SUSTAINABLE ENERGY AUTHORITY OF IRELAND

ENERGY SECURITY IN IRELAND

2020 Report

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September 2020

Report prepared for SEAI by Byrne Ó Cléirigh.

Disclaimer

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

The Sustainable Energy Authority of Ireland

The Sustainable Energy Authority of Ireland (SEAI) is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with Government, homeowners, businesses and communities to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies. SEAI is funded by the Government of Ireland through the Department of Communications, Climate Action and Environment.

SEAI is the official source of energy data for Ireland. We develop and maintain comprehensive national and sectoral statistics for energy production, transformation and end-use. These data are a vital input in meeting international reporting obligations, for advising policymakers and informing investment decisions. SEAI's core statistics functions are to:

- Collect, process and publish energy statistics to support policy analysis and development in line with national needs and international obligations;
- Conduct statistical and economic analyses of energy services sectors and sustainable energy options;
- Contribute to the development and promulgation of appropriate sustainability indicators.

Acknowledgements

SEAI gratefully acknowledges the cooperation of all the organisations, agencies, energy suppliers and distributors that provide data and respond to questionnaires throughout the year.

We also gratefully acknowledge those with whom we consulted for this report, including:

- The Commission for Regulation of Utilities
- The Department of Communications, Climate Action and Environment
- Eirgrid
- Gas Networks Ireland
- The National Oil Reserves Agency

Executive Summary

Energy security, in its simplest terms, means having uninterrupted access to reliable, affordable supplies of energy. Secure supplies of energy are essential for our economy and for maintaining safe and comfortable living conditions. Energy security is complex because it comprises many diverse elements. There are also intricate interactions with the other two important pillars of energy policy: sustainability and competitiveness. In particular, energy security must be considered in the context of global energy consumption's significant contribution to climate disruption and the need to fully align the energy sector with the Paris Agreement.

Unfortunately, the world is not on track to meet the Paris Agreement goal of limiting the increase in global average temperature this century to well below 2.0°C above pre-industrial levels, whilst pursuing efforts to limit the increase further to 1.5°C. To do so will require fundamental changes in the global energy system, which currently remains heavily dependent on fossil fuels. Because of the level of change required over the coming decades, future energy security cannot be evaluated by focussing solely on traditional supply chains and patterns of usage, or by limiting the scope of analysis to existing policy and commitments with respect to emissions.

While the energy transition poses challenges for energy security, it also presents several notable opportunities – illustrating the link to both sustainability and competitiveness. For example, both energy efficiency and indigenous renewable energy supply can strengthen energy security, while reducing the energy sector's contribution to climate change and reducing Ireland's bill for imported fossil fuels.

Import dependency

Energy import dependency is one of the simplest and most widely used indicators of a country's energy security, with indigenous energy sources generally considered to be more secure than imported energy.

Ireland's import dependency was 67% in 2018, down from an average of 89% between 2001 and 2015. This improvement was mostly due to the beginning of production of gas from the Corrib field and increasing use of indigenous renewable energy. Despite this improvement, Ireland is still one of the most import dependent countries in the EU. Oil makes up by far the largest share of energy imports: in 2018, oil accounted for 73% of total energy imports, natural gas 17%, coal 8.2% and renewables 1.4%.

While the overall import dependency figure provides a useful context, a deeper understanding of energy security requires more detailed information on individual energy sources. This includes the countries from where each fuel is sourced, global market conditions, transportation and other infrastructure requirements. It also requires analysis of the current trends in energy use, and of the significant changes that will occur in energy use both nationally and globally over the coming years. This report gathers together and summarises data and analysis from a wide range of sources into one focused document to provide a basis for understanding these issues.

Gas

Natural (fossil) gas accounted for 31% of Ireland's primary energy requirement in 2018. 61% of the gas came from indigenous production (mostly from the Corrib Field), down from 66% in 2017. The remainder was imported via an interconnector system with the UK, which itself imports almost half of its gas, via pipeline from European neighbours and as liquefied natural gas (LNG) from further afield. The supply from Corrib has already peaked and is projected to decline throughout the 2020s. In the short term at least, the deficit between forecast gas demand and declining indigenous production will be filled by imports via the UK.

Gas markets have become progressively more globalised due to the increase in LNG trade and the completion of pipeline projects linking producers with new markets. Natural gas met almost half of the world's energy demand growth in 2018, making it the fastest growing energy source globally.

In the EU, natural gas accounts for approximately one quarter of energy consumption. 88% of this gas is imported and gas security remains an important policy priority for the Union. There has been significant investment in gas infrastructure in Europe since the 2009 gas dispute between Russia and Ukraine, which disrupted supplies to some member states. There have also been several initiatives introduced over this period to help prevent future disruptions and to respond more effectively if they occur. Among these were the establishment two security of supply standards for assessing the resilience of gas networks in the event of disruptions to key infrastructure: an infrastructure standard, incorporating the so-called N-1 criteria, and a supply standard.

In 2018, Gas Networks Ireland (GNI) and EirGrid examined Ireland's resilience to a gas disruption using these standards. Their work concluded that, at the time, Ireland could only meet 37% of total demand in the event of the loss of the entire interconnector system under peak demand conditions (N-1 criteria). However, because the EU regulation allows countries to meet the N-1 standard on a regional basis, Ireland continued to meet the requirements when assessed with the UK. In 2018, a project was completed to twin a 50 km section of onshore pipeline in Scotland that forms part of Ireland's interconnector system, and complementary work is ongoing to upgrade an adjacent compressor station. As well as strengthening gas security, these upgrades facilitate the splitting of the interconnectors into separate systems for the purposes of the infrastructure standard. GNI and EirGrid calculated that the N-1 position would improve as a result of these upgrades. They also found that Ireland met the gas supply standard, which requires countries to meet the needs of protected customers (including homes) for 30 days, in the case of a similar infrastructure disruption under average winter conditions.

While gas will continue to be required in Ireland's electricity generation and heat sectors out to 2030, the future for gas beyond 2030 is less certain. There may be enduring roles for fossil gas with carbon capture and storage, and for green gases such as biomethane or green hydrogen, but the nature and extent of these roles needs further consideration in the context of a net-zero 2050 ambition.

In 2019 the Minister for Communications, Climate Action and Environment announced that the Department would carry out a review of the security and sustainability of Ireland's electricity and natural gas systems, which will focus on the period to 2030, in the context of achieving carbon neutrality by 2050. This SEAI report provides up to date data and information which can be used as an input to this review.

Oil

Oil accounted for 49% of Ireland's primary energy requirement in 2018, one of the highest rates of oil dependency in the EU. 71% of oil is used for transport. There is also significant oil use in residential heating and in the industrial sector, and it plays an important role as a secondary fuel for gas-fired electricity generation.

International crude oil markets are currently well supplied, and many major producers are operating below maximum capacity. Global oil supply has become more diverse and less dependent on regions of political instability. Oil price is a key factor for dictating market share for different producers, with Organizsation of the Petroleum Exporting Countries (OPEC) and Russian producers typically requiring higher prices to break even than many US producers do. In Europe, production has been declining since the late 1990s in almost all oil-producing countries, particularly Norway and the UK, which are the region's biggest producers.

Apart from a small amount of indigenous biofuel production, Ireland imports all of its oil. The likelihood of a new indigenous supply of crude oil is low given the low levels of recent offshore drilling activity, low oil prices and Ireland's policy position that there will be no future licensing for offshore oil exploration.

Ireland's only oil refinery, located at Whitegate, Co. Cork, processes crude oil from diverse sources, which reflects the global nature of the international crude oil market. The refinery's output is equivalent to 30-40% of Ireland's demand. The remainder of the country's demand is met from imports of refined products, 64% of which came from the UK in 2018. The refining sector throughout Europe is experiencing significant competition from operators in developing regions, which could increase European dependence on refined product from further afield.

Because of the near total dependence of Ireland's transport sector on oil-based products, oil will likely remain the dominant fuel in this sector for the next decade, although an increasing proportion of petrol and diesel will be displaced by biofuels and electrification over this period. Energy efficiency, electrification and biomass have the potential to reduce Ireland's dependence on oil for heat.

Electricity

In 2018, 52% of electricity generated was from gas, wind had the second largest contribution at 28%, with other renewables at 5%. Coal fell to 7% from 16% in 2016, principally because of technical problems at Moneypoint power station.

While Ireland currently has significant surplus power generation capacity, EirGrid anticipates that there will be a need for additional generation capacity from 2026. SEAI's latest national energy projections anticipate electricity demand to increase over the period to 2030. The most significant technological driver for the anticipated demand increase is the expected growth of data centres, which can have demand levels comparable to those of large towns.

The Climate Action Plan 2019 established an ambitious framework for growth in renewable electricity, with a 70% target for renewables for 2030. Most additional renewable generation capacity over this period is expected to come from wind (onshore and offshore) and solar. It is likely that all non-renewable electricity generation by 2030 will be from gas. While 2030 will be an important milestone, it will also be a critical step on a pathway to achieving a fully decarbonised electricity network in the following decades. It is not yet clear how this will be achieved.

Supply/demand index

The supply/demand index is an indicator of the medium-to-long-term energy security of the whole energy system. The supply/demand index for Ireland shows an overall increase in energy security over the period 2005-2018. Looking to 2030, further significant displacement of imported oil and gas with energy efficiency and indigenous renewable supplies would increase Ireland's future energy security score. Despite this, because oil and gas account for 80% of primary energy and because Ireland is likely to become more reliant on non-EU oil and gas as EU supplies decline, it is likely that the index score will decrease over the next decade.

The index, and other indicators of energy security, must be considered in the context of the parallel goals of sustainability and competitiveness.

Impact of Brexit

There is a risk that Brexit could lead to a divergence in energy policy and regulation between the UK and Ireland over time. Brexit has also had some immediate impacts on the energy relationship between the two countries. Both will have repercussions for Ireland's energy security, although the full extent of these may not be fully understood for some time.

Impact of COVID-19 pandemic

This report was substantially completed in early 2020, before the World Health Organisation's declaration of a pandemic and before COVID-19 had a significant impact beyond China. Almost all the statistical data in the report is for the period up to 2018, as this is the most up-to-date data available at the time of writing.

At the time of publication (September 2020), the global health crisis arising from the pandemic is ongoing. It is having a profound impact on economic activity and energy demand throughout the world. The future course of the pandemic remains very uncertain and its longer-term implications for energy demand and energy security are yet to be determined.

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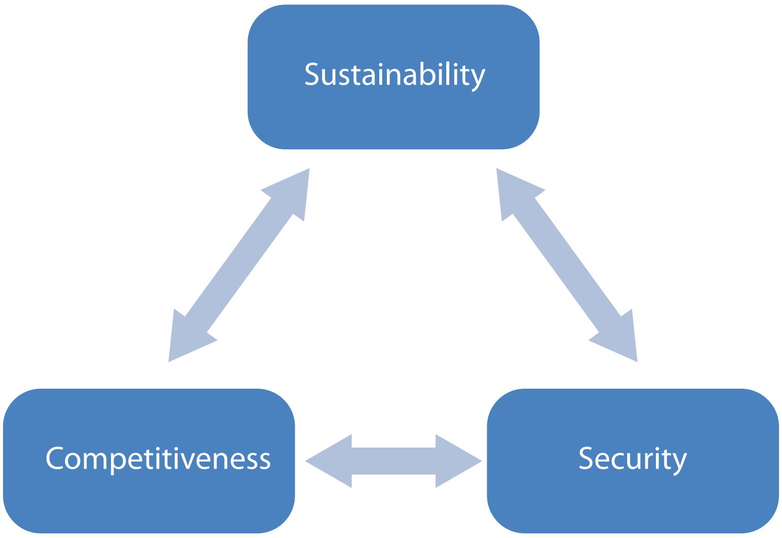
1 INTRODUCTION

1.1 Objective of this report

This report is the sixth in a series reviewing energy security in Ireland. It provides a comprehensive overview of the wide range of issues relevant to energy security in order to inform a better understanding of energy security and the complex interactions between it and the other pillars of energy policy, that is, sustainability and competitiveness. It is intended to inform debate and provide context and information to the policy community, energy market participants, investors and the public.

Figure 1: Three pillars of energy policy



This report considers the issue of energy security holistically. The metrics and indicators presented in this report address a wide range of issues relevant to the topic of energy security. They span a range of national and international concerns, including the linkage between energy security and global energy consumption's significant contribution to climate disruption. The complexity of this area of energy policy does not allow for simple analysis or solutions.

For the most part, the report provides a review of data and publications relevant to energy security that are already in the public domain, rather than presenting the results of new analysis[1]. By aggregating, organising, and summarising what is sometimes rather eclectic public data into one focused document, the report is designed to provide the reader with an accessible overview of the topic. The report is heavily referenced to allow the reader to delve deeper into areas of particular interest.

In 2019, the Minister for Communications, Climate Action and Environment announced that the Department would carry out a major review of the security and sustainability of Ireland's energy supply, in the context of the 2030 targets for 70% renewable electricity and the broader decarbonisation pathway to 2050 [1]. This report has been prepared and published in advance of the Department review and may be used as an input to it.

1.2 Energy security concepts

At a high level, the importance of energy security is well understood: secure supplies of energy are essential for all economic activity, for the effective delivery of public services, and for maintaining safe, sustainable, and comfortable living conditions. However, energy security as a concept is relatively complex because it comprises many diverse elements relating to import dependency, fuel diversity, the capacity and integrity of the supply and distribution infrastructure, energy prices, physical risks, physical disruptions, emergencies and the long-term sustainability of the energy system.

Energy security is described by the International Energy Agency (IEA) as '*the uninterrupted availability of energy sources at an affordable price*' [2]. As a concept, it incorporates both a short-term focus on the resilience and flexibility of energy

1 An exception is the update of supply/demand analysis contained in section 7, which is original analysis carried out for this report.

systems and long-term goals relating to the policy, decisions and investments required to balance energy supply with economic development and environmental drivers.

A broad interpretation of energy security is used in this report.

Different factors related to the availability of energy supply and trends in energy demand present both risks and opportunities for energy security. On the demand side, the key variables are economic growth, the energy intensity of economic activity, price and demand moderation driven by sustainability objectives. Both energy efficiency and demand moderation present significant opportunities to strengthen energy security.

On the supply side, key variables include physical infrastructure (for example, interconnectors, national transmission and distribution networks, oil terminals, port infrastructure, dispatchable electricity generators, renewable energy installations), the availability of indigenous resources (including social acceptance of extraction or infrastructure), and the robustness of global fuel supply chains (for example, to geopolitical or weather events).

Traditionally, much of the analysis of supply-side factors focuses on risks to physical energy availability. Supply-side risks include:

- Natural disasters and extreme weather events, including those caused by climate disruption, for example, the Japanese earthquake that led to the nuclear reactor meltdowns at Fukushima Daiichi (2011), Hurricane Katrina (2005), Storm Emma (2018) and, insufficient cooling capacity from rivers for some nuclear plants in Europe during the summer of 2018.
- Civil and regional conflicts, for example, recent conflicts in Libya, Syria, Ukraine, Yemen, and Iraq.
- Geopolitical tensions, for example, trade sanctions against Russia and Iran.
- Political change and uncertainty, e.g. Brexit.
- Major accidents, for example, Buncefield fire (2005), Deepwater Horizon oil spill (2010).
- Cyber threats, for example, the 2015 cyber-attack on the Ukrainian electricity network and the 2019 ransom-ware attack on a South African electricity supplier.
- Infrastructure capacity constraints, for example, the ability to cope with sudden surges in demand.
- Investment uncertainty, for example, regulatory and, or, policy uncertainty.
- Resource variability, for example, variation in average wind speeds.
- Civil and labour disputes.

The development of indigenous, distributed renewable energy sources mitigates many of the risks associated with relying on global supply chains and large single pieces of infrastructure, and reduces the exposure to fossil fuel price shocks.

Although the risks to physical energy availability are often associated with energy supply, they can also impact on demand if the access, or perceived access, to energy sources is interrupted. Regulatory and policy frameworks also have impacts.

Ireland's National Risk Assessment, which is prepared annually by Government to assist departments and agencies in developing mitigating actions, highlights how '*in terms of energy-related risks, disruptions to the supply or price of oil, gas, or electricity could have significant economic, social or competitive impacts, and our geographic position renders us particularly vulnerable to such disruptions*' [3].

Most identifiable risks can be mitigated to some extent, although the costs of doing so can be prohibitive for some risks, especially those related to catastrophic events. All risks to the energy supply/demand balance ultimately impact on price. Price, in turn, affects demand and impacts on the investment climate.

1.3 Energy security and the energy transition

Energy security cannot be considered in isolation from the other two pillars of energy policy, that is, sustainability and competitiveness. Energy security, in particular, must be viewed in the context of the climate crisis and the need to fully align the energy sector with the Paris Agreement goals of 1.5°C and 2.0°C limits on global temperature rise.

Unfortunately, the world is not on track to meet these limits. The UN's Emissions Gap Report 2019 highlighted that if all countries' unconditional commitments to greenhouse gas reductions are implemented[2], the world would still be on course for a 3.2°C temperature rise [4]. The report found that countries would need to triple the ambition of their current pledges to achieve the 2.0°C goal and to increase their ambition fivefold to achieve the 1.5°C goal – identifying a target reduction of 7.6% per annum for the period 2020 to 2030.

2 These commitments are referred to as nationally determined contributions.

More ambitious action to achieve these goals will require significant changes throughout the world's energy systems. However, the pace of transition is slow. The assessment of the IEA is that '*the momentum behind clean energy transitions is not enough to offset the effects of an expanding global economy and growing population*' [5]. The IEA's stated energy policy scenario for future energy demand, which is based on policies that are either already in place or have already been announced does '*not see a peak in global energy-related CO_2 emissions by 2040 – obviously far from the early peak and rapid subsequent decline in emissions targeted by the Paris Agreement'*. The projections for this scenario *'imply a 50% probability of a 2.7°C stabilisation (or a 66% chance of limiting warming to 3.2°C) – not nearly enough to avoid severe effects from climate change*' [5]. The European Green Deal, introduced in late 2019, is a roadmap incorporating proposed EU-wide emissions reductions that are more ambitious than those currently targeted[3] – up to a 50-55% reduction compared to 1990 levels [6].

This requirement for comprehensive and rapid change to the energy system is a crucial consideration when analysing energy security. Future energy security cannot be evaluated by focussing solely on traditional supply chains and patterns of usage, or by limiting the scope of analysis to existing policy and commitments with respect to emissions. All aspects of energy security must be examined in the context of the level of change required to avoid catastrophic climate disruption. This is especially true for energy security over the longer term. While many of the changes required to Ireland's energy system throughout the 2020s have been identified in Climate Action Plan 2019 [7] – albeit with the need to enhance or accelerate them to rise to the level of ambition proposed for the European Green Deal – the pathway for deeper decarbonisation beyond 2030 is less defined. For example, the role that gas (fossil or renewable) will play in electricity generation out to 2050 remains to be determined. This uncertainty has implications for investment decisions, especially for infrastructure that has a long lead time and, or, payback period.

1.4 Projections for future supply and demand

In seeking to assess future energy security, this report refers to different projections of future energy supply and demand. The different projections were prepared by different organisations for different purposes. All projections are scenarios that incorporate many assumptions.

SEAI prepares the annual National Energy Projections for Ireland [8] in collaboration with the Economic and Social Research Institute (ESRI). These projections for energy supply and demand in Ireland are used to inform the debate on future energy trends and to assist the Government in measuring progress towards targets and taking corrective measures, where necessary. They are also used by the Environmental Protection Agency (EPA) to inform Ireland's greenhouse gas emissions projections [9]. They are underpinned by an understanding of relationships between energy use, economic growth, energy prices, and energy policies. These relationships provide the basis for projecting how energy use may develop into the future. This report presents a higher and lower SEAI projection for future demand. SEAI's higher projection assumes lower fossil fuel prices (which lead to higher energy demand) and that the Climate Action Plan will not be implemented in full. As such, it is a worst-case scenario used for comparison and is not considered likely, or desirable. The lower projection is based on higher fossil fuel prices (which tend to reduce demand) and on the successful implementation of the ambitious policies and measures contained in the Climate Action Plan to improve energy efficiency and increase renewable energy use. From a sustainability perspective, it is essential that future energy demand follows the lower projection. This will also improve energy security and competitiveness.

This report also references projections from EirGrid and Gas Networks Ireland (GNI), which are prepared in fulfilment of these organisations' remits.

In examining the global outlook for oil and gas, this report also refers to different projections by the IEA. Its stated energy policies scenario reflects current policy positions and is the central scenario discussed in some of its key publications, but it is not consistent with achieving the Paris goals. On the other hand, its sustainable development scenario 'c*harts a pathway for the global energy sector fully aligned with the Paris Agreement*' [5]. The world is not yet on track to meet this scenario.

1.5 Additional information

The energy data drawn from the national energy balance presented in this report is the most up-to-date data available at the time of writing. The energy balance is updated whenever more accurate information is known. The most up-to-date energy balance is available from the 'Energy Statistics in Ireland' section of SEAI's website at www.seai.ie/data-and-insights/seai-statistics/.

It should be noted that while SEAI reports on energy metrics and indicators of energy security, the statutory authority for ensuring energy security lies elsewhere. The Commission for Regulation of Utilities (CRU) has the statutory obligation to ensure electricity and gas energy security in Ireland and Department of Communications, Climate Action and Environment (DCCAE) and the National Oil Reserves Agency (NORA) are responsible for oil security and oil stocks respectively. These organisations, along with EirGrid and GNI, publish many useful documents that provide a thorough overview of energy

3 The current EU emission reduction target is at least a 40% reduction in EU-wide emissions by 2030, compared to 1990.

security in Ireland. These are referenced extensively throughout this report and are included in a comprehensive list of references towards the end of the document.

Feedback and comment on this report are welcome and should be sent to epssu@seai.ie.

1.6 Impact of the COVID-19 pandemic

This report was substantially completed in early 2020, prior to the World Health Organisation's declaration of a pandemic and before COVID-19 had a significant impact beyond China. Almost all the statistical data in the report is for the period up to 2018, as this is the most up-to-date data available at the time of writing.

At the time of publication (August 2020), the global health crisis arising from the pandemic is ongoing.

The pandemic is having a profound impact on economies throughout the world, with repercussions for energy demand. In the first half of 2020, the confinement measures and restrictions on economic activities introduced in many countries resulted in sharp decreases in energy demand. For example, global road transport activity had fallen by 50% below 2019 levels by the end of March 2020 and air travel in some European countries had declined by 90% [10]. In Ireland, the combined demand for petrol and diesel in April 2020 (in litres) was 41% of that in April 2019 [11]. In many countries that implemented comprehensive lockdown measures electricity demand dropped by 20% or more and weekday electricity consumption patterns resembled those typically experienced on Sundays [10]. In Ireland, the morning peak in electricity demand had fallen by 200 MW by the last week in March [12].

The future course of the pandemic remains very uncertain. As a result, although COVID-19 continues to have severe impacts on economic activity, the longer-term implications for energy demand and energy security are yet to be determined. In mid-2020, the IEA estimated that annual global energy demand could decrease by 6% in 2020, which would be the largest percentage reduction in 70 years and more than seven times larger than the impact of the 2008 financial crisis [10].

The durations of these impacts are likely to vary between sectors. Some of the most dramatic impacts on energy markets appear to have been relatively short-lived. For example, the price of West Texas Intermediate, the benchmark price for US crude oil, had dropped from over US$60 per barrel at the end of 2019 to trade at below zero in late April 2020, because of a scarcity of storage capacity and a collapse in demand. However, by June 2020 the price had recovered to trade at approximately US$40 per barrel. In the case of electricity, demand has been recovering gradually as lockdown restrictions are being lifted in different countries. It is also noteworthy that the proportion of electricity sourced from renewables in the EU and elsewhere increased during lockdown periods because of lower operating costs and priority access to electricity networks. While the dramatic reductions in global demand are expected to reduce energy-related CO_2 emissions for 2020, the IEA has cautioned that 'as after previous crises…the rebound in emissions may be larger than the decline, unless the wave of investment to restart the economy is dedicated to cleaner and more resilient energy infrastructure' [10].

Other aspects of demand will take longer to recover. For example, demand for jet fuel is likely to be constrained for a more prolonged period given the impacts of the pandemic on activity in the aviation sector.

The economic shock arising from COVID-19 will also affect energy sector investment. The IEA anticipates that global energy investment could fall by one fifth in 2020 because of disruptions caused by economic restrictions, dramatic reductions in revenues and overcapacity in some markets. The oil and gas sectors are likely to be the most severely impacted, with utility-scale renewable electricity being more resilient [13]. However, post-pandemic stimulus packages may provide opportunities to promote economic recovery while also tackling energy and climate objectives.

The pandemic has emphasised the importance of secure energy supplies to the functioning of essential services, especially the dependence of health systems on reliable electricity supplies. In developed countries, robust electricity networks have accommodated increased demand for health services and facilitated the rapid expansion of remote working. In contrast, many health facilities in Africa have no access to electricity, and electricity reliability problems in Africa and South Asia limit the extent to which social distancing can be practiced [10].

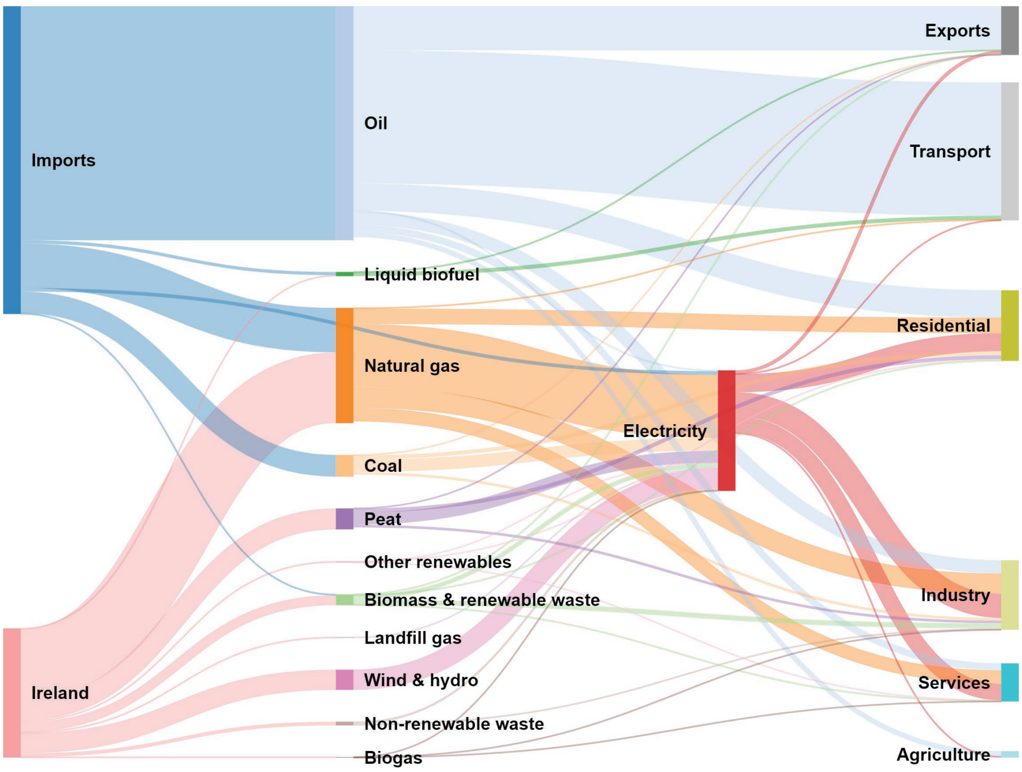
2 OVERVIEW OF ENERGY DEMAND, SUPPLY, AND IMPORT DEPENDENCY

2.1 Ireland's import dependency

A basic and long-standing rule of thumb in examining energy security is that indigenous energy sources are considered to be more secure than energy that is imported. In reality, every supply chain needs to be considered on its own merits; energy imports can be based on stable secure global markets and indigenous sources can be exposed to a variety of sources of insecurity. Nevertheless, energy import dependency remains one of the simplest and most widely used indicators of a country's energy security.

Ireland is not endowed with significant indigenous fossil fuel resources. As a result, the country has maintained a very high energy import dependency since 1990, even though indigenous renewable resources are playing an increasingly important and growing role in the energy mix. *Figure 2* shows the split between Ireland's indigenous and imported energy as a flow diagram. This provides a useful overview of the energy security landscape, clearly illustrating the significance of each fuel type and end-use segment. There are two key points: the high dependency on imports and the dominant role that oil occupies as a fuel of choice, especially in the transport sector.

Figure 2: Energy flows in Ireland 2018[4]

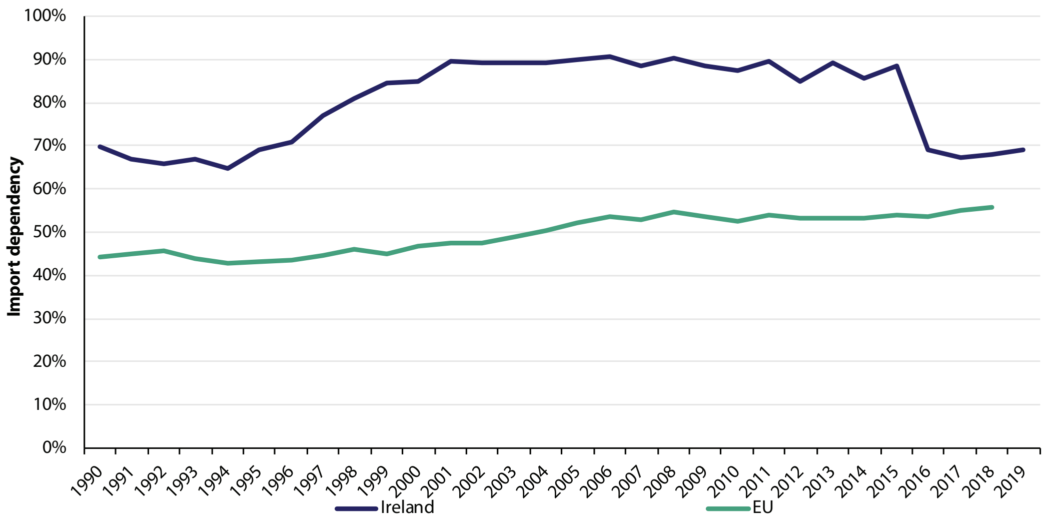


Source: SEAI

Ireland's import dependency was 67% in 2018. *Figure 3* shows how this dependency has changed over time and how it compares with that of the EU. Imports grew from 70% of energy requirements in 1990 to between 85-91% throughout the 1999-2015 period, peaking at 91% in 2006 and then dropping dramatically in 2016. There are two main reasons for this pattern. The first is the increase in energy use across all sectors (particularly transport) from the 1990s through to the economic crisis in 2008, followed by a decrease over the period to 2012 and a subsequent resumption of growth since then. The second reason is the fluctuating contribution from indigenous sources over the period, especially from natural gas.

4 Energy transformation, transmission and distribution losses are not shown in this diagram. This is why, for example, there is much more energy shown entering the electricity node than leaving it.

Figure 3: Import dependency of Ireland and the EU 1990-2019

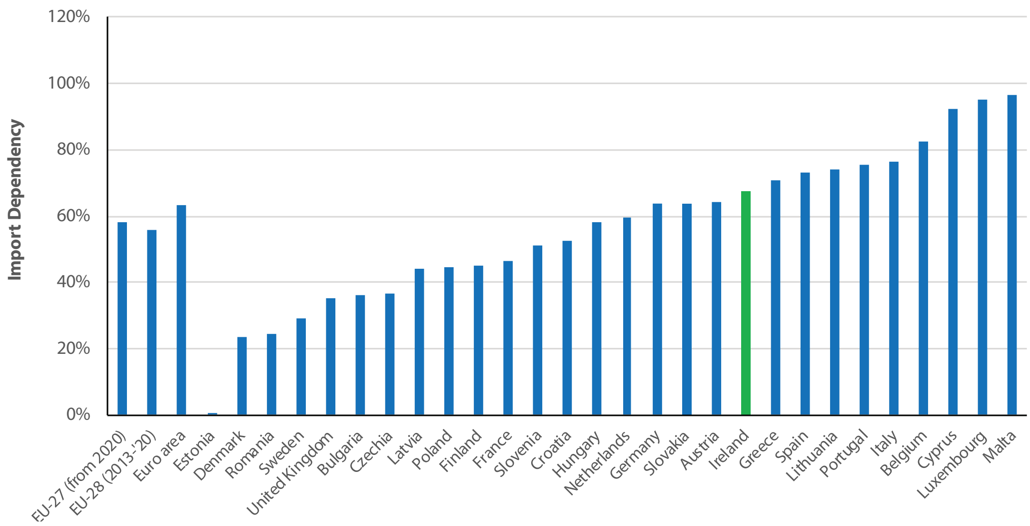


Source: SEAI & Eurostat

Although the import dependency shown for the EU in 2018 is 56%, there is significant variation between individual member states. This is shown in *Figure 4*.

Among the less import-dependent countries, some have clear comparative advantages arising from abundant indigenous resources of fossil fuels (for example, UK, Denmark, Romania) or hydro (for example, Sweden, France). Others have a history of using biomass for heat (for example, Finland) and others still have pursued ambitious policies to exploit other renewable resources (for example, Denmark) or nuclear energy (for example, France). The two least import-dependent countries (Estonia and Denmark) both export significant amounts of energy, which reduces their import dependency.

Figure 4: Import dependency of Ireland and EU member states 2018



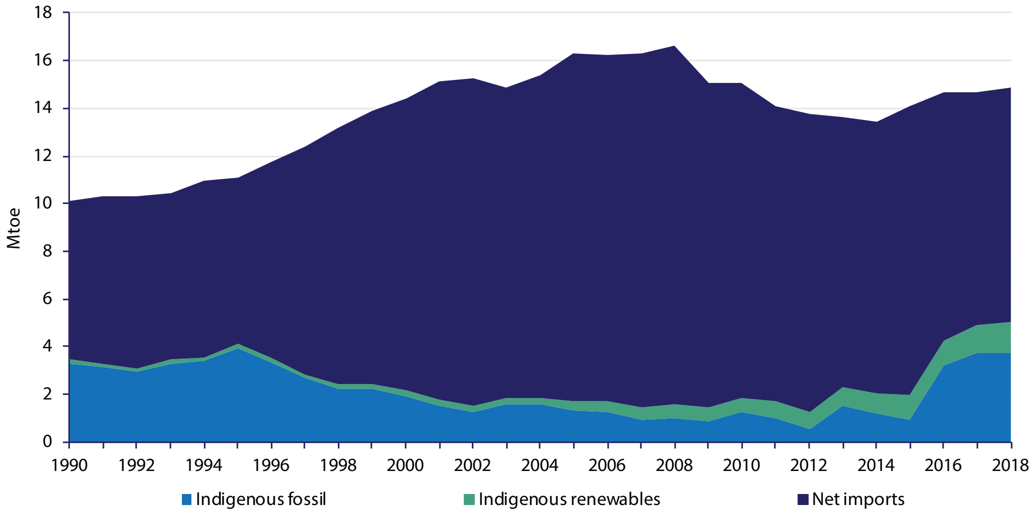
Source: Eurostat

2.2 Provenance of Ireland's energy

2.2.1 Indigenous production

Figure 5 shows the contribution of Ireland's indigenous energy production to the overall energy requirement over the period 1990–2018. *Figure 6* provides a breakdown of the indigenous production by fuel.

Figure 5: Contribution of indigenous energy sources 1990-2018



Source: SEAI

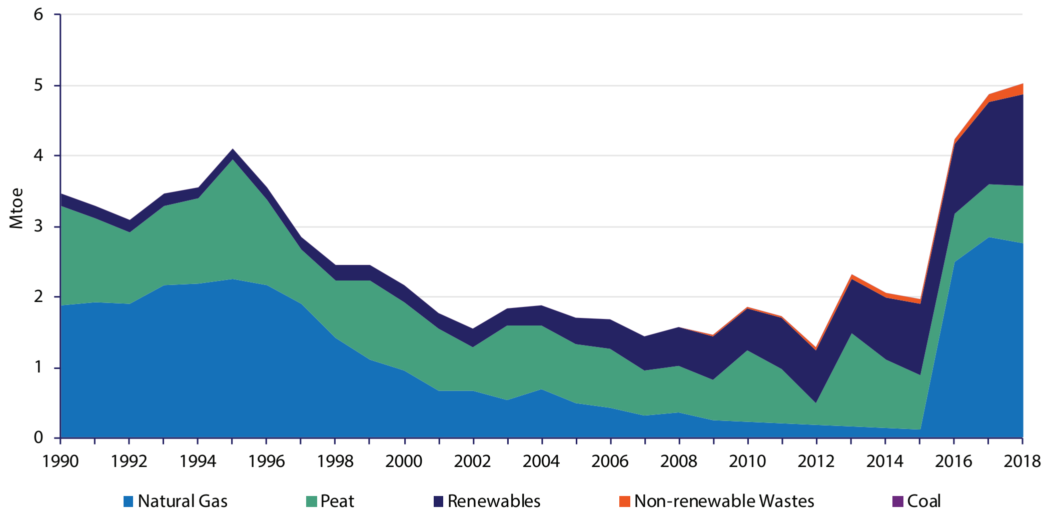
The most significant changes in indigenous energy production have resulted from changes in natural gas production: production at Kinsale peaked in 1995 and declined sharply thereafter, while production at Corrib began in 2015 before ramping up significantly in 2016. By 2018, indigenous natural gas production accounted for 55% of total indigenous production and 19% of Ireland's energy requirement.

Peat production has been on a generally declining trend over the same period. However, production is weather dependent, which leads to spikes in drier years, when excess production is stockpiled, and troughs in wetter years. 2012 had a particularly wet summer and was a record low year for peat production at just 321 thousand tonnes of oil equivalent (ktoe), with 471 ktoe of peat being used from stockpiles to meet demand. 2013, however, had good conditions for peat harvesting with 1,327 ktoe of peat was produced (in part to replenish stockpiles), the highest since the earlier spike in 1995. In 2018, peat production was 16% of total indigenous production and 5.5% of the total energy requirement. Peat's contribution to the electricity generation mix in 2018 was 10%. Two of Ireland's three peat-fired generating stations will cease generation by the end of 2020 [14], while the current planning permission for the third will expire in 2023.

The growth of renewable energy, coming from a low base prior to 2004, has counteracted this reduction in peat production. In the intervening period, renewable energy production increased 361% or 12% per annum. In 2018, renewable energy production accounted for 26% of total indigenous energy production and 9% of the total energy requirement. Increasing the deployment of renewables is part of the strategy to improve energy security for Ireland.

Non-renewable wastes accounted for the remaining 2.9% of indigenous production in 2018 (1.0% of total energy requirement).

Figure 6: Indigenous energy sources by fuel 1990-2018



Source: SEAI

2.2.2 Energy imports

Figure 7 shows the trend for net fuel imports (imports minus exports) over the period 1990–2018. Imports peaked in 2008 before trending downwards by 23% in the following years. In 2018, energy imports were 33% below the 2008 peak.

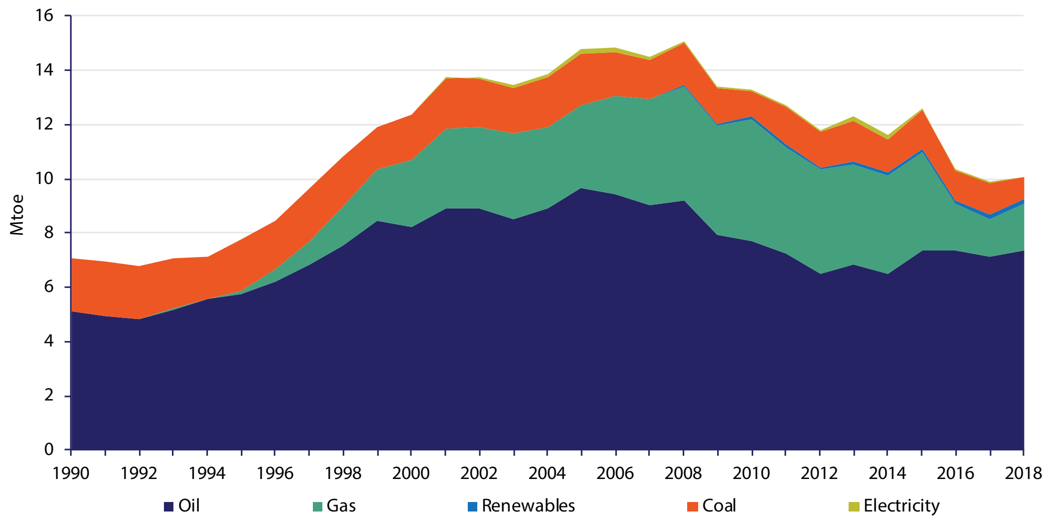
The dominance of imported oil is clear. In 2018, oil accounted for 73% of total imports, natural gas 17%, coal 8.2% and renewables 1.4%.

Oil and coal imports match the profile of demand for these fuels, given that there is no indigenous production. Oil imports have grown rapidly from the mid-nineties, driven largely by transport demand, reaching a peak in 2005. Coal imports have declined gradually because of fuel switching in electricity generation and residential heating.

Gas imports show the most dramatic changes over the period. These have been caused by demand growth, which is largely due to increased usage of gas for power generation, and by the changes in production levels at Kinsale and Corrib.

Renewable imports comprise both liquid biofuels and solid biomass. Electricity imports and exports are via interconnection with the UK. After being a net importer of electricity for fourteen consecutive years, Ireland has been a net exporter of electricity since 2016.

Figure 7: Energy imports by fuel 1990-2018

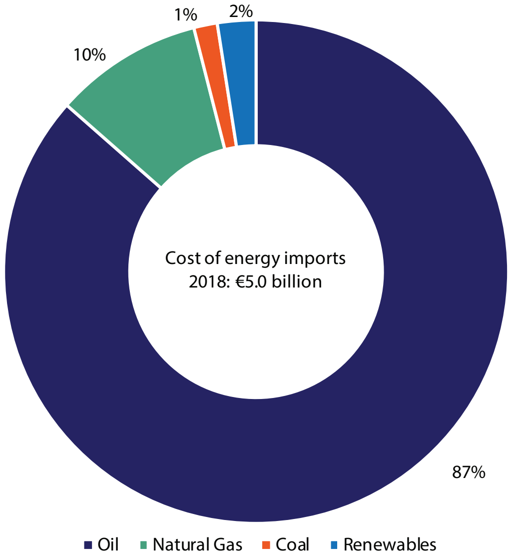


Source: SEAI

2.2.3 Energy import costs

SEAI estimates that the total cost of Ireland's energy imports in 2018 was €5.0 billion. *Figure 8* provides a breakdown of this estimate by fuel type. Unsurprisingly, oil imports dominate the energy import bill, accounting for an estimated €4.3 billion, or 87% of the total. This is because of the large proportion of oil imported in energy terms, as seen in *Figure 2* and *Figure 7*.

Figure 8: Cost of imported energy by fuel 2018



The most significant factor affecting energy prices in Ireland is global oil prices, which have shown dramatic fluctuations in recent years. As well as having a direct impact on the prices of heating oil and transport fuels, global oil prices also influence other energy prices, notably those of natural gas. However, the relationship between oil and gas prices in Europe has become complex in recent years, partly due to the rapid growth of LNG imports to Europe.

In Ireland, natural gas prices have a significant influence on electricity prices because of the country's reliance on natural gas for power generation. This reliance also means that Ireland's electricity security is closely linked to its natural gas security.

SEAI publishes a biannual report on electricity and gas prices in Ireland based on EU legislation on transparency of gas and electricity prices [15]. These reports contribute to the understanding of the key contributing factors underlying price changes.

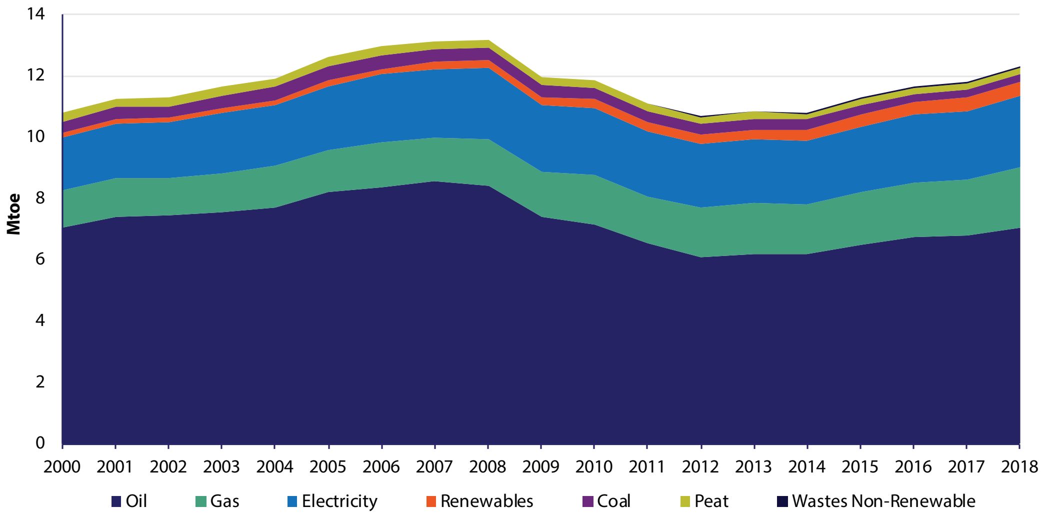
2.3 Meeting Ireland's energy demand

2.3.1 Demand

Final energy demand is a measure of the energy that is delivered to energy end-users in the economy to undertake activities as diverse as heating and lighting communities, manufacturing, providing essential services, and moving people and goods. It excludes the quantities of energy required to transform primary energy sources, such as crude oil, into forms suitable for end-use, such as transport fuels and electricity.

Figure 9 shows the breakdown of final energy demand by fuel over the period 2000–2018. Final consumption peaked at 13.2 Mtoe in 2008, fell by 19% by 2012 and increased by 15% by 2018. 2018 final consumption was 12.3 Mtoe, which is 6.6% below the 2008 peak. Oil dominates, accounting for 57% of the total in 2018, with 71% of this being used in transport. Electricity, natural gas, and renewables account for 19%, 16% and 3.8% respectively. It is noteworthy that final consumption of renewables accounts for renewable energy consumed directly by end-users (for example, biomass for heat and biofuels for transport) but not the large amount of renewable energy used to generate electricity.

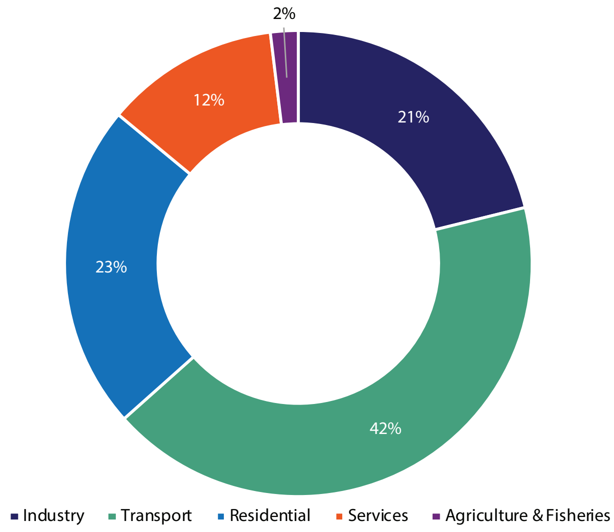
Figure 9: Final consumption by fuel 2000-2018



Source: SEAI

Figure 10 illustrates the sectors in which energy is being used. The scale of the transport and residential sectors are notable. Together they account for 65% of final demand. Both these sectors comprise very large numbers of relatively small end-users. This is a challenge for energy policy makers because achieving meaningful change, in terms of both strengthening demand-side energy security and decarbonisation, depends on influencing very many individual decision makers about their consumption patterns and fuel choices.

Figure 10: Final consumption by sector 2018

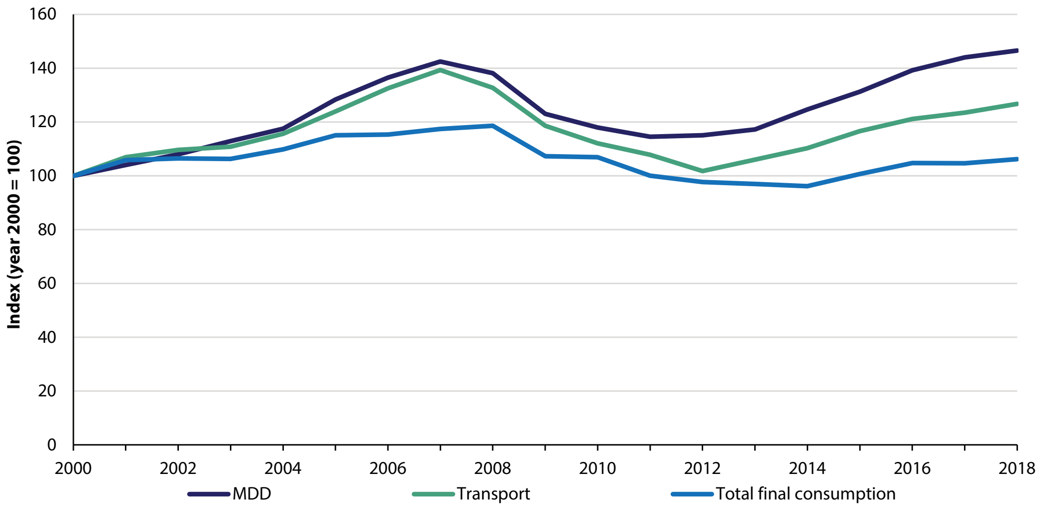


Source: SEAI

It is also interesting to examine the trend in final consumption over time and its relationship with economic activity. *Figure 11* shows the trends in total energy demand, transport's consumption and modified domestic demand[5] as indices relative to their 2000 values. It illustrates how transport final energy demand was very strongly coupled to economic activity during the 2000-2009 period.

5 Modified domestic demand is an indicator of domestic demand calculated by the CSO that is designed to give better insight into Irish domestic economic activity. It excludes trade in aircraft leasing and R&D-related intellectual property (IP) imports.

Figure 11: Index of modified domestic demand and final consumption by sector 2000-2018



Source: SEAI & CSO

With the onset of the economic crisis in 2008, transport consumption reacted strongly to the fall in economic activity, mainly due to a significant reduction in activity in road freight and international aviation. Between 2007 and 2011, modified domestic demand fell by 5.3% per annum while transport consumption fell by 6.2% per annum. For the period 2013 to 2015, transport energy growth matched growth in modified domestic demand, with annual growth rates of 4.7% and 4.5% respectively. Since 2015, the growth in transport consumption has softened to 2.2% per annum, while the annual growth in modified domestic demand has been 3.7%.

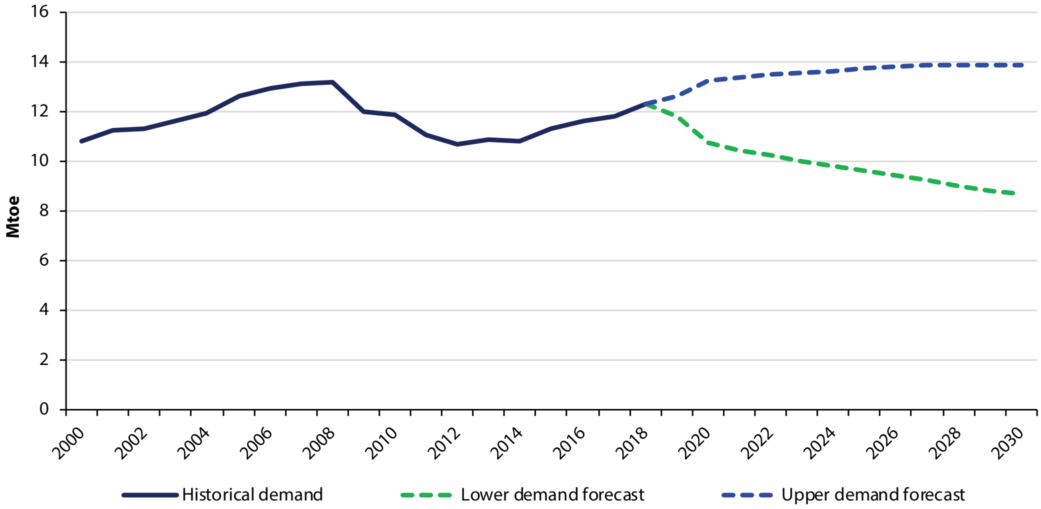
2.3.2 Future demand

Despite evidence of relative decoupling of energy demand from economic activity in recent years, there remains an enduring relationship between the two. This has implications for energy security, especially in the case of transport, which is the dominant driver for oil imports. Transport is considered the most difficult of all sectors to diversify from fossil fuel consumption and decarbonise.

Figure 12 shows the historical trend in final energy demand since 2000 and the national energy projections prepared by SEAI for the period to 2030. The lower projection is based on higher fossil fuel prices and the implementation of the policies and measures contained in the Climate Action Plan [7]. This projection could be lowered further in due course in accordance with the more ambitious decarbonisation targets proposed in the European Green Deal [6]. The higher projection is a worst-case scenario used for comparison and is not considered likely[6]. The projections indicate an annual change in final energy demand of between -2.9% and +1.0% between 2018 and 2030.

6 Additional information on SEAI's projections is provided in section 1.4.

Figure 12: Historical and projected final energy demand 2000-2030



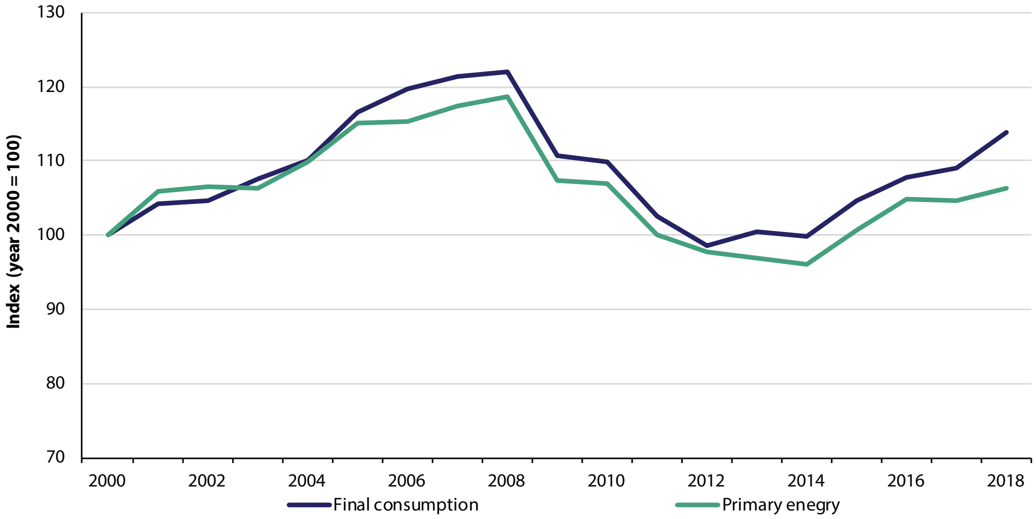
Source: SEAI

2.3.3 Supply

Primary energy is the total amount of energy used in Ireland. It includes the energy overhead required to convert primary sources of energy into forms that are useful for the final consumer, for example, the energy used in oil refining processes and for power generation, transmission, and distribution. This energy overhead is not all directly related to the level of economic activity. Instead, it is dependent to a large extent on the efficiency of the transformation process and the technologies involved.

Ireland's primary energy requirement in 2018 was 14.6 Mtoe, 19% more than final demand. *Figure 13* shows the trends in both final energy demand and primary energy supply over the period 2000–2018, as indices relative to their 2000 values. The primary energy requirement in 2018 was 5.2% higher than it was in 2000, whereas final demand was 12.9% higher. The main reason for this is an improvement in the efficiency of Ireland's electricity supply over this period – from 36% in 2000 to 52% in 2018.

Figure 13: Index of final consumption and primary energy supply 2000-2018



Source: SEAI

Greater efficiency of transformation improves energy security because it decreases the amount of primary energy required to meet a given level of final demand.

2.4 Impact of Brexit on energy security

Much of Ireland's energy policy is derived from EU policy and legislation. This was also the case for the UK prior to its departure from the EU in early 2020. Therefore, a legacy of the UK's membership of the EU is an energy policy framework that is closely aligned with that of other member states, including Ireland's. One practical example of this alignment is the single electricity market, which has operated on an all-island basis since 2007.

The 2019 National Risk Assessment concluded that '*Brexit poses a particular risk as Ireland imports the vast majority of its energy requirements, oil, gas and transport fuels, from or via the UK*' [3]. In its 2019 review of Ireland's energy policies the IEA noted that '*the vote of the United Kingdom to leave the European Union poses unique challenges, although the full impact on the energy sector of Ireland cannot yet be determined*' [16]. It added that '*maintaining beneficial energy relations between Ireland and the United Kingdom is in the interest of both countries*'.

There is a risk that Brexit could lead to a divergence in energy policy and regulation between the UK and Ireland over time. Brexit has also had some immediate impacts on the energy relationship between the two countries. Both will have repercussions for Ireland's energy security, although the full extent of these may not be fully understood for some time.

The potential implications of Brexit on specific aspects of energy security are discussed in relevant chapters.

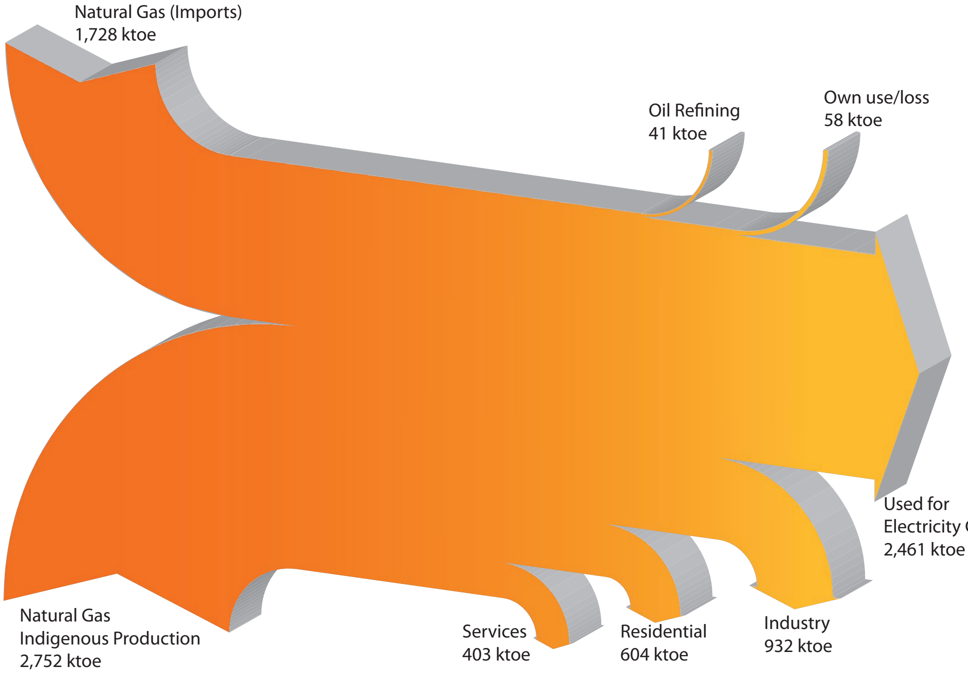
3 FOSSIL AND RENEWABLE GAS

3.1 Gas demand

3.1.1 Historical demand

Figure 14 presents an energy flow diagram for gas usage in 2018. The total input is shown on the left while outputs on the right are categorised by sector. This illustrates that most of the gas[7] was indigenously produced in 2018 and that electricity generation was responsible for the largest share of demand.

Figure 14: Natural gas energy flows in Ireland 2018



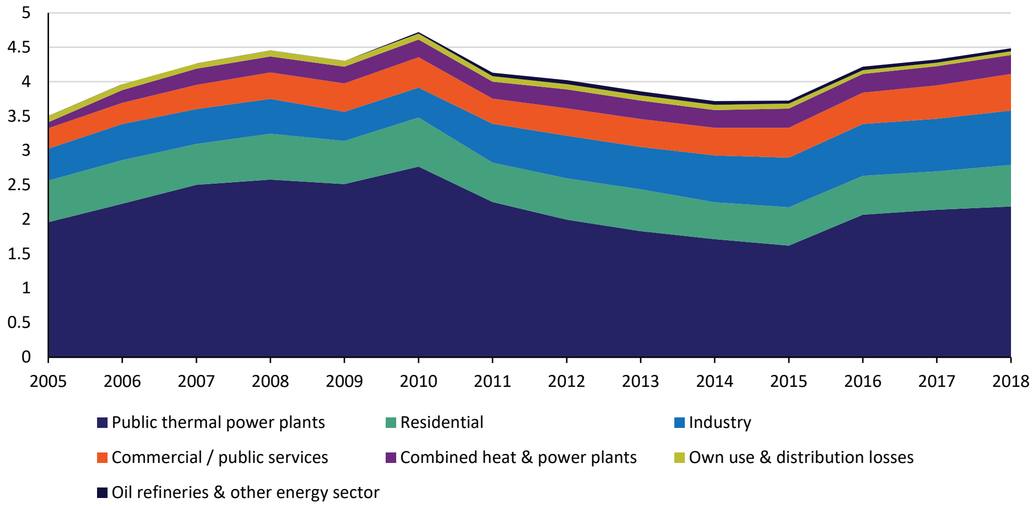
Source: SEAI

The breakdown of natural gas demand since 2005 is shown in *Figure 15*. Demand grew until the onset of the financial crisis in 2008. The subsequent peak in 2010 was partly due to the commissioning and connection of two new gas-fired power plants at Aghada and Whitegate. Between 2010 and 2014, gas demand for electricity generation decreased by 38%, or 11.3% per annum. This was due to a number of factors, including: an overall reduction in electricity demand post 2008; increased renewable electricity generation, particularly wind; increased use of coal between 2010 and 2012 due to market forces (prices) and; higher electricity imports from the UK due to increased interconnection and market signals. The use of gas in the power sector jumped by 23% in 2016, giving rise to a 13% increase in total gas use. This coincided with Ireland changing from being a net importer of electricity to being a net exporter.

Industrial gas demand decreased by 8% between 2005 and 2009, before increasing by 87% over the subsequent nine years. Despite this growth, industrial consumption accounted for only 18% of primary gas demand in 2018, with the residential and services sectors consuming 14% and 12% respectively. While residential demand did fluctuate over the period shown, 2018 consumption was just 0.4% lower than it was in 2005. Total demand for gas grew to 4.48 Mtoe by 2018, which was 5% below the 2010 peak.

7 Unless otherwise stated, in this section, the term 'gas' refers to natural gas, which is essentially methane, and is of fossil origin.

Figure 15: Gas primary energy demand by end-use 2005-2018

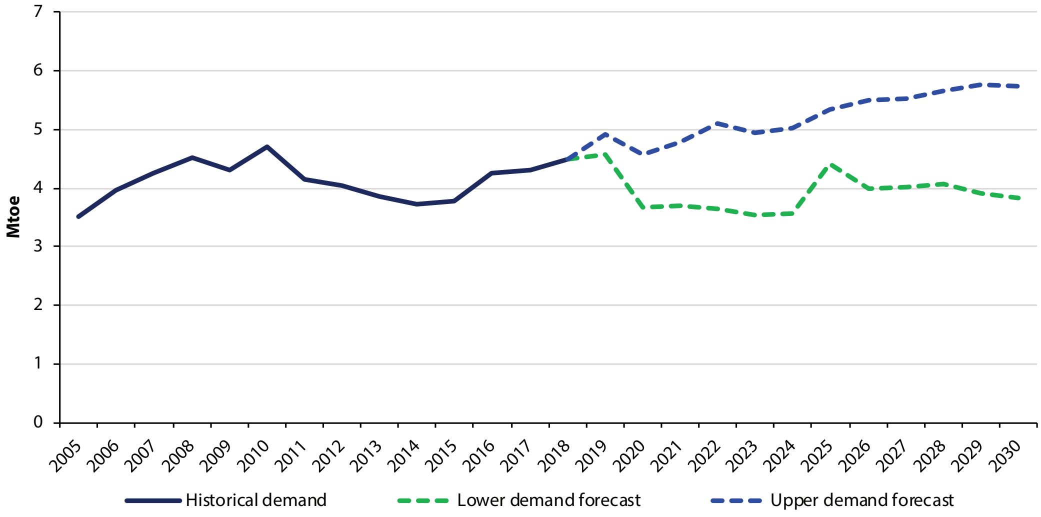


Source: SEAI

3.1.2 Future demand

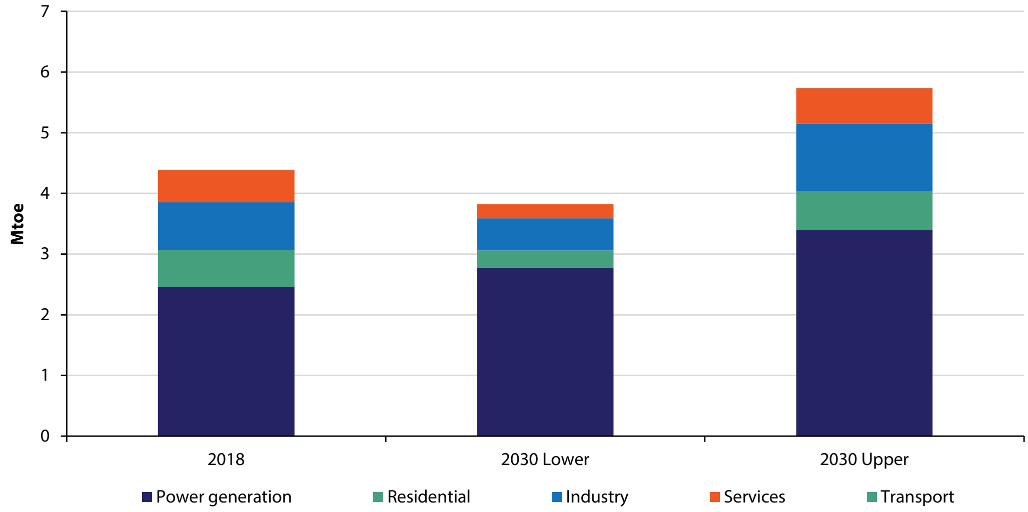
Figure 16 shows the historical trend in primary energy gas demand and the national energy projections produced by SEAI for the period 2019-2030. *Figure 17* provides a breakdown of demand for 2018 and for two alternative projections for 2030. Both figures include gas used for power generation as well as final consumption.

Figure 16: Historical and projected primary energy demand for gas 2005-2030



Source: SEAI

Figure 17: Primary energy demand for gas in 2018 and 2030



Source: SEAI

In the period to 2030, gas demand will depend on several factors including the pace of transformation in the power and heat sectors, fossil fuel prices and underlying economic conditions.

SEAI's higher projection assumes lower fossil fuel prices (which encourage higher energy demand) and that Climate Action Plan 2019 [7] will not be implemented in full. As such, it is a worst-case scenario used for comparison and is not likely. The lower projection is based on higher fossil fuel prices (which tend to reduce demand) and on the successful implementation of the ambitious policies and measures contained in the Climate Action Plan to improve energy efficiency and increase renewable energy use. From a sustainability perspective, it is important that gas demand follows the lower projection. This may be lowered in time as the European Green Deal is translated into national action [6]. Lower demand will also enhance energy security and competitiveness.[8]

The main reason for the variation in natural gas use in the SEAI projections is the amount of gas consumption projected for the electricity sector. SEAI anticipates that demand for electricity will grow significantly over the next decade as the population and economy grows, and both heat and transport are increasingly electrified – see chapter 5. Natural gas accounted for 54% of power generation in 2018. The extent to which additional electricity demand will be met by gas-fired generation is dependent on several factors, including: the timing of the final phase-out of generation from coal and peat; the rate of deployment of renewable electricity capacity and; the level of technology and infrastructure development required to accommodate large amounts of renewable generation on the electricity system.

Demand from other sectors will also evolve over time. In its Network Development Plan 2018 (draft), GNI projected a 20% increase in industrial and commercial demand and an 8.4% increase in residential sector gas demand between 2017 and 2018 and between 2026 and 2027 (median scenario) [17]. However, these forecasts predated Climate Action Plan 2019, which announced the Government's intention to ban the installation of gas boilers in new dwellings from 2025 and to assess how and when existing gas boilers (domestic and commercial) should be replaced [7]. The Plan also includes a target of 600,000 heat pumps by 2030, including 400,000 in existing buildings.

The rate of uptake of natural gas for transport will also impact on demand, but this is likely to be small compared to other sources of demand.

Gas security could be improved and the requirement for investment in new gas infrastructure reduced by constraining future gas consumption at levels lower than those envisaged in the projections shown in *Figure 16*. However, this would require policies and measures even more ambitious than those envisaged in the Climate Action Plan.

While gas will continue to be required in the electricity generation and heat sectors out to 2030, the future for gas beyond 2030 is less certain. The use of fossil gas without carbon capture will need to be eliminated. There may or may not be a role for fossil gas with carbon capture and storage, depending on the development of this and other competing technologies. Similarly, there may be a role for green gases such as biomethane or green hydrogen, but the role they could play and the scale at which they could be used is uncertain. This uncertainty on the future of gas post 2030 is an important consideration when looking at investment decisions that may have longer payback periods.

If gas use significantly reduces and the customer base begins to steadily shrink, an energy security issue referred to as the utility-death-spiral could arise. This occurs when the burden of the fixed costs of infrastructure is spread over a smaller and

8 Additional information on SEAI's projections is provided in section 1.4.

smaller number of customers, leading to higher fixed charges for the remaining customers. This can potentially lead to a self-re-enforcing cycle that threatens the viability of a network. This potential risk will need to be explored further when examining future potential pathways for the gas grid.

3.2 Gas supply

3.2.1 International developments

3.2.1.1 Global demand

Natural gas met almost half of global energy demand growth in 2018, making it the fastest growing energy source. Demand increases in 2018 were driven by global economic growth, fuel switching away from coal in the power sector and industrial development.

The IEA's latest World Energy Outlook [18] anticipates global energy demand to increase until 2030 for all its policy and technology development scenarios, with demand subsequently reducing by 10% by 2040 in its sustainable development scenario. While power generation is expected to remain the biggest consumer of gas globally, industrial use, both as fuel and as a chemical feedstock, is anticipated to be the biggest contributor to future growth [18]. The IEA anticipates that the biggest demand increases will come from the Asia-Pacific region, particularly China and developing Southeast Asian countries. Industrial development is anticipated to be the biggest contributor to Asia-Pacific growth.

The European Commission estimates that achieving the 2030 climate and energy targets would result in a 26% reduction in European gas demand compared to 2015 levels [19], while the IEA projects that EU gas demand would decline to 81% of 2018 levels by 2030, and to 55% of 2018 levels by 2040, under its sustainable development scenario [18].

3.2.1.2 Global supply

Natural gas markets have become progressively more globalised due to the increase in LNG trade and the completion of pipeline projects linking producers with new markets. Technological developments have made shale gas and LNG cheaper, leading to more supply and more export options for that supply. For its sustainable development scenario, the IEA projects that long-distance trade in natural gas will increase by almost a quarter by 2040, with long-distance trade in LNG increasing by approximately 80% as long-distance pipeline trade decreases by approximately 20% [5].

The US is the world's largest producer of natural gas. It went from being a net importer of natural gas in 2000 to become a net exporter and is expected to remain the world's largest gas producer for the foreseeable future [18][20]. Advances in technology have contributed to a rapid growth in oil and gas production from shale formations in the US over the last decade. Between 2010 and 2018, shale gas increased from 26% to 75% of US natural gas supply. Shale oil production also contributed (to a lesser extent) to natural gas supply growth because some shale oil contains significant quantities of entrained natural gas known as associated gas. The US Energy Information Administration estimates that only 25% of associated gas production is recovered and sold. The remaining 75% is flared [20]. New gas recovery infrastructure and pipelines are being constructed to recover more of this flared gas [21]. In 2018, 12% of total US natural gas production came from associated gas recovery [22].

Russia is the world's second largest producer of natural gas. Small production increases are forecast through the next decade. Several notable infrastructural enhancements will broaden export options for Russian gas, including: Nord Stream 2, which will double export capacity of the existing Nord Stream route to the EU; the Power of Siberia pipeline linking Russia and China and; capacity increases of liquefaction plants for gas exports to other markets [20].

A steady decline of European production is forecast to continue, leaving Europe increasingly dependent on imports. Over the next five years, Norwegian gas (approximately 50% of European production) will plateau while Dutch and British gas fields will continue to decline steadily.

Major government investment programmes have aided the rapid growth of Chinese natural gas production over the past decade. Historically, Chinese indigenous production has contributed more to domestic demand than imports. Despite this growth in indigenous production, it is not expected to keep pace with demand, which is forecast to double over the next decade. China will become more dependent on imports as the gap between production and demand widens.

Iran is the largest producer in the Middle East. It is expected to expand its production by 2-3% per annum until 2024. Much of this will likely be consumed by domestic demand growth. Qatar exports more LNG than any other country and plans to increase its output by 43%. Its export facilities operated at maximum capacity in 2018 [21].

The production and transport of natural gas gives rise to greenhouse gas emissions that are additional to those generated from the final combustion of the gas. The extent of these supply chain emissions varies considerably depending on the source of production. They typically range from 15% to 50% of combustion emissions but can be considerably more. Methane leakage to atmosphere is by far the largest source of emissions between the reservoir and the consumer [5].

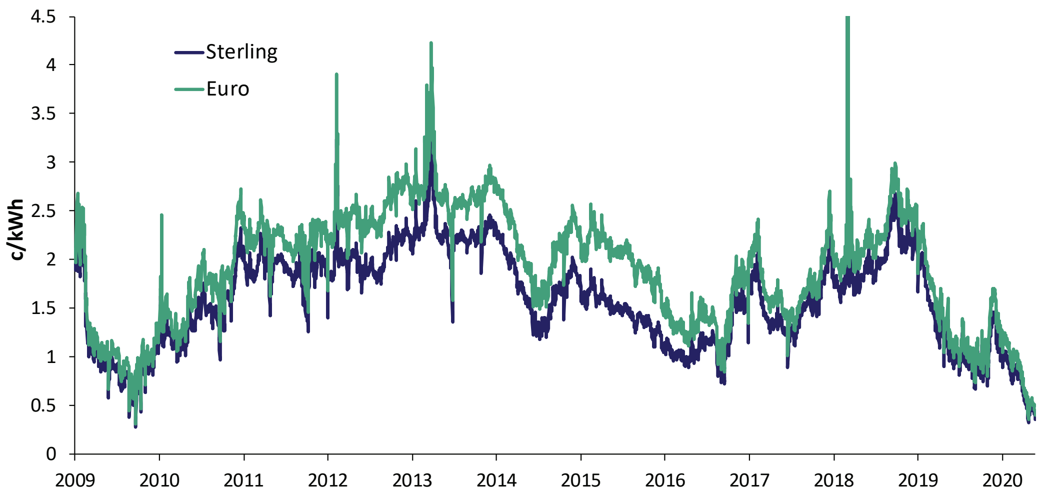
In 2018, there were over 220 trillion cubic meters of natural gas reserves on earth, a 30% increase on 2008 levels [23]. The IEA estimates that even in the stated energy policies scenario, 52% of proven reserves would remain unburned by 2040, while 58% would need to remain unused in the sustainable development scenario [5].

3.2.2 International gas prices

Natural gas pricing mechanisms can be broken into three categories: gas-on-gas, which is based on gas supply and demand; oil price escalation, which links gas prices to a benchmarked oil price and; regulated and bilateral agreements. The UK National Balancing Point is an example of a hub for gas-on-gas pricing. In Europe, pricing has gradually moved away from oil price escalation to gas-on-gas competition. Roughly 80% of trade was based on oil price escalation in 2005 but this decreased to 30% by 2018 [20]. European gas prices are increasingly influenced by LNG imports from regions with different prices and pricing mechanisms, such as the US (100% gas-on-gas pricing) and Qatar (regulated SMR).

Irish wholesale natural gas prices are referenced to the virtual Irish Balancing Point and based on those at the UK National Balancing Point. After three years of progressively higher prices, UK and Dutch gas prices more than halved in late 2018 and remained at these levels through 2019. *Figure 18* shows the gas price at the UK National Balancing Point in sterling and euro. The sterling-to-euro exchange rate affects the Irish Balancing Point price. The price spike in early 2018 arose because of Storm Emma, which disrupted elements of the UK's gas supply infrastructure during a time of very high demand from the commercial and residential sectors.

Figure 18: UK national balancing point gas price 2010-2020



Source: National Grid (UK)

The price drop in late 2018 was driven by several factors including: a warmer-than-forecasted winter in Asia and Europe; reduced Japanese LNG demand as its nuclear power fleet came back online; additional US LNG liquefaction capacity; the US-China trade dispute, which restricted LNG flows from the US to China and; high Russian and Norwegian gas flows to Europe. Asian LNG spot prices dropped, bringing them closer to European prices. This led some LNG exporters to divert cargos to Europe, which further loosened an already well-supplied market [20].

3.2.3 Ireland's gas supply

Figure 19 shows Ireland's indigenous gas production and gas imports from 2005 to 2018, and projections for indigenous production and demand for the period to 2027.

Indigenous gas production enters the grid at Bellanaboy in Mayo (Corrib field) and Inch in Cork (Kinsale and related fields[9]). The Kinsale fields began producing gas in the late 1970s but have been in decline since 1995. Ireland's first natural gas interconnector with the UK was constructed in 1993, with a second added in 2002. Both connect to the UK at Moffat in Scotland. Imports via the UK grew throughout the 1990s and exceeded indigenous production throughout the period, from 1999 to 2015. By 2015, 97% of Ireland's gas demand was supplied from imports and Ireland had become very reliant on the Moffat interconnector system. During the 2000-2015 period, the UK also became increasingly reliant on imported gas, initially from Norway, Belgium, and the Netherlands, and subsequently from further afield. Both these trends had implications for Ireland's gas security.

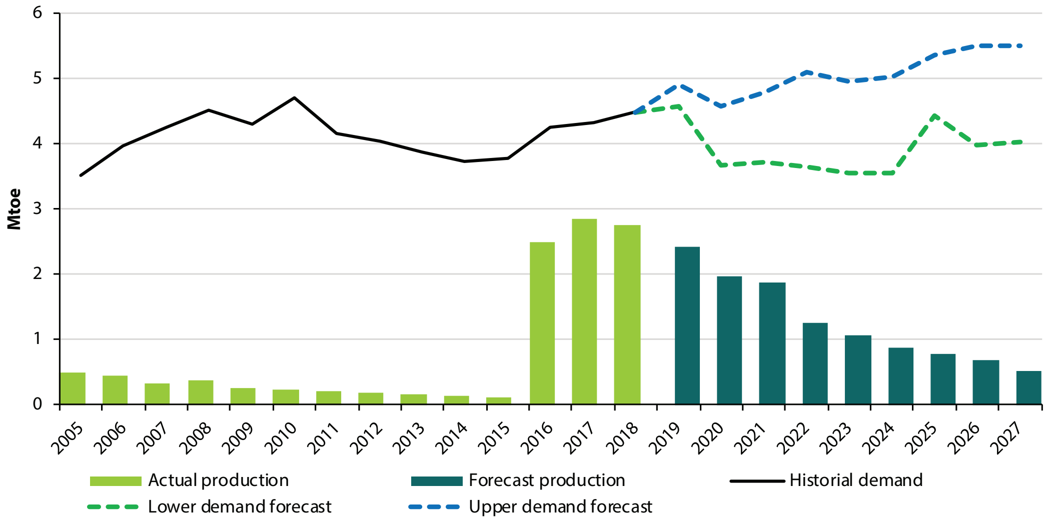
By 2015, production from Kinsale accounted for only 3% of national demand [24]. Kinsale has remained at a low level since then and production is expected to cease in 2020 [17]. The Corrib field was discovered in 1996 and commenced commercial

9 Kinsale Head field, Ballycotton field, Southwest Kinsale field and Seven Heads field.

production in late 2015. Since then, it has displaced significant quantities of imported gas and reduced Ireland's reliance on the interconnector system. In 2018, 61% of Ireland's gas demand was met from indigenous production (mostly Corrib), down from 66% in 2017.

However, supply from Corrib has already peaked and is projected to decline throughout the 2020s and into the 2030s: GNI anticipates that by 2026 or 2027 the supply from Corrib will be less than 30% of initial peak production levels. GNI's expected production profile of Corrib until 2027 is shown in *Figure 19* along with the historical and forecast demand data introduced in *Figure 16*.

Figure 19: Historical and projected indigenous natural gas production 2005-2027[10]



Source: SEAI & GNI

The gap between the historical demand and production shown in *Figure 19* was met by imports from the UK. In the short term at least, the deficit between forecast gas demand and declining production from Corrib will also be filled by imports via the UK.

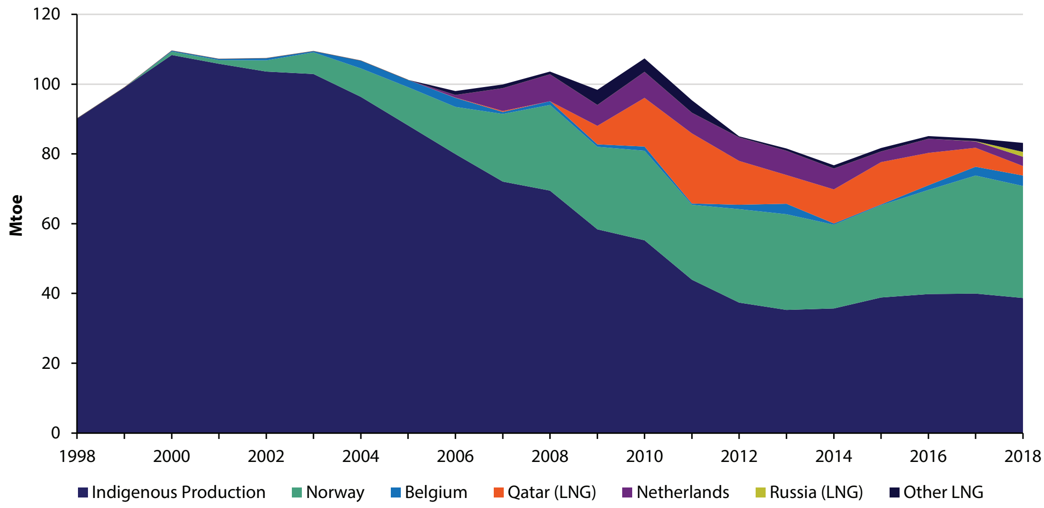
3.2.4 UK's gas supply

As all of Ireland's gas imports come via the UK, it is relevant to examine the source of gas supply to that market.

Natural gas accounts for the largest share of the UK's primary energy supply and the UK is the third-largest producer of natural gas in the European Economic Area. The UK became a net importer of natural gas in 2004, having previously been a net exporter. *Figure 20* shows UK natural gas production and imports from 1998 to 2018 [25]. Indigenous production declined significantly from a peak in 2000 until 2013, as several fields approached end of life and others grew less economically viable. In 2014, the UK Government embarked on a strategy to maximise natural gas recovery, through tax and other incentives. Production grew in 2014 and has since stabilised.

10 The actual demand, actual production and SEAI forecast data presented in *Figure 19* are for calendar years. The forecast production data is for gas years.

Figure 20: UK natural gas production and imports 1998-2018

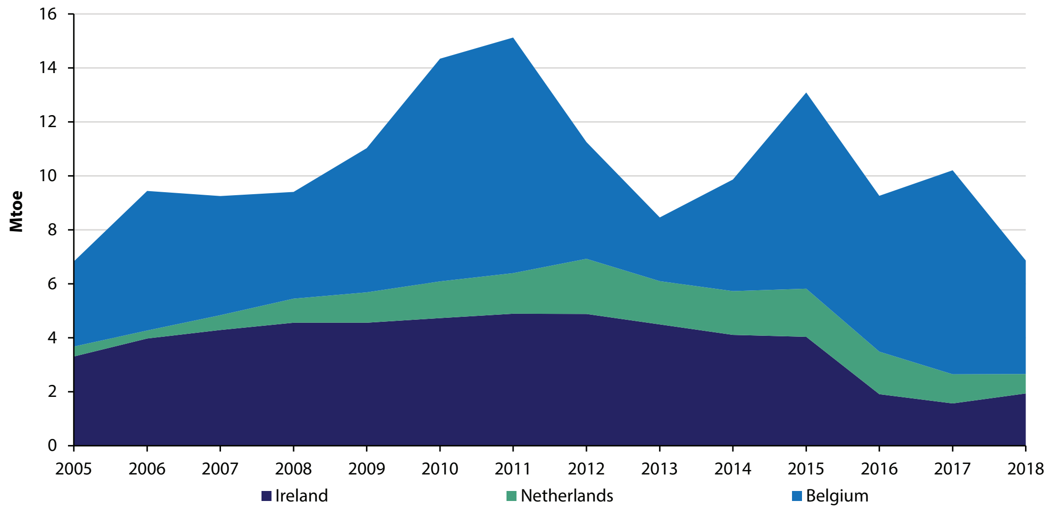


Source: Digest of UK Energy Statistics

Approximately 48% of UK demand in 2018 was met by imports, with most coming via pipeline from Europe [25]. A growing amount is imported as LNG via three import terminals. LNG imports increased by 6.4% in 2018 to account for 15% of imports, as decreased demand in Asia and increased global supply lowered LNG prices. LNG growth is expected to continue as domestic production decreases. The sources of the UK's LNG imports have diversified in the past decade, growing from three sources in 2008 (Qatar, Algeria, Trinidad & Tobago) to ten in 2018, with supplies from Russia and the US growing rapidly.

The UK exports gas via pipeline to Belgium, the Netherlands and Ireland. In 2018, UK gas exports were equivalent to 10% of its combined domestic production and imports. The export quantities are shown in *Figure 21*. The decline in exports to Ireland in 2016 was caused by the commencement of commercial production at Corrib. Ireland accounted for 28% of the UK's exports in 2018 [25].

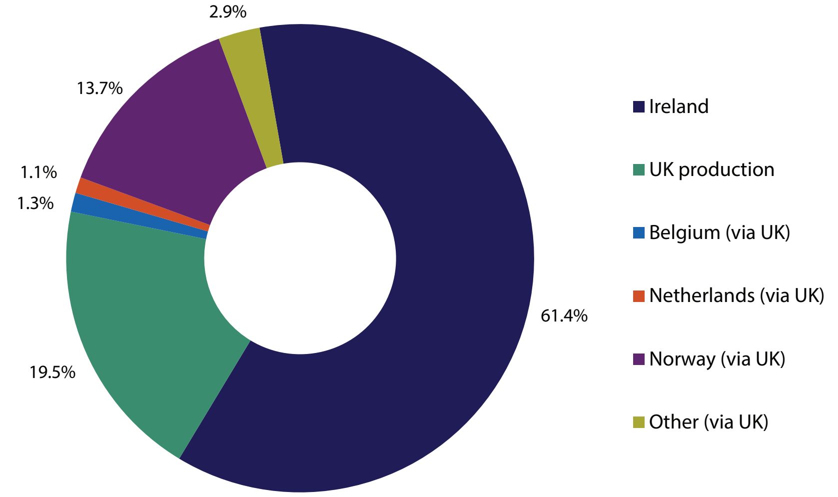
Figure 21: UK natural gas exports 2000-2018



Source: Digest of UK Energy Statistics

Figure 22 shows a breakdown of Ireland's 2018 natural gas supply in which imports from the UK are allocated on a simple pro rata basis to the sources of the UK's gas supply [25].

Figure 22: Breakdown of Ireland's natural gas supply 2018 (incorporating simple pro rata of UK gas supplies)



Source: Digest of UK Energy Statistics

In its 2019 review of the UK's energy policies, the IEA concluded that the UK's security of gas supply mechanisms are strong, noting that it has abundant infrastructure, a diverse supply (domestic production, pipeline imports and LNG) and a liquid market [26].

Aspects of the UK's gas security have been tested and validated in recent years. An unplanned shutdown of the Forties Pipeline System (North Sea) in 2017 reduced production by an amount equivalent to 12% of a typical winter's day demand, but this was balanced by imports from continental Europe. In 2018, severe weather conditions caused by Storm Emma disrupted elements of supply infrastructure at the same time as demand from the commercial and residential sectors increased by over 40% (over five days). A deficit warning was issued, gas prices hit a 20-year high and, '*the market reacted by optimising both the demand and the supply side*' [26].

The UK's role as a regional partner for Ireland on gas security is discussed in section 3.4.3, and the potential impacts of Brexit on gas security are addressed in section 3.7.

3.2.5 Oil and gas exploration

3.2.5.1 Offshore exploration

In total, 133 exploration wells and 28 appraisal wells have been drilled in Irish offshore waters; there have been four commercial gas discoveries (Kinsale Head, Ballycotton, Seven Heads and Corrib) and no commercial discoveries of oil to date.

In its 2019 country report, the IEA recommended that Ireland should, '*ensure a stable and streamlined regulatory framework, and conduct regular licensing rounds, to encourage exploration activities and, subsequently, develop domestic [natural gas] reserves*' [16]. However, the extent to which any new source of indigenous natural gas would strengthen Ireland's energy security would be dependent on the timing of its production, in the context of Ireland's transition away from fossil fuels, including natural gas. The lengthy development period for Corrib[11] and uncertainty regarding the role that natural gas will play in Ireland's energy mix beyond 2030 would be important considerations in this regard.

In late 2019, DCCAE published a new policy statement on oil and gas exploration [27]. All future licensing rounds and licensing applications for offshore exploration will be for natural gas only, not oil. The rationale for the differentiation between oil and natural gas is the role that gas is anticipated to play as a transition fuel. All applications and authorisations in place before 23 September 2019 that relate to oil will not be affected by the new policy.

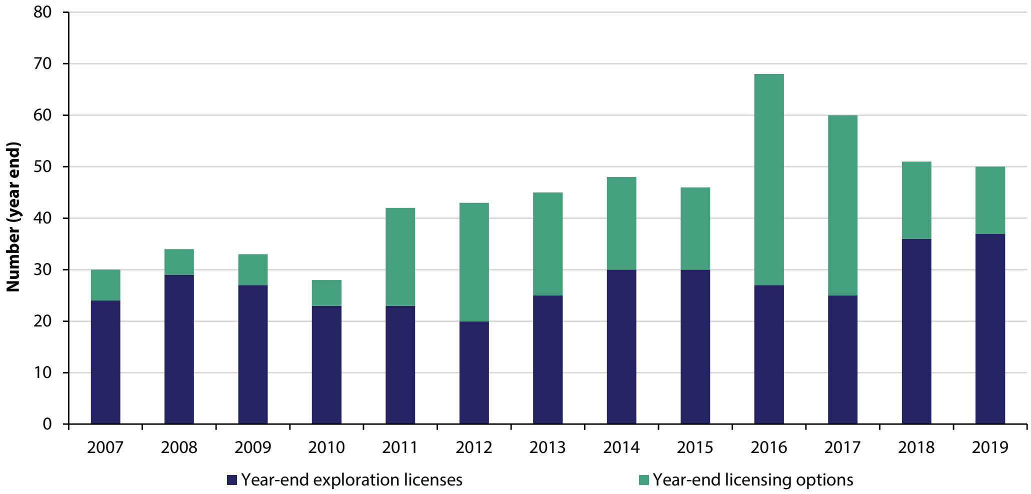
The 2019 policy acknowledges the complexities involved in exploring for natural gas while excluding oil, especially as current research indicates that mixed oil-gas sources are the most likely sources of natural gas in Irish waters. The policy restricts future authorisations for production to natural gas that is found in a gaseous or solid state. The licensing terms for exploration, development and production will be revised in light of the new policy statement.

In 2020, the Government indicated that it intends to also cease issuing new licences for the exploration and extraction of natural gas.

Figure 23 shows the number of offshore exploration licences and licensing options as of the end of December each year.

11 Should a future commercial discovery in the vicinity of Corrib leverage existing production and, or, processing infrastructure, it is likely that the development time for such a discovery would be less than that for Corrib.

Figure 23: Number of licences 2007-2019

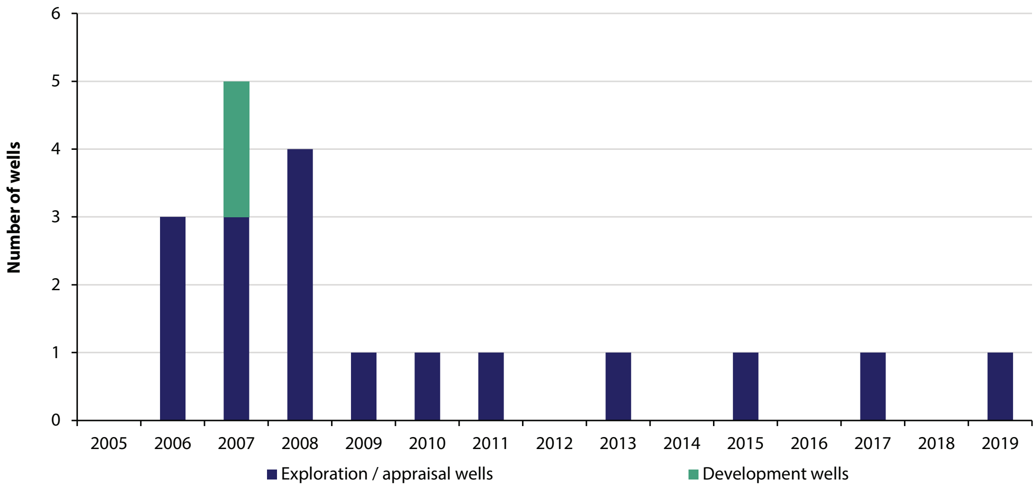


Source: DCCAE Petroleum Affairs Division

Despite the relatively high numbers of licences and options in recent years, the level of exploration activity has been low. *Figure 24* shows the amount of drilling that has taken place in Irish waters. An explanation of the graph legend is as follows:

- Exploration wells are drilled on valid prospects outside the interpreted limits of commercial or potentially commercial discovered hydrocarbons.
- Appraisal wells are drilled after the establishment of the location of hydrocarbon accumulations, within the interpreted limits of commercial or potentially commercial discovered hydrocarbons, for the purpose of delineating the size and productive capacity of the reservoir(s).
- Development wells are drilled for the purpose of production, injection, observation, or disposal of fluid to, or from, known fields.

Figure 24: Wells spudded and drilled in Ireland for exploration 2005-2019



Source: DCCAE Petroleum Affairs Division

All technical data acquired or generated under petroleum authorisations must be reported to DCCAE. DCCAE maintains the national repository of this data and provides access to it once confidentiality periods have expired. This facilitates effective petroleum exploration and research.

The Government is currently undertaking a significant reform of policy and legislation in the area of marine planning. It expects to adopt a new national marine planning framework in late 2020, having approved the general scheme of a new marine planning and development management bill in 2019.

Given the relatively low levels of recent offshore drilling activity and the length of time it can take to progress commercial finds to commercial operation, the short-to-medium-term prospect of a new supply of natural gas does not appear likely. The likelihood of an indigenous supply of crude oil is also low given the relatively low oil price and the 2019 policy position.

3.2.5.2 Onshore exploration

A region known as the Northwest Ireland Carboniferous Basin, encompassing Cavan, Roscommon, Donegal, Sligo and Leitrim had previously been identified as a shale rich area [28]. Unconventional gas exploration and extraction, which includes the process commonly referred to as hydraulic fracturing of low-permeability rock, has been prohibited by law since 2017 [29]. The legislation applies to onshore exploration and extraction undertaken in Ireland. It does not prohibit these activities offshore, nor does it prohibit the importation of unconventional gas produced elsewhere.

Since December 2019, the Government no longer accepts applications for any form of conventional oil or gas exploration onshore, including in internal waters [27].

3.2.6 Renewable gas

Biogas is a mixture of methane (50-75%), carbon dioxide (25-45%) and small amounts of water (2-7%), as well as trace gases such as hydrogen sulphide, oxygen, nitrogen, ammonia, and hydrogen.

Anaerobic digestion plants convert feedstocks into biogas. Typical feedstocks include agricultural waste, municipal waste, industrial waste, and energy crops. After some purification, biogas can be combusted in boilers or CHP plants to provide heat and electricity. It can also be upgraded to natural gas quality, known as biomethane. Biomethane can be injected into the gas network at appropriate points and transported to customers.

Although biogas contributed 0.1% of Ireland's primary energy requirement in 2018, there are several waste feedstocks that could be used for anaerobic digestion; biogas and biomethane could make a significant contribution to Ireland's energy mix over time [30].

GNI is proposing a 'hub and pod' system whereby on-farm anaerobic digesters in regional clusters (pods) would produce and purify renewable gas, which would then be transported to central injection points (hubs). GNI is currently undertaking its Causeway Project to develop a biomethane injection facility and a national compressed natural gas (CNG) refuelling network [31]. As part of this project, Ireland's first biomethane injection facility has been commissioned, in Kildare. The project received funding from the EU Connecting Europe Facility.

SEAI estimates that 120-203 ktoe of biogas could be produced from sustainable feedstocks in Ireland by 2030 [30]. Climate Action Plan 2019 referenced a policy assumption of 1.6 TWh (138 ktoe) of biomethane injection by 2030[12] and committed to establishing a target for indigenous biomethane injection for 2030. GNI estimates that 200 ktoe of renewable gas could be produced by 2026 or 2027 (medium forecast) [17]. It also has a target to achieve 20% renewable gas on the gas network by 2030 [17], which is equivalent to over five times its forecast for 2026 or 2027 and over seventy times the contribution from biogas in 2018.

Although renewable gas can reduce reliance on imported gas, there are energy security risks associated with its dependence on adequate supplies of feedstock, notably grass and slurry. Although grass is an indigenous resource, grass supply is not always secure, as was evident during recent severe fodder shortages in the agriculture sector.

The sustainability of biogas is also an important consideration because of the diversity of potential feedstocks and challenges associated with large-scale biogas production.

The Renewable Energy Directive 2009/28/EC (RED) sets out sustainability criteria for biogas that is used for transport [32]. These criteria relate to greenhouse gas saving requirements and requirements for conserving carbon stock and biodiversity. The recast Renewable Energy Directive [33] will introduce a mandatory sustainability framework for biogas used for heating, cooling or electricity production. This framework will be based on three overarching sustainability criteria relating to agricultural biomass, forest biomass and greenhouse gas emissions. The recast Directive requires member states to establish sustainability requirements based on these criteria and to apply them to biogas used in installations with fuel capacities of 2 MW or more.

As well as being reliant on the availability of limited feedstock resources, producing biogas at large scale requires the management of complex sustainability challenges. These can include increased fertiliser use and misalignments between incentives related to agriculture, energy, and climate objectives.

There is additional information on bioenergy sustainability criteria provided in section 6.3.3.1. The criteria and their potential impact on biogas as a renewable resource are examined in detail in SEAI's Sustainability Criteria Options and Impacts for Irish Bioenergy Resources [34].

12 This policy assumption had been previously included in the Draft National Energy & Climate Plan (NECP) 2021-2030 [64].

3.2.7 Hydrogen

Hydrogen does not produce any CO_2 emissions at the point of use and could serve similar energy applications to natural gas in the medium-to-long term. Currently, most hydrogen is produced by separating it from natural gas using steam methane reforming (SMR), which produces CO_2 emissions. However, hydrogen can also be produced via electrolysis, which would produce no CO_2 emissions if it used renewable electricity. Electrolyser technology is evolving rapidly and may offer a large-scale cost-effective and sustainable alternative to SMR over time. In its 2019 country review, the IEA noted that Ireland's significant offshore wind resources could offer potential opportunities for hydrogen production [16].

In the UK, a feasibility study led by Northern Gas Networks concluded that it was technically feasible to convert the gas network in the city of Leeds to 100% hydrogen [35]. Follow-up work is ongoing to further evaluate the UK gas distribution system's ability to accommodate 100% hydrogen, including at a dedicated test facility in Derbyshire. In January 2020, the HyDeploy demonstration project began injecting up to 20% hydrogen into the existing natural gas network in the vicinity of Keele University, supplying 100 homes and 30 faculty buildings [36].

Gas imported to Ireland from the UK must adhere to a GNI gas composition specification. Any significant change to the composition of the gas in the UK's network could have implications for different elements of Ireland's gas infrastructure.

GNI is investigating the potential to introduce hydrogen into the Irish network in the longer term. Ireland's '*low-pressure distribution network has polyethylene pipework which is understood to be compatible with 100% hydrogen. Work is also underway to evaluate the compatibility of the high-pressure steel transmission pipelines with hydrogen…Existing boilers are also understood to be compatible with small percentage blends of hydrogen*' [37].

GNI's Vision 2050 document presents a scenario for 2050 whereby a '*net zero carbon gas network*' could include 13% hydrogen, with the balance comprising biomethane (37%) and natural gas abated with carbon capture and storage (50%) [37]. GNI is monitoring the work being undertaken by Northern Gas Networks and is also participating in Irish and European fora and initiatives that are assessing how hydrogen could be used in existing gas networks.

3.3 EU gas security

3.3.1 Policy and regulation

Natural gas security is an important policy priority at EU level because gas accounts for approximately a quarter of the EU's energy consumption; the EU imported 88% of its gas in 2018 [38]. Many member states have a high gas import dependency and several are heavily reliant on a single supplier, including some which are entirely reliant on Russia. In 2010, the European Commission introduced Regulation 994/2010 [39] in an attempt to safeguard the security of the gas supply following lessons learned from the Russian-Ukrainian gas disputes in the preceding years, which had caused severe gas disruptions to several EU countries.

Analysis of results from stress tests undertaken following the introduction of the 2014 Energy Security Strategy supported the strengthening of cooperation between member states during potential disruptions [40]. In 2017, Regulation 2017/1938 was introduced to enhance gas security at EU level by helping to prevent future disruptions and responding to them more effectively if they occur [41]. The new repealed Regulation 994/2010. Appendix 1 of this report contains additional discussion on the evolution of gas security policy at EU level, while the implications of these EU regulations for Ireland are discussed throughout the remainder of this chapter.

3.3.2 EU gas infrastructure

There have been several notable gas infrastructure improvements since the 2009 disruption and the EU now has approximately 2,000 GW of gas pipeline and LNG terminal capacity [42].

The Nord Stream pipelines, which link Germany directly with Russia, bypassing Ukraine, Belarus, and Poland, were commissioned in 2011 and 2012. The Nord Stream 2 capacity expansion project began in 2018. It will double the capacity of the existing infrastructure, allowing it to supply up to 22% of the EU's 2018 natural gas demand [43]. In an indication of the geopolitical sensitivity that can be associated with gas pipelines, the US introduced economic sanctions on firms involved in the project in late 2019.

The Southern Gas Corridor is an EU-supported infrastructural project linking natural gas fields in Azerbaijan to natural gas networks in EU countries. When fully completed, the project will have the capacity to supply over 5% of the EU's total 2018 gas consumption [44]. It comprises three main elements: the South Caucasus Pipeline linking Azerbaijan and eastern Turkey via Georgia (in place since 2006); the Trans-Anatolian Pipeline linking northeast Turkey to northeast Greece (completed in 2019); and the Trans-Adriatic Pipeline linking northeast Greece to southeast Italy via Albania (operational in 2020). Future capacity expansion plans envision the Corridor supplying as much as 20% of the EU's 2018 demand.

There has also been significant investment in LNG infrastructure throughout Europe. There are now thirty-one operational LNG terminals in the EU, the UK and Norway[13], with a further nine under construction and approximately thirty more in planning [45]. Approximately half of the operational facilities commenced operation since 2009 and LNG imports met 22% of the EU's gas demand in 2019 [38]. This is over double the average for the preceding five years [38]. The EU has significantly more LNG regasification capacity than it currently uses, although 2019 saw a steep increase in capacity utilisation to 50%, up from 28% in 2018 [20] [38] [46]. Nineteen EU countries also have operational gas storage facilities, with an additional 3% of capacity under construction and a further 12% being planned [47].

A recent report by the European Climate Foundation has questioned whether significant additional investment is required for new gas infrastructural projects in Europe [42]. The analysis focussed on the 32 new gas infrastructural projects designated as projects of common interest by the European Commission[14] and five projects which were not of common interest, including Nord Stream 2. The 32 projects of common interest would amount to 338 GW of additional capacity, at a cost of €29 billion. The report found that existing European gas infrastructure would be sufficient to meet demand in 2030, including for a 'high demand' scenario. It also highlighted that existing infrastructure would be '*resilient to a wide range of potential extreme disruptions, including year-long disruptions from Ukraine, Belarus and Algeria. The loss of supply from Russia or Algeria…[would be]…compensated by imports from other sources, primarily via existing LNG terminals in the west of Europe*'. The report concluded that there is a risk of overinvestment in unnecessary gas infrastructure in Europe.

The European Network of Transmission System Operators for Gas (ENTSOG) produces biannual security of supply outlooks, which provide an overview of the ability of the European gas system to meet market demand, including demand for storage injection.

3.4 Gas infrastructure

3.4.1 Ireland's gas network

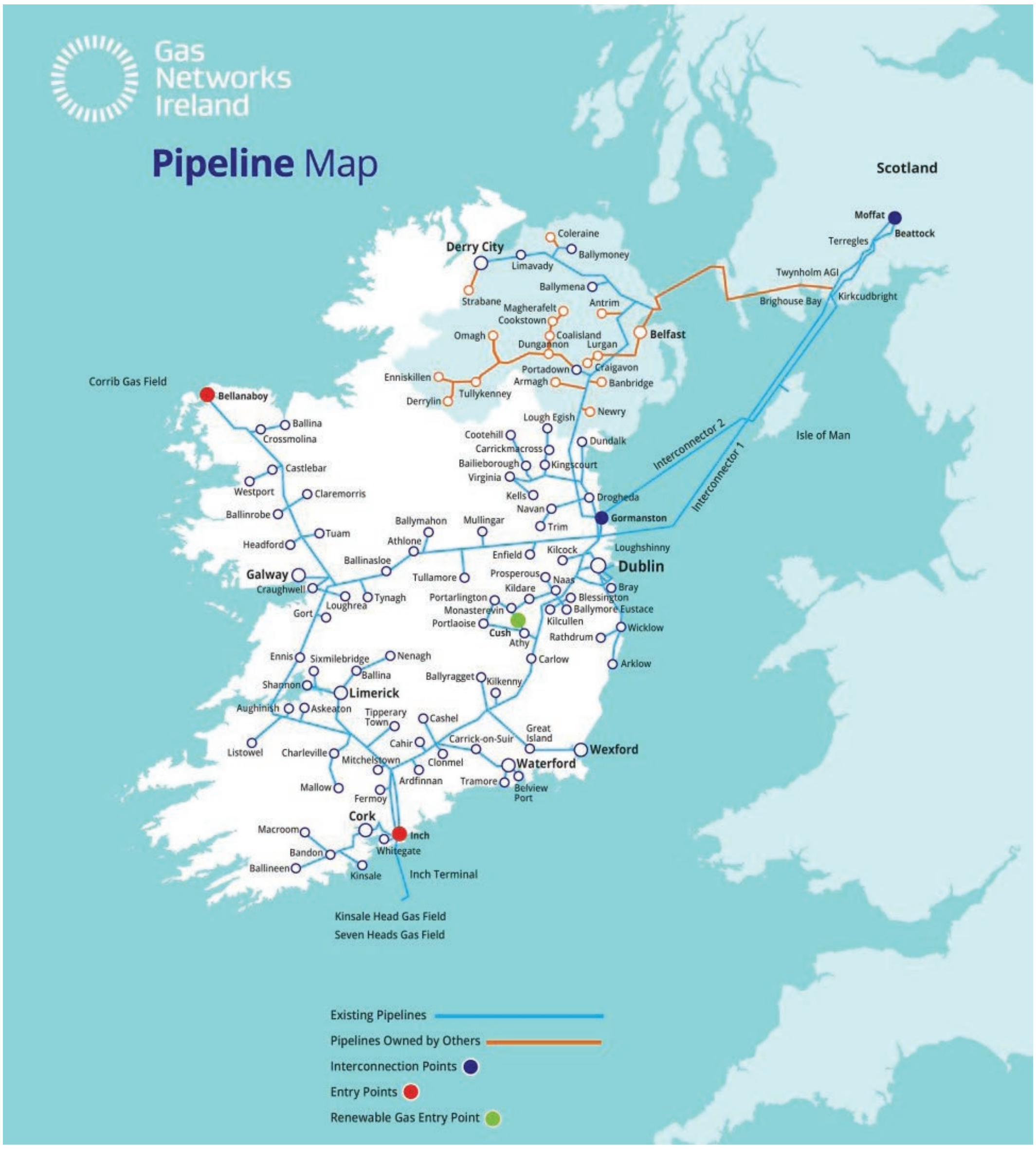
Ireland's natural gas infrastructure is shown in *Figure 25*. The natural gas network is operated by GNI and comprises over 14,000 km of gas pipeline, two subsea interconnectors and onshore assets in Scotland. It serves almost 688,000 users across 21 counties in Ireland [17].

The high-pressure transmission network conveys gas from three entry points (Bellanaboy, Inch and Moffat) to transmission-connected customers and to distribution networks throughout Ireland. The Inch entry point, located in Cork, connects the Kinsale fields and storage facility to the onshore network, while the Bellanaboy entry point, in Mayo, connects the Corrib field. The onshore network primarily consists of a ring-main system, with spur lines serving towns and large business, and a compressor station at Midleton in Cork.

13 Norway also has six LNG export terminals, five of which are small scale.

14 Projects of common interest are key cross-border infrastructure projects that link the energy systems of EU member states. They can benefit from accelerated permitting procedures and funding [51].

Figure 25: Ireland's gas network



Source: Gas Networks Ireland

3.4.2 Interconnection with the UK

The Moffat entry point, located onshore in Scotland, connects the Irish gas system to that of the National Grid in Great Britain. It allows for the import of gas to Ireland but not the physical export of gas from Ireland to Great Britain[15]. The two subsea interconnectors (Interconnectors 1 and 2) between Scotland and Ireland, two compressor stations at Beattock and Brighouse Bay in Scotland and sections of onshore pipeline between Brighouse Bay and Moffat are all considered to be part of Ireland's transmission system.

The Northern Ireland network connects to Ireland's network via the South-North Pipeline, which is fed from Interconnector 2 and at Twynholm in Scotland via the Scotland-Northern Ireland Pipeline. The Isle of Man network is also connected to Interconnector 2.

Ireland's reliance on a single piece of infrastructure at Moffat had long been identified as a risk to security of supply [48] [49]. A 50 km section of single pipeline between Cluden and Brighouse Bay in Scotland had been identified as posing a particular weakness. In 2018, a project was completed to twin this section of pipeline. It was designated a project of common interest by the European Commission and received €33.7 million of funding from the EU. Complementary work is ongoing to upgrade the Beattock Compressor Station in Scotland. According to GNI, this will increase the resilience of this infrastructure and reduce '*the security of supply risk associated with the Moffat Entry Point, particularly as Ireland reverts*

15 Although the interconnector does not allow for physical gas flows from Ireland to Great Britain, virtual flows or trades happen in both directions.

to a high dependency on GB gas supplies (via Moffat) within the next 10 years' [17]. Noting these upgrades at Moffat, the IEA nonetheless concluded in 2019 that '*there is high reliance on a limited amount of gas infrastructure, raising concerns for security of gas supply in Ireland*' [16]. The level of risk posed by this reliance is discussed in section 3.4.3.

EU Regulation 2017/1938 requires that all interconnectors between member states have permanent bidirectional capacity, unless an exemption is granted, as provided for in the Regulation. GNI completed a feasibility study in 2018 on making Moffat bi-directional and subsequently undertook an assessment to determine if there was a market requirement for the facility. Based on the outcomes of this work, GNI does not envisage that the project will progress to the next stage in the near term. However, GNI '*will continually monitor ongoing market dynamics and developments – should a market requirement for the facility arise, or new lower cost sources of gas come online in Ireland, Gas Networks Ireland will further review the status of the project*' [50]. Moffat is subject to an exemption from the requirement to have bidirectional capacity until September 2022[16].

3.4.3 Natural gas storage

While natural gas storage does not diversify supply, it can strengthen resilience to a disruption. The commercial feasibility of such projects in Ireland is dependent on having high summer-winter price spreads at the UK national balancing point. These spreads have fallen significantly in recent years and remain at historical lows, partly due to LNG imports into the UK and Europe. The most likely location for a gas storage facility in Ireland would be a depleted gas field.

Until recently, an underground facility at the Kinsale gas field provided seasonal gas storage, but this facility is now due to be decommissioned. Ervia is currently investigating the feasibility of using this depleted field for the large-scale storage of carbon dioxide from power stations and other heavy industry in the vicinity of the existing pipeline infrastructure at Kinsale and Inch. The project was designated a project of common interest by the European Commission in 2019 [51].

The IEA and the Irish Academy of Engineering have also expressed their support for the development of gas storage in Ireland [16] [52].

Islandmagee Energy Limited is proposing to develop a gas storage facility at Islandmagee, Antrim. The intention is to store 500 million cubic metres of gas in up to seven caverns, which would be created in a salt bed beneath Larne Lough [53]. The project was granted planning permission and a gas storage licence in 2012. Islandmagee Energy Limited completed front end engineering design in late 2018. The project had been designated a project of common interest by the European Commission but is not included on the latest (fourth) list of such projects [51].

3.4.4 Liquefied natural gas (LNG)

Ireland does not have dedicated infrastructure for importing LNG. However, very small quantities of LNG are imported in containerised format for use at larger industrial facilities that are not located on the natural gas network.

In its 2019 review of Ireland's energy policies, the IEA recommended that the Government should '*optimise the role of gas in the transition to a low-carbon-energy system, including encouraging, through appropriate regulation and policy, the development of an LNG import facility and seasonal gas storage*' [16]. The IEA concluded that developing LNG import facilities would substantially improve gas security in Ireland by providing access to the global LNG market, but also emphasised the requirement for cost-benefit analysis when deciding on public investment in infrastructure.

Shannon LNG proposes to construct an LNG importation terminal approximately four kilometres west of Tarbert, Co. Kerry, on the Shannon Estuary. The proposed terminal consists of a deep-water jetty, up to four storage tanks (of 200,000 m3 each) and regasification facilities. The initial phase of the development would have a maximum export capacity of 17.0 mscm/d; following subsequent phases, the proposed final maximum capacity would be 28.3 mscm/d. Planning permission was granted for the terminal, for a pipeline to the national gas grid and for a 500 MW CHP plant [54]. However, a decision to extend planning permission by five years until 2023, without undertaking a new environmental impact study, has been the subject of legal deliberation at national and European level [55]. The project is currently designated a project of common interest by the European Commission [51]. In 2020, the Government indicated that it intends to withdraw the project from the project of common interest list in 2021.

There is also commercial interest in the development of a floating storage and regasification unit in Cork Harbour.

3.4.5 Security of Ireland's gas network

EU Regulation 2017/1938 defines two security of supply standards that are used to assess how Ireland's network would be impacted by the loss of its largest piece of gas infrastructure: an infrastructure standard, incorporating the so-called N-1 criteria, and a supply standard [41]. The N-1 calculation determines the percentage of gas demand that could be met on a day of exceptionally high gas demand in the event of the loss of Ireland's largest single piece of gas infrastructure. EU regulation allows for countries to meet the standard on a regional basis, that is, by considering the loss of the largest single piece of gas infrastructure within a region.

16 Confirmed via email communication from GNI (4 December 2019).

GNI and EirGrid undertook a Long Term Resilience Study in 2018 [56] to examine Ireland's resilience to a prolonged gas disruption by applying these standards to then-current levels of gas demand and for different future demand scenarios. It examined the implications of the loss of the largest single piece of Ireland's gas infrastructure, which, at the time, was the entire Moffat interconnector system. The Study concluded that: '*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 and Corrib gas fields*'. Notwithstanding this, because EU regulation allows countries to meet the N-1 standard on a regional basis, Ireland continued to meet the requirements when assessed with the UK.

As well as strengthening gas security, the upgrades at Moffat have facilitated the splitting of the interconnectors into separate systems for the purposes of the infrastructure standard. As a result, the largest single piece of Irish infrastructure is now Interconnector 2. Interconnector 1 would still be available in the event of the N-1 scenario. GNI and EirGrid calculated that the N-1 position would improve, as a result of these upgrades.

The supply standard in the Regulation stipulates that member states must be capable of supplying gas to meet the needs of protected customers for 30 days, should a disruption in the single largest piece of gas infrastructure under average winter conditions occur. In Ireland, protected customers are defined as 'a*ll residential gas customers, SMEs, hospitals, nursing homes, high-security prisons, district heating schemes and other essential social services*'[17] [56]. The Long Term Resilience Study found that Ireland meets this standard and is expected to do so for the foreseeable future.

3.5 Outlook for gas security

3.5.1 Demand moderation

Moderation of final demand for both gas and electricity through efficiency measures and absolute reductions in energy services will help offset Ireland's growing dependency on imported gas and reduce the country's exposure to a gas supply disruption. The phasing out of gas boilers from 2025, increased levels of biomass heating, the electrification of heat[18] and extensive retrofitting of the residential sector[19], as envisaged in the Climate Action Plan [7], will reduce gas demand in the built environment.

Achieving the 70%-by-2030 renewable electricity target would also moderate demand for gas over time, which could reduce the requirement for additional gas infrastructure. However, peak-day gas demand would still be comparatively high, because it would be driven by the amount of gas required to meet a very large proportion of Ireland's electricity demand on a low-wind day, via gas-fired generation.

The pace and magnitude of such changes will dictate the extent of the role that natural gas plays in the energy transition and of the actual size of the future deficit between indigenous production and gas demand. This, in turn, will have an important impact on security of supply risk and on the requirement for new gas infrastructure. The broad spread between the upper and lower demand forecasts discussed in this chapter are noteworthy in this context.

3.5.2 GNI and EirGrid's Long Term Resilience Study

GNI and EirGrid's Long Term Resilience Study presented an analysis of selected supply-side options for improving gas security in the context of the gas deman scenarios modelled for the study [56].

These scenarios were modelled before the finalisation of Climate Action Plan 2019, which introduced several measures that will moderate gas demand. The median gas scenario used for the study was informed by an EirGrid electricity scenario in which gas-fired electricity generation would account for approximately 43% of electricity demand by 2030 (57% renewable electricity). It was assumed that coal and peat-fired generating stations would be replaced with gas-fired generation and that wind and solar capacity would increase to 5,800 MW and 500 MW respectively by 2030 [57]. EirGrid's latest scenarios account for the 70%-by-2030 renewable electricity target introduced in the Climate Action Plan. They indicate that achieving the 70% target would require significantly more wind and solar capacity and that gas-fired generation would account for only 30% of electricity production [58].

The GNI and EirGrid study determined that either a fixed or floating LNG terminal could '*lead to a significant improvement in Ireland's security of supply position*', increasing the N-1 position for 2030 from 47% (base case) to 111% for their median demand scenario, that is, in the event of an N-1 disruption in 2030, 111% of modelled demand could be met if such a terminal was in place, compared to 47% for a base case. The study also concluded that a permanent gas storage facility could enhance the resilience of the system by boosting the N-1 position from 47% to 68% by 2030 (median demand) and recommended that opportunities for gas storage in Ireland and Europe be monitored.

17 Electricity generation is not classified as a protected customer.
18 600,000 heat pumps targeted by 2030, including 400,000 in existing buildings.
19 500,000 homes to be retrofitted to B2 equivalent.

The study considered a concept for a 509 kilometre interconnector between Cork and northwest France. It concluded that such an interconnector could increase the N-1 position from 47% to 73% by 2030 (median demand scenario). However, it also found that such an interconnector would have the highest capex of the options considered (€727 million).

3.5.3 Areas for further analysis

While natural gas use may grow out to 2030, unabated fossil gas use must drop to zero by 2050 at the latest. It is unclear what future role the gas grid will play in the energy system. There may be a role for indigenously produced renewable gas or hydrogen, but the future for fossil gas imports after 2030 is uncertain. This is an important consideration for any infrastructural investment decisions, which are typically made on timelines much longer than 10 years.

All analysis of options to strengthen Ireland's gas security should consider demand-side reduction and renewable energy supply options, as well as supply-side options relating to gas infrastructure. The potential risk that overinvestment in infrastructure could result in stranded assets; infrastructure projects that experience unanticipated or accelerated loss in value should also be considered.

3.5.4 DCCAE review of security of energy supply

In 2019, the Minister for Communications, Climate Action and Environment announced that the Department would carry out a review of the security of energy supply of Ireland's electricity and natural gas systems [1]. This review will focus on the period to 2030 in the context of ensuring a sustainable pathway to 2050.

3.6 Emergency planning

3.6.1 Obligations under EU Regulation 2017/1938

EU Regulation 2017/1938 mandated the ENTSOG to undertake an EU-wide gas supply and infrastructure disruption simulation to assess the major supply risks for the EU.

The CRU is Ireland's designated competent authority under the Regulation and is required to prepare a National Security of Supply Risk Assessment, a National Gas Preventative Action Plan, and a National Gas Supply Emergency Plan. GNI provides technical support to the CRU in fulfilling this role. Ireland's first Risk Assessment and National Gas Preventative Action Plans [59] were submitted to the European Commission in 2018 and the CRU also published its first National Gas Supply Emergency Plan [60] in 2018. The Regulation requires that all three documents be updated every four years.

The objective of the National Gas Supply Emergency Plan '*is to ensure a consistent and coordinated response to an unplanned gas supply interruption in order to ensure that a gas supply emergency is prevented, or if not possible is resolved expeditiously and competently, thereby minimising effects on the operation of the gas market at a national, regional and European level*'. The CRU Plan provides a framework for the interaction between the requirements of Regulation 2017/1938 and GNI's own operational emergency plan, which is referred to as the Natural Gas Emergency Plan [24].

The Regulation also requires gas suppliers in Ireland to notify the CRU of long-term supply contracts that exceed prescribed thresholds.

3.6.2 Solidarity and regional co-operation

EU Regulation 2017/1938 also introduced a solidarity principle whereby member states must assist each other to guarantee supply to vulnerable consumers, even during severe gas crises. Member states must work together in regional risk groups to assess the gas security risks (common risk assessment) and plan co-operative actions to mitigate the consequences of those risks. Ireland is listed in two regional risk groups.

A separate UK and Ireland Gas Emergency Planning Group facilitates regional co-operation between the two countries. It includes representatives from government departments and the electricity and gas sectors in both jurisdictions.

There is also a protocol in place between GNI and the UK National Grid that describes voluntary load shedding arrangements in the event of a gas supply emergency.

3.6.3 Gas Electricity Emergency Planning Group

The Gas and Electricity Emergency Planning group (GEEP) comprises representatives from DCCAE, the CRU, GNI, EirGrid and ESB Networks. The purpose of the group is '*to focus on short-term issues relating to security of supply and emergencies in electricity and gas, and provide a medium for interaction between the gas and electricity sectors. The GEEP also encompass some longer term and wider energy/emergency policy issues, which may emerge and be of relevance to the gas and electricity sectors*' [61].

3.6.4 Natural Gas Emergency Plan

The Natural Gas Emergency Plan is a management procedure for managing a natural gas emergency. It is prepared by GNI and approved by the CRU [24].

3.6.5 Inter-operator co-operation

There is a Joint Operators Agreement in place between GNI and EirGrid, which allows for co-operation between the two organisations in the event of a natural gas or electricity disruption or emergency.

3.7 Impact of Brexit on gas security

Since the development of Interconnector 1, Ireland's approach to gas security has been based on close co-operation with the UK. Although the interconnectors continue to remain in place and to provide imports that augment Ireland's domestic production, Ireland is no longer physically connected to the EU internal energy market. Furthermore, the contribution of the interconnectors to Ireland's gas security could evolve over time if policy, regulation, or market conditions in the UK diverge from those in the EU.

In the short term, Brexit also poses potential challenges for Ireland in the context of EU Regulation 2017/1938. One challenge relates to the N-1 infrastructure standard. Prior to Brexit, Ireland's ability to comply with the standard was based on its regional treatment alongside the UK, as permitted under the Regulation. Since Brexit, Ireland does not comply with the standard even though Brexit did not result in any immediate change to the resilience of Ireland's infrastructure.

A second challenge lies in the fact that the UK is no longer legally bound by the measures encompassed in the solidarity principle in the Regulation. The IEA has stated that strong regional co-operation will remain crucial for Ireland's gas security in the post-Brexit era [16]. Ireland may need special arrangements with the UK and, or, other member states to ensure that it has access to gas supplies during a gas crisis.

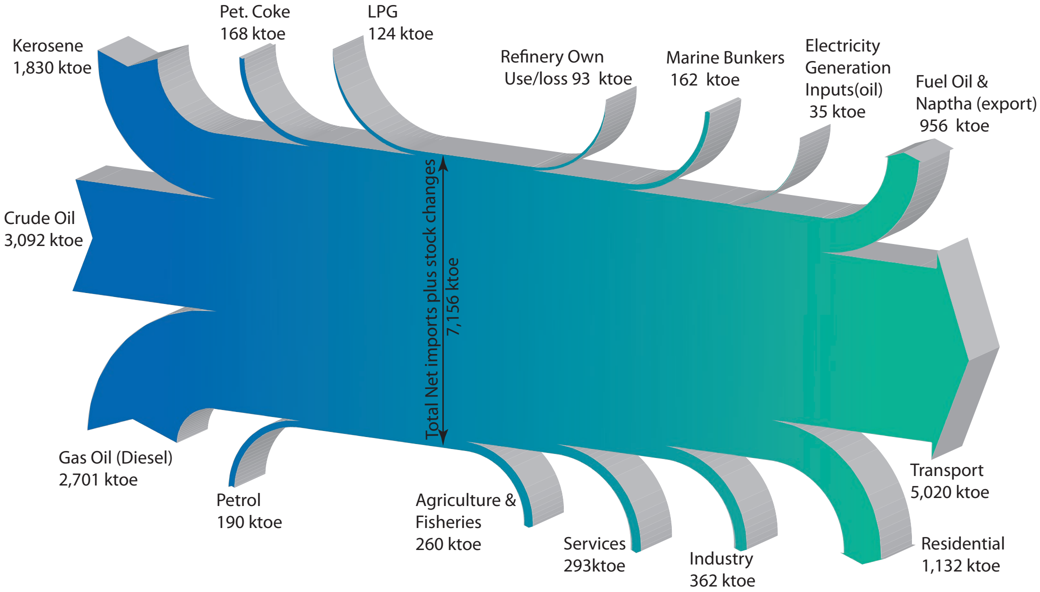
4 OIL, OIL PRODUCTS AND BLENDED BIOFUELS

4.1 Oil demand

4.1.1 Historical demand

Figure 26 shows the oil balance for Ireland as a flow diagram for 2018. Transport accounts for by far the largest end-use of oil, but there is also significant use in residential heating and in the industrial sector. Power generation accounts for just 0.5% of oil use, although oil plays an important role as a secondary fuel for other thermal generators, notably gas.

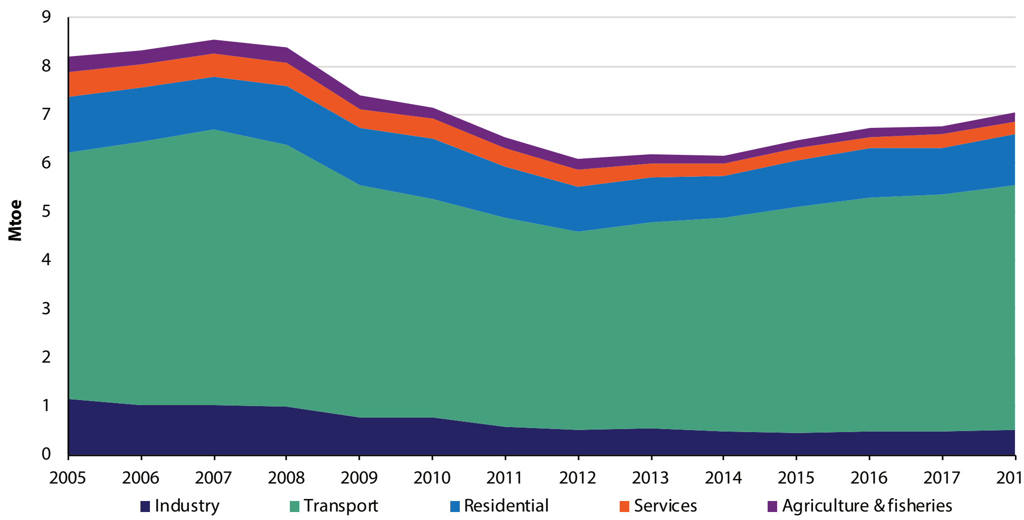
Figure 26: Oil energy flows in Ireland 2018



Source: SEAI

Ireland's oil dependence, as a proportion of gross inland consumption (primary energy demand), was the fourth-highest of the 28 EU member states in 2018 at 50% [38]. The three member states that were more dependent on oil than Ireland in 2018 were Cyprus (90%), Luxembourg (65%) and Malta (54%). Despite this, Ireland is a minor consumer in overall terms, accounting for approximately 1.3% of total European consumption and 0.14% of global consumption [38].

Figure 27: Final consumption of oil and biofuels 2005-2018



Source: SEAI

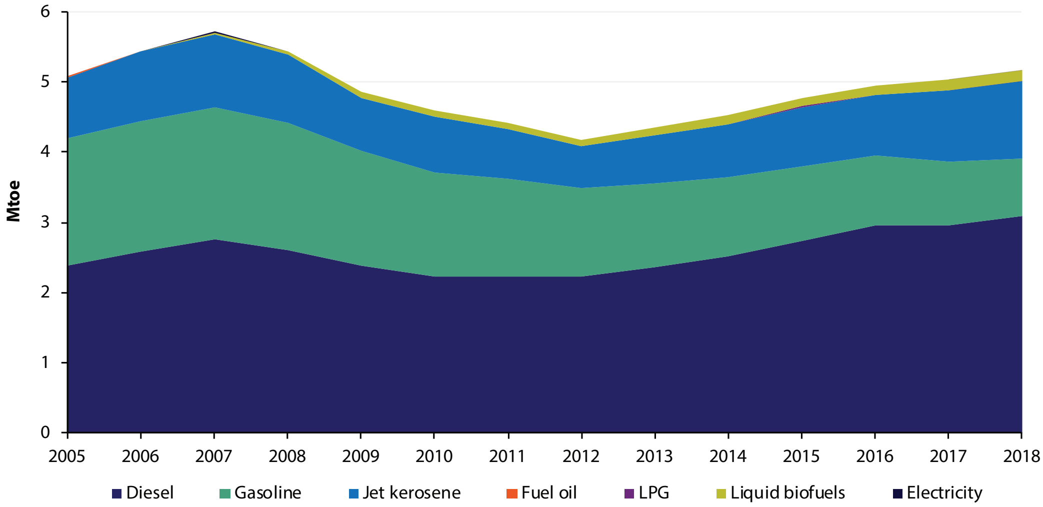
The breakdown of final demand for oil and biofuels since 2005 is shown in *Figure 27*. Biofuels, which accounted for 3.1% of energy use in transport in 2018, are blended with petrol and diesel by suppliers to comply with the Biofuels Obligation Scheme[20].

Oil demand peaked in 2007 before dropping by 27% between 2008 and 2012. This reduction was caused by economic contractions, which impacted road freight and international aviation, in particular. Demand for oil subsequently increased by 2.5% per annum between 2012 and 2018, as the economy returned to growth. At 7.1 Mtoe, total oil demand in 2018 was 17% below the 2007 peak.

Transport is the key area to consider from an oil security perspective. It is the dominant end-use and driver for oil use in Ireland, accounting for over 71% of oil demand in 2018. By 2018, while oil demand for road freight was 36% below the 2007 peak, international aviation had exceeded its previous peak and had reached an all-time high. *Figure 28* shows the breakdown of transport's final energy consumption by fuel type. In 2018, 97% of total fuel usage in the sector was supplied by fossil-oil-based products. Of all sectors in the economy, this level of dependence on a single fuel source is unique. The sector also exhibits by far the highest fossil fuel dependency and lowest degree of electrification (0.1%) of any sector.

The type of fuel used is closely aligned to the mode of transport. Jet kerosene is used for air transport. Petrol is almost exclusively used for road transport, the bulk for private car use. Diesel is used for road (78% of road transport) and rail transport (90% of rail transport). Diesel accounted for 59% of the fuel used in transport in 2018.

Figure 28: Transport final energy demand by fuel type 2005-2018



Source: SEAI

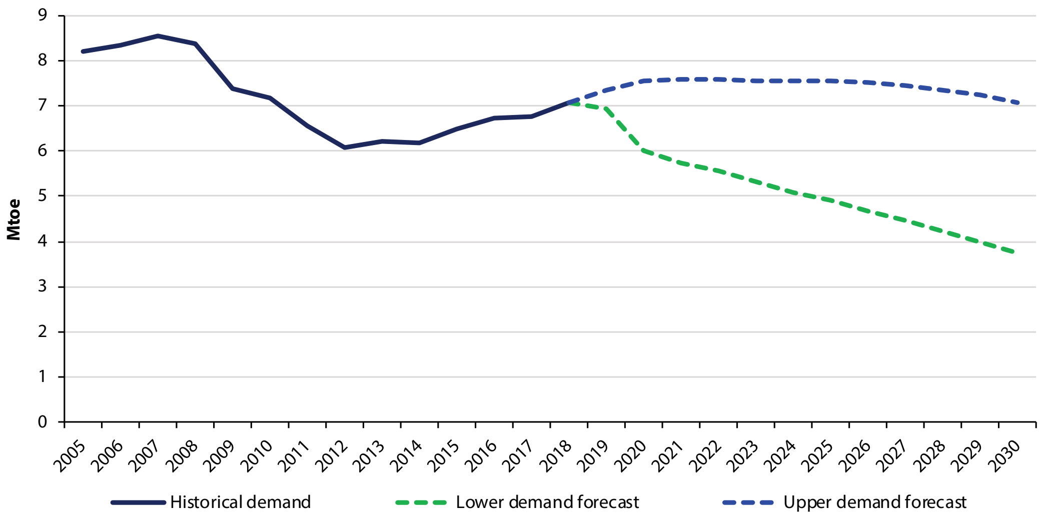
Demand for transport fuels has a relatively low price elasticity. In other words, increases in fuel prices cannot readily be compensated for by a reduction in demand. This is a result of a lack of alternative transport options, particularly in the short term. Increased fuel and transport costs pass rapidly through to other sectors of the economy in the form of increased prices for goods and services.

4.1.2 Future demand

Figure 29 shows the historical trend in demand for oil products and blended biofuels, and SEAI's projections for the period 2019-2030. *Figure 30* provides a breakdown of demand for 2018 and 2030.

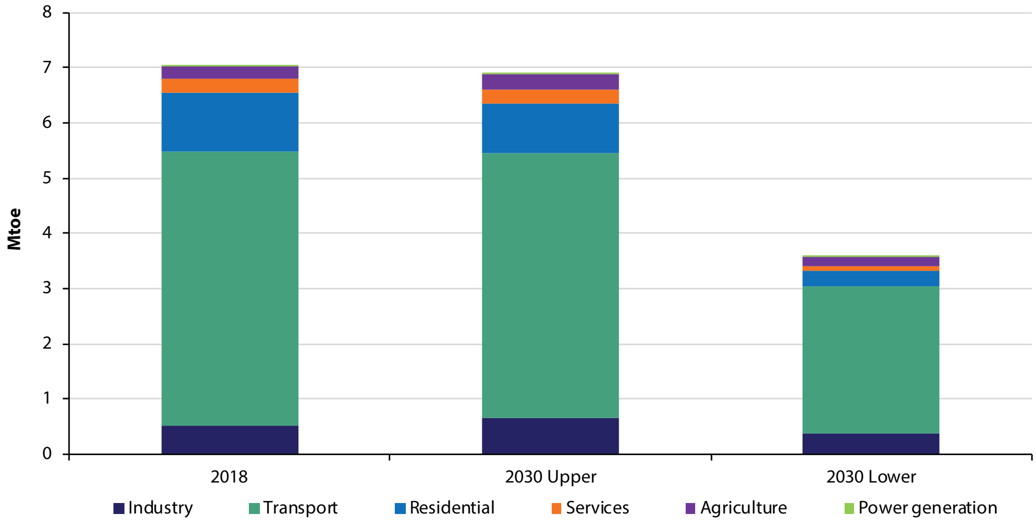
20 The 3.1% figure is for the transport sector, including aviation. The Biofuels Obligation Scheme only applies to road transport fuels.

Figure 29: Historical and projected final consumption of oil and blended biofuels 2005-2030



Source: SEAI

Figure 30: Final consumption of oil and blended biofuels in 2018 and 2030



Source: SEAI

As with the other projections in this report, SEAI's higher projection is a worst-case scenario based on lower fossil fuel prices and does not account for the measures contained in the Climate Action Plan [7]. The lower projection is based on higher prices and more ambitious policies and measures. The gap between the upper and lower forecasts illustrates a degree of uncertainty about future demand. The factors contributing to uncertainty in oil demand include the fossil fuel prices, the policies and measures rolled out and the underlying economic conditions, as well as the rate of improvement in vehicle efficiency and the pace of electrification in transport sectors. The ambitious EU-level decarbonisation target proposed in the European Green Deal [6] could result in a an even lower projection for Ireland's future oil demand. Reducing oil demand will be important for decarbonising Ireland's energy system. It will also benefit energy security and competitiveness.

Because of the near total dependence of the transport sector on oil-based products, oil will likely remain the dominant fuel in the sector for at least the next decade. This ongoing demand from transport will be the main factor underpinning the overall demand for oil throughout the 2020s. An increasing proportion of petrol and diesel will be displaced by biofuels over this period. The outlook for biofuels is discussed in section 4.2.4.3. Climate Action Plan 2019 also introduced a target of having 840,000 electric cars and 95,000 electric vans and trucks by 2030. This is equivalent to approximately 40% of the current car fleet and 30% of the current light goods vehicle fleet [7]. CNG will also displace relatively small quantities of oil consumption. Unlike other oil products, demand for jet kerosene is forecast to continue growing beyond the mid-2020s.

In the built environment, Government intends to prohibit the installation of oil boilers in new dwellings from 2022 and has established a target of 600,000 heat pumps by 2030, including 400,000 in existing buildings [7]. Biomass will also displace some oil consumption in the services and industrial sectors. A key supporting policy is already in place in the form of the Support Scheme for Renewable Heat.

4.2 Oil supply

4.2.1 International developments

4.2.1.1 Global demand

Global oil demand is dominated by road transport (43%) and industry (19%) [18] [23]. Petrol makes up one-third of global demand, with gasoil (including diesel) and kerosene combined accounting for another third[21].

There are significant regional variations in oil product demand. For example, despite having only 4% of the world's population, the US consumes 30% of global petrol production but only 15% of gasoil/diesel and jet kerosene [22] [23]. The EU consumes 23% of the world's gasoil/diesel and aviation fuel but only 9% of its petrol [38] [23]. In Ireland, petrol accounts for only 14% of total oil demand, with gasoil/diesel and kerosene combined, accounting for 85% [38].

Global oil demand has risen by almost 10% in five years [22] [23], climbing from 92 million barrels per day in 2014 to over 100.7 million barrels per day in 2019 [22]. Most of this growth came from China, India and Saudi Arabia [62], with China accounting for 42% of global demand growth between 2007 and 2018. By comparison, EU and US demand has remained relatively flat [23] [38].

The IEA anticipates that if governments only adhere to existing policy commitments and declared future policy measures (stated energy policies scenario), global oil demand would plateau by 2030, with economic development in India, China and Southeast Asia driving most future growth. In this scenario, Chinese consumption would plateau between 2030 and 2040 but Indian demand could continue to increase until at least 2040 [18] [62]. For its sustainable development scenario, which incorporates more rapid decarbonisation, the IEA anticipates that global demand would plateau and decline from the early 2020s, with demand in India, China and Southeast Asia peaking in 2030 before declining through to 2040. This scenario would align global energy use with the commitments set out in the Paris Agreement [18].

The rate of economic development in Sub-Saharan Africa will also have a significant impact on global demand growth.

While vehicle efficiency improvements and growing electric vehicle sales are projected to dampen demand for fuel consumption by the 2030s in some markets, if the popularity of SUVs continues to grow, it will increase demand. SUVs typically consume 25% more fuel than medium-sized cars, on a per kilometre travelled basis [18]. Globally, SUV sales have grown from 17% of total car sales in 2010 to nearly 40% in 2018. SUVs accounted for almost half of new car sales in the US and China in 2018. The IEA estimates that approximately 5% of the 10-million-barrels-per-day increase in global demand between 2010 and 2019 was attributable to the increasing popularity of SUVs [18].

Growth in heavy goods vehicles, aviation, shipping, and petrochemicals (that is, plastics, rubber, chemical intermediates) are expected to increase consumption in these sectors. The IEA expects most of the growth in aviation will come from Latin America and Africa, while European demand is expected to plateau. Oil (fuel oil) is still used extensively in power generation, particularly in the Middle East and Asia [62]. As renewable technologies and natural gas become cheaper and more accessible, oil's contribution to electricity generation is expected to decline.

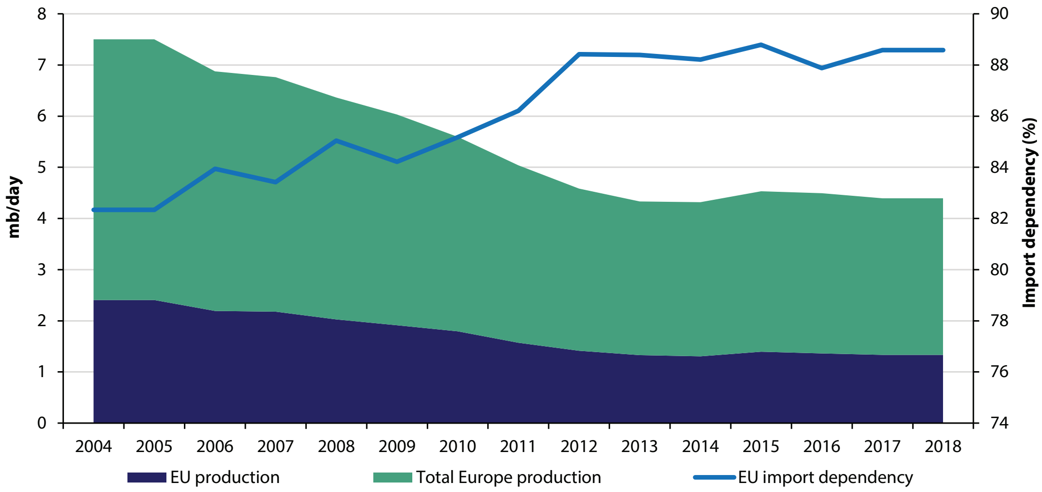
The IEA's sustainable development scenario suggests that global oil demand needs to reduce to 87 million barrels per day by 2030 and 67 million barrels per day by 2040. This equates to a 33% reduction in global oil demand by 2040.

4.2.1.2 Global supply

Oil production has been in decline since the late 1990s in almost all European oil-producing countries, particularly in Norway and the UK, which are the region's biggest producers. The decline in European production since 2005 is shown in *Figure 31* along with the EU's import dependency over this period. The EU relied on imports for approximately 88% of its oil requirements in 2017. If the UK's 2017 production was counted as non-EU, the EU's import dependency would have been over 95% [38]. By 2040, European production is expected to decline by 30% compared to 2018 levels [18].

21 The remaining third is made up refinery gas, liquefied petroleum gas (LPG), solvents, petrochemical feedstocks, petroleum coke, lubricants, bitumen, wax, other refined products, refinery fuels and losses.

Figure 31: European[22] oil production and oil import dependency

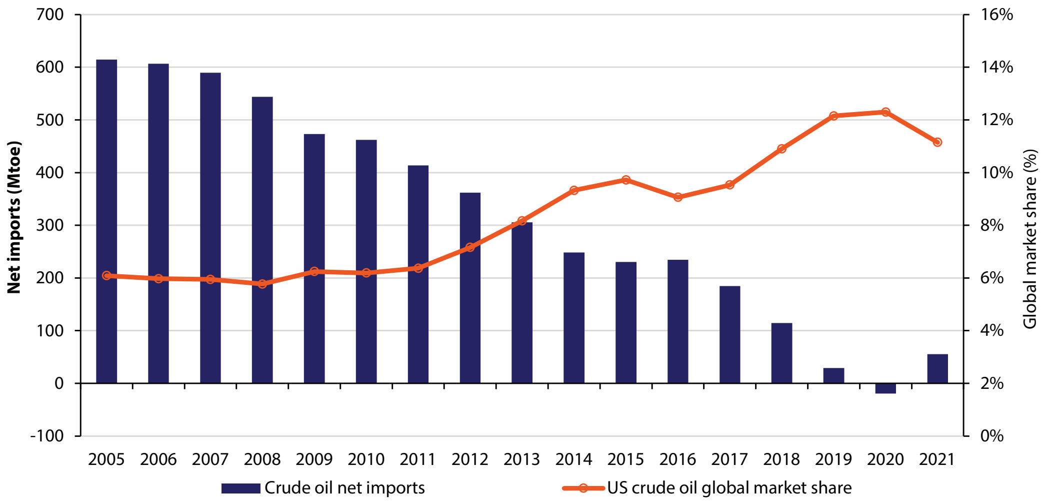


Source: Eurostat

Notwithstanding the decline in European production, international oil markets are currently well supplied, and many major producers are operating below maximum capacity [22]. Global oil supply has become more diverse and less dependent on regions of political instability. Future output growth in the US, South America, Middle East, and Russia will see global capacity keep pace with demand. In 2018, there were over 1,700 billion barrels of proven oil reserves on earth, a 70% increase on 2005 levels [18] [23]. The IEA estimates that even in the stated energy policies scenario, 50% of these proven oil reserves would remain unburned by 2040, while 59% would need to remain unused in the sustainable development scenario [5].

Figure 32 shows how the US shale oil boom, which began in 2005, has significantly reduced US dependence on imported oil. Shale oil, or tight oil, comprises crude oil and condensates that are extracted using a process called hydraulic fracturing. Hydraulic fracturing facilities are smaller and generally cheaper to operate than conventional oil extraction. They can also be shut down or restarted at short notice. This flexibility allows producers to respond more nimbly to market fluctuations than traditional producers.

Figure 32: US oil net imports of oil (crude and product) and US share of global crude market 2005-2021[23]



Source: US Energy Information Administration (EIA)

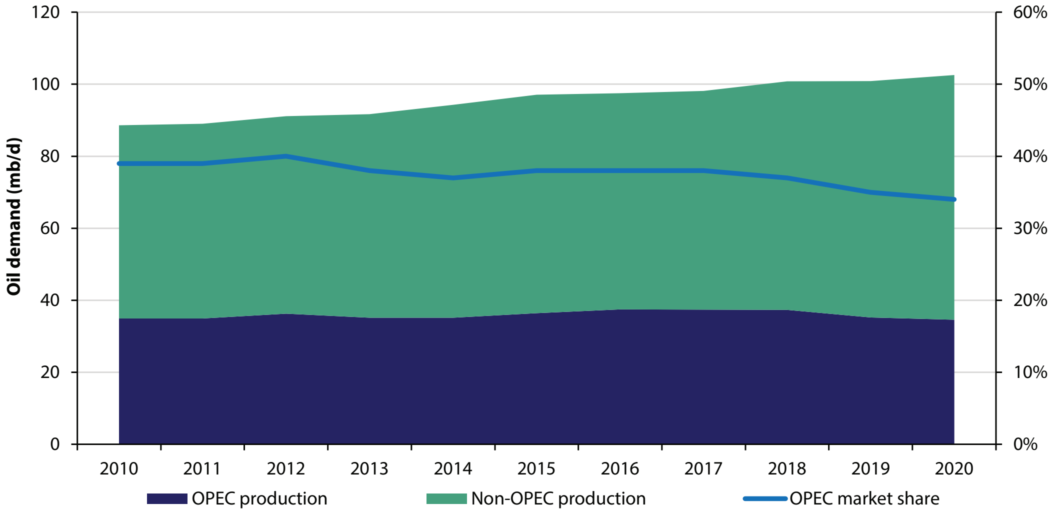
By 2015, US production was limited by oversupply in its domestic market. In late 2015, the US Congress lifted a ban that had been imposed on US crude oil exports in 1975. A surge in production and international exports followed. By 2018, the US had doubled its pre-shale-oil-boom output and supplied nearly 11% of global petroleum production. Growth in

22 Total Europe production includes production from Norway and Albania.
23 2020 and 2021 are projections by the US Energy Information Administration.

US crude oil exports has been slowed in recent years by bottlenecks in pipelines and ports. However, US Department of Energy forecasts predict US shale oil production could take the US oil market share from 11% in 2018 to 14% by 2030 [22].

US shale oil generally has a lower breakeven cost than OPEC[24] and Russian fields [63]. US output growth in 2016 and 2017 caused a global supply glut equivalent to roughly 2-3% of demand. Faced with an oversupplied market and depressed prices, OPEC and Russia agreed, in 2017, to co-ordinated reductions in oil output. As they did, US producers continued to increase production, forcing OPEC and Russia to further constrain their production quotas. This pattern has seen OPEC's market share drop from 40% in 2010 to 34% in 2019, as shown in *Figure 33*.

Figure 33: OPEC and non-OPEC shares of global oil production

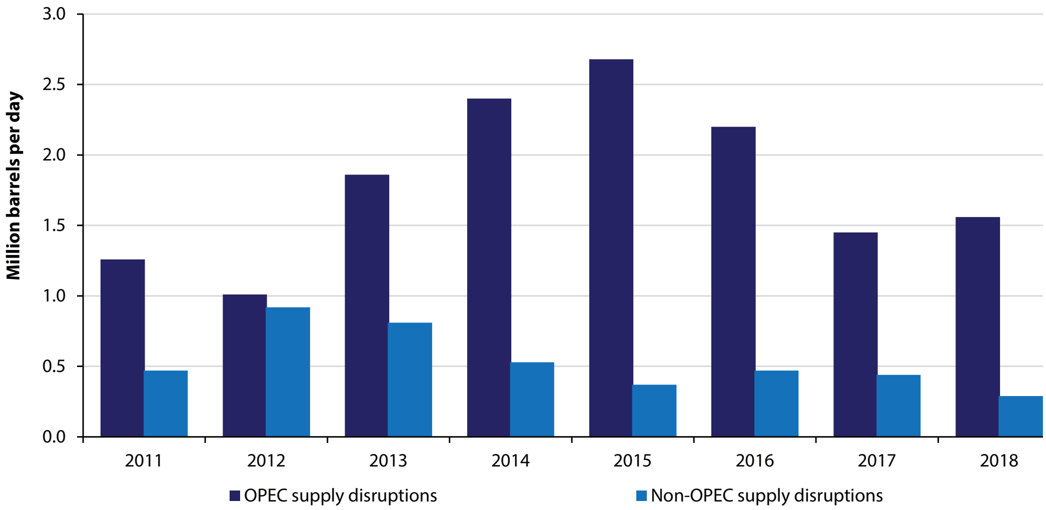


Source: US Energy Information Administration

OPEC's market share is expected to remain relatively stable or even grow as new cost-efficient Iraqi and Saudi capacity comes online [18] [62].

Even though OPEC accounts for less production than non-OPEC countries do, *Figure 34* shows how annual supply disruptions from OPEC nations have been significantly higher than those from non-OPEC countries.

Figure 34: OPEC and non-OPEC supply disruptions



Source: US Energy Information Administration (EIA)

Due to co-ordinated supply cuts in recent years, OPEC and Russian production is operating 4% below its maximum [22]. Elsewhere, Brazil is set to increase its output by over 50% by 2030, growing to almost 5% of global oil production [18] [62].

24 Organisation for the Petroleum Exporting Countries. As of January 2020, the OPEC members are Algeria, Angola, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Republic of the Congo, Saudi Arabia, United Arab Emirates and Venezuela.

In its Oil Market Report 2019, the IEA predicts an oversupply of refined products (that is, transport fuels and petrochemical feedstocks) by 2024, due to the commissioning of several large refineries in the Middle East and Asia [62]. Cheap resources (such as natural gas fuel), low labour costs and less stringent regulation give refineries operating in developing regions a competitive advantage over aging, higher-cost European oil refineries. This supply glut is expected to result in refinery closures in Europe [62], potentially increasing European dependence on refined product passing through the Suez Canal and Strait of Hormuz. Saudi Arabia, Kuwait and the UAE already supply 20% of EU jet kerosene demand (2018) [38].

Moderation in Europe's oil demand in line with the IEA's sustainable development scenario would reduce Europe's exposure to oil supply risk.

4.2.2 International oil prices

Crude oil and oil products are commodities traded on international markets. Ireland is neither a crude oil producer nor a significant world player in terms of demand for oil products, so it does not influence the price of oil.

Oil prices are based on benchmarked price assessments in different regions. In Ireland and Europe, oil prices are based on the Dated Brent price benchmark. Dated Brent is based on a blended profile of high-quality North Sea crudes. Other crudes and products are priced at a discount or premium, based on their quality and yield relative to Dated Brent. Dated Brent pricing, which is shown in *Figure 35*, is used by oil markets in the Atlantic basin, as well as South America, Africa, Eurasia and the Mediterranean. In the US, crude oil is benchmarked against high-quality West Texas Intermediate while trade in the Indian Ocean and Southeast Asia is often priced against the Dubai benchmark. Crude oil contracts are settled in US dollars and volumes are measured in barrels.

Surging US shale oil output in mid-2014 generated a 2-3% supply glut, which led to prices falling from a 4-year average of $110/barrel to $50/barrel (Dated Brent). A repeated pattern of OPEC cuts in response to US output increases has seen prices average $63 per barrel over the past three years.

Figure 35: Price of crude oil in Europe (Dated Brent) 2005-2020

Source: US Energy Information Administration (EIA)

Oil price is a key factor for dictating market share for different producers. OPEC members typically require much higher prices to break even than US shale oil producers do: breakeven prices for OPEC nations range from $80-110/barrel [63], while, on average, US shale oil producers require just $50/barrel [64]. At $54/barrel, Iraq's breakeven value is an exception to the higher OPEC production costs, which will support Iraq's projected future production growth [63] [62].

The price of finished oil products depends on several factors other than the underlying price of crude oil. Petrol, diesel and jet kerosene are typically traded at a premium to crude oil, with such premia typically making up 15-25%[25] of product wholesale prices [22]. Europe has a diesel and jet kerosene deficit while the US and Middle Eastern producers run a surplus [23], so European diesel and jet fuel premia are higher. As well as causing a spike in crude oil prices, the 2019 drone attacks on Saudi Arabian oil infrastructure caused some product premia to rise [65] due to Saudi Arabia's relatively large contribution to global product supply (2%) [23].

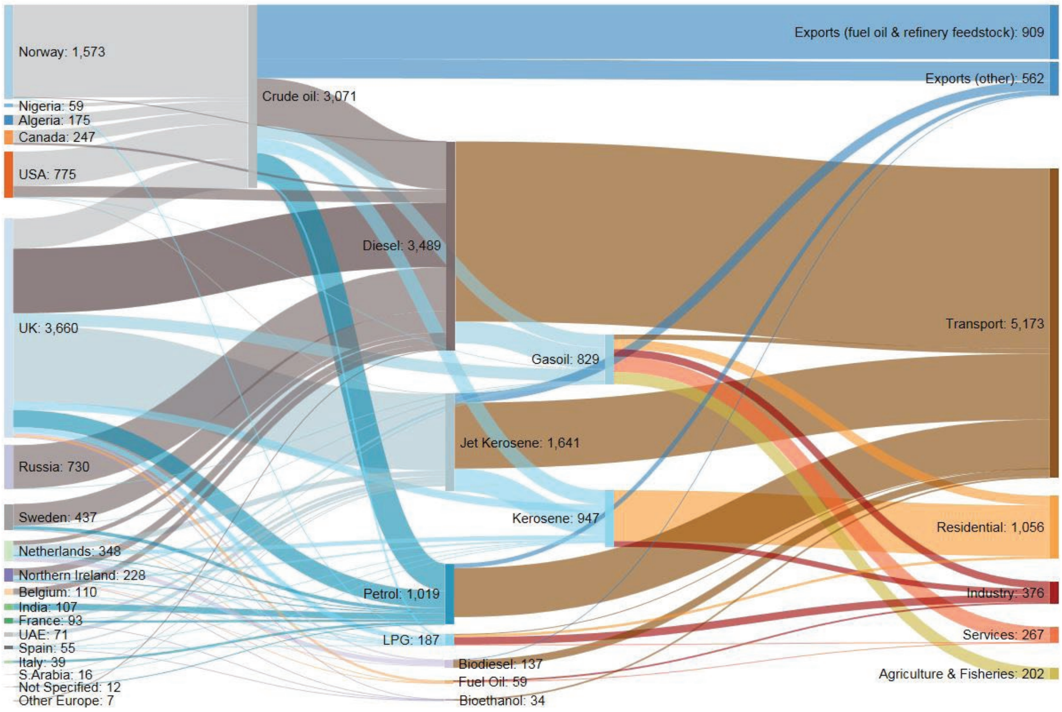
25 Based on US Energy Information Administration data for oil prices 2017-2019 [22].

4.2.3 Ireland's oil supply

Apart from a small amount of indigenous biofuel production, Ireland imports all its oil demand – as either crude oil, refined oil products or biofuel products. 36% of Ireland's oil imports are crude oil and 64% are refined products [38].

Figure 36 presents an energy-flow diagram for oil in Ireland in 2018. The total input is shown on the left while outputs on the right are categorised by sector. This illustrates the provenance of Ireland's oil supply, the breakdown of production output from indigenous refining and the breakdown of end-use by sector. It also shows how all of Ireland's imported kerosene is imported as dual-purpose kerosene (jet kerosene), but some is then sold as kerosene for heating. Similarly, some imported diesel is sold as gasoil.

Figure 36: Oil energy flows in Ireland 2018 (ktoe)[26]



Source: DCCAE & SEAI

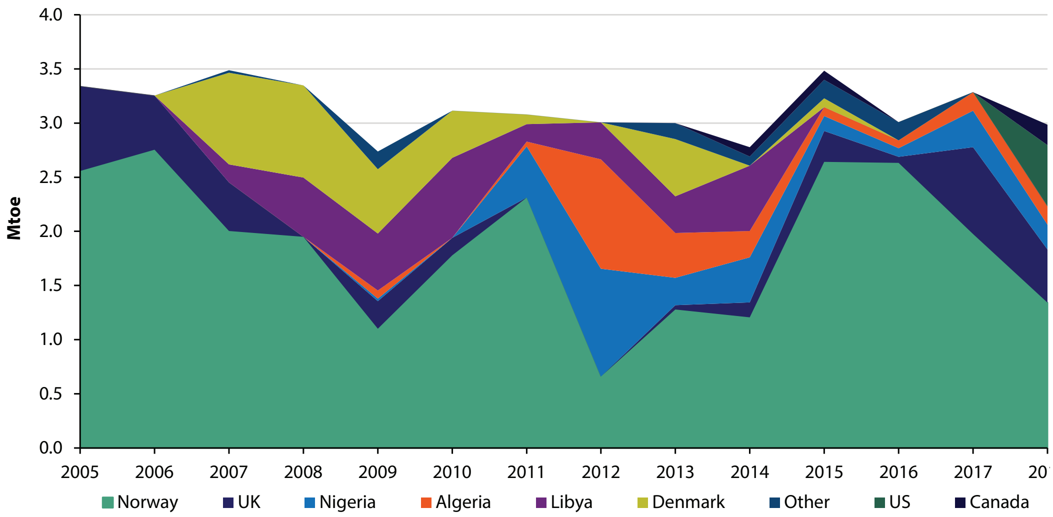
4.2.3.1 Crude oil imports and indigenous refining output

Ireland has one oil refinery, located at Whitegate, Co. Cork. It can process up to 75,000 barrels per day of crude oil. Whitegate's refined product output is equivalent to 30-40% of Ireland's inland demand [66]. The sources of the crude oil imported to Whitegate between 2005 and 2018 are shown in *Figure 37*. While most was sourced from Norway, Denmark and the UK during the period shown, the provenance of the crude has changed over time. In 2014, almost half of the crude oil came from OPEC nations (Libya, Nigeria, and Algeria) [38]. No Libyan crude oil has been imported since the outbreak of the Second Libyan Civil War (2014). In 2018, 45% of the crude came from Norway, 19% from the US, 16% from the UK and 20% from other sources [38]. US crude accounted for 69% of crude imports in 2019.

The diversity of sources reflects the global nature of the international crude oil market. The trends shown for Ireland mirror global trends of declining North Sea output, shale-driven US output growth, and disruptions in Libya, Nigeria, and other OPEC producers.

26 There are some statistical differences in the data presented in the flow diagram because data has been collated from different sources.

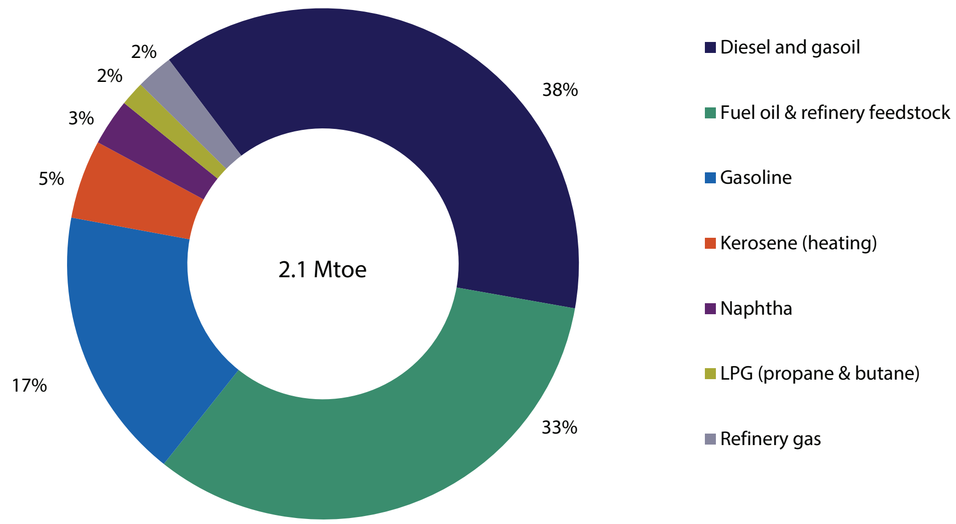
Figure 37: Crude oil imports 2005-2018



Source: Eurostat

Figure 38 provides a breakdown of production from Whitegate in 2017 by product type. It supplies Ireland with diesel, petrol, LPG, kerosene (heating oil), gasoil (heating oil), but does not produce jet kerosene (aviation fuel). All of Ireland's jet kerosene is imported. In 2017, roughly 33% of Whitegate's production was fuel oil and refinery feedstock [38].

Figure 38: Whitegate refinery production 2017



Source: Eurostat

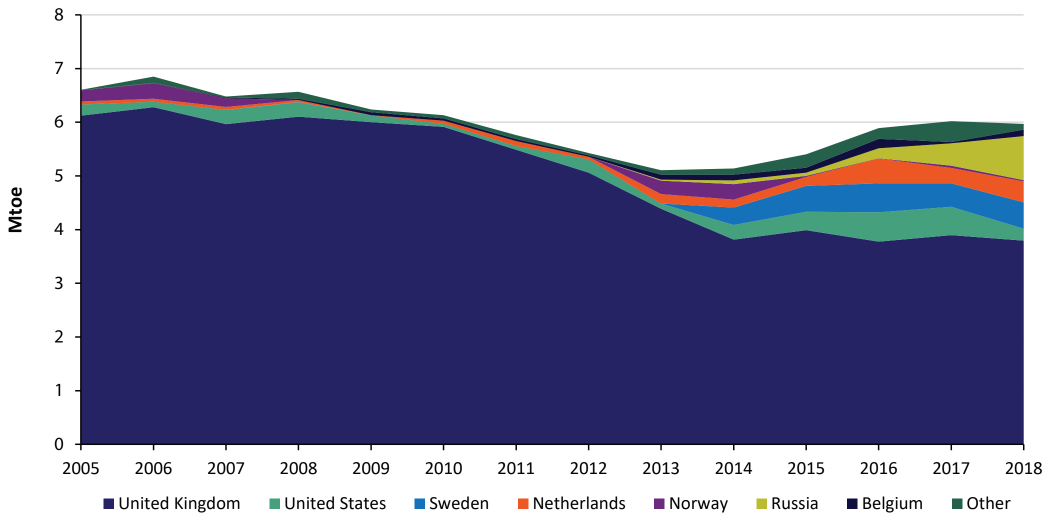
In 2017, the refinery exported 1.378 Mtoe of oil products, mostly to the UK. The 60-70% of Ireland's oil (refined) product demand that is not produced at Whitegate is imported.

4.2.3.2 Refined oil product imports

Figure 39 shows the breakdown of Ireland's oil product[27] imports by country. The UK supplies most of Ireland's product imports but its share has declined from 93% in 2005 to 64% in 2018, partly because of refinery closures between 2009 and 2014. The diversity of supply in recent years reflects a well-supplied and increasingly competitive oil product market.

27 Oil product refers to refined product and does not include crude oil, other refinery feedstocks or intermediates.

Figure 39: Oil product imports 2005-2019



Source: Eurostat

4.2.4 Liquid biofuels

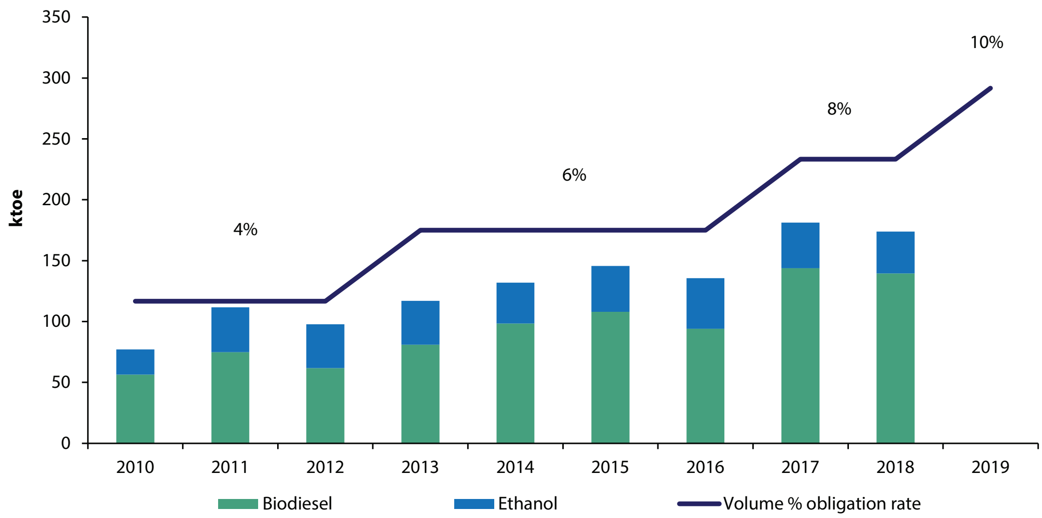
In 2018, liquid biofuels made up 3.1% of oil consumption in the transport sector[28].

4.2.4.1 Biofuel Obligation Scheme

The Renewable Energy Directive 2009/28/EC requires that member states achieve 10% renewable energy in transport by 2020 [32]. The Biofuel Obligation Scheme was introduced in Ireland in 2010 as one element in a two-part approach to meeting the EU target: the second being the promotion of electric vehicles.

Since the inception of the scheme, there has been a steady increase in the quantity of biofuel being placed on the market in Ireland, in line with the increasing biofuel obligation. *Figure 40* shows the quantities of bioethanol, which is blended with petrol, and biodiesel, which is blended with diesel, placed on the market in Ireland since 2010 and illustrates their relative market shares. It also shows the level of the biofuel obligation (%) over this period.

Figure 40: Biofuel placed on the market 2010-2018



Source: NORA

The Renewable Energy Directive 2009/28/EC also introduced sustainability criteria for biofuels by establishing a greenhouse gas savings requirement[29] and requirements for conserving carbon stock and biodiversity. Only biofuels that

28 Including aviation, which is not within the scope of the Biofuel Obligation Scheme.

29 The requirement is 50% greenhouse gas savings relative to a fossil fuel comparator and, for new biofuel plants that start production from 1 January 2017, 60% greenhouse gas savings from 2018.

meet the sustainability criteria can be counted towards the 10% target. As a means of promoting biofuels derived from waste, residues and other advanced feedstocks, biofuels produced from these sources may be counted twice for the purposes of the renewable transport target[30]. In Ireland, most biofuel used for road transport qualifies for double counting.

It should be noted that the Biofuel Obligation Scheme is a volume-based obligation on road transport fuels, whereas the Renewable Energy Directive 2009/28/EC target is an energy obligation that also includes rail transport. Because the energy content of biodiesel and bioethanol is lower than that of diesel and gasoline, the 10% Renewable Energy Directive 2009/28/EC target is equivalent to a 12% volume obligation, approximately. This difference between volumetric and energy percentages, coupled with the double-counting principle and the exclusion of rail from the scope of the Biofuel Obligation Scheme, can cause confusion when biofuel data is reported for different purposes. For example, in 2018, the 8% volume obligation was satisfied, while the physical quantity of biofuel actually supplied amounted to 3.9% of road and rail transport energy, and the weighted share of renewables for the purposes of the Renewable Energy Directive 2009/28/EC target was 7.2%.

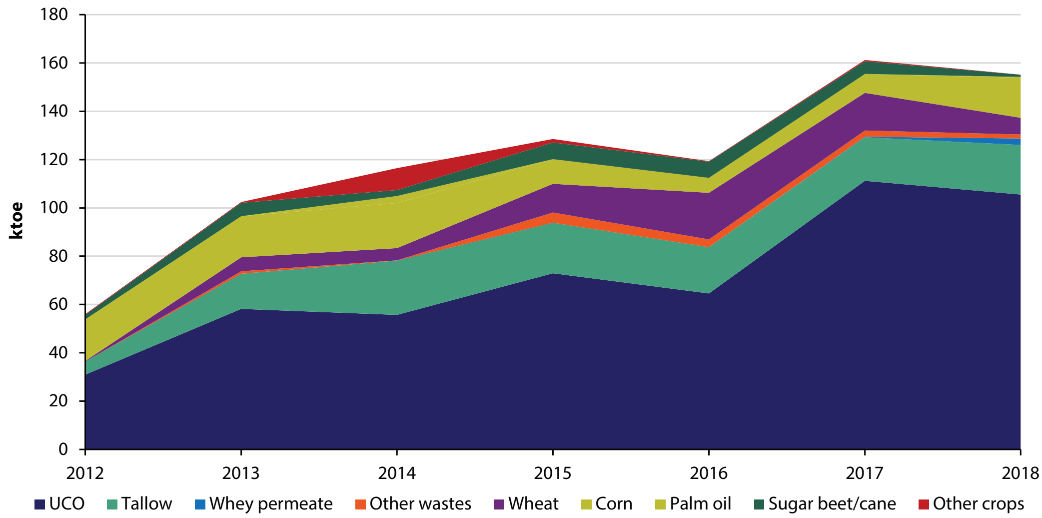
The volume of biodiesel being placed on the market has been increasing in line with the obligation, which is 11% for 2020. In 2018, biodiesel accounted for 75% of biofuel consumption. While the national bioethanol blend rate has increased over time, there has been a steady decline in the demand for petrol. Consequently, the bioethanol consumption has remained relatively static, averaging around 57 million litres per year since 2011. Small volumes of bio-LPG are also being placed on the market, but they are not significant in comparison to the volumes of biodiesel and bioethanol.

The Fuel Quality Directive (FQD) established environmental specifications for petrol and diesel used in road transport and in non-road mobile machinery [67]. It also introduced an obligation on energy suppliers to reduce the lifecycle carbon intensity of transport fuels by 6%, by 2020, compared to a 2010 fuel baseline standard of 94.1 gCO_2eq/MJ. As almost all suppliers of fuel to the transport sector in Ireland are oil companies, biofuels will play a significant role in meeting both the Renewable Energy Directive 2009/28/EC and FQD targets. Emission savings arising from electricity use in road vehicles, from upstream emission reductions[31] and from the use of lower carbon-intensity fossil fuels, such as CNG and LPG, can also contribute towards the FQD target.

4.2.4.2 Sources of Ireland's biofuel supply

Biofuels can be produced from diverse feedstocks. *Figure 41* shows the breakdown of the feedstocks used to produce biofuels for the Irish market since 2012. Used cooking oil (UCO) is the dominant feedstock. It accounted for 83% of biodiesel and 62% of biofuel in 2018 (by volume).

Figure 41: Biofuel feedstocks 2012-2018



Source: NORA

Indigenous biofuel production accounted for 13% of supply in 2018. Indigenous biodiesel production was approximately 27 ktoe, equivalent to 21% of biodiesel supply and 1% of total diesel supply[32]. Additional indigenous biodiesel production capacity was completed in 2019. Indigenous bioethanol production for use in the transport sector amounted to approximately 3 ktoe in 2018, equivalent to 9% of bioethanol supply and 0.3% of total petrol supply.

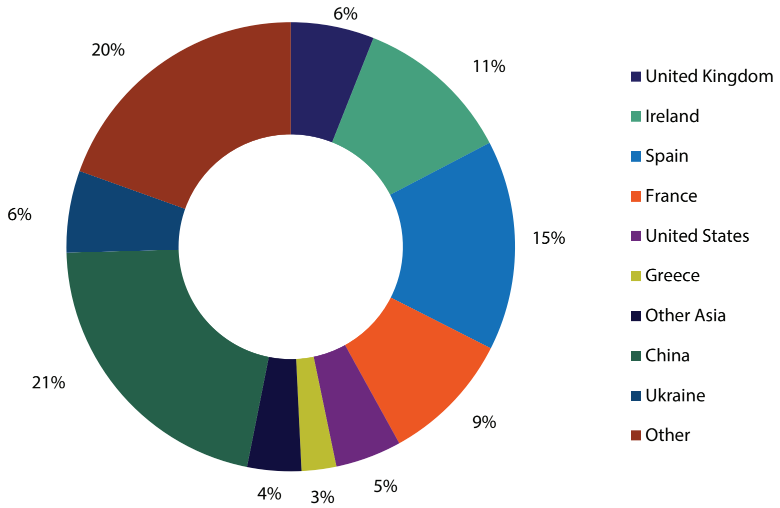
30 This double counting cannot be used for the purposes of the overall renewable energy target.

31 Upstream emission reductions (UERs) are generated by implementing greenhouse gas reduction projects at upstream sites that produce or extract nonbiological raw material that is used for producing fuels for transport and is supplied for uses covered by the FQD.

32 Some of this indigenous production was exported.

Ireland's biofuel feedstocks were sourced from fifty-eight different countries in 2018. *Figure 42* shows the main countries from which biofuel feedstocks were sourced in 2018. China supplied 21% of the feedstock, with 15% coming from Spain and almost 10% from France.

Figure 42: Sources of Ireland's biofuel feedstocks 2018



Source: NORA

4.2.4.3 Outlook for biofuels

The implementation of the Recast Renewable Energy Directive [32] will shape Ireland's biofuel market in the period to 2030. The Recast Directive introduced an obligation on fuel suppliers to achieve 14% renewable energy in transport by 2030. It also established sub-targets for advanced biofuels[33], limits on the contribution of biofuels produced from crop-based feedstocks and limits on the contribution of biofuels produced from used cooking oil and tallow.

The Recast Directive allows for multiple counting of biofuels produced from wastes and residues, and of biofuels and other renewable energy consumed in particular forms of transport. For example, renewable electricity consumed in electric vehicles can be quadruple-counted and renewable fuels consumed in aviation can be 1.2-times counted. Member states also have options to reduce the 14% target, depending on the level at which a crop-based feedstock limit is set.

Therefore, there are several permutations arising from the Recast Directive that make determining its precise impact on Ireland's biofuel market difficult to predict. Notwithstanding this, the general ambition of the Directive is to increase the penetration of biofuel and renewable energy in the transport sector while ensuing there is a shift away from crop-based biofuels and an increase in the penetration of advanced biofuels.

The Draft National Energy & Climate Plan 2021-2030 [68] included two scenarios that referenced 2030 targets for bioethanol and biodiesel blends of 10% and 12% respectively[34], referred to as E10[35] and B12[36]. These targets are more ambitious than those in the Recast Directive in terms of the quantities of biofuel required, but less prescriptive in terms of the types of biofuels specified. As well as requiring significant increases in the quantities of bioethanol and biodiesel supplied[37], achieving the targets set out in the Draft National Energy & Climate Plan will require some notable constraints on biofuel blend rates to be overcome.

The fuel specification used for petrol, EN 228, specifies two limits for ethanol blending – 5% (E5) and 10% (E10). Fuel companies in Ireland adhere to the 5% limit. Since 2016, Ireland has been blending bioethanol with petrol at a rate of approximately 5%. A transition to E10 would require a change to the type of petrol into which the bioethanol would be blended and could also require changes to terminal and forecourt infrastructure. While both E5 and E10 blends are sold side-by-side at individual forecourts in many other countries, Ireland has a more homogeneous petrol market. Forecourts are typically not configured for selling more than one petrol blend. Most could supply E5 or E10, but not both. In addition, Whitegate Refinery, and the UK refineries, from which Ireland imports most of its petrol, currently only produce a petrol

33 Advanced biofuels are biofuels that are produced from wastes and residues.
34 These targets refer to physical blending, that is, they do not allow double counting.
35 Gasoline (petrol) with 10% ethanol, by volume.
36 Diesel with 12% biodiesel, by volume.
37 SEAI anticipates that the absolute quantities of biofuels supplied may peak in the mid-2020s even though the blend rates could continue to rise until 2030. This is because more electric vehicles will displace more internal combustion engines as the decade progresses, which will reduce the demand for liquid transport fuels.

blend stock suitable for E5. This makes Ireland's future adoption of E10 dependent on decisions by individual Irish suppliers regarding the product(s) that they choose to put on the market and on the position in the UK.

While E5 is currently the predominant blend in the UK, the UK's refinery, terminal, and forecourt infrastructure is more flexible than Ireland's. As a result, UK suppliers could choose to remain on E5, switch entirely to E10, or supply both. Any future significant adoption of E10 in the UK would impact Irish fuel suppliers because the UK refineries would almost certainly begin to produce a petrol blend stock suitable for E10, which would create an opportunity for E10 supply in Ireland. This would also affect Whitegate Refinery because it is very unlikely that it would produce both E5 and E10 petrol blend stocks. Therefore, it is likely that a transition to E10 in Ireland would be precipitated by a significant move to E10 in the UK, very soon after which most of the petrol supplied in Ireland would also be E10. In early 2020, the UK Government initiated a consultation on the potential introduction of E10 [69].

Oil companies in Ireland currently blend biodiesel at approximately 5%. The EN 590 fuel specification for diesel, which is ubiquitous in Ireland and the EU, limits blending to 7%[38]. To reach the National Energy & Climate Plan target of 12% biodiesel, alternative approaches to conventional biodiesel blending with diesel will be required. One option would be to promote alternative specifications to EN 590 which enable higher blends, such as EN 16709. This allows for B20 and B30 blends in captive fleets. Another standard, EN 16734, covers B10 for use in vehicles that are compatible with B10.

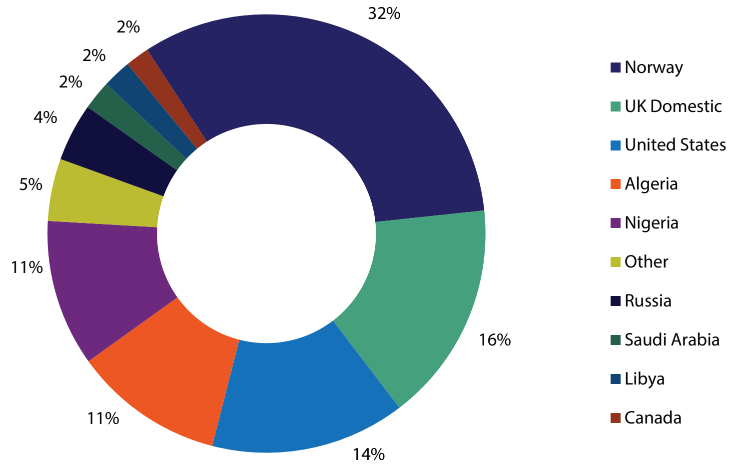
Another option would be to blend hydrogenated vegetable oil (HVO) with diesel. While HVO is biodiesel, it is not limited to a 7% blend by EN 590. It can be blended to much higher rates. However, it is currently significantly more expensive than conventional biodiesel and its supply is limited.

4.2.5 UK oil market

As 16% of Ireland's crude oil imports and 69% of its refined product imports come from the UK (2018), it is worth examining the UK oil market more closely.

The UK is Europe's second biggest oil producer after Norway. Most of its crude oil is produced in the North Sea, but with smaller quantities produced in Dorset and in the Liverpool Bay area of the Irish Sea. Production output has been in decline since it peaked in 1990. The country became a net importer in 2011 and by 2014, production was roughly 30% of 1990 levels [70]. In 2014, the UK government embarked on a new policy to boost indigenous production, called the Maximising Economic Recovery Strategy [71] [72], which introduced a more favourable tax regime for exploration and production activities. Production subsequently increased by 27% [70]. Despite this, the UK remains a net importer, with domestic production equivalent to roughly two-thirds of final oil consumption. *Figure 43* shows the UK's domestic production of crude oil and its imports in 2018. UK production is expected to continue to decline due to a lack of new investment in the North Sea oil sector [72] [23] [71].

Figure 43: Sources of UK crude oil 2018



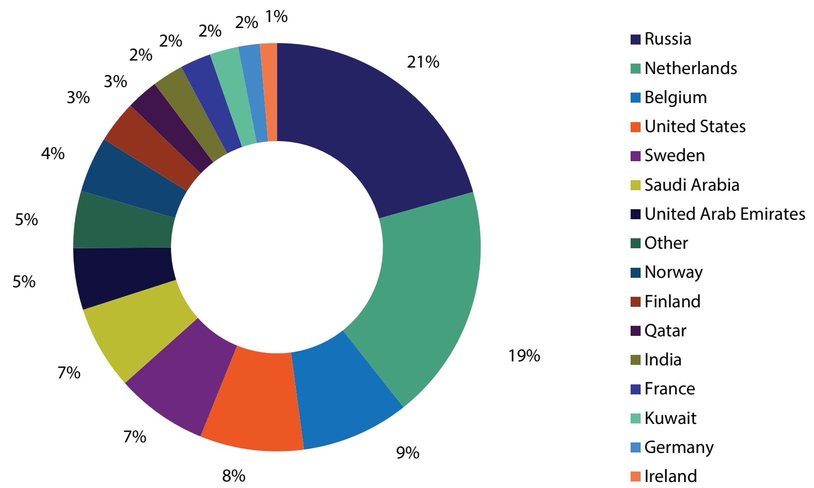
Source: Digest of UK Energy Statistics 2019

Like much of Western Europe's refining capacity, the UK refining sector runs a petrol surplus (30% of production). The UK is therefore well placed to supply Irish petrol import requirements, with 54% of Ireland's petrol imports coming from the UK in 2018. Ireland accounted for 16% of the UK's oil product exports in 2018 [72].

38 The EN 590 specification limits fatty acid methyl ester blending to 7%. Fatty acid methyl ester, which has physical properties similar to diesel, is the vast majority of biodiesel consumed in Ireland.

Conversely, UK refinery output meets only 60% of UK diesel and kerosene (jet fuel and heating oil) demand [38]. The remaining 40% is imported from the Netherlands, Sweden, Russia, the US and Saudi Arabia, among others [38]. *Figure 44* shows the source of UK oil product imports in 2018. The Netherlands, Russia and Sweden were the three largest sources, accounting for 44% of imports between them.

Figure 44: UK oil product imports 2018



Source: Digest of UK Energy Statistics 2019

According to the IEA, the UK held oil stocks equivalent to 238 days of net imports in 2018, comfortably above the IEA's 90-day requirement.

4.3 Oil infrastructure

4.3.1 Refining

Whitegate Refinery has been privately operated since September 2001; it changed ownership in 2016 when Irving Oil purchased it from Phillips 66. Phillips 66 had been under obligation to operate the refinery until 2016, in accordance with a purchase agreement with the State dating from 2001.

Whitegate Refinery is small and lacks the complexity of many European and international refineries. A study commissioned by the Department of Communications, Energy and Natural Resources (now DCCAE) highlighted the oil security benefits that the Whitegate Refinery could offer and concluded that the existing oil import facilities on the island of Ireland provide a robust infrastructure that would offer alternatives should a serious disruption occur at any of the six principal oil ports on the island of Ireland[39]. The 2015 energy white paper also emphasised the strategic energy security benefits of the continued operation of Whitegate Refinery on a commercial basis [73].

4.3.2 Terminals and storage

Given Ireland's near total dependence on imported oil, the oil terminals and storage facilities on the island of Ireland are particularly important from a security of supply perspective. Oil is imported via the six principal oil ports at Dublin, Whitegate (Cork), Foynes (Limerick), Galway, Derry, and Belfast[40]. Oil products are imported by ship, unloaded to storage tanks at the ports and then distributed by road by a fleet of approximately 900 vehicles [74]. Ireland has no distribution pipelines. Biofuels are imported as either blended or unblended product through the six oil ports.

Dublin Port has the largest throughput capacity, at over 100,000 tonnes of refined product per week, which is approximately one-third of the total throughput capacity of all of the facilities on the island of Ireland [74]. It supplies approximately half of the Irish market. The IEA's 2019 country review of Ireland's energy policies commented that '*a potential disruption to Dublin Port would cause a risk to the country's oil supply, as the capacity of…[Whitegate, Foynes and Galway]…to increase their throughputs is not sufficient to provide an alternative route for supply. However, a major supply disruption may be avoided if the two ports in Northern Ireland (Belfast and Derry) could be mobilised. Belfast could make a significant contribution as it typically operates at about half its maximum oil transit capacity*' [74].

39 The six principal oil ports are Dublin, Whitegate (Cork), Foynes (Limerick), Galway, Derry and Belfast.
40 Jet kerosene is also imported by ship directly to Shannon Airport.

The ports have different configurations and storage capabilities. For example, jet kerosene, which makes up roughly 13% of Ireland's oil demand, is not imported at all the ports. Whitegate Refinery imports refined product and refines crude oil. Unlike the terminals, it can respond to an import disruption by producing more product from crude oil.

4.4 Emergency response

4.4.1 IEA and EU co-operation

Ireland was a founding member of the IEA. Given its inception during the 1973 and 1974 oil crisis, it originally had a strong focus on oil security. In recent years, its focus has widened to encompass gas and electricity security, and sustainability. The IEA adopted a new strategy in 2015, which is based on three pillars:

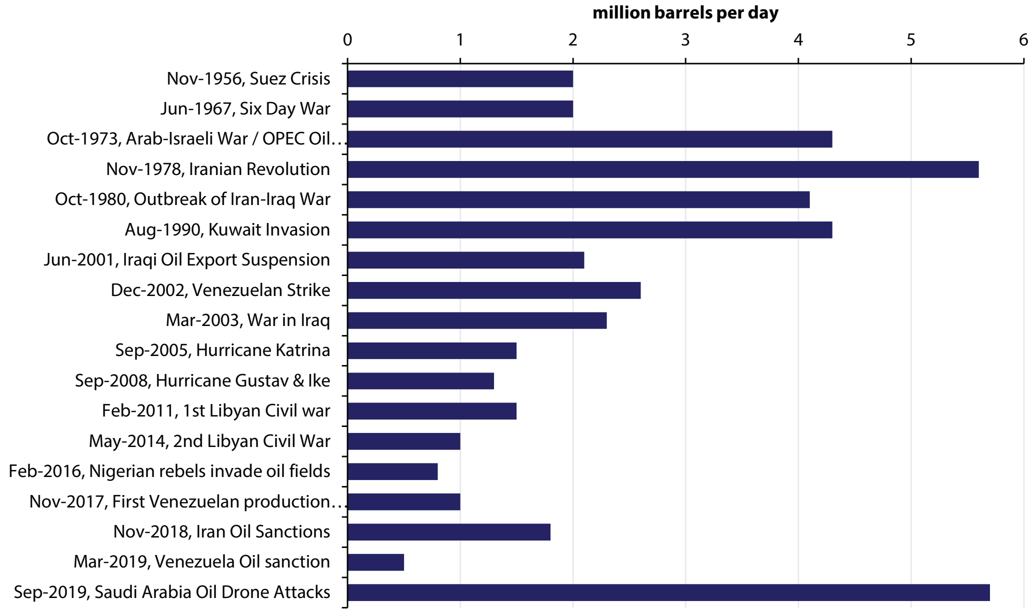
- Strengthening and broadening its commitment to energy security beyond oil, to natural gas and electricity;
- Enhancing engagement with major emerging economies; and
- Greater focus on sustainable energy technologies, including energy efficiency.

Ireland is also a member of the EU's Oil Co-ordination Group. This group provides a forum for EU-wide co-ordination in the event of international or regional-level supply disruption and for the dissemination of good practice in oil emergency planning.

4.4.2 Oil market disruptions

Natural disasters, technical faults and geopolitical tensions are notable sources of risk for global oil markets. *Figure 45* illustrates the impact of the major oil supply disruptions that have occurred since oil became the dominant fuel of the global economy in the 1950s. The first significant disruption was the Suez Crisis in 1956. The first oil crisis in 1973 and 1974 resulted from the Arab-Israeli conflict and the decision by the OPEC to reduce oil production and to raise prices. This led directly to the establishment of the IEA in 1974. The Iranian revolution in 1978 and 1979 precipitated what was then the largest disruption, commonly referred to as the second oil crisis. The 2019 drone attacks on Saudi Arabian oil infrastructure at Abqaiq and Khurais resulted in the temporary loss of 5.7 million barrels per day of processing capacity, making it the largest ever supply disruption, in absolute terms. It led to a temporary spike in oil prices of 20% [18], but it did not trigger a co-ordinated stock release by IEA member countries. Such co-ordinated releases have only occurred on three occasions: in the build up to the 1991 Gulf War; after Hurricanes Katrina and Rita damaged oil infrastructure in the Gulf of Mexico in 2005; and in response to the disruption of oil supplies from Libya during its civil war in 2011.

Figure 45: Major oil supply disruptions 1950-2019



Source: IEA

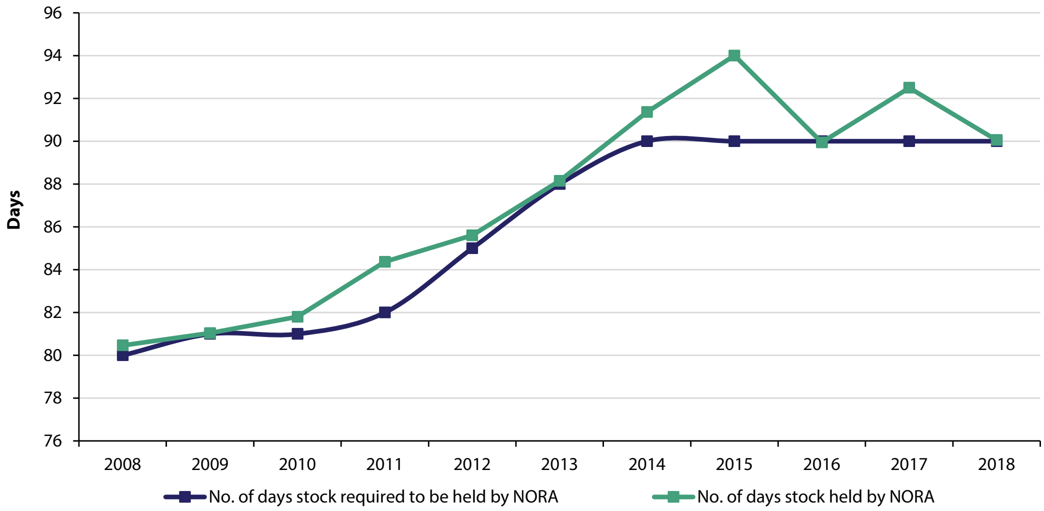
Approximately 45% [75] of all OPEC exports pass through the Strait of Hormuz, a shipping bottleneck which is the location of significant geopolitical tension.

4.4.3 National oil reserves

Ireland's oil stock policy has evolved in response to its international commitments arising from membership of the EU and the IEA. EU Directive 2009/119 obliges member states to maintain minimum oil stocks corresponding to at least 90 days of average daily net imports or 61 days of average daily inland consumption, whichever is the greater [76]. For Ireland, this equates to 90 days of imports, which aligns with the IEA requirement on members to hold at least 90 days of net oil imports.

NORA is responsible for managing Ireland's oil stocks, on behalf of the Minister for Communications, Climate Action and Environment. *Figure 46* illustrates the number of days consumption that NORA is obliged to hold each year, as well as the actual number of days' consumption held.

Figure 46: NORA stock holding requirement 2008-2018



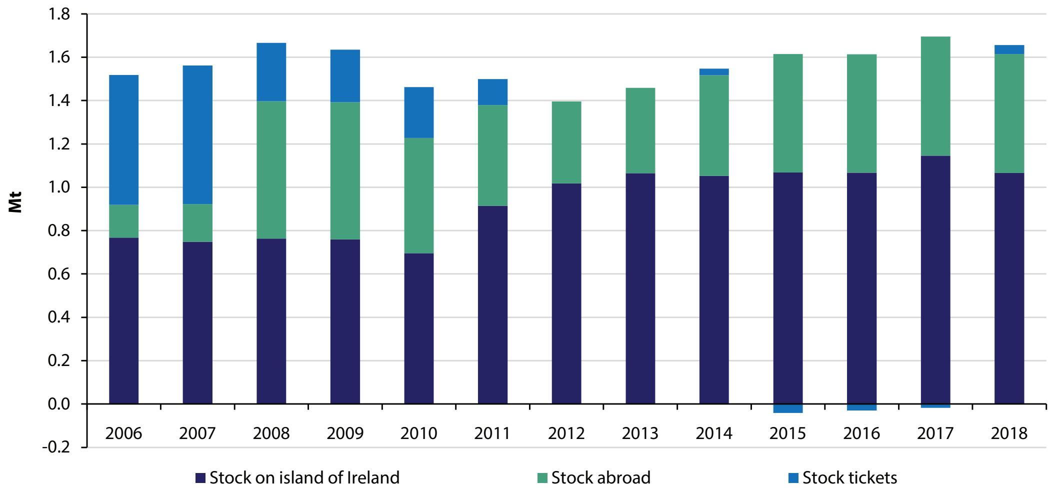
Source: NORA

NORA meets its obligation through a combination of two mechanisms:

- Stocks owned by NORA and stored in Ireland and in other member states with whom Ireland has concluded a bilateral oil stockholding agreement.
- Stocks held by NORA under short-term commercial contracts ('stock tickets') in Ireland and in other member states with whom Ireland has concluded a bilateral oil stockholding agreement. While these contracts are in effect, they provide NORA with an option to purchase oil in the event of an oil supply shortage.

Figure 47 illustrates the quantity of stock held during the period 2006-2018. In line with Government policy to improve the security of Ireland's oil supplies, NORA has increased both the quantity of physical stocks held and the quantity held on the island of Ireland.

Figure 47: NORA oil stocks 2006-2019



Source: NORA

The purchase and maintenance of Ireland's oil stocks are funded by a €0.02 levy that is liable on every litre of petrol, diesel, kerosene (excluding jet kerosene), gasoil and fuel oil (excluding marine bunkers) disposed of in Ireland[41].

4.4.4 Responding to an oil supply disruption

A disruption to Ireland's oil supplies could arise due to global events or local incidents that affect exports from other jurisdictions to Ireland, imports to Ireland, or distribution within Ireland.

The Minister for Communications, Climate Action and Environment has overall responsibility for oil security policy and DCCAE develops, prepares, and maintains emergency plans. Should an oil disruption occur, DCCAE would liaise and co-ordinate with relevant stakeholders, including the EU, IEA, other Government departments and agencies, the Government Taskforce on Emergency Planning, NORA, and the oil industry.

NORA would play a significant role in responding to an oil supply disruption. As well as maintaining oil reserves, NORA has an emergency release model to assist with managing a release of strategic stock. The model would be used to gather and collate data supplied by Irish oil companies and would inform decision making on how much product should be released, from where it should be released, and to whom. NORA undertakes regular emergency release exercises with the oil industry to enhance its and the oil companies' preparedness to respond to an oil supply disruption.

4.5 Impact of Brexit on oil security

Most of Ireland's oil product imports and a significant proportion of its crude oil imports pass through the UK. However, crude oil, oil products and biofuels are all globally traded commodities on international markets via flexible supply chains. Unlike gas and electricity imports, which currently rely on fixed links to the UK, crude oil, oil products and biofuels are all imported by ship. There are several refineries located throughout northwest Europe and North America that offer the same products as those currently imported into Ireland from the UK.

EU Directive 2009/119 obliges member states to maintain their emergency oil stocks within the EU. Ireland currently holds approximately 9% of its stocks in Northern Ireland and 11% in Great Britain [74]. There are security of supply benefits for Ireland associated with storing stocks in the UK, especially in Northern Ireland, compared to storing them further afield.

41 Oil consumers that hold 55 days' worth of stock in the State are exempt from paying the levy.

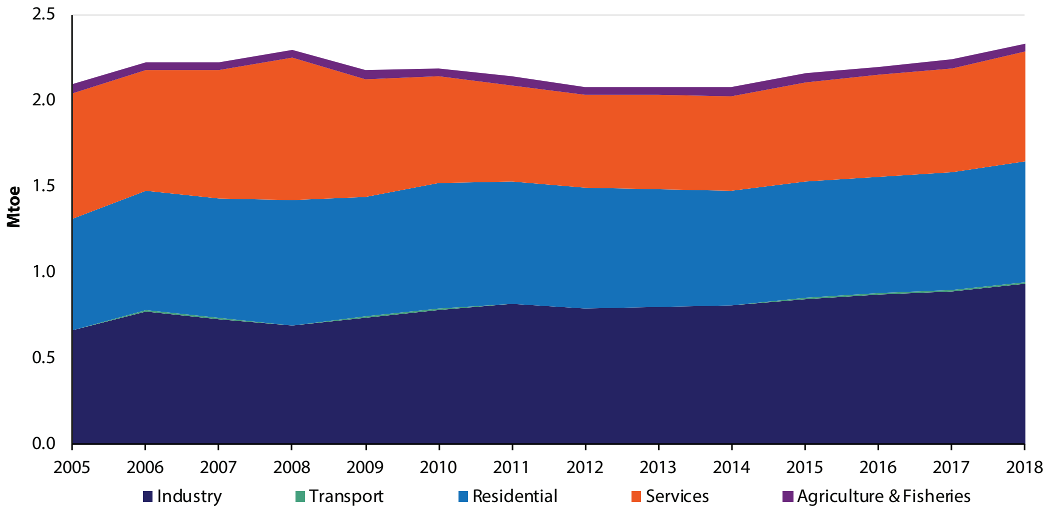
5 ELECTRICITY

5.1 Electricity demand

5.1.1 Historical demand

Figure 48 shows the breakdown of final electricity consumption by sector over the period 2005–2018. After peaking at 2.3 Mtoe in 2008, consumption fell by 1.9% per annum until 2013 before stabilising in 2014 and increasing by 3.0% per annum between 2014 and 2018. Consumption in 2018 was 1.8% higher than the 2008 peak. Industry accounted for 40% of consumption in 2018, with the residential and services sectors consuming 30% and 27% respectively. Transport accounted for just 0.2% in 2018, the vast majority of which was used by rail.

Figure 48: Final consumption of electricity by sector 2005-2018

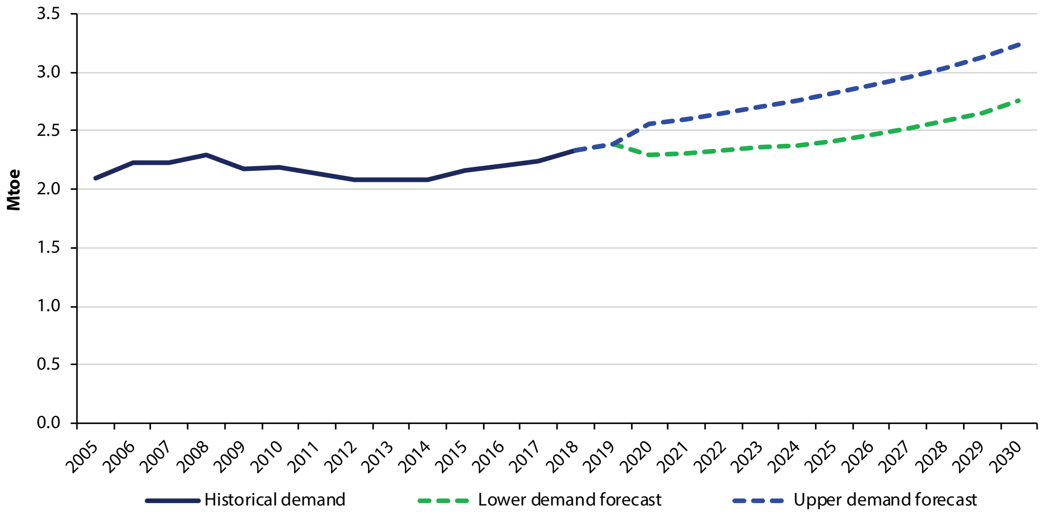


Source: SEAI

5.1.2 Future demand

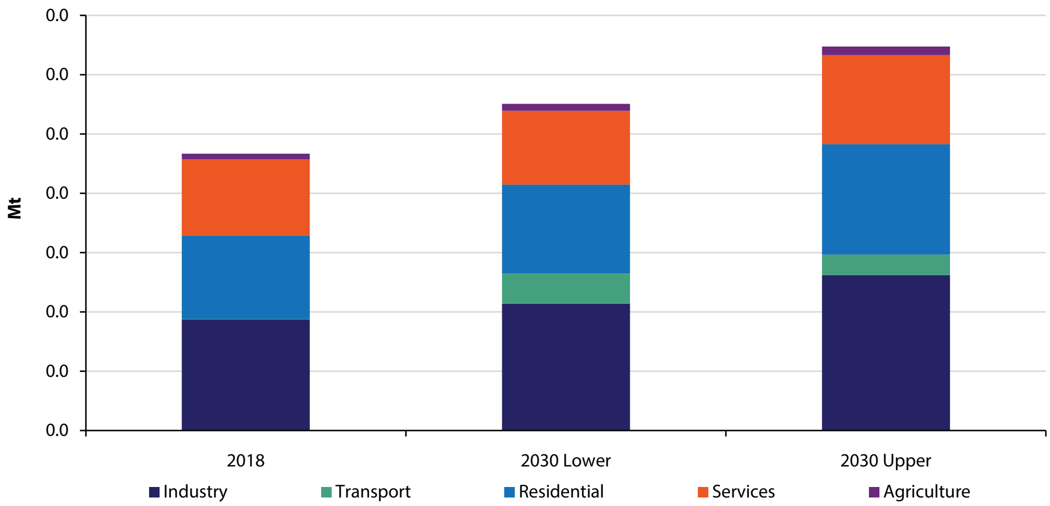
The latest national energy projections produced by SEAI anticipate electricity demand to continue to increase over the period to 2030 at growth rates comparable to those experienced since 2014. *Figure 49* shows the historical trend in total final electricity demand and SEAI's projections for demand for the period 2019-2030. *Figure 50* provides a breakdown of demand for 2018 and for two alternative projections for 2030. The projections indicate an annual growth in final electricity demand of between 1.4-2.8% between 2018 and 2030, although the implementation of energy efficiency measures additional to those set out in Climate Action Plan 2019 could moderate demand further [7].

Figure 49: Historical and projected final consumption of electricity 2005-2030



Source: SEAI

Figure 50: Final consumption of electricity in 2018 and 2030

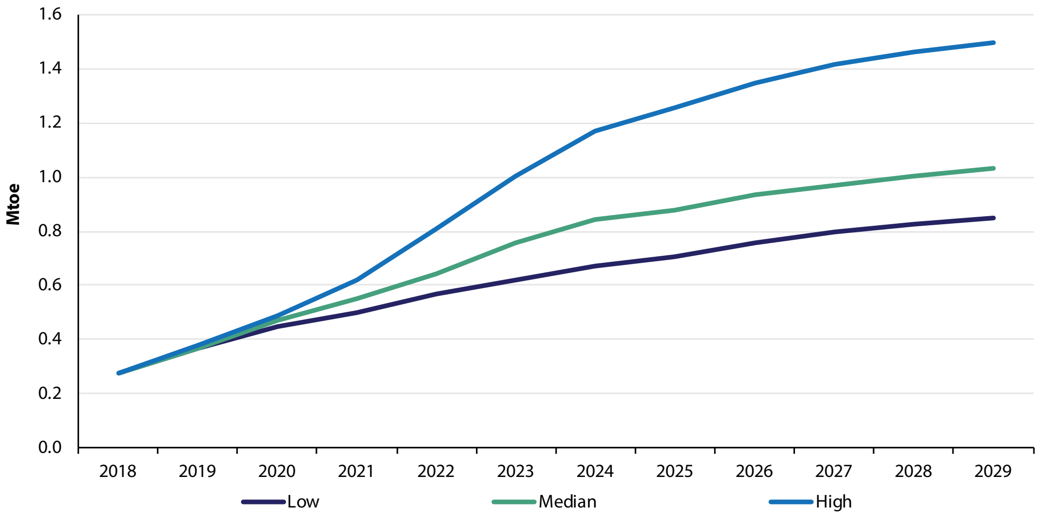


Source: SEAI

The most significant driver for the anticipated demand increase is the expected growth of data centres, which can have demand levels comparable to those of large towns. *Figure 51* shows projected growth in data centre demand from low, median and high demand forecast scenarios developed by EirGrid[42] [77]. This data indicates that data centres could account for 76% of electricity demand growth over the period shown and that by 2029 they could account for 26% of electricity demand, up from 6% in 2018 (low scenario).

42 The SEAI demand forecasts presented in *Figure 49* are based on the lower EirGrid projection shown in *Figure 51*.

Figure 51: Projected electricity consumption by data centres 2018-2029



Source: EirGrid

The actual rate of demand growth will depend on the timing of investment decisions by data centre operators. The rate of growth over the last two years has been less than EirGrid had forecast. This experience will be incorporated into EirGrid's next round of forecasts. Unlike many other electricity users, data centres typically have flat demand profiles. The Government has acknowledged that data centres '*pose considerable challenges to the future planning and operation of Ireland's power system*' [78]. These are discussed later in this chapter.

Another driver of the anticipated growth in electricity demand is the proposed electrification of heat and transport over the next decade. The Climate Action Plan sets out ambitious electrification targets that will shift demand from fossil fuels (mainly oil) to electricity: 936,000 electric vehicles on the road and 600,000 heat pumps installed in buildings by 2030 [7]. For both technologies, the amount of fossil fuel demand displaced will be greater than the corresponding increase in electricity demand, due to the higher efficiencies of both electric vehicles and heat pumps compared to internal combustion engines and fossil fuel boilers, respectively.

EirGrid, together with the electricity System Operator for Northern Ireland (SONI), publishes an annual All-Island Generation Capacity Statement (GCS) that sets out estimates for electricity demand and generation capacity for the following decade. EirGrid's demand forecasts are linked to ESRI forecasts for economic growth and are updated annually in the GCS. As total annual electricity demand fluctuated over recent years, so too did the peak winter demand. As a result, forecasts for peak demand have evolved as the economic outlook deteriorated at the start of the recession and then improved in recent years. EirGrid's 2008 forecast (median) for peak demand in 2025 was approximately 8,000 MW[43]. This was scaled back to approximately 5,100 MW in the 2015 GCS but is up to approximately 6,400 MW in the most recent forecast [77].

The modelling underpinning the latter is based on approximately 500,000 electric vehicles and 400,000 homes with heat pumps and solar PV by 2030. While these penetration levels would represent significant growth from current levels, they are considerably lower than the targets set out in the Climate Action Plan. EirGrid plans to update its modelling to account for the latest relevant targets and reflect this in its next GCS, which is expected later in 2020.

5.2 Electricity supply

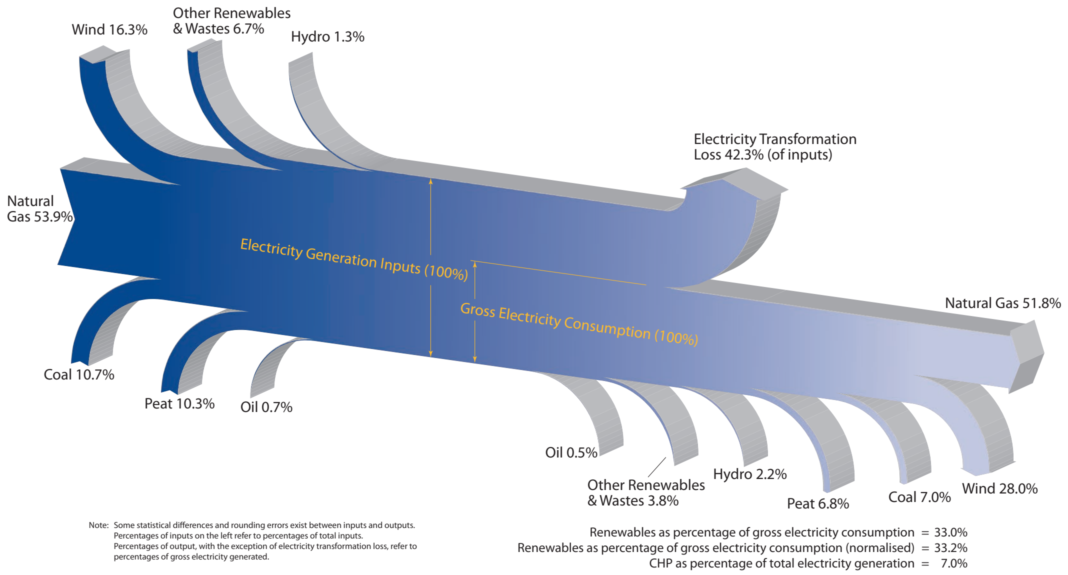
5.2.1 Electricity generation

Figure 52 shows graphically the flow of energy in electricity generation and supply for 2018. The relative size of the final electricity consumption and the energy lost in transformation and transmission remains striking even after an eleven-percentage-point improvement in the efficiency of electricity generation since 2005. These losses represented 43% of the energy inputs in 2018.

The electricity outputs are shown in terms of the fuel used to generate the electricity. In recent years, the increasing share of renewable electricity has acted to reduce the reliance on imported fossil fuels for electricity generation.

43 Republic of Ireland only.

Figure 52: Flow of energy in electricity generation 2018



Source: SEAI

5.2.2 Electricity from gas

54% of the energy input for electricity generation in 2018 was from natural gas, down from a peak of 61% in 2010. In terms of energy security, the dominance of gas is a risk both to the physical security of supply and in terms of exposure to price variation.

There were 15 gas-fired generation units on the electricity system in 2019, ranging in capacity from 81-444 MW and with a total capacity of 3,857 MW[44]. Together, they accounted for 51% of dispatchable generation capacity or 33% of total generation capacity. EirGrid anticipates that 194 MW of this existing capacity (2 generation units) will close by 2023 and an additional 408 MW of new gas plant (5 units) will be available in 2023 [77].

The relationship between gas and electricity security was recently examined in a joint study by GNI and EirGrid to evaluate Ireland's resilience to a long-duration gas disruption [56]. The study included an analysis of the impact of a major gas disruption on the electricity system and concluded that '*in most cases there…[would be]… limited or no impact on power generation as a result of a gas shortfall*' because demand would be met by other sources, notably back-up fuels.

Gas-fired electricity generators are required to be capable of switching to a backup or secondary fuel, such as distillate oil, when required [79]. While operating on secondary fuel, they must be capable of producing no less than 90% of their electrical capacity when on primary fuel. High-merit generators (operating more than 2,630 hours per annum) are required to hold stocks equivalent to five days' operation at their rated capacity on primary fuel, while lower merit generators are required to hold stocks equivalent to three days of such operation.

EirGrid is empowered to regularly test the secondary-fuel operation of gas-fired generators. The Integrated Single Electricity Market (I-SEM), which was introduced in October 2018, includes a new secondary fuel incentive mechanism for generators – the secondary fuel availability generator performance incentive. This is a per-MWh charge on generators who cannot meet previously declared secondary fuel generation capabilities during secondary fuel tests. According to EirGrid, it '*sends a signal to industry on the importance of secondary fuel availability as it relates to system security. It is essential to ensure the continued security of supply…*' [80].

In the event of a significant gas disruption or other relevant gas supply emergency, EirGrid is responsible for deciding which power stations should fuel switch or, if required, reduce output.

5.2.3 Electricity from renewables

Renewable electricity generation includes wind, hydro, landfill gas, biomass, and biogas. The contribution from these sources to electricity generation for the period 2005-2008 is shown in *Figure 53*. In 2018, renewables accounted for 33% of electricity generated.

Wind energy has been the largest source of renewable electricity since 2005 and the second-largest source of all electricity since 2013 (behind natural gas). In 2018, it accounted for 28% of electricity generation, which was over a third more than all other non-natural-gas generation combined. For brief periods in 2019, the instantaneous proportion of total electricity

44 There were also 378 gas-fired CHP units with a total electrical capacity of 325 MW (2018).

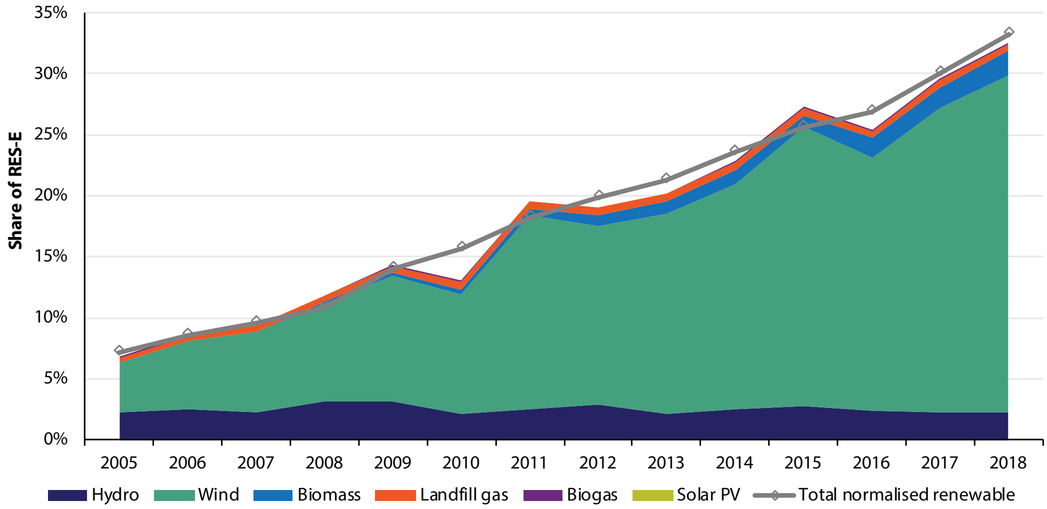
generated by wind on the island of Ireland peaked at 84% of the island's demand[45] [81]. It contributed 85% of renewable electricity output in 2018, with bioenergy and hydro accounting for 8% and 7% respectively. Solar PV contributed 0.2%.

The significant growth in biomass generation since 2008 is attributable to co-firing of biomass with peat in the peat power stations and the commissioning of two new waste-to-energy facilities[46].

The noticeable dips in the proportion of renewable electricity in 2010 and 2016 were due primarily to reduced levels of wind speed and rainfall resulting in reduced wind and hydro generation in both years. Hydro electricity in 2016 was 16% less than in 2015 and electricity from wind in 2016 was 6% less than 2015 despite a 16% increase in installed wind generating capacity.

In calculating the contribution of hydro and wind energy for the purpose of Ireland's overall 16% target for renewable energy by 2020, the effects of climatic variation are smoothed through use of a normalisation rule. In *Figure 53* the grey trend line depicts the total normalised renewable energy contribution.

Figure 53: Renewable energy contribution to gross electricity consumption by source 2005-2018



Source: SEAI

Replacing the use of fossil fuels for electricity generation with electricity generated from zero-carbon renewable energy sources is a key part of Ireland's strategy to decarbonise the energy system. This also increases energy security by reducing dependence on imported fossil fuels.

The Climate Action Plan introduced a target of 70% renewable electricity by 2030. This target is technically feasible but is ambitious and will be challenging to achieve. It will require a significant increase in the rate of installation of wind capacity compared to what has been achieved up until now. The capacity of onshore wind will need to be approximately doubled, and an offshore wind industry will need to be developed. Existing windfarms will also need to be re-powered. There will also be significant technical challenges in incorporating such large amounts of variable non-synchronous generation on the grid, as discussed in section 5.4.2.

The anticipated increase in electricity demand over the period to 2030 will have the effect of increasing the absolute amount of renewable electricity generation required to meet the target, which is set as a percentage of usage.

5.2.4 Electricity from coal, peat and oil

Together, coal, peat and oil accounted for 22% of the energy input for power generation in 2018, down from 29% in 2017 and from over 70% in the early 1990s. Unlike gas and most sources of renewable electricity, these fuel types can be stored with relative ease, which can enhance security of supply. However, these fuels are very carbon intensive and are being phased out of the power generation mix over the next few years.

11% of the energy input for power generation came from coal in 2018. A significant outage at Ireland's only coal-fired generating station, at Moneypoint, contributed to a 44% reduction in coal use for power generation between 2017 and 2018. Provisional figures for 2019 show that coal use for electricity generation reduced by a further 70% due to a combination of continuing technical problems, record high carbon prices and market factors. The Government has committed to the cessation of coal-fired generation by 2025 at the latest [7].

45 During these short periods, more electricity was generated on the island of Ireland than was required to meet demand in Ireland and Northern Ireland, with the excess being exported. The instantaneous peak of total electricity generated by wind in Ireland was 93% (September 2018).

46 Only a portion of the electricity generated by waste-to-energy facilities is renewable. The balance is classified as non-renewable waste.

Peat's contribution to the generation mix has been between 10-13% over the last ten years and peat-fired generation was supported via a public service obligation (PSO) levy for most of the last two decades. This support was phased out by the end of 2019 and in November 2019, ESB announced that both of its peat-fired stations would cease generation at the end of 2020 [14]. The current planning permission for the only other peat-fired station, at Edenderry, will expire in 2023. It currently produces approximately 43% of its output from biomass. Subject to planning approval, Bord na Móna plans to operate the station beyond 2023 with biomass only.

Although there are several oil-fired stations in Ireland's portfolio of generating stations, their role is limited to that of peaking plants and their annual generation output is low. Oil is also used as a secondary fuel in gas-fired plants and can be used as an alternative fuel in other generating stations. Oil accounted for between 1-2% of the energy input for electricity production in each of the last ten years.

The dates for the phasing out of fossil fuels from the electricity sector remain under ongoing review [7].

Oil and coal-fired generators are required to maintain stocks of their primary fuel in quantities equivalent to those referenced for gas-fired generators in section 5.2.2 [79]. The new secondary fuel availability generator performance incentive incorporated into I-SEM also applies to these generators.

5.2.5 Electricity imports and exports

The Republic of Ireland's electricity system is physically connected with that of Northern Ireland and that of Great Britain through a number of interconnectors, which allow electricity to be imported or exported.

After fourteen consecutive years of being a net importer of electricity from the UK, Ireland switched to being a net exporter in 2016. Net electricity imports peaked at 8.1% of generation in 2013 before dropping to 2.3% in 2015. Net exports amounted to 2.4% and 2.3% in 2016 and 2017 but were only 0.1% in 2018. The change from net importer to net exporter was due to increased generation capacity in Ireland and market signals (including the introduction of a carbon floor price) in the UK that made imports from Ireland more attractive.

In the next decade, imports and exports of electricity will play an important role in balancing the variable electricity produced from intermittent renewables such as wind and solar, as discussed more in section 5.4.2.3.

Before the introduction of I-SEM, power sometimes flowed across the two interconnectors between the island of Ireland and Great Britain in the opposite direction to that suggested by the prevailing economic conditions, that is, it exported from the higher-priced market to the lower-priced market. One of the objectives of the introduction of I-SEM was to improve the efficiency in which interconnectors with Great Britain are operated[47]. I-SEM has changed the way in which interconnector capacity is traded. While the interconnectors do not trade in the energy markets, they do offer capacity and participate in capacity and balancing markets. They also offer hedging instruments called financial transmission rights, which protect the holders from price differentials between the two coupled markets (island of Ireland and Great Britain) [82].

5.2.6 Outlook for electricity generation

The increasing electrification of heat and transport will increase the economy's reliance on electricity.

The Climate Action Plan has established an ambitious framework for significant growth in renewable electricity over the period to 2030. Most of the additional renewable generation capacity over this period will be from wind (onshore and offshore) and solar. It is also likely that, by 2020, all non-renewable electricity generation will be from gas. While it is anticipated that, in 2030, the contribution from gas will be significantly lower than current levels, Ireland will still be reliant on gas-fired generation during periods of unfavourable weather patterns. Blocking anticyclones will be particularly problematic because they can reduce wind output over several days and can affect neighbouring (interconnected) electricity systems at the same time.

A system based on 70% renewables, balanced by gas, would allow Ireland to reduce the carbon intensity of the electricity system to close to 170 gCO_2/kWh by 2030 (2018 = 375 gCO_2/kWh). While 2030 will be an important milestone, it will also be a critical step on a pathway to achieving a fully decarbonised electricity network in the longer term. It is not yet clear how this will be achieved. There are several emerging technologies at various stages of development that could potentially complement weather-dependent renewable generation, in addition to interconnection and battery storage. These include gas-fired generation with carbon capture and storage, small-scale modular nuclear generators, and electro-fuels[48].

By the end of the decade, it should be clearer whether gas (fossil and/or renewable) will retain its crucial role in electricity generation out to 2050 or if it will follow oil, coal and peat out of the generation mix. However, in the period to 2030, gas will play an important role in power generation and its availability will be critical for Ireland's energy security.

47 In the context of I-SEM, the existing interconnector between Ireland and Northern Ireland is considered an element of the single-market transmission system, rather than an interconnector between separate markets.

48 Electro-fuels are a form of energy storage whereby carbon-neutral fuels are manufactured when renewable electricity generation is plentiful – renewable electricity is transformed to carbon-neutral fuels.

5.3 Electricity prices

There are several components that determine the price of electricity. The generation mix is a critical component, particularly because two-thirds of Ireland's electricity fuel mix is still based on internationally traded commodities, that is, natural gas and coal. During periods of volatile price movements in these fuels, there is a strong knock-on impact on electricity prices. With over half of Ireland's electricity being generated from natural gas, the variability in the price of gas significantly impacts on the price of electricity.

Other factors that affect wholesale electricity prices include the level of competition in electricity generation, labour and administration costs, and the renewable energy resource level available at a given time. The wholesale cost of electricity is established by the electricity market (I-SEM). The new market incorporates several different ways in which electricity generators and suppliers can trade over different time periods:

- A forward's market allows market participants to manage their risk.
- Two ex-ante markets (day-ahead and intraday) enable participants to bid for the delivery or purchase of power. The electricity price for each trading period is determined from these bids.
- A balancing market is used to balance supply and demand across the system.
- A capacity market acts as a mechanism for generators to recover their fixed costs.

Increasingly, the availability of wind energy is having an impact on wholesale prices, especially via the ex-ante and balancing markets. In times of high fossil fuel prices, wind, and hydro generation, both of which effectively have zero fuel costs, reduce the overall cost of electricity generation. The presence of significant amounts of renewable energy in the generation mix acts as a hedge against fossil fuel price increases and reduces the associated volatility in electricity prices [83].

The cost of investment in transmission and distribution systems is recovered through use of system charges for these systems: transmission use of system charges and distribution use of system charges. These charges are regulated by the CRU and are used to generate revenue for infrastructural investment.

There are also several taxes and levies on electricity in Ireland:

- Electricity tax, which is an excise duty, is charged on supplies of electricity to non-residential customers. There are two tax rates: €0.50 per megawatt hour (MWh), for electricity supplied for business use; and €1 per MWh, for electricity supplied for non-business use.
- The PSO levy is charged to all electricity customers. It was introduced in 2001 as a charge on all electricity consumers to support energy policy goals relating to sustainability and security of supply that would not otherwise have been met by the market.
- VAT is applied to electricity sales at the reduced rate, which is currently 13.5%. VAT is applied to base electricity price, to the PSO levy, and to the electricity tax. VAT can be recovered by businesses.

Since its introduction, the PSO levy has been used to support electricity generation from renewable sources, to support security of supply and to promote generation using indigenous fuels (peat). While the amount of PSO levy used to support renewables has risen significantly over the past decade, with the deployment of additional renewable capacity, the PSO support for security of supply finished in 2016 (Tynagh and Aughinish generating stations) and the PSO support for peat generation was phased out by the end of 2019. The Government recognises that the forecast growth in demand from data centres is '*likely…[to]…result in higher network charges and PSO levies for consumers unless mitigating measures are taken to minimise such charges*'. Some large electricity consumers, including data centres, may seek to meet their electricity needs via corporate power purchase agreements, which '*could also play a role in reducing the costs of public support for renewables*' [78]. The Climate Action Plan established a target of meeting 15% of electricity demand from renewable electricity contracted via corporate power purchase agreements.

The CRU publishes biannual electricity and gas retail market reports, which provide information on trends in retail gas and electricity process [84].

5.4 Electricity infrastructure

The anticipated growth in electricity consumption and plans to significantly decarbonise generation will place additional demands on existing electricity infrastructure and will give rise to a requirement for new infrastructure.

5.4.1 Generation adequacy

Ireland currently has significant surplus power generation capacity. However, the rapid demand growth that has been forecast coupled with anticipated closures of some generating stations will erode this position over the next few years.

EirGrid and SONI's GCS 2019-2028 concluded that '*there is not adequate generation capacity to meet demand from 2026 for Ireland once Moneypoint closes*' [77].

The statement, which assumed that the three peat stations would still be operating by at least 2025 and which was published prior to the ESB's announcement of the closure of its two peat stations in 2020[49], also cautioned that '*should any other plant close then this could give rise to earlier deficits. Also, poor availability of the generation fleet, as seen in 2018, could give rise to deficits*'. Outages at Moneypoint and Great Island in 2018 contributed to a notable deterioration in generator availability in 2018 – from over 86% in 2015-2017 to approximately 80% in 2018 (average 365-day annual system-wide availability) [77].

The mechanism for securing additional generation capacity in I-SEM consists of annual capacity auctions run by the Single Electricity Market Operator (SEMO). Separate auctions secure capacity for the following year (T-1), for two years into the future (T-2) and for four years into the future (T-4). The objectives of the auctions are to deliver wholesale electricity at least cost while encouraging new investment and innovation. 696 MW of new generation capacity[50] was successful in the first T-4 auction, which was for the 2022/23 capacity year [85], while a further 265 MW was successful in the second T-4 auction (2023/2024 capacity year) [86]. T-1 and T-2 auctions that were run in late 2019 secured 5,732 MW of total capacity (123 MW of which is new capacity) and 4,107 MW of total capacity (103 MW new) respectively [87][88]. Although the auctions are technology neutral, technologies that are deemed to be less reliable from a generation adequacy perspective, are 'de-rated' as part of the auction process. The new capacity that was successful in the two T-4 auctions includes gas generation, wind generation, demand-side units and battery storage. There is a locational requirement in the auction process to ensure that there is adequate capacity for the Dublin area[51].

The limited electrical linkages between Ireland and Northern Ireland currently act as a physical constraint on capacity reliance between the two jurisdictions. An advantage of the proposed second North-South Interconnector is that the all-island electricity system would be capable of operating electrically as one system. Generation capacity from both jurisdictions could be available to meet the combined load. This would provide a capacity benefit in terms of generation adequacy.

EirGrid and SONI have also forecast a generation deficit for Northern Ireland by 2025 even though demand growth in the jurisdiction is predicted to be modest. The deficit will arise because of assumed plant closures.

5.4.2 Transmission and distribution

5.4.2.1 Existing networks

To transport electricity from the point of generation to the point of use, Ireland relies on an extensive transmission network, which operates at high voltage, and a distribution network, which operates at medium to low voltage.

The transmission network, a meshed network of high voltage lines and cables for the transmission of bulk electricity, forms the backbone of the electricity supply system, and is detailed in *Figure 54*. EirGrid is the transmission system operator, responsible for planning and operating the transmission system. The transmission systems in Ireland and Northern Ireland are operated by EirGrid and SONI on an all-island basis.

The electricity distribution system is the responsibility of ESB Networks Ltd. It is responsible for building, operating, maintaining, and developing the electricity network and serving electricity customers.

EirGrid and SONI produce the All-Island Ten-Year Transmission Forecast Statement, an annual publication which describes the development of the transmission system on the island of Ireland. The most recent publication analyses the period 2018–2027 [89]. It estimates the likely available capacity at various nodes on the transmission system, assuming certain growth rates in peak demand. The statement includes the following notable conclusions:

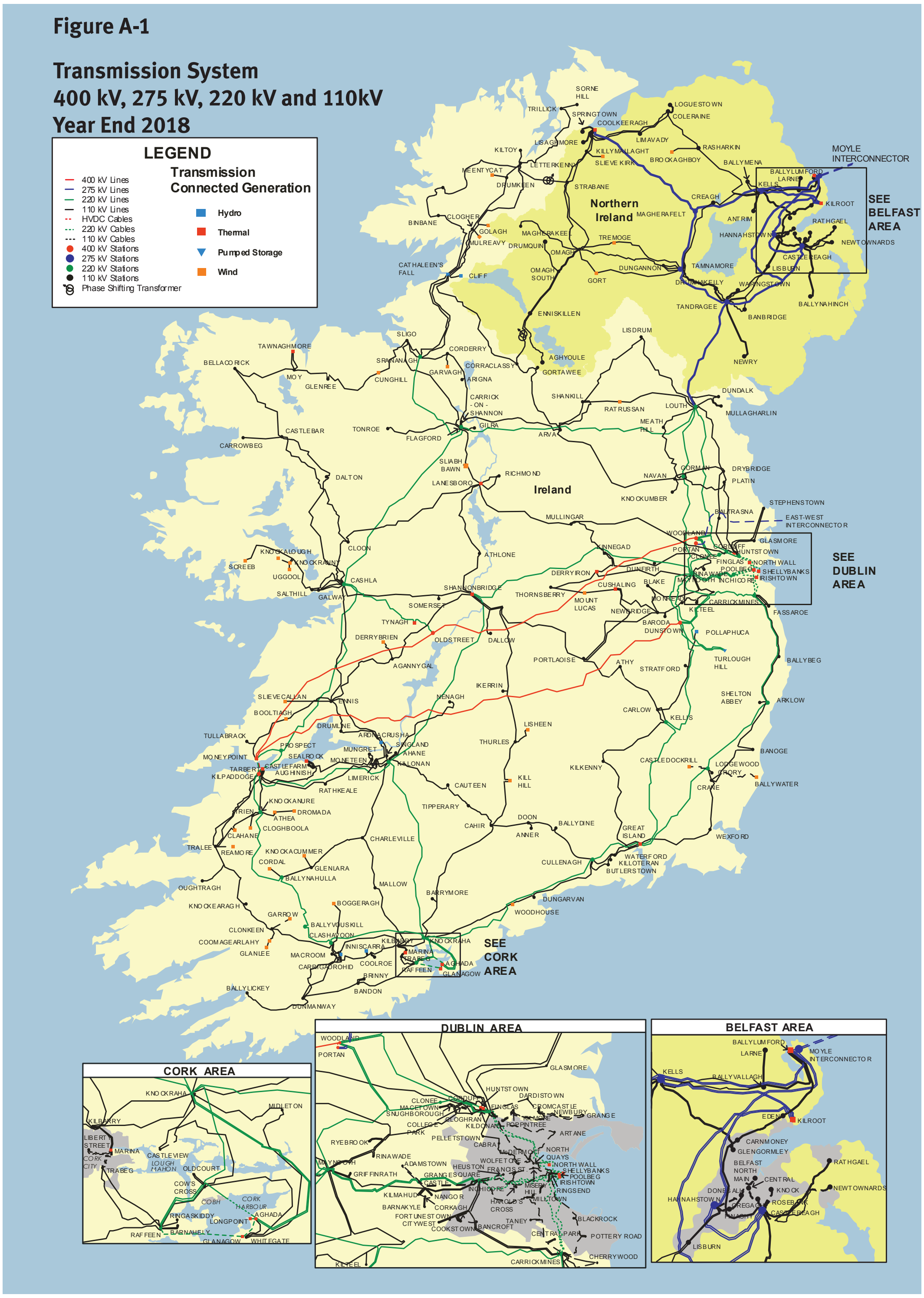
- '*A large portion of…data centres are connected or plan to connect in the Dublin area. Depending on the level of demand connections, new large-scale generation, transmission solutions, demand side response and/or storage will be required to maintain security of supply in the area*'. EirGrid is progressing two projects to reinforce the network in the Dublin region.
- '*Several [transmission system] stations on the island are approaching, or have the potential to exceed, their rated short circuit current level…We manage the transmission system to mitigate possible risks while investment plans are in place to resolve these issues*'.
- '*There are opportunities for new generation of significant scale close to the large demand centres in the east of the island, in particular in the east of Northern Ireland and in north Dublin. The results [of EirGrid's analysis] also show that future generation connections in the north-west, west and south-west regions would require network reinforcements*'.

49 The median scenario in GCS 2019-2028 assumed that the three peat stations would transition fully from peat to biomass by 2030: 30-35% biomass by 2020, 50% biomass by 2030 and 100% biomass by 2030. EirGrid also modelled a scenario with the closure of the two ESB peat stations by 2025 ('reduced peats, median demand'). This scenario projected a deeper capacity deficit from 2026 than the median scenario.

50 The capacity auctions are run on an all-island basis. This capacity figures referenced in this report are de-rated capacities for the Republic of Ireland only.

51 An assessment of generation capacity for the East coast has been undertaken by EirGrid [114].

Figure 54: Electricity transmission system



Source: EirGrid [89].

5.4.2.2 Grid development strategy

In 2008, EirGrid published Grid25, which detailed a long-term strategy to develop the national electricity transmission grid until the year 2025 [90].

EirGrid reviewed the strategy in 2011. At that stage, the cost of Grid25 was reduced from €4 billion to €3.2 billion due to revised future demand forecasts and the proposed adoption of new technologies. In 2017, EirGrid published a further update on the grid development strategy [91], which accounted for the latest economic conditions, technology developments and feedback from consultation processes on major projects.

Three major projects had been identified as being of particular importance for the functioning of the transmission grid. These are:

- The North–South interconnector;
- The Grid West project;
- The Regional Solution (formerly Grid Link).

The North-South interconnector is a proposed 400 kV overhead line between the electricity networks in Ireland and Northern Ireland. The proposed route runs between Meath and Tyrone. EirGrid's 2017 grid development strategy noted that the project '*would bring about major cost savings and address significant issues around the security of electricity supply. This is particularly the case in Northern Ireland. A key benefit is that it would remove bottlenecks between the two systems. This would enable the two systems to work together as if they were a single network. This would benefit residents and businesses on both sides of the border*'. It would also facilitate the addition of greater amounts of renewable generation. EirGrid estimated that the interconnector would create savings of €40-60 million by 2030. The project has been designated a project of common interest by the European Commission [52,53], and has cleared all planning and legal hurdles in Ireland. The planning process in Northern Ireland is ongoing. EirGrid expects the new interconnector to be available in 2023 [77].

Grid West was proposed to facilitate the connection of large amounts of renewable generation in the north Mayo region. In 2017, EirGrid announced that the original project, which would have incorporated 400 kV technology, would be replaced with a smaller 110 kV development, referred to as the North Connacht 110 kV project. This change arose because of a reduction in the renewable generation capacity planned for the region. EirGrid expects this new infrastructure to be operational in 2024.

The Regional Solution comprises several independent projects that would strengthen the security of supply in the south and east of the country. They would also facilitate the integration of renewables. The projects include series compensation on the existing 400 kV network[54], an underwater cable across the Shannon estuary and uprating 110 kV infrastructure in the southeast of the country (Great Island to Wexford circuit, Great Island to Kilkenny circuit and Wexford substation). These projects are all underway.

Between 2016 and 2018, EirGrid completed the construction of 217 km of new circuits, uprated another 242 km and refurbished a further 101 km. It plans to construct, uprate, or refurbish another 574 km in 2019 and 2020.

EirGrid now expects that the final cost of its grid development strategy will be between €2.6-2.9 billion [91]. In its most recent electricity price review, the CRU approved €984 million of transmission capital investment for the 2016-2020 period.

5.4.2.3 Integrating large amounts of renewable electricity

Ireland has a target of 40% of electricity to come from renewable energy sources by 2020 and a target of 70% by 2030, while Northern Ireland has a 40% renewable electricity target to be reached by 2020. Wind has been the major contributor to the rapid growth in renewable electricity since the early 2000s and will continue to be the predominant technology for new renewable electricity capacity for several years. The installed capacity of wind energy in Ireland in 2019 was 4,137 MW.

EirGrid's latest energy scenarios' publication forecasts that the 70%-by-2030 target could be achieved with 9,000-10,000 MW of wind energy capacity (onshore and offshore) and 600-2,000 MW of solar capacity, as well as smaller amounts of hydro and marine energy[55] [58]. EirGrid estimates that the rate of curtailment of variable renewable energy sources could increase to approximately 10% by 2030 as capacity is added to the system. Climate Action Plan 2019 also set out indicative levels of capacity that could be required to reach the target: up to 8,200 MW of onshore wind, at least 3,500 MW of offshore renewable energy and up to 1,500 MW of grid-scale solar. The actual amount of additional wind and other capacity required to meet the 70% target will depend on several factors including demand growth, the capacity factors realised by new wind and solar developments, the wider generation mix, the levels of interconnection and storage achieved by 2030, and other advances in electricity system infrastructure and operation.

The technological characteristics of wind and solar generation technologies are different to traditional generation sources. As a result, they present a range of operational challenges for the power system. Wind and solar are dependent on weather conditions and are inherently variable. This variability must be managed to ensure demand for electricity is always met.

52 PCIs are key cross-border infrastructure projects that link the energy systems of EU member states. They can benefit from accelerated permitting procedures and funding [51].

53 The North-South interconnector is classified as being part of a PCI cluster by the European Commission [51]. The cluster also includes the Renewable Integration Development Project (RIDP), which is a proposed reinforcement of the electricity transmission grid in the north and the north-west of the island. RIDP is still at study/pre-planning stage, but it has been granted PCI status and could involve an interconnector element between Ireland and Northern Ireland.

54 Series compensation is a technology that would enable EirGrid to safely and securely put more power on existing transmission lines.

55 The values referenced indicate the range in forecast capacities from EirGrid's 'centralised energy' and 'coordinated action' scenarios, both of which would achieve the 2030 renewable electricity target.

Additionally, both forms of generation are non-synchronous, which poses unique challenges when integrating into a small, lightly interconnected, island, synchronous system.

Achieving the targeted levels of renewable integration on a synchronous system is unprecedented and presents significant challenges for the real-time operation of the power system. As these challenges will not be encountered in larger systems, such as those on mainland Europe, for many years, Ireland and Northern Ireland can lead the way in the integration of non-synchronous renewable generation.

In response to the challenge of meeting the 2020 target, EirGrid initiated a multi-year programme, Delivering a Secure, Sustainable Electricity System (DS3). The objective of the DS3 programme is to enable the operation of the electricity system in a secure manner while achieving the 40%-by-2020 target.

To ensure system stability, a limit is placed on the amount of non-synchronous generation allowed on the grid at any instant, known as the system non-synchronous penetration limit. When DS3 was initiated, this limit was set at 50%[56]. The DS3 programme aims to address the various factors that influence this limit, with the ultimate aim of increasing it to 75%. In April 2018, the limit was increased to 65%, at which point the power system on the island of Ireland became the first in the world to reach this level. EirGrid aims to increase this gradually to 75% over the coming years. The target will be reviewed as the DS3 programme progresses, depending on the progress of various work streams.

The DS3 programme comprises three main pillars (system performance, system policies and system tools) and eleven separate work streams. The programme brings together many different strands, including the development of financial incentives for better plant performance and the development of new operational policies and system tools to use the portfolio to the best of its capabilities. The programme involves many different stakeholders, including the distribution system operators, regulatory authorities, generators (fossil and renewable), as well as government departments.

To meet the 70%-by-2030 target, EirGrid believes that the system must be capable of operating with up to 95% of renewable generation. This will require EirGrid '*to operate the system in a more dynamic and responsive way. In turn, this will require improvements to infrastructure to make the grid stronger, and more flexible*' [92]. It may also require regulatory changes: the CRU anticipates that the 2030 target will drive transformational change in the electricity system over the period to 2030 and recently published its intention to '*to set a regulatory framework that ensures that the electricity network companies have the resources, capability, flexibility and incentives to deliver this [transformational] change. Given this level of transformational change, the CRU is considering changes to the regulatory framework*' [93].

Interconnection can play an important role in reducing the curtailment of variable renewable energy sources [94]. It can also facilitate renewable electricity by providing '*much-needed flexibility to electricity markets for the integration of a high share of intermittent renewables. This is particularly important for a small system such as that of Ireland*' [16].

Accommodating large amounts of weather-dependent renewable generation will also pose challenges for system operation during periods of unfavourable weather patterns. The requirement for more accurate and more granular weather forecast data for electricity system operation will also stretch the capabilities for even the most sophisticated weather forecasting tools. The capability limitations of weather forecasting are an important consideration for electricity security.

5.4.2.4 Connecting to the network

By 2018, the transmission and distribution system operators had received approximately 36,000 MW of applications for connections to the electricity system. This volume significantly exceeds the capacity needed by the system for the foreseeable future and the CRU concluded that the existing connection policy was no longer fit for purpose. In March 2018, the CRU published a decision on the first stage of a new enduring connection policy framework for generators seeking connections to the electricity system [95]. The objective of the new framework is to expedite the connection of projects that are well developed. Only 'shovel ready' projects that have planning permission are eligible to apply for connection under the first stage of the new ECP framework. In late 2019, the CRU published a proposed decision for a second stage for the new policy (ECP-2), which included a target of 150 connection offers over the 2020-2022 period [96]. It is also proposed that the second stage would prioritise large renewable energy projects while also incorporating specific provisions to facilitate community-led projects.

As well as streamlining the deployment of well-developed renewable electricity projects, which generate electricity from indigenous resources, the new policy facilitates the connection of new technologies that provide system services and enhance electricity security, for example, battery storage.

5.4.2.5 Smarter networks

ESB Networks is undertaking a pilot project in Dingle, Co. Kerry, to trial smart technologies on the electricity distribution network that will facilitate local renewable electricity generation and the electrification of heat and transport. The objective is to strengthen security of supply at a local level by reducing outages and enhancing the resilience of the network on the Dingle Peninsula.

56 These limits for non-synchronous generation are expressed on an all-island basis.

The CRU has approved the phased roll-out of smart meters, beginning with 250,000 meters in 2020. Smart meters can play an important role in energy efficiency, especially in the built environment. According to the CRU, smart meters '*could cause a 2.5% reduction in overall electricity demand and a peak-time demand reduction of 8.8%*' [61].

5.4.2.6 Interconnection

Every EU member state has a target to have interconnection capacity with neighbouring member states by 2020 that is equivalent to at least 10% of the electricity produced by its power plants. The European Commission noted that Ireland had been on the path to achieving this target and has set out proposals to increase the target to 15% for 2030 [97]. However, the former was in the expectation that the North-South interconnector would be operational by then.

The transmission networks of Northern Ireland and Ireland are connected electrically by means of one 275 kV double-circuit connection between Louth and Armagh. This circuit can provide approximately twice as much capacity for south-to-north flows as it can for north-to-south flows. As discussed in a previous section, the proposal for a second North–South Interconnector with Northern Ireland is necessary to improve the security of electricity supply, especially for Northern Ireland.

There are two interconnectors between the island of Ireland and Great Britain. The Moyle interconnector is a dual monopole high voltage direct current (HVDC) link between Antrim and Scotland. Its maximum import capacity from east to west is 450 MW and from west to east is 500 MW, although the contracted capacity from west to east is currently 307 MW. The East–West Interconnector is a HVDC interconnector between the Irish transmission system and the system in Great Britain. It runs between Dublin and North Wales and has a capacity of 500 MW in either direction.

Additional interconnection will be important for accommodating the high levels of renewable generation required to meet the 70% renewable electricity target.

There are several proposals for additional interconnector projects with Great Britain and France[57], including two which have been classified as projects of common interest by the European Commission and have been awarded financial support from the EU Connecting Europe Facility. These are the Celtic Interconnector and Greenlink. EirGrid is processing interconnector applications for both, following direction from the CRU.

The Celtic Interconnector is a proposed HVDC electrical link between east Cork and the north-west coast of France [98]. The project promoters, EirGrid and Réseau de Transport d'Électricité, expect the project to be commissioned in 2026. It would have a capacity of 700 MW in either direction along its 575 km length, 500 km of which would be undersea. The CRU and the French Commission de Régulation de l'Energie (CRE) have agreed that 65% of the estimated €950 million investment costs would be allocated to Ireland and 35% to France. The European Commission has agreed to provide €530 million of funding. According to the CRU, '*the Celtic Interconnector could help to lower electricity prices, reduce greenhouse gas emissions and provide greater energy security which is of benefit to consumers and stakeholders*' [99]. Public consultation on the project is ongoing.

Greenlink is a proposed 500 MW HVDC electricity interconnector between Wexford and south Wales [100]. Planning applications for the marine components of the project, which includes approximately 170 km of undersea cable, were submitted in November 2019. The project promotor, Greenlink Interconnector Limited, expects the project to be commissioned in 2023 after a three-year construction phase. The project would require approximately €400 million of private investment. The CRU's cost-benefit assessment of the project concluded that it '*has the potential to deliver benefits for Irish consumers where significant decarbonisation of electricity generation occurs*' [101].

Because of their relatively early stage of development, neither the Celtic Interconnector nor Greenlink were counted as contributing capacity in EirGrid's GCS, which forecast a capacity deficit from 2026. The promoters of both projects maintain that their interconnectors would enhance the security of Ireland's electricity supply, would facilitate the integration of additional renewable energy, and would put downward pressure on electricity bills for Irish consumers.

Electricity interconnection can also enhance gas security. In 2018, the UK's electricity interconnection links played a role in mitigating the impacts of a significant disruption to its gas system during Storm Emma. The IEA highlighted this in its review of the UK's energy policies: '*at least three points…were key to the response [to the gas disruption], but these are also areas worth monitoring more carefully. The first was that gas and electricity security are increasingly interrelated as the response of the electricity market, coincided with a very strong wind output. Second, although they had little or no effect on annual gas bills, higher prices over a few hours is a feature of both gas and electricity markets to maintain supply security. Third, the event showed that the interconnected nature of the UK and continental European gas and electricity markets, in fact, enhanced the security of supply of each*' [26].

The GNI and EirGrid study concluded that electricity interconnection can mitigate the impact of a gas supply disruption in Ireland '*by substituting for electricity produced by gas fired generators to a limited extent*'.

57 GCS 2019-2028 lists eight interconnector projects that are at a preliminary stage [77].

5.4.2.7 Electricity storage

Energy storage strengthens energy security by enhancing flexibility and providing contingency in the event of supply disruption. It also facilitates the integration of greater levels of variable renewable energy generation by storing excess output when the renewable resource is plentiful and releasing it for use when required.

DCCAE and the Northern Ireland Department of Trade and Investment commissioned work to model the impact on the electricity grid of different types of energy storage, which found that '*these included very short-term storage in intelligent storage heaters in domestic premises, intermediate-level storage in battery and ice banks, and very large-scale compressed air storage in salt caverns. The work demonstrated that significant levels of storage, in particular multi-megawatt-scale grid-connected storage, would be needed to maximise the utilisation of... [renewable energy sources for electricity]. Small-scale storage would facilitate more efficient use of the networks, maintain high standards of security of supply, and keep network operating costs lower than they would be without storage*' [102].

Batteries are rapidly evolving along with versatile technologies that have the potential to provide different services for electricity markets. There is significant interest in developing battery storage facilities in the Irish market: over 2,400 MW of battery capacity met the criteria to be processed by EirGrid and ESB Networks following the closure of the applications window for the ECP-1 connection process in 2018 [103]. Approximately 700 MW of this capacity is either being processed, has a live connection offer, or has a contracted connection. Battery projects such as these typically focus on providing system services that involve discharging energy over very short durations (milliseconds or seconds) to stabilise the electricity network under certain conditions. These services, including frequency regulation, facilitate the deployment of more variable renewable generation onto the system.

Pumped storage facilities typically discharge their energy over longer periods than batteries and provide other important services for the network that can also facilitate more renewable generation. A proposed pumped storage facility at Silvermines, Co. Tipperary, has been included in the European Commission's latest list of projects of common interest [51]. The proposed project, which is at 'an advanced pre-development stage' and is being promoted by Siga-Hydro Limited, is a 360 MW hydro plant incorporating approximately 650,000 MWh of annual storage capacity [104]. If developed, it would be slightly larger than Ireland's only existing pumped storage facility at Turlough Hill (292 MW).

At a much smaller scale, the electrification of heat and transport will see demand shifting from a fuel that is easily stored (oil) to one that is more technically complex to store (electricity). Notwithstanding this, the decarbonisation benefits of electrification are compelling and the rate of development of electricity storage technologies is rapid. Electric vehicles themselves act as storage devices and smart meters can also play a role in balancing supply and demand at local level.

5.4.3 Cyber security

Recent years have witnessed increasing levels of concern regarding potential cyber threats to energy systems in Europe, especially networked systems. Sources of threat include malicious state and non-state actors, as well as non-malicious errors or technical faults. In late 2015, a cyber attack on the Ukrainian electricity network left almost a quarter of a million customers across three distribution regions without power for several hours. More recently, a July 2019 ransomware attack on an electricity supplier in South Africa left customers in Johannesburg without power because they were unable to purchase prepaid electricity.

In Ireland, the Network and Information Systems Directive [105] was transposed into national legislation in 2018. It introduced binding cyber security obligations on certain infrastructure operators (operators of essential services) in the energy sector. Ireland has identified 64 such operators across all sectors, including energy [106]. These operators must take appropriate technical and procedural cyber security measures and notify the relevant authority in the event of serious incidents. National Network and Information Systems compliance guidelines for operators of essential services include indicative incident reporting levels above which network and information systems security incidents in the electricity, gas and oil sectors are likely to have a significant impact [107]. The reporting levels for electricity and natural gas are based on disruptions of 10 GWh and 200 GWh respectively, both over seven-day periods. The threshold for the oil sector is based on a disruption amounting to 50,000 barrels per day.

Ireland's first National Cyber Security Strategy set out a series of measures that would be taken to build the capability of the National Cyber Security Centre (NCSC), which is an operational unit within DCCAE with responsibility for network and information security [108]. The NCSC works with utility operators and with authorities in other jurisdictions to ensure that risks to critical national infrastructure are managed appropriately. It is the national competent authority with responsibility for providing guidance on the cyber security of critical national infrastructure and for auditing security controls in relevant sectors. The second National Cyber Security Strategy was published in 2019 [109].

5.5 Emergency planning

5.5.1 EU member state cooperation

EU Regulation 2019/941 [110] was introduced in 2019 to strengthen emergency planning and response among member states. It requires member states to evaluate major electricity security risks and to develop plans to prevent and deal with those risks. It establishes common approaches for doing so at national and regional levels and includes measures for improving information exchange, transparency, and accountability during crises.

The Electricity Coordination Group comprises national governments, energy regulators, the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E). It is a forum for policy co-ordination and information sharing in areas that have cross-border impact.

5.5.2 Role of the CRU

The CRU has a statutory obligation[58] to monitor the security of electricity supply in Ireland and work closely with all market players to ensure long-term electricity security. Its monitoring activities with respect to electricity security are summarised in *Figure 55*.

Figure 55: CRU's security of supply monitoring framework

Scope of Monitoring	Input/Activity		
Short-term monitoring	• Operational report • Weekly generation report • Additional monitoring	Security of supply	Real-time system control and stability
Medium-term monitoring	• Operational report • Monthly availability report • Summer and winter outlook reports • Ad hoc reporting	Security of supply	System management & capacity management
Long-term monitoring	• Generation capacity statements • Transmission forecast statements • Transmission development plan	Security of supply	Management (strategic) long-term capacity
Other monitoring	• Other networks monitoring • Fuel monitoring	Security of supply	

Source: CRU

The CRU reports every two years to the European Commission on the details of these monitoring arrangements. Its most recent report concluded that it was *'confident that the current monitoring arrangements are sufficient to identify credible threats to the security of supply of electricity. The CRU is also satisfied that the market framework in place and the new ancillary services and I-SEM arrangements, including a new capacity mechanism, are appropriate to encourage new investment and enhance security of supply'* [61]. It added that it would continue *'to assess the appropriateness of the current framework both at national and EU level and identify where any improvements can be made'*.

The CRU also chairs the GEEP group, which is described in chapter 3.

5.6 Impact of Brexit on electricity security

Ongoing close co-operation between Ireland and the UK with respect to electricity is in the interest of both countries [16]. Nonetheless, Brexit poses several challenges for Ireland's electricity security; the full extent of the impact of these challenges is not yet clear.

One challenge relates to I-SEM. Both governments and the European Commission are committed to maintaining I-SEM and the IEA has recommended that '*Ireland should continue working to maintain the beneficial structures and efficiencies*' of the single market [16]. While the legal basis for the single market is enshrined in legislation in both jurisdictions, the market was designed to operate within a framework of common EU rules on electricity markets. If there is regulatory divergence between the UK and the EU in this area, it could have implications for I-SEM.

A second challenge concerns Ireland's integration with the EU energy market. Since the UK left the EU, Ireland has had 0% interconnection with other EU member states [97]. Ireland will therefore not achieve the 10% interconnection target by

58 In accordance with SI 60 of 2005, which transposed Directive 2003/54/EC and Directive 2005/89/EC into Irish legislation.

2020. If the Celtic Interconnector proceeds it would re-establish interconnection with another EU member state and direct market coupling with the EU electricity market. For this reason, the IEA concluded that Brexit has strengthened the case for this project and recommended that Ireland try to maintain efficient interconnection with both the UK and EU member states [16].

Because generation adequacy is currently higher in Ireland than it is in Northern Ireland, Northern Ireland's electricity security is dependent on links with Ireland, including the proposed second North–South Interconnector. EirGrid has concluded that Brexit does not weaken the case for the second interconnector, nor will it *'diminish…the benefits that will accrue across the island of Ireland from this project'* [91].

In its review of the UK's energy policies, the IEA commented that Brexit could *'pose serious investment challenges to new interconnector projects…[involving the UK]…, as costs and benefits may change depending on the future trade relations with the European Union countries'* [26]. The Brexit process has also created uncertainty for investors in the Irish electricity market, which *'will likely lead to project developers factoring in a higher level of risk, which could result in higher capital costs or investment decisions being deferred or potentially cancelled'* [16].

6 COAL, PEAT AND SOLID FUELS

6.1 Coal

Figure 56 shows the primary energy use of coal split into the portion used for electricity generation in conventional power plants, direct use for residential heating, and other, which includes use in industry, the services sector, and CHP units[59]. Between 2005 and 2017, approximately 75% of all coal use in Ireland was for electricity generation.

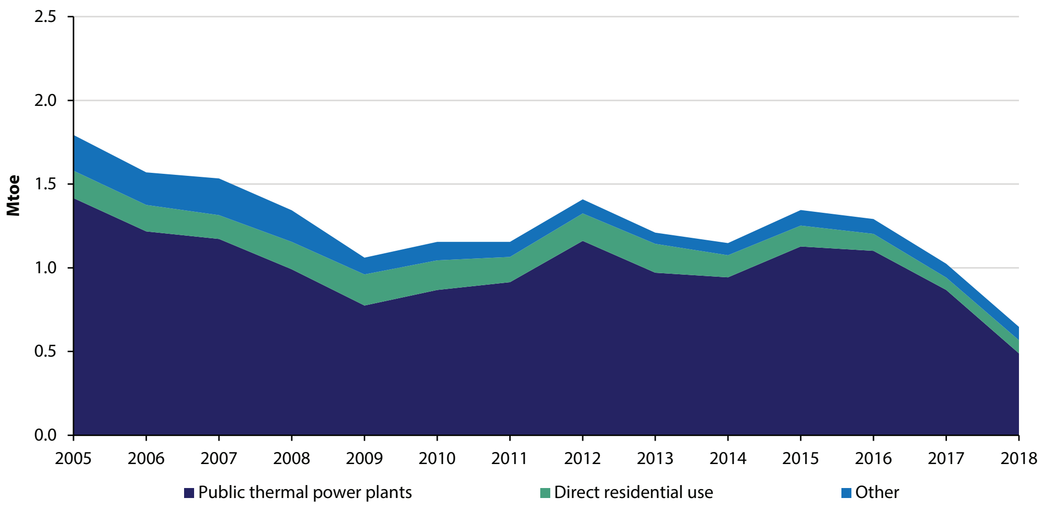
Overall coal use declined by 27% between 2005 and 2016 and then by 47% from 2016 to 2018. The latter was primarily due to a sharp decrease in consumption in the power sector due to a technical outage at Ireland's only coal-burning power station, located at Moneypoint in Co. Clare. Provisional figures for 2019 show that coal use for electricity generation reduced by a further 70%, due to a combination of continuing technical problems, record high carbon prices and market factors.

Coal-fired electricity generation provides a source of fuel diversity and fuel storage for the electricity generation system. However, coal-fired generation is highly carbon-intensive and eliminating coal from the generation mix is an essential step to decarbonise the electricity system. The Government has committed to the cessation of coal-fired generation by 2025, at the latest [7].

The residential sector was the next largest consumer of coal in 2018, after power generation, accounting for 21% of consumption. Consumption in the sector was 37% lower in 2018 than it was in 2005. As outlined in Climate Action Plan 2019, the Government has committed to sharply reducing fossil fuel use in the built environment [7].

Bituminous (smoky) coal accounted for 50% of coal consumption in the residential sector in 2018. The burning of smoky coal in areas designated as low-smoke zones is prohibited. From September 2020, this ban is being extended to all towns, whose population exceed 10,000.

Figure 56: Coal use 2005-2018

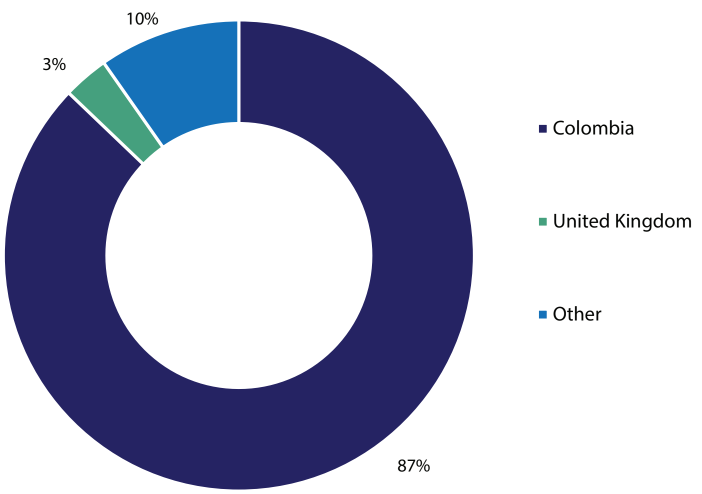


Source: SEAI

Since 1995, all coal demand in Ireland has been met by imports. *Figure 57* illustrates the source of coal imports in 2017. 87% of Ireland's coal came from Colombia in 2017 [38].

59 Coal has not been used for CHP since 2005.

Figure 57: Coal imports by country of origin 2017



Source: Eurostat

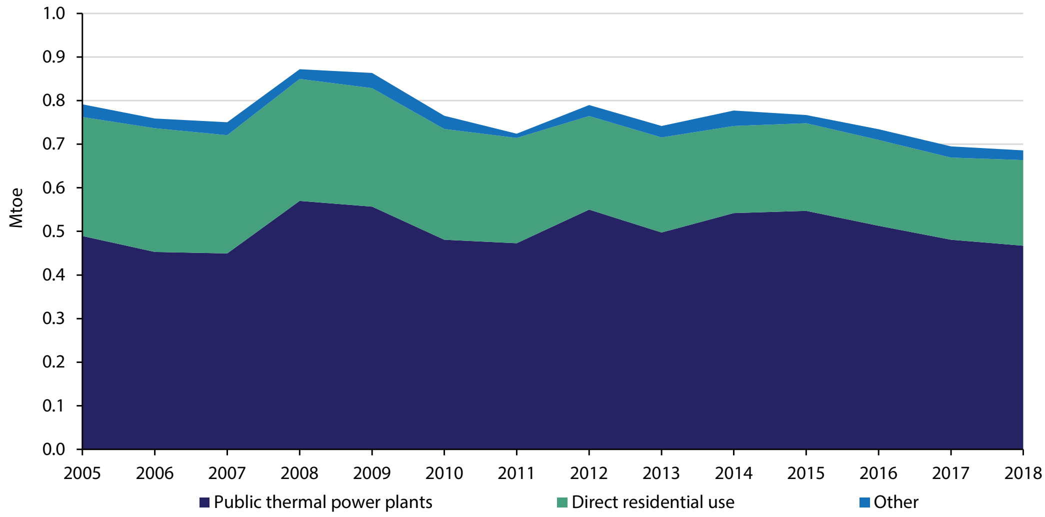
6.2 Peat

Figure 58 shows the primary energy use of peat broken down by the share used for electricity generation in conventional power plants, direct use for residential heating, and other. After increasing to 872 ktoe in 2008, peat use fell by an average of 2.4% per annum to 686 ktoe in 2018. Power generation accounted for 68% of peat use in 2018, with direct use in households accounting for 29%.

For most of the last two decades peat-fired power generation was supported by a PSO levy on electricity consumers, as described in chapter 5. This policy supported the use of indigenous fuel for electricity generation and contributed to employment in the midlands region. This support was phased out by the end of 2019 and two of Ireland's three peat-fired stations will close in 2020 [14]. The planning permission for the third peat station will expire in 2023.

SEAI estimates that approximately two-thirds of peat use in the residential sector in 2018 was sod peat, with briquettes accounting for one-third.

Figure 58: Peat use 2005-2018



Source: SEAI

All of Ireland's peat is indigenously produced. Peatlands cover 1.03 million hectares of the country. Under Articles 2 and 4 of the EU Habitats Directive, Ireland is obliged to protect and, where possible, restore raised boglands.

Bord na Móna has committed to stopping the production of peat for energy purposes by 2028 [111].

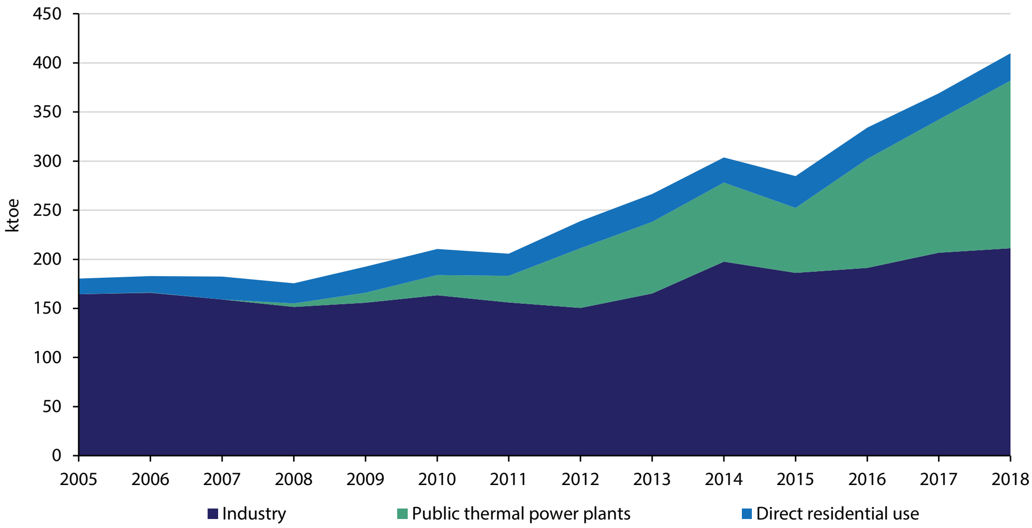
6.3 Solid biomass and wastes

6.3.1 Solid biomass

Solid biomass covers organic, non-fossil material of biological origin which may be used as fuel for heat production or electricity generation. It includes wood, firewood, wood chips, wood pellets, wood wastes (barks, sawdust, shavings, chips, black liquor, etc.), the renewable fraction of municipal solid wastes and other solid wastes (straw, oat hulls, nut shells, tallow, meat and bone meal, etc.).

Figure 59 shows the primary energy use of biomass split into the portion used for electricity generation in conventional power plant, direct use for industrial heating and CHP, and heating in the built environment. Overall biomass consumption has grown by 33% from 180 ktoe in 2005 to 410 ktoe in 2018. Almost half of consumption in 2018 was for thermal energy purposes in the industrial sector where it is burned directly for heat (48% of biomass use in 2018) or used in CHP units (0.5% of biomass in 2018). The wood processing industry is the majority user of solid biomass in industry, where residual wood waste is used for heat. Biomass use for electricity generation through co-firing with peat and non-renewable wastes accounted for 42% of consumption in 2018. The balance was used for heating in the built environment, with 6.8% being used in households and 4.4% in the services sector.

Figure 59: Biomass use 2005-2018



Source: SEAI

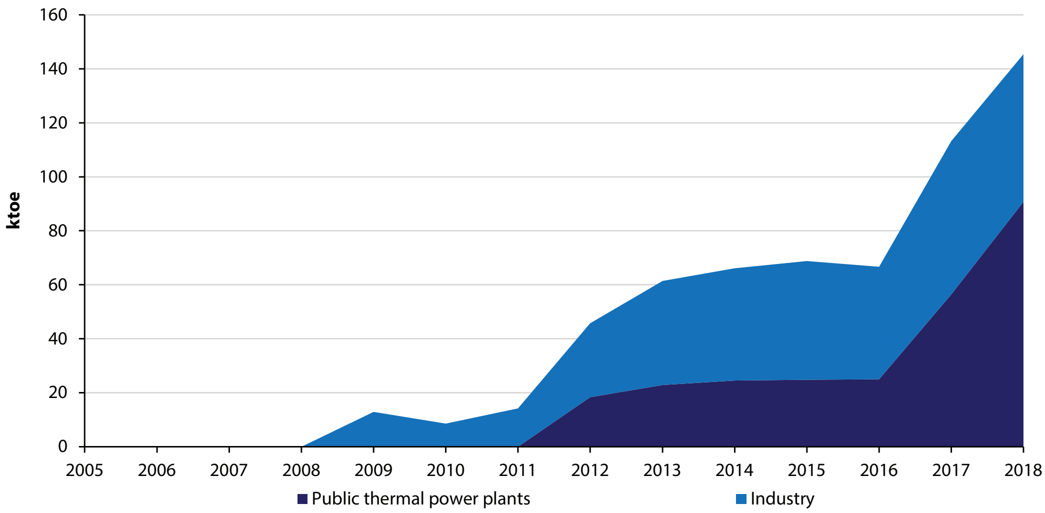
In 2019, the Government's Support Scheme for Renewable Heat introduced an operational support for the usable heat output from biomass heating systems in the non-domestic sector.

Most biomass used in Ireland is produced indigenously (94% in 2018), including 80% of the biomass that is co-fired with peat at Edenderry power station. Biomass used for the latter mainly comprises forestry residues that have limited alternative uses. Relatively small quantities of wood-based biomass are imported for domestic and other small-scale applications.

6.3.2 Non-renewable wastes

Non-renewable wastes have contributed to Ireland's energy supply since 2009, growing to 145 ktoe by 2018. The breakdown of this consumption between direct heating in the industrial sector and power generation, which is at two dedicated waste-to-energy plants, is shown in *Figure 60*.

Figure 60: Non-renewable waste use 2005-2018



Source: SEAI

6.3.3 Outlook for solid biomass and wastes

6.3.3.1 Solid biomass

The recast Renewable Energy Directive [33] will have a significant influence on future biomass supply in Ireland, particularly on biomass imported from outside the EU. The Directive will introduce a mandatory sustainability framework for solid biomass. This will be based on three overarching sustainability criteria relating to agricultural biomass, forest biomass and greenhouse gas emissions:

- Biomass fuels produced from agricultural biomass cannot be made from raw material obtained from land with a high biodiversity value[60], land with high carbon stock[61] or land that was peatland.
- Biomass fuels produced from forest biomass can only be sourced from countries that have harvesting laws and appropriate monitoring and enforcement systems, and which comply with certain requirements relating to land use, land use change and forestry (LULUCF)[62].
- All biomass fuels used for electricity, heating and cooling need to achieve at least a 70% lifecycle greenhouse gas emission saving relative to a fossil fuel comparator[63]. This threshold will increase to 80% for installations that will commence operations in for post 2026.

The recast Directive requires member states to establish sustainability requirements based on these criteria and requires installations with fuel capacities of 20 MW or more to adhere to them. Independent verification will be required for biomass use that will be counted for the purposes of 2030 renewable energy targets.

Given the nature of Irish legislation relating to agriculture and forestry, and the monitoring and enforcement systems already in place for Irish agricultural and forestry biomass, indigenous biomass from these sources should satisfy the first two sustainability criteria. This is also likely to be the case for equivalent biomass sourced from within the EU. However, these two criteria could restrict the use of some biomass feedstocks sourced from further afield, especially from countries with less developed regulatory structures. In general, the 70% greenhouse gas emissions saving threshold can be met for biomass that is typically used in Ireland (for example, forest residues, sawmill residues and short-rotation poplar), provided the transport distance is less than 10,000 km [34].

While Ireland does not currently import significant quantities of biomass, any increase in demand would be impacted by the sustainability constraints introduced in the recast Renewable Energy Directive. In practice, this could reduce the sources of non-EU biomass available for use at large biomass using facilities (≥20 MW fuel capacity) in Ireland.

60 For example, primary forests (that is, those with no clearly visible human activity), specially protected areas, special areas of conservation and highly biodiverse grasslands.

61 For example, wetlands and continuously forested areas.

62 The LULUCF requirements include that source countries must have submitted nationally determined contributions in accordance with the United Nations Framework Convention on Climate Change Paris Agreement and have national systems in place for reporting greenhouse gas emissions and removals from land use, including forestry and agriculture.

63 For biomass fuels used to produce electricity, the fossil fuel comparator is 183 gCO_{2eq}/MJ. For biomass fuels used to produce useful heat, heating and, or, cooling, the fossil fuel comparator is 80 gCO_{2eq}/MJ. Where direct physical substitution of coal can be demonstrated, the fossil fuel comparator is 124 gCO_{2eq}/MJ.

6.3.3.2 Waste

The future availability of both renewable and non-renewable waste for energy purposes will be influenced by waste management policy and market dynamics.

7 ENERGY SECURITY SCORE

7.1 Supply/demand index

This chapter presents a high-level score for Ireland's energy security over time using the supply/demand index. This index provides a score based on the overall security of a country's energy system, ranging from zero (no security) to 100 (fully secure). It was developed by the Energy Research Centre of the Netherlands (ECN) [112]. SEAI published calculated values for the index for Ireland in each of the previous versions of the energy security report (2006, 2007, 2011 and 2016).

The supply/demand index is a measurement of the medium-to-long-term energy security of the whole energy system. It is based on a combination of objective information contained in energy balances and subjective weighting factors and scoring rules. It differs from other energy security metrics as it takes a holistic approach and covers both supply and demand-side elements, incorporating final-energy demand, energy conversion and transport, and primary-energy supply. The index provides a method to compare relative security year-on-year. It should be considered as one of several inputs when deliberating Ireland's energy security; it should not be the only decision-making criteria. While it does implicitly account for some of the security benefit arising from energy efficiency and local renewable energy supply, it does not explicitly address the sustainability and competitiveness pillars of energy policy. All three pillars must be considered when evaluating options for energy system development.

In general, the supply/demand index result for Ireland will improve if:

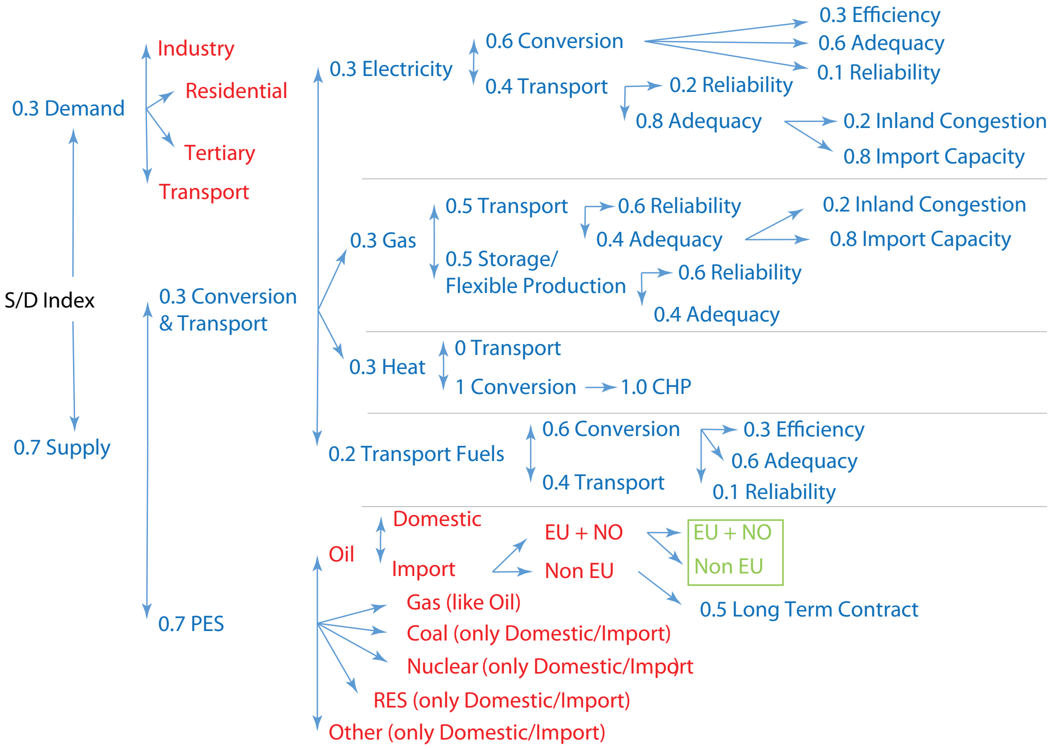
- The energy intensity of demand for energy in Ireland (that is, more output per unit of energy) improves relative to the best performing EU member states.
- Increased shares of energy are sourced nationally, rather than internationally.
- Increased shares of energy sources are sourced from Europe (the EU, UK, and Norway), instead of from outside Europe.
- The capacity of Ireland's energy conversion and transmission systems increases relative to the demand for energy from these systems.

The index score is not influenced by the resilience of specific items of energy infrastructure or by the availability of strategic reserves of certain fossil fuels (for example, oil), even though these aspects do impact on energy security.

7.2 Supply/demand index method

The index comprises nested branches that represent different aspects of the energy system, as shown in *Figure 61*. Each branch and sub-branch are assigned a weight and a score. These weights and scores combine along three main branches to give overall scores for primary-energy supply, conversion and transport, and energy demand. These three branch scores combine to give the overall index score.

Figure 61: Supply/demand index weighting and scoring structure



Source: Adapted from EU Standards for Energy Security of Supply [113]

Some of the weights are based on default values established during the original development of the index. These subjective weights reflect the perceived vulnerabilities of each element of the index and are based on expert professional judgement available to ECN at that time. They are shown in blue in *Figure 61*. Other weights are based on data from Ireland's energy balance, that is, they are Ireland-specific and can vary from year to year. For example, the sub-branches below the demand and primary-energy supply branches are weighted based on the relevant sub-branch's share of demand and primary-energy supply, respectively. They are shown in red in *Figure 61*.

The scoring rules are different for the different branches:

- For the demand-side branch (overall weighting 0.3), the scoring rules comprise ratios between energy intensity indicators calculated for Ireland's end-use sectors and benchmark values for these indicators based on data for the best-performing EU member states.
- The conversion and transport branch (overall weighting 0.7 x 0.3 = 0.21) addresses the efficiency, adequacy, and reliability of different elements of energy conversion and transportation. The scoring rules are based on quantitative and qualitative data measuring different technical characteristics of the energy system.
- The primary energy supply branch (overall weighting 0.7 x 0.7 = 0.49) quantifies the relative contributions to energy security from supplies of different energy types. The scoring rules are based on the share of indigenous supply for the different energy types. For oil and gas supply, the split between imports from within and outside the EU (and Norway)[64] also contributes to the score.

The application of some of the scoring rules has been refined since the previous update and the demand benchmarks have been updated to the latest year for which all international data is available[65,66].

The supply/demand index methodology is described in detail in ECN's EU Standards for Energy Security of Supply [113]. The application of the methodology to Ireland and the results of this analysis are described below.

64 Where supply/demand index calculations are based on the split between EU and non-EU imports, imports from Norway and the UK are included with EU imports.

65 The latest year for which all of the international benchmarks are available is 2016.

66 These changes, coupled with updated historical datasets, mean that the results shown in this report cannot be directly compared with the results published by SEAI in previous reports. However, all the supply/demand index results presented in this report have been calculated in a consistent manner using the refined approach. Comparisons can therefore be made between the values shown in this report for different years.

7.3 Energy security score 2005-2018

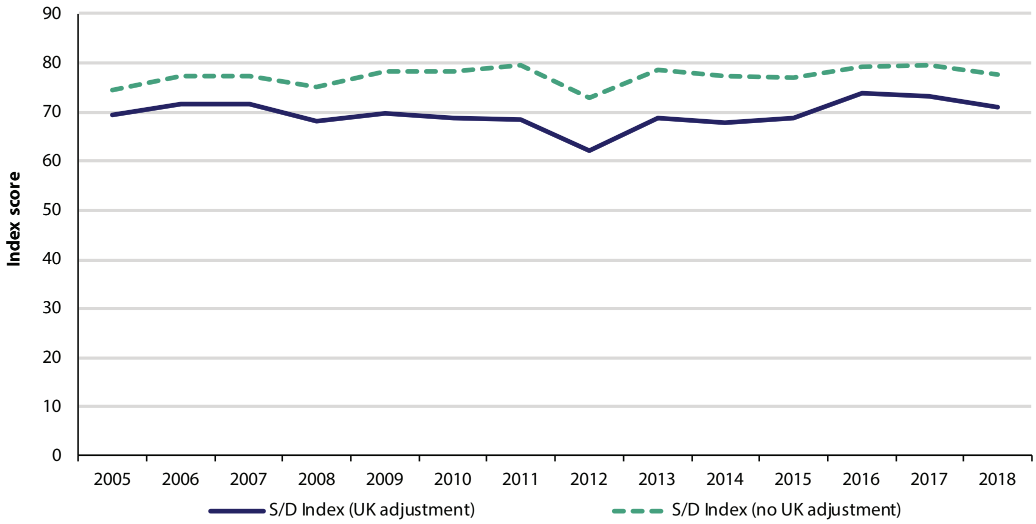
7.3.1 Overall score

Two values for the updated index are shown for the 2005-2018 period in *Figure 62*. 2018 is the latest year for which statistical data used for the calculation of the index is available. An upward trend in the index over time suggests an improvement in energy security, based on the methodology used, and vice versa for a downward trend. The overall results of this analysis show that while Ireland's energy security has strengthened slightly since 2005, the index result remained reasonably consistent throughout the period examined.

The index methodology deems non-EU imports to be less secure than EU imports. The lower set of results shown in *Figure 62* ('UK adjustment') accounts for the fact that Ireland has a heavy dependence on the UK for the supply of refined petroleum products and natural gas and that the UK itself imports a significant amount of its oil and gas, including from outside the EU. This has a knock-on effect on Ireland's energy security. Irish imports of oil and gas from the UK are weighted as being EU or non-EU in proportion to the percentage of UK imports originating from these sources. *Figure 62* illustrates the significant influence that this adjustment has on the overall index score. This is because of the dominant weighting of primary energy supply in the index (0.49) and the key role that imported oil and gas play in Ireland's energy mix. The sources of the UK's supplies of gas and oil are discussed in sections 3.2.4 and 4.2.5 of this report.

Note that none of the supply/demand index results presented in this report are affected by the UK's departure from the EU. The UK was a member of the EU throughout the period for which the index was calculated. The impact of Brexit on different aspects of Ireland's energy security is discussed elsewhere in this report.

Figure 62: Supply/demand index score 2005-2018



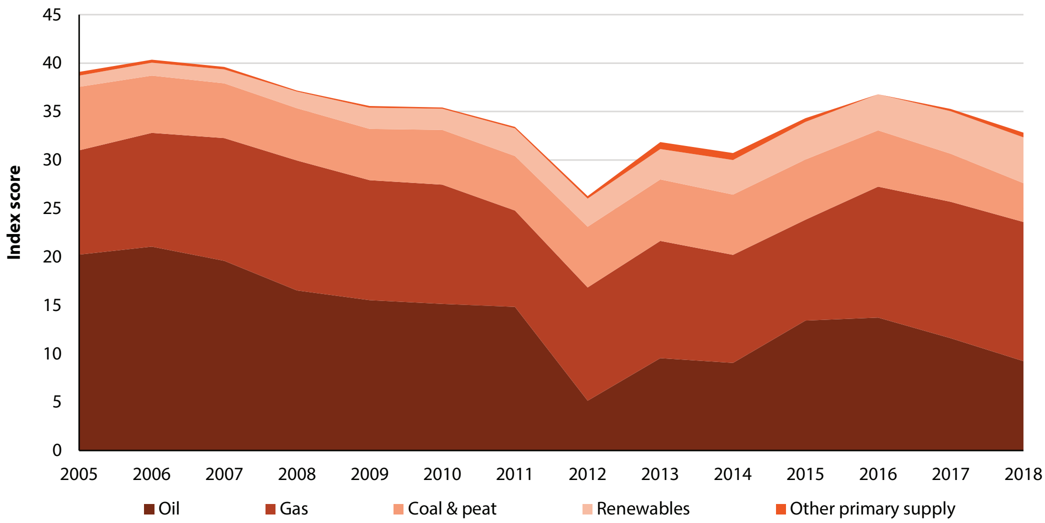
Source: SEAI

The factors contributing to Ireland's overall score since 2005 can be identified by examining the scores for the three main index branches, that is, primary energy supply, conversion and transport, and energy demand. These branch scores are discussed in the following sections of the report. All of the results shown for the branch scores are for the UK-adjusted calculation, that is, oil and gas imports to Ireland from the UK are weighted according to the provenance of the UK's oil and gas supplies.

7.3.2 Primary energy supply

The annual scores for the security of primary energy supply for the period 2005-2018 are shown in *Figure 63*. This is the most dominant of the three main branches of the index, with a maximum potential weighted score of 49 (out of 100 total index points). The weighted score decreased by 33% between 2005 and 2012 before increasing by 40% by 2016 and then subsequently dropping by 11% by 2018. These changes were mainly driven by changes to Ireland's oil and gas supplies over the period. The 2018 score was 67% of the maximum possible score.

Figure 63: Supply/demand index primary energy supply score 2005-2018 (max = 49)



Source: SEAI

The score contribution from oil to the primary energy supply branch of the index reduced dramatically in 2012, before increasing to a peak in 2016 and then decreasing by 33% over the subsequent two years. These variations were attributable to changes to the countries of origin of Ireland's oil supplies in these years, and to the way that the supply/demand index methodology determines the risk posed by EU and non-EU supply sources. *Figure 37* in chapter 4 illustrates how the provenance of Ireland's crude oil can vary dramatically from year to year and how a significant proportion of imports came from outside Europe in 2012-2014 and from 2017 onwards. It is worth noting that the supply/demand index considers imports from all non-EU countries as being equally risky. It does not differentiate between imports from relatively stable non-EU regions (for example, North America) and imports from non-EU regions that are prone to more significant geopolitical tension (for example, Libya). While very little North American crude oil was imported to Ireland between 2005 and 2017, US and Canadian crudes accounted for a large proportion of imports in 2018 and 2019.

The supply/demand index does not account for the short-term oil security benefits arising from the strategic storage of oil reserves.

The commencement of gas production in Corrib increased Ireland's indigenous gas production from 3% of demand in 2015 to over 60% in 2018 – see section 3.2.3. This resulted in a 38% increase in the security score contribution from gas between 2015 and 2018, that is, because indigenous gas displaced imported gas. As with oil, the provenance of Ireland's gas imports (EU versus non-EU) has an important bearing on the score each year. However, unlike oil, most of Ireland's imported gas is from the EU, even after imports from the UK have been adjusted to account for its imports. In 2018, 7.7% of Ireland's gas imports, or 3.0% of total gas consumption, originated from outside the EU.

The score contribution from coal and peat supply declined by 39% over the period examined. This was due to a decrease in these fuels' share of primary energy supply rather than to changes in the security of the fuels themselves.

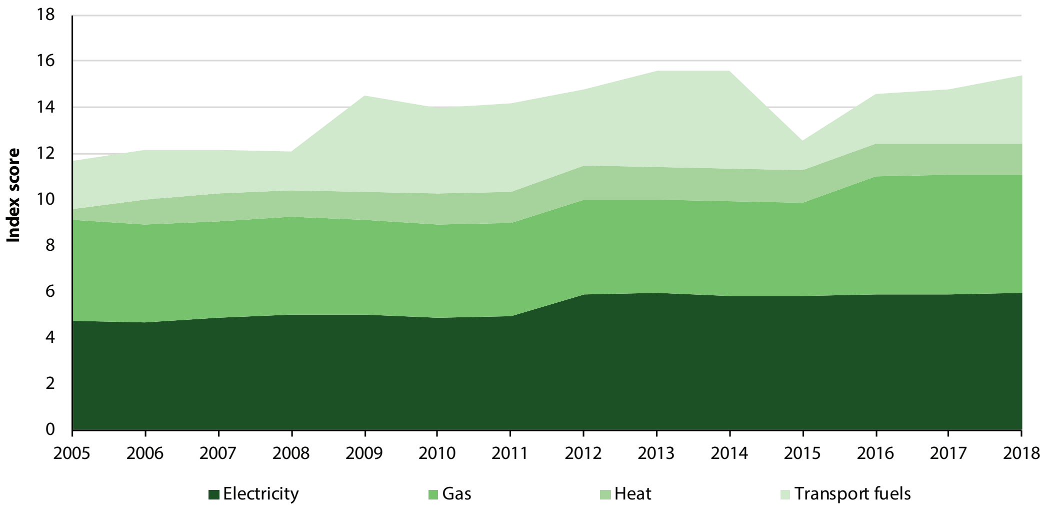
The increase in indigenously produced renewable energy over the period, particularly wind and biomass, improved the score contribution from renewables by 313% since 2005. This increased score contribution is approximately one-and-a-half times the magnitude of the score reduction attributable to lower coal and peat consumption over the same period.

Several factors could impact on the future score for the primary energy supply branch of the index over the period to 2030. Increasing shares of indigenous renewable energy supply for electricity, heat and transport, in line with the targets set out in Climate Action Plan 2019 [7], would contribute to a higher score, especially if these renewable supplies displace oil and gas imports from outside Europe.

7.3.3 Conversion and transport

This branch addresses the conversion and transport of electricity, natural gas, heat, and transport fuels. The maximum potential weighted score for the branch is 21 (out of 100 total index points). The annual scores for Ireland are shown for 2005-2018 in *Figure 64*. The score increased by 32% over the period examined. The 2018 score was 73% of the maximum possible score.

Figure 64: Supply/demand index conversion and transport score 2005-2018 (max = 21)



Source: SEAI

The dominant sub-branches are electricity and gas (30% weighting each), with lesser contributions from heat and transport fuels (20% weighting each).

The scoring rules for the electricity sub-branch account for the efficiency, adequacy, and reliability of dispatchable electricity generation[67] and the adequacy and reliability of the transmission system, including interconnection. The score contribution from electricity increased by 26% over the period. This was due to increased efficiency in dispatchable generation (+15% over the period), the increased import capacity provided by the East-West Interconnector, from 2012 onwards, and high levels of generation reserve. The latter is scored relative to a generation reserve factor, which is the ratio of installed dispatchable capacity to peak demand. A score of 1.2 or above is deemed to be sufficiently secure. Ireland's reserve factor was above 1.2 for every year shown in *Figure 64* except 2006, when it was 1.12. It was 1.52 in 2018.

The score for gas conversion and transport is based on the adequacy of gas transmission, storage, and flexible production. The score contribution increased by 17% over the period, mainly because of the increased contribution to production adequacy from 2016 onwards from Corrib. High levels of interconnection capacity from Scotland and of indigenous production (since 2016) yielded a maximum score for import capacity adequacy throughout the period. In 2018, interconnection capacity plus indigenous production was 2.4 times consumption. Although the recent upgrades to the gas interconnection infrastructure at Moffat have improved the resilience of this infrastructure, they do not impact on the supply/demand index result for the gas transport sub-branch because the application of the scoring methodology already results in a maximum score for this sub-branch.

The scoring for the heat sub-branch is based on the amount of energy supplied from CHP. The low-score contribution reflects the relatively low amount of CHP in Ireland (7.9% of electricity available for final consumption in 2018).

The score contribution from transport fuels is largely dependent on the reserve capacity of Whitegate oil refinery each year. This calculation is based on the ratio of the refinery's annual output to its maximum capacity. The scoring rule results in a zero contribution to security when reserve capacity is less than 5%, that is, when the refinery operates at 95% capacity (or more). The refinery operated at a relatively high capacity in 2005-2008 and 2015, hence the lower score contribution for these years. It operated with greater reserve between 2009 and 2014, and again between 2016 and 2018, which resulted in a higher score for this sub-branch for these years.

The score for the conversion and transport branch will be improved by the implementation of several actions set out in the Climate Action Plan [7], including actions that will:

- Increase the efficiency of thermal electricity generation;
- Increase electricity interconnection capacity;
- Increase CHP capacity;
- Reduce demand for natural gas, for example, energy efficiency, electrification of heat; and
- Moderate peak demand for electricity and natural gas, for example, energy efficiency.

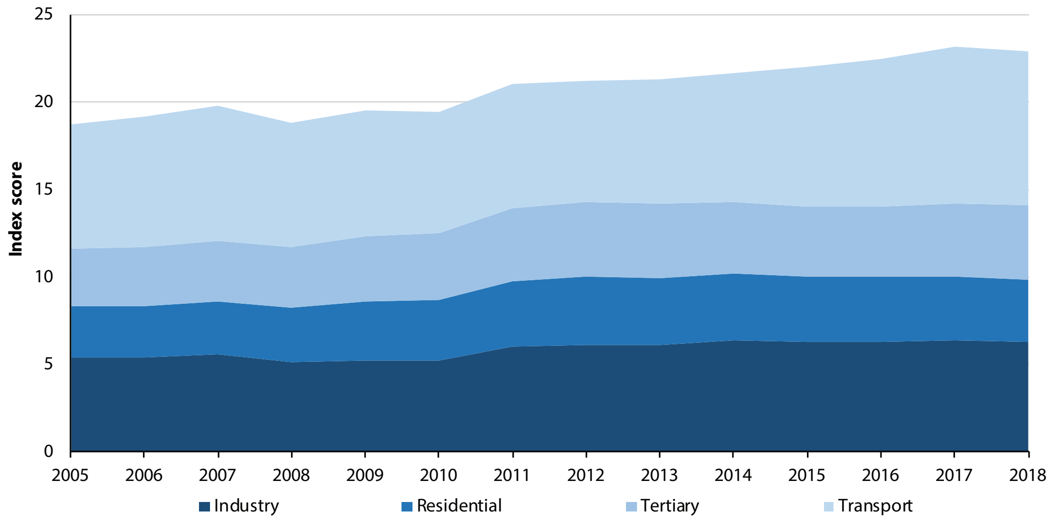
67 Dispatchable generators are generators that can be dispatched at the request of power grid operators.

7.3.4 Demand

The annual scores for the energy demand branch of the index are shown in *Figure 65*. The maximum potential weighted score for this branch is 30 (out of 100 total index points). Overall, the contribution to the supply/demand index score from demand security increased by 23% between 2005 and 2018 because of an aggregate decrease in energy intensity across the industry, residential, tertiary and transport sectors of the economy over the period. The 2018 score was 76% of the maximum possible score.

The sectoral demand sub-branches are weighted based on each sector's share of final energy demand. The scoring rules are calculated by benchmarking Ireland's demand intensity in each sector against the average of the five best-performing EU member states. The same EU benchmarks based on 2016 data are used for consistency.

Figure 65: Supply/demand index demand score 2005-2018 (max score = 30)



Source: SEAI

The industry and tertiary score contributions are very high, with both sub-branches contributing maximum scores since 2013. This is because both sectors have energy intensities that are lower than the EU benchmarks when measured on a per-unit of gross value added (GVA) basis. This highlights the high value-added nature of the Irish economy. GVA is linked to GDP, which in Ireland, is strongly influenced by the activities of multinational companies. Some of the activities of these companies result in large amounts of value added, but very little consumption of energy.

It can be argued that in Ireland's case, an alternative to GVA should be used to address the impacts of the activities of multinationals. However, the supply/demand index model uses international benchmarks based on GVA and the practice internationally is to use GDP and GVA; for comparison purposes we have followed this convention. For this reason, care must be taken in interpreting any indicators based on GVA or GDP for Ireland.

The demand security score for the residential sector increased by 20% over the period shown, which reflects a downward trend in energy use per capita in the sector since 2005. Demand security in transport increased by 24% over the period, but the statistical data used to calculate the energy intensity of the freight sector in Ireland is based on EU average data; care should therefore be taken in interpreting this.

The score for the demand branch will be improved by the implementation of the energy efficiency measures set out in the Climate Action Plan [7], especially those that will improve the energy intensity of the residential and transport sectors.

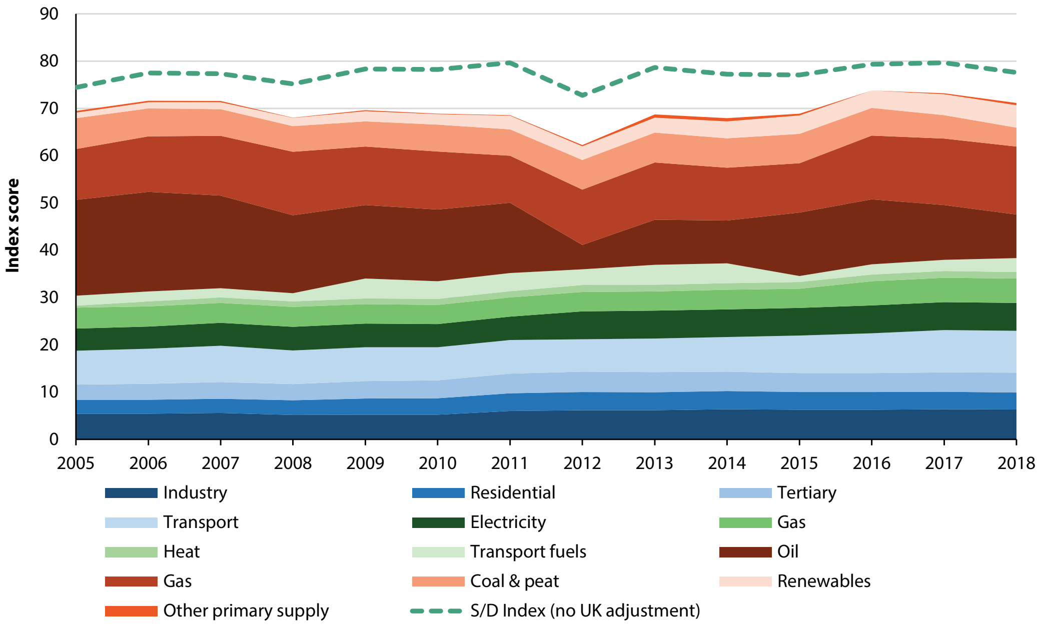
7.3.5 Overall score

Combining the results of the analysis for primary energy supply, conversion and transport, and energy demand gives the overall result of the supply/demand index, as shown in *Figure 66*. The unadjusted UK calculation is also presented, for comparison.

Taken together, the demand-side and the supply-side conversion and transport improved by 26% over the 2005-2018 period. These are the branches over which Ireland has most domestic control through policy, regulation and local infrastructural investment, for example, energy efficiency initiatives, enhanced interconnection, improved generation efficiency in electricity sector. Together, they contributed the two highest relative scores in 2018, that is, 76% and 73% of maximum possible scores, compared to 67% for primary energy supply. The strengthening of their security scores has more than offset a 16% decrease in the security score for primary energy supply over the same period.

The score contribution from primary energy supply fluctuated significantly over the period as the provenance of Ireland's energy supplies, especially oil and gas, varied between indigenous, EU and non-EU sources. The score contributions from the supply of oil and gas are the two largest sub-branch score contributions shown in *Figure 66*. Together, they accounted for 33% of the index score for 2018 and are likely to be key influencers on future index scores. The increasing share of domestic renewable energy sources between 2005 and 2018 has steadily improved the energy supply score.

Figure 66: Supply/demand index score breakdown 2005-2018



Source: SEAI

Looking to 2030, further significant displacement of imported oil and gas with energy efficiency and indigenous renewable supplies will increase Ireland's future energy security score. Despite this, oil, and gas, which accounted for almost 80% of primary energy in 2018, will continue to heavily influence the supply/demand index. The large increase in non-EU oil imports in 2018 was the main reason for the reduction in the overall index score between 2017 and 2018. Ireland is likely to become more reliant on non-EU oil and gas as EU supplies decline. Because the index methodology deems non-EU oil and gas supplies to be less secure than EU supplies, it is likely that the index score will decrease over the next decade.

ABBREVIATIONS

ACER: Agency for the Cooperation of Energy Regulators

CO_2: carbon dioxide

CHP: combined heat and power

CNG: compressed natural gas

CRE: Commission de Régulation de l'Energie (France)

CRU: Commission for Regulation of Utilities

CSO: Central Statistics Office

DCCAE: Department of Communications, Climate Action and Environment

DS3: Delivering a Secure, Sustainable Electricity System

ECN: Energy Research Centre of the Netherlands

ECP: enduring connection policy

ENTSO-E: European Network of Transmission System Operators for Electricity

ENTSOG: European Network of Transmission System Operators for Gas

EPA: Environmental Protection Agency

ESRI: Economic and Social Research Institute

EU: European Union

FQD: Fuel Quality Directive

GCS: All-Island Generation Capacity Statement

GDP: gross domestic product

GEEP: Gas and Electricity Emergency Planning Group

GNI: Gas Networks Ireland

GVA: gross value added

HVDC: high voltage direct current

HVO: hydrogenated vegetable oil

IEA: International Energy Agency

IP: intellectual property

I-SEM: Integrated Single Electricity Market

LNG: liquefied natural gas

LPG: liquefied petroleum gas

LULUCF: land use, land use change and forestry

NCSC: National Cyber Security Centre

NORA: National Oil Reserves Agency

OPEC: Organization of the Petroleum Exporting Countries

PSO: public service obligation

PV: photovoltaic

R&D: research & development

SEAI: Sustainable Energy Authority of Ireland

SEMO: Single Electricity Market Operator

SONI: System Operator for Northern Ireland

SUV: sports utility vehicle

toe: tonne of oil equivalent

UCO: used cooking oil

UNFCCC: United Nations Framework Convention on Climate Change

VAT: value added tax

GLOSSARY OF TERMS

Carbon dioxide (CO_2): a compound of carbon and oxygen formed when carbon is burned. Carbon dioxide is one of the main greenhouse gases. Units used in this report are gCO_2 (grams of CO_2).

Combined heat & power (CHP): CHP refers to plants which are designed to produce both heat and electricity. CHP plants may be autoproducer (generating for own use only) or they may also sell electricity and heat to off-site users.

Dispatchable generation: electricity generators that can be dispatched at the request of power grid operators, for example, biomass, gas, and coal generators.

Energy intensity: the amount of energy used per unit of activity. Where possible, any monetary values used for activity levels are in constant prices.

Gross domestic product (GDP): the gross domestic product represents the total output of the economy over a period.

Gross value added (GVA): value added is an economic measure of output. The value added of industry, for instance, is the additional value created by the production process through the application of labour and capital. It is defined as the value of industry's output of goods and services less the value of the intermediate consumptions of goods (raw materials, fuel, etc.) and services.

Final consumption (or final demand): This is the energy used by the final consuming sectors of industry, transport, residential, agriculture and services. It excludes the energy sector such as electricity generation, oil refining, etc.

Modified domestic demand: modified domestic demand is an indicator of domestic demand calculated by the CSO that is designed to give a better insight into Irish domestic economic activity. It excludes trade in aircraft leasing and R&D-related intellectual property imports.

Non-dispatchable generation: electricity generators that cannot be dispatched at the request of power grid operators, for example, wind and solar generation.

Non-renewable wastes: the non-renewable portion of wastes used as an energy source.

Non-synchronous electricity generation: electricity from sources such as wind turbines and HVDC interconnectors is non-synchronous. It does not provide the same inertia as traditional synchronous generation. Power systems with a high penetration of variable non-synchronous generation pose challenges for frequency control over multiple timeframes.

Projects of common interest (PCI): Projects of common interest are key cross border infrastructure projects that link the energy systems of EU countries. They are intended to help the EU achieve its energy policy and climate objectives.

Primary energy: this is the total requirement for all uses of energy, including energy used to transform one energy form to another (for example, burning fossil fuel to generate electricity) and energy used by the final consumer.

Synchronous electricity generation: in a synchronous system, such as the all-island system, the conventional generating units are synchronised – the waveforms of the generated voltages at each generating plant are synchronised, producing electricity at a nominal frequency of 50 Hz. This synchronisation comes from the physical rotation of the large rotors in the electricity generation plant. The physical inertia of these large rotating units also gives the electricity system inertia, that is a resistance to changes in frequency over very short time periods. This system inertia is an important characteristic in terms of the overall system stability of the electricity grid.

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APPENDIX 1: EU Gas Security

The EU imports more than half of its energy, at a cost of over €1 billion per day. It is particularly reliant on imported natural gas (69% import dependency) and crude oil (90%) [36]. Energy security and member states' reliance on energy imports are an important focus of policy at EU level.

In 2010, the European Commission introduced Regulation 994/2010 [35] in an attempt to safeguard the security of the gas supply following lessons learned from the Russian-Ukrainian gas disputes in the preceding years; these caused severe gas disruptions to several EU countries.

The Commission subsequently released its European Energy Security Strategy [114] amid growing concerns among member states about their vulnerability to supply disruptions. The Strategy seeks to promote enhanced co-operation among member states. A series of stress tests undertaken by 38 countries were among the short-term measures introduced. These focused on two simulated energy-disruption scenarios:

- A complete cessation of Russian gas imports to the EU; and
- A disruption to Russian gas imports via the Ukraine.

The analysis of the stress tests concluded that a prolonged gas supply disruption would have a serious impact on the EU and identified several short-term measures that could serve to enhance security of supply at EU level. The Strategy also introduced five key areas to address longer-term challenges: increased energy efficiency; increased production in the EU and diversification of supplier countries and routes; completion of the internal energy market and development of infrastructural links; harmonised external energy policy, and; improving emergency response, enhancing solidarity mechanisms and protecting critical infrastructure.

The Commission subsequently published the Energy Union Strategy in 2015 [115]. It includes five interrelated dimensions, one of which is 'energy security, solidarity and trust', and sets out a vision for energy security in Europe:

> *'Our vision is of an Energy Union where Member States see that they depend on each other to deliver secure energy to their citizens, based on true solidarity and trust, and of an Energy Union that speaks with one voice in global affairs'.*

The Energy Union Strategy builds on the EU Energy Security Strategy and emphasises:

- Diversification of energy sources, suppliers and routes;
- Collaboration on energy security between Member States, system operators, industry and all other stakeholders;
- A stronger and more united EU role in international energy markets; and
- More transparency on intergovernmental and commercial gas supply agreements, especially with respect to EU law.

'Energy Union and climate' was one of ten formal priorities of the Juncker Commission period (2014-2019) [116]. For the period 2021-2030, member states are required to develop integrated national energy and climate plans that cover all five dimensions of the Energy Union Strategy, including 'energy security, solidarity and trust'.

In 2017, the Commission introduced a new regulation to further strengthen gas security [37]. It requires:

The ENTSOG to undertake an EU-wide gas supply and infrastructure disruption simulation.

- Member states to work together in regional groups to assess the gas security risks (common risk assessments) and plan co-operative actions to mitigate the consequences of those risks (preventive action plans and emergency plans).
- Transmission system operators to enable permanent bidirectional capacity on all interconnectors between member states. This requirement is subject to some exemptions.
- Natural gas companies to notify national competent authorities of contracts that exceed 28% of the annual gas consumption in the member state.
- Transmission system operators to enable permanent bi-directional capacity (reverse flow) on all cross-border interconnectors, subject to some exemptions.

It also introduced a solidarity principle whereby member states must assist each other to always guarantee supply to vulnerable consumers, even during severe gas crisis situations.

'Security, solidarity and trust' is one of six policy areas in the European Green Deal, which is one of six formal priorities of the von der Leyen Commission period (2019-2024) [117]. This framework recognises the interdependencies between climate change and energy security.

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