Irish Academy of Engineering

NATURAL GAS

Essential for Ireland's Future

Energy Security

July 2018
Ref. No. 01/02/07.18

THE IRISH ACADEMY OF ENGINEERING

The Irish Academy of Engineering is an all-island body, concerned with long-term issues where the engineering profession can make a unique contribution to economic, social and technological development.

Its members are Irish Engineers of distinction, drawn from a wide range of disciplines, and membership currently stands at 145.

Drawing on the experience and knowledge of its distinguished members, the Academy works to facilitate communication and dialogue on engineering-related matters. It regularly publishes reports and analyses, some jointly with other learned and professional bodies.

The Irish Academy of Engineering
22 Clyde Road, Ballsbridge, Dublin 4
Telephone: +353 1 665 1337
academy@iae.ie
www.iae.ie

Taskforce Members

Gerry Duggan
Michael Hayden
Terry Nolan
Don Moore
Jim O'Brien
David Timoney

Disclaimer

The members of the Taskforce and the contributors participated in extensive discussions in the course of a series of meetings, and submitted comments on a series of draft reports. Its contents convey the general tone and direction of the discussion, but its recommendations do not necessarily reflect a common position reached by all members of the Taskforce, nor do they necessarily reflect the views of the organisations to which they belong.

CONTENTS

1. EXECUTIVE SUMMARY

Natural gas plays a critical role in Ireland's energy mix and economy. Gas provides around 30% of Ireland's total primary energy and generates about 50% of Ireland's electricity. Many indigenous and multinational companies in Ireland rely on gas. Approximately 650,000 households in Ireland use natural gas for home heating.

Long-term energy outlooks from the International Energy Agency and other organizations forecast that worldwide gas consumption will continue to grow in the next 20 to 30 years. Ireland's Government has a vision of transitioning to a low-carbon economy by 2050. This will require a large increase in renewables and a shift to lower-carbon fuels like natural gas. Natural gas has the lowest carbon emissions of all fossil fuels and is an ideal complement to renewables. Ireland's dependence on gas will increase when the use of coal and peat for electricity generation ends around 2025/2030. Natural gas will be critical for Ireland's transition to a low-carbon future.

Ireland currently has two main sources of gas supply – Corrib and pipeline imports from Britain. There is also a small amount of gas supply from Kinsale. Corrib is expected to supply around 60% of Ireland's demand this year, with 5% coming from Kinsale and 35% imported from Britain. Gas supply from Kinsale will end by 2021. Gas production from Corrib has already started to decline and by 2025 will supply less than 20% of Ireland's demand. Corrib production is expected to cease around 2030. In the absence of new measures Ireland would then be totally dependent on Britain for our gas supply. By 2030, Britain will need to import 75% of its gas due to the decline in North Sea production. Britain's gas imports will then come from Norway, Russia, Qatar and various countries outside Europe. The gas supply route to Ireland will be longer than at present with a greater risk of supply disruption and price volatility.

Relying on imported gas from Britain for all of Ireland's gas supply beyond 2030 is not advisable. Alternative sources of supply and supply routes need to be developed. Developing a Liquefied Natural Gas (LNG) import terminal in Ireland would enhance Ireland's security of gas supply and provide access to the increasingly competitive global LNG market. Development of some gas storage is recommended. Ireland is the only country in the EU without gas storage – despite our peripheral location and the criticality of gas in our energy mix. Exploration for gas offshore Ireland should also be promoted, with appropriate licensing terms and a fit-for-purpose regulatory framework. A combination of indigenous offshore gas and LNG imports would ensure the most competitive supply and best energy security.

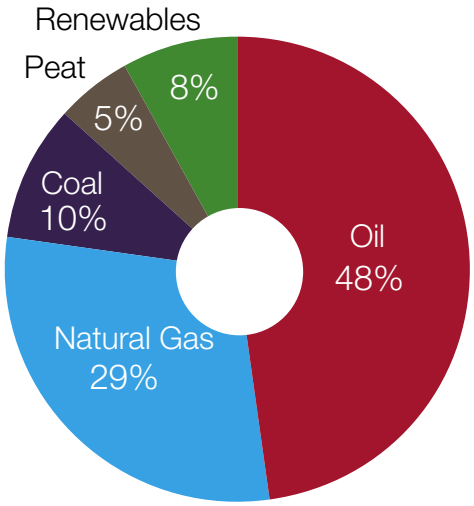
A strategic government plan is needed to diversify Ireland's gas supply. This strategic plan should include appropriate fiscal, licensing and legislative frameworks to facilitate the development of new sources of gas supply and encourage investment. The plan needs to factor in a lead-time of five to ten years for large energy infrastructure developments in Ireland. In view of the criticality of Ireland's future gas supply, this plan should be initiated forthwith.

2. INTRODUCTION

2.1 Importance of gas in Ireland's energy mix

Natural gas accounted for 29.4% of Ireland's total primary energy requirement in 2016[1] - see Figure 1. Fossil fuels – oil, natural gas, coal and peat - accounted for around 92% of total energy requirements in 2016 with renewables delivering around 8% of total primary energy.

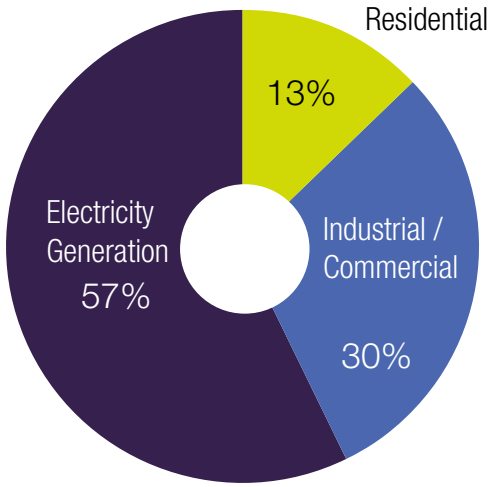
Figure 1: Ireland's Primary Energy Requirements



Consumption of natural gas in Ireland increased steadily from 1978 until 2008. Consumption peaked in 2008 and then declined over the next five years due to the economic downturn and increase in renewables. Ireland's gas consumption has been rising again since 2014 as the economy recovered. Gas consumption has increased by about 16% in the past two years. Total gas consumption in 2017 was approximately 5.1 billion cubic metres[2] (equivalent to 56 TWh).

Gas use is categorized into Electricity Generation, Industrial/Commercial and Residential sectors as shown in Figure 2.

Figure 2: Ireland's Gas Use

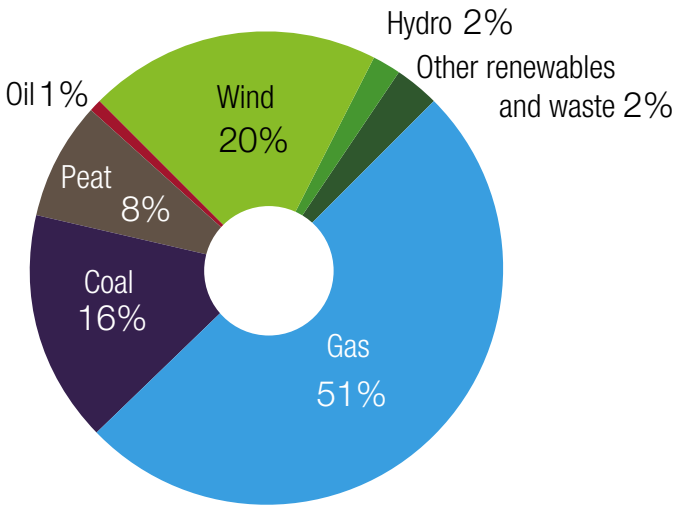


1 SEAI Energy in Ireland Report 2017
2 BP Statistical Review of World Energy 2018

Electricity

Natural gas is the largest energy source for electricity generation in Ireland. In 2016, natural gas accounted for 51% of electricity generation – see Figure 3. Renewables accounted for around 25%.

Figure 3: Electricity Generation 2016 – Outputs by Fuel



The amount of gas used for electricity generation varies widely depending on electricity demand and the amount of wind generation available. At peak demand and with low wind generation, gas fuels around 80% of Ireland's electricity generation. On the other hand, with low electricity demand and a large amount of wind generation, gas-fired generation can be as low as 15%.

Industrial/Commercial Sector

Gas usage for industry in Ireland has increased in recent years and now accounts for about a third of total gas consumption. There was a 50% increase in industrial/commercial gas use between 2009 and 2016. The main users are the dairy-processing, food and drinks, pharmaceutical and chemical industries. Demand in the industrial sector is less variable than the electricity or residential sectors.

Residential

Around 650,000 households in Ireland – 35% of all households - use natural gas for central heating. Gas demand in the residential sector is seasonal and very weather-dependent. Use of gas for residential heating is relatively low in Ireland compared with other European countries. Only 35% of homes use gas for heating in Ireland compared with 80% in Britain and 90% in the Netherlands.

2.2 Sources of Ireland's gas supply

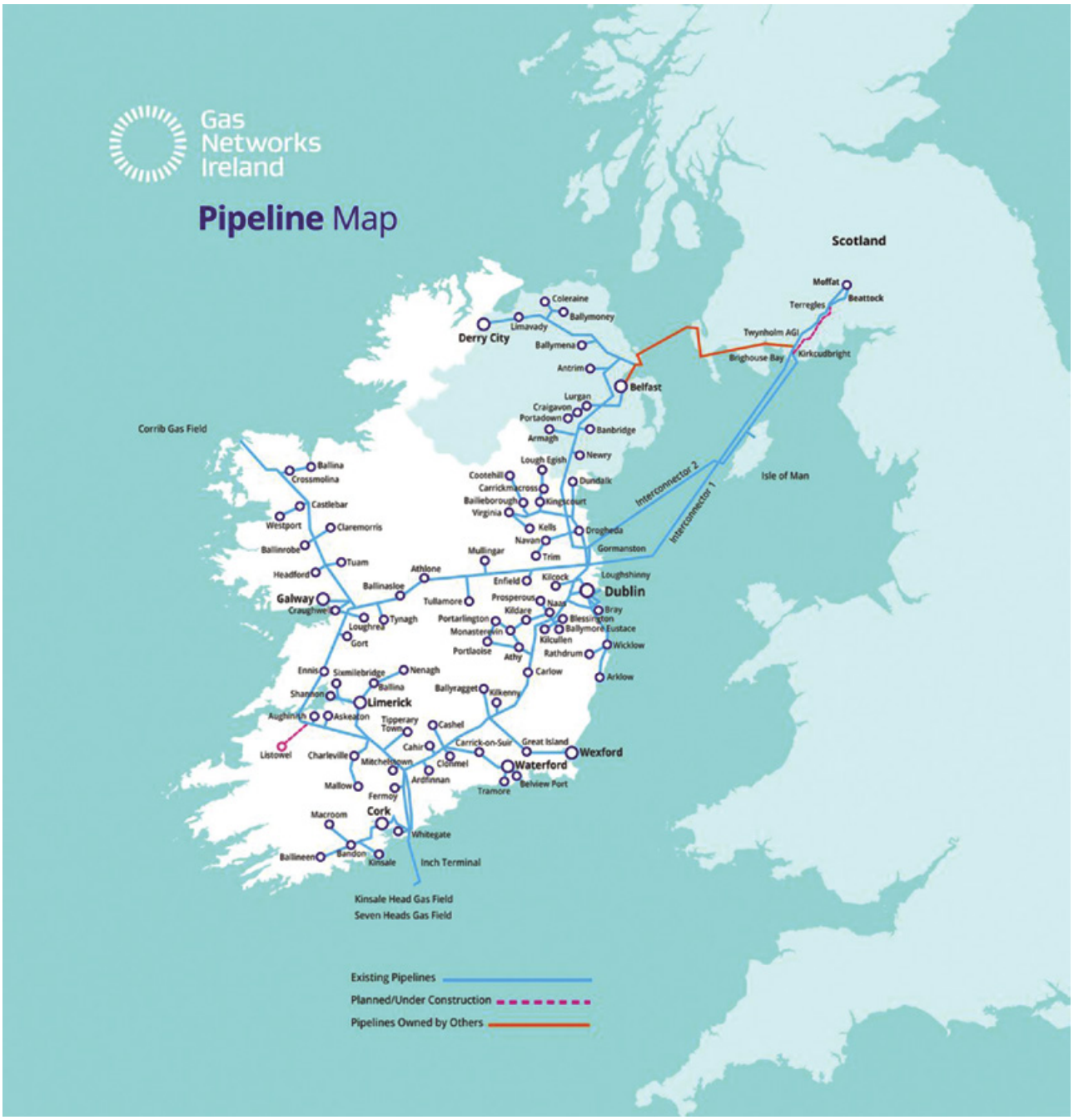
Indigenous gas production started in 1978 when the Kinsale gasfield commenced gas deliveries. Kinsale supplied all of Ireland's natural gas from 1978 to 1995. Since then, production from Kinsale has gradually declined and Ireland became increasingly dependent on imports from Britain – 95% of Ireland's gas was imported from Britain in 2015. The Corrib Gas Field came on stream in December 2015 and this has improved Ireland's gas supply security. In 2017 around 65% of Ireland's gas demand was supplied from indigenous sources, mainly Corrib, with 35% coming from Britain.

2.3 Ireland's gas transmission system

The Gas Networks Ireland (GNI) transmission network – 2,500 kilometres of high-pressure pipeline - comprises the Republic of Ireland onshore system, two interconnectors to Scotland and onshore pipelines in Scotland connecting to Britain's National Transmission System (NTS) at Moffat.

The construction of a new 50-kilometre pipeline in Scotland at a cost of €100 million, which will be completed this year, will further reinforce Ireland's interconnection to Britain's gas transmission system. This will result in two separate pipelines and interconnectors between Britain and Ireland – significantly enhancing Ireland's supply security and increasing the network system's capacity.

Figure 4: Ireland's Gas Network



3. IRELAND'S GAS OUTLOOK TO 2040

3.1 Short/medium term - up to 2026

Each year, GNI publishes a Network Development Plan which provides a view of how the gas network may develop over the coming 10-year period. The 2017 Network Development Plan[3] considers three scenarios up to 2026, namely low, median and high demand scenarios. In GNI's median demand scenario, annual gas demand is expected to grow by 12.5% by 2026 with no growth forecast in the low demand scenario and growth of 23% forecast in the high demand scenario.

- Economic (GDP) growth of 2.8% p.a.
- Renewable generation will continue to rise – reaching 40% of generation in 2023.
- Around 12,600 new residential gas connections each year.

3.2 Longer term – up to 2040

The Government's 2015 Energy White Paper highlights the ambition for a radical transformation of Ireland's energy system to meet climate change policy objectives. The vision set out in the White Paper is a reduction of between 80% and 95% in greenhouse gas emissions by 2050 compared with 1990 levels. The White Paper indicates that in the short to medium term there will be a shift away from more carbon-intensive fuels like peat and coal to lower-carbon fuels like natural gas as Ireland transitions to a low-carbon future.

Based on an examination of long-term energy outlooks from the International Energy Agency and various other organizations (see box below), the Academy believes that natural gas will continue to be a large part of the world's, Europe's and Ireland's energy mix until at least the middle of this century.

To form a view on how gas use in Ireland might change in the next 20 to 30 years, the Academy has studied the various scenarios for global and European gas in the World Energy Outlook 2017[4] which was published by the International Energy Agency (IEA) in November 2017.

WEO 2017 presents three scenarios for global energy through to 2040.

The Current Policies Scenario excludes new policy targets and considers only the impact of those policies and measures that are enacted in legislation as of mid-2017.

The New Policies Scenario describes where existing policies and announced intentions might lead the energy system.

The Sustainable Development Scenario is based on an integrated approach on the energy-related aspects of the UN Sustainable Development Goals and determined action on climate change.

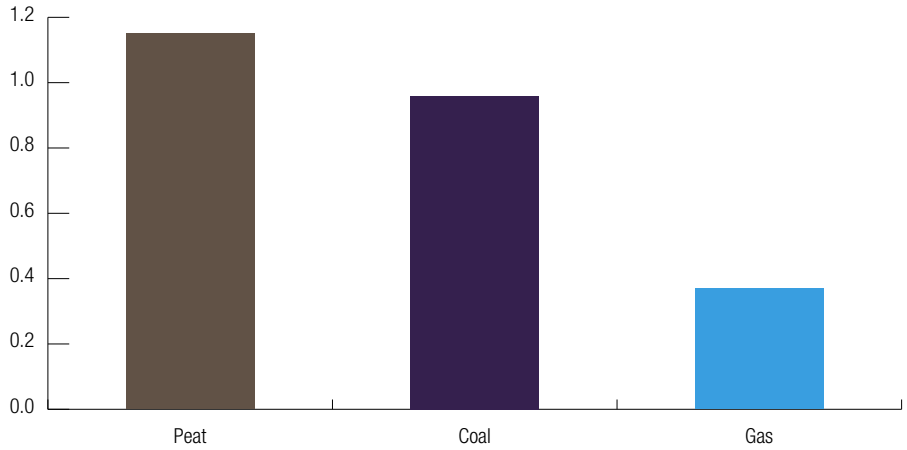
In the New Policies Scenario (the central scenario), global energy demand would rise by 30% between today and 2040 and global gas demand would rise by 45%. In the Sustainable Development Scenario, gas would become the largest single fuel in the global mix as coal use declines and oil consumption peaks. Gas consumption in 2040 would be 20% higher than today. Most of the increased demand comes from Asia and the Middle East in all scenarios. EU gas demand in 2040 would be around the same as 2016 levels in the New Policies Scenario; 20% higher in the Current Policies Scenario and about 20% lower in the Sustainable Development Scenario.

Many organisations – government energy agencies, major oil companies, large consulting companies - publish long-run energy projections and outlooks. Comparing the IEA's Energy Outlook with these alternative projections helps to highlight differences of view and areas of uncertainty. BP's latest World Energy Outlook includes a comparison with outlooks from other sources. All outlooks show global energy demand continuing to grow over the next 20 to 30 years with gas growing faster than all other energy sources, apart from renewables.

3 GNI Network Development Plan 2017
4 World Energy Outlook 2017 published 14th November 2017

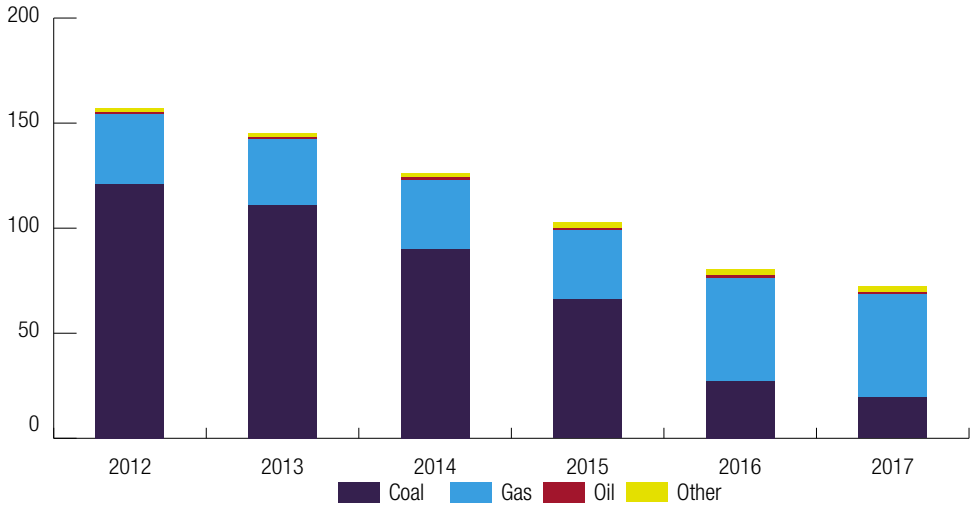
Renewables will account for a growing share of Ireland's electricity supply in the next 20 to 30 years. Wind and solar generation are expected to provide up to a half of Ireland's annual electricity. Fossil fuels will be needed to generate the other half – a higher share than many European countries which have nuclear power stations (about 25% of the EU's electricity generation[5] comes from nuclear power). Natural gas is the cleanest-burning fossil fuel, producing around half the carbon dioxide – see Figure 5 - and just one tenth of the air pollutants of coal.

Figure 5: Electricity Generation – Carbon Emissions[6] by Fuel Type (tonnes CO_2 per MWh generated)



Several countries, including the US and the UK have achieved significant reductions in carbon emissions by switching from coal to gas for electricity generation. US power generation emissions fell by 25% between 2006 and 2016 largely as a result of coal to gas switching.[7] UK carbon emissions from power stations reduced by 30% between 2015 and 2017[8] due to an increase in renewables and a large shift from coal-fired to gas-fired generation – see Figure 6.

Figure 6: Carbon dioxide emissions from UK electricity generation (million tonnes)



In the Academy's view, a combination of renewables and gas-fired generation will be the most effective way to reduce emissions in Ireland's electricity supply. Gas is a lower carbon, cost-effective back-up to the variability of wind, solar and hydropower generation. It is likely that gas-fired generation will replace coal and peat-fired generation in Ireland in the next ten years and this will increase Ireland's dependence on natural gas. Gas would then account for over 90% of Ireland's electricity generation at times of very low renewables generation.

5 Eurostat June 2017
6 GNI Network Development Plan 2017
7 IEA World Energy Outlook 2017
8 Greenhouse gas emissions reduced from 103.3 $MtCO_2$ to 71.8 $MtCO_2eq$.between 2015 and 2017 (UK BEIS Report "2017 UK Greenhouse Gas Emissions 2017 Provisional Figures")

Gas use in the residential sector is likely to continue for several decades. While better home insulation and increased penetration of electrically powered heat pumps will reduce residential energy consumption, natural gas will continue to be an important component in the residential sector fuel mix until at least 2040. Oil accounted for 38% of final energy consumption in Ireland's residential sector in 2016[9] – the highest of all EU countries; gas accounted for 21%. The comparable figures for the UK were 6.3% for oil and 63.3% for gas. A previous Academy Report indicated the economic potential for converting another 300,000 homes from oil to gas firing, also with associated decarbonisation benefits. Electrifying residential heating will increase energy demand. Depending on the amount of renewable generation available, the higher demand for electricity may result in a higher demand for gas as input to electricity generation.

Gas will also continue to be used in the industrial sector where there is no viable and clean alternative. An increased use of gas in transportation is expected – especially LNG for maritime transport.

In view of the foregoing, the Academy believes that natural gas will continue to play a critical role in Ireland's energy mix until at least 2040.

3.3 Energy storage technologies

Energy storage technologies, including batteries, can increase the flexibility of the grid and capacity to integrate more electricity from renewable sources. However, cost-competitive large-scale battery storage and delivery of electricity, equivalent to that provided by fossil-fuel generation plants, is not expected in the foreseeable future. Energy storage with today's technologies would simply not be capable of supplying Ireland's electricity requirements. To put this into perspective, Ireland's annual electricity demand is approximately 30,000 GWh. If Ireland was to rely on renewables only with energy storage as back-up when there was no wind-generation, a storage capacity of 82 GWh would be needed for just one day's electricity supply with no renewable generation available. This electric storage capacity would be equivalent to about 50 Turlough Hill pump storage systems (1,648 MWh capacity) or around six million Tesla wall-mounted batteries (Powerwall 2 with 13.5 kWh storage). Lengthy periods of very low wind generation occur occasionally - there was virtually no wind-generated electricity in Ireland over a 6-week period of exceptionally cold weather in November and December 2010. Even with the very considerable increase in wind generation capacity since 2010, renewable generation accounted for less than 15% of Ireland's electricity output in the period mid-June to mid July 2018.

The Academy does not believe that electricity storage is a realistic solution to the problem of intermittent renewable electricity supply. Bloomberg New Energy Finance (BNEF) produces regular reports indicating that as the capital cost of wind generation and particularly solar photovoltaic generation continues to fall sharply, as does the cost of battery storage, these technologies will play an increasingly important role in the future. The Academy agrees with this view. But even if the cost of battery storage falls to the $70/kWh in 2030, as projected by BNEF, this still implies that the capital investment required to provide storage equivalent to just one day's average electricity consumption in 2030 would be $7,000 million, assuming a 2% p.a. growth in electricity demand to 2030. Therefore, in the Academy's view Ireland will continue to depend on fossil fuels for electricity generation, especially natural gas, until at least the middle of this century.

9 Eurostat report March 2018. Oil includes all petroleum products.

4. IRELAND'S GAS SUPPLY SECURITY – KEY ISSUES

4.1 No indigenous gas supply yet identified after Corrib

Corrib is expected to supply around 60% of Ireland's[10] demand this year, with about 5% of supply coming from Kinsale and 35% imported from Britain. The Kinsale storage facility will end gas deliveries in 2021. Corrib production has already started to decline. By 2025 Corrib will supply only 20% of Ireland's annual demand. Corrib is expected to cease production around 2030. Ireland will then be totally dependent on imported gas for the first time since Kinsale gas production started in 1978.

It is unlikely that any new indigenous sources of gas supply – apart from biogas – will be developed before 2030. In the event of a gas find, the time-frame for development would be at least 10 years due to the complexity of Ireland's permitting and regulatory environment. Corrib production started 20 years after initial discovery and 15 years after the project was sanctioned for investment by the developers. Comparable developments in the Norwegian and UK sectors of the North Sea[11] were completed in three and six years respectively from project sanction to start of production.

Biogas from renewable sources has the potential to supply some of Ireland's gas needs. Gas Networks Ireland estimate that up to 20% of Ireland's gas demand could potentially be met from renewable sources. However, there are significant challenges to be overcome – planning and permitting, public acceptance, scale and costs of infrastructure needed, gas quality control etc. It is likely to take several decades to develop a large-scale renewable gas industry in Ireland. In the Academy's view, renewable gas will account for only a small part of Ireland's gas supply by 2040. Biogas (Anaerobic Digestion) plants are generally small scale (typical production around 500 cubic metres per hour of biomethane) which would mean that several hundred such plants would be required to supply 20% of Ireland's gas demand. Total bioemethane production in the EU in 2016 was 17,264 GWh from 502 plants (average 34.4 GWh/plant). On this basis, Ireland would need 300 plants to supply 20% of its gas demand. The number of injection points into the grid could be reduced by developing a system of local or regional hubs which would reduce gas infrastructure costs but require transporting biomethane by road to the regional hubs. Development of a renewable gas supply in Ireland on any significant scale in Ireland by 2040 is unlikely in the Academy's view, but could become an important supply source in the longer term.

4.2 Ireland has no dedicated gas storage facilities

The Southwest Kinsale reservoir, operated by Kinsale Energy, was used as a gas storage reservoir since 2001. The storage capacity of the facility was about 230 million cubic metres (equivalent to about 18 days' supply). Kinsale Energy ceased gas storage operations in April 2017 and the remaining cushion gas is now being produced. Kinsale Energy is currently working on a plan to decommission the Kinsale Area gas fields, including the gas storage facility, commencing in 2020/2021.

A 2012 IEA review[12] recommended that *Ireland should consider a cost-effective fiscal investment framework to facilitate the commercial development of offshore gas storage facilities recognizing the benefits to Ireland's security of supply concerns and put in place the necessary legislative framework.*

A 2016 CER assessment report[13] noted that *in the cold periods of January and December 2010 a combination of production and storage gas from Kinsale contributed to 16% of Ireland total demand. Without this source of gas, the Moffat entry point would have been strained and unable to deliver the gas required to meet demand.*

The closure of the Kinsale gas storage facility means Ireland has no gas storage. Countries in Western Europe have an average of 100 days' gas supply in storage. Austria has over a year's supply of gas in storage. See table in Appendix 2. Ireland is the only country in Europe without gas storage, despite being quite remote from the main gas hubs in Europe and with less interconnection than most other countries.

10 Republic of Ireland
11 Ormen Lange in Norway – 3 years; Laggan Tormore in UK – 6 years.
12 International Energy Agency Report "Energy Policies of IEA Countries; Ireland -2012 Review"
13 CER Report Reference CER/16/340 "National Preventive Action Plan – Gas – 2016-2018 Ireland

4.3 Ireland's dependence on gas supply from Britain

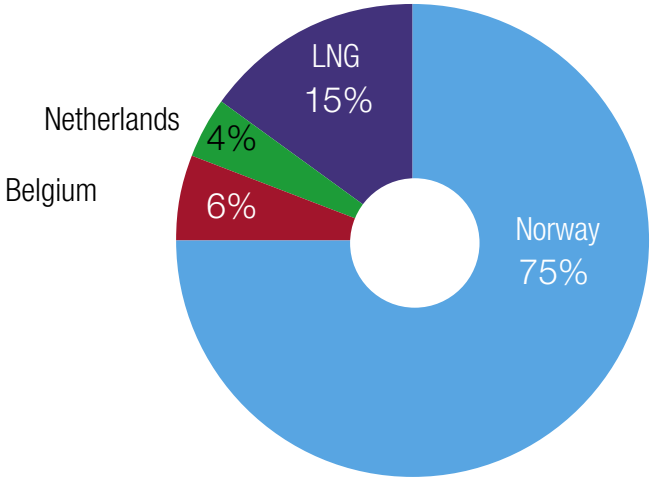
Ireland will be almost totally dependent on Britain for gas supply within ten years, unless new supply sources are established. For this reason, it is worthwhile examining how Britain's supply situation is changing.

At present, Britain has several sources of gas supply and various supply routes – production from fields in the North Sea, pipelines from Norway, Belgium and the Netherlands and LNG import terminals – see map below and details in Appendix 3.

Norway supplies most of the imports; LNG share of Britain imports has varied between 15% and 30% in the past five years.

Figure 7: UK Gas Infrastructure

Figure 8: Britain Gas Imports - 2017



There are several factors which are likely to impact Britain's security of gas supply in the medium to long term.

Britain's gas production is declining. Prior to 2000, Britain was self-sufficient in gas. Britain now imports about half of its gas supply. UK North Sea gas production in 2030 will be 50% below current levels[14]. Britain will then be importing about 75% of its gas needs. Norway could supply up to 25% of Britain's gas demand but Britain will rely on pipeline imports from continental Europe, mainly Russian gas and LNG imports for more than half of its gas supply.

Britain has limited gas storage. Britain's largest gas storage facility, the Rough Field off the Yorkshire coast, was closed in 2017. The Rough Field was used for gas storage for over 30 years and played a critical role in ensuring the security of Britain's supply. Britain now has only a limited amount of gas storage – just 7 days' supply compared with around 100 days' supply for other large countries in Western Europe. See Appendix 2. This means Britain needs additional pipeline imports from continental Europe and LNG imports at times of peak demand. This was evident earlier this year during the extreme weather events[15] at the beginning of March when a gas deficit warning was issued by National Grid, the system operator. Wholesale gas prices soared to a 12-year high and this incentivised imports by pipeline from Belgium and the Netherlands and LNG deliveries to UK terminals. The situation might have been more serious if the severe weather spell was more prolonged or if the additional supplies were not available from Europe.

Brexit could increase gas supply risks faced by Britain. By 2040 the EU will be importing 80% of its gas needs – about half of this will come from Russia. Security of gas supply will be a critical issue for the EU in the longer term due to the high dependence on gas imports, mainly from Russia. Post Brexit, the UK will no longer be part of the EU's gas-sharing mechanisms and regional gas shortages emergency planning arrangements. It is likely that Britain will enter into new agreements with the EU on gas security of supply. But if this does not happen and Britain becomes a competitor to the EU for LNG or pipeline gas, then securing supplies in an emergency would become more difficult for Britain.

Changes in flow patterns in Britain transmission system. Britain's gas transmission system was designed to move gas from north to south. Gas from the North Sea entered the transmission system at the St Fergus terminal in the north of Scotland and travelled southwards to the rest of Scotland, England and Wales. Declining North Sea production now means a decrease in supply at St Fergus and reduced flows from Scotland. Significant investment in infrastructure will be needed from 2025 onwards to meet peak gas demand levels in Scotland, including exports to Ireland via Moffat. A growing proportion of the gas will be imported in southern England and Wales – increasing the length of the supply chain and transportation costs to Ireland. Ireland's ability to respond to a supply outage or demand spike may be impacted.

14 Britain Oil and Gas Authority Report September 2017
15 National Grid, Britain's system operator issued a Gas Deficit Warning on 1st March 2018 as forecast demand soared due to 'Beast from the East' and Storm Emma.

4.4 Brexit

A detailed examination of the Brexit challenges and issues for Ireland's future gas supply is beyond the scope of this report. However, Brexit may have implications in terms of Ireland's gas supply security.

The main issues are likely to be:

- Ireland will no longer have a physical gas interconnection with the EU and could find itself isolated from the EU's internal energy market.
- Post-Brexit, Ireland may not comply with certain requirements in the EU Security of Supply Regulation, including the Infrastructure Standard. The Infrastructure Standard (so-called N-1 Standard) requires the natural gas network to continue to meet gas demand if the single largest piece of infrastructure fails on a day of exceptionally high gas demand. To pass the Infrastructure Standard test, Ireland has adopted a regional approach, which takes the island of Ireland and Britain as one region for assessment. On a stand-alone basis, Ireland's gas system would only meet 28% of gas demand in 2018/2019 under the test. The situation will improve when the onshore pipeline twinning project in Scotland is completed but will still be short of the required EU standard. In the absence of legislative change or a derogation, Ireland may be obliged to build additional infrastructure to comply with the Infrastructure Standard post-Brexit.
- The revised EU regulation[16] on security of gas includes a new 'solidarity principle' requiring EU Member States to be ready to help neighbouring countries in the event of a gas crisis. The new regulation ensures a regionally coordinated and common approach when choosing the security of supply measures. Special arrangements may be needed for Ireland to receive gas supplies from other EU Member States via Britain under the 'Solidarity Principle'.

4.5 Risk of a gas supply disruption

Ireland's gas network has been shown to be very reliable and resilient over many years of operation. The construction of a new 50-kilometre pipeline in Scotland will further reinforce Ireland's interconnection to Britain. This will result in two separate pipelines and interconnectors between Britain and Ireland. The risk of an interconnector failure will then be extremely low, but an infrastructure failure or serious outage could occur elsewhere in the Irish gas system. Infrastructure failures and supply disruptions are rare but do occasionally occur. Gas supplies from the Corrib Gas Terminal at Bellanaboy were interrupted for 21 days in 2017. The incident at Austria's main gas pipeline hub at Baumgarten[17] in December 2017 caused a very serious interruption in gas supplies to several European countries.

In view of the criticality of gas for Ireland's energy supply, it is important to have more than one source of supply and supply route. Sufficient redundancy in the physical gas infrastructure is needed to cater for a supply disruption or infrastructure failure.

16 Security of Gas Supply Regulation (EU) 2017/1938 replacing Regulation (EU) 2010/99

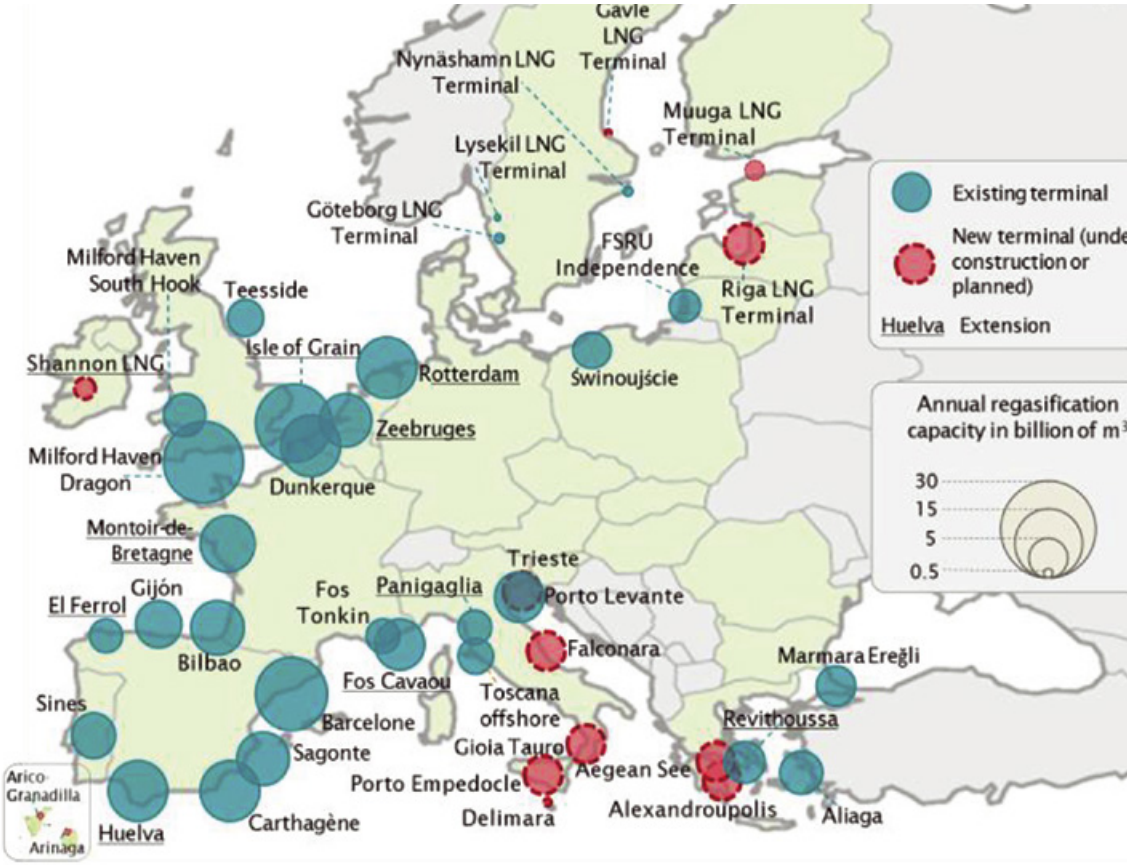
17 Baumgarten is a key distribution and reception hub for gas in Europe – about a third of Russia's gas imports to Europe flow through Baumgarten. A state of emergency was declared in Italy due to lack of gas supplies

5. MEASURES TO IMPROVE IRELAND'S GAS SUPPLY SECURITY

5.1 Develop LNG import facilities

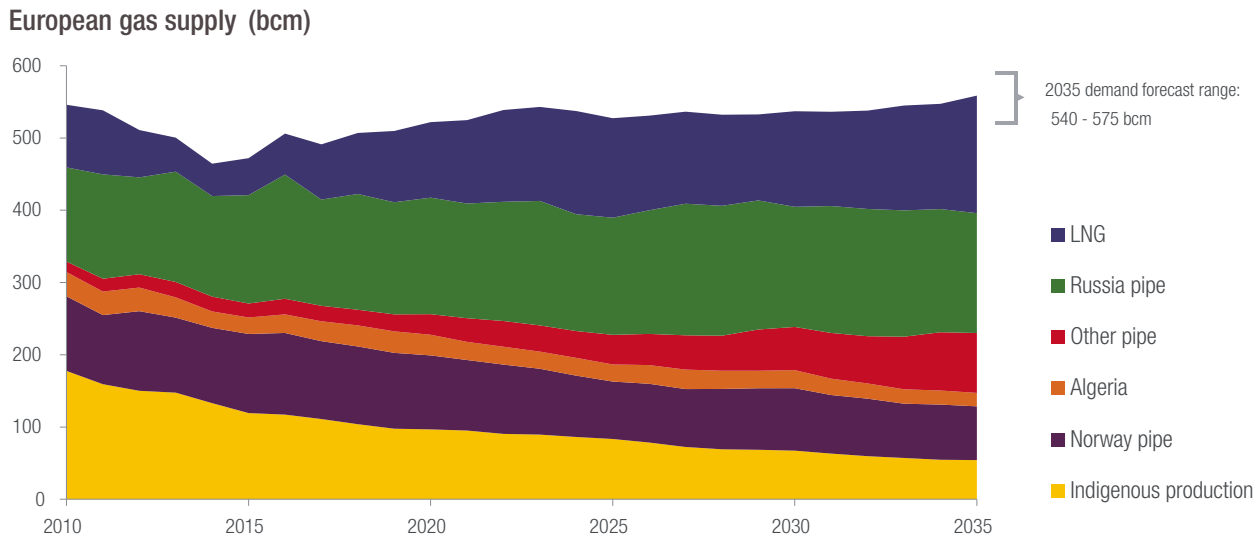
There has been a significant growth in Liquefied Natural Gas (LNG) imports into Europe in the last ten years. There are now 24 LNG import terminals in 10 different countries. LNG imports accounted for 14% of total EU gas imports in 2017. Spain imports around 50% of its gas supply as LNG through six terminals. LNG is being increasingly used to improve gas supply security even in countries with ample pipeline connections. Ireland is the only country in northwest Europe without an LNG import terminal.

Figure 9: Existing and Planned LNG Import Terminals in Europe



LNG is now the fastest growing supply source of natural gas in the world. LNG liquefaction sites worldwide are expected to double by 2040, with the main additions coming from the United States and Australia, followed by Russia, Qatar, East Africa and Canada. LNG imports into Europe will increase as domestic production declines as illustrated in Figure 10.

Figure 10: Growing EU Reliance on LNG Imports[18]



There is a growing market in the use of LNG for marine transport e.g. container ships, ferries, cruise liners and LNG bunkering facilities are being developed in many countries. The EU's Alternative Fuels Directive requires an appropriate number of refuelling points for LNG at maritime ports[19] by 2025. Ireland has committed to setting targets for the LNG facilities at three ports (Dublin, Cork and Shannon/ Foynes)[20].

There has been a trend towards Floating Storage and Regasification Units (FSRUs) in recent years. FSRUs are large vessels which can be docked in a port to store and regasify LNG and feed it into a transmission network. FSRUs are a fast and flexible way to get access to natural gas supplies. The cost of a new FSRU is typically 40-50% lower than that of an onshore facility but FSRUs generally have higher operating costs. FSRUs typically contain less storage than onshore systems. Onshore terminals generally contain between 200 and 600 thousand cubic metres of LNG storage capacity, whereas floating terminals typically have between 125 and 175 thousand cubic metres storage[21].

Development of LNG import facilities in Ireland – either an FSRU or onshore-based - would help with both the security and diversity of Ireland's natural gas supply and would give Ireland direct access to competitive global LNG prices. An onshore tank storage capacity of 400 thousand cubic metres would provide ROI supply for around 17 days[22]. An FSRU with a tank storage capacity of 150 thousand cubic metres would provide around 6 days' supply.

5.2 Maintain strategic gas storage reserves

Ireland should maintain gas storage as is the practice in all other European countries. The various options need to be evaluated – using a depleted gas field, salt cavern or LNG storage. Islandmagee Storage Limited has planning approval for a £280 million natural gas storage facility using salt caverns in Antrim[23]. LNG storage volumes are small but important at times of peak demand. LNG send-outs from Britain's three terminals were able to provide 20% of Britain supply on 1st March when Britain was facing a supply deficit. The possibility of using the Corrib Field as a storage facility in the longer term could also be considered. Gas storage brings added benefits – shortening of the gas supply chain, more flexibility to deal with short-term demand volatility and an increase in the peak capacity of the gas system.

18 Shell LNG Outlook 2017
19 TEN-T Core Network
20 EU Report of November 2017 – "Summary of National Plans"
21 IGU LNG Report 2017, page 50
22 LNG storage volumes. Using 600:1 volume conversion factor and average ROI daily consumption of 14.5 mscm/day (2017)
23 Northern Ireland Department of Environment press release, 18th October 2012.

5.3 Promote offshore gas exploration and development

Exploration for offshore gas should be promoted with appropriate licensing terms and a fit-for-purpose regulatory framework to attract investment. The economic benefits from the Kinsale and Corrib gas field developments have been very significant as well as supplying gas for almost half a century. Gas has been produced from the Kinsale Head area since 1978. Kinsale Gas enabled Ireland to be self-sufficient in gas supply until 1995 and was instrumental in the development of the national gas network in Ireland. The availability of natural gas from Kinsale drove growth of the chemical and pharmaceutical industries in Cork Harbour. The Corrib development provided over 1,000 full-time jobs over the period 2004 to 2015 and is expected to contribute over €6 billion to Ireland's GDP over the field's life-time.

Any new gas discovery near the Corrib Field could possibly use the existing infrastructure which would mean a shorter time-frame for development, lower costs and less environmental impact.

Banning exploration in Ireland will not reduce Ireland's gas consumption or greenhouse gas emissions. On the contrary, it would result in more gas imports and less energy security. It would result in an increase in greenhouse gas emissions as the imported gas is likely to be transported over very large distances, as well as increasing Ireland's cost of imports.

5.4 Improve back-up fuel arrangements at electricity generation plants

Switching from gas to oil at electricity generation plants is one of the measures that can be utilised in the event of a gas supply shortage. Gas-fired generators in Ireland are required to have sufficient stocks of distillate fuel for up to 5 days' operation. But a report by the energy regulator[24] in 2015 indicted that that seven secondary fuel tests were unsuccessful out of a total of 20 tests carried out generation units in 2014. A review of regulatory requirements would be appropriate. Increasing the volumes of secondary fuel held at some power stations might also be considered – especially if these fuels could be included in Ireland's strategic oil stocks. Contingency planning for fuel resupply should also be developed.

5.5 Develop EU PCI projects to improve Ireland's gas supply security

A list of EU infrastructure projects (Projects of Common Interest) has been developed to improve the integration of the EU's internal energy market. The list of projects is updated every two years. Projects are assessed on a range of criteria including impact on diversity of supply, market integration and security of supply. Infrastructure projects with PCI status benefit from faster and more efficient permit granting procedures, improved regulatory treatment and access to financial support under the EU Connecting Europe Fund. Projects with PCI status include an LNG terminal on the Shannon estuary and a gas storage facility in Larne. Ireland should seek to maximize benefits under the EU PCI scheme by identifying and submitting projects based on improving gas supply security. Brexit may help to strengthen Ireland's case for PCI project status and EU funding

24 Commission for Energy Regulation Report CER/15/213 "Review of Fuel Stock Obligations for Electricity Generators as specified in CER/09/001"

5.6 Invest in measures to decarbonize natural gas

Measures to decarbonize natural gas in Ireland's energy system should be pursued. Carbon Capture and Storage (CCS) has the greatest potential of any technology to reduce emissions. The Academy believes that CCS development is feasible with existing technology by 2030. Significant work on the financial, regulatory and legal framework will be required if it is to become viable. The Kinsale gasfield would have many advantages for CCS – large gas reservoir, existing infrastructure, two modern CCGT plants close to the existing gas pipeline.

As mentioned earlier, biogas from renewable sources has the potential to supply some of Ireland's gas needs. In the Academy's view, it is likely to take several decades to develop a large-scale renewable gas industry in Ireland and biomethane production on any significant scale in Ireland by 2040 is unlikely. The biomethane industry should nevertheless be promoted as it has the potential to supply renewable gas, albeit limited volume, in the longer term.

Decarbonization technologies such as a switch from natural gas to hydrogen for certain applications are being trialled in several European countries. Ireland has one of the most modern networks in Europe and is suited to transporting other gases like hydrogen. Hydrogen does not contain any carbon and only emits water vapour when combusted or used in a fuel cell for heating. The potential for use of hydrogen in Ireland needs to be explored through R&D and small-scale trial projects.

6. CONCLUSIONS

6.1 Natural gas is critical for Ireland's energy supply

Gas plays a critical role in Ireland's energy mix. Gas supplies around 30% of Ireland's total primary energy and is used to generate about 50% of Ireland's electricity. Many indigenous and multinational companies in Ireland rely on gas. Approximately 650,000 households in Ireland depend on natural gas for home heating.

6.2 Natural gas will be essential for Ireland's transition to a low-carbon future

Electricity generation in Ireland in the future will be a combination of renewables and natural gas. Ireland's dependence on natural gas for electricity generation will increase further when coal and peat use in generation end. Gas would then account for over 90% of Ireland's electricity generation at times of very low renewables generation. Natural gas has the lowest carbon emissions of all fossil fuels and is the ideal complement to renewables. Gas will also be needed for many industries in Ireland where there is no low-carbon alternative. Gas will be critical for Ireland's transition to a low-carbon future.

6.3 Ireland will have no indigenous natural gas supply after 2030

Corrib will only supply around 20% of Ireland's annual gas demand in 2025. Corrib production will cease by around 2030. This will leave Ireland in the vulnerable position of having no indigenous gas supply and being totally dependent on gas imports from Britain.

6.4 Ireland needs to develop alternative gas supply sources

Ireland needs to develop diverse sources and routes of gas supply to ensure its energy security in the longer term. By 2030, Britain will need to import 75% of its gas due to the decline in North Sea production. The gas supply route to Ireland will be longer than at present with a greater risk of supply disruption. Ireland should have at least two separate supply sources and supply routes. Developing an LNG import terminal would enhance Ireland's security of supply and provide access to the competitive global gas market. Exploration for offshore gas should be promoted in parallel. Options of gas storage in Ireland also need to be assessed.

6.5 A strategic plan for gas supply security is needed

A strategic government plan is needed to diversify Ireland's gas supply. This strategic plan should include appropriate fiscal, licensing and legislative frameworks to facilitate the development of new sources of gas supply and encourage investment. The plan needs to factor in a lead-time of five to ten years for large energy infrastructure developments in Ireland.

APPENDIX 1 GNI GAS TRANSMISSION SYSTEM

Gas supply in Ireland is delivered via a network of approximately 13,772 km of pipelines. The integrated supply network is sub-divided into 2,433 km of high pressure (>16 bar) subsea and cross-country transmission pipe, and approximately 11,339 km of lower pressure distribution pipe (<16 bar).

There are three entry points for gas into the GNI high-pressure transmission system - Moffat (Scotland) Bellanaboy (Corrib Gas) and Inch (Kinsale Gas)

The **Moffat** entry point connects the Irish natural gas system to Britain National Transmission System which is owned and operated by the National Grid Gas (NGG). The Moffat entry point allows for the importation of gas to Ireland, through an onshore transmission network in Scotland (referred to as the South West Scotland Onshore System) and two subsea interconnectors. From the connection with the NTS at Moffat, the Scotland based onshore system consists of:

- A compressor station (5 compressors in parallel) at Beattock, which is connected to Brighouse Bay by two pipelines from Beattock to Cluden.
- Some 80 km of pipeline including a 50 km single pipeline from Cluden to Brighouse Bay.
- A compressor station at Brighouse Bay.
- Two pipelines – Interconnector 1 (IC1) and Interconnector 2 (IC2) connecting Ireland to the South West Scotland Onshore System. IC1 and IC2 connect to the onshore Irish system north of Dublin at Loughshinny and Gormanston respectively. IC1 was built in 1993 and has a capacity of 17 million cubic metres per day. IC2 was built in 2002 and has a capacity is 23 million cubic metres per day.

The construction of a new 50-km pipeline in Scotland will be completed in 2018 and will further reinforce Ireland's interconnection to the GB market and hence Ireland's security of supply. This will result in a fully twinned pipeline between Beattock and Brighouse Bay compressor stations and an entire dual interconnector between Great Britain and Ireland.

The Inch entry point connects the Kinsale and Seven Heads gas fields, as well as the Kinsale storage facility, to the onshore network. There is also a compressor station at Midleton, Co. Cork that compresses the gas from Inch to facilitate transmission throughout the system.

The **Bellanaboy** entry point connects the Corrib gas field to the onshore network. The Bellanaboy entry point is connected to the onshore ring main via the Mayo-Galway pipeline.

Gas is delivered from Moffat to the Northern Ireland gas system at Twynholm. The gas is then delivered to Northern Ireland customers via the Scotland to Northern Ireland Pipeline (SNIP) which runs from Twynholm in Scotland to Larne and forms part of Northern Ireland's transmission system.

APPENDIX 2 UNDERGROUND GAS STORAGE – EUROPE[25] [26]

Country	Working Gas Capacity (billion cubic metres)	Annual consumption (billion cubic metres)	Days' Supply	Average daily consumption (million cubic metres per day)	Maximum withdrawal rate (million cubic metres per day)	Ratio withdrawal rate to average daily consumption
Austria	8.75	8.7	367	24	97	4.1
Belgium	0.86	15.4	20	42	15	0.4
Denmark	1.00	3.2	114	9	25	2.9
France	12.85	42.6	110	117	210	1.8
Germany	22.29	80.5	101	221	642	2.9
Italy	18.45	64.5	104	177	296	1.7
Netherlands	12.43	33.6	135	92	257	2.8
Portugal	0.2	4.6	16	13	7	0.6
Spain	3.02	28	39	77	16	0.2
Britain	1.4	76.7	7	210	103	0.5
Ireland	0	4.8	0	13	0	0.0

Average Day's Supply (excluding Ireland) 101

25 Gas Infrastructure Europe March 2018 (working gas capacities and maximum withdrawal rates)
26 BP Statistical Review of World Energy 2017 (annual gas consumptions)

APPENDIX 3 BRITAIN'S GAS INFRASTRUCTURE

There are three sources of natural gas imports into Britain:

1. Pipeline gas from the Norwegian continental shelf (NCS)
    - The Vesterled pipeline link: This pipeline connects St Fergus in Scotland to several Norwegian gasfields. This pipeline has a capacity of 14.2 billion cubic metres per year.
    - The Langeled pipeline: from Nyhamna in Norway to Easington in Yorkshire and is the second longest underwater gas pipeline in the world at 1,200km. The pipeline has a capacity of 26.3 billion cubic metres per year.
2. Pipeline gas imports via two interconnectors from Belgium and the Netherlands
    - Britain-Belgium interconnector (UK): This pipeline runs between Bacton and Zeebrugge and connects Britain to the mainland Europe gas network. This pipeline has an import capacity of 26.9 billion cubic metres per year. It is the only pipeline that is bi-directional, meaning it can both import gas to Britain as well as export gas to mainland Europe.
    - Britain – Netherlands pipeline (BBL): This runs from Balgzand to Bacton. This pipeline has an import capacity of 16.4 billion cubic metres per year.
3. LNG Import terminals
    - South Hook, Milford Haven - capacity of 21 billion cubic metres per year.
    - Dragon, Milford Haven – capacity 7.6 billion cubic metres per year.
    - Isle of Grain, Kent – capacity 20.4 billion cubic metres per year.

The Irish Academy of Engineering
22 Clyde Road, Ballsbridge, Dublin 4
Telephone: +353 1 665 1337
academy@iae.ie
www.iae.ie

Published by: The Irish Academy of Engineering
ISBN: 978-0-9935995-6-9