Your Grid, Your Views, Your Tomorrow.

A Discussion Paper on Ireland's Grid Development Strategy

Appendix 1

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3/27/2015

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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 across the island. In order to implement Government energy policy, we need to develop the Irish electricity transmission system to guarantee a secure supply of electricity for today and for future generations.

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

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

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

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

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

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

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

Chapter 2: Drivers of Grid Investment

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

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

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

The main drivers of grid investment are:

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

Changes in Demand for Electricity

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

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

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

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

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

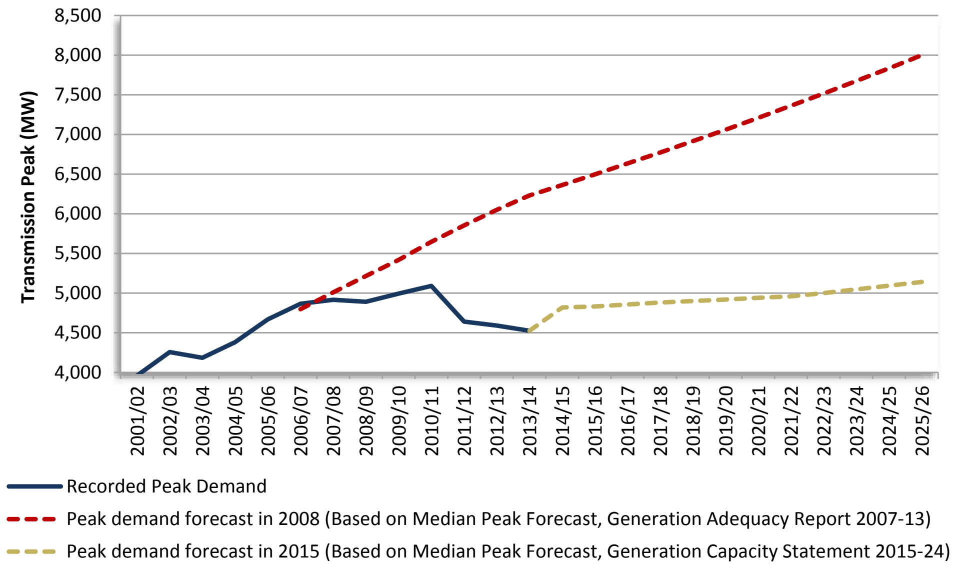


Figure 2-1 Actual Demand and Forecast Demand to 2025

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

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

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

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

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

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

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

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

Regional Demand Growth

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

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

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

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

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

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

Forecasting Demand

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

Population Change

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

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

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

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

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

Changing Generation Patterns

Renewable Generation

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

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

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

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

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

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

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

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

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

[8] As at the date of publication.

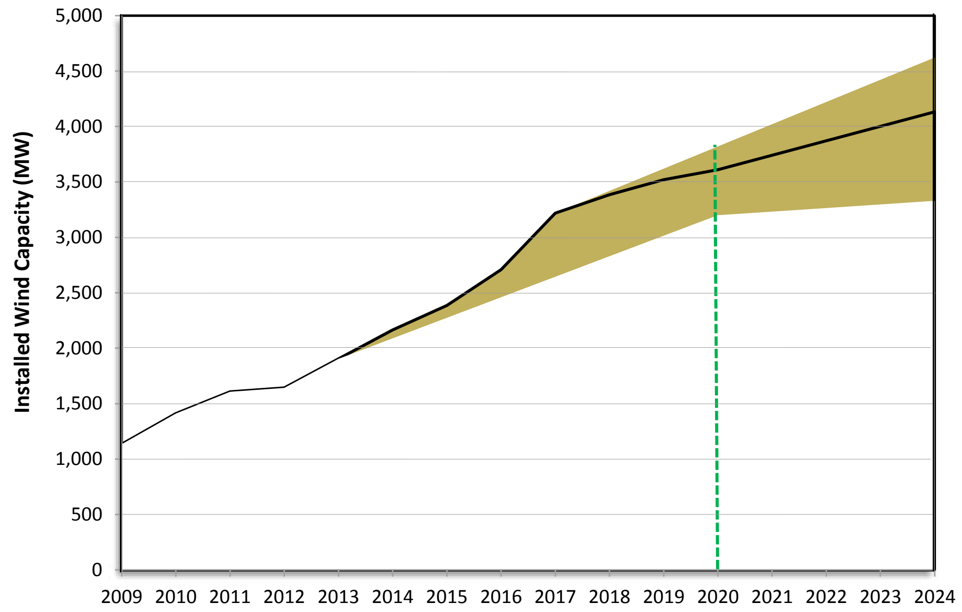


Figure 2-2 Band of Possible Wind Capacity Requirements to meet the 2020 Renewable Target[9]

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

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

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

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

Conventional Generation

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

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

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

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

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

Interconnection

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

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

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

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

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

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

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

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

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

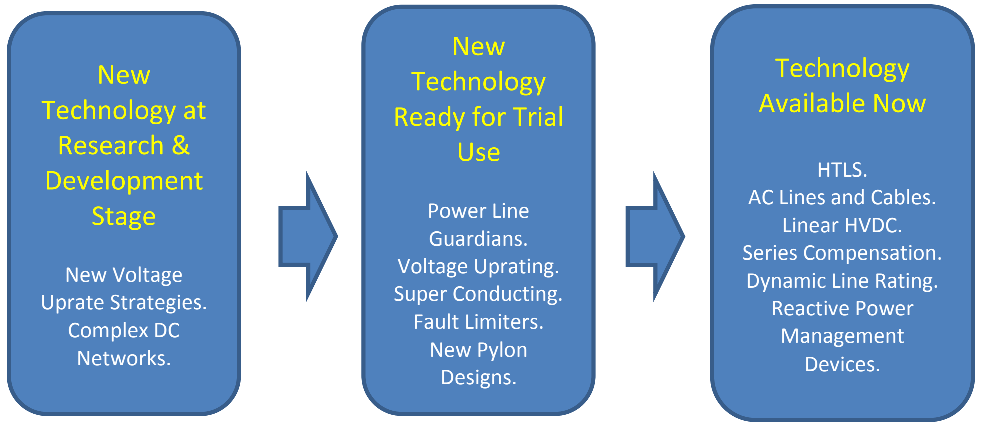
Chapter 3: Technology

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

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

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

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



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

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

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

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

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

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

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

Technological changes

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

These issues include:

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

Reactive Power

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

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

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

System Inertia

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

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

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

Harmonic Distortion

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

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

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

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

Technology – Available now

New High Temperature Low Sag (HTLS) overhead line conductors

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

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

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

AC underground cable technology and its use

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

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

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

The obvious advantage of underground cable circuits is the potential for reduced visual impact compared to overhead line technologies. This must be balanced against the potential impacts on sensitive environmental and ecological areas from what can be significant civil engineering works. This is addressed in considerable detail in the report commissioned by the Department

of Communications, Energy and Natural Resources (DCENR) on the Study on the Comparative Merits of Overhead Electricity Transmission Lines Versus Underground Cables.[14]

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

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

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

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

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

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

Linear HVDC and DC transmission

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

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

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

[14] http://www.dcenr.gov.ie/NR/rdonlyres/4F49D5FA-0386-409A-8E72-6F28FD89EC7C/0/FinalReport_StudyonOHLversusUGC_June2008.pdf
[15] http://www.eirgrid.com/media/Tepco%20Report%20North%20South.pdf
[16] http://www.eirgridprojects.com/media/TransGrid%20Report.pdf

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

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

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

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

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

Series Compensation

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

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

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

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

Dynamic Line Rating

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

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

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

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

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

Reactive Power Management Devices

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

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

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

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

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

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

Fixed Reactive Power Management Devices

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

Technology – Ready for Trial Use

Power Line Guardians

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

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

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

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

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

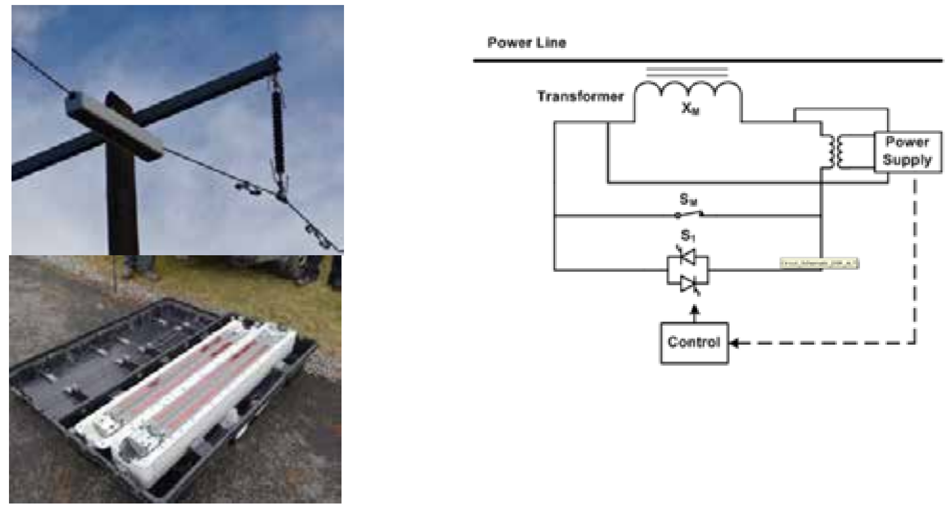


Figure 3-2: Power Line Guardians

Voltage Uprating

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

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

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

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

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

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

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

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

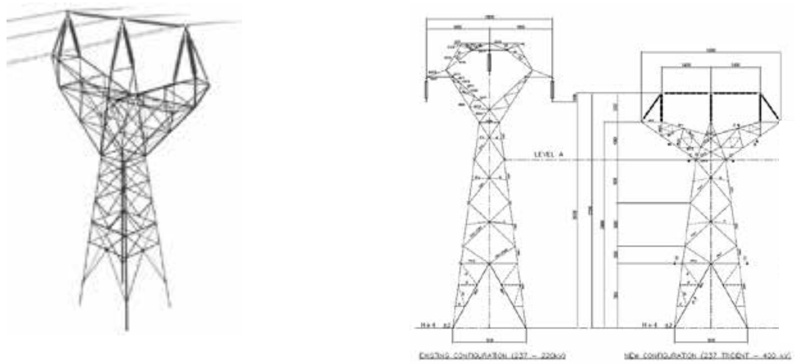


Figure 3-3: Prototype voltage uprate technology using composite insulators (left, new example 400 kV design; right, comparison to existing 220 kV line)

Super-Conducting Fault Current Limiters

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

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

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

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

New Overhead Line Structures/New Pylon Design

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

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

Figure 3-4: Examples of new pylon designs

Technology – Research & Design Stage

Complex DC Networks

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

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

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

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

New Voltage Uprating Strategies

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

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

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

Other Smart Grid Concepts

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

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

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

Chapter 4: Proposed Strategy for Grid Development

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

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

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

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

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

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

The proposed new strategy statements are:

Strategy 1

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

We acknowledge the sensitivities associated with major transmission infrastructure development.

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

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

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

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

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

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

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

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

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

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

Impact of technological choice

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

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

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

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

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

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

Proposed Grid Development Strategy

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

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

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

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

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

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

- The cost of circuit uprates is lower than anticipated in 2008. At the time of the launch of Grid25, it was standard practice to achieve higher ratings on overhead lines by using heavier conductors. This often requires a complete re-build of the line. As outlined in Chapter 3, EirGrid adopted the HTLS conductor for uprating lines wherever feasible. This conductor provides an increase in capacity of about 60%, without excessive increases in conductor weight. This negates the requirement to change the support structures, thus significantly reducing the cost of uprates.

- A reduction in the scope, or in some cases a deferral, of a number of projects due to the lower forecast demand described in Chapter 2 and shown in Figure 4-1. This has had a significant impact, particularly evident in networks supplying major towns and cities.

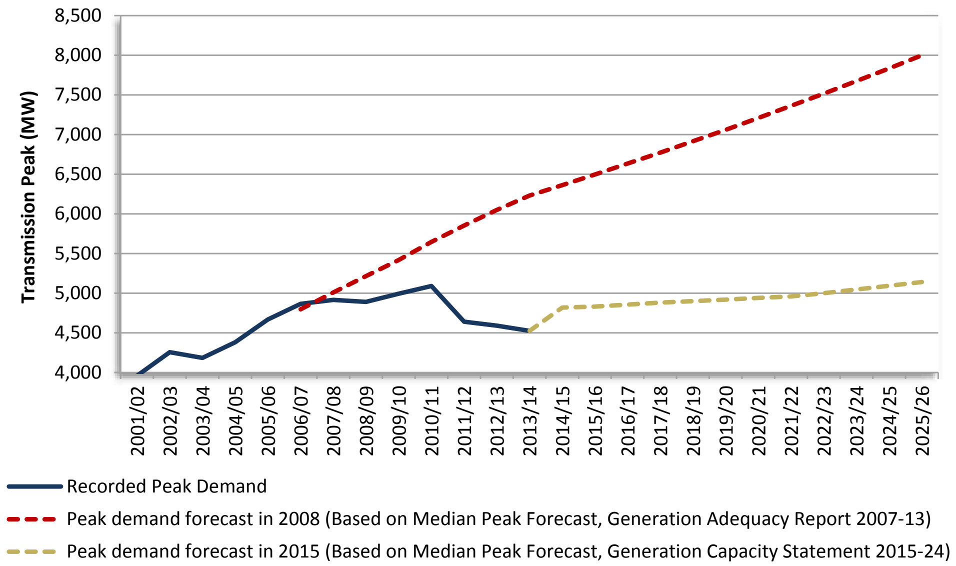


Figure 4-1 Actual Demand and Forecast Demand to 2025

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

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

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

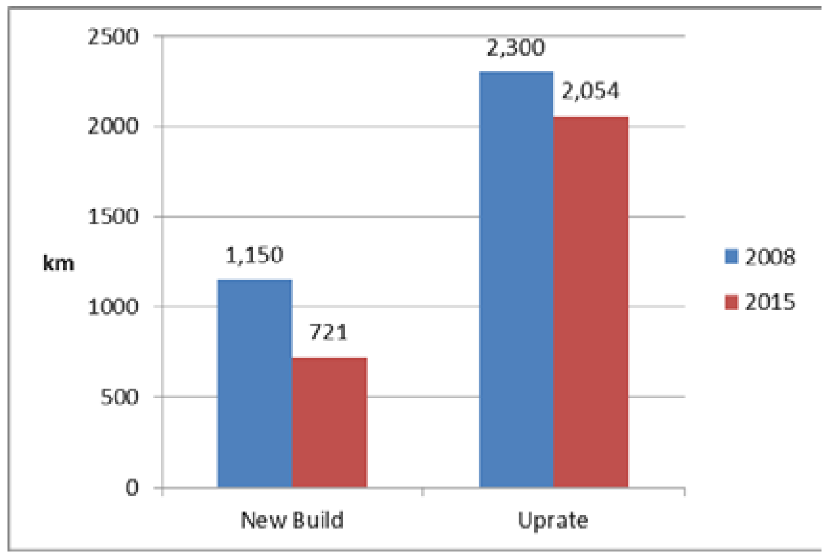


Figure 4-2 Comparison of uprates/modified circuits compared with new build

Chapter 5: Regional Development and Major Projects

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

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

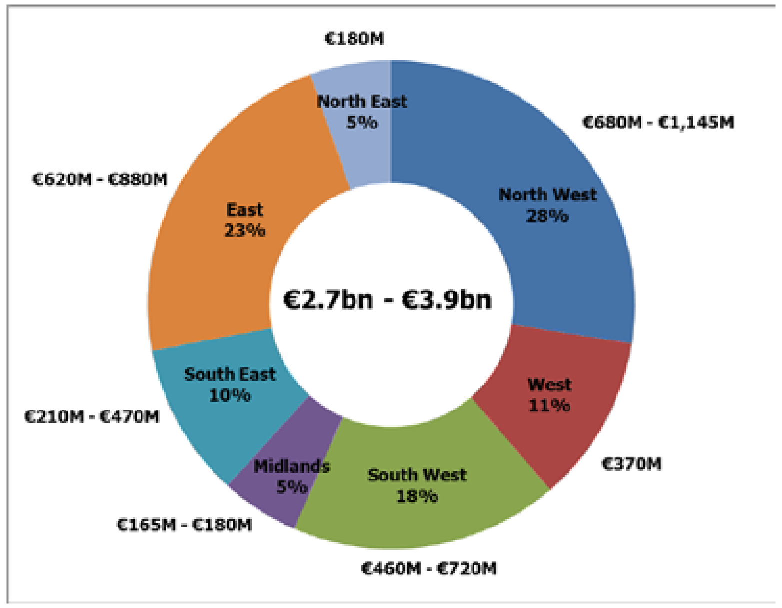


Figure 5-1 Regional breakdown of investment

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

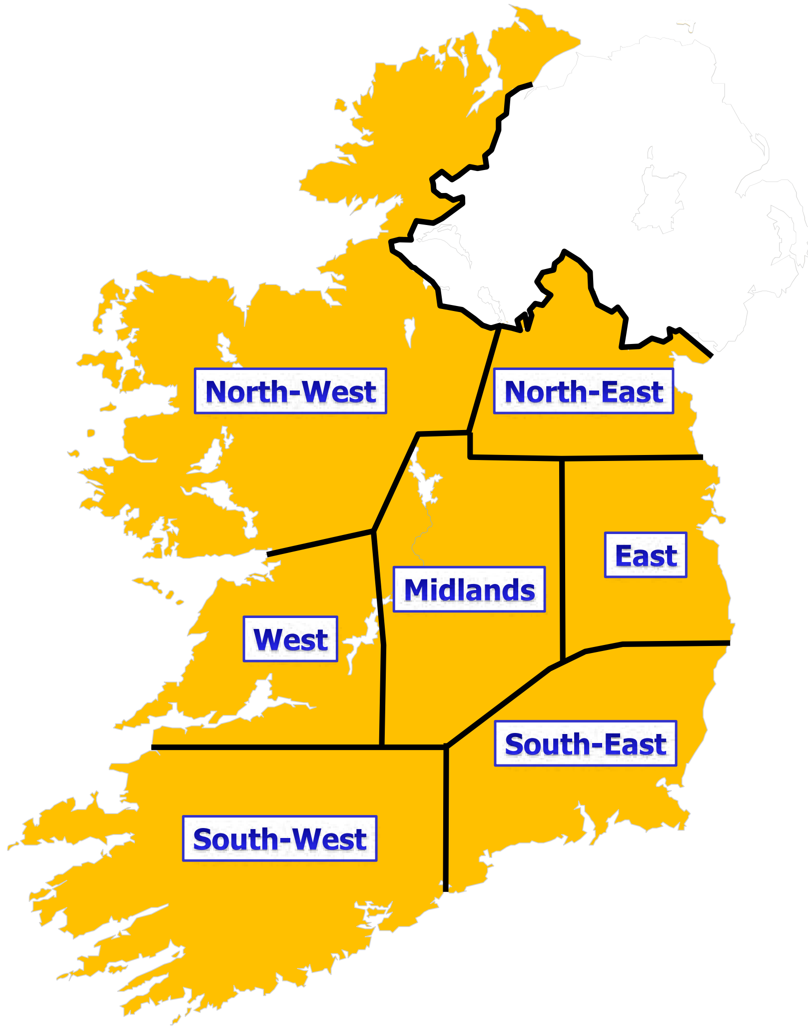


Figure 5-2 Regional Map

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

It is important to note that Wind Farm Power Station (WFPS) location symbols are *only indicative* and their purpose is to highlight possible wind resources in the area. Major grid

developments are highlighted and categorised as new assets, uprated or modified assets, or areas of continuing investigation.

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

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

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

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

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

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

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

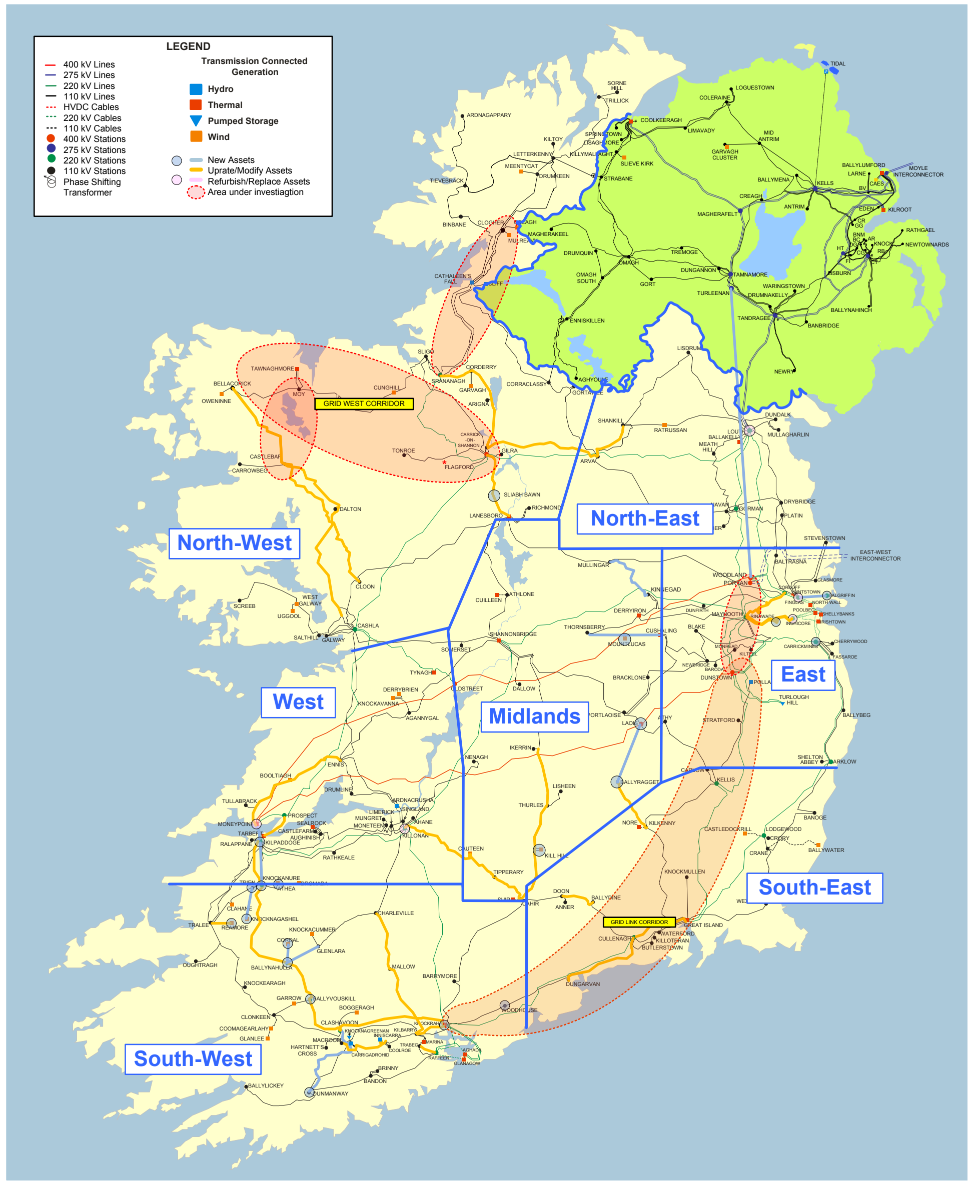
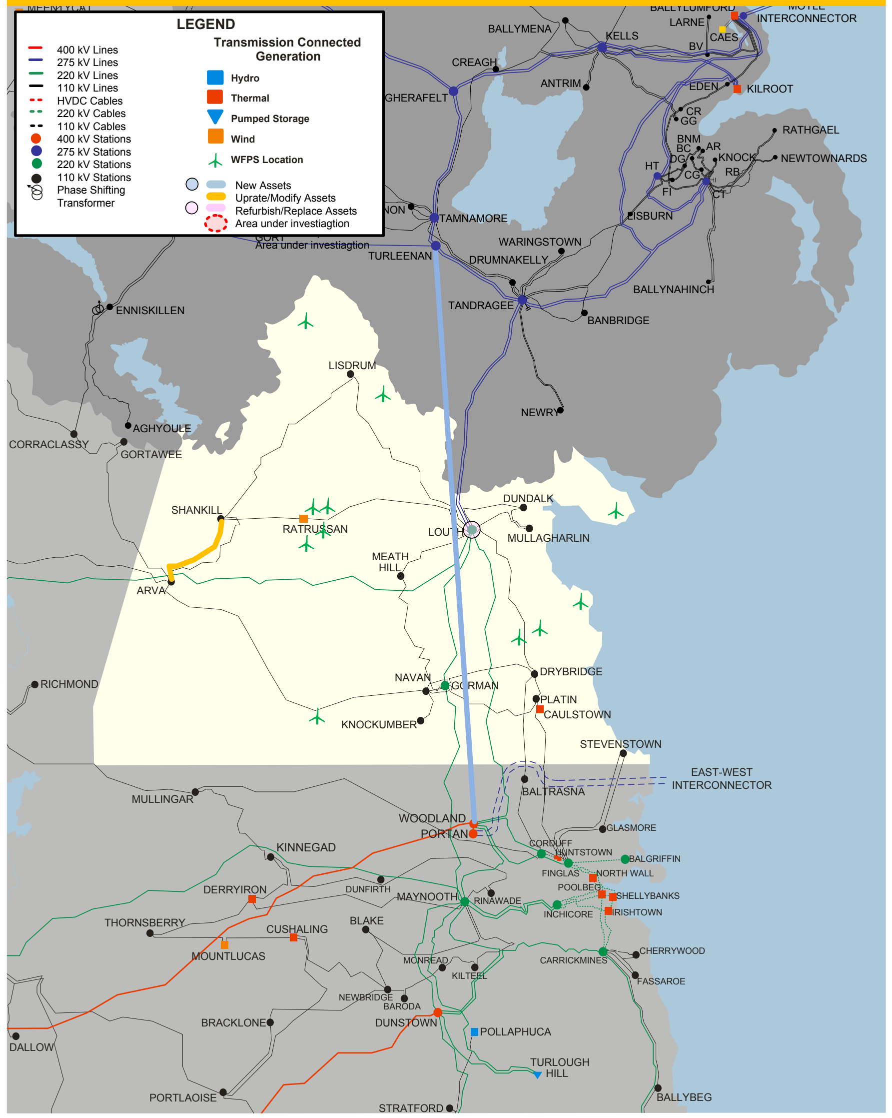


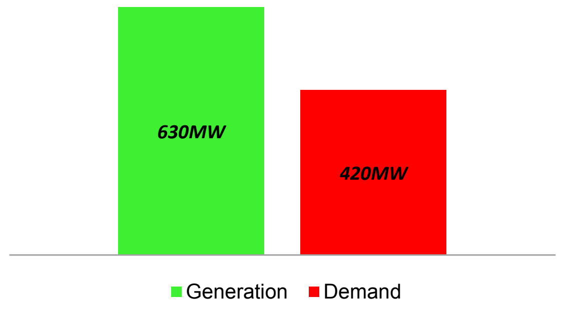
Figure 5-3 National Map Regional Projects

NORTHEASTREGION



NORTHEASTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Regional Projects

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

Regional Description

[22] Available capacity in the network for increased demand

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

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

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

The North-South Interconnector Project

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

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

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

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

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

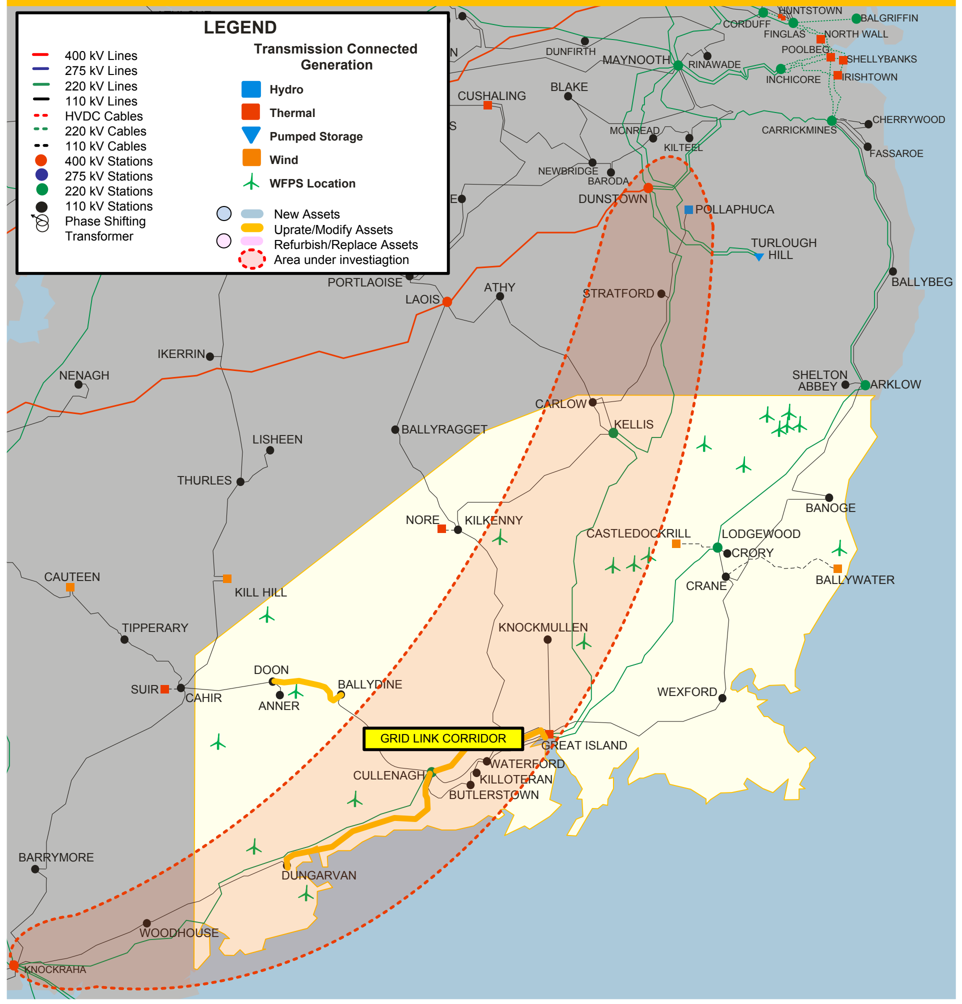
The North South Interconnector Project will additionally ensure the long-term security of supply for the North East part of the network in Ireland.

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

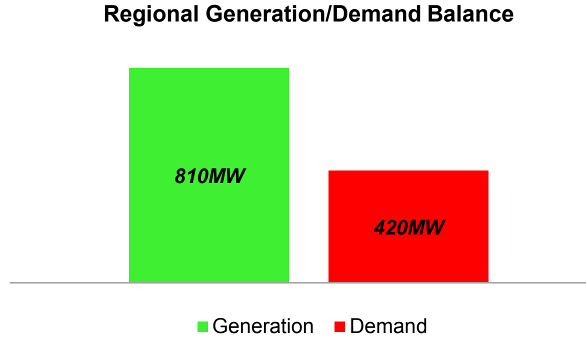
In addition, while underground cables using HVDC technology would be feasible, their use on this project would introduce higher costs to the consumer, would not facilitate future grid connections and reinforcements along the route, and does not comply with best utility practice.

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

SOUTHEASTREGION



SOUTHEASTREGION Summary Table



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Projects

- Uprating of Ballydine – Doon 110 kV circuit

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

Regional Description

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

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

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

The Grid Link Project

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

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

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

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

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

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

Underground option

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

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

400 kV AC option

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

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

Regional Solution

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

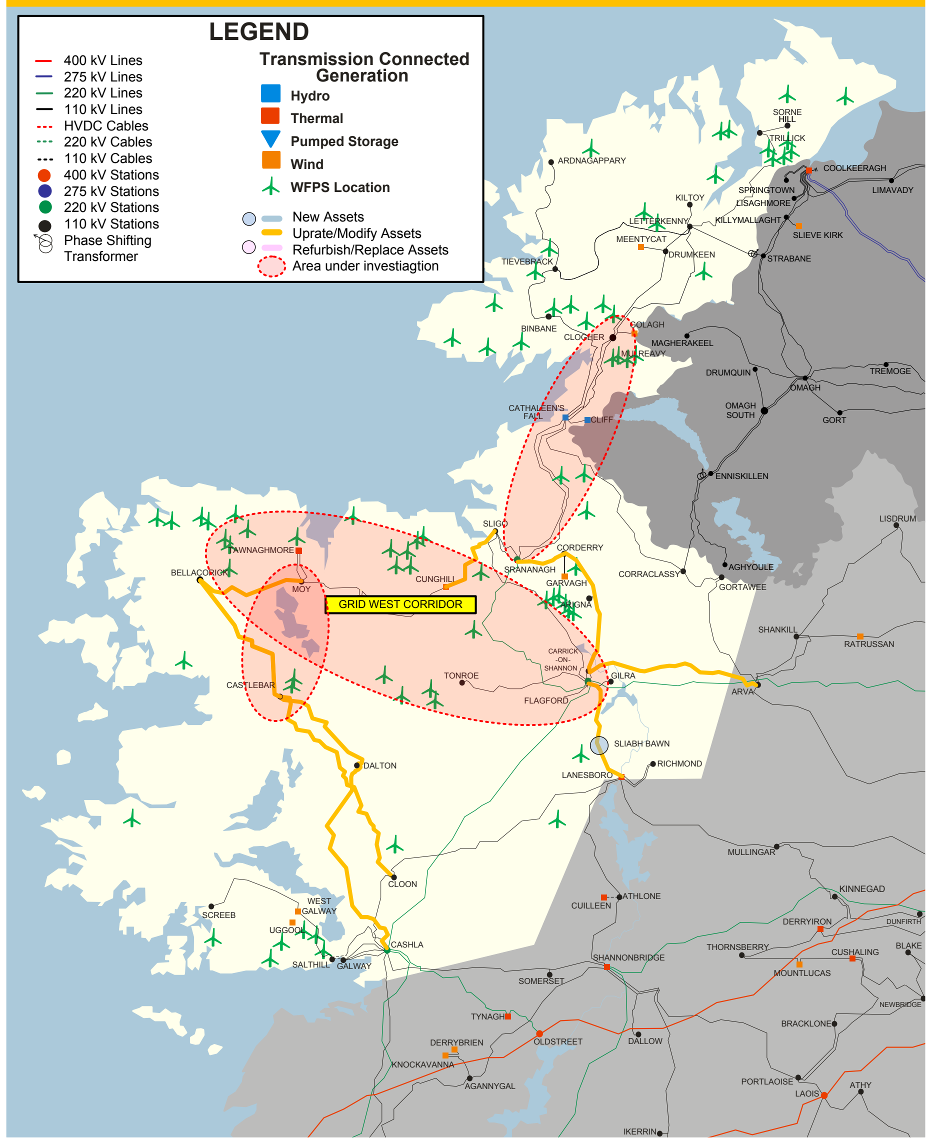
This option is built around installing series compensation technology which would change the characteristics of the existing 400 kV circuits (from Moneypoint in Co. Clare, to the 400 kV substations Woodland and Dunstown that supply Dublin) to make them suitable for a much higher power transfer capability.

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

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

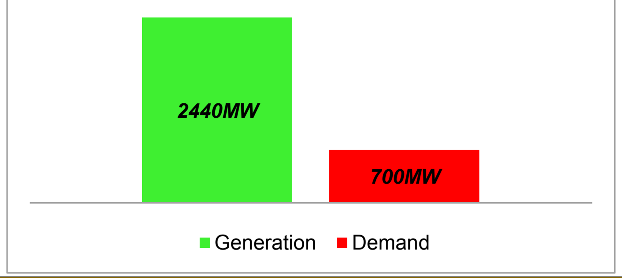
The estimated capital cost for this option would be €200-250m.

NORTHWESTREGION



NORTHWESTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Regional Projects

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

[25] Available capacity in the network for increased demand

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

The Grid West Project

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

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

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

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

HVDC Cable Option

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

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

400 kV Overhead Option

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

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

220 kV Overhead Option

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

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

The Northwest Project

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

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

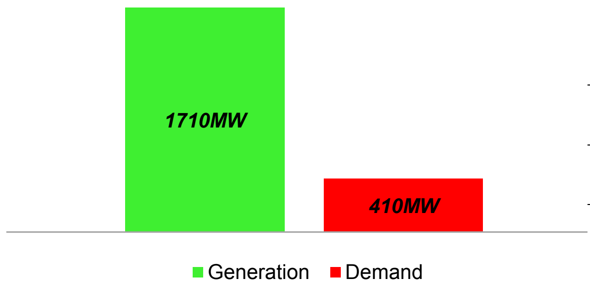
A range of technological options will be considered and consulted upon for any such projects in line with EirGrid's commitments in this new grid development strategy and out new approach to public consultation.

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

WESTREGION

WESTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Regional Projects

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

[29] Available capacity in the network for increased demand

Regional Description

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

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

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

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

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

The Moneypoint – North Kerry Project

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

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

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

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

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

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

Moneypoint 400/220/110 kV substation

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

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

This project is currently under construction.

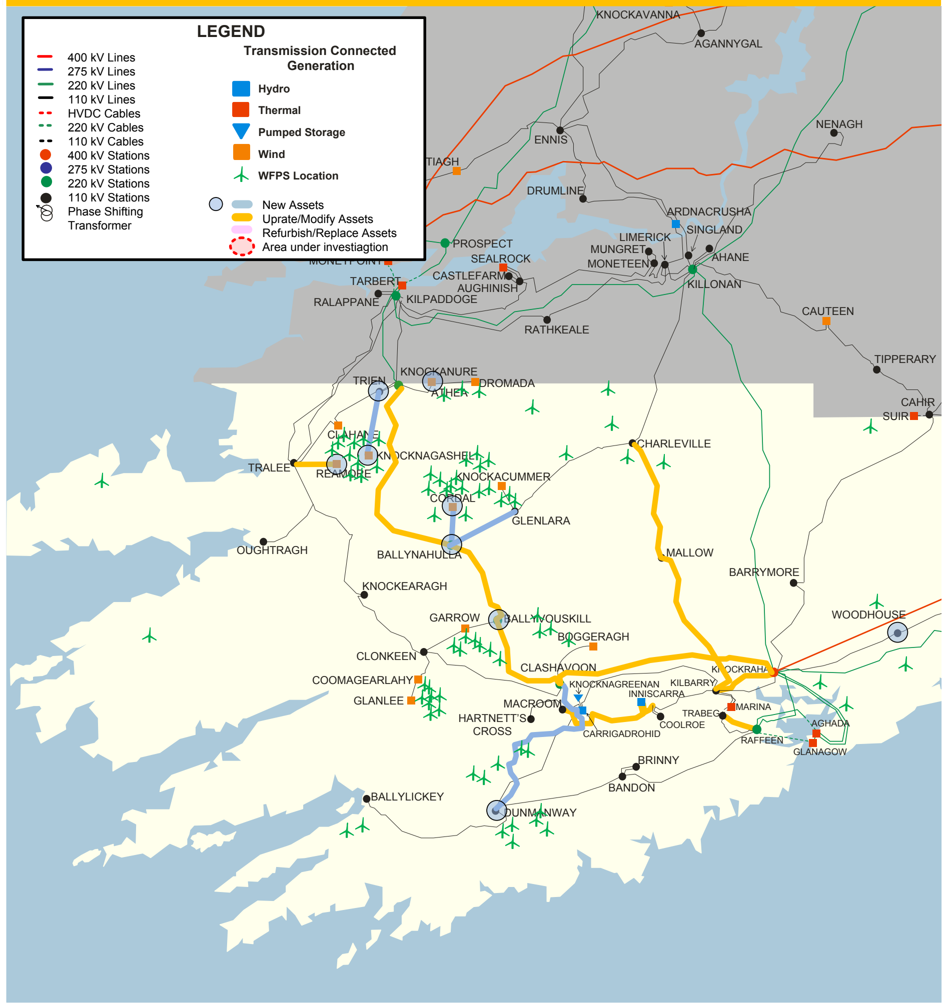
Kilpaddoge 220/110 kV substation

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

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

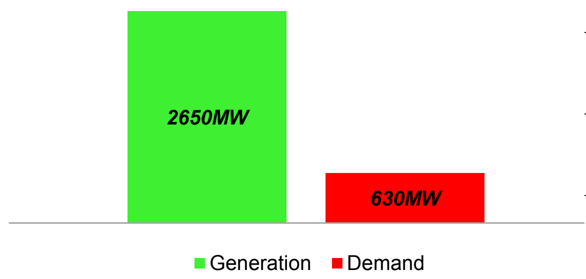
This project is currently under construction.

SOUTHWESTREGION



SOUTHWESTREGION Summary Table

Regional Generation/Demand Balance



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Regional Projects

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

[30] Available capacity in the network for increased demand

Regional Description

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

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

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

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

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

Knockanure, Ballynahulla, and Ballyvouskill substation Projects

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

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

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

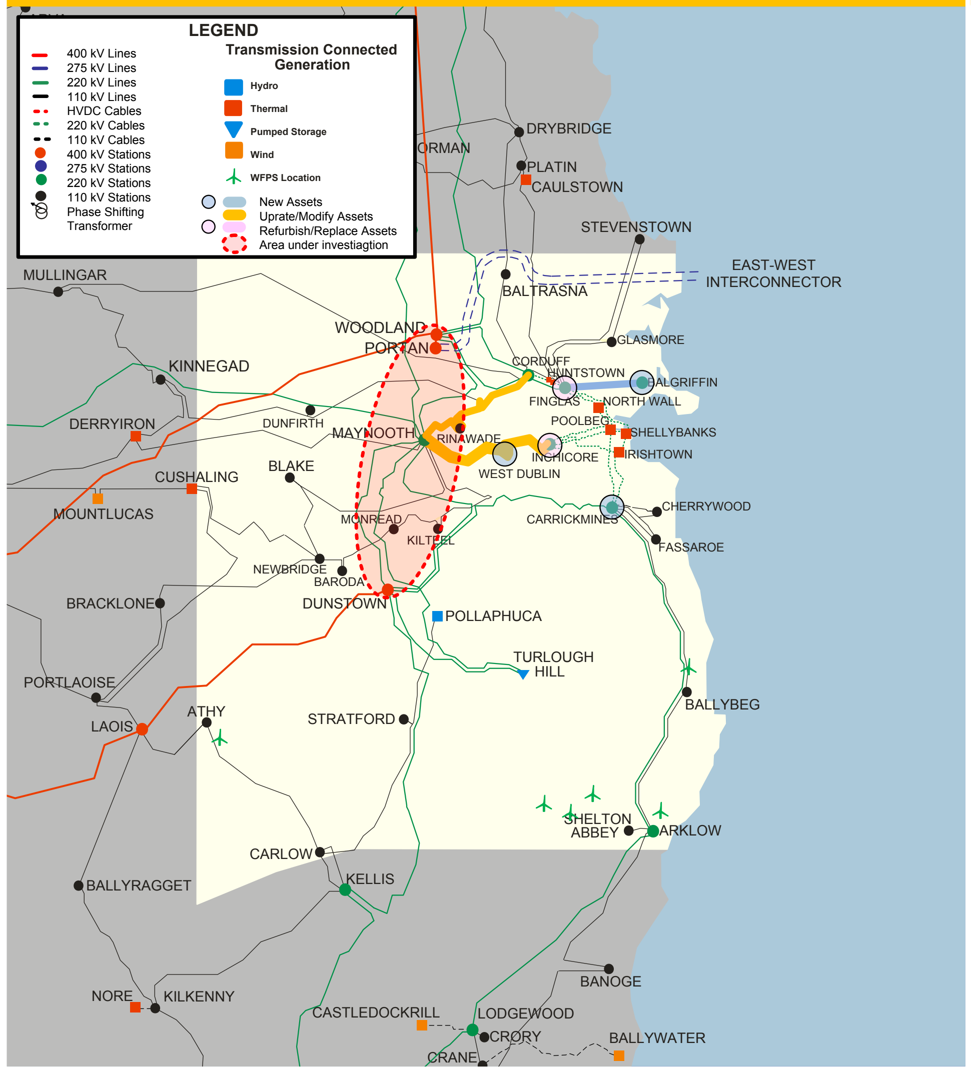
Clashavoon Dunmanway 110 kV Circuit

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

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

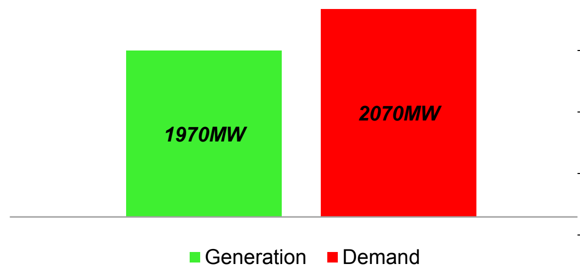
This project is currently in the construction phase.

EASTREGION



EASTREGION Summary Table

Grid25 Regional Generation/Demand Balance



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Regional Projects

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

[31] Available capacity in the network for increased demand

Regional Description

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

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

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

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

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

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

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

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

Reinforcement of the Greater Dublin Area

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

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

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

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

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

Belcamp 220/110 kV Substation Project

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

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

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

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

New West Dublin 220/110 kV Substation Projects

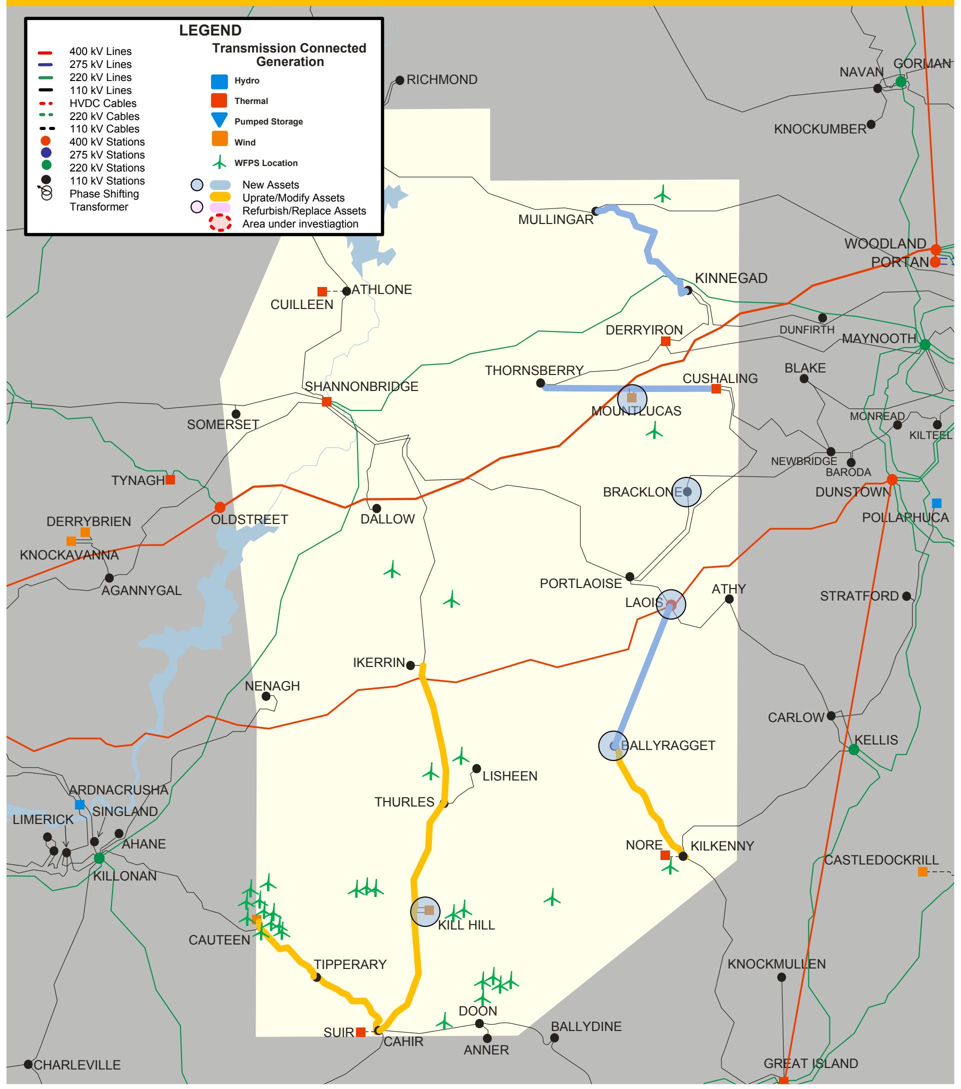
The new West Dublin substation will provide a new high voltage supply point that will supply existing and new load, thereby alleviating the loading on constrained substations and circuits within the area.

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

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

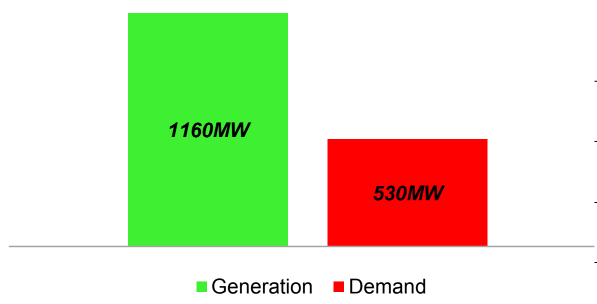
New 110 kV circuits will be installed to connect the existing 110 kV network and new large-scale demand customers into this new substation.

MIDLANDS REGION



MIDLANDS REGION Summary Table

Grid25 Regional Generation/Demand Balance



Main Regional Demand Centres

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

Summary of Development Projects

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

Major Regional Projects

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

Other Regional Projects

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

[32] Available capacity in the network for increased demand

Regional Description

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

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

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

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

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

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

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

Laois-Kilkenny Reinforcement Project

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

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

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

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