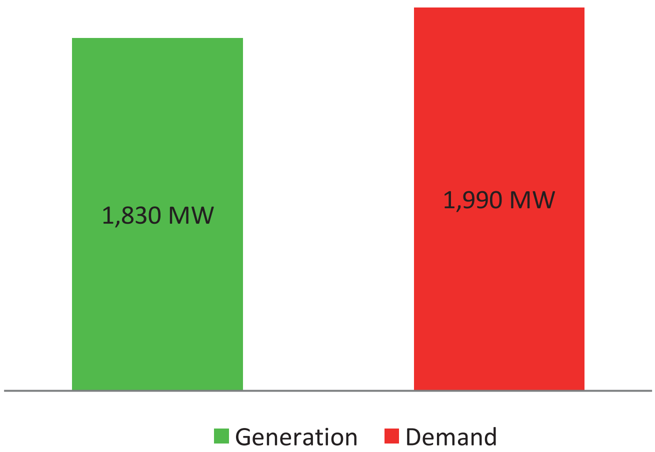
The new substation is being built to facilitate the connection of a new demand customer. It will be connected to the existing 220 kV network in the area.

DUBLINREGION



DUBLINREGION Summary Table

Forecast Regional Generation/Demand Balance



Main Regional Demand Centres

Location	*Forecast Demand (MW)*[52]	*Additional Demand Capacity (MW)*[53]
Carrickmines	***397***	***90***
Finglas	***480***	***90***
Inchicore	***360***	***90***

Summary of Development Projects[54]

Type of Projects	*No. of Projects*	*Project kilometres*	*Total Regional Cost*
New build circuits	*0*	*0*	€0.2 billion
Uprate circuits	*2*	*36*	
New substations	*2*	*N/A*	

Major Regional Projects

- New Belcamp 220/110 kV substation in North Dublin and circuits to connect to the existing 220 kV network
- New 220/110 kV substation in West Dublin and circuits to connect to the existing 220 kV network

Other Notable Regional Projects

- Reconfiguration and major refurbishment of Inchicore, Finglas and Carrickmines 220 kV substations
- Reactive power support required to strengthen system voltage

[52] Source: All Island Transmission Forecast Statement 2015.
[53] Available capacity in the network for increased demand. Source: All Island Transmission Forecast Statement 2014. These figures will vary due to the level of large industrial demand customers that are connected, contracted and interested in connecting in the Dublin area.
[54] Anticipated at the time of publication of this strategy - subject to ongoing review.

Regional Description
The Dublin region is the major load centre on the Irish transmission system. Approximately one third of total 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 existing transmission network in the Dublin region is comprised of 220 kV and 110 kV infrastructure. These are primarily fed from the existing 400 kV substations at the western edge of the Dublin area – Woodland in Co. Meath, and Dunstown in Co. Kildare. 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. We are currently investigating grid development options for connecting the Woodland and Dunstown 400 kV substations, to increase the capacity of the often congested and highly loaded Dublin transmission network. This and other projects which support the network in the Greater Dublin Area are also detailed in the Mid-East region. 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. We are 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, south and west 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.

New 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.

Belcamp will be connected to the existing 220 kV network with new 220 kV cables to Finglas and Shellybanks 220 kV substations.

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 Project

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 the new West Dublin 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.

The Oval, 160 Shelbourne Road, Ballsbridge, Dublin D04 FW28 • Telephone: 01 677 1700 • www.eirgrid.com