Long Term Resilience Study

2018

Gas Networks Ireland

EIRGRID

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Executive Summary

The Department of Communications, Climate Action and Energy (DCCAE), with support from the Commission for Regulation of Utilities (CRU), asked Gas Networks Ireland and EirGrid to examine Ireland's resilience to a prolonged gas disruption, and to make recommendations on how Ireland can future-proof its gas supply, and ensure it is resilient to periods of disruption. Any potential impacts on the electricity system as a result of gas supply disruptions are also considered. This report examines the current landscape, likely future demand and the possible options to enhance the resilience of the gas system, if considered necessary.

This report examines the current and future security of one of Ireland's key energy sources. It looks at potential options for ensuring the security and sustainability of our gas supply long into the future. It considers how to develop a resilient energy system in a cost-efficient way that makes sense for the Irish economy.

A sustainable, secure gas supply is crucial for the long-term competitiveness of Ireland's economy, and is integral to Government energy policy.

Today, natural gas accounts for almost 30% of Ireland's total primary energy requirement (TPER), which is in line with the international average. Ireland's gas demand amounted to over 55 TWh in 2017. Gas fired power generation accounts for approximately half of Ireland's electricity generation requirements.

In its 2015 document, 'Ireland's transition to a low carbon energy future', the Department of Communications, Energy and Natural Resources (now DCCAE) outlined its vision for Ireland's energy future, and confirmed its core objectives of sustainability, security of supply and competitiveness.

In the transition to a more sustainable future, and the phasing out of more carbon intensive fuels such as peat and coal, gas is likely to become increasingly important for electricity, transport and heating.

This report examines the long term security of supply position up to 2040, and considers two possible gas demand scenarios: a median demand scenario and a high demand scenario. The median demand scenario represents the primary demand forecast, or in our view the most likely outcome. A high demand scenario is also included to ensure that the analysis holds true over a range of possible gas demands.

The median demand scenario would see a 17% increase in gas demand by 2030, while the high demand scenario would see demand rise by 27%. The median demand scenario would result in annual gas demand of over 62 TWh. In the high demand scenario, gas demand would reach over 70 TWh by 2030.

Ireland's gas network is well equipped to deal with the forecasted peak demand. However, there are opportunities to build greater flexibility and resilience into the system.

In this report we will consider an EU-defined calculation to assess how Ireland's gas network would be affected by the loss of its largest piece of gas infrastructure. The so-called N-1 calculation, which is outlined in EU regulation 2017/1938, shows what percentage of gas demand could be served in the event of such a disruption. In particular, the infrastructure standard which is defined within the regulation, refers to the loss of the single largest piece of infrastructure on a day of exceptionally high gas demand. The gas network is designed to meet the demand of all gas customers on a 1-in-50 year peak day, i.e. a severe winter peak day that is statistically likely to occur once every fifty years. Currently Ireland can only serve 37% of demand in the event of the loss of the single largest piece of infrastructure (i.e. the entire gas interconnector system) on a 1-in-50 year peak day. The portion of gas served is met by gas from the Inch[1] and Corrib gas fields.

The security of supply regulation allows countries to meet the requirements on a regional basis, and Ireland currently meets the requirements when assessed alongside the UK. Given uncertainty around Brexit, it is important that Ireland reviews this arrangement.

However, Gas Networks Ireland is already working to improve the gas security of supply position. Work is ongoing on a project to complete the twinning of the gas interconnector system. This is a significant investment, supported by EU funding and will have a long-lasting impact on security of supply. This project will facilitate the splitting of the interconnector system and the creation of two entirely separate systems, which will be capable of operating independently. These will then be considered as separate pieces of infrastructure for the purposes of security of supply calculations.

Even in our current position, supply to gas users is relatively secure with little impact on end users. EU regulation also defines a supply standard which relates to protected customer demand. This refers to domestic gas customers, and essential services, such as hospitals. Ireland meets this standard currently and is projected to do so for the foreseeable future. A major disruption would see little impact on most gas users, and power generation would remain secure thanks to other types of generation and backup fuels (distillate oil) which are required to be held at large gas power stations. Gas fired generators are required to have a supply of backup fuel equivalent to 5 days continuous running at full output. For peak day outages these backup fuels are effective in mitigating potential outages.

1 Until recently Kinsale Energy Limited (KEL) operated the South West Kinsale gas field as a gas storage facility via the Inch Entry Point. The remaining gas in the field is now being blown down with production of gas expected to cease in 2020/21.

For longer outages the average demand is lower and so there is more gas available to the power generation sector. In such circumstances power generation could be served by a combination of back up fuels and the available gas.

This report considers the security of supply position in other EU member states, and looks at what Ireland can learn from the experiences of each of the countries considered. Finland, Lithuania, Portugal and Greece were identified as having security of supply positions which are comparable to Ireland. They have all either introduced, or are due to introduce, measures to further enhance the resilience of their gas supply. These measures include Liquefied Natural Gas (LNG) imports, additional import routes for pipeline gas and the development of gas storage.

In this report, we outline a number of possible ways for Ireland to improve its security of supply position. These options include integration of bio-methane (renewable natural gas), LNG import terminals (fixed and floating options), further gas interconnection (e.g. to France) and permanent gas storage.

A cost-benefit analysis was used to weigh the possible costs and benefits of each potential option, but further analysis is required before proceeding with the preferred option(s). The detailed analysis conducted to date represents a thorough and considered first step, designed to identify the most viable mitigation measures and inform future policy.

The analysis, which provides a relative comparison of potential mitigation measures, is consistent with the methodology used by the European Network of Transmission System Operators (ENTSOs) for gas and electricity. This ENTSOG methodology considers capital and operational costs, plus security of supply and sustainability benefits. Private benefits, such as company profits, are not addressed. This analysis shows which projects require the least private benefit to recoup their costs.

Based on our findings, the most economically advantageous option for Ireland to enhance its security of supply is a floating LNG terminal, along with bio-methane integration. These measures would significantly improve Ireland's security of supply position.

According to the EU, floating LNG terminals are a cost-effective solution that have changed the dynamics of investment in import capacity. The EU Commission has said that Ireland has the highest potential for bio-methane production per capita in the EU, as was noted in a report by the Sustainable Energy Authority of Ireland (SEAI) in 2017.

Until recently Ireland had an underground gas storage facility connected to the Inch Entry Point, which operated on a seasonal basis. However, storage operations there have now ceased. With a reduced seasonal gas price differential in recent years, continued operation of the facility was no longer economically viable. The remaining base or cushion gas used to support pressures in the storage facility is currently being extracted from the field and this is expected to cease in 2020/21.

Key Recommendations

1. Conduct a detailed cost-benefit analysis for a floating LNG terminal

The most economically advantageous option to improve the resilience of Ireland's gas supply is a floating LNG terminal.

However, as the social benefits do not outweigh the costs. A detailed assessment of private benefits is required to determine whether such an investment would provide a broad societal benefit and a return for investors. Price and cost simulations and public consultation can be used to better understand the commercial interest in such a terminal. The analysis should include a robust Cost Benefit Analysis (CBA) including private benefits and consideration of possible funding and ownership options.

A floating LNG terminal would provide a direct connection for Ireland to the global LNG market and would allow Ireland to diversify its gas supply. However, greater exposure to the LNG market comes with price risk, which could result in usage of an LNG terminal fluctuating. This variability of utilisation needs to be considered in terms of cost recovery. We recommend further analysis, including multi-scenario modelling of future LNG and pipeline gas prices to inform the level of utilisation and the private benefits associated with operating an LNG terminal.

2. Enable the production of bio-methane in Ireland

Bio-methane can help improve Ireland's security of supply position, providing an indigenous and sustainable energy supply source, especially for the heat and transport sectors.

However, without appropriate support, Ireland's considerable potential for bio-methane is unlikely to develop to the extent required to have a significant impact in terms of security of supply and sustainability.

Its development hinges on its attractiveness to investors. While private benefits are excluded from the scope of this study, they are an important consideration for policymakers. A stable regulatory and financial framework is required to encourage investment in bio-methane production. Any support scheme would be contingent on a CBA analysis.

3. Monitor opportunities for permanent gas storage in Ireland and gas storage operations in the rest of Europe

While it may not be economically viable to develop a gas storage facility in the short term, such a facility could potentially provide considerable benefits in the future, depending on gas market conditions.

We recommend monitoring gas market seasonal price spreads and storage facility development across Europe. Opportunities for gas storage in Ireland should also be monitored, with options for a gas storage site here reviewed when conditions for storage have improved and/or specific cost estimates can be made.

The remainder of this report is structured as follows and will explain clearly why we are making the recommendations described above:

- **Section 2** outlines the current position.
- **Section 3** considers factors likely to drive change in gas demand and supply.
- **Section 4** outlines the gas demand scenarios.
- **Section 5** explains how we evaluate the security of supply.
- **Section 6** looks at the options for improving security of supply. This section also presents examples from other countries.
- **Section 7** recommends the next steps to ensure Ireland's continued security of supply.

2.

The Current Position

From just 31 kilometres of transmission pipeline in 1978, the Gas Networks Ireland network currently has over 14,000 kilometres of transmission and distribution pipelines.

A lot has changed in the last 40 years, and in the next 40, the energy landscape will shift again. Ongoing developments, such as an EU-backed Project of Common Interest (PCI) to parallel a 50 km section of gas pipeline in Scotland and Gas Networks Ireland's planned splitting of Ireland's gas interconnector system, will change Ireland's gas network and improve its security of supply position.

Today, natural gas accounts for almost 30% of Ireland's total primary energy requirement (TPER), which is in line with the international average. Gas fired power generation accounts for approximately half of Ireland's electricity generation requirements.

Up until recently Ireland was heavily dependent on gas imports from the Moffat entry point in Scotland via onshore pipelines in Scotland and two subsea interconnectors. However, the Corrib gas field has been operating since late 2015 and has improved Ireland's security of supply position significantly. As Corrib production declines, gas imports from Britain will once again represent the dominant source of supply. Thus Ireland could potentially have a high level of dependence on a single import route. The Government's energy white paper stresses the importance of the "diversity of energy supply sources to avoid over-dependency on any particular fuel, supplier, route or region".[2]

2 https://www.dccae.gov.ie/documents/Energy%20White%20Paper%20-%20Dec%202015.pdf

Despite the Irish gas system's reliance on imports, it has sufficient capacity to meet usage demands across various areas, such as residential, industrial, transport and electricity generation.

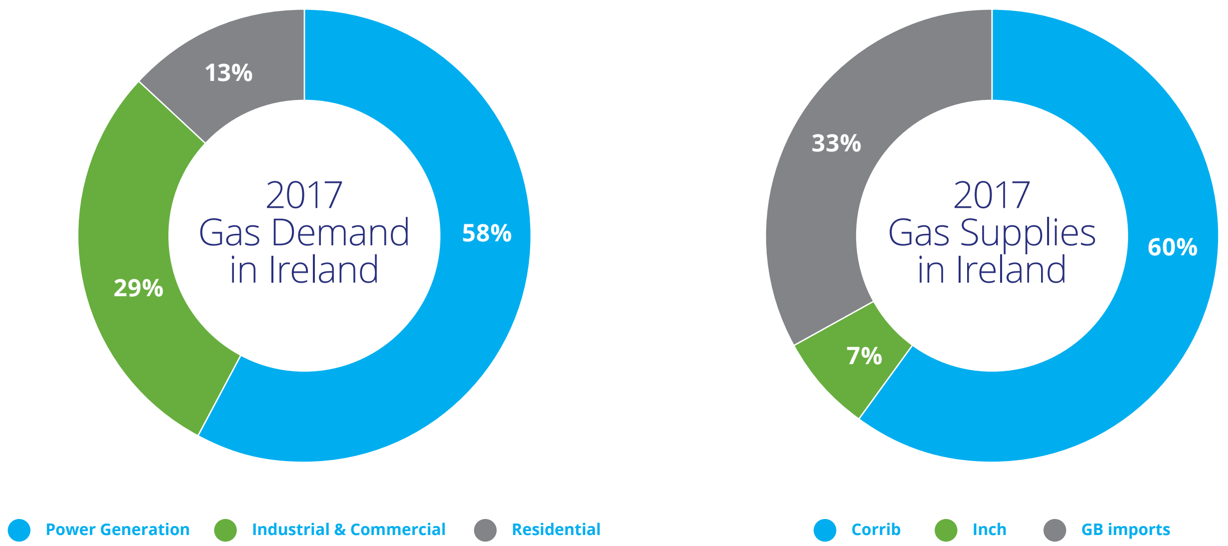
Gas supply and demand must balance, requiring a flexible system that can respond to demand peaks. The Gas Networks Ireland system is designed to meet the demand of all gas customers on a 1-in- 50 year peak day, i.e. a severe winter peak day that is statistically likely to occur once every fifty years. Two separate 1-in- 50 peak day events occurred in winter 2009/10 and winter 2010/11. The natural gas network has consistently demonstrated resilience and reliability during periods of extreme weather, particularly during January and December 2010 when record sub-zero temperatures were recorded.

While Ireland's gas system has displayed resilience and reliability in the past, and continues to do so today, there is still more to do in order to meet regulatory requirements on security of supply.

Ireland does not currently meet the infrastructure standard, a calculation defined in EU regulation that assesses whether a country can serve all of its demand in the event of a disruption of the single largest piece of gas infrastructure (a so called "N-1" disruption) on a day of exceptionally high gas demand. The infrastructure standard, which is outlined in EU regulation 1938/2017, shows what percentage of gas demand could be serviced in the event of such a disruption. Currently Ireland can meet about 37% of total gas demand in this 1-in-50 year, peak day "N-1" disruption scenario.

This report examines the long term security of supply position for the years 2030 and 2040, with 2025 used as a starting point for the analysis and potential mitigation measures assessed over the horizon of the study i.e. out to 2040.

Figure 2.1: Gas Demand and Supply



3.

A Changing Landscape

A changing policy environment, infrastructure developments and an evolving economy are shifting both the supply and demand side of Ireland's gas system. As the landscape shifts, it is crucial that we maintain Ireland's security of supply, given its key strategic importance for our economy.

3.1 Policy

Internationally, there's a growing focus on sustainability. The European Council has set an EU-wide target of a 40% reduction in greenhouse gas emissions by 2030 versus 1990 levels. By 2050 the European Parliament is targeting an 80% reduction in greenhouse gas emissions versus 2005 levels.

Ireland, in line with other EU member states, has signed up to the Paris Climate Change Agreement, and is fully committed to delivering on its climate change objectives within the current EU frameworks. However, the Government faces a number of challenges in meeting these targets. For example:

- coal and peat still account for approximately 25% of electricity generation
- older housing stock has relatively poor energy efficiency
- carbon emissions in the transport sector increased by 142% between 1990 and 2016

Future gas supply and demand will be heavily influenced by the Government's long term decarbonisation objectives, with gas demand likely to rise initially as Ireland shifts away from more carbon-intensive fuels, like peat and coal, to lower-carbon fuels like natural gas in the transition.

The 2015 Energy White Paper *"Ireland's Transition to a Low Carbon Energy Future"* sets out a road-map for Ireland to reduce its greenhouse gas emissions by 80 to 95% by 2050. The strategy is clear that non-renewable energy sources will make a significant, though progressively smaller, contribution to our energy mix over the course of the energy transition. The Paper noted that as Ireland makes this transition the development of Ireland's indigenous oil and gas resources has the potential to deliver significant and sustained benefits, particularly in terms of enhanced security of supply, import substitution, fiscal return and national and local economic development. It is noted that there is presently significant interest in exploration for oil and gas offshore Ireland, following the 2015 Atlantic Margin Licensing Round. The discovery of a new indigenous gas source would reduce Ireland's import dependency and diversify its gas supplies, thereby strengthening Ireland's gas supply.

Alongside decarbonisation, another potential change on the horizon comes in the shape of Brexit. Ireland must consider the risks therein and plan accordingly.

3.2 Infrastructure

A number of forthcoming developments will improve Ireland's gas security of supply position.

For example, the EU Project of Common Interest (PCI) to parallel or twin a single 50 km section of gas pipeline from Cluden to Brighouse Bay in Scotland will improve Ireland's resilience. This twinning project is under construction and due for completion by the end of 2018. The completion of the twinning project will boost import capacity, and further increases could be delivered with relatively modest investment in compressor stations and ancillary equipment.

Following on from the completion of the twinning project, Gas Networks Ireland intends to split the interconnector system into two entirely separate systems which will be capable of operating independently of one another. This piece of work will be completed by 2021. As well as providing redundancy on the entire interconnector system, this will allow each interconnector to be considered as separate pieces of infrastructure for the purposes of security of supply calculations. This will mean that an "N-1" disruption will now refer to the loss of a single stream of the Interconnector system as opposed to the whole system, thus improving Ireland's position with respect to both the infrastructure and supply standards.

The splitting of the gas interconnector system is an important long-term investment for Ireland, and will lead to a significant and lasting improvement in the security of supply position for Ireland.

3.3 Economy

Gas is likely to become increasingly important for electricity, transport and heating, and both demand scenarios considered in this report point to increased demand for gas in the years to come.

The level of future economic growth will be a key factor in Ireland's future gas demand. How many houses will be built in the years to come? How many new businesses will be started? And what proportion of these homes and businesses will connect to the gas network? This is explored in more detail in the next section.

4.

Gas Demand Scenarios

In order to evaluate the long term security of supply position we first need to determine how gas demand will develop in the long term. To do this we have considered the various types of usage that drive gas demand, such as power generation, the residential sector, transport and industry.

Two gas demand forecast scenarios have been developed, a median demand scenario and a high demand scenario. The first would see a 17% increase in gas demand by 2030 relative to current demand (2018), while the second would see demand rise by 27%. As mentioned earlier in this document, the median demand scenario represents our primary forecast; or in our view the most likely outcome.

The median demand scenario is aligned with Ireland reaching long-term decarbonisation targets. However, we note that this scenario requires substantial public and private investments, as well as large scale behavioural change and the adoption of new technologies by consumers.

While the median demand scenario is our central forecast, we also consider the high demand scenario to ensure the robustness of our analysis. It is prudent from a security of supply perspective to consider a scenario where not all foreseen changes materialise and reflect this in projected gas demand.

The median and high demand scenarios were developed across the main gas demand sectors as shown in Figure 4.1.

Figure 4.1: Gas demand forecasting inputs

Power Generation	Industrial & Commercial	Residential	Transport
Electricity demand	**Gross domestic product**	**Annual quantity**	**Fast fill stations**
Available generation capacity	**New connections**	**New connections**	**Heavy Goods Vehicles & Buses**
Fuel & CO_2 prices	**Energy efficiency**	**Energy efficiency**	**Usage profiles**

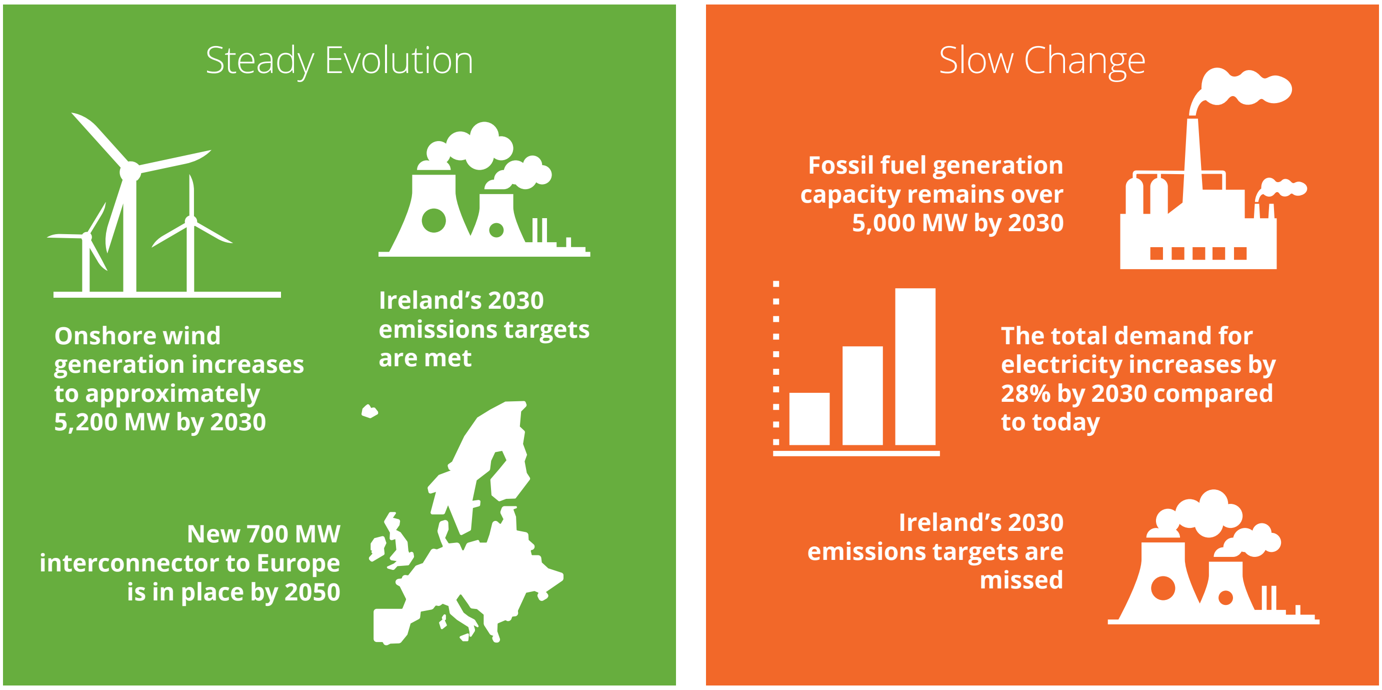
4.1 Power generation

Gas Networks Ireland and EirGrid have developed two gas demand scenarios for the power generation sector. These are based on the electricity demand scenarios detailed in EirGrid's Tomorrow's Energy Scenarios document[3]. The 'steady evolution' scenario is used to inform the median gas demand scenario, and the 'slow change' scenario informs the high gas demand scenario.

In broad terms, the 'steady evolution' scenario assumes higher growth in renewables and higher growth in electricity demand, while the slow change scenario envisages lower growth in renewables and lower electricity demand growth. However both scenarios show substantial growth in renewables relative to current levels (2018).

3 http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Tomorrows-Energy-Scenarios-Report-2017.pdf

Figure 4.2: Eirgrid's 'Slow Change' and 'Steady Evolution' scenarios



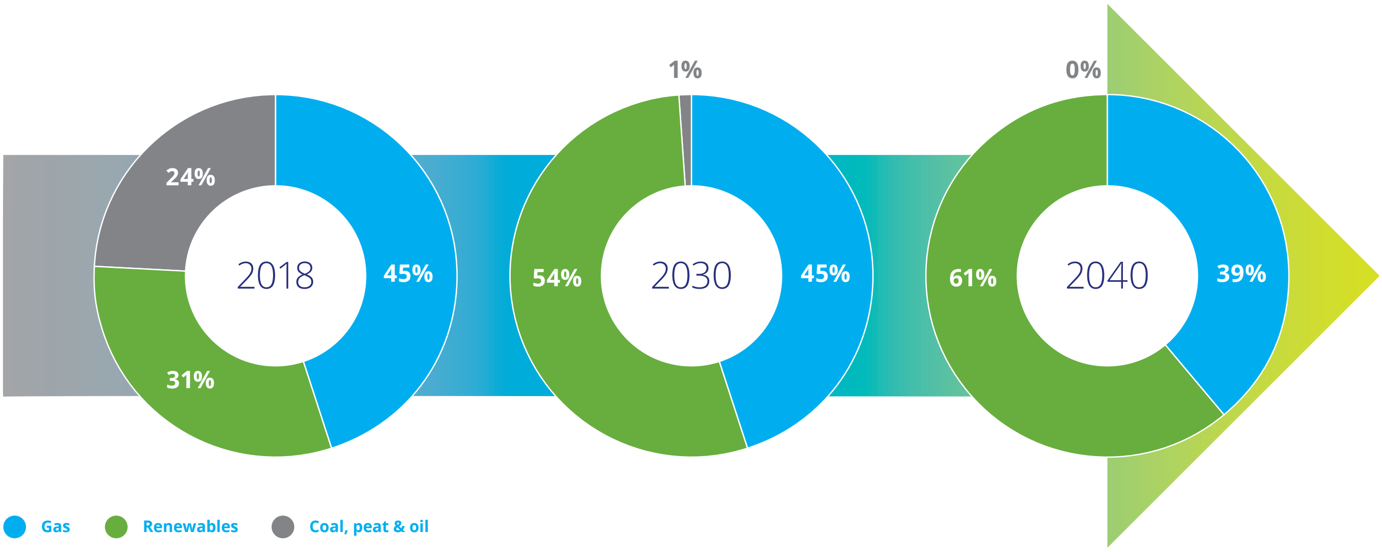
Ireland's power generation sector has made substantial progress towards decarbonisation over the last 25 years, with the carbon intensity of the sector almost halving from 900 grams of carbon dioxide per kilowatt hour in 1990 to 482 grams in 2016. Much of this progress has been attributed to the growth of renewables as part of the fuel mix, and the uptake of fuel switching from highly carbon intensive fuels to natural gas.

As part of our median demand scenario, the following key actions are assumed:

- Coal and peat plants are replaced by new gas generators
- Additional interconnection to Europe is in place
- Wind capacity doubles from its current level of 3,080 MW to over 7,000 MW by 2040.

The impact of these changes can be seen in Figure 4.3. There is an almost complete elimination of carbon intensive coal, peat and oil from the system before 2030. By 2040 there is very high penetration levels of renewable generation and efficient despatchable gas fired generation to ensure security of supply.

Figure 4.3 Evolution of electricity generation



4.2 Industrial & commercial

Industrial and commercial (I&C) connections to the gas network include small to medium enterprises (SMEs) and large industrial and commercial customers. New connections include both new and existing businesses.

The number of new businesses connecting to the gas network in the future will depend on a number of factors, such as economic growth and the range of alternative options available. Gas Networks Ireland has developed two demand forecasts, based on the number of new connections and economic growth forecasts.

The Central Statistics Office (CSO) has estimated that there are over 185,000 active businesses in Ireland. Of these, Gas Networks Ireland estimates that approximately 87,000 are located within 30 metres of the natural gas network. There are currently 27,000 connected to the gas network, while the remaining 60,000 represent a significant opportunity for Gas Networks Ireland.

Gas Networks Ireland has a target of almost 700 new industrial and commercial customers per annum. This figure is used in the high demand scenario projections. For the median demand scenario, Gas Networks Ireland has assumed increased competition from alternative technologies with new connections dropping to just over 400 per annum by 2040. Energy efficiency measures are also incorporated into the projections, and will impact on future levels of gas demand from industrial and commercial users.

Four hundred new connections per year would result in an increase of 33% in industrial and commercial connections over the forecasting horizon. However, energy efficiency measures are assumed to significantly lower average demand per customer. The net impact therefore is a growth in gas demand of 11% by 2040 relative to current demand levels.

4.3 Residential

The Economic and Social Research Institute (ESRI) estimates that 25,000 new houses will be needed per annum to meet housing demand in Ireland. Gas Networks Ireland estimates that approximately 40% of new housing stock will use gas as its primary heat source in the high demand scenario.

In addition, there are currently 300,000 houses in close proximity to the gas network which are not yet connected. In the higher demand scenario, a connection rate of 3,000 mature houses per annum is assumed in the high demand scenario. Gas Networks Ireland is cognisant that there is competition for gas from other sectors and has therefore included a lower connection rate of mature houses for the median demand scenario.

Forecasting on the number of new residential connections to the gas network, combined with assumptions on annual usage for residential connections has been used to predict future residential gas demand.

The assumed usage in the long term forecasts is considerably less than the usage associated with existing housing currently and reflects expected improvements in energy efficiency in the residential sector. In terms of energy efficiency, the median demand scenario has included a substantial reduction in average annual residential demand. In 2017/18 we assume an average annual gas demand of 11,150 kWh per household. By 2040 this has declined to 10,100 kWh per household.

The net effect of new connections and energy efficiency measures is reflected in the median and high demand scenarios. In the median gas demand scenario, gas demand is expected to decline by 3% between 2025 and 2040. In the high demand scenario gas demand is expected to grow by 4.5% between 2025 and 2040.

4.4 Transport

In the future, Compressed Natural Gas (CNG) will play a much bigger role in the transport industry. A growing focus on Natural Gas Vehicles (NGVs) will lead to increased gas demand.

CNG is a viable transport fuel providing an alternative to diesel that is better for the environment. CNG vehicles are also quieter than diesel vehicles, and help to reduce noise pollution. A CNG vehicle emits 22% less carbon dioxide, 97% less carbon monoxide, 60% less nitrogen oxides and 75% less non-methane hydrocarbon than diesel fuel while emitting virtually no particulate matter.

Currently, heavy goods vehicles account for 20% of all energy related carbon dioxide emissions in the road transport sector, despite accounting for only 3% of the total number of road vehicles. Utilising CNG to power trucks and buses offers a real solution to reducing emissions from diesel-fuelled heavy vehicles. Gas Networks Ireland is currently targeting at least 5% penetration of CNG or Renewable Gas (RG) for commercial transport by 2025. It is also targeting a 10% penetration in the bus market by that date.

Gas Networks Ireland is undertaking a European funded project called the Causeway Study to deliver 14 high capacity fast-fill CNG Stations at strategic locations around the country, and a renewable gas injection point. The first public station has now been successfully commissioned at the Topaz Dublin Port service station. Longer term Gas Networks Ireland plans to develop a 70-station CNG fuelling network by 2025, targeting 102 stations by 2030.

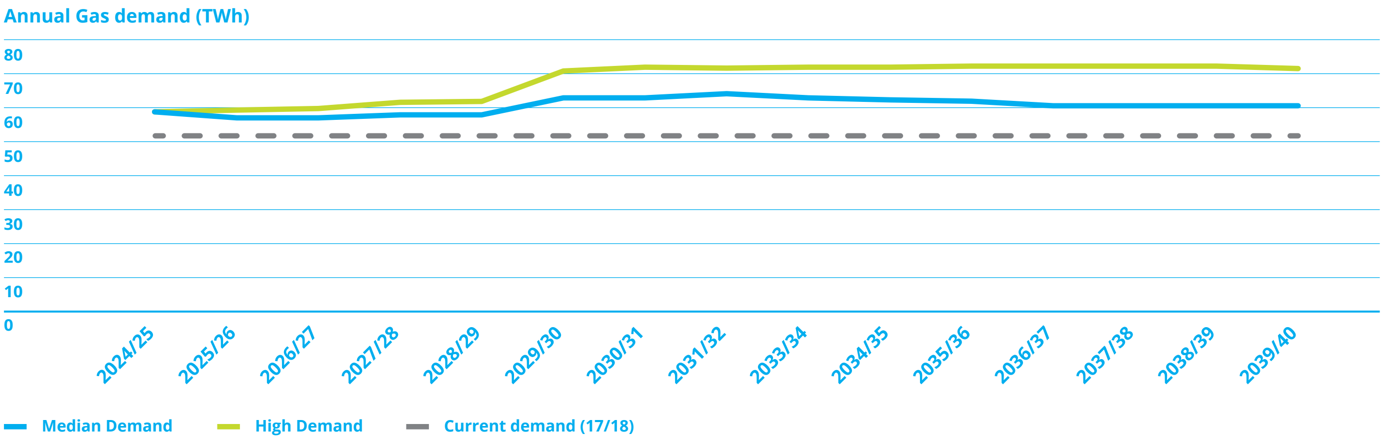
In the high demand scenario, it is assumed that there will be more than 2,700 CNG fuelled vehicles on Irish roads by 2030 and over 5,600 by 2040. The median demand scenario is based on 1,500 CNG vehicles by 2030 and almost 3,000 CNG vehicles by 2040.

4.5 Aggregate demand

Each of these four inputs feeds into overall gas demand. In both scenarios modelled, gas demand looks set to increase significantly in the years ahead.

- In the median demand scenario, total gas demand is expected to reach over 62 TWh by 2030, representing a relative increase of almost 17% compared to current demand. However, gas demand between 2030 and 2040 would decline somewhat due to the impact of increased renewable energy. Gas demand would still be above current levels (2018).
- In the high demand scenario gas demand is expected to reach over 70 TWh by 2030, representing an increase of around 27% relative to current gas demand. In this scenario gas demand is expected to stay at this level until 2040.

Figure 4.4: Annual demand



4.6 Exceptional or peak day demands

When modelling future gas demand scenarios, we need to take account of variability in the demand cycle, with peak day demand reflected in our forecasts. The gas network is designed to meet the demand of all gas customers on a 1-in-50 year peak day, i.e. a severe winter peak day that is statistically likely to occur once every fifty years.

For the purpose of the N-1 Security of supply calculations, the 1-in-50 year peak day (the infrastructure standard) and average year peak demand days (the supply standard) are used. Section 5 will explain in greater detail the EU rules for calculating how much demand can be serviced in the event of a major supply disruption during peak demand.

Peak day forecasts show the same broad trend as the annual demand outlook. There are a number of interesting points to consider. For example, the residential sector tends to account for a larger proportion of overall gas demand on peak days, as this sector is particularly sensitive to weather conditions. In 2030 residential gas demand accounts for around 11.5% on an annual basis but on a peak day this rises to 20% of overall gas demand.

5.

Security Of Supply

The key questions this report seeks to address is how secure is Ireland's gas supply and how can we ensure its security long into the future. Today, Ireland has a secure gas supply, and this is expected to continue based on our forecasts.

However, there is room to improve and build greater resilience and flexibility into our gas network. For example, Ireland currently fails to meet certain EU standards for how much demand can be serviced in the event of a major supply disruption during peak demand. The options outlined in section 6 would help to improve Ireland's security of supply position.

Already Ireland is taking steps to improve its security of supply position. As outlined earlier, work to split the interconnector system in two, which improves Ireland's security of supply position, is ongoing. When completed, Interconnector 1 (IC1) and Interconnector 2 (IC2) will operate independently and IC2 will become Ireland's largest single piece of gas infrastructure.

This section looks at the current and projected security of supply position for Ireland up to 2040. It assumes that no new major infrastructure projects are advanced other than those which have already been identified.

5.1 EU regulations

Prompted by a 2009 gas dispute between Russia and the Ukraine, the EU decided to establish common standards for the security of gas supply.

In December 2010, the European Parliament introduced Regulation (EU) No 994/2010 to safeguard security of gas supply across the EU. This regulation provided common infrastructure and supply standards at EU level.

In November 2017, this regulation was repealed and replaced with Regulation (EU) 2017/1938. The newer regulation introduced a solidarity principle, which aims to develop a stronger collective response to energy supply risks in the future. It states that "in the event of a severe gas crisis, neighbouring member states will help out to ensure gas supply to households and essential social services".

Regulation 2017/1938 establishes two important security of supply standards: the Infrastructure Standard and the Supply Standard. These standards are used to assess how a country's gas network would be affected by the loss of its largest piece of gas infrastructure, and to evaluate if it has sufficient capacity to meet the demand of protected customers. These standards are central to the analysis presented in this report in terms of evaluating Ireland's security of supply position.

Regulation (EU) 2017/1938

Article 5, the Infrastructure Standard: "Ensure that the necessary measures are taken so that in the event of a disruption of the single largest gas infrastructure, the technical capacity of the remaining infrastructure, is able to satisfy **total gas demand** during a **day of exceptionally high gas demand**."

Article 6, the Supply Standard: "Ensure the **gas supply to the protected customers** for a period of **30 days** in the case of disruption of the single largest gas infrastructure **under average winter conditions**."

Protected customer demand is defined as all non-daily metered (NDM) sector customers. This refers to customers with annual gas usage of less than 5.55 GWh, and includes all residential gas customers and SMEs in the Industrial & Commercial sector. Protected customer demand also includes priority customers in the daily metered (DM) sector, such as:

- Hospitals and nursing homes including retirement homes
- High security prisons
- District heating schemes and further categories of essential social services as determined by the Commission for Regulation of Utilities (CRU) from time to time.

5.2 The infrastructure standard

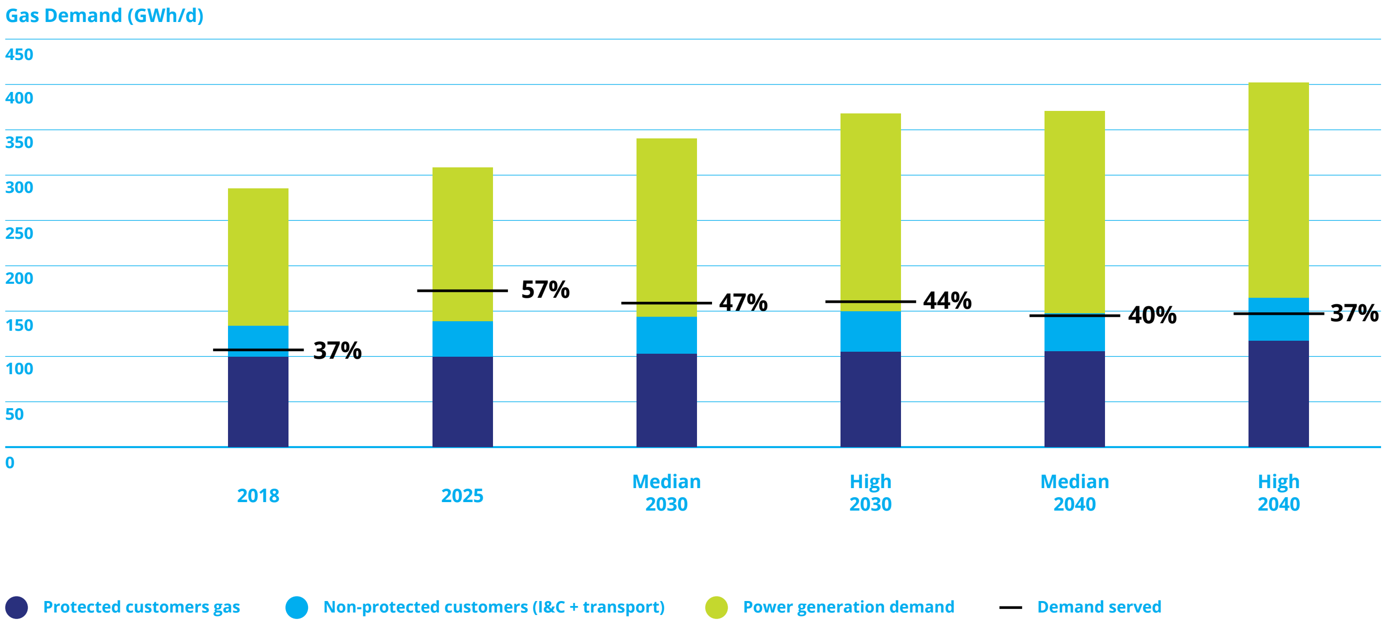
Today Ireland's largest piece of gas infrastructure is the Moffat interconnector system in Scotland. If, on a 1-in-50[4] winter peak day (i.e. a severe winter peak day that is statistically likely to occur once every fifty years), this interconnector system failed, Ireland would not have sufficient gas supply to meet 100% of demand as required by the standard. Currently about 37% of demand can be met under such circumstances. This means that Ireland does not meet the infrastructure standard set out in the EU regulations.

The so-called N-1 disruption calculation shows what percentage of gas demand could be serviced by remaining infrastructure in the event of such a disruption. The N-1 result for the infrastructure standard is widely seen as the key indicator for the overall resilience of European gas infrastructure.

While the 2018 calculation is provided for context, our analysis looks forward to 2040. In both the median and high gas demand scenarios, Ireland faces a significant shortfall for 2025, 2030 and 2040, with the percentage of gas served ranging from 37% to 57%. See Figure 5.1 for the N-1 results and the impact on the various gas demand sectors. In all cases protected customer demand is met.

The security of supply regulation allows countries to meet the requirements on a regional basis, and Ireland currently meets the requirements when assessed alongside the UK. Given uncertainty around Brexit, it is important that Ireland monitors developments in this regard. Ireland may need to consider the regulatory implications with regard to the infrastructure standard or address the shortfall through investment in infrastructure.

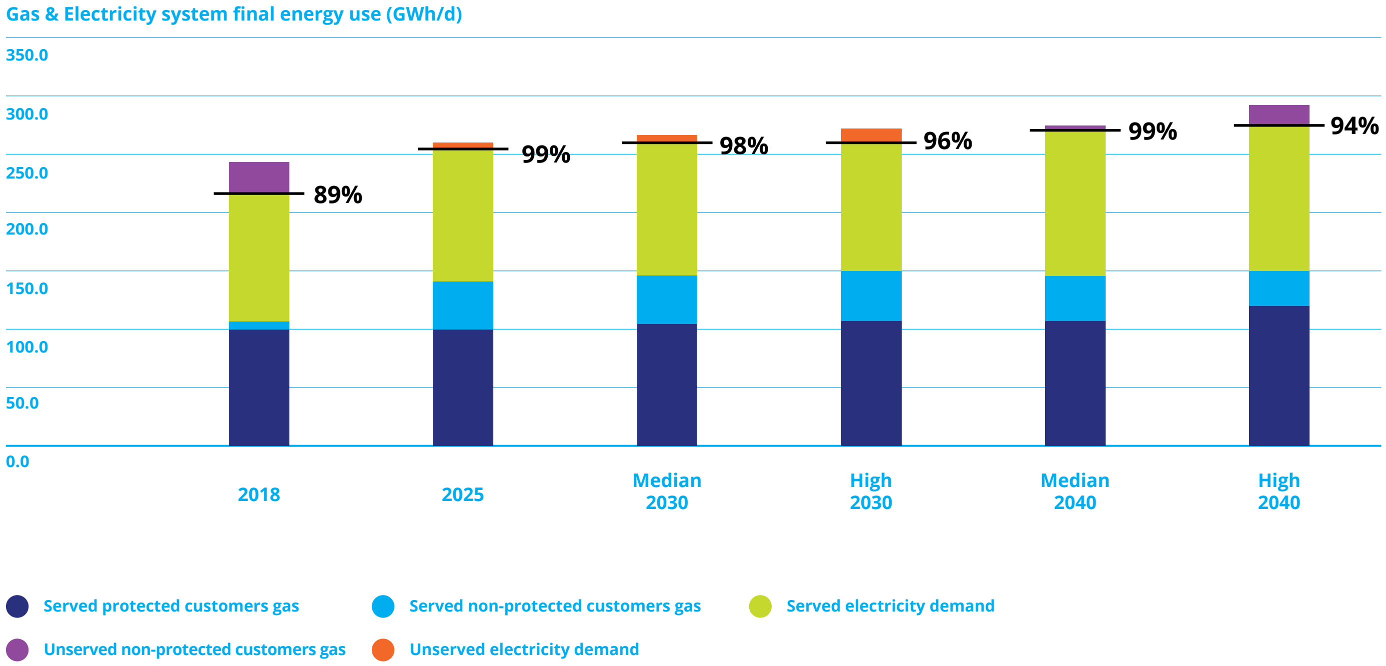
Figure 5.1: Infrastructure standard, N-1 position on a 1-in-50 peak day



4 The N-1 calculations presented here refer to a 1-in-50 year peak day, as the gas network is designed to this standard. Regulation (EU) 1938 / 2017 refers to a 1-in-20 year peak day.

The ongoing project to split the interconnector system in two means that in the case of an N-1 disruption Ireland would still have access to gas supplies from IC1. This would mean that, even in an N-1 scenario, there would be very little loss in terms of final energy use[5] for the gas and electricity systems and that the system is capable of withstanding the loss of the single largest piece of gas infrastructure without significant impact on end users. This is shown in Figure 5.2.

Figure 5.2: Gas & electricity system, Final Energy Use – 1-in-50 year peak day.



In year 2018 all protected customer gas demand is met through supplies from Corrib, however non-protected gas demand including gas used for power generation is impacted. This does not however result in any impact on the electricity system as back up fuels at gas power plants and other forms of power generation meet the power generation requirement. In later years gas supplies from IC1 minimise any impact on gas end users. The shortfall for gas demand in power generation is for the most part covered by back up fuels and other power generation even in the case of these extreme peak day demands for gas and electricity.

5 Final Energy Use refers to energy used by gas and electricity end customers including residential, industrial and commercial users. It does not refer to gas used in power plants.

5.3 The supply standard

Under EU rules, this standard ensures that countries have enough gas supply to service the needs of protected customers for a period of 30 days in the case of disruption of the single largest gas infrastructure under average winter conditions. Ireland defines protected customer demand as all residential gas customers, SMEs, hospitals, nursing homes, high security prisons, district heating schemes and other essential social services.

Ireland currently meets this standard and is projected to do so in the future too. In all cases, Ireland has sufficient gas supply to meet protected customers' demand.

5.4 Extended outages

A set of disruption calculations for prolonged outages have also been developed to further test the resilience of the system and to determine any possible impact on the electricity system. The extended outage scenarios are as follows:

- 2 week cold spell (under 1-in-50 year conditions)
- 1-month supply disruption, supposing average winter conditions
- 3-month supply disruption, supposing average winter conditions

The two week cold spell is the most onerous outage scenario as this refers to a severe weather event (i.e. a 2 week cold spell in a 1-in-50 year winter). The one month and three month outages refer to average year winter conditions, averaged over a longer period, so a greater proportion of gas demand is served due to the lower demand requirement. In all of these cases there is a shortfall in terms of the available gas supply, with some impact on the power generation sector.

Table 5.1: Base case extended outages, N-1 results – median & high demand scenarios.

			Median		High	
Extended Outages – median demand	**2018**	**2025**	**2030**	**2040**	**2030**	**2040**
2-week cold spell	54%	72%	67%	59%	59%	53%
1-month average winter	57%	89%	81%	72%	70%	63%
3-month average winter	59%	90%	82%	73%	76%	65%

5.5 The electricity system

An analysis of the impact on the electricity system of a major gas infrastructure disruption was also conducted, measuring Expected Energy Not Supplied (EENS).

The availability of other forms of power generation, residual gas supplies and so on were factored into these calculations to determine if there was any impact on the electricity system as a result of a major gas infrastructure disruption. In most cases there is limited or no impact on power generation as a result of a gas shortfall.

Demand is met through a combination of other sources, including backup fuels which are required to be held at gas power plants. Gas fired generators are required to have a supply of backup fuel equivalent to 5 days continuous running at full output. For peak day outages these backup fuels are effective in mitigating potential outages. For longer outages the average demand is lower and so there is more gas available to the power generation sector. Less back-up fuel is consumed in the system and thus back-up fuel stocks can be stretched over a longer duration. In such circumstances power generation could be served by a combination of back-up fuels and the available gas.

The largest electricity demand shortfall predicted for 2030 is in the high demand scenario, and represents a loss of around 9%. In 2040 there is no shortfall in the electricity system, as additional gas plant capacity is assumed, which will have additional back up fuels. If electricity demand is not served by gas in these circumstances, the additional gas plants will have a reserve of back up fuel which can help meet electricity demand.

Distillate oil, which has far higher CO_2 emissions than natural gas, is typically used as the back-up fuel. But there are operational risks associated with switching over to back-up fuels, and the costs of running on back-up fuels for power generators are also a lot higher.

5.6 The outlook

Once the splitting of the gas interconnector system is complete, the gas system will be capable of withstanding the loss of the single largest piece of gas infrastructure without significant impact on end users.

However, despite the positive outlook regarding the security of supply position, measures which may further enhance security of supply resilience could be considered. This would bolster Ireland's security of supply position in the face of challenges such as a lack of gas import diversification and the potential market risk associated with Brexit.

Diversification is also a key factor in ensuring security of supply as the more import routes available the more resilient the security of supply position. Ireland's gas supplies are among the least diversified in Europe. An LNG import terminal or a gas connection to another country would significantly improve Ireland's supply diversification position.

These, and other mitigation measures, are evaluated in the next section.

6.

Options

Gas Networks Ireland and EirGrid have examined a number of options which could improve Ireland's security of supply position. These potential mitigation measures would improve the overall resilience of the gas network system, and also reduce any potential negative impact on the electricity system.

In this analysis, we have considered the following options and their impact on the supply position:

- Bio-methane production
- Fixed Liquefied Natural Gas (LNG) terminal
- Floating LNG terminal
- Further gas interconnection
- Permanent gas storage
- Non-gas mitigation measures:
  - Electricity interconnection
  - Oil stocking

Before we consider our analysis of the possible options available, let's consider the experiences of other countries. Natural gas plays an important role in the energy systems in many countries, making up a significant proportion of total primary energy requirement (TPER) and contributing to electricity output in many countries.

For example, Finland, Lithuania, Portugal and Greece have relatively similar sized gas markets to Ireland and all four countries rely heavily on imported gas. Each of them has, or is planning, mitigation measures to make them less vulnerable to supply disruptions.

In terms of the options considered in other countries to boost gas supply resilience, the following key themes are evident.

I. Liquefied Natural Gas (LNG) terminal development

Portugal, Greece and Lithuania have successfully developed LNG import terminals which have diversified their gas supply. Finland is also developing LNG storage facilities.

II. Additional Import routes for pipeline gas

Finland, Greece and Lithuania are developing interconnectors with other countries to increase the resilience of their gas supplies. For example, the BalticConnector will end Finland's sole reliance on its interconnector with Russia.

III. Developing gas storage

Portugal has successfully developed gas storage facilities and now holds enough storage capacity (underground gas storage and LNG) to meet over 100% of its peak demand. In Lithuania, LNG supplies imported through the LNG terminal in Klaipeda that are not immediately consumed, can be stored in underground storage in Latvia.

The European Experience

Portugal

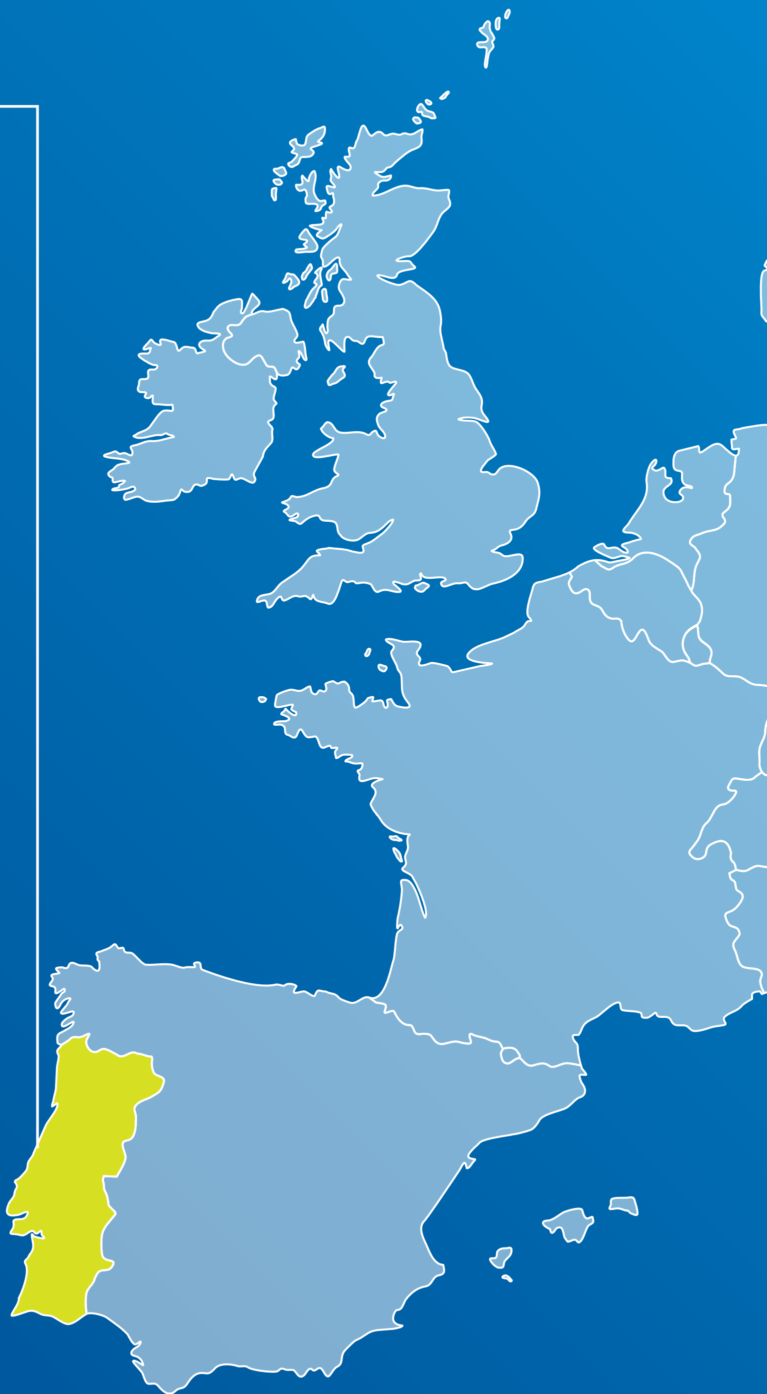
Portugal does not have an indigenous supply of gas, so is reliant on imports to meet gas demand. Gas is imported through two interconnectors with Spain and through the LNG terminal at Sines. Portugal is addressing its security of supply concerns as follows:

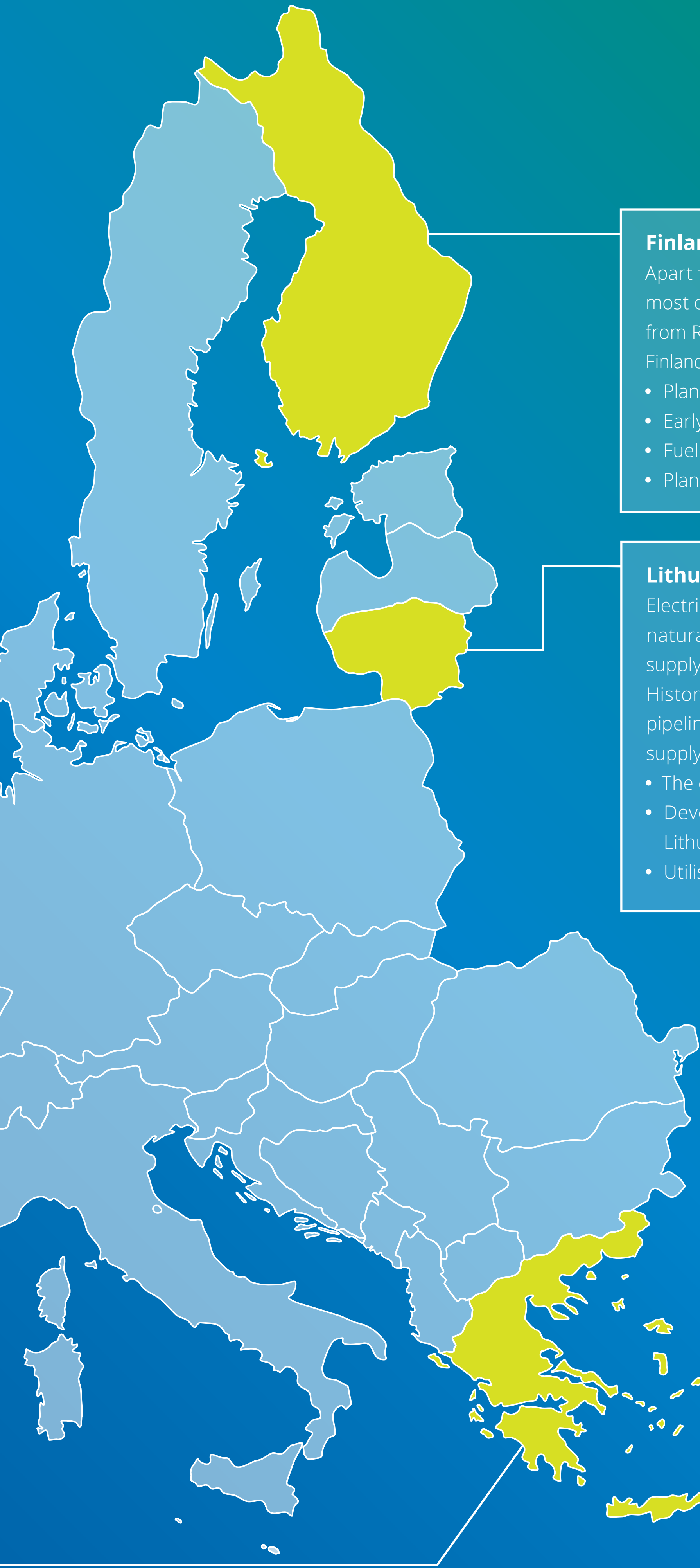
- A third interconnector with Spain
- Sines LNG terminal
- Permanent underground storage

Greece

Greece is also highly dependent on imports of natural gas to meet gas demand. It is highly reliant on Russian gas imports, with an average of over 60% of its gas supply coming from Russia between 2010 and 2016. Greece is addressing its security of supply concerns as follows:

- Diversification of supply sources
- Development of LNG import terminals





Finland

Apart from bio-methane, Finland relies on imports to meet most of its gas demand. All of its gas imports come directly from Russia, leaving it vulnerable to gas supply disruptions. Finland is addressing its security of supply concerns as follows:

- Planned development of the BalticConnector
- Early warning systems with Russia
- Fuel switching
- Planned development of LNG storage

Lithuania

Electricity is generated mainly from renewable sources and natural gas, but Lithuania does not have an indigenous supply of natural gas and so is highly dependent on imports. Historically all gas was imported from Russia via a single pipeline from Belarus. Lithuania is addressing its security of supply concerns as follows:

- The construction of an LNG terminal in Klaipeda
- Developing a gas interconnector between Poland and Lithuania
- Utilising underground storage facilities in Latvia

6.1 Evaluating possible options for improving Ireland's security of supply

We have conducted both a cost benefit analysis and a qualitative assessment for each potential measure. Each scenario is evaluated over a 20 year time horizon, with 2025 as the starting point for the analysis.

6.2 Cost benefit analysis (CBA)

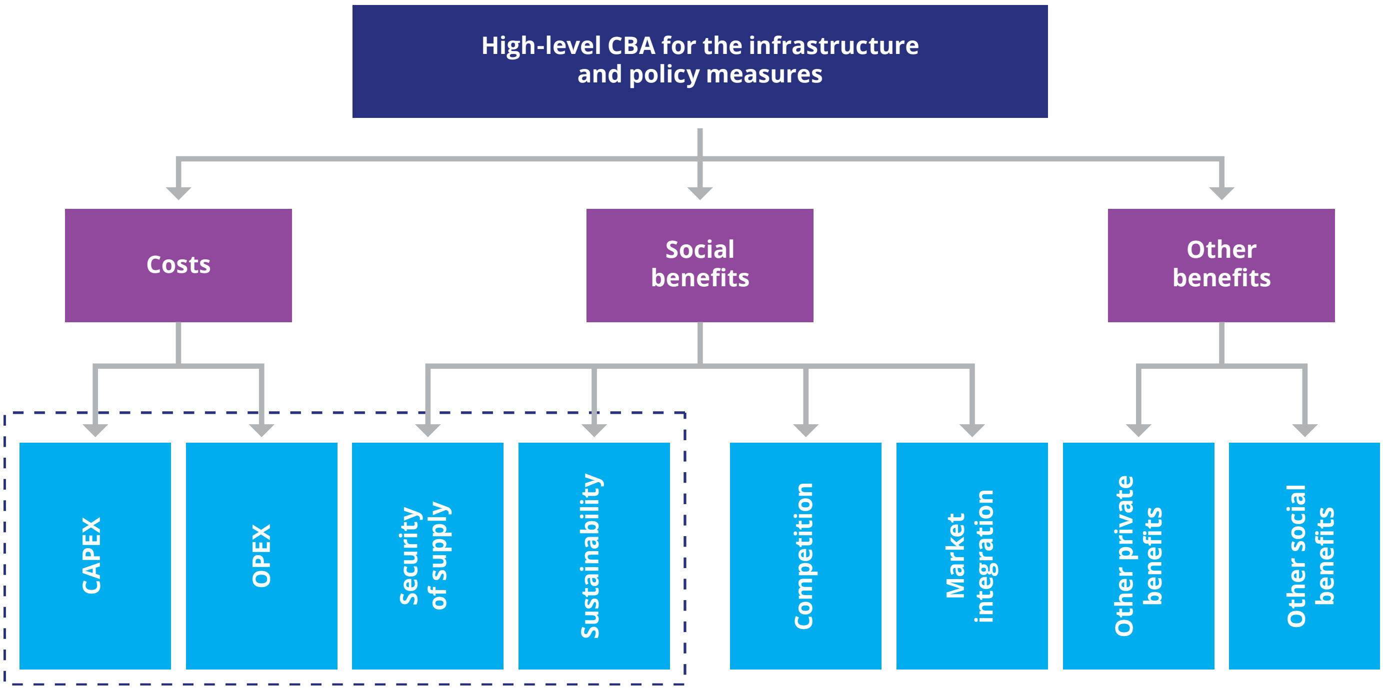
Our analysis quantifies the costs and benefits of each possible mitigation measure using a CBA methodology. The analysis, which provides a relative comparison of potential mitigation measures, is consistent with the methodology used by the European Network of Transmission System Operators (ENTSOs) for gas and electricity.

The CBA analysis accounts for capital costs (capex) and operational costs (opex). It considers both security of supply and sustainability benefits. For the sustainability benefit, emissions savings are evaluated with respect to projected CO_2 pricing.

To assess the security of supply benefit, we calculate the value of lost load (VoLL). The Value of Lost Load (VoLL) is defined as the value that consumers place on a unit of non-delivered gas. Therefore it represents the value that consumers attribute to security of supply. The VoLL used in our calculations is specific to Ireland and takes into consideration the real costs of a gas outage in Ireland.

This CBA methodology, while useful for a relative comparison of possible options, does not deal with private benefits, such as company profits. It is designed to show which projects deliver the greatest social benefits, and require the least private benefit to recoup their costs.

Figure 6.1: CBA Methodology



The detailed analysis conducted to date represents a thorough and considered first step, and was designed to identify the most viable mitigation measures and inform future policy. To add to this report's findings, a more detailed and comprehensive CBA for each of the possible mitigation measures is required before proceeding. This should include consideration of any private benefits associated with the preferred option(s).

6.3 Qualitative assessment

A qualitative assessment has also been undertaken alongside the CBA analysis. This assessment considers the potential barriers to the success of each considered option, and recommends the best way(s) to overcome these barriers.

The scenarios considered in this study increase Ireland's ability to deal with an outage in the gas system. However, the security of supply benefits of most options do not outweigh the costs. Thus other benefits and considerations need to be taken into account before any investment decision is made.

6.4 Bio-methane production

In March 2017, a European Commission study[6] highlighted Ireland's potential to produce more renewable gas per capita than any other country within the EU by 2030. In June 2017, a Sustainable Energy Authority of Ireland (SEAI) report[7] highlighted that Ireland has a number of waste sources, such as food waste, manure and slurry, which could be used to produce bio-methane at little or no cost.

Bio-methane is a key component of Gas Networks Ireland's growth strategy, with several bio-methane projects likely to connect to the network in the short term. By 2025 it is expected that there will already be substantial volumes of bio-methane on the system. Gas Networks Ireland estimates that up to 30% of demand could be met by renewable gas by 2040.

Gas Networks Ireland have considered a number of bio-methane production scenarios. A 'Hub and Pod' system appears to be the best solution with the widest application for the Irish agriculture sector. This system involves on-farm Anaerobic Digesters in regional clusters (Pods), where organic matter is broken down by anaerobic bacteria and converted into methane. Each Pod has its own efficient, low cost gas purification unit. The gas is then brought to central injection points (Hubs). Currently four renewable gas projects in Ireland are using a 'Hub and Pod' system, with 12 more projects in development. Further growth is expected, with up to 43 hubs in place by 2030.

The Department of Communications Climate Action and the Environment is currently examining how best to support biomethane production and injection in to the gas Grid.

CBA: The costs associated with connecting bio-methane to the network are lower than the cost of expanding interconnector capacity to deal with future demand. Bio-methane is clearly beneficial in terms of security of supply, but the main benefit is a sustainability benefit.

Table 6.1: Biomethane Development – key assumptions

	2025	2030	2040
Biomethane production (GWh/yr)	4,260	11,467	18,465
No. of Biomethane injection facilities - cumulative	21	36	56
Capex - cumulative - (€ mln.)	18.9	32.4	50.4
Annual opex (€ mln.)	0.4	0.7	1.1

Qualitative assessment: In contrast to the other infrastructure scenarios considered, bio-methane production can be increased in incremental steps, which allows government and investors to respond to a changing gas market and minimise risk. While the projected growth in bio-methane is not sufficient to replace gas production at Corrib, it will reduce Ireland's reliance on gas imports and reduce the need for incremental increases in the interconnector system capacity in the future, should it be required. Bio-methane also helps Ireland to meet its environmental targets, create employment and boost regional development.

6 Optimal use of biomethane from waste stream: An assessment of the potential of biomethane from digestion in the EU beyond 2020'
https://ec.europa.eu/energy/sites/ener/files/documents/ce_delft_3g84_biogas_beyond_2020_final_report.pdf

7 'Assessment of Cost and Benefi¬ts of Biogas and Biomethane in Ireland'
https://www.seai.ie/resources/publications/Assessment-of-Cost-and-Benefits-of-Biogas-and-Biomethane-in-Ireland.pdf

6.5 Liquefied Natural Gas (LNG)

Liquefied Natural Gas (LNG) has the potential to offer a significant security of supply benefit as well as access to a diversified worldwide LNG market. We have considered two options: fixed and floating.

Floating LNG regasification facilities provide similar benefits to a fixed LNG terminal in terms of security of supply and source diversification, but at a lower cost and typically with shorter lead times.

One key advantage of a floating LNG terminal is that it carries a far lower stranding risk. If a fixed LNG terminal is no longer required and closes, there is little scope to recoup the investment. However, a floating LNG terminal can be easily moved, offering an opportunity for it to be sold if it is no longer needed in Ireland.

A significant amount of new liquefaction capacity is currently under construction, in the US and Australia in particular. However LNG prices are currently low and may need to recover somewhat to stimulate further investment in LNG liquefaction capacity.

CBA: The floating LNG option delivers the same security of supply benefit as the fixed LNG terminal, but at a much lower cost. As a result, a floating LNG terminal is seen as an effective, lower cost solution and a preferred mitigation measure.

Table 6.2: LNG key assumptions

	Floating LNG	Fixed LNG
LNG Storage volume (m^3)	174,000	400,000
Equivalent volume of gas (GWh)	1,073	2,467
Max send out rate (GWh/d)	233	233
Total Capex € mln.	375	600
Total Opex € mln. / yr	12	20

Qualitative assessment: Both the fixed and floating LNG terminal lead to a significant improvement in Ireland's security of supply position. The floating LNG terminal has a number of advantages over a fixed terminal:

- Lower costs
- Shorter lead time
- Opportunity to monetise residual value as a floating LNG terminal can be moved and sold to others if the terminal is no longer needed in Ireland.

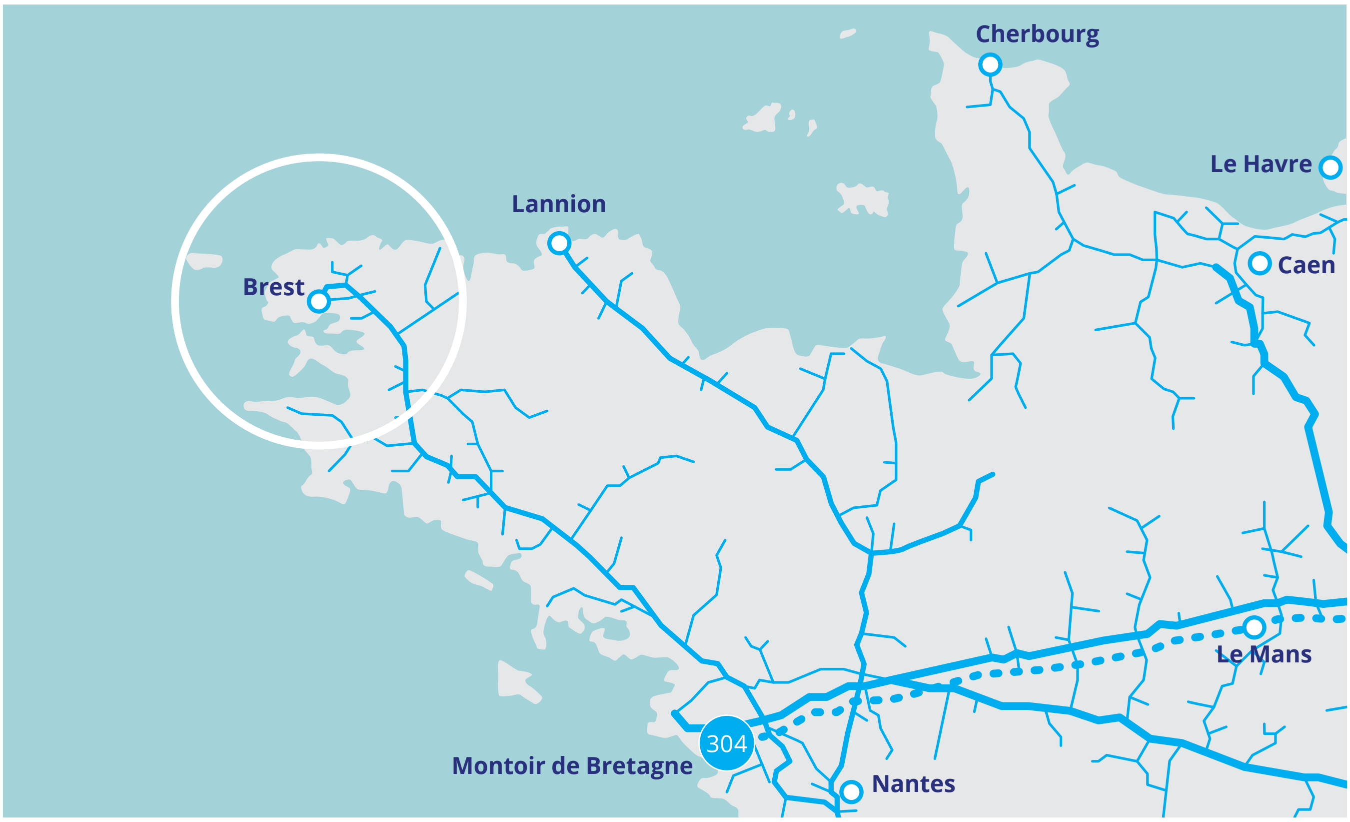
6.6 Gas Interconnector to France

A gas pipeline between Ireland and France would allow Ireland to integrate with European gas markets, provide more diverse supply and improve the security of supply position.

In order to transport gas between France and Ireland, to allow for gas imports from France, additional infrastructure would be required. This would include a subsea interconnector pipeline between France and Ireland and some reinforcement of the gas network in Cork where the subsea pipeline would connect with the Irish gas network.

Based on our analysis, the best option would be connecting the gas networks from Cork to Brest using a subsea pipeline. This represents the shortest possible route between Ireland and France at 509 km.

Figure 6.2: Potential tie-in location for Ireland to France gas interconnector



CBA: A gas interconnector to France, while having a positive impact in terms of security of supply and diversification, would have less impact than either of the LNG options. Building a gas interconnector would not on its own result in Ireland meeting the required EU infrastructure standard. This option requires the largest capital investment of the mitigation measures under consideration.

Table 6.3: Gas Interconnector to France – key assumptions

Interconnector Capacity (GWh/d)	100
Pipeline Length (km)	509
French Compressor station discharge pressure (bar g)	120
Inlet pressure at RoI landfall (bar g)	70
Total Capex (€ mln.)	727
Total Opex (€ mln./yr.)	2.7

Qualitative assessment: A gas interconnector to France would allow large volumes of gas to be imported in to Ireland, improving the security of supply position and diversifying Ireland's supply. However, based on the cost assumptions developed, this option would not appear to be to be the most economically advantageous option due to the large capital investment required.

6.7 Permanent gas storage

Until recently Ireland had an underground gas storage facility in Kinsale, which operated on a seasonal basis. However, storage operations there have now ceased. With a reduced seasonal gas price differential in recent years, continued operation of the facility was no longer economically viable.

The most likely underground storage option for Ireland is likely to be a depleted gas field as Ireland does not have access to salt caverns or any other suitable geological structures.

In the longer term the Corrib gas field could potentially be used as a storage facility, but not during its productive life as a gas field. A significant divergence between winter and summer gas prices would also need to re-emerge in order to make gas storage a viable option.

CBA: Like the gas interconnector to France, the permanent storage option does not offer the same security of supply mitigation benefits as the two LNG options. Permanent storage alone is not sufficient in terms of extra capacity so as to meet the infrastructure standard.

Table 6.4: Underground gas storage – key assumptions

Working volume (GWh)	5514
Deliverability (GWh/d)	79.4
Cushion gas requirement	45% of total capacity
Total Capex (€ mln.)	423
Total Opex (€ mln. / yr.)	8.8

Qualitative assessment: In contrast to the other infrastructure options considered, and despite an improvement in the N-1 position, gas storage does not allow Ireland to import or produce more gas. It only allows imported gas to be used at different times in order to better cope with demand peaks. Initial estimates suggest that the private benefits required for a storage site to be viable are greater than those required for a floating LNG terminal.

6.8 Key Questions

What impact would these measures have on Ireland's security of supply position?
Based on the security of supply calculations outlined earlier, we've considered how each of the possible options outlined above would improve Ireland's capacity to service demand in the event of a major gas infrastructure disruption.

While the N-1 calculation shows an improvement in all scenarios, the improvement is greatest in the case of the two LNG options, as shown in Table 6.5. The permanent storage and gas interconnector options also add significantly to the resilience of the system. Furthermore Figure 6.3 overleaf shows that the most cost efficient option to improve the N-1 position would appear to be a floating LNG terminal coupled with bio-methane production.

Table 6.5: Infrastructure standard N-1 position for proposed mitigation measures

			Median demand		High demand	
Infrastructure standard	**2018**	**2025**	**2030**	**2040**	**2030**	**2040**
Base Case	37%	57%	47%	40%	44%	37%
Bio-methane	37%	57%	51%	47%	48%	45%
Floating LNG	37%	57%	111%	103%	103%	95%
Fixed LNG	37%	57%	111%	103%	103%	95%
Permanent Storage	37%	57%	68%	63%	64%	59%
Gas IC to France	37%	57%	73%	67%	69%	63%

Which option leads to the most diversified supply mix?
Diversification is a key factor in ensuring security of supply as the more import routes available the more resilient the security of supply position. The CBA methodology underpinning this report's analysis considers the Import Route Diversification (IRD) indicator, which provides a measure of the diversification of import routes. The analysis showed that an LNG import terminal or a gas connection to another country, such as France as considered here, would yield the greatest improvement in Ireland's supply diversification position.

Which is the most cost advantageous option?

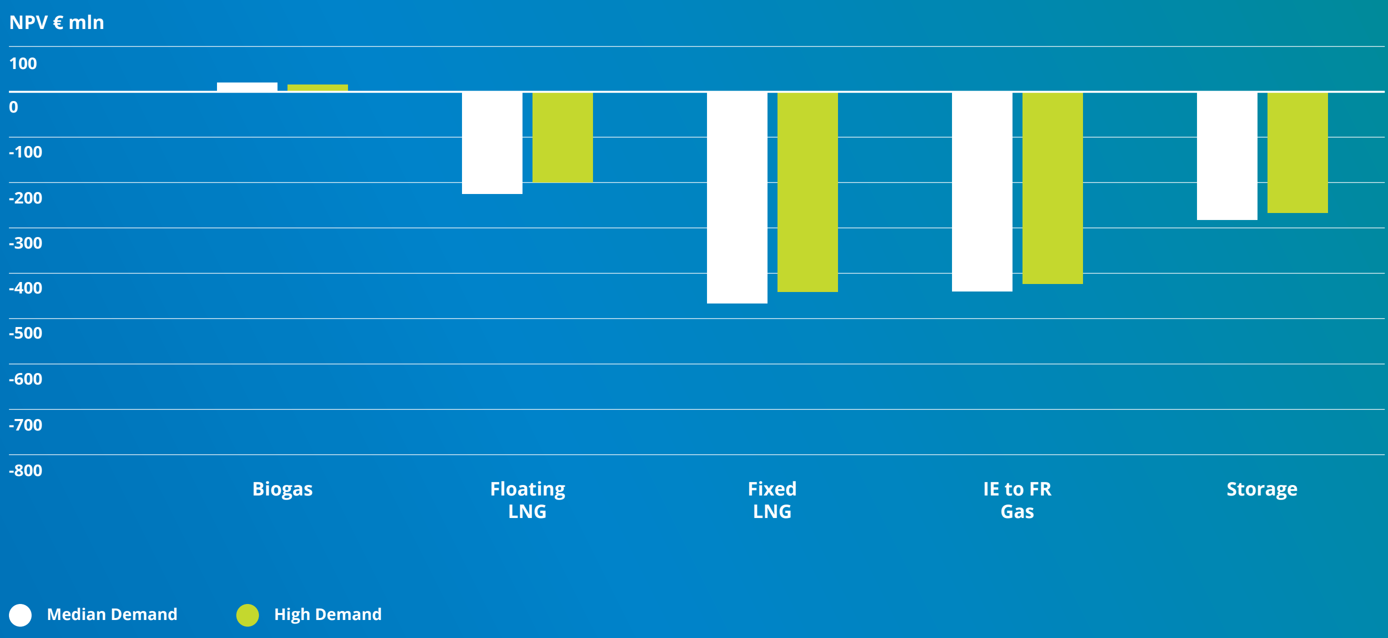
The CBA results were used to provide a relative comparison of projects as shown in Figure 6.3. These results do not give an absolute NPV value for the projects as private benefits, such as profits earned are not included in the analysis, in line with the ENTSOG methodology. This approach in effect shows which projects would need the least private benefits to show an overall societal benefit in order to provide a relative comparison.

The NPV results for each CBA tend to be dominated by project costs. This is due to the fact that security of supply mitigation benefits are dependent on both the Value of lost load (VOLL) and the probability of occurrence. The probability of losing the largest piece of infrastructure is quite low which feeds into the security of supply benefit.

The two LNG options offer the largest security of supply benefit. The floating LNG option, effectively has the same security of supply benefit as the fixed LNG terminal as the max send out rate is assumed to be the same in each case. However the costs associated with the floating terminal over the duration are substantially lower and this is resulted in the project ranking.

Based on the results of CBA analysis a floating LNG terminal, coupled with bio-methane development, is the most cost-effective option for Ireland to improve its security of supply position. While bio-methane shows a positive NPV result, bio-methane is not in itself effective in addressing the N-1 shortfall, as shown in Table 6.5 previously.

Figure 6.3: CBA Project comparison – Net Present Value



6.9 Non-gas mitigation measures

While much of the focus of this report is on improvements to gas infrastructure to improve Ireland's security of supply position, we also consider two non-gas mitigation measures that could be beneficial in the event of a major gas outage.

6.9.1 Electricity interconnection

A sensitivity study has been conducted to assess the potential for additional electricity interconnection to Europe and Great Britain to act as a mitigation measure for a gas infrastructure disruption event

Given the diversification effect, greater reliance could be placed on interconnection to continental Europe than additional interconnection to Great Britain. For this study, it is assumed that the additional electricity interconnection would be operational post-2025.

Electricity interconnectors can reduce demand for gas by substituting for electricity produced by gas fired generators to a limited extent. For the range of scenarios studied additional electricity interconnection can improve the infrastructure standard N-1 position by up to 2.2% for the gas network. However the improvement is significantly less than improvements from the LNG infrastructure projects studied, which improves the infrastructure standard N-1 position by over 50%.

While the study indicates increased electricity interconnection would deliver some limited benefit during a N-1 gas network disruption, this should not be considered the primary benefit or driver of increased electricity interconnection. In this context, an electricity interconnector will compare unfavourably to the other gas infrastructure projects assessed in this report.

However, these projects cannot be considered directly comparable as there are further non-security of supply benefits to electricity interconnection including increased opportunity for trade between Ireland and the coupled European electricity market, greater integration for the EU internal energy market in line with EU targets for electricity interconnection, and enablement of increased renewable energy penetration.

The costs and benefits of electricity interconnectors are assessed through the ENTSO-E Ten Year Network Development Plan (TYNDP) assessment process. This includes detailed assessments of the above benefits and others using a cost benefit methodology approved by the European Commission.

The treatment of electricity interconnectors in terms of security of supply needs to reflect the bi-directional nature of interconnector electricity flows and the availability of the physical electricity interconnectors. In the study, this has been accomplished by de-rating the capacity of the electricity interconnectors.

Within Great Britain, the electricity system has delivered secure supplies to date, although system stress has been greater in the electricity system than the gas system in recent years. However in the long-term, the Great Britain capacity market should be able to deliver the capacity needed to ensure electricity security of supply.

The French electricity market is also considered as it represents a potentially interconnected market in the future. The French electricity market is well connected with other EU member states. The French electricity supply mix is evolving to being less dependent on nuclear with greater levels of renewable and gas-fired generation. While electricity demand in France is sensitive to cold temperatures statistically, there is a lower level of coincident stress events between Ireland and France than between Ireland and Great Britain.

6.9.2 Oil stocking

An ability to rapidly switch to an alternative fuel in the event of a gas outage enhances system resilience and improves the security of supply position. Gas-fired power generators are designed to switch to another fuel, such as distillate oil, if necessary.

In 2009, Ireland's energy regulator imposed back-up fuel stocking requirements, making Ireland one of seven European countries to impose fuel stocking obligations. Gas fired generating units in Ireland must be capable of operating on a back-up fuel at no less than 90% of their primary fuel registered capacity.

The analysis shows that current back-up fuel stocking at gas fired power generation plants has a positive impact on the security of supply position and is sufficient in mitigating any impact on end users. Additional back-up fuel stocking requirements will not yield security of supply improvements, in terms of the key measures of security of supply such as the N-1 position as defined in the infrastructure standard. In this context there is no knock on effect on the electricity system as the infrastructure standard refers to a one day supply disruption and there will be sufficient back up fuels to keep thermal plants on line. For the longer duration outages considered in this report the demand requirements are less onerous[8] and so there is more gas available to serve gas power generation plants.

It should be noted that gas power plants are not well suited to running on back-up fuels for an extended period of time and this can introduce risks in terms of system operation. Furthermore, additional obligations would bring additional costs and requires that adequate stores of the back-up fuel are available.

8 The infrastructure standard refers to "a day of exceptionally high demand", whereas for the longer durations these refer to average conditions spread over a longer period.

7.

Next Steps and Recommendations

Ireland's gas network is well equipped to deal with forecasted peak demand in the years ahead. But we can improve further, by enhancing our security of supply position and building greater flexibility into our gas system.

The ongoing project to split Ireland's gas interconnector system means that protected customers, industrial customers and a significant portion of the power sector can be supplied with gas even in the unlikely event of failure of the largest piece of gas infrastructure.

However, Ireland still needs to do more to meet the infrastructure standard laid out in EU regulations.

In the years ahead, gas demand looks set to increase, while a decrease in indigenous production will make Ireland more dependent on gas imports. Spare capacity in our gas system will decline between 2025 and 2030, and will continue to decrease between 2030 and 2040.

Despite some challenges ahead, Ireland's gas system is secure and has adequate capacity to meet the needs of protected customers in all scenarios.

Other EU member states in a similar security of supply position to Ireland are currently progressing projects to enhance the resilience of their energy systems. Options pursued include LNG import terminals, gas storage and diversification of supplies through further interconnections.

We've considered these measures, and also the development of bio-methane, as possible solutions for Ireland. Bio-methane represents a significant opportunity for Ireland, given we have the highest bio-methane potential per capita in the EU. As well as the sustainability benefit, bio-methane can also provide a direct security of supply benefit and diversify gas sources.

The various options considered were evaluated using a cost benefit analysis methodology, designed to provide a relative comparison of gas infrastructure projects. A floating LNG terminal, coupled with bio-methane development, is the most cost-effective option for Ireland to improve its security of supply position. While other options, such as additional gas interconnection would bring security of supply benefits too, the impact of LNG is greater.

We recommend the following actions to ensure Ireland's continued security of supply:

1. Conduct a detailed cost-benefit analysis for a floating LNG terminal

The most economically advantageous option to improve the resilience of Ireland's gas supply is a floating LNG terminal.

However, the social benefits do not outweigh the costs. A detailed assessment of private benefits is required to determine whether such an investment would provide a broad societal benefit and a return for investors. Price and cost simulations and public consultation can be used to better understand the commercial interest in such a terminal. The analysis should include a robust Cost Benefit Analysis (CBA) including private benefits and consideration of possible funding and ownership options.

A floating LNG terminal would provide a direct connection for Ireland to the global LNG market and would allow us to diversify our gas supply. However, greater exposure to the LNG market comes with price risk, which could result in usage of an LNG terminal fluctuating. This variability of utilisation needs to be considered in terms of cost recovery. We recommend further analysis, including multi-scenario modelling of future LNG and pipeline gas prices to inform the level of utilisation and the private benefits associated with operating an LNG terminal.

2. Enable the production of bio-methane in Ireland

Bio-methane can help improve Ireland's security of supply position, providing an indigenous and sustainable energy supply source, especially for the heat and transport sectors.

The potential of renewable gas is clearly recognised under the EU's Renewable Energy Directive. Already Ireland is making progress in this regard. A certification scheme for renewable gas is currently being developed here and Gas Networks Ireland is involved in a project to install the first renewable gas injection facility in Ireland. The project will inject a considerable amount of renewable gas into the system and will act as a template for future projects.

However, without appropriate support, Ireland's considerable potential for bio-methane development is unlikely to develop to the extent required to have a significant impact in terms of security of supply and sustainability.

While private benefits are excluded from the scope of this study, they are an important consideration for policymakers. A stable regulatory and financial framework is required to encourage investment in bio-methane production. Any support scheme would be contingent on a CBA analysis.

3. Monitor opportunities for permanent gas storage in Ireland and gas storage operations in the rest of Europe

While it may not be economically viable to develop a gas storage facility in the short term, such a facility could potentially provide considerable benefits in the future, depending on gas market conditions.

We recommend monitoring gas market seasonal price spreads and storage facility development across Europe. Opportunities for gas storage in Ireland should also be monitored, with options for a gas storage site here reviewed when conditions for storage have improved and/or specific cost estimates can be made.

EIRGRID

Gas Networks Ireland