SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Energy Security in Ireland: A Statistical Overview

2016 Report

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January 2016

Sustainable Energy Authority of Ireland

The Sustainable Energy Authority of Ireland has a mission to play a leading role in transforming Ireland into a society based on sustainable energy structures, technologies and practices. To fulfil this mission SEAI aims to provide well-timed and informed advice to Government, and deliver a range of programmes efficiently and effectively, while engaging and motivating a wide range of stakeholders and showing continuing flexibility and innovation in all activities. SEAI's actions will help advance Ireland to the vanguard of the global green technology movement, so that Ireland is recognised as a pioneer in the move to decarbonised energy systems.

Energy Policy Statistical Support Unit (EPSSU)

SEAI has a lead role in developing and maintaining comprehensive national and sectoral statistics for energy production, transformation and end-use. This data is a vital input in meeting international reporting obligations, for advising policy-makers and informing investment decisions. Based in Cork, EPSSU is SEAI's specialist statistics team. Its core 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

The authors wish to express their gratitude to those who provided data and analysis for this report and also to those who commented on previous versions of this report.

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Highlights

Energy security comprises many diverse factors, including import dependency, fuel diversity, the capacity and integrity of the supply and distribution infrastructure, energy prices, physical risks, supply disruptions and emergencies.

Ireland had an import dependency of 85% in 2014, estimated to cost €5.7 billion, down from a peak of 91% in 2006. In absolute terms, net energy imports peaked in 2008, and decreased by 23% since then. This was primarily due to the fall in energy demand over that period.

In 2014, 97% of imports were fossil fuels (not including the fossil fuel content of imported electricity) namely oil (56%) , natural gas (31%), and coal (10%). The remainder was electricity (2%), and biofuels (1%).

Indigenous energy production in 2014 comprised of peat (47%) renewable energy sources (44%), natural gas (6%) and non-renewable wastes (3%).

Reliance on Oil

Ireland's oil dependency was the fourth highest in the EU in 2013, at 49% of all energy use. All of Ireland's oil is imported.

Oil imports cost an estimated €4.4 billion in 2014, 77% of the total cost of energy imports.

The majority (73%) of Ireland's oil imports were in the form of oil products, such as petrol and diesel, with the remainder as crude oil. 76% of oil product imports were from the UK.

Prior to 2009 the vast majority of Ireland's crude oil imports came from the UK and Norway. Since then the source has become much more variable, with significant imports from North and West Africa, reflecting the global nature of the international crude oil market.

Over 70% of oil used in Ireland in 2014 was for transport. 97% of energy used in the transport sector was from oil based products. This near total dependence on a single fuel source is unique to this sector.

Reliance on Natural Gas

In 2014, 96% of natural gas used in Ireland was imported compared to an EU average of 65%.

All of Ireland's natural gas imports come from the UK. The UK has been a net importer of natural gas since 2011.

The Corrib gas field was anticipated to commence full commercial production in late 2015 and is expected to meet 77% of the Republic of Ireland's annual gas demand in its first full year of commercial production. While Corrib will greatly enhance Ireland's security of supply in the short-term, in the medium-to-long-term, post 2020, Ireland is likely to remain largely dependent on imported natural gas to meet demand.

Electricity generation in Ireland relies heavily on natural gas, with 46% of the electricity generated coming from natural gas in 2014.

Overall Energy Security

The Supply/Demand index is a measure of medium-to-long-term energy security of the whole energy system.

The Supply/Demand index for Ireland shows an overall decreasing trend over the period 2000–2014, indicating a reduction in overall energy security.

This overall reduction in energy security is mainly due to the increasing shares of Ireland's oil and gas that are ultimately sourced from outside the EU and OECD.

In the past Ireland's oil and gas was mostly produced in the North Sea and supplied by the UK and Norway, the UK remained Ireland's largest energy trading partner in 2014. Due to declining North Sea oil and gas production the UK is now a net importer of crude oil, oil products and natural gas. It increasingly sources its energy imports from outside the EU and OECD, and this has a knock on effect on Irish energy security. This trend is expected to continue as reserves of oil and gas from the North Sea continue to decline in the coming years.

Diversifying the fuel mix enhances energy security, particularly where there is an over-reliance on a single fuel source. In this regard, transport is the least secure energy sector, being almost entirely dependent on oil based products, and has the greatest need of increased fuel diversity.

Diversification of the electricity generation fuel mix by increasing indigenous renewable electricity production has reduced the demand for imported fossil fuels and the associated exposure to their variations in price.

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1 Introduction

This report is the fifth in a series reviewing energy security in Ireland. The complex interaction and trade-offs between the three pillars of energy policy (energy security, competitiveness and protection of the environment) requires a better understanding of energy security, informed by accessible data and analysis.

This report considers the issue of energy security holistically. By aggregating and organising what is sometimes rather eclectic public data into one focused document the report is designed to provide a context for informed action and decision making in the area of energy security. The complexity of this area of energy policy does not allow for simple solutions or measurement.

For an individual country or region, quantifying energy security is not trivial and there is very little consensus on what metrics should be used. The task is generally reduced to using simple metrics such as import dependency or fuel dominance. Criticisms of these metrics include the fact that they are narrowly focused and only capture specific aspects of energy security. There have been a number of efforts to carry out more detailed analysis of the issue. Two useful developments have been: portfolio optimisation for the electricity sector, and; the development of aggregated energy security indicators. In the case of the latter, these include: indicators based on the Shannon index, which captures diversity in suppliers in addition to fuel diversity; the Herfindahl–Hirschman Index, which incorporates market concentration of suppliers, and; the Supply/Demand (S/D) index developed by ECN.

This report is intended to inform debate and provide information to policymakers, energy market participants, investors, and the public. The metrics, or 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, and examine primary fuels and their conversion into energy services. As energy plays a vital role in society, underpinning all areas of economic activity, the economic impact of supply or price fluctuations can be significant and widely felt.

The layout of the report is as follows. Section *2* presents general energy security concepts, and reviews policy activity impacting on energy security. It discusses recent energy security developments, both international and in Ireland, on a fuel-by-fuel basis. Section *3* presents data at the national level on issues such as the overall supply and demand of fuels, and international trends in fuel and carbon prices. Section *4* examines the energy security of each of the major fuel sources in Ireland, looking more closely at the end-uses of each fuel that drive demand, and the markets from which Ireland imports these fuels. Section *5* looks at the security of the physical infrastructure that supports Ireland's energy system, focusing on natural gas and electricity infrastructure. Section *6* looks at statistics and recent developments for the exploration for indigenous fossil fuel sources. As part of the commitment to develop and improve energy security indicators, SEAI commissioned research for this report to update the S/D index of energy security. This analysis is included in section *7* of the report, and helps to bring together the many disparate factors affecting energy security, and to improve our overall understanding of Ireland's energy security.

The energy data drawn from the national energy balance presented in this report is the most up-to-date at the time of writing. The energy balance is updated whenever more accurate information is known. To obtain the most up-to-date balance figures visit the statistics publications section of the SEAI website (www.seai.ie/statistics). An energy data service is also available at this website, by following the link to the Energy Statistics Databank. This service is hosted by the Central Statistics Office (CSO) with data provided by SEAI.

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 Energy Regulation (CER) has the statutory obligation to ensure electricity and gas energy security in Ireland and the Oil Supply Division of the Department of Communications, Energy and Natural Resources (DCENR) and the National Oil Reserve Agency (NORA) are responsible for oil security and oil stocks respectively. These organisations along with EirGrid and Gas Networks Ireland (GNI) publish a number of reports that are important in providing a thorough overview of energy security in Ireland, including:

- Electricity Security in Ireland—CER;
- Gas Security in Ireland—CER;
- Network Development Plan—GNI;
- Generation Capacity Statement—EirGrid;
- Transmission Forecast Statement—EirGrid;
- Financial Statements—NORA.

Many of the metrics are included in the annual Energy in Ireland reports but are repeated here for their specific relevance to energy security.

Feedback and comment on the report are welcome and should be sent by post to the address on the back cover or by email to epssu@seai.ie.

2 Concepts, Policy and Recent Developments

2.1 Energy Security Concepts

At a high level, the imperative for energy security is straightforward and well understood: secure supplies of energy are essential for all economic activity, for the effective delivery of public services, and for maintaining safe 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 and emergencies.

Energy security is described by the International Energy Agency (IEA) as 'the uninterrupted physical availability of energy sources at an affordable price'[1]. The IEA expands on this definition by explaining that 'energy security has several dimensions: long-term energy security mainly deals with timely investments to supply energy in line with economic developments and sustainable environmental needs. Short-term energy security focuses on the ability of the energy system to react promptly to sudden changes within the supply-dmand balance. Lack of energy security is thus linked to the negative economic and social impacts of either physical unavailability of energy, or prices that are not competitive or are overly volatile.'

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

The risks to energy security are strongly related to the availability of fuel supply and trends in energy demand. On the supply side, key variables include the size of the physical resources, robustness of infrastructure (e.g. electricity networks, gas pipelines, oil terminals), the feasibility (including political) and costs of extraction, as well as geopolitical and weather events. The key variables on the demand side are economic growth, changing economic structure and price.

Figure 1 illustrates the multifaceted nature of energy security. Although the risks to physical energy availability are depicted on the supply side they can also impact on the demand side if the access, or perceived access, to energy sources is interrupted. Regulatory and policy frameworks also have impacts.

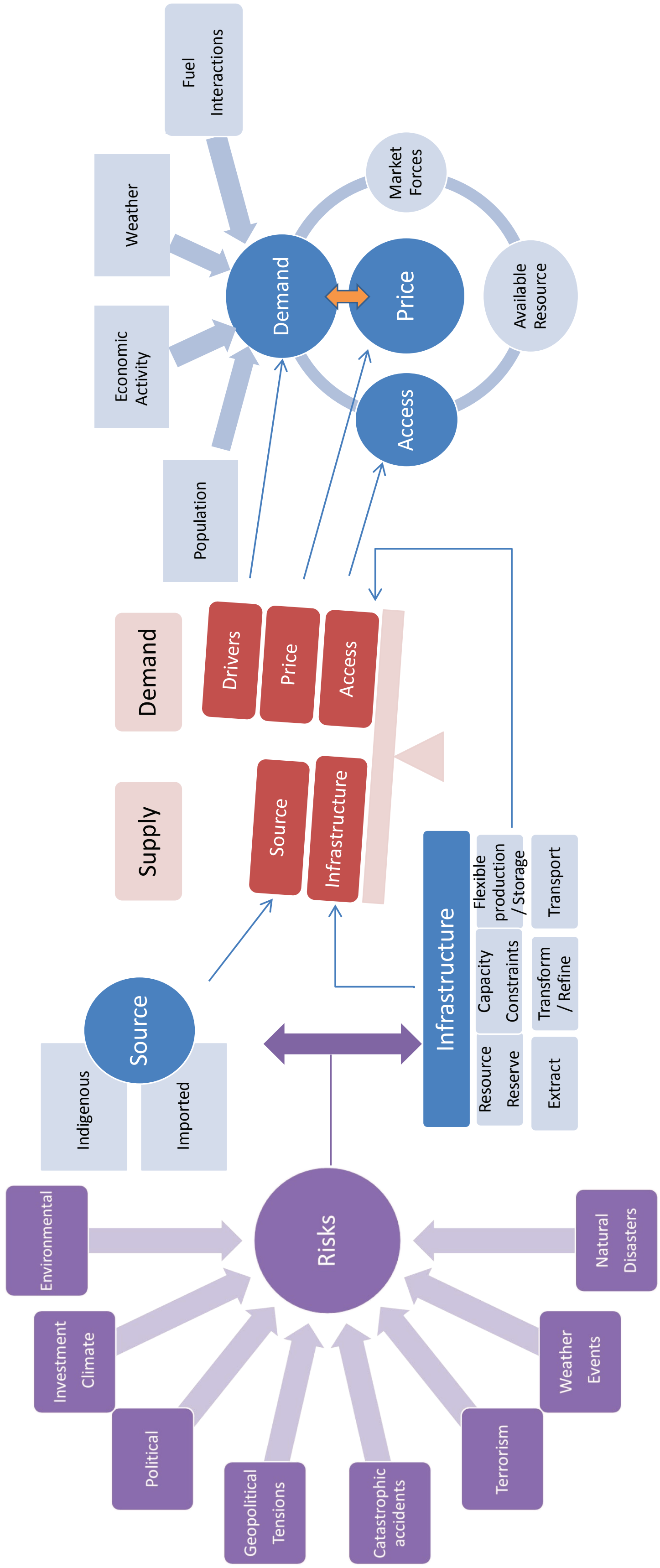
Energy security risks include:

- Natural disasters and extreme weather events, e.g. the Japanese earthquake that led to the nuclear reactor meltdowns at Fukushima Daiichi (2011), Hurricane Katrina (2005);
- Civil and regional conflicts, e.g. recent conflicts in Libya, Syria, Ukraine and Iraq;
- Geopolitical tensions, e.g. trade sanctions against Russia and Iran;
- Political instability, e.g. the 'Grexit' political crisis (2015);
- Major accidents, e.g. Buncefield fire (2005), Deepwater Horizon oil spill (2010);
- Infrastructure capacity constraints, e.g. sudden surges in demand;
- Investment uncertainty, e.g. regulatory and/or policy uncertainty;
- Resource variability, e.g. variation in average wind speeds;
- Civil and labour disputes.

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 IEA. Webpage, accessed 11th November 2015. 'Energy Security'. Available from www.iea.org/topics/energysecurity/.

Figure 1 *Representation of energy security*



Source: SEAI

2.2 International Developments and Cooperation

2.2.1 Global Developments

Global energy demand has recovered since the international economic crisis, and has continued to grow since 2009 as economies have emerged from recession. Demand growth has been largely driven by growth in non-OECD countries, with OECD countries reducing demand in the period 2010–2012. By 2012, global total final energy consumption amounted to 8,979 million tonnes of oil equivalent (Mtoe), 40% of which was in OECD countries (IEA, 2014b).

Notwithstanding the economic recovery, global energy markets remain dynamic and uncertain. Recent trends, including the collapse of oil prices, the continued emergence of unconventional gas and oil, increasing geopolitical instability, low carbon prices and the looming challenge for nations to secure meaningful agreement on climate change, have all had impacts and contributed to uncertainty.

An imminent challenge for all governments is to secure global agreement on a successor to the UN Framework Convention on Climate Change (UNFCCC), which is set to expire in 2020. The twenty-first Conference of the Parties (COP 21) to the UNFCCC, which will take place in Paris in late 2015, will seek to achieve agreement on a framework for limiting global temperature rise to not more than two degrees Centigrade. In advance of this, the EU has signalled its intention to reduce greenhouse gas emissions by 40% by 2030 and by 80% by 2050 (both relative to 1990 levels).

2.2.2 IEA Cooperation

Ireland was a founding member of the IEA, which was established in 1974 to provide a collective response to major disruptions in the supply of oil, such as the 1973–1974 oil crisis. Today, the IEA works towards improving energy security by:

- Promoting diversity, efficiency and flexibility within the energy sectors of the IEA member countries;
- Remaining prepared collectively to respond to energy emergencies;
- Expanding international cooperation with all global players in the energy markets.

The IEA retains a strong focus on oil and gas, although it also works to promote affordable and sustainable energy.

2.2.3 EU Energy Security

The EU is the world's largest importer of energy, importing 53% of its energy supplies at an annual cost of €400 billion. It has a particular reliance on imported natural gas (66%) and crude oil (>90%)[2]. Energy security is one of the three high-level objectives of EU energy policy and Member States' reliance on energy imports is a focus of policy at EU level.

The European Commission introduced legislation on gas energy security (Regulation (EU) No. 994/2010) in 2010 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. Since then, the European Commission has published two high-level strategy documents that address energy security at EU level.

The first Energy Security Strategy (EC, 2014), was introduced in 2014 amid growing concerns among Member States about their vulnerability to supply disruptions. Among the short-term measures introduced with the Strategy was a series of energy stress tests undertaken by 38 countries. These focused on two simulated energy disruption scenarios:

- A complete cessation of Russian gas imports to the EU;
- 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 help 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 infrastructure links; harmonised external energy policy, and; improving emergency response, enhancing solidarity mechanisms and protecting critical infrastructure.

2 European Commission. Webpage, accessed 11th November 2015. 'Energy Security Strategy'. Available from https://ec.europa.eu/energy/en/topics/energy-strategy/energy-security-strategy.

The second high-level strategy introduced by the Commission, the Energy Union Strategy (EC, 2015b), was published in 2015. 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;
- More transparency on intergovernmental and commercial gas supply agreements, especially with respect to EU law.

'Energy Union and climate' is one of 10 priorities[3] listed by the European Commission and the Energy Union Strategy is part of a broader Energy Union 'package' that also seeks to prioritise electricity interconnection, including the achievement of a 10% electricity interconnection target by 2020 (EC, 2015c).

2.3 National Policy

2.3.1 Energy Security

The 2007 Energy White Paper, Delivering a Sustainable Energy Future for Ireland (DCENR, 2007), emphasised energy security as one of three pillars of Irish energy policy. As part of an ongoing review of national energy policy, Government published a Green Paper on Energy Policy in Ireland (DCENR, 2014), which reaffirmed energy security as a pillar of policy and requested consultation feedback on six 'priority areas' including 'ensuring a balanced and secure energy mix'. A new Energy White Paper is expected late in 2015.

While the DCENR oversees the formulation and implementation of policy with respect to energy security, several other organisations including the CER, the NORA, GNI and EirGrid have specific responsibilities. Several of these responsibilities are summarised in this chapter.

2.3.2 Interaction with Other Policy Areas

The Draft National Risk Assessment 2015 (Department of the Taoiseach, 2015) identified separate risks related to energy security and climate change as requiring national mitigation, specifically:

- Disruption to energy supply and price shocks;
- Climate change and extreme weather.

There is a complex interrelationship between energy security and the other two pillars of national – and EU – energy policy, i.e. sustainability and competitiveness. The interface between energy security and energy sustainability, which has a particular focus on decarbonisation, is particularly noteworthy. On one hand, improving energy sustainability by reducing demand through energy efficiency, and by increasing the contribution of indigenous renewable energy, has the effect of improving energy security. On the other hand, other elements of the energy system that enhance energy security give rise to significant amounts of energy-related greenhouse gas emissions.

For instance, the ongoing generation of electricity from coal and peat, which are among the most carbon intensive fuel sources, contributes to the diversity of Ireland's energy mix and, therefore, to energy security. The availability of cheap coal on European markets, coupled with low carbon prices has increased the amount of coal fired generation in Ireland and Europe. Moneypoint, which is Ireland's only coal plant, is expected to cease operations in its current configuration by 2025 and debate continues as to what should replace it. The choice of replacement technology at Moneypoint will have important implications for the security and sustainability of Ireland's electricity system. Government policy recognises the energy security benefits of certain fossil-fuel technologies and has supported both peat generation and certain amounts of gas fired generation through the public service obligation (PSO) levy. The last of the current PSO support for the peat and gas stations will expire by 2020.

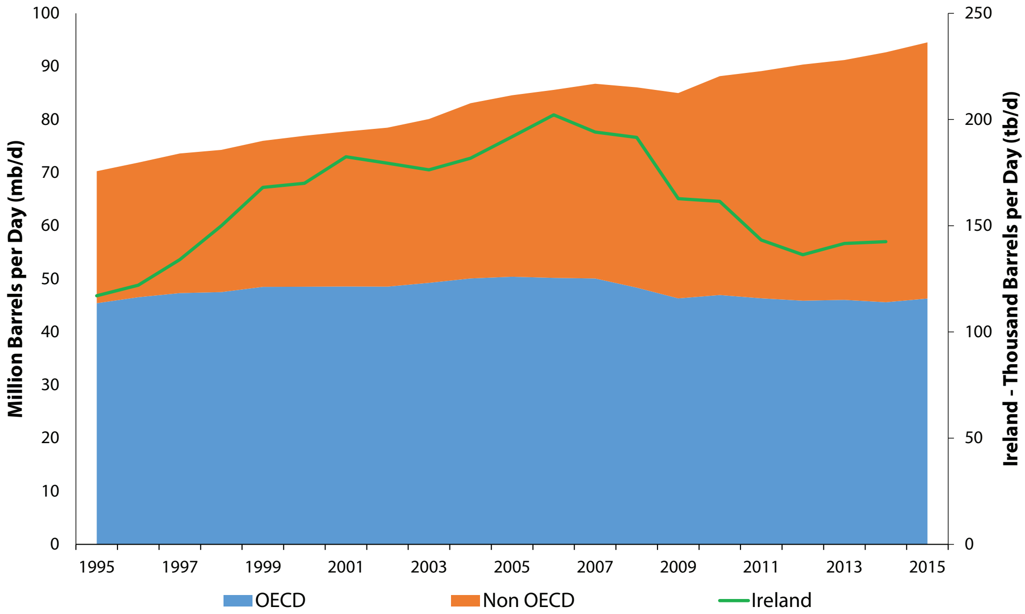
3 European Commission. Webpage, accessed 11th November 2015. '10 Priorities'. Available from http://ec.europa.eu/priorities/index_en.htm.

2.4 Oil

2.4.1 International Developments

Globally, the demand for oil has mirrored the general upward trend in energy demand, with a notable decrease in the 2008–2009 period as a consequence of the economic crisis—see *Figure 2*. In 2014, global oil demand was 92.7 mb/d and it is forecast to increase to 94.5 mb/d for 2015 and 95.7 mb/d for 2016 (IEA, 2015c). This growth will be driven by demand in non-OECD countries. Oil demand in OECD countries reached a plateau in the 2004–2007 period and subsequently dropped from a high of 50.3 mb/d (2005) to 45.6 mb/d (2014), which is similar to the level of demand experienced in the early 1990s.

Figure 2 *Global oil demand 1990–2015*



Source: International Energy Agency

According to the IEA, the global demand for oil will increase to 104 mb/d over the period up to 2040, driven by demand in non-OECD countries, particularly China. This projection accounts for the impact of energy efficiency measures, which will have the effect of reducing demand by 22% (IEA, 2014d). The IEA forecasts that the medium-term growth in oil demand will be met by non-OPEC supplies, mostly from non-conventional sources in the US (tight oil)[4], Canada (oil sands)[5] and Brazil (deep water)[6]. In the longer term, conventional supplies from OPEC producers will be relied upon for increased supply.

In the shorter term, relatively low oil prices are impacting on the production of unconventional and high cost suppliers, which are primarily non-OPEC. While non-OPEC supplies are growing, the growth rates have been tempered by low prices and supplies are projected to reduce in the short term, particularly in the US. It is anticipated that the increase in supply from Iran, an OPEC producer, as a consequence of the easing of international sanctions, will also impact on higher cost suppliers.

2.4.2 Ireland's Demand for Oil

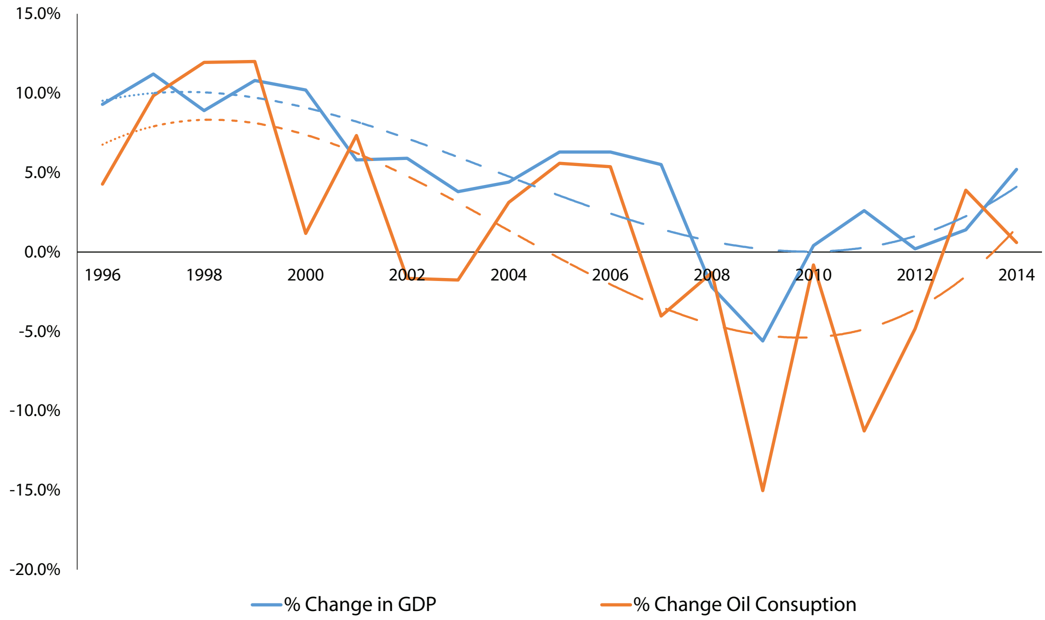
The trend in Ireland is similar to that of the other OECD countries (see *Figure 2*), albeit more pronounced as a consequence of the rapid economic expansion in the late 1990s and early 2000s, and the relative severity of the recession. In general, the demand for oil has been driven by the prevailing economic conditions. *Figure 3* illustrates the relationship between the changes in GDP and oil demand in Ireland since 1996. The solid line shows the annual percentage change in each trend while the dashed lines show the fitted polynomial trend lines for each series. ,

4 Tight oil (also known as Light Tight Oil or LTO) is oil contained in low permeability rock formations. It is an unconventional oil source recovered by the hydraulic fracturing of rock, using the same techniques developed for recovery of shale gas.

5 Oil sands (also know as tar sands) are a combination of clay, sand, water and bitumen. It is an unconventional oil source requiring heavy, expensive, energy intensive processing before it can be converted into useful forms.

6 Deep water oil reservoirs are those that require drilling below a significant depth of sea water; in some cases in depths of over 2,000m of sea water with the reservoir a further 5,000m below the ocean floor.

Figure 3 *Ireland's GDP vs oil consumption*



Source: CSO and SEAI

2.5 Gas

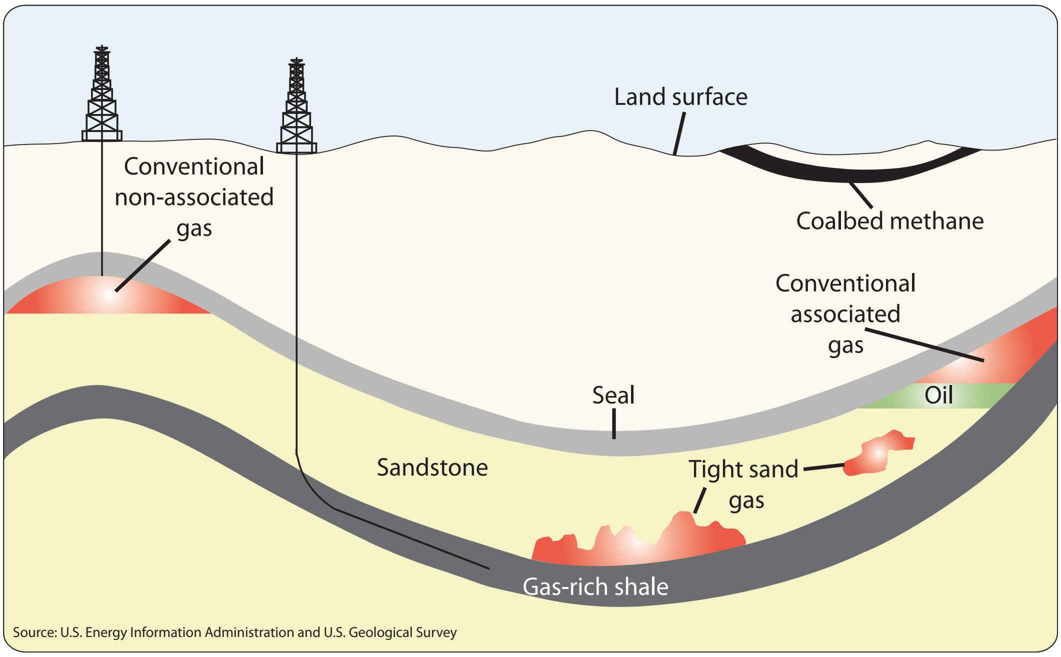
2.5.1 International Developments

The natural gas market has become more global, as more gas pipeline capacity has been developed and inter-regional liquefied natural gas (LNG) trade has grown (IEA, 2014a). Contributory factors include the continuing growth of unconventional gas in North America, which has impacted on inter-regional flows of LNG, and Europe's growing reliance on natural gas imports. The IEA estimates that the volume of gas traded between regions will grow by a further 30% between 2012 and 2018, while OECD Europe's gas production will have dropped by 25% between 2010 and 2020 (IEA, 2015a).

Unconventional gas includes shale gas, coal-bed methane, tight gas (from low permeability reservoirs) and methane hydrates. *Figure 4* illustrates where the different sources of natural gas resources are found. Methane hydrates, which are not shown in *Figure 3*, are solid compounds containing methane trapped within water crystals found under sediments on the ocean floor. Production of unconventional gas in the USA grew from 166 Gm^3 in 2000 to 460 Gm^3 by 2012[7]. Net imports of natural gas to the USA dropped by 56% over this period[8], even though demand for gas increased by over 9%. This significantly reduced the requirement for LNG imports to the USA.

7 IEA. Webpage, accessed 11th November 2015, 'Unconventional gas production database'. Available from www.iea.org/ugforum/ugd/
8 IEA. Webpage, accessed 11th November 2015 'United States Balance 2013'. Available from www.iea.org/Sankey/#?c=United States&s=Balance.

Figure 4 *Schematic geology of natural gas resources*



Source: U.S. Energy Information Administration and the U.S. Geological Survey

After several years of growth, the global demand for natural gas fell by 0.7% in 2014 (IEA, 2015b). European demand and pipeline imports to Europe both dropped significantly due the mild winter conditions throughout the continent in 2014.

The ongoing conflict in Ukraine has raised fresh concerns about European gas security. The previous Russia–Ukraine gas dispute, in 2009, resulted in severe gas disruptions in several countries, especially in Eastern Europe. Since then European gas supply options have been diversified to a degree by increased LNG import capacity and by new transit pipelines for Russian gas that bypass Ukraine. Russia has also signalled its intention to explore gas markets to the east.

The European Commission is currently working on the preparation of a comprehensive LNG and gas storage strategy, which will set out how these technologies can enhance energy security and competitiveness within the EU [9].

2.5.2 Ireland's Natural Gas Supply

In 2012, the IEA (IEA, 2012) concluded that Ireland is 'vulnerable to a gas supply disruption, and would benefit significantly if there were a greater diversification and flexibility of supply in terms of entry points and sources. In this regard, the development of upstream gas fields, such as Corrib, and the proposal to build an LNG terminal in the Shannon Estuary, would be highly beneficial to Ireland's security of supply.'

The Green Paper (DCENR, 2014) also noted the undesirability of an over-reliance on gas, but concluded that the supply of gas from Corrib and the proposals for LNG at Shannon means that Ireland 'looks set to have ample capacity and more diversified supply sources for natural gas, which will enhance security of supply.'

The Corrib gas field, located 83 km off the northwest coast of Mayo, is due to begin gas production late in 2015. The field is expected to supply 77% of the Republic of Ireland's annual demand in its first full year of production. It is expected that the field will have a life span of 15 to 20 years, although production rates will begin to decline after approximately five years (CER, 2014; GNI, 2015).

2.6 Electricity

2.6.1 International Developments

There remains considerable uncertainty regarding the role that nuclear power will play in the aftermath of the 2011 accident at Fukushima Daiichi. The IEA has projected that 190 GW of net additional nuclear generation capacity will

9 European Commission. Webpage, accessed 11th November 2015. 'Consultation on an EU strategy for liquefied natural gas and gas storage'. Available from https://ec.europa.eu/energy/en/consultations/consultation-eu-strategy-liquefied-natural-gas-and-gas-storage.

be added globally in the period 2014–2035 (IEA, 2014c). This compares with estimated net additions of 620 GW, 920 GW and 2,230 GW of coal, gas and renewable generation respectively over the same period.

2.6.2 Relationship between Gas Security and Electricity Security

The reliance on natural gas for power generation in Europe has strengthened the linkages between gas and electricity security. This is particularly relevant for Ireland where gas fired generation represents 46% of electricity production. The CER was established in 1999 as Ireland's independent energy regulator . Its role includes maintaining the security of supply of both electricity and natural gas (CER, 2014).

2.6.3 New Wholesale Electricity Market

The CER and the Utility Regulator in Northern Ireland are currently working on the design of a new wholesale electricity market for the island of Ireland, I-SEM, which will be compliant with new European electricity codes. The high level design of the I-SEM seeks to maximise benefits for consumers in the short-term and long-term, ensuring security of supply and meeting environmental requirements (SEM Committee, 2015).

2.7 Emergency Management

The Task Force on Emergency Procedures (TFEP) was created by the CER in 2005; its role is to identify, implement and monitor procedures to be followed in the event of an emergency on the electricity and/or gas networks (CER, 2007). TFEP consists of representatives from the CER, DCENR, GNI, EirGrid and ESB Networks.

Gas Networks Ireland performs the role of the National Gas Emergency Manager (NGEM), appointed by the CER under Statutory Instrument (SI) 697 of 2007 (GNI, 2015). The NGEM is responsible for preparing the Natural Gas Emergency Plan (NGEP) and for declaring a natural gas emergency. The NGEP may be activated by the NGEM in the event that it is not possible to maintain sufficient balance between supply and demand. The Gas Emergency Response Team may be convened by the NGEM under the NGEP; the team consists of representatives from: NGEM, the CER, EirGrid and DCENR. Due to electricity generation's dependency on gas supply, in the event of a natural gas emergency, EirGrid (as the Transmission System Operator) may be required to load-switch power stations or load-shed electricity customers (CER, 2012).

2.8 Energy Prices

While conflicts in Libya and the Middle East have impacted on oil production in affected countries, the availability of oil from other OPEC countries, as well as from Russia and the USA, coupled with reduced demand in OECD countries has contributed to a collapse in prices since mid 2014. 2015 prices (~US$45–US$65 per barrel) are the lowest they have been since 2009 and are at approximately half the level they were at during the period 2011–2014.

While low oil prices are generally beneficial for energy consumers, they threaten the viability of higher cost oil producers, notably those of unconventional oil in North America. They also have a significant impact on countries whose economies are heavily reliant on oil revenues, for example Russia, Iran, Iraq, Venezuela, Nigeria and Saudi Arabia. The nature and extent of the impact varies between different countries; nonetheless, it has the potential to give rise to geopolitical instability.

There are complex direct and indirect linkages between prices for different energy types in different regions. For instance, unlike crude oil trades, which are priced relatively consistently across the globe, natural gas prices exhibit significant regional variation. The growth in unconventional gas in North America has coincided with a divergence between US and European gas prices since 2007. Although prices have converged somewhat since 2012, US import prices by pipeline remained 46% lower than European prices in 2014 (US$5.11/MBtu[10] versus US$9.54/MBtu) (IEA, 2015b). On the other hand, both American and European LNG prices converged at US$8.5/MBtu in 2014.

The transformation of the US natural gas market has had impacts on the prices of other energy supplies. For example, unconventional gas has displaced some coal from the US generation mix, which has, in turn, given rise to lower coal prices in Europe (DCENR, 2014). This, together with very low carbon prices has led to an increase in coal fired generation output in Europe.

The European carbon price has remained low following the price collapse in 2008 because of a large surplus of allowances arising from lower-than-expected emission levels during the ensuing period of economic turmoil. The European Commission acknowledges that this poses a significant challenge for the EU Emissions Trading Scheme (ETS) and has proposed a number of reform initiatives to tackle it.

10 Million British thermal units (MBtu)

2.8.1 Oil and Gas Exploration

The level of interest in the 2015 Atlantic Margin Licensing Round is encouraging for the prospects of future exploration of oil and gas in Irish offshore waters.

Several exploration licences are held for sites in the Irish territorial waters and in recent years, the Barryroe oil field, located 50 km off the southern coast, was evaluated as a 'large oil discovery with mid-case recoverable oil reserves of circa 300 million barrels' (O'Sullivan, J., 2014). Notwithstanding this discovery, a lease undertaking has not yet been put in place. Given the relatively low oil price, 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 an indigenous supply of crude oil does not appear likely. In the longer term, a commercially viable discovery of oil or natural gas in Irish offshore waters would almost certainly enhance Ireland's energy security.

Unconventional gas exploration and extraction (UGEE) includes the process commonly referred to as hydraulic fracturing of low permeability rock to enable the extraction of natural gas. The Environmental Protection Agency (EPA) is currently coordinating the UGEE Joint Research Programme, which is a multi-agency, cross-border research project on 'the potential impacts on the environment and human health' from UGEE[11]. The publication of the research outputs is expected by the end of 2016. Government has stated that no decision will be made on proposals for the use of UGEE until the results of this research have been considered.

11 EPA. Webpage, accessed 11th November 2015. 'UGEE Research Programme'. Available from www.epa.ie/researchandeducation/research/researchpillars/water/ugee%20research/#.ViS7ZmdOPcv.

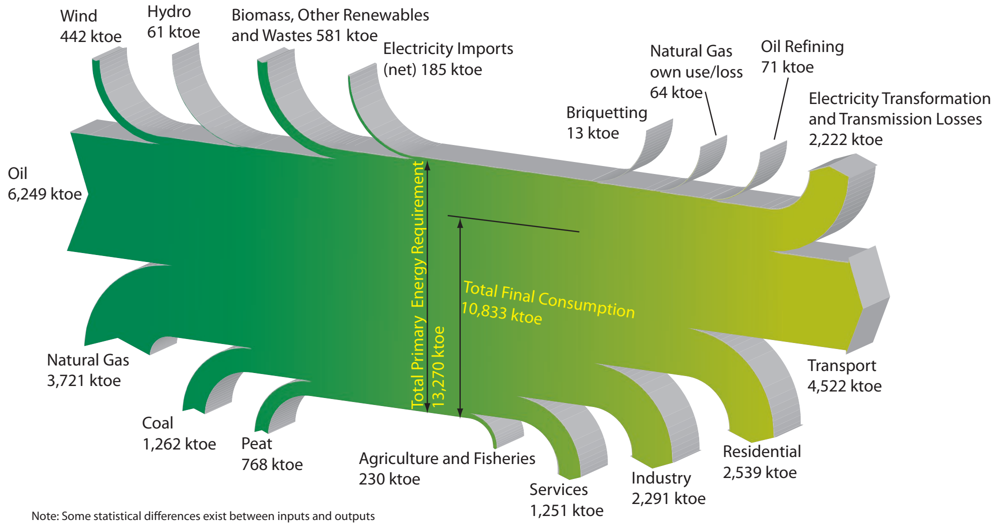
3 Context: Energy Supply, Demand and Prices.

3.1 Supply and Demand

Figure 5 shows the energy balance for Ireland in 2014 as a flow diagram. This provides a useful overview of the energy landscape, illustrating clearly the significance of each of the fuel inputs (by relevant thickness), energy lost in transformation and final energy demand to each of the end-use markets, electricity, thermal and transport.

The main point to note is the dominant role that oil occupies as a fuel of choice, which is primarily due to demand in the transport sector. Other points of relevance include the relatively small overall contribution of renewables, and the fact that electricity transformation losses still account for a significant proportion of primary energy supply (16.7%).

Figure 5 *Energy flow in Ireland in 2014*



Source: SEAI

3.1.1 Supply

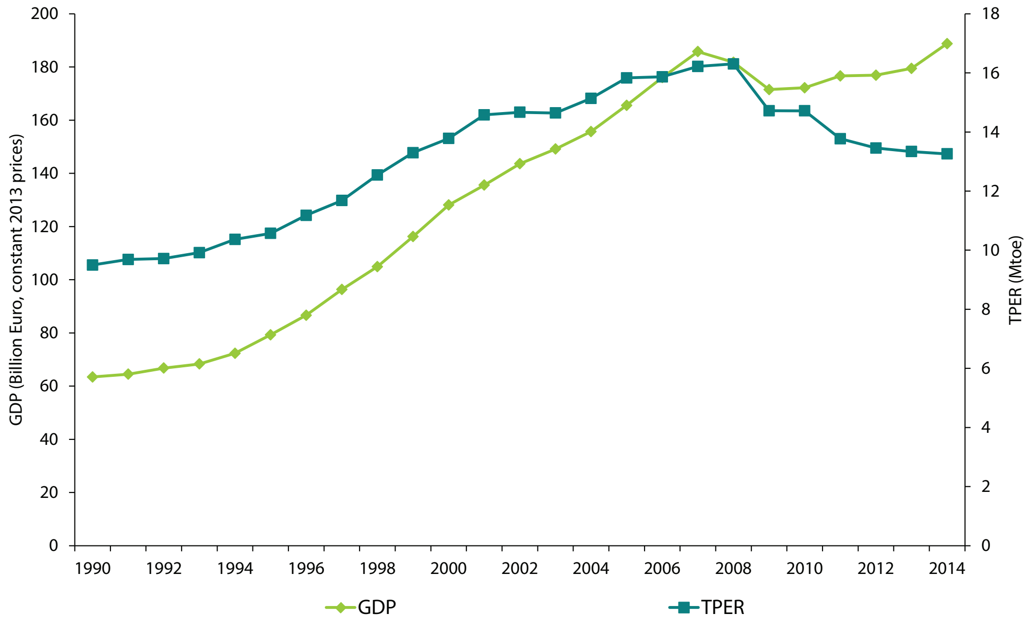
Total Primary Energy Requirement (TPER) is the barometer used to gauge movements in energy supply[12]. TPER is defined as the total amount of energy used within Ireland in any given year. TPER includes the energy requirements for the conversion of primary sources of energy into forms that are useful for the final consumer, for example electricity generation and oil refining. These conversion activities are not all directly related to the level of economic activity that drives energy use but are dependent to a large extent, as in the case of electricity, on the efficiency of the transformation process and the technologies involved. Greater efficiency of transformation will improve energy security as the requirement for energy products is reduced.

Figure 7 shows the trend in energy supply over the period 1990–2014, showing also the trend for GDP. In Ireland the growth in TPER has historically been driven largely by economic growth. After the economic crisis of 2008 Ireland entered a recession with a decline in GDP and a corresponding decline in TPER. From 2010 to 2014, however, there was a decoupling of the two trends, with GDP returning to growth but TPER continuing to decline slightly. The continuing overall decline in TPER since 2010 is a result of competing trends in the various subsectors of the economy, as is discussed further in section *3.1.2*.

Primary energy requirement in Ireland in 2014 was 13.3 Mtoe, down 0.6% for the year and down 18.7% from a peak of 16.3 Mtoe in 2008.

12 Many of the metrics are included in the annual Energy in Ireland reports but are repeated here for their specific relevance to energy security.

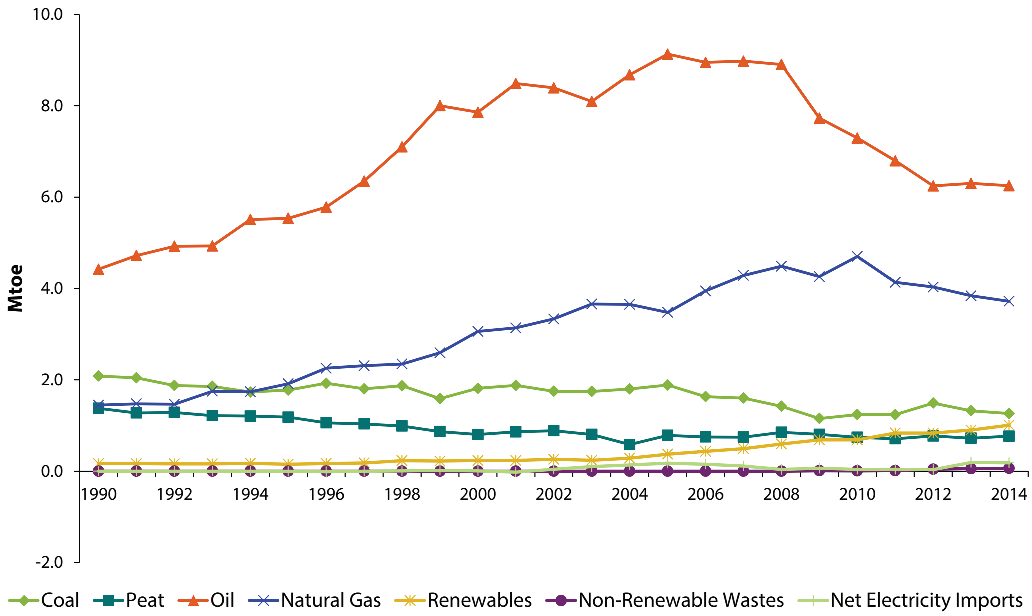
Figure 6 *Total primary energy requirement and GDP 1990–2014*



Source: SEAI

Figure 7 shows the trends for the primary energy supply of each fuel type over the period 1990–2014; *Table 1* presents the underlying data and growth rates for selected years. Oil consumption declined significantly after reaching a peak of 9,130 ktoe in 2005, reducing by 32% to 6,249 ktoe in 2014, but remained the single largest fuel source in that year, accounting for 47.1% of TPER. Natural gas has also reduced in recent years though not as severely as oil. Peak gas demand was reached in 2010, boosted by a severe cold weather late in the year. Between 2010 and 2014 primary gas supply fell by 21% to 3,721 ktoe, accounting for 28.1% of TPER in 2014, up from a a share of 22.2% of TPER in 2000. Renewable energy sources have seen large percentage increases from a low base, reaching a combined total of 7.6% of TPER in 2014. Section *4* provides a more detailed analysis of energy security for each fuel type.

Figure 7 *Total primary energy requirement by fuel type 1990–2014*



Source: SEAI

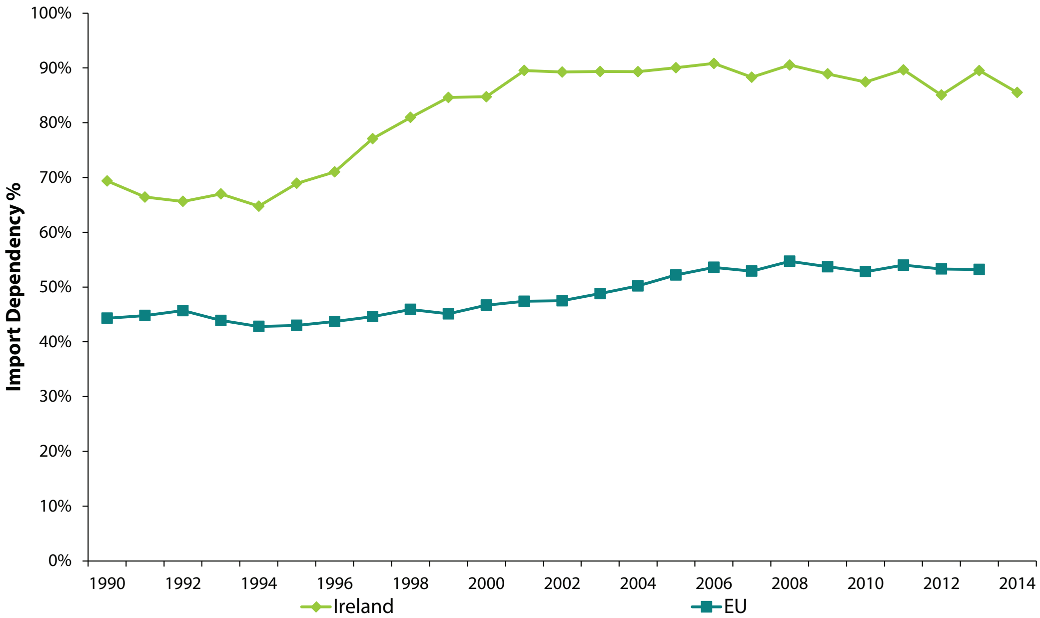
Table 1 *Growth rates, quantities and shares of TPER fuels*

	Quantity (ktoe)		Share		Growth			Annual average Growth		
	1990	2014	1990	2014	1990–14	2000–14	2008–14	2000–05	2005–10	2010–14
Fossil Fuels (Total)	9,330	12,001	98.2%	90.5%	**28.6%**	-11.3%	-23.4%	2.5%	-1.8%	-3.7%
Coal	2,085	1,262	22.0%	9.5%	**-39.4%**	-30.4%	-11.2%	0.8%	-8.0%	0.4%
Peat	1,377	768	14.5%	5.8%	**-44.2%**	-4.3%	-9.9%	-0.4%	-1.1%	0.8%
Oil	4,422	6,249	46.6%	47.1%	**41.3%**	-20.5%	-29.8%	3.0%	-4.4%	-3.8%
Natural Gas	1,446	3,721	15.2%	28.1%	**157.3%**	21.6%	-17.1%	2.6%	6.2%	-5.7%
Renewables (Total)	168	1,010	1.8%	7.6%	**502.0%**	329.6%	69.3%	9.7%	13.0%	10.1%
Hydro	60	61	0.6%	0.5%	**1.7%**	-16.3%	-26.8%	-5.7%	-1.0%	4.3%
Wind	0	442	0.0%	3.3%	-	2006.6%	113.3%	35.4%	20.4%	16.2%
Biomass	105	301	1.1%	2.3%	**185.3%**	165.8%	71.4%	9.8%	3.1%	9.3%
Other Renewables	2	206	0.0%	1.6%	**8618.9%**	634.6%	57.9%	8.9%	33.7%	2.9%
Non-Renewable (Wastes)	0	63	0.0%	0.5%	-	-	-	-	-	64.8%
Electricity Imports (net)	0	185	0.0%	1.4%	-	2092.9%	377.3%	83.6%	-25.5%	46.2%
Total	**9,497**	**13,259**			**39.6%**	**-3.8%**	**-18.7%**	2.8%	-1.4%	**-2.6%**

3.1.1.1 Overall Energy Import Dependency

Ireland is not endowed with significant indigenous fossil fuel resources and as a result has a very high energy import dependency. Between 1995 and 2001 import dependency grew significantly. This was due to both the increase in energy use across all sectors (but particularly in transport), and to the decline in indigenous production of natural gas at Kinsale after 1995, and decreasing peat production. *Figure 8* illustrates the trend in import dependency since 1990 and compares it with that of the EU. Domestic production accounted for 30.6% of Ireland's energy requirements in 1990 but by 2001 that had reduced to 10.5%. It remained at just 14.5% in 2014, resulting in Ireland having an import dependency of 85.5%.

Figure 8 *Import dependency of Ireland and the EU 1990–2014*

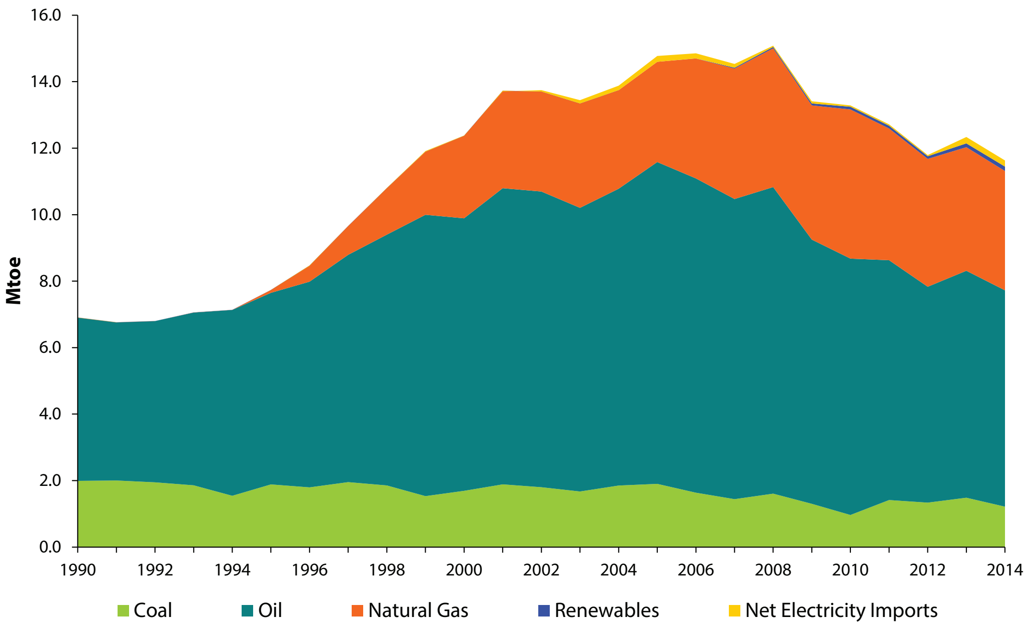


Source: SEAI

Figure 9 shows the trend for net fuel imports (imports minus exports) over the period 1990–2014. Imports peaked in 2008 at 15.1 Mtoe and showed an overall decreasing trend until 2014 when imports were 11.6 Mtoe, a drop of 22.9% from the peak. The dominance of imported oil and gas is clear. Renewable imports consist of both liquid and solid biofuels. Electricity imports come via interconnector from the UK. In 2014 oil accounted for 56% of total imports on an energy basis, natural gas 31%, coal 10%, electricity 1.6% and renewables 1.1%.

Oil imports match the profile of oil TPER given that there is no indigenous production, growing rapidly from the mid nineties, driven largely by transport demand, and reaching a peak in 2005. Similarly for coal, imports match the primary energy requirement which reduced gradually over the time period due to fuel switching in electricity generation and residential heating. Gas imports show the most dramatic increase, due both to the decline of indigenous natural gas reserves at Kinsale and also to the increase in gas demand, driven largely by the increased usage of gas in electricity generation.

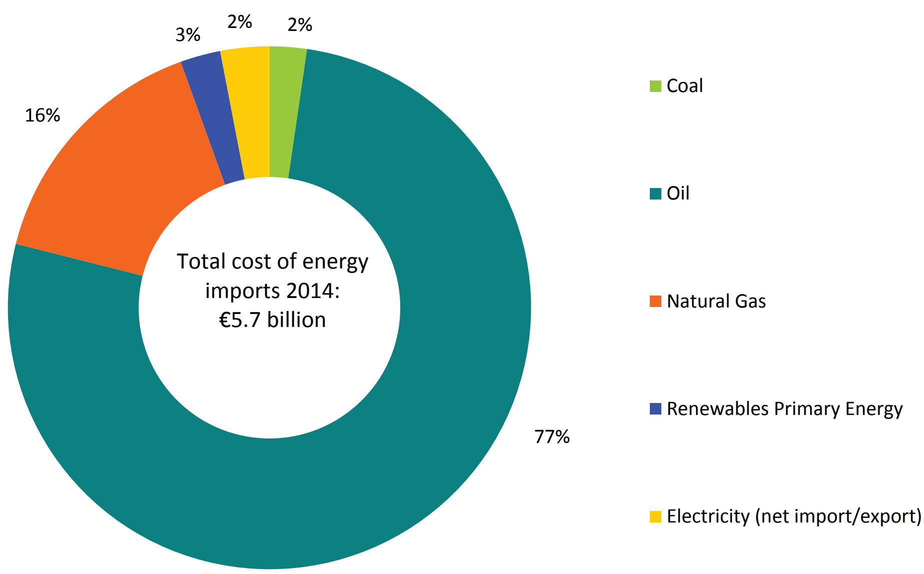
Figure 9 *Imported energy by fuel 1990–2014*



Source: SEAI

Figure 10 shows the estimated cost of Ireland's energy imports by fuel type for 2014. Oil imports dominate Ireland's energy import bill, accounting for an estimated €4.4 billion, 77% of the total cost of energy imports, estimated at € 5.7 billion. This is because of the large proportion of oil imported in energy terms, as seen in *Figure 9*, combined with the high cost of oil and oil products, in particular relative to gas.

Figure 10 *Cost of imported energy by fuel 2014*



Source: SEAI

3.1.1.2 Indigenous Energy Production

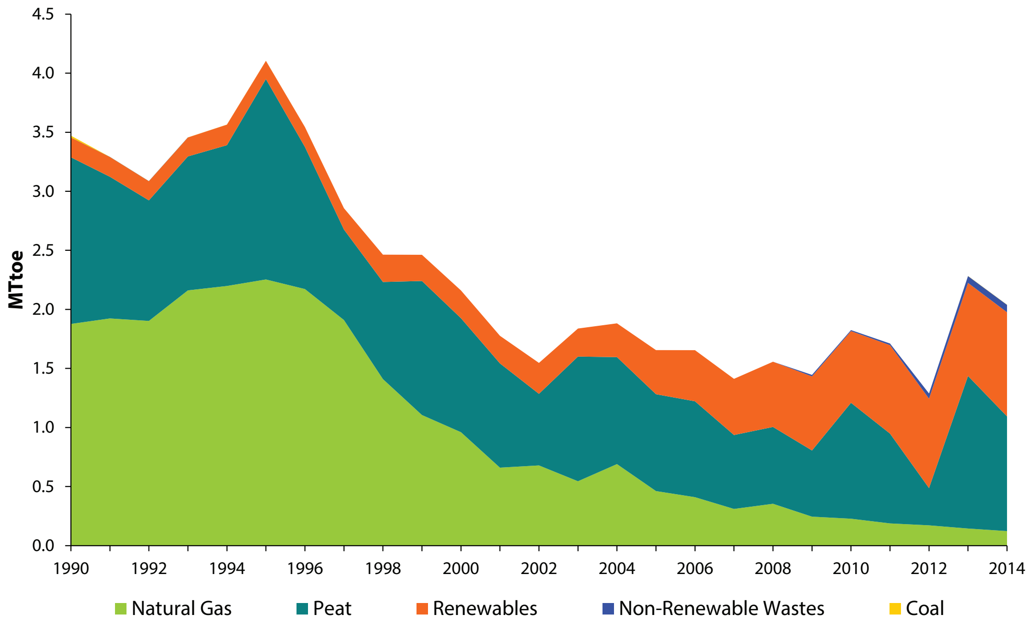
Figure 11 shows the indigenous energy production in Ireland over the period 1990–2014. The overall reduction in indigenous production is largely due to the reduction in natural gas production, and also to the reduced demand for peat. Indigenous gas production peaked in 1995 at 2,253 ktoe but declined sharply thereafter. By 2014 it had fallen to just 123 ktoe, 6% of total indigenous production.

Peat production is weather dependent which leads to spikes in good 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 315 ktoe, with 465 ktoe of peat being used from stockpiles to meet demand. 2013 in turn had good conditions for peat harvesting and 1,292 ktoe of peat was produced (in part to replenish stockpiles), the highest since the earlier spike in 1995. In 2014 peat production was 971 ktoe, 48% of total indigenous production. Overall there has been a declining trend in peat demand and production over the time period.

Countering this reduction in fossil fuel production has been the growth of renewable energy production, coming from a small base prior to 2004. In the ten year period 2005–2014 renewable energy production increased 172% or 12.7% per annum. In 2014 renewable energy production was 882 ktoe and accounted for 43% of total indigenous energy production. Increasing the deployment of renewables is part of the strategy to improve energy security for Ireland.

Non-renewable wastes accounted for the remaining 3% of indigenous production in 2014.

Figure 11 *Indigenous energy sources by fuel 1990–2014*



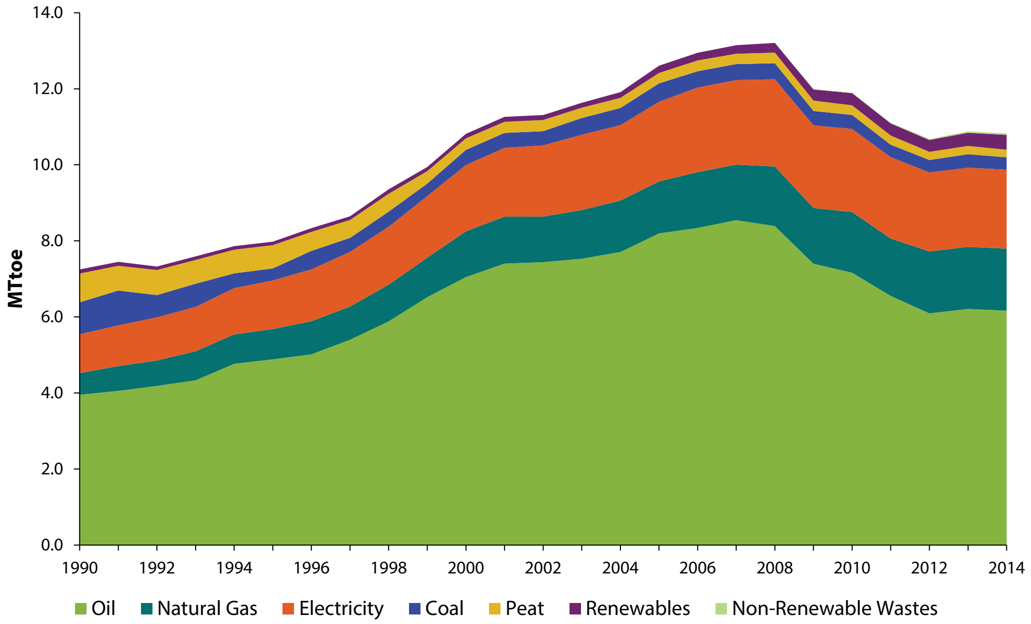
Source: SEAI

3.1.2 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 manufacturing, movement of people and goods, essential services, and other day-to-day energy requirements of living. This is also known as Total Final Consumption (TFC) and is essentially total primary energy less the quantities of energy required to transform primary sources, such as crude oil, into forms suitable for end-use consumers, such as refined oils, electricity, patent fuels, etc. (Transformation, processing and/or other losses entailed in delivery to final consumers are known as 'energy overhead'.) Trends in final energy demand, i.e. the amount of energy used directly by final consumers, are assessed both in terms of the mix of fuels used and the consumption by individual sectors.

Figure 12 shows the shift in the pattern of final energy demand by fuel over the period 1990–2014. Ireland's TFC in 2014 was 10.8 Mtoe, a decrease of 18.0% on the 2008 peak of 13.2 Mtoe, and 49.3% above 1990 levels. Oil dominates, accounting for 56.9% of TFC in 2014, with electricity and gas accounting for 19.2% and 15.1% respectively.

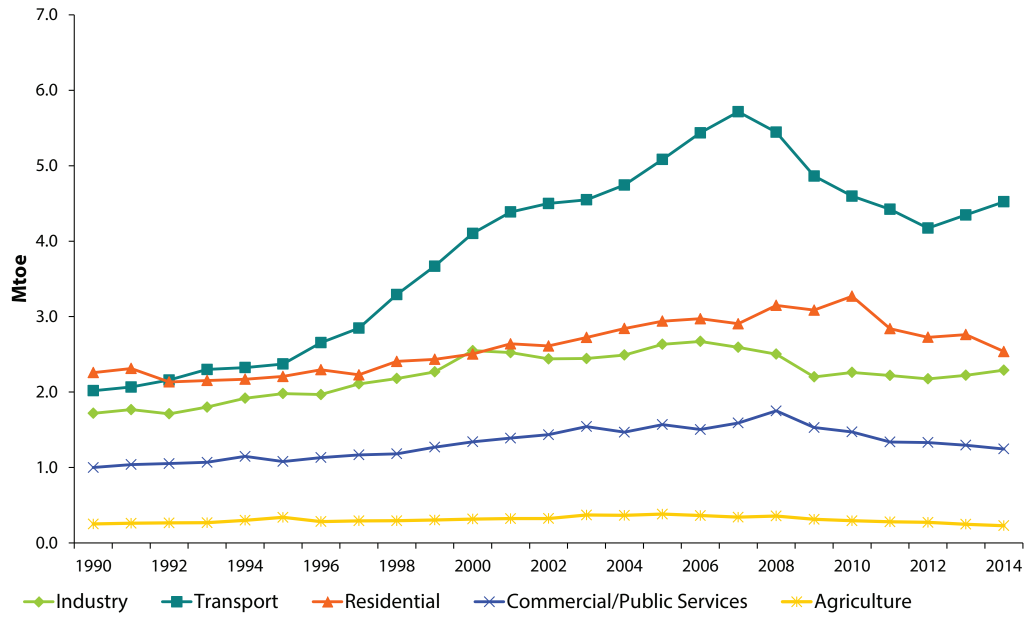
Figure 12 *Total final consumption by fuel 1990–2014*



Source: SEAI

It is also interesting to examine TFC by sector to see where most of the energy is being used, as shown in *Figure 13*. Over the period 1990–2014 the most striking trend was that of transport. In 1990 transport final energy demand was 2,019 ktoe, with a share of 28% of TFC, less than that of residential. At its peak in 2007 transport final energy had grown by 183% to 5,715 ktoe and a 43% share of TFC, almost double that of residential, the next largest sector.

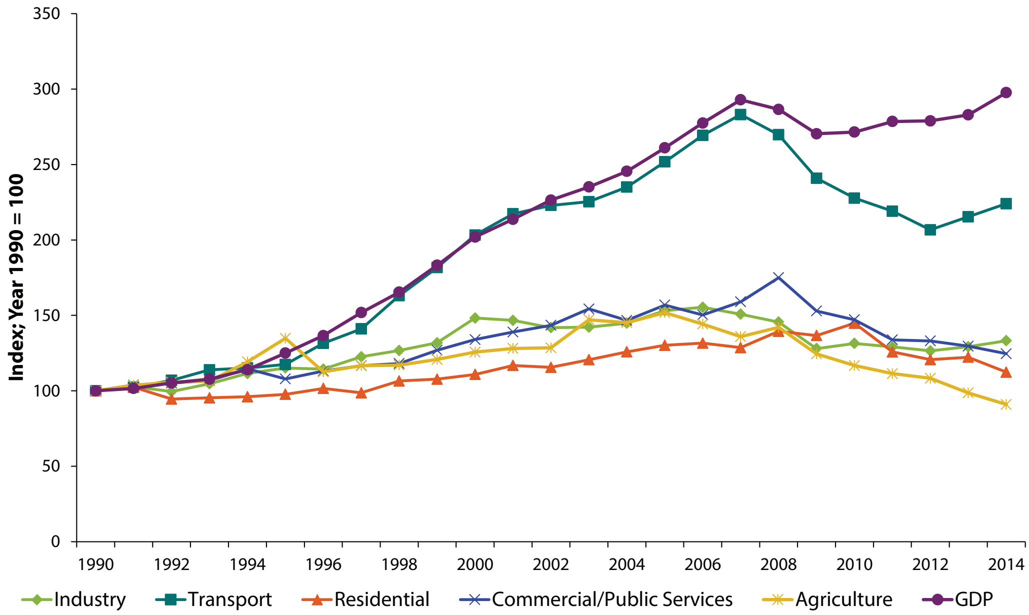
Figure 13 *Total final consumption by sector 1990–2014*



Source: SEAI

During the time period 1990–2007 transport final energy was very strongly coupled to GDP growth, as can be seen from *Figure 14* which shows the trend for the TFC by sector and GDP expressed as indices relative to their 1990 values.

Figure 14 *Index of GDP and total final consumption by sector 1990–2014*



Source: SEAI

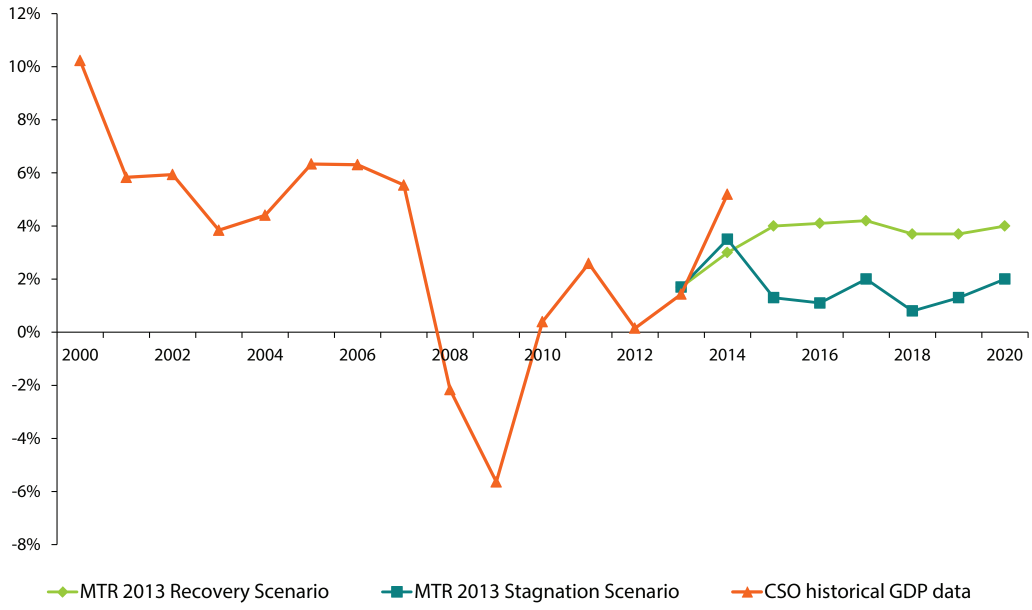
With the onset of the economic crisis in 2008 transport TFC reacted strongly to the fall in GDP, mainly due to a significant reduction in activity in road freight and international aviation. Between 2007 and 2009 GDP fell by 3.3% per annum while transport TFC fell by 7.7% per annum. There was a decoupling of the trends between 2009 and 2012, with GDP growing by 1.0% per annum and transport TFC continuing to decline sharply at 5.0% per annum. The most recent data suggests that this apparent decoupling was a lagged response in transport energy demand and that for 2013 and 2014 transport energy growth has again matched that of GDP, with growth averaging 4.1% and 3.3% per annum respectively for the two years. This has implications for energy security as the transport sector is the dominant driver for imports of oil products. Transport is considered as the most difficult of all sectors to diversify from fossil fuel consumption and decarbonise.

3.2 Macroeconomic Drivers

Energy supply depends on i) the demand for energy services and ii) how that demand is delivered. Energy service demand in turn is driven primarily by economic activity. Projections for economic growth in the current economic climate are being redefined frequently. Energy projections depend on macroeconomic forecasts and fuel-price projections, as well as incorporating envisaged energy policy plans.

Figure 15 shows the historical trend in GDP growth in Ireland from 2000 to 2014, according to figures produced by the CSO. Shown also is a projection of GDP growth for the period 2013–2020 from the Economic and Social Research Institute (ESRI) (ESRI, 2013). As discussed in the previous section, the contraction in GDP in 2008 and 2009, and the sluggish growth from 2010 to 2013, had a significant impact on energy consumption across the economy, particularly on transport. The expected return to stronger, steady growth in GDP in the period 2014–2020 will have a significant impact on energy demand for that period.

Figure 15 *Historical and projected growth in GDP 2000–2020*



Source: ESRI

3.3 Energy Prices

The most significant factor affecting energy prices in Ireland is global oil prices, which have shown dramatic fluctuations in recent years. This has particular effect in Ireland due to Ireland's high dependence on oil. In addition there is the knock-on impact oil prices have on other energy prices, in particular natural gas. As a consequence of the increase in natural gas prices, and because of Ireland's reliance on natural gas for electricity generation, electricity prices have increased.

SEAI publishes a biannual report on electricity and gas prices in Ireland[13] based on the methodology for the revised EU Directive on transparency of gas and electricity prices (European Council, 1990), which came into effect on the 1st January 2008. These reports help with the understanding of the key contributing factors and the precise impact of energy price increases. The new methodology reflects more accurately the actual cost of gas and electricity to final consumers as it incorporates all the factors in the cost of their use.

In the following sections on price, real prices are used for any price comparisons over time. Real prices are where the effects of inflation have been factored in, so essentially they are a 'constant price'.

3.3.1 Carbon Prices

Fossil fuel energy prices are now affected by carbon taxes, depending on their carbon content (coal prices per kWh are affected more than gas). These taxes have been introduced with the aim of encouraging innovation in alternative low carbon technologies. To date carbon taxes have remained too low to impact significantly on energy prices and fuel choices, but they are providing a signal of what may come.

In Ireland a carbon tax of €15 per tonne of CO_2 (€/tCO_2) came into effect in December of 2009, initially solely on liquid based fuels for transport. In May 2010 the tax was extended to liquid fuels for space and water heating in buildings. The rate was increased to 20 €/tCO_2 in December 2011 for transport fuels, and also in May 2012 for liquid fuels for space and water heating. The carbon tax was extended to solid fuels (i.e. coal and peat) from May of 2013, at a lower rate of 10 €/tCO_2. This rate increased to 20 €/tCO_2 after May 2014.

As ETS installations already face a carbon price for their emissions, these installations were excluded from the impact of the new tax. Diesel use in the agriculture sector is effectively exempt from any increases in the tax beyond 15 €/tCO_2 by way of tax reliefs available to farmers. Also, some of the impact of the carbon tax on freight vehicles was unwound by way of a diesel rebate scheme introduced in 2013 that allows some of the costs of excise tax on diesel to be reimbursed to freight operators if the tax inclusive cost of diesel exceeds €1.24.

13 Available from www.seai.ie/Publications/Statistics_Publications/

While the carbon tax is not applied to electricity at the point of purchase, generators in the Single Electricity Market (SEM) are subject to a carbon revenue levy[14] proportional to the carbon emissions of their generation portfolio. All electricity consumers are subject to a PSO levy to support the use of indigenous fuels and renewables. There has also been a small level of excise duty levied on non-household use of electricity since October 2008, called the electricity tax.

3.3.1.1 EU Emissions Trading Scheme

The EU ETS works on the 'cap and trade' principle. A cap, or limit, is set on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system. The cap is reduced over time so that total emissions fall. In 2020, emissions from sectors covered by the EU ETS will be 21% lower than in 2005. The Commission has proposed that by 2030 they would be 43% lower. Within the cap, companies receive or buy emission allowances which they can trade with one another as needed. They can also buy limited amounts of international credits from emission-saving projects around the world. The limit on the total number of allowances available ensures that they have a value. Launched in 2005, the EU ETS is now in its third phase, running from 2013 to 2020.

A large surplus of emission allowances has built up in the ETS since 2009. This has largely been attributed to, by varying degrees, the economic crisis (which has reduced emissions more than anticipated), high imports of international credits, and renewable energy policies. This surplus has led to a persistent depressed price for carbon (on average less than 8 €/tCO_2 for 2015) and thus a weak incentive to reduce emissions.

As a short-term measure the Commission postponed the auctioning of 900 million allowances[15] until 2019/20. This 'back-loading' was implemented through an amendment to the EU ETS Auctioning Regulation, which entered into force on 27th February 2014. Back-loading of auction volumes does not reduce the overall number of allowances to be auctioned during phase 3, only the distribution of auctions over the period.

As a long-term solution, changes will be introduced to reform the EU ETS by establishing a market stability reserve, which will be established in 2018 and become operational on 1st January 2019. The back-loaded allowances will be placed in the reserve in 2019, and it is intended that any remaining allowances not allocated by the end of the current trading phase in 2020 should also be placed in the reserve.

The Commission has also proposed a broader review of the EU ETS for the phase 4 period 2020–2030. The Commission points out that to achieve the target of a minimum 40% reduction in EU emissions, the sectors covered by the EU ETS will have to reduce their emissions by 43% compared with 2005, and proposes that to achieve this the overall number of emission allowances should decline at an annual rate of 2.2% from 2021 onwards, compared with 1.74% currently. This amounts to an additional emissions reduction in the sectors covered by the EU ETS of some 556 million tonnes over the decade. The proposed reforms also address issues around carbon leakage and the establishment of support for energy sector modernisation and low carbon innovation.

3.3.2 Oil Prices

Oil is a commodity traded on the international market and crude oil prices are dependent on market forces. The market forces that principally influence oil prices are supply and demand. Global economic growth patterns and political stability are two factors that may impact on the supply or demand, as discussed in section *3.1*. As Ireland is neither a producer nor a significant world player in terms of demand, it cannot influence the price of oil.

Figure 16 shows the spot price, in US dollars per barrel, of European Brent oil from July 2007 to July 2015. Since 2000, oil prices grew steadily and, since 2004, have not returned to the cheap price of $30 per barrel. Oil prices post 2005 were driven by rapid economic growth in China and India in particular, without an accompanying rise in supply, and they peaked in July 2008 at more than $140 per barrel. The effect of the recession on oil prices is clearly visible, with the dramatic reduction in price (to as low as $34 per barrel in December 2008) due to falling oil demand. Prices recovered to exceed the $100 per barrel mark in February 2011 and achieved a relatively stable high oil price, fluctuating around $110 per barrel until 2014. This period of stable, record high oil prices allowed for the exploitation of large reserves of unconventional oil and gas that had been uneconomic to exploit at previous lower prices.

This period of high oil prices came to end in September 2014 when prices dropped back below $100 per barrel and continued to fall until January 2015, bottoming at $45 per barrel. The average price in the first six months of 2015 was $58 per barrel. The IEA, in its 'Medium Term Oil market Report 2015', notes that unlike previous sharp price drops, the most recent one is both supply and demand driven. On one hand there was record non-OPEC supply growth in 2014 driven by North American non-conventional oil production. On the other was unexpectedly weak demand growth as major emerging economies such as China enter into a period of economic development that is less oil

14 Electricity Regulation (Amendment) (Carbon Revenue Levy) Act 2010.

15 One allowance is equivalent to the right to emit one tonne of carbon dioxide.

intensive than previously forecast. Further demand-side issues include the recasting of national energy policies in light of climate-change concerns and increased fuel competition due to the increased globalisation of the natural gas market and steep reductions in the cost of renewable energy technologies.

Figure 16 *European crude oil spot prices 2007–2015*

Source: U.S Energy Information Agency 2015

3.3.3 Natural Gas Prices

The International Gas Union (IGN) provides a detailed analysis of both global gas price trends and changing global gas price formation mechanisms (IGN, 2015), a brief summary of which is provided here.

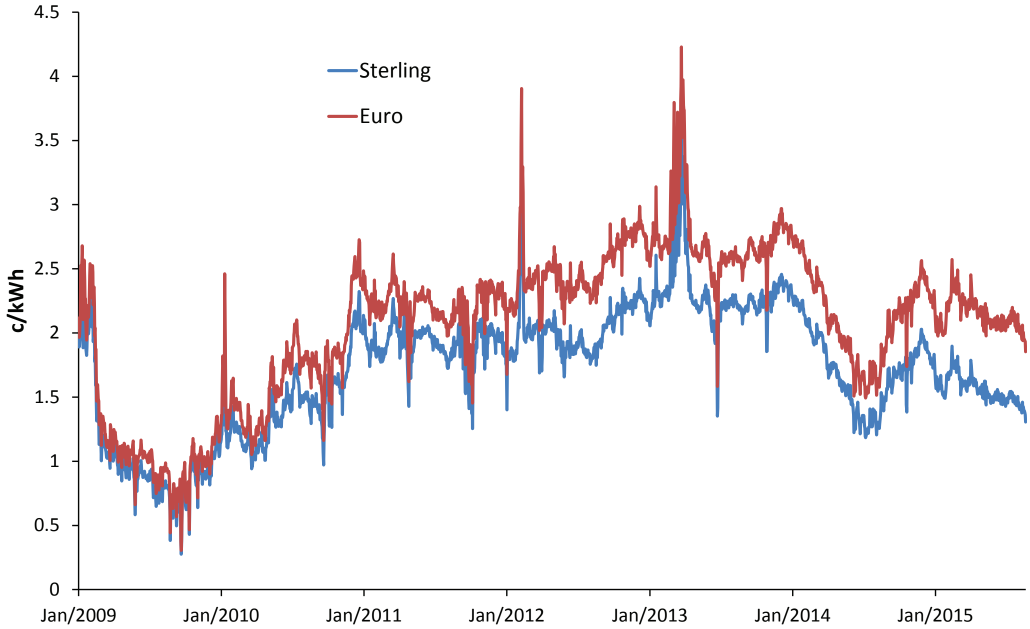
Traditionally gas prices have been linked to oil prices with varying time lags and linkages. This type of pricing mechanism is referred to as Oil Price Escalation (OPE), where gas price is linked, usually through a base price and an escalation clause, to a competing fuel, typically crude oil or another oil product. There are a number of alternative pricing mechanisms, the most important of which is Gas-on-Gas Competition (GOG). In this case gas price is determined by the interplay of supply and demand. Trading takes place at physical hubs (e.g. Henry Hub in the US) or notional hubs (e.g. National Balancing Point (NBP) in the UK) and over a variety of different periods (daily, monthly, annually, or other periods).

Europe is one of the regions where the most significant changes in price formation mechanisms have taken place. There has been a broadly continuous move from OPE to GOG since 2005. In 2005 78% of European gas was priced by OPE and 15% by GOG; in 2014 OPE accounted for 61% and GOG 32%. Initially there was a decline in the volume of gas imported under the traditional oil indexed contracts, with the balance being replaced by imports of spot gas and through increasing volumes being traded at hubs. Subsequently these traditional contacts have been allowed to expire or the terms have been renegotiated to include a proportion of hub/spot price indexation in the pricing terms. The renegotiations have also seen the introduction of hybrid pricing formulas where oil indexation is partly maintained within a price corridor set by hub prices.

The trend towards GOG and away from OPE was reinforced by the continued decline in domestic production in the UK through the old legacy contracts, which are in the OPE category, and its replacement by pipeline and LNG imports, all at GOG. Northwest Europe (i.e. Belgium, Denmark, France, Germany, Ireland, Netherlands, UK) has seen the most dramatic change in price formation mechanisms, with a complete reversal in the ratio of OPE to GOG, from 72% OPE and 27% GOG in 2005 to 12% OPE and 88% GOG in 2014, as a result of increased hub trading and contract renegotiations, as noted above.

Ireland currently relies on the UK for all of its natural gas imports, accounting for 96% of gas use in 2014. The UK system average gas price from 2009 to 2015 is given in *Figure 17*.

Figure 17 *UK national balancing point gas price 2009–2015*



Source: UK Transmission National Grid (Gas)

In 2009, as oil prices increased, gas markets with strong linkages to oil prices, including most of continental Europe, saw prices averaging about 9 $/MBtu[16]. In North America and the UK (and hence also Ireland), prices averaged less than half this level, on an energy basis around one-thirdthat of oil (IEA, 2011). This resulted in gas prices in Ireland being lower than the EU average during 2009 (SEAI, 2010). In 2010, this situation changed however, as gas prices in the USA and the UK decoupled, with USA prices remaining low and UK prices increasing and realigning with European prices as LNG imports to Europe increased steadily (EC, 2010).

The latest European Commission quarterly report on European gas markets notes that the NBP spot price for the first half of 2015 was stable relative to the variations seen in 2014, but that there was a clear downward trend as falling oil prices and steady LNG supply put pressure on European hub prices. It further notes that the German border price closely followed the development of NBP and that this suggests that Germany's gas trading partners have turned to hub based pricing (EC, 2015a).

3.3.4 Electricity Prices

There are a number of components which determine the price of electricity. The generation mix, which is mostly made up of fossil fuels in Ireland, is a critical component. This is particularly significant with respect to an electricity fuel mix that relies on internationally traded fuels such as gas, oil and coal. During periods of volatile price movements in these fuels there is a strong knock-on impact on electricity prices. 45% of Ireland's electricity was generated from natural gas in 2014 (down from a high of 61% in 2010), therefore the variability in the price of natural gas significantly impacts on the price of electricity in Ireland. Other factors that affect electricity prices include the level of competition in electricity generation, labour costs, taxation policy and the level of investment in infrastructure (i.e. improving the transmission and distribution networks).

The wholesale cost of electricity is established by the SEM and reflects the generator's fuel and short-term operating costs. A carbon revenue levy is imposed on all generators in the SEM that is proportional to the emissions of their generating portfolio. Capacity payments are made to generators based on a measure of their availability. These payments are required to ensure the expected demand of the system is met even under situations of unexpected failure of generation during system peak demand or unusual or unanticipated increases in demand.

There are charges for the use of the transmission and distribution systems know as use of system charges (Transmission Use of System (TUoS) and Distribution Use of System (DUoS)). These use of system charges are regulated by the CER and are used to invest in the electricity infrastructure. There are also supplier administration costs. There are a number of taxes and levies on electricity in Ireland. Value Added Tax (VAT) is applied to the base price of electricity at a rate of 13.5%. VAT can be recovered by businesses.

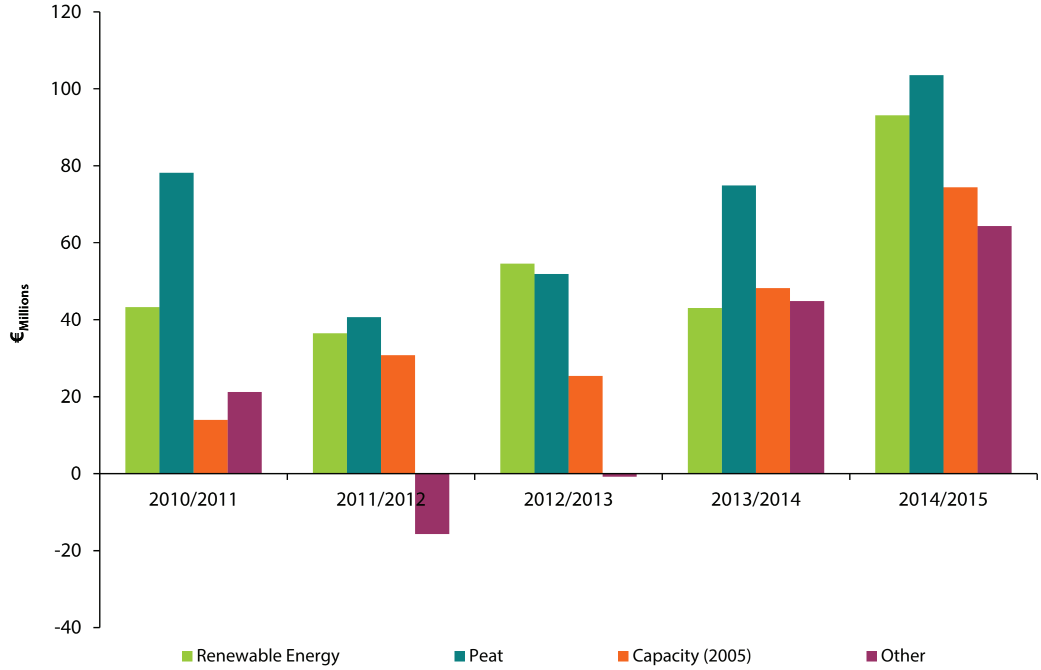
16 1 MBtu (million British Thermal Units) = 293 kWh

In accordance with the EU Energy Tax Directive, the Finance Act 2008 introduced excise duty, called electricity tax, on supplies of electricity made on or after 1st October 2008. 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. This is not applied to electricity for residential use.

The PSO levy is charged to all electricity customers. It is designed to support the national policy objectives of energy security, the use of indigenous fuels (i.e. peat) and the use of renewable energy sources in electricity generation. Specifically, the proceeds of the levy are used to recoup the additional costs incurred by all suppliers by having to source a proportion of their electricity supplies from such generators.

The levy, which is calculated by the CER in accordance with the relevant legislation and particular terms of the various PSO schemes, is recoverable from all final customers of electricity, based on the proportion of maximum demand attributed to each category of accounts (Domestic, Small/Medium, and Large). *Figure 18* shows the cost breakdown for the PSO from 2010 to 2015.

Figure 18 *PSO cost breakdown 2010–2015*



Source: Commission for Energy Regulation (CER)

In the four years prior to 1st October 2010 the PSO levy was effectively set at zero for various reasons (CER, 2010a). This changed for the 2010/2011 period. In that period, peat generation accounted for 50% of the levy, renewables 28%, capacity 9% and other (admin and R-factor correction[17]) 14%. For the 2014/2015 period peat accounted for 31% of the positive costs of the total PSO, renewables 28%, capacity 22% and other 19%. Since 1st October 2014 domestic electricity consumers have been charged a flat rate of €5.36 per month for PSO, a 50% increase on the previous year. Small business consumers had a flat rate charge of €18.47 per month in 2014/2015, a 71% increase on 2013/2014. Medium and large business consumers were charged at a rate of €2.85 per month per kVA of maximum import capacity—up 85% on the previous year.[18]

SEAI and EirGrid conducted a joint modelling exercise to investigate the impact of increased wind generation on electricity generation costs in 2011 (SEAI and EirGrid, 2010; Clancy et al., 2015). The study concluded that while capital costs of wind energy plants are higher than conventional generation, wind energy can act as a hedge against high fuel costs by depressing the wholesale cost of electricity. A recently published study carried out by the ESRI (Lynch and Curtis, 2015) found that increased wind generation reduces average electricity production costs but does not necessarily lead to a corresponding decrease in consumer costs, providing a benefit to electricity producers. The authors also conclude that increased wind generation acts as a hedge against very high electricity prices in high fuel price scenarios, reducing the variance in electricity prices.

17 R-factor is the over or under recovery of PSO in the previous period.

18 For more information on the PSO charge for 2014/15 see SEAI's report 'Electricity & Gas Prices in Ireland: 1st Semester (January – June) 2014'. Available from www.seai.ie. See also www.cer.ie

4 Energy Security Examination by Fuel

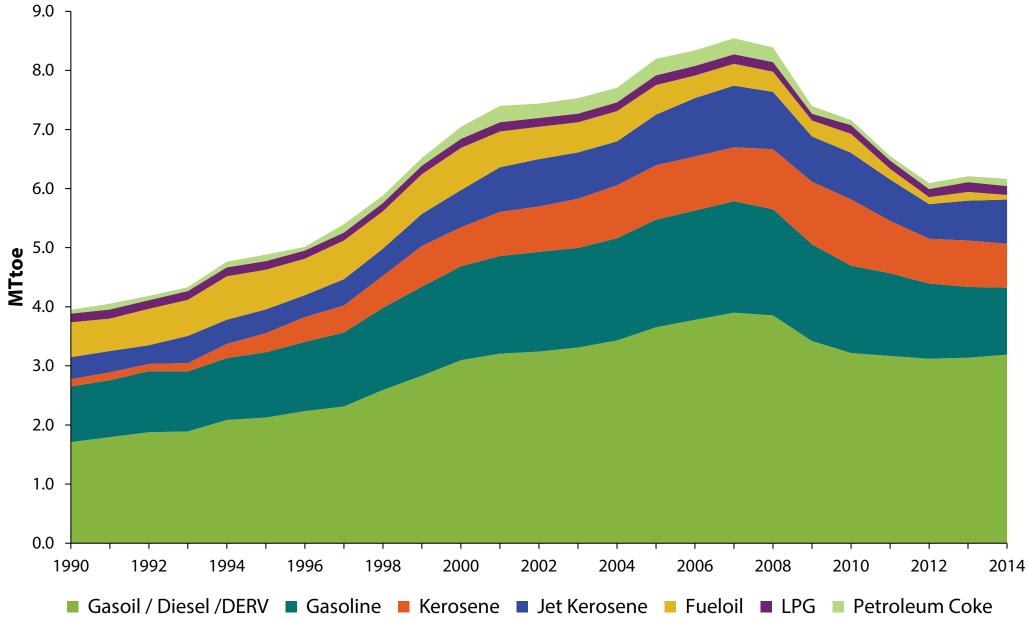
4.1 Oil

4.1.1 Oil Usage

According to EU statistics[19], Ireland's oil dependence, as a proportion of gross inland consumption, was the fourth highest of the 28 EU Member States in 2013 at 49%. Of the three Member States more oil dependent than Ireland the top two were the small island states of Cyprus and Malta which have oil dependencies of over 90%; the other was Luxembourg. Despite this Ireland is clearly a minor consumer in overall terms, accounting for approximately 1.2% of total European consumption and just 0.16% of global consumption.

Figure 7 and *Table 1* in Section *3.1.1* show the trends for the primary energy supply of oil by fuel type[20] over the period 1990–2014. Oil remained the dominant fuel used in Ireland in 2014 at 47.1% of the TPER. This was a decrease from a peak dependence on oil of 60.2% of TPER in 1999. By 2012 this had fallen to 46.4%, marginally lower than in 1990, making it the lowest share recorded over the whole period 1990–2014. In absolute terms oil consumption has declined significantly since reaching a peak of 9,130 ktoe in 2005, reducing by 32% to 6,249 ktoe in 2014, as can be seen in *Figure 19*.

Figure 19 *Final consumption of oil by fuel type; 1990–2014*



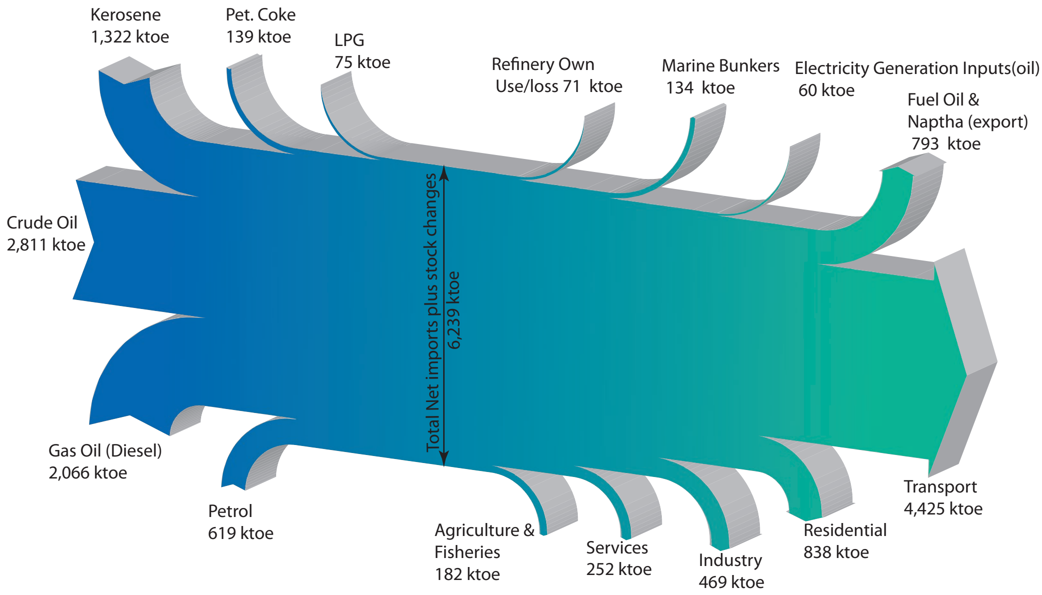
Source: DCENR (Oil Division)

Figure 20 shows the oil balance for Ireland as a flow diagram for a single year, 2014. 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.

19 Eurostat. Database, accessed 11th November 2015. Available from http://ec.europa.eu/eurostat/data/database.

20 In the refining process crude oil is split into various fractions, for example gasoline (also known as petrol, used as transport fuel) and fuel oil (used in power stations).

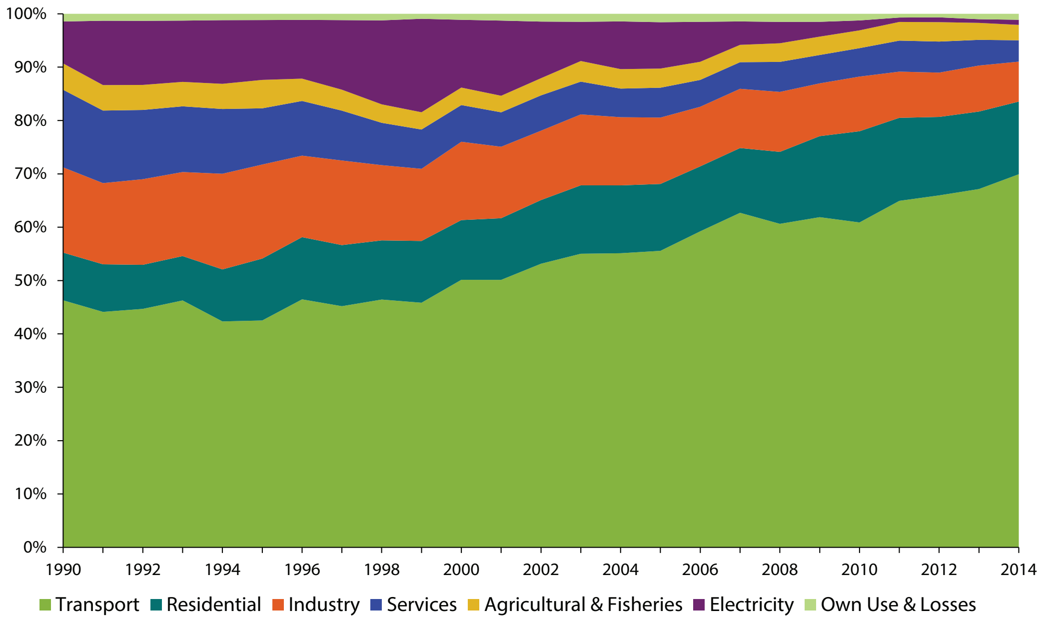
Figure 20 *Oil energy flow 2014*



Source: SEAI

Figure 21 shows the share of oil used by end-use between 1990 and 2014. The clear trend is the increasing dominance of the transport sector in driving oil demand. In 2014, 70.5% of oil TPER excluding non-energy uses (e.g. lubricants) was for transport. The next largest end-use of oil was in the residential sector which accounted for 13.7% of oil TPER. Oil remained a significant fuel source in the residential sector in 2014 accounting for 34% of TFC.

Figure 21 *Share of oil TPER (excluding non-energy use) by end-use 1990–2014.*

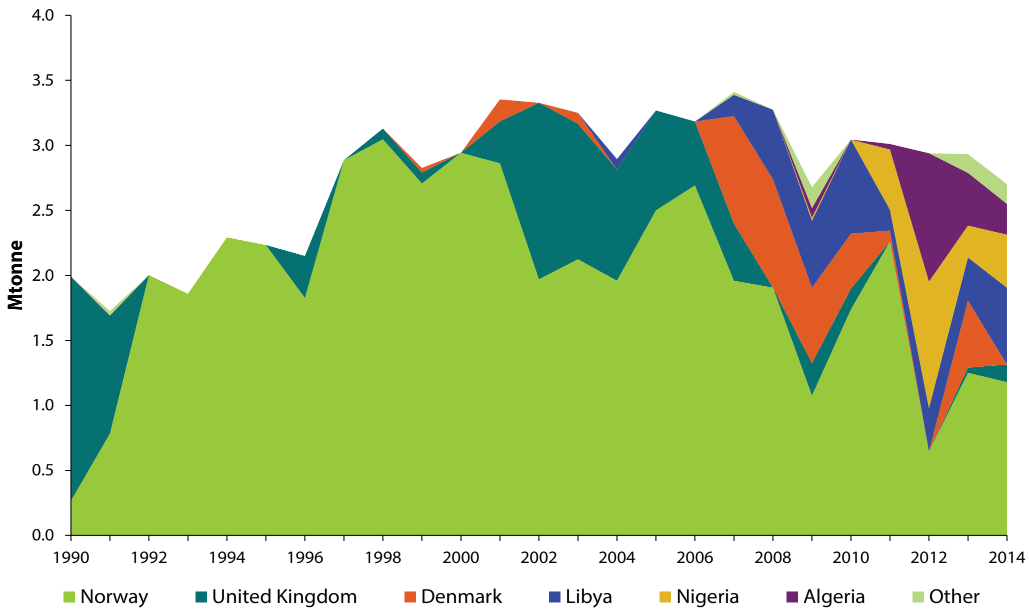


Source: SEAI

4.1.2 Oil Imports

Figure 22 illustrates where the crude oil used in Ireland is sourced. Over the time period examined most of Ireland's crude oil was sourced in Norway and the UK. Since 2009 the source of crude has become more variable; in 2011 22% of crude imports came from Libya, Nigeria and Algeria, in 2012 these three countries supplied 78% of crude imports, and in 2013 33%. Provisional data for 2014 suggests approximately 48% of crude came from African countries, 49% from the EU and 3% from Canada. This reflects the global nature of the international crude oil market.

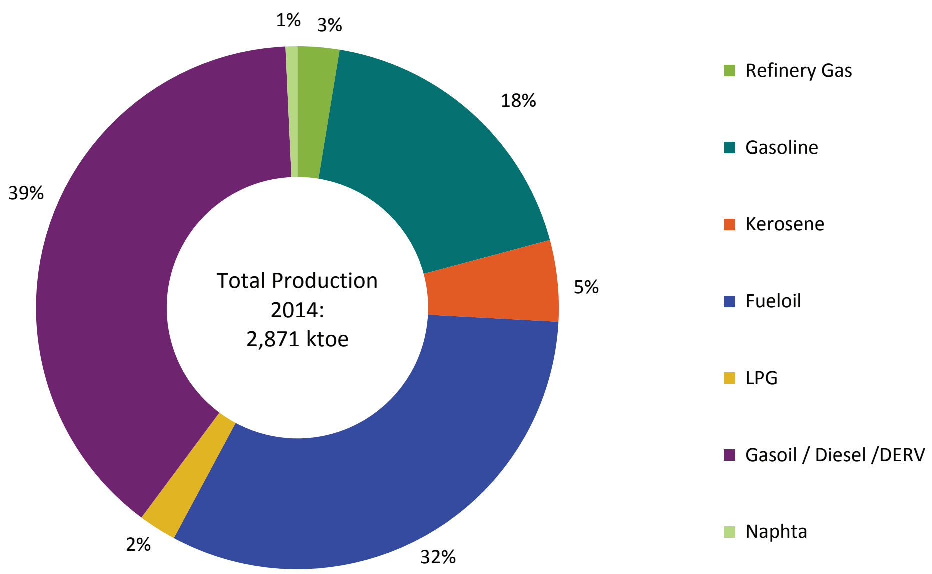
Figure 22 *Ireland's crude oil imports 1990–2014*



Source: DCENR (Oil Division)

Ireland has one oil refinery, located at Whitegate, Co. Cork, which is currently operated by Phillips 66. The crude capacity of the Whitegate facility is 71,000 barrels per day (27.4 million barrels per year). In 2014, the facility produced 2,871 ktoe of oil products[21]. *Figure 23* provides a breakdown of transformation outputs from the Whitegate refinery in 2014 by product type. In 2014, the refinery also exported 1,406 ktoe of crude oil and oil products abroad, mostly to the UK.

Figure 23 *Whitegate refinery production 2014*

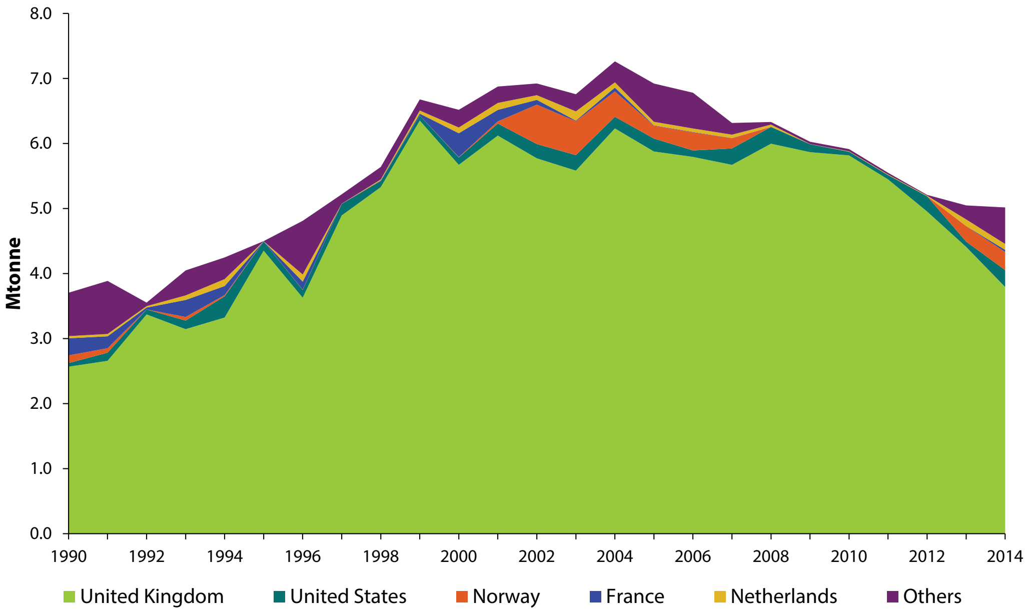


Source: ConocoPhillips

21 Note that 2014 was not a typical year at Whitegate as there was a full shutdown for maintenance and investment programmes, which typically occurs once every five years. During the shutdown Whitegate imported finished oil products.

Crude oil accounted for 37% of the total oil imported to Ireland for energy uses in 2014, meaning that the majority of oil imported to Ireland is in its final product form (petrol/diesel/kerosene, etc.). The UK is the main source of Ireland's oil product imports, as illustrated in *Figure 24*. Provisional data for 2014 shows that 76% of oil product imports were from the UK, with the next three largest sources being Sweden, Norway and the USA accounting for 6.1%, 5.6%, and 5.2% respectively. Inland distribution of oil products within Ireland is by road from a number of marine terminals and the road loading facility located at the Whitegate oil refinery.

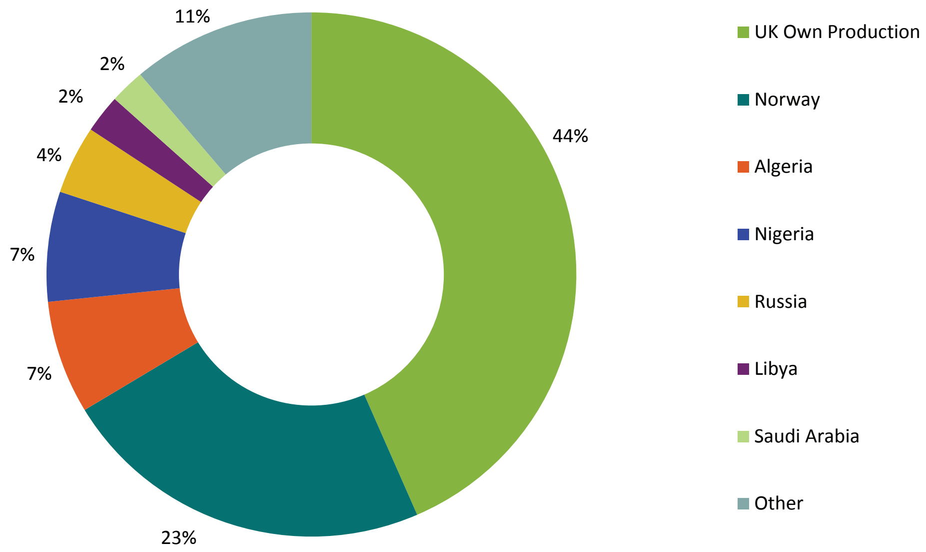
Figure 24 *Ireland's oil product imports 1990–2014*



Source: DCENR (Oil Division)

As Ireland depends heavily on the UK for oil product imports it is worth examining the UK petroleum industry more closely. Comprehensive data and commentary on UK energy statistics are provided in the UK Department of Energy and Climate Change (DECC) Digest of UK Energy Statistics (DUKES), which include separate sections on the natural gas and petroleum industries (DECC, 2015). The 2015 report notes that an active oil industry and trade in the UK leads to significant volumes of both crude oil and oil products being imported and exported to meet global and UK demand. The UK has been a net importer of crude oil since 2011 when imports surpassed exports. Despite this the UK's own North Sea production remains significant; in 2013 the UK produced more crude oil than any other country in the EU, and the second most in the European Economic Area after Norway. The UK's production of crude oil and natural gas liquids would be sufficient to meet nearly two thirds of UK domestic refinery demand. Crude oil exports decreased slightly in 2014 and, at 28 million tonnes, are now at their lowest level since 1978. In the future further declines in crude exports and increases in imports will be seen, as indigenous crude production continues to decline. *Figure 25* shows the UK's domestic production of crude oil and its imports in 2013.

Figure 25 *UK crude oil production and imports 2013*

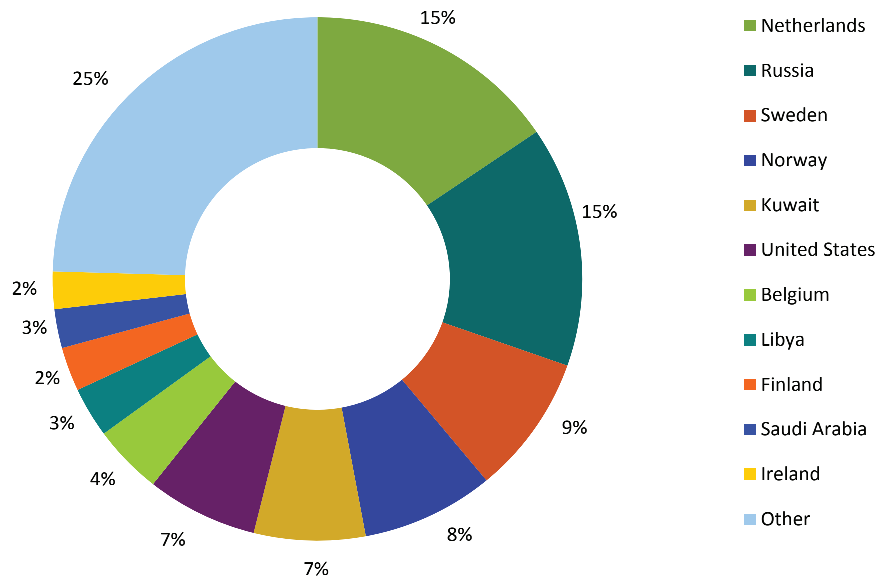


Source: Eurostat

A significant proportion of the UK's domestic crude oil production was processed into petroleum products at the UK's six oil refineries. This is despite the fact that, since 2008, three refineries have shut and capacity at some of the remaining plants has been rationalised, resulting in refining capacity at the end of 2014 being 25% lower than in 2008.

In 2014, the UK was a net importer of oil products, as well as crude oil. In particular, the 2015 DUKES report notes that the UK is a large importer of road diesel and jet kerosene. Diesel imports are required in part due to the recent increased dieselisation of the UK car fleet, which has increased diesel demand and decreased that for petrol, resulting in a misalignment with domestic refinery production, which is geared towards petrol production. *Figure 26* shows the source of UK oil product imports in 2013. The Netherlands, Russia and Sweden were major suppliers of diesel while Asian states such as Kuwait supplied large amounts of jet fuel (from generally more modern refinery operations than those in Europe).

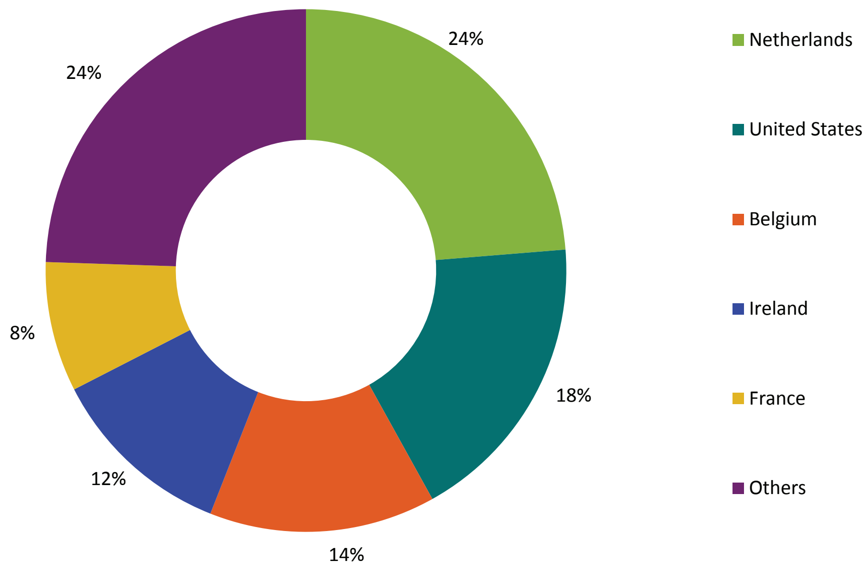
Figure 26 *UK oil product imports 2013*



Source: Eurostat

Figure 27 shows the destination of exports of petroelum products from the UK, excluding crude oil, in 2013; Ireland accounted for 12%. Of the products exported to Ireland in 2013, 43% was diesel, 20% jet kerosene, and 16% petrol. Note that Ireland has no indigenous production of aviation fuel and typically imports it all from the UK.

Figure 27 *UK exports of oil products, excluding crude oil 2013*



Source: Eurostat

4.1.2.1 Oil Market Disruptions

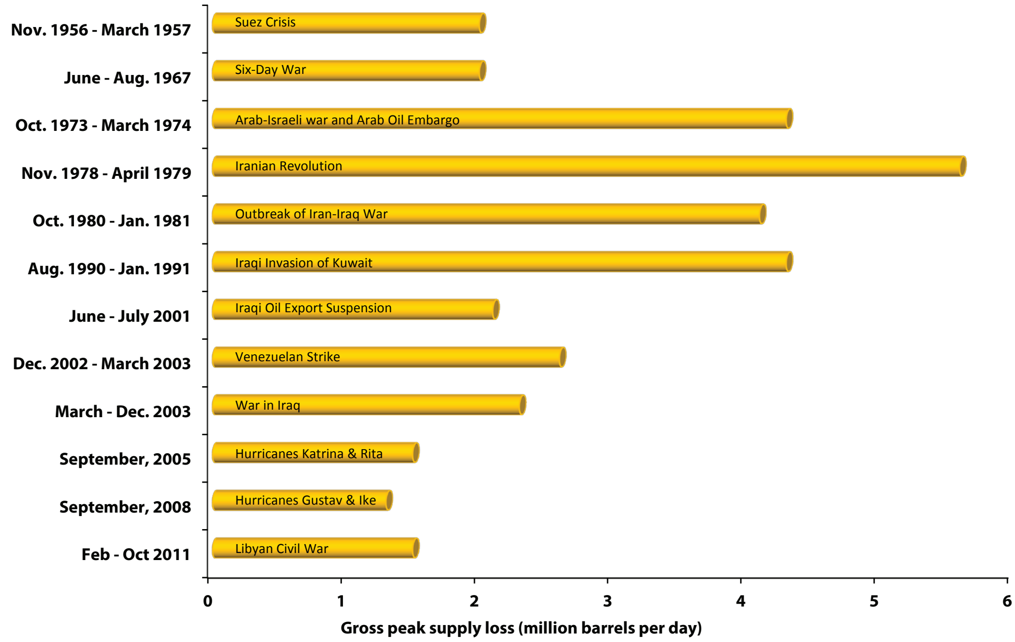
The IEA lists the following as the global threats to oil energy security:

- Capacity constraints both in production and refining;
- Uncertain investment climates;
- Geopolitical tensions and terrorism;
- Natural disasters such as extreme weather conditions;
- ... the unexpected event.

The core responsibility of the IEA is to ensure and improve the energy security of its members. It originally had a strong focus on oil security but more recently also with regard to gas and electricity security. A recent IEA report (IEA, 2014a) provides an overview of the major oil supply disruptions that have occurred since oil became the dominant fuel of the world economy in the 1950s, as shown in *Figure 28*. The first significant disruption was the Suez Canal Crisis in 1956. The first oil crisis in 1973/74 resulted from the Arab–Israeli conflict and the decision by the Organisation of Arab Petroleum Exporting Countries (OAPEC) to reduce oil production and to raise prices. This led directly to the establishment of the IEA in 1974. The largest disruption was due to the Iranian revolution in 1978–79, commonly known as the second oil crisis. The most recent major disruption to global oil supply was due to the Libya conflict in 2011 and was estimated as a gross peak loss of 1.5 million barrels per day.

IEA member countries have taken collective action in response to a supply crisis on three occasions: in 1991 in the build up to the Gulf War; in 2005 after Hurricanes Katrina and Rita damaged offshore oil rigs, pipelines and oil refineries in the Gulf of Mexico, and; in 2011 in response to the disruption of oil supplies from Libya.

Figure 28 *Major world oil supply disruptions 1950–2014*



Source: International Energy Agency

4.1.3 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. Directive 2009/119/EC 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 greater. 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.

Following the implementation of European Community Regulations in 1995[22], responsibility for the management of Ireland's oil stocks was vested in the NORA. This body acts as an agent on behalf of the Minister for Communications, Energy and Natural Resources.

Figure 29 shows the number of days of consumption that NORA is obliged to hold each year, as well as the actual number of days of consumption held. Stock holdings are held either directly by the Agency itself or on its behalf by third parties, either within Ireland or within countries with which Ireland has concluded a Government-to-Government Oil Stockholding Agreement. Oil stocks may be either wholly owned by NORA or held on NORA's behalf under what, in the industry, is termed 'stock tickets'. The latter is a mechanism whereby NORA has the option to purchase, under commercial contracts and at market prices, volumes of oil in the event of an oil emergency being declared. The maintenance of these strategic reserves is funded through the NORA levy paid by oil suppliers and consumers. This is a €0.02 per litre levy on the disposal of motor spirit, gasoil, diesel, kerosene (excluding jet fuel) and fuel oils.

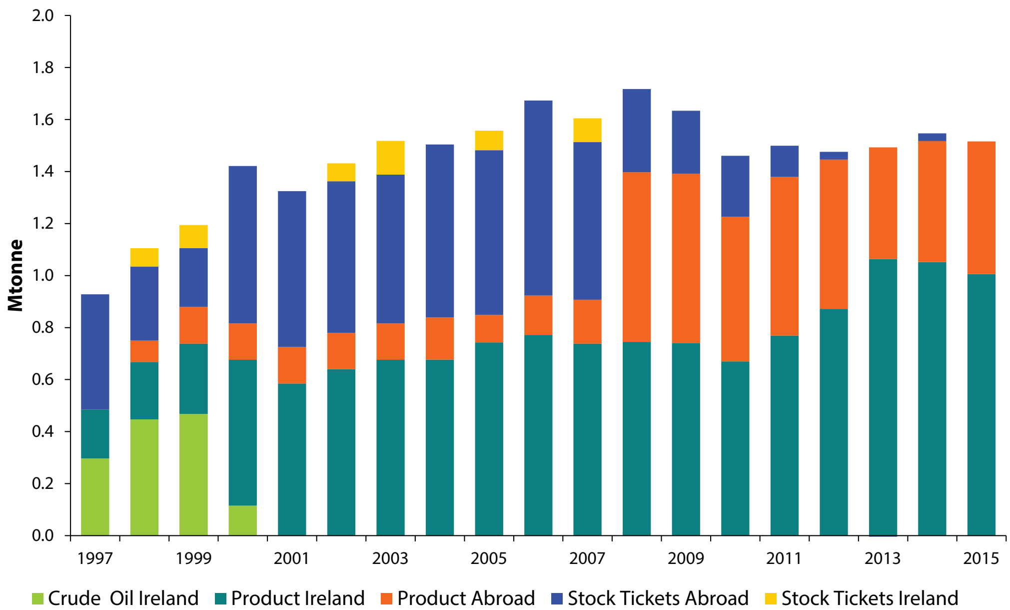
22 SI 96/1995—European Communities (Minimum Stocks of Petroleum Oils) Regulations, 1995.

Figure 29 *NORA oil stock requirements 2008–2015*

Source: NORA

Figure 30 illustrates Ireland's oil stock levels during the period 1997–2015. Product refers to holdings of oil products (petrol, diesel, etc.) that are held either in Ireland or in other jurisdictions covered by a relevant Oil Stockholding Agreement. NORA has been steadily increasing the volume of physical stocks held and is seeking to maximise the volumes held in Ireland to strengthen Ireland's security of supply in line with Government policy. The Minister for Communications, Energy and Natural Resources has overall responsibility in Ireland for the maintenance of oil supplies during adverse circumstances.

Figure 30 *NORA oil stocks 1997–2015*



Source: NORA

4.1.4 Transport Energy

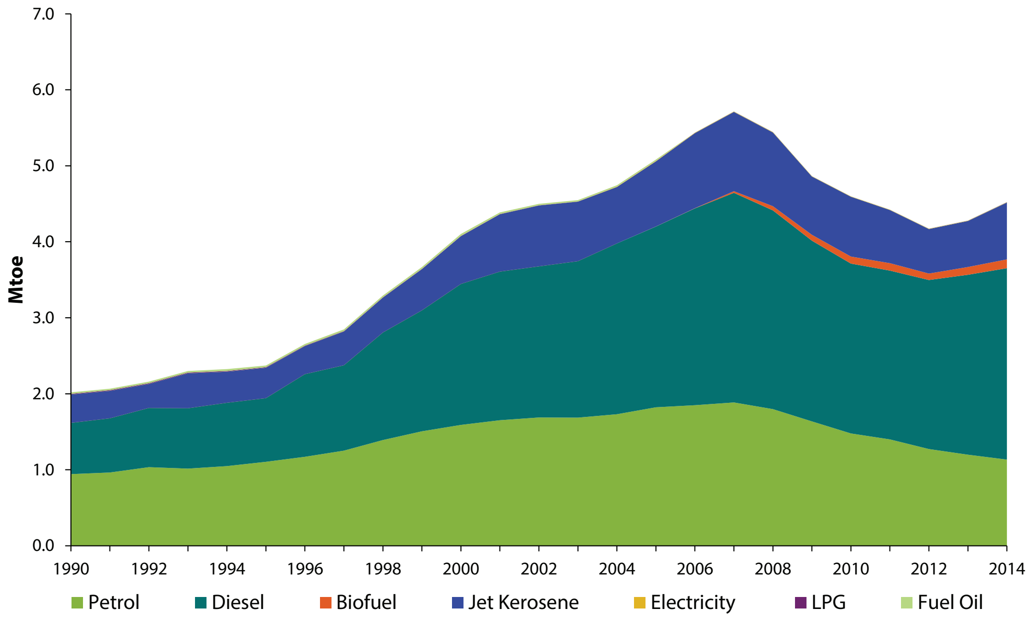
Transport is a key area to consider from an oil security perspective. As can be seen from *Figure 20* and *Figure 21*, it is increasingly the dominant end-use and driver for oil use in Ireland, accounting for over 70% of oil primary energy requirement in 2014.

Figure 31 shows the breakdown of transport final energy consumption by fuel type. The key feature to be noted is that, in 2014, 97.4% of total fuel usage in the sector was supplied by oil based products. Out of all sectors in the economy this near total dependence on a single fuel source is unique. Transport exhibits by far the highest fossil fuel dependency and lowest degree of electrification of any sector. In terms of energy security, the diversification of transport energy is a major concern. Alternative transport fuels include liquid biofuels, compressed natural gas (CNG), biogas and electricity. Policies aimed at this critical area have the dual benefit of contributing strongly towards Ireland's renewable energy targets for the transport sector, progress on which is required for Ireland to meet its binding 2020 renewable energy targets, as well as contributing to energy security.

Fuel consumption in transport is closely aligned to the mode of transport used. Jet kerosene is used for air transport. Petrol is almost exclusively used for road transport, the bulk for private car use although there is a significant number of petrol driven taxis in operation. Diesel consumption is used for navigation, rail, and road purposes but the bulk is used for road transport. This diesel road transport consumption is used for freight transportation, public transport in buses and taxis, private car transport, and other applications such as in agricultural, construction and other machines. Diesel accounted for over half of the fuel used in transport in 2014. Biofuels consumption is predominantly due to the blending of liquid biofuels with petrol and diesel by suppliers in order to comply with the biofuels obligation scheme that requires motor fuels to be at least 6% by volume from renewable sources.

Figure 31 also highlights the dramatic growth in transport energy demand between 1990 and 2007. This reversed in the period 2007–2012 in response to the economic crisis of 2008 and Ireland's overall weak economic performance leading up to 2012. Significantly the trend for transport energy consumption has returned to strong growth in 2013 and 2014 in response to the strengthening economy[23].

Figure 31 *Transport final energy demand by fuel type 1990–2014*



Source: SEAI

The IEA has noted (IEA, 2014a) that the increased concentration of oil usage in the transportation sector accentuates the potential economic impact of a supply disruption. Demand for transportation fuels is considered to have a relatively low price elasticity; increases in fuel prices cannot readily be compensated for by a reduction in demand, due primarily to the lack of alternative options, particularly in the short-term, for consumers to switch away from oil based transportation fuels. Critically, increased fuel and transportation costs pass rapidly through to other sectors of the economy in the form of increased prices for goods and services.

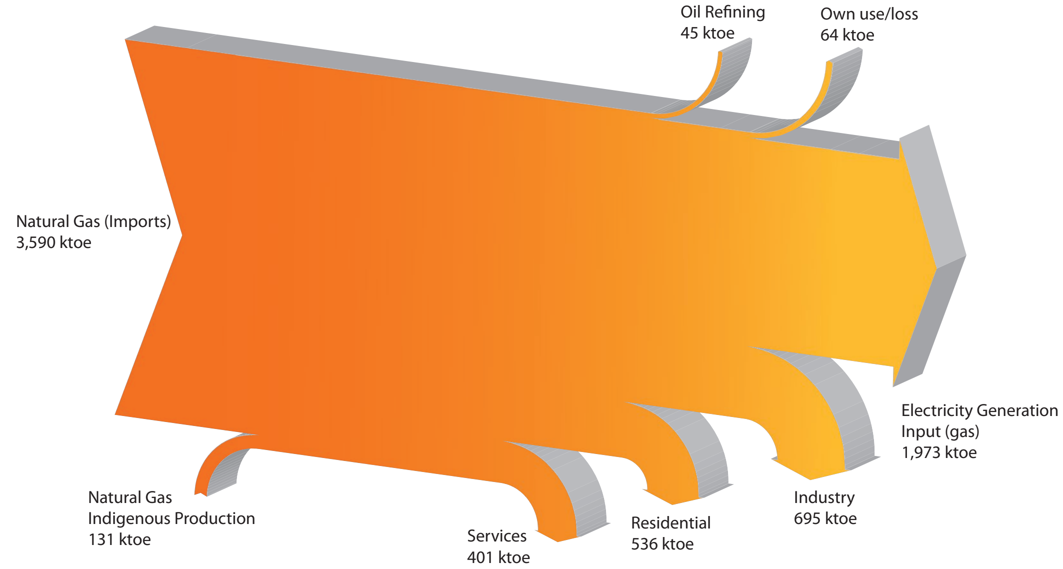
23 Fore a more detailed analysis of energy use in Ireland's transport sector, see SEAI's report 'Energy in Transport; 2014 report'. Available from www.seai.ie

4.2 Natural Gas

4.2.1 Natural Gas Usage

Figure 32 presents an energy flow diagram for gas usage in 2014. The total input, categorised by imported and indigenous, is shown on the left while outputs on the right are categorised by sector. This illustrates that the majority of gas is imported and electricity generation is responsible for the largest share of output.

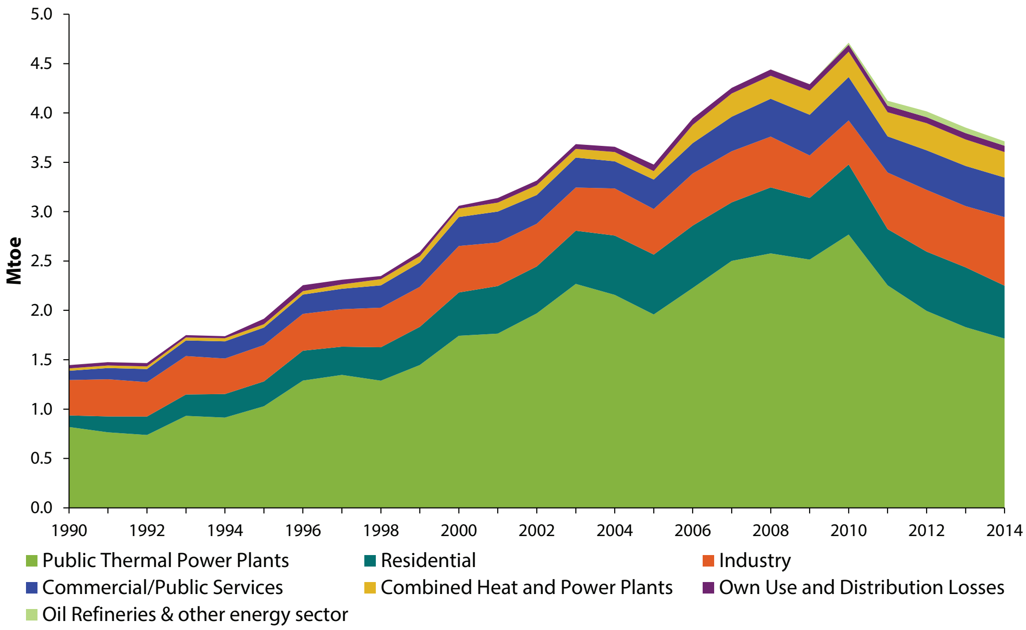
Figure 32 *Natural gas energy flow in Ireland 2014*



Source: SEAI

The growth of natural gas demand between 1990 and 2014 is shown in *Figure 33*. Total gas demand reached a peak in 2010 at 4.7 Mtoe, 225% above 1990 levels (annual average growth of 6.1%). Electricity generation was the main source of growth in gas demand over the period. Gas demand of public thermal power plants increased by 238% between 1990 and 2010 due to the opening of a number of new gas powered plants. The 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: the overall reduction in electricity demand post 2008; the increased amount of renewable electricity generation, particularly wind; the increased use of coal between 2010 and 2012 due to market forces; and the increased amount of electricity imports from the UK due to increased interconnection.

Figure 33 *Gas primary energy demand by end-use 1990–2014*

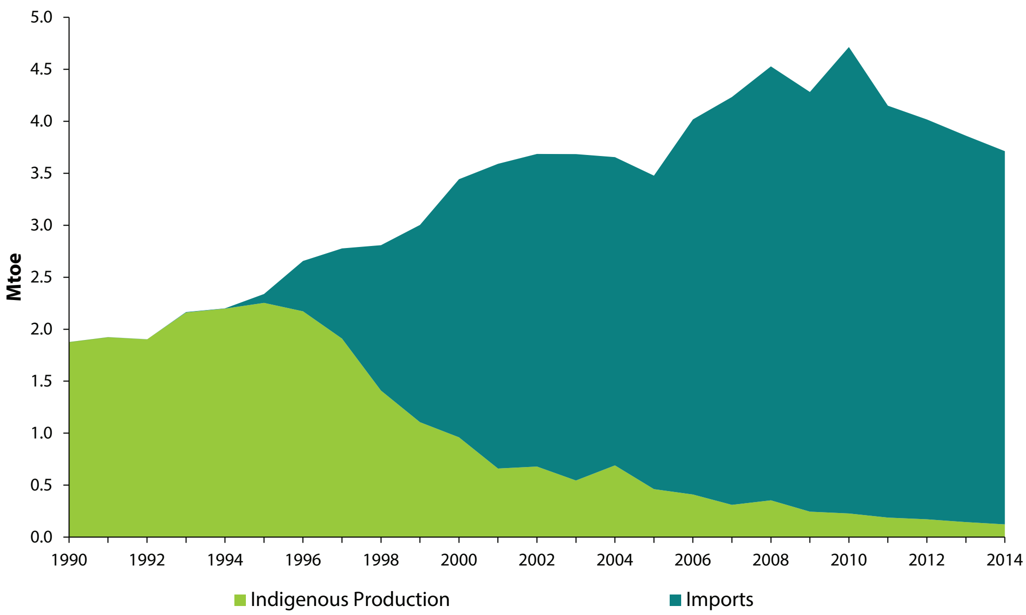


Source: SEAI

4.2.2 Natural Gas Imports

For a period Ireland was able to fully meet gas demand from indigenous production at the Kinsale gas field, but with the decline of production there since the mid nineties import dependency has steadily increased, and in 2014 96% of natural gas used in Ireland was imported. This compares with a 65% import dependency for natural gas overall in the EU. *Figure 34* shows Indigenous production and imports of natural gas from 1990 to 2014. All of Ireland's imported natural gas is sourced from the United Kingdom.

Figure 34 *Natural gas indigenous production and imports 1990–2014*

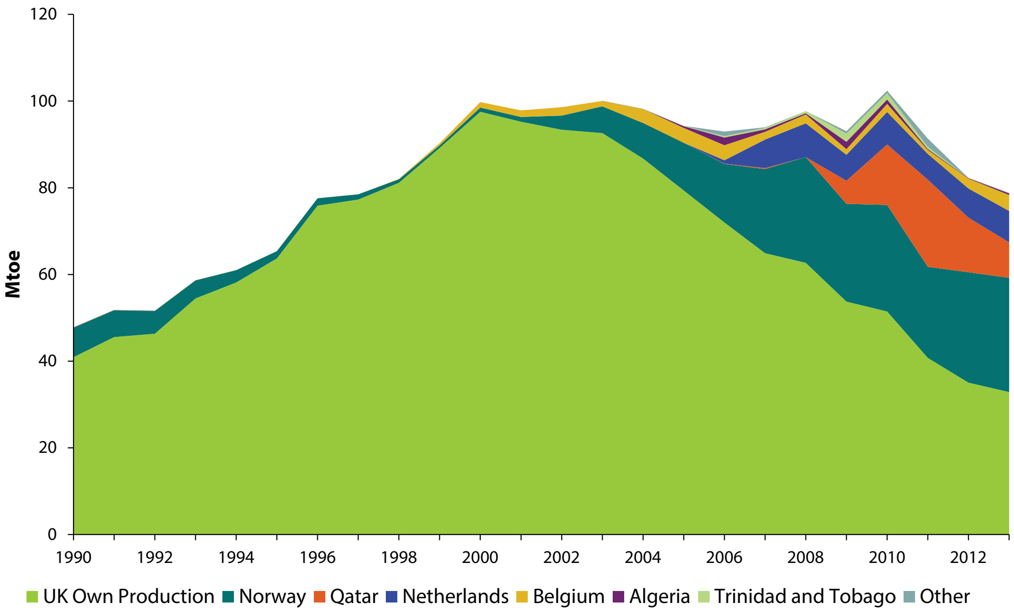


Source: SEAI and IEA

Currently all gas imported to Ireland comes from the UK so it is relevant to examine the source of gas to the UK market. *Figure 35* shows UK natural gas production and imports from 1990 to 2013. The decline in domestic UK production, following peak production in 2000, and the consequent increasing reliance on imports can be clearly seen. In 2011, UK natural gas imports exceeded its domestic production for the first time. In 2013, the UK imported

40% more gas than it produced. Norway accounted for 57% of UK gas imports in 2013, followed by Qatar on 18%, the Netherlands on 16%, Belgium on 8%, and others on 1%. Imports from Norway, Belgium and the Netherlands are via pipeline while imports from Qatar are in the form of LNG transported by ship. LNG accounted for 19% of UK gas imports (8.8 ktoe) in 2013, down from a high of 47% (23.6 Mtoe) in 2011.

Figure 35 *UK natural gas production and imports 1990–2013*



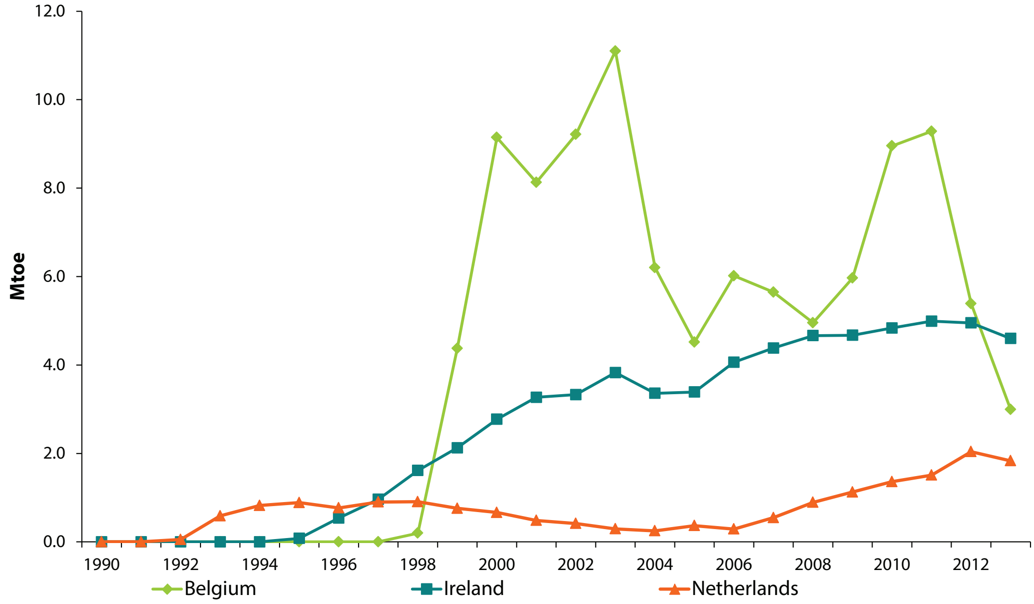
Source: UK National Grid

The UK National Grid has examined future scenarios for UK gas import dependency (National Grid, 2014; National Grid, 2015). Given the range of uncertainties involved, rather than making a single forecast, a number of scenarios considering differing levels of ambition and progress in terms of the economy, political will, technological development, social pressure and environmental goals were examined. These factors influence assumptions on the further development of indigenous gas production on the UK continental shelf, shale gas and biomethane on the supply side, and on domestic gas consumption on the demand side. Depending on these assumptions UK import dependency may range between 35% and 90% by 2035, the principal difference being the development or not of a UK shale gas industry. In developing these forecasts the UK National Grid takes into account Ireland's import requirements, accounting for the coming on stream of Corrib gas, and of gas demand in Ireland based on estimations that Gaslink produced in its Network Developments plan.

The UK's increased import infrastructure, afforded by new LNG terminals, has ensured that UK exports remain robust, despite the decrease in the UK's production (DECC, 2015)[24]. Since 2000 the main destination of UK gas exports has been Belgium, though in 2013 Ireland's imports made up just under half (49%) of the total, followed by Belgium (32%) and the Netherlands (19%), as illustrated in *Figure 36*. In 2013, UK gas exports were equivalent to 12% of combined domestic production and imports.

24 Department of Energy and Climate Change, 2015. Digest of UK Energy Statistics Chapter 4.

Figure 36 *UK natural gas exports 1990–2013*

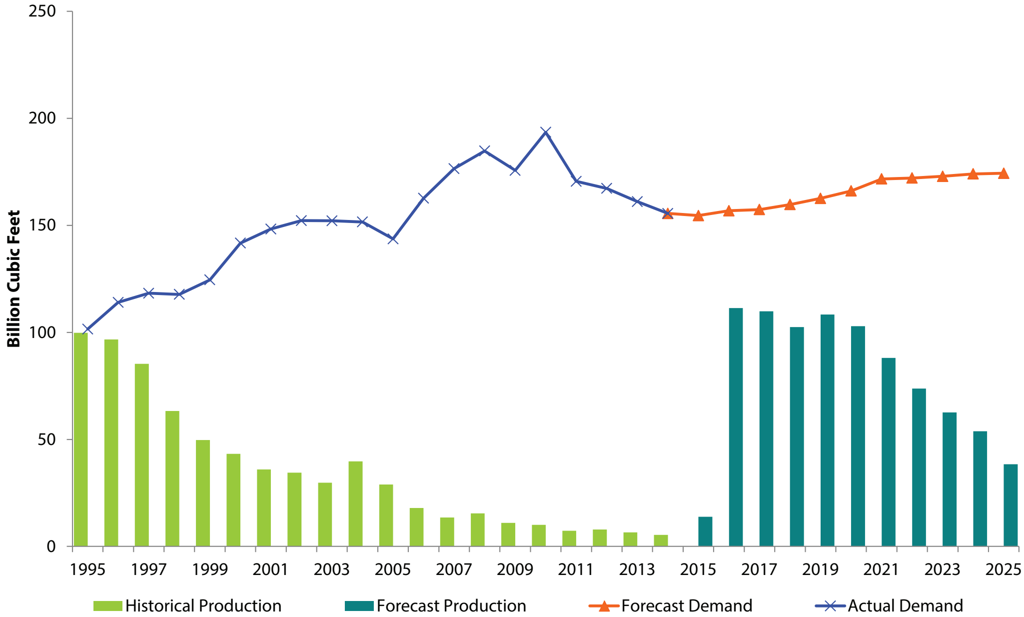


Source: UK National Grid

4.2.3 Indigenous production

The Corrib gas field was discovered off the west coast of Ireland in 1996. Approximately 70% of the size of the Kinsale Head field, it has an estimated producing life of just over 15 years. The Corrib gas field is anticipated to commence full commercial production in late 2015 or early 2016. In its latest ten year assessment of Ireland's gas network (GNI, 2015), GNI note that the Corrib gas field is expected to meet 77% of the Republic of Ireland's annual gas demand in its first full year of commercial production, with the Inch and Moffat Entry Points providing the remainder. The expected production profile of the Corrib field until 2025 is shown in *Figure 37*. Following the forecast decline in Corrib gas supply through the following years, the Moffat Entry Point should re-emerge as the dominant ROI system supply point from 2018, supplying 64% of annual ROI system demands by 2023/24. Therefore, while Corrib will greatly enhance Ireland's security of supply in the short term, in the medium-to-long-term, post 2020, Ireland is likely to remain largely dependent on imported natural gas to meet demand.

Figure 37 *Historical and projected indigenous natural gas production*



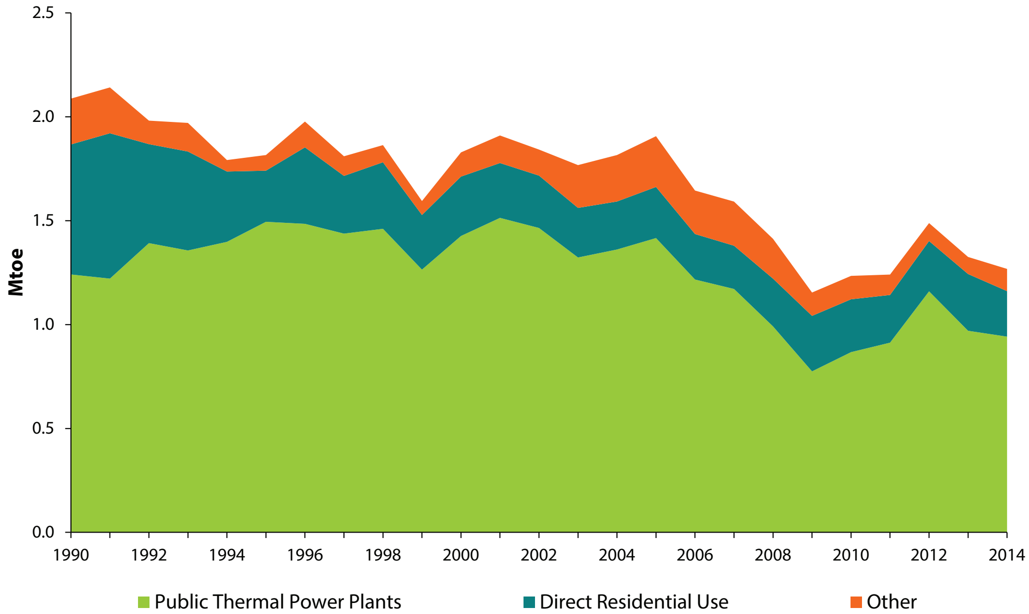
Source: Gas Networks Ireland

4.3 Coal

Figure 38 shows the primary energy use of coal split into the share used for electricity generation in conventional power plant, direct use for residential heating, and other, which includes use in industry, the services sector, and combined heat and power (CHP) units. Overall coal use declined by 39% over the period, from 2.1 Mtoe in 1990 to 1.3 Mtoe in 2014 (2.1% per annum). The share of coal use in conventional power plant generation in 1990 was approximately 59%. This had increased to 74% by 2014.

Coal is currently considered as an important source of fuel diversity in the electricity generation sector from a security of supply perspective. The only coal burning plant in the state is located at Moneypoint on the Shannon estuary in Co. Clare and is operated by ESB. It is currently expected that the plant in its current form will be decommissioned around 2025. Debate continues as to what should replace it. The latest Green Paper on energy policy notes that the decision on how to replace Moneypoint's power generation will have to be taken in a timely fashion, to allow adequate time for replacement planning and delivery (DCENR, 2014).

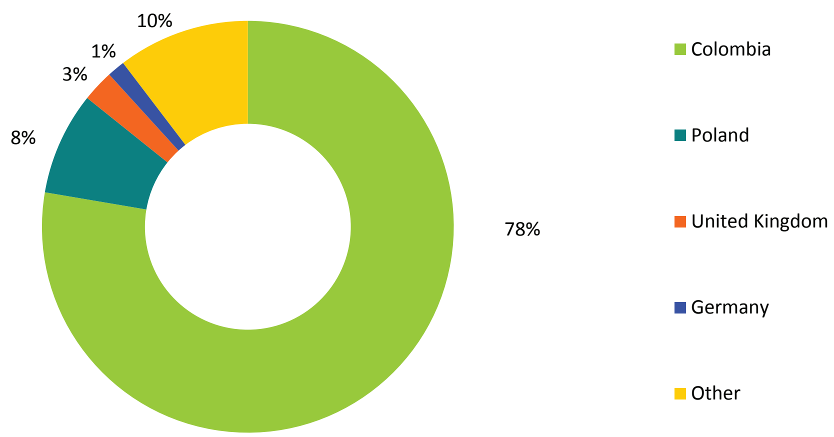
Figure 38 *Coal use 1990–2014*



Source: SEAI

Since 1995 all coal demand in Ireland has been met by imports. *Figure 39* illustrates the source of coal imports in 2014. The bulk supply of coal to Moneypoint power station comes mostly from Columbia, making it the largest source of Irish coal in 2014, at 78%. It is followed by Poland, at 8% and the UK at 3%.

Figure 39 *Coal imports by country of origin 2014*

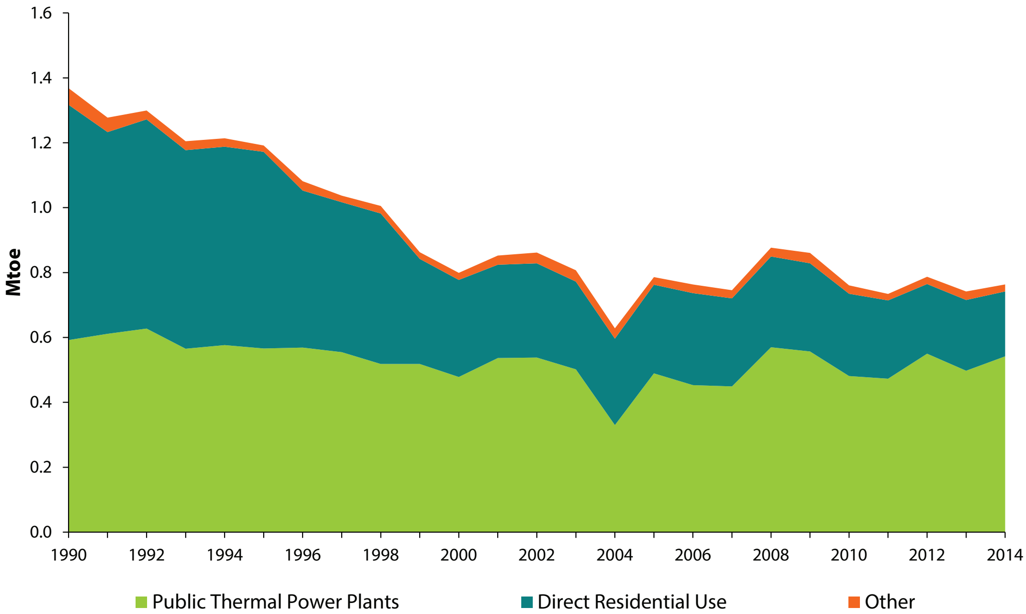


Source: SEAI

4.4 Peat

Figure 40 shows the primary energy use of peat split into the portion used for electricity generation in conventional power plants, direct use for residential heating, and other uses. Again, there was an overall declining trend in peat use, from 1,377 ktoe in 1990 to 768 ktoe in 2014, a decline of 44% (2.4% per annum). Direct peat use in households reduced by 72%, while peat use in electricity generation decreased by just 8% over the full time period. As a result the share of peat use for electricity generation increased, from 43% in 1990, to 71% of all peat consumption in 2014.

Figure 40 *Peat use 1990–2014*



Source: SEAI

For a number of years peat electricity generation has been supported by a PSO, as described in section *3.3.4*. This has been Government policy, in order to maintain the use of an indigenous fuel source in electricity generation, and in order to maintain employment in the relatively scarcely populated Irish Midlands region. The PSO is due to expire in 2015 for the Edenderry station and in 2019 for the West Offaly and Lough Ree peat stations. Extensions to these peat PSOs are not envisaged. The Irish Government has set a 30% biomass co-firing target for all of the peat fired stations by 2015. Market dynamics, regulatory decisions on priority dispatch for hybrid renewables, as well as policy decisions on REFIT 3 and in the forthcoming Bioenergy Strategy, will influence the future of peat in the Irish electricity generation fuel mix when the current peat PSOs have expired.

4.5 Renewables

4.5.1 Liquid Biofuels

The Renewable Energy Directive 2009/28/EC (RED) mandates a 10% share of renewable energy in total transport demand by 2020. There are strict sustainability criteria attached to biofuels in the RED. The European Union (Biofuel Sustainability Criteria) Regulations (SI 33 of 2012), referred to as the Sustainability Regulations, were introduced in February 2012. These Regulations require that biofuels placed on the market must satisfy the carbon and sustainability criteria of the RED in order to be counted towards the biofuel obligation.

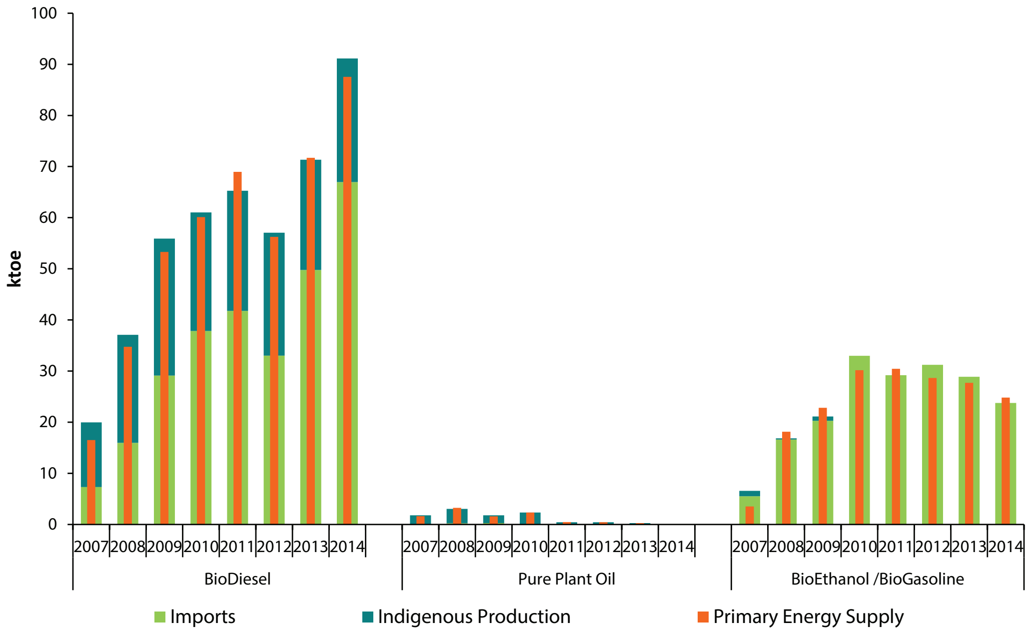
Sustainable sources as defined by Article 17 of the Directive are:

- The greenhouse gas emission savings from the use of biofuels and bioliquids shall be at least 35%, in accordance with the methodology prescribed in the Directive. This percentage increases to 50% from 2017 and (for new biofuel plants that start production from 1st January 2017) 60% from 2018.
- Biofuels and bioliquids shall not be made from raw materials obtained from land with high biodiversity value.
- Biofuels and bioliquids shall not be made from raw materials obtained from land with high carbon stock.

An additional constraint in terms of biofuel production in the EU arises due to agricultural cross-compliance policy that limits the amount of land that can be transferred to tillage (Singh, et al., 2009).

Figure 41 shows the contribution of different biofuels to Ireland's transport energy supply from 2007 to 2013. There was a noticeable drop in the usage of biofuels, particularly biodiesel, between 2011 and 2012. This was caused by both a reduction in total transport energy demand and also a significant increase in the amount of biodiesel which was eligible for double certification (from 58% to 99%), thus reducing the amount of biodiesel required to be placed on the market in order to satisfy the biofuel obligation. The increase in the biofuel obligation from 4% to 6% in 2013 reversed this one-year decline, leading to a 17% increase in the unweighted biofuel consumption in 2013. In 2014 this increased again by 13% to 112 ktoe.

Figure 41 *Biofuels production, imports and usage 2007–2014*



Source: SEAI

The graph distinguishes between the amount of biofuels produced and imported (the thicker green bars) and the amount used (the thinner orange bars). The difference between the amounts produced and imported versus the final consumption is accounted for by stock changes. The dominant biofuel was biodiesel, representing 78% of consumption in 2014. The remaining 22% was from bioethanol. It is apparent from *Figure 41* that in recent years there were more biofuels imported than produced indigenously. Indigenous production retained in Ireland accounted for just 21% of biofuels supply (on an energy basis) in 2014. The proportion of indigenous production compared to imports varies according to the biofuel. All bioethanol used in Ireland after 2010 was imported, i.e. no indigenous bioethanol production, whereas all of the pure plant oil used for transport purposes was produced in Ireland. There is some indigenous production of biodiesel from waste oil and from rapeseed but 73% of all biodiesel consumed in 2014 was imported. The sources of biofuels are likely to come under increased scrutiny with the focus on the sustainability criteria for biofuels in the RED and the double weighting in the renewable transport fuel (RES-T) calculation for biofuels from wastes, residues, non-food cellulosic material, ligno-cellulosic material or algae.

4.5.2 Solid Biomass and Wastes

Solid biomass covers organic, non-fossil material of biological origin which may be used as fuel for heat production or electricity generation. It is primarily wood, wood wastes (firewood, wood chips, barks, sawdust, shavings, chips, black liquor, etc.) and other solid wastes (straw, oat hulls, nut shells, tallow, meat and bone meal, etc.). Most of the solid biomass used in Ireland is for thermal energy purposes in the industrial sector where it is burnt directly for heat or used in CHP units. As well as CHP, biomass is used for electricity generation through co-firing with peat in existing power plants. Most biomass used in Ireland is currently produced indigenously (86% in 2014). Imported biomass is primarily in the form of wood pellets but includes significant amounts of sunflower husks, which are co-fired with peat at Edenderry power plant.

4.5.3 Biogas

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. Farm, municipal or industrial-based anaerobic digestion plants convert waste material into biogas. The biogas produced can be upgraded to fossil ('natural') gas quality, known as Renewable Natural Gas (RNG). GNI estimates that, utilising existing mature technologies and using existing and available waste and residue sources in Ireland, RNG has the potential to satisfy over 30% of Ireland's gas demand by 2030, reducing the dependance on imports and improving security of supply.

4.5.4 Renewable Electricity

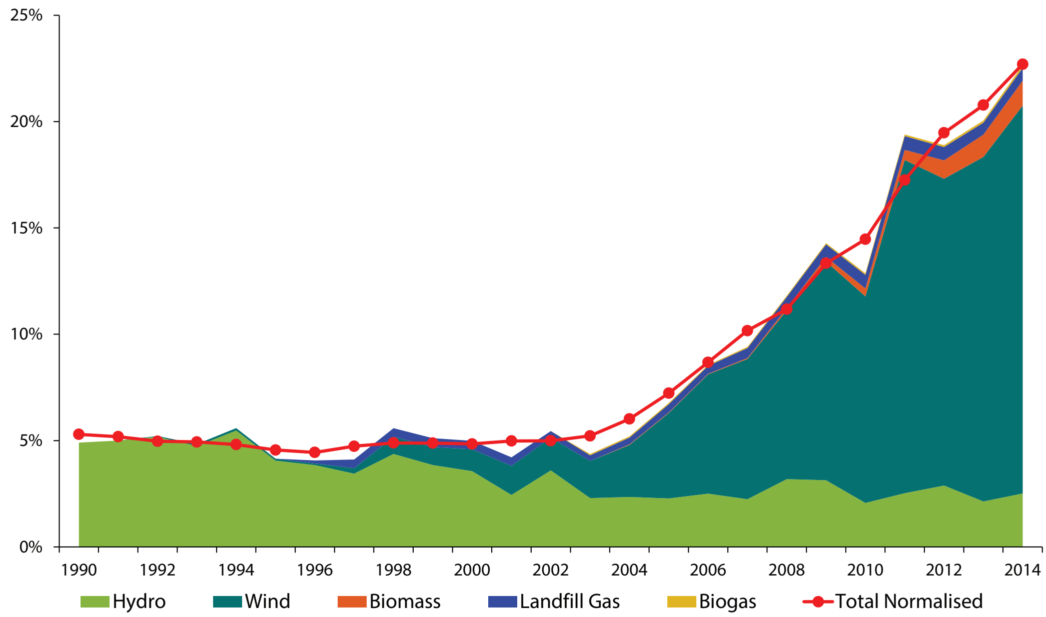
The contribution from renewable energy sources to electricity generation (RES-E) for the period 1990–2014 is shown in *Figure 42* and *Table 2*. Renewable generation includes wind, hydro, landfill gas, biomass and biogas. In 2014 renewables accounted for 14.5% of the energy inputs to electricity generation and accounted for 22.7% of gross electricity consumption.

While historically hydro was the largest contributor to renewable electricity in Ireland, during the 2000s electricity production from wind energy increased dramatically, to the point where it accounted for over 80% of the renewable electricity generated in 2014. There has also been a small contribution from wastewater biogas since 2003 and from solid biomass CHP since 2004. Since 2008, biomass has been used for electricity generation through co-firing with peat at peat generation stations. The more than doubling of electricity generation from renewable energy is clearly visible in *Figure 42,* dominated by the growth in wind energy. In 2014, wind energy alone accounted for 18.2% of all electricity generated, second only to gas which represented 45.8%, and ahead of coal on 14.3%.

The noticeable dip in the proportion of RES-E in 2010 was due primarily to reduced levels of wind speed and rainfall resulting in reduced wind and hydro generation. Hydro electricity in 2010 was 34% less than in 2009 and electricity from wind was 5% less than 2009 in spite of a 10% increase in installed capacity. In calculating the contribution of hydro and wind energy for the purpose of the overall 16% target for renewable energy in Ireland by 2020 in the Renewable Energy Directive (2009/28/EC) the effects of climatic variation are smoothed through use of a normalisation rule. In *Figure 42* the total normalised renewable energy contribution is shown by the red trend-line. As 2014 was close to the long-term average for wind speeds over the year, when normalisation is applied to the wind and hydro contributions to smooth the effects of annual variation, the renewable generation as a percentage of gross electricity generation was only marginally higher than the actual, and remained at 22.7% (correct to one decimal place). The national target for renewable electricity is 40% by 2020[25].

While wind accounted for 18.2% of electricity generated over the full year of 2014, at times the instantaneous proportion of total electricity generated by wind exceeded 50%

Figure 42 *Renewable energy contribution to gross electricity consumption by source 1990–2014*



Source: SEAI and EirGrid

4 Energy Security Examination by Fuel

25 For a more detailed discussion of Ireland's renewable energy targets for electricity, transport and heat see the SEAI publication 'Renewable Energy in Ireland'. Available from www.seai.ie/Publications/Statistics_Publications/Renewable_Energy_in_Ireland/

Table 2 *Renewable electricity as percentage of gross electricity consumption*

	1990	1995	2000	2005	2010	2011	2012	2013	2014
Renewables % of Gross Electricity	4.9	4.1	5.0	6.8	12.9	19.4	18.9	20.1	22.1
Hydro	4.9	4.1	3.6	2.3	2.1	2.5	2.9	2.1	2.5
Wind	-	0.1	1.0	4.0	9.7	15.7	14.4	16.2	18.2
Biomass	-	-	-	-	0.4	0.5	0.9	1.1	1.2
Landfill gas	-	-	0.4	0.4	0.6	0.6	0.6	0.6	0.6
Biogas	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1

Source: SEAI and EirGrid

4.6 Electricity

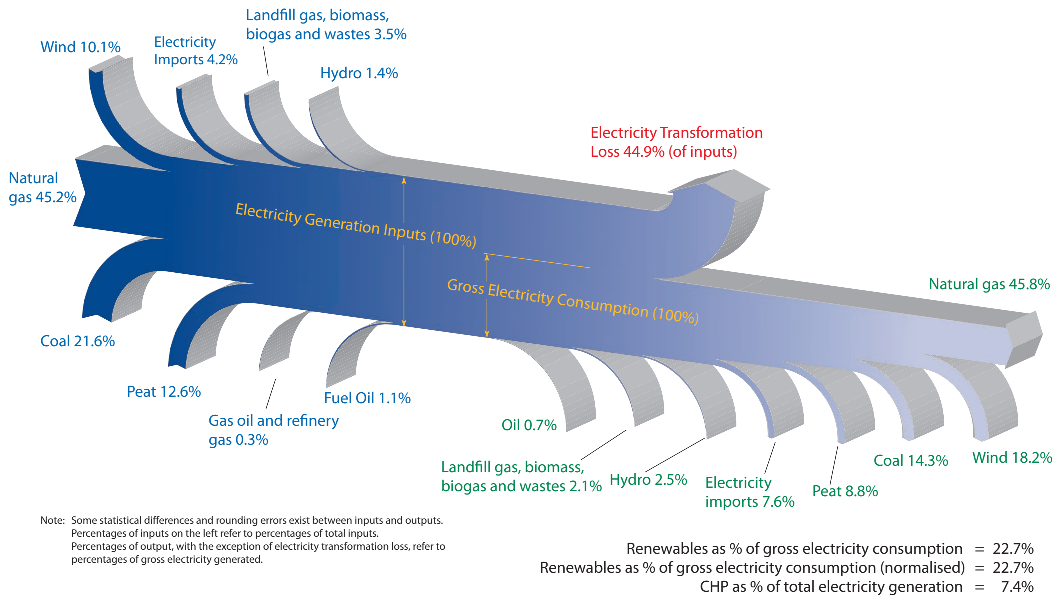
4.6.1 Electricity Generation Fuel Mix

Figure 43 shows graphically the flow of energy in electricity generation and supply for 2014. The relative size of the final electricity consumption and the energy lost in transformation and transmission remains striking even after a decade of steadily improving efficiency of electricity generation. These losses represented 44.9% of the energy inputs in 2014.

The electricity outputs are shown by the fuel used to generate the electricity. The dependence on natural gas in electricity generation in 2014 was 46%, down from a peak of 64% in 2010. In terms of energy security the dominance of gas is a significant risk both to the physical security of supply and also in terms of exposure to price variation. In recent years the increasing share of renewable electricity has acted to reduce the reliance on imported fossil fuels for electricity generation, in particular displacing natural gas generation.

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 electricity generation mix acts as a hedge against fossil fuel price increases and reduces the associated volatility in electricity prices (Lynch and Curtis, 2015).

Figure 43 *Flow of energy in electricity generation 2014*



Source: SEAI

4.6.2 Secondary Fuelling of Gas Fired Power Stations

In 2009, the CER imposed requirements stating that gas fired generating units must be capable of operating on secondary fuel and must hold stocks of that fuel (CER, 2009). While operating on secondary fuel, generating units must be capable of producing no less than 90% of the unit's capacity when on primary fuel. High merit generating units (operating more than 2,630 hours per annum) are required to hold stocks equivalent to five days' operation at the unit's rated capacity on primary fuel, while lower merit generating units (operating less than 2,630 hours per annum) are required to hold stocks equivalent to three days of such operation. Non-gas units, excluding renewable and peat units, are required to maintain stocks of the equivalent quantities of their primary fuel. The CER decision also empowered EirGrid to regularly test the secondary-fuel operation of gas fired units. The CER is currently conducting a review of the fuel stock obligations for electricity generators to take account of developments since 2009, such as the increase in wind generation and the commissioning of the East–West Interconnector (CER, 2015). Following a review of the responses to the consultation paper CER/15/213, the CER will issue a follow-up paper by the end of 2015.

4.6.3 Role of the Commission for Energy Regulation

The CER holds the statutory obligation[26] to monitor the electricity security of supply in Ireland and work closely with all market players to ensure long-term electricity security. This monitoring includes:

- the balance between supply and demand;
- the level of expected future demand;
- the envisaged additional capacity being planned or under construction;
- the quality and level of maintenance of the transmission networks;
- the measures to cover peak demand;
- the measures to deal with a shortfall of capacity by one or more suppliers.

In the short term, electricity energy security is dependent on operational security only. In the longer term the issue is more complex and the security of electricity supply is dependent on access to primary fuels, market adequacy and system adequacy, which in turn is reliant upon generation adequacy and network adequacy.

The CER is responsible for monitoring the security of supply of electricity and reports biennially[27] to the European Commission on the findings of this monitoring, along with any measures taken or proposed. In its latest report to the Commission, the CER noted that electricity generation in Ireland was still heavily reliant on imported fossil fuels, and that, in 2013, 63.9% of electricity generation was supplied by such fuels (CER, 2014).

26 The legal basis for this is founded in Regulation 28 of SI 60 of 2005 – 'European Communities (Internal Market in Electricity) Regulations 2005'.
27 Under Directives 2005/89/EC and 2009/72/EC

5 Security of Physical Energy Infrastructure

5.1 Oil Infrastructure

Ireland has one oil refinery, located at Whitegate, Co. Cork, which is currently operated by Phillips 66. The crude capacity of the Whitegate facility is 71,000 barrels per day (27.4 million barrels per year), see Section *4.1.2*.

The current owner of the refinery, Phillips 66, is under an obligation to continue operations at the refinery until 2016. However, according to the IEA, in the context of international developments, which have seen significant divestments and shut-downs in European refineries since 2008, there is a possibility that the refining operations could be commercially shut down after 2016 (IEA, 2012). At the time of writing, the refinery is on the market.

In 2013, a Government-commissioned report on the strategic case for oil refining (DCENR, 2012) highlighted the additional oil security benefits that the Whitegate refinery may offer and concluded that the existing oil import facilities on the island of Ireland provide a robust infrastructure that would offer alternatives in the event of a serious disruption at any of the six principal oil ports. In light of those findings, Government is liaising with the Irish oil industry and appropriate public bodies to determine available policy options that may facilitate the commercial future of refining in Ireland.

5.2 Natural Gas Infrastructure

Ireland's natural gas infrastructure is presented in *Figure 44*. The natural gas transmission network in Ireland is operated by GNI (formerly Gaslink), which provides an overview of the current network infrastructure and security of supply issues in its annual Network Development Plan (GNI, 2015). The high pressure transmission network conveys gas from two entry points (at Inch and Moffat) to directly connected customers and distribution networks throughout Ireland, as well as to connected systems at exit points in Scotland (the Scotland–Northern Ireland Pipeline) and the Isle of Man. The Moffat entry point, located onshore in Scotland, connects the Irish natural gas system to that of Transco in the UK, and allows for the importation of UK gas to Ireland but not the exportation of gas from Ireland to the UK. The Inch entry point, located in Cork, connects the Kinsale and Seven Heads gas fields and the Kinsale storage facility to the onshore network. The Irish system has three compressor stations, Beattock and Brighouse Bay in southwest Scotland, and Midleton near Cork.

The Moffat entry point currently supplies over 93% of the annual gas demand to the Republic of Ireland's system and will continue to do so until the coming on stream of Corrib gas. This heavy reliance on a single piece of infrastructure has long been identified as a critical security of supply weakness. In particular a 50 km section between Cluden and Brighouse Bay in Scotland is served by just a single pipeline. A project to 'twin' this section of pipeline is of key national and regional importance and this has been recognised by the inclusion of this project at EU level in a list of key energy infrastructure projects, referred to as Projects of Common Interest. The project was awarded €33.7 million by the EU, which equates to 36.4% of the total project costs, the maximum amount that the project can receive. The CER approved the project in May 2015 and the pipeline will be completed in 2017.

Regulation No (EU) 994/2010 requires EU Member States to fulfil the N-1 standard, which requires the natural gas network to continue to meet gas demand in the event that the single largest piece of infrastructure fails on a day of exceptionally high gas demand. In the event that a Member State cannot fulfil the N-1 standard on a national basis, the Regulation permits the adoption of a regional approach. Due to Ireland's heavy reliance on the Moffat Interconnector Ireland cannot meet the N-1 on a national basis, and therefore the UK and Ireland have adopted a regional approach towards the implementation of the regulation.

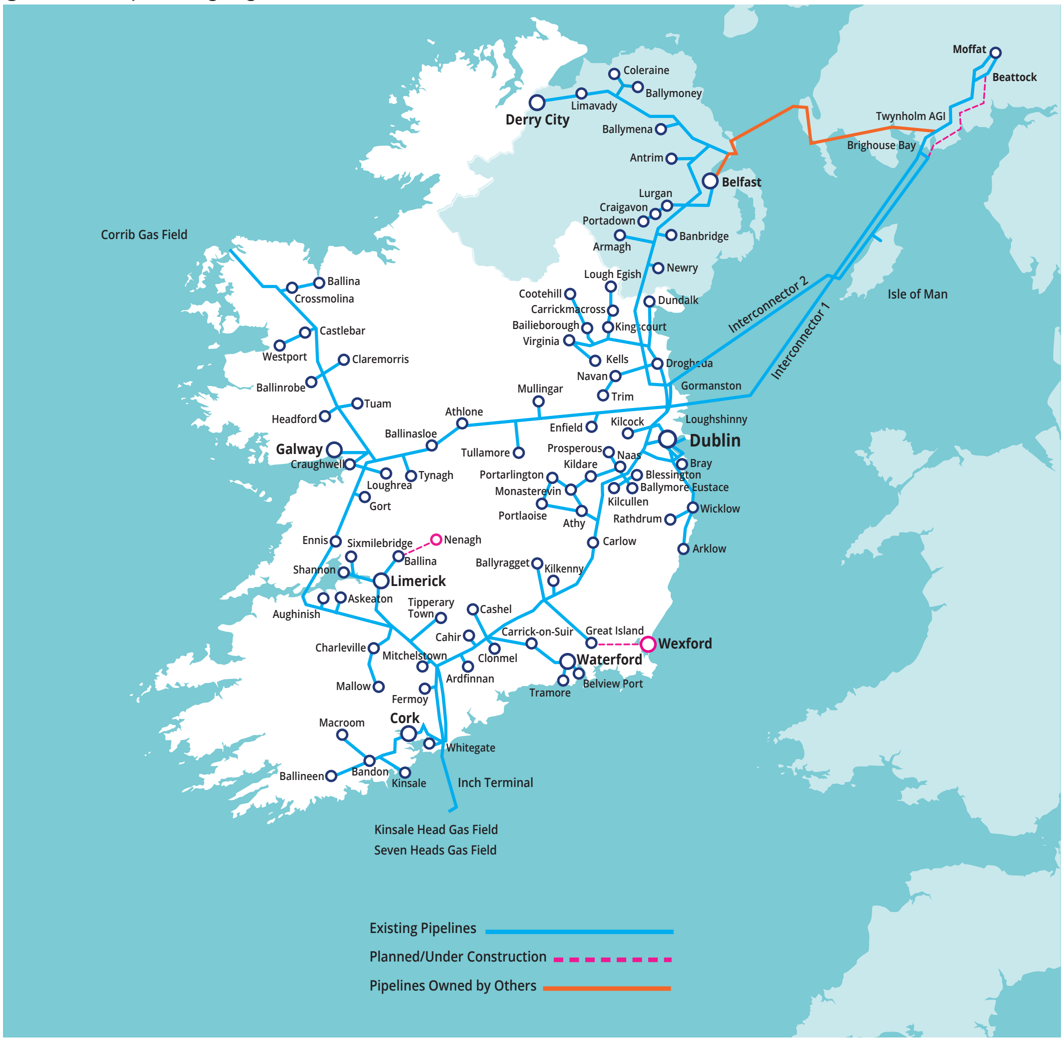
GNI note that an increasing challenge in the operation of the national gas network comes from increased demand variation due to increased ramping of gas fired electricity generation plants. This, in turn, is due to increasing amount of wind generation on the electricity network, as it is gas powered electricity generation plants that provide the flexibility required for the electricity system to respond to changes in wind generation. This has an impact on flow profiles and system operation of the gas network. Relatively small changes in power sector generation can have a disproportionate effect on gas demand.

5.2.1 LNG

Shannon LNG proposes to construct the country's first LNG importation terminal approximately four km 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 m^3 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 has been received for the terminal, for a pipeline to the national gas grid and for a

500 MW CHP plant. The earliest possible date for the commencement of commercial operations is 2018, 'assuming a resolution to a number of uncertainties and delays' (GNI, 2015). This project was identified by the EU as a key energy infrastructure project, and has been labelled a 'Project of Common Interest'.

Figure 44 *Map of the gas grid*



Source: Gas Networks Ireland

5.2.2 Natural Gas Storage

Currently, the only operating natural gas storage facility in Ireland is located at Kinsale and is connected to the national gas grid at the Inch entry point. The facility is operated by PSE Kinsale Energy Limited (KEL) and has a working volume of approximately 230 Mscm, approximately equivalent to 5% of the Republic of Ireland's annual gas consumption. KEL has advised the CER that it plans to cease storage operations in 2016, with the potential for a reduced storage service in 2016/17, depending on market conditions. Once the storage service ceases there will be no further injections into Southwest Kinsale and production gas will be supplied from the Inch entry point during winter and summer periods. Currently production is expected to cease in 2020/2021 (GNI, 2015).

Islandmagee Storage Limited (IMSL) is seeking to develop a gas storage facility at Islandmagee, Co. Antrim. It is planned that 500 million cubic metres of gas will be stored in up to seven caverns, which are to be created in a salt bed beneath Larne Lough[28]. In October 2012, the Northern Ireland Utility Regulator granted a licence to IMSL to store gas at the facility. In June 2015, the first salt core well was drilled at the site to facilitate analysis and design work. Construction could commence before the end of 2016, at the earliest, with the first caverns becoming operational in 2019.

28 For more information see www.islandmageestorage.com/

5.3 Electricity Infrastructure

5.3.1 Electricity Generation Adequacy

EirGrid, together with Soni, the electricity system operator for Northern Ireland, publishes an annual All-Island Generation Capacity Statement (GCS) which sets out the estimate for electricity demand and generation capacity for the following ten years. The most recent statement (2015) stated that there should be 'sufficient generation plant on the island to meet the agreed adequacy standard for the years 2015–2024' (EirGrid, 2015). The security of supply in the Republic of Ireland is forecasted to exceed the adequacy standard for the years 2015–2024 assuming the current generating portfolio remains available, along with imports from Great Britain through the East–West Interconnector.

Total annual electricity demand in Ireland reduced between 2008 and 2014, and along with this there has also been a reduction in the annual winter peak. This has meant that recent forecasts of winter peak loads have been revised downwards compared with those forecast prior to the beginning of the economic crisis in 2008.

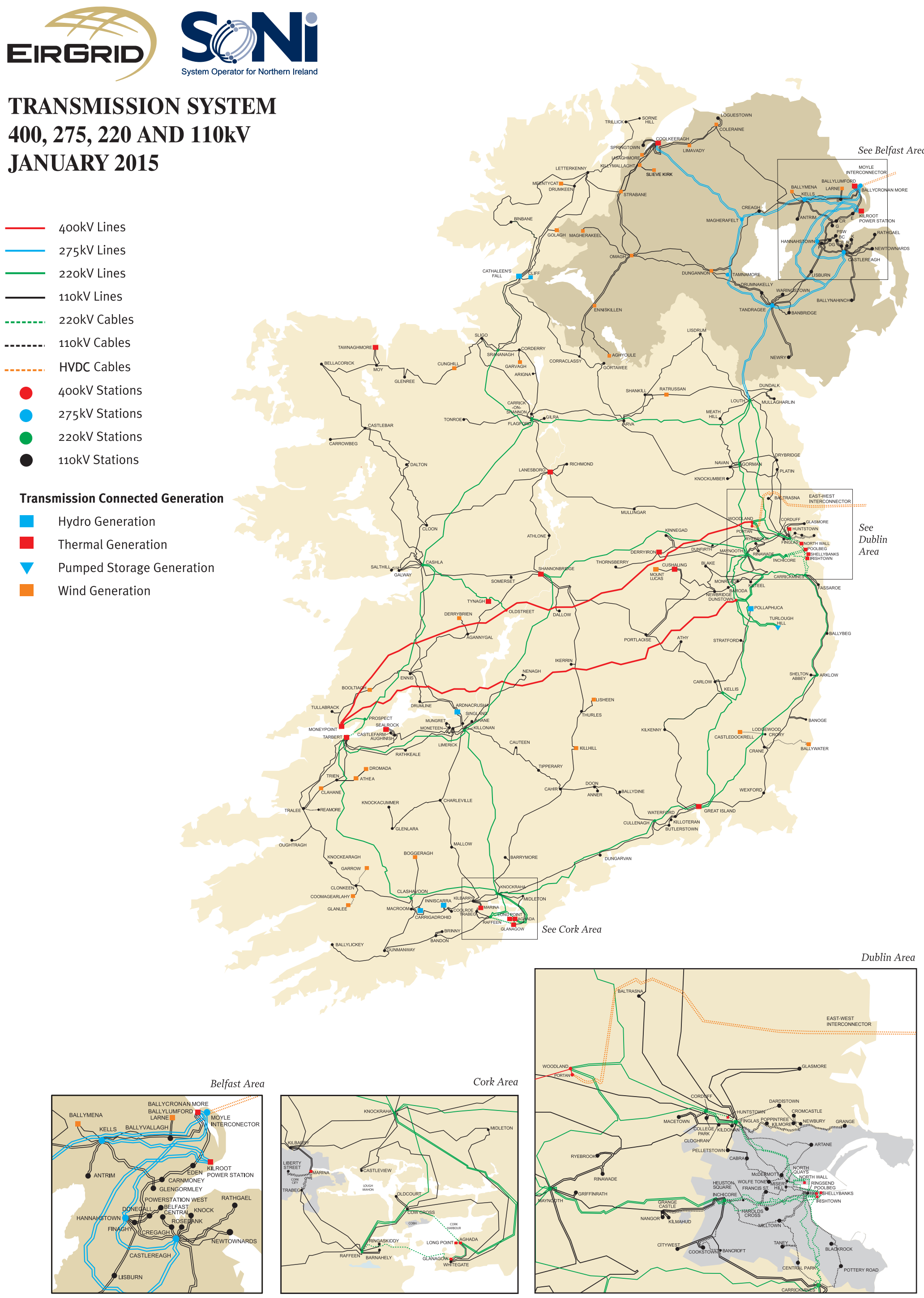
5.3.2 Electricity Transmission and Distribution Networks

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 electricity distribution system in the Republic of Ireland is the responsibility of ESB Networks Ltd. They are responsible for building, operating, maintaining and developing the electricity network and serving all electricity customers in the Republic of Ireland.

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 in Ireland, and is detailed in *Figure 45*. EirGrid is the transmission system operator, responsible for planning and operating the transmission system.

Figure 45 *Electricity transmission and distribution system*



Source: EirGrid

5.3.2.1 Grid25

In 2008 EirGrid published Grid25 which detailed a long-term strategy to develop the national electricity transmission grid until the year 2025 (EirGrid, 2008). Since 2008, EirGrid has completed the construction of over 330 km of new circuits and has uprated over 1,200 km of circuits—adding capacity without building new infrastructure (EirGrid, 2015).

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 through the use of new technologies. EirGrid's demand forecasts are based on the ESRI long-term forecast of moderate growth in economic activity. These forecasts are updated annually in the GCS. The 2015 peak demand forecast for 2025 has been scaled back considerably compared to earlier estimates. It is now forecast at approximately 5,100 MW, compared to the 2008 peak demand forecast of approximately 8,000 MW. A second review began in 2015 and is currently underway. This review involves a reappraisal of the drivers and the overall need for some of the investments envisaged in the original strategy.

Three major projects have been identified to be of particular importance with regard to the functioning of the electricity transmission grid. These are:

- The North–South interconnector—EirGrid and SONI have jointly proposed a new high capacity electricity interconnector between the electricity networks of Ireland and Northern Ireland;
- The Grid West project—with the aim of facilitating the connection of large amounts of renewable energy generation in the north Mayo region;
- Grid Link—with the aim of bolstering the transmission grid in the southeast region.

Originally new overhead lines were proposed for all three projects. Under the current review the financial and technical drivers for these proposals have been reviewed in all three cases.

Following this review of the North–South project, a new 400 kV AC overhead line is still considered as the most effective and appropriate solution. The project was designated a Project of Common Interest by the European Commission in October 2013. EirGrid has noted that without this second North–South Interconnector, the current interconnector arrangement between Northern Ireland and Republic of Ireland 'creates a physical constraint that affects the level of support that can be provided by each system to the other', and that the security of electricity supply in Northern Ireland would be at risk if this project was delayed (EirGrid, 2014).

On the Grid West project, as part of the ongoing review, EirGrid has published a report considering three options for delivering the project: an overhead line; an underground cable; a combined approach using both overhead lines and underground cables.

With regards to the Grid Link project there remains a risk to the security of supply in the south and east of the country due to heavy power flows through this part of the transmission network. The recent review of the Grid25 strategy has resulted in a revised proposal involving the introduction of a technology known as 'series compensation' onto the Irish transmission grid for the first time. This advanced technology would allow more power to be transmitted on existing lines and, significantly, it would require no significant new overhead infrastructure in the southeast. Instead, electricity generated in the southwest would be routed towards the existing 400 kV line from Moneypoint in Co. Clare, crossing the Shannon estuary via a new underwater cable. Although series compensation technology has been used mainly on long-distance lines, for example in the US, this would be one of the first times it has been used in a network the size of Ireland's.

5.3.2.2 Delivering a Secure Sustainable Electricity System (DS3)

Ireland has a target of 40% of electricity to come from renewable energy sources by 2020, while Northern Ireland has separately also set a 40% renewable electricity target to be reached by 2020. As shown in Section *4.5.4* this rapid expansion in renewable electricity generation is predominantly being met by wind. The growth of wind generation presents a range of operational challenges for the power system. The technological characteristics of wind generation are different to traditional generation sources. Wind generation is dependent on weather conditions and is inherently variable. This variability must be managed to ensure demand for electricity is met at all times. Additionally, wind generation is a non-synchronous technology (see Appendix 1), which poses unique challenges when integrating into a small, lightly interconnected, island, synchronous system.

Achieving this level 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 have the opportunity to lead the way in the integration of non-synchronous renewable generation.

In response to these challenges EirGrid Group began a multi-year programme, 'Delivering a Secure, Sustainable Electricity System', (DS3). The aim of the DS3 programme is to enable the operation of the electricity system in a secure manner while achieving the 2020 renewable electricity targets. 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 (SNSP) limit. Currently this limit is set at 50%. The DS3 programme aims to address the various factors that influence the SNSP limit, with the ultimate aim of increasing the limit from 50% to 75%. This target will be reviewed as the DS3 programme progresses, depending on the progress of various work-streams

The DS3 programme is made up of three main pillars: system performance; system policies; system tools. 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. Standards for wind farms and conventional plants are also being reviewed to provide enhanced operational flexibility for the future. The programme involves many different stakeholders, including the Distribution System Operators (DSOs), Regulatory Authorities, conventional generators and renewable generators, as well as Government Departments.

5.3.2.3 Interconnection

The East–West Interconnector, a 500 MW direct current interconnector, was completed in 2012. It connects the transmission system in the Republic of Ireland with that in Great Britain.

The transmission system in Northern Ireland is also connected to that in Great Britain through the Moyle Interconnector to Scotland. The interconnector nominally has a capacity of 500 MW however it is currently operating at a capacity of 250 MW due to a prolonged forced outage as a result of an under-sea fault, following previous separate faults in 2011 and 2010. It is expected to be repaired in 2018, after which it is expected to have a maximum import capacity of 450 MW (EirGrid, 2015).

Currently, the transmission networks of Northern Ireland and the Republic of Ireland are connected electrically by means of one 275 kV double circuit connection between Louth and Armagh. As discussed in the previous section, a proposal for a second North–South Interconnector with Northern Ireland is necessary to improve the security of electricity supply, particularily in Northern Ireland, and this is currently in the planning process.

EirGrid is currently working in cooperation with their French counterparts (Réseau de Transport d'Électricité) to explore the possibility of an Ireland–France interconnector.

EirGrid notes that the current level of interconnection capacity linking Ireland to other markets is in line with the current EU objective of 10%. The European Commission is now considering 2030 targets, one of which is a possible increase in interconnection targets to 15%.

5.3.2.4 Transmission Forecasts

EirGrid and Soni produce the Ten Year Transmission Forecast Statement (TYTFS), an annual publication which describes the development of the transmission system on the island of Ireland. The most recent publication analyses the period 2014–2023. It estimates the likely available capacity at various nodes on the transmission system, assuming certain growth rates in peak demand. The analysis suggests that, at the majority of the stations tested, there would be opportunities to add loads of up to 10 MW. This would be equivalent to the consumption of a typical pharmaceutical plant, for example.

6 Fossil Fuel Exploration

6.1 Oil and Gas Exploration

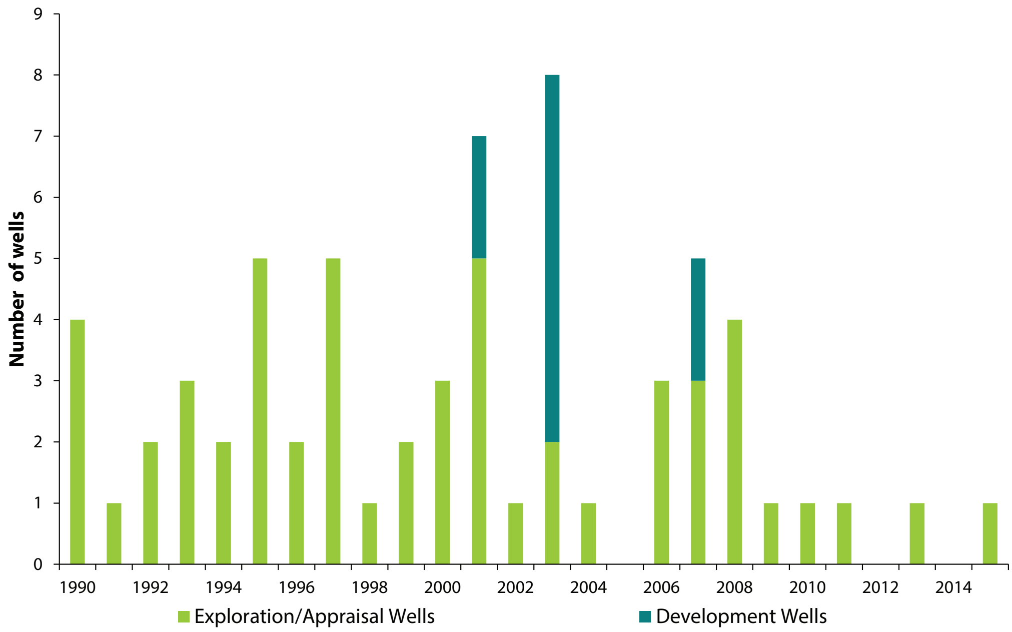
Since exploration began in Irish offshore waters four commercial gas discoveries (Kinsale Head, Ballycotton, Seven Heads and Corrib) have been made. There have been no commercial discoveries of oil to date.

Ireland's strategy for the exploitation of indigenous oil and gas resources aims to maximise the level of exploration activity and increase the level of production activity, while ensuring a fair return to the State from these activities. It is only through active exploration that the potential of Irish offshore waters will be proven.

Given that the cost of a single exploration well in the Atlantic can be in excess of €100 million, a key element of the State's strategy for this sector is that industry rather, than the Exchequer, should carry the financial risk associated with exploration. Exploration in Irish offshore waters is heavily capital intensive, particularly in the Atlantic Margin with its deep waters, distance from shore and adverse weather conditions. Ireland faces competition for exploration investment from established and proven oil and gas provinces and from emerging provinces with similar exploration profiles. *Figure 46* shows the amount of drilling for oil and gas taking 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 subsequent to 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 46 *Wells spudded and drilled in Ireland for exploration 1970–2015*



Source: DCENR (PAD)

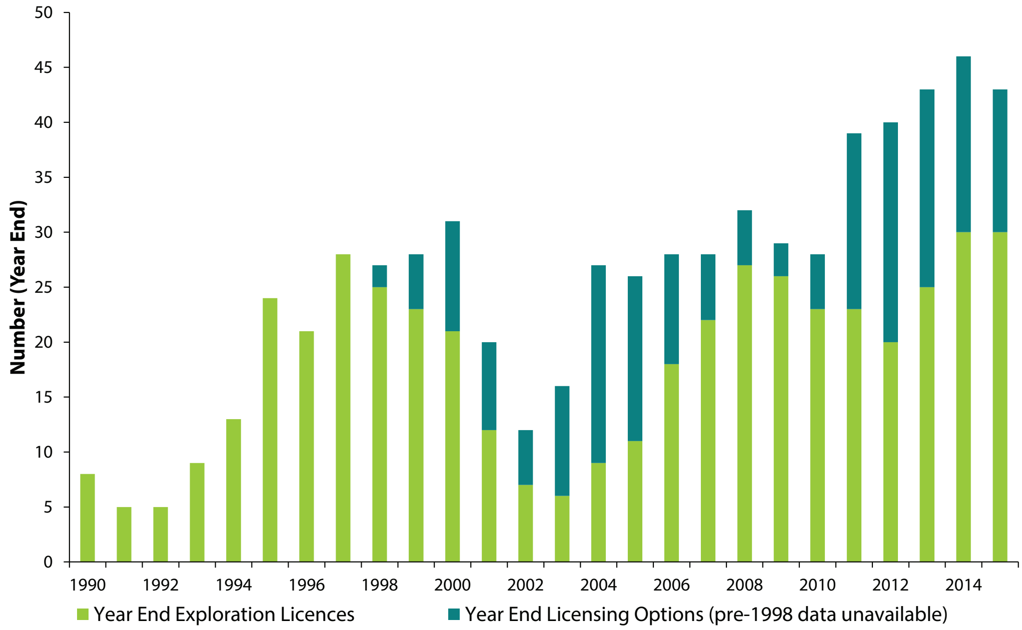
In recent years Government has repositioned the proposition offered to industry through:

- Promotion of Ireland as an exploration investment destination;
- Provision of cost-effective entry licensing mechanisms, such as those offered under the 2011 and 2015 Atlantic Margin Licensing Rounds;

- Deepening knowledge of Irish offshore waters by initiating and supporting data acquisition projects such as the 2D Atlantic Margin Regional Seismic Survey Project, and actively supporting research projects such as the new SFI Irish Centre for Research in Applied Geoscience (iCRAG);
- Reworking and modernising Ireland's regulatory and fiscal frameworks, in particular the Petroleum (Exploration and Extraction) Safety Acts 2010 and 2015, and the revised fiscal terms included in the Finance Bill 2015.

These efforts have resulted in the highest ever level of extant authorisations. Moreover, 43 applications for licensing options have been received from 17 companies in response to the 2015 Atlantic Margin Licensing Round. This is by far the largest number of applications received in any licensing round held for Irish offshore waters. The applicant companies include majors, mid-cap companies, and smaller companies. The response to the Licensing Round is a further positive signal of the building momentum in oil and gas exploration offshore Ireland. It is expected that the outcome of the Round will be published by early 2016. The number of licences to explore that have been granted since 1970 are shown in *Figure 47*.

Figure 47 *Number of licences 1990–2015*



Source: DCENR (PAD)

6.1.1 Unconventional Gas

In light of public concerns regarding the social and environmental impacts of unconventional gas exploration and extraction (UGEE, also known as hydraulic fracturing), Government has adopted a precautionary approach and has tasked the EPA with coordinating a multi-agency, all-island programme of research on the potential impacts on the environment and human health from UGEE projects. The research programme is funded by the EPA, DCENR and the Northern Ireland Environment Agency. It will provide the scientific basis to assess the potential impacts associated with any proposed UGEE projects in Ireland. The programme of research, which will not be completed before 2016, will assist regulators in making informed decisions about whether this technology can be utilised in Ireland. No applications proposing the use of this technology will be considered in advance of the findings of the research programme or before the appropriate consideration of such findings.

6.2 Coal and Peat

There may also be reserves of coal. For example, the Kish Bank Basin, offshore Dublin, is thought to contain significant quantities of bituminous coal. However, an extensive programme of exploration is required to quantify resources. A Geological Survey of Ireland report in 1986 considered the potential for exploiting this coal. Currently, however, there are no exploration licences covering the area.

Peatlands cover 1.03 million hectares of the Republic of Ireland and approximately 25,000 hectares, or 8% of the area once classified as raised bogs, are currently actively harvested. There have not been any new bogs acquired in the last 20 years by the State agency responsible for peat harvesting (Bord na Mona). Under the EU Habitats Directive Ireland is obliged under Articles 2 and 4 to protect and, where possible, restore raised boglands.

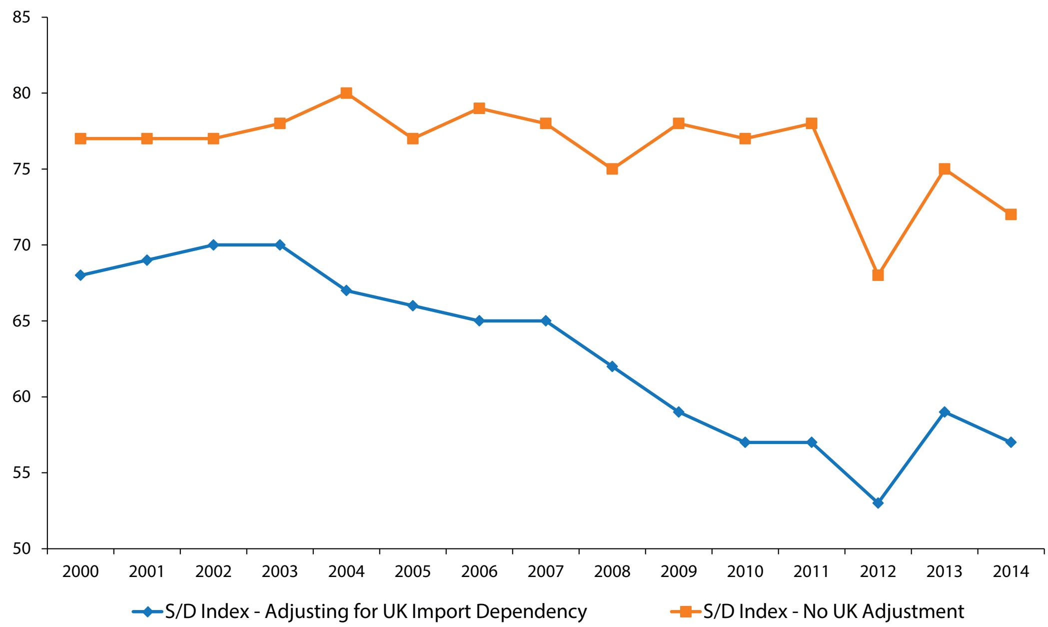
7 Quantifying Overall Energy Security

7.1 Supply/Demand Index

The supply/demand index (S/D index) provides a score based on the overall security of a country's energy system, ranging from zero (no security) to 100 (fully secure). The index covers not only the supply of primary energy sources but also the conversion and transport of secondary energy carriers and the final energy demands. The S/D index is based largely on objective information contained in energy balances combined with weighting factors and scoring rules, using existing indicators to the largest extent possible. The index differs from other energy security metrics as it takes a holistic approach and covers both supply and demand.

The following section presents the S/D index for Ireland as a time-series from 2000 to 2014. It also accounts, for the first time, for the fact that the UK, Ireland's largest energy trading partner, has seen its indigenous production of oil and gas from the North Sea rapidly depleted, and has itself become a net importer of oil and gas, with a significant portion of its imports coming from outside the EU. This has a knock-on effect on Ireland's energy security. The overall results of this analysis, summarised here in *Figure 48*, highlight that the long-term trend for Ireland's energy security is declining. In the short to medium-term, energy security will improve due to the coming on stream of natural gas from the Corrib field. However, in the medium and long-term, the overall trend for energy security is expected to continue to decline due to the diminishing supplies of oil and gas in the EU and OECD.

Figure 48 *Energy security supply/demand index scores 2000—2014*



Source: J Glynn.

7.2 Description of the Supply/Demand Index Method

The S/D index is a measurement of the medium-to-long-term energy security of the whole energy system. Multiple other energy security metrics are suitable for sector specific analysis at higher temporal resolution, assessing sectoral vulnerability to specific risk factors (SEAI, 2006). For example, the electricity transmission system operator publishes an annual generation adequacy report where they compute the power system's hours of loss of load expectation. The gas system operator similarly computes the gas capacity adequacy statement planning for a 1:50 peak demand event, akin to the winter of 2010. The S/D index, on the other hand, takes a system-wide view, including both supply and demand side elements, covering final energy demand, energy conversion and transmission (C&T), and primary energy supply.

The index was first developed by the Energy Research Centre of the Netherlands (ECN) and Clingendael International Energy Programme (CIEP). The index was proposed as a European standard for energy security assessment (de Jong et al., 2006). Using the S/D index the score for the EU-27 in 2005 was calculated as 65, and in 2020 it was predicted to fall to 62 (Scheepers, M. et al., 2007).

In 2006, SEAI commissioned ECN to calculate the S/D index for Ireland for the years 2005 and 2020, and the results of this were published in the first report by SEAI on energy security in Ireland which was published in 2006. ECN were commissioned to update this analysis for the 2007 and 2011 reports. As part of the continuing commitment to develop and improve energy security indicators, for this report SEAI commissioned the following research, which updates and examines the S/D index for Ireland for the full time period 2000–2014.

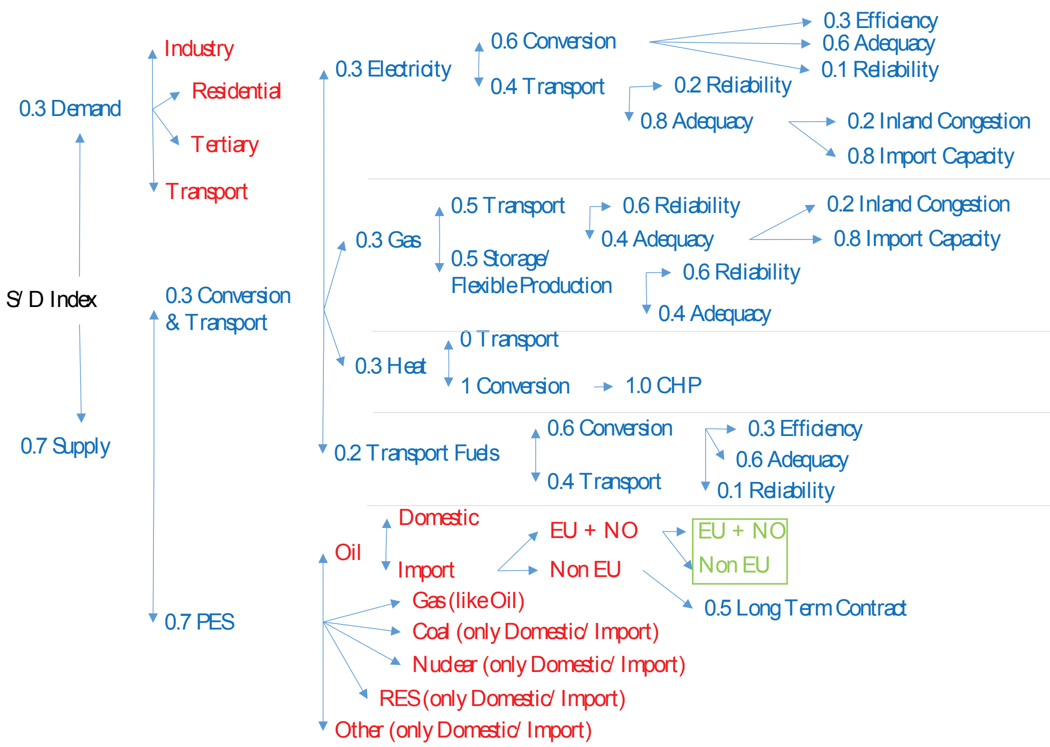
This most recent update expands the Index into a time-series within the constraints of historical data availability, updating the index to 2014, and further aims to account for the changing nature of the UK primary energy supply as was indicated as important in the previous energy security report in this series (SEAI, 2011).

The S/D index compiles quantitative and qualitative data in assessing energy system security. Quantitative data is used in weighting the sectoral demands proportionately to sectoral final energy consumption, as is primary energy supply weighted by the commodity shares of TPER. Each element in the structure of the index shown, below in *Figure 49,* is comprised of a weight and a score.

Scores are calculated by qualitative data measuring the relevant technical characteristics of the energy system, scored within a qualitative range of 0–100 and weighted according to their relative importance to the overall energy security of the system. The qualitative weights of each element, which reflect the perceived vulnerabilities of each element of the index, were decided upon by an expert survey and review in the original construction of the index, and as such are subjective and open to scrutiny on a country-by-country basis (Scheepers et al., 2007). The sum of the product of the weight and score of each level of the index structure gives an overall energy security score out of 100.

The scoring rules, qualitative weights, and demand benchmarks largely remain the same as in previous updates to allow comparison with previous studies. However, updated datasets are used and give rise to some changes in the S/D score for previous assessments. As already mentioned there is one significant change to the quantification and scoring of imported oil and gas via the UK. Irish imports of oil and gas from the UK are weighted as from EU + Norway (NO) or Non EU in proportion to the percentage of UK imports originating from outside the EU. This is implemented in an effort to account for the chain of supply of UK primary energy imports given the heavy dependence Ireland has on the UK for the primary energy supply of both refined petroleum products and natural gas. This has a strong influence on the overall index score given the dominant weighting primary energy supply receives, and the dominant scores oil and gas receive as a result of their proportions of primary energy requirement. The data input, structure and results of the S/D index are detailed in the following sections.

Figure 49 *Supply/Demand index weighting and scoring structure (adapted from Scheepers et al., 2007)*



Source: J. Glynn

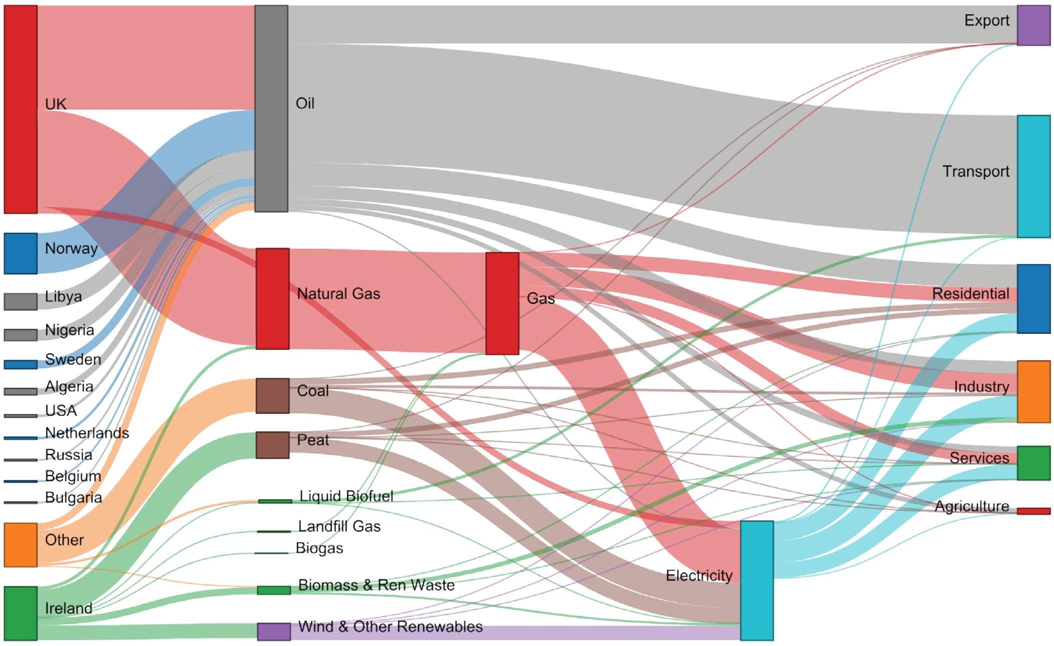
7.3 Quantifying Security of Energy Supply

7.3.1 Security of Primary Energy Supply

Primary energy supply underpins the transmission, conversion and provision of energy service demand, and as such is heavily weighted in the S/D index. The dominance of imported oil and the long-term trends in increased gas supply are discussed in Section *3.1.1* and *Figure 7,* and are further illustrated by the 'Sankey' diagram in *Figure 50* below, which also highlights the country of origin of each fuel type. The Sankey shows the flow of energy from the countries of origin of primary energy supply on the left, through conversion and transmission stages, to sectoral demand for final energy consumption on the right. The magnitude of those energy flows are represented by the thickness of the connecting paths coloured by energy type, visualising import dependency, primary energy shares, supplier diversity, fuel diversity, electricity fuel mix, efficiency, and TFC shares per sector.

For the S/D index the weight of each fuel type in primary energy supply is calculated as the ratio of the fuel primary energy requirement to TPER. In 2014 oil was 47% of primary energy requirement, gas was 28%, solid fuels in the form of coal and peat were 18%, renewable energy sources provided 8%, while other non-renewable wastes and electricity imports provided 2%.

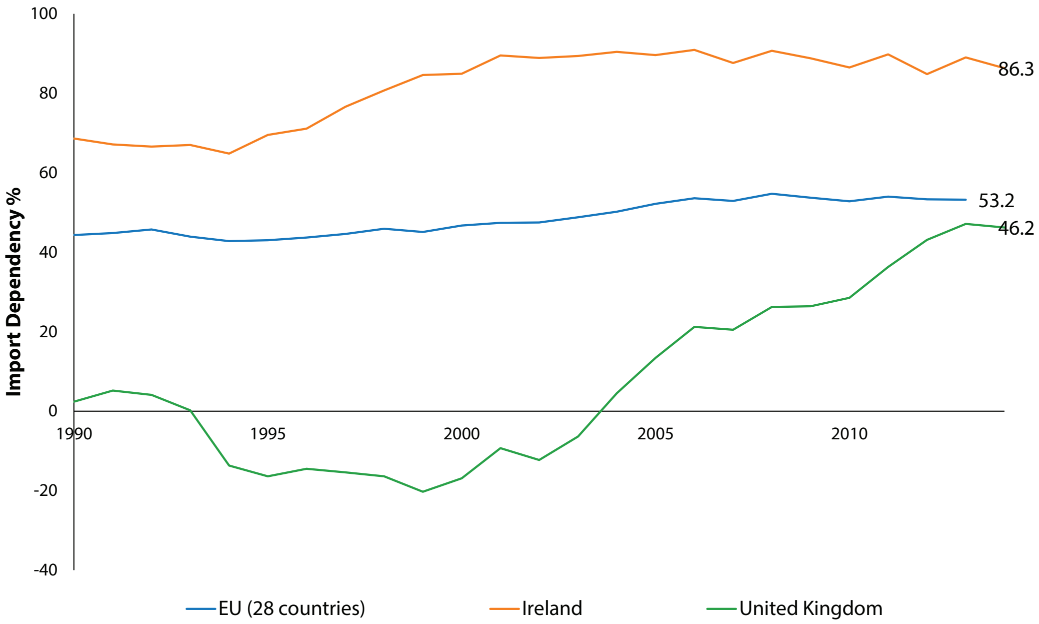
Figure 50 *Ireland energy system Sankey diagram for 2014*



Source: IEA and SEAI

The ratio of imported primary energy requirement to total primary energy requirement gives the measure of import dependency. *Figure 51* shows import dependency for Ireland, the UK and the EU. Irish import dependency declined marginally in 2014 to 86.3% from 89% the previous year. The EU has had a slowly upward long-term trend in import dependency with a recent stabilisation. EU import dependency in 2013 was 53.2%. As illustrated in *Figure 50*, Ireland imported 7,688 ktoe of oil, gas and electricity from the UK in 2014. Ireland also exported 1,406 ktoe of crude oil and refined products in 2014. The UK's rate of increase of import dependency, coincident with the decline rates of production of North Sea oil and gas, is a considerable indication of Irish energy security. The UK became net energy importers in 2004, at an import dependency that year of 4.5%, rapidly rising in 2014 to 46.2%. It is because of this development that this update to the S/D index re-weights Irish imports of oil and gas from the UK, considering the proportion of imports to the UK from the EU and Norway, and non-EU countries.

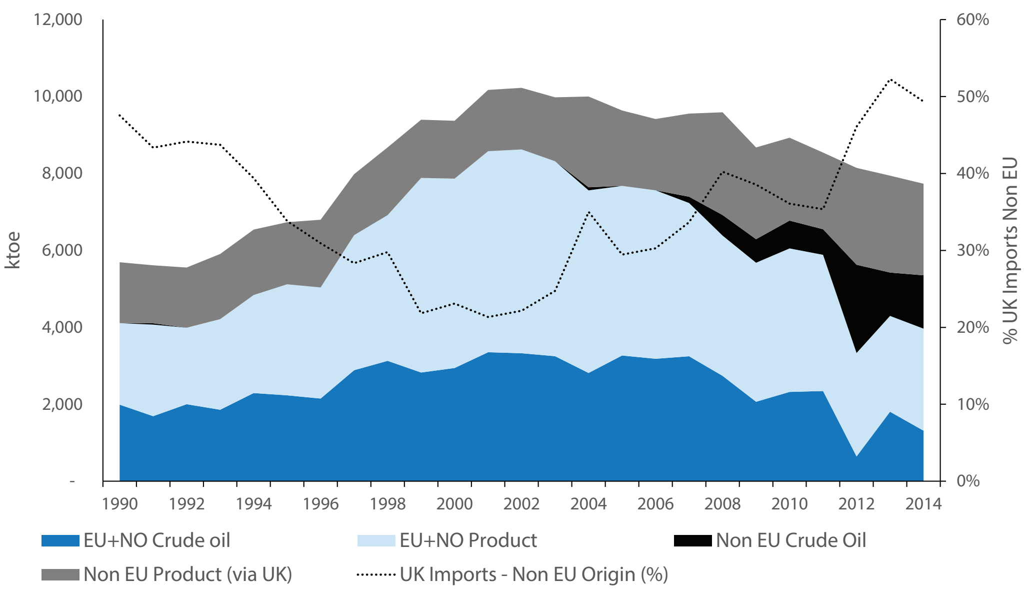
Figure 51 *Irish, EU-28 and UK import dependency*



Source: Eurostat

Total supply of oil to Ireland is shown in *Figure 52*. The trend follows the overall decline from the peak of consumption of oil products in 2007, taking in more recent reductions in output from the Whitegate refinery to 2,871 ktoe in 2014. 2014 saw an uptick in primary energy requirement for oil (which is net of oil exports). From 2008 onwards, there has been a considerable increase in the supply of crude oil from non-EU countries, both as direct imports and by proxy through the UK. In 2014, 51.4% of crude oil imports to Ireland originated outside the EU and 49% of UK oil imports originated outside the EU. Reweighting UK oil product imports to Ireland by their EU vs non-EU distribution of suppliers shows that the share of oil products imported to Ireland from non-EU countries at 47.3% in 2014. Accounting for UK oil supplier diversity, overall Irish oil imports (crude and product) from the EU and Norway accounted for 51.3% of supply in 2014.

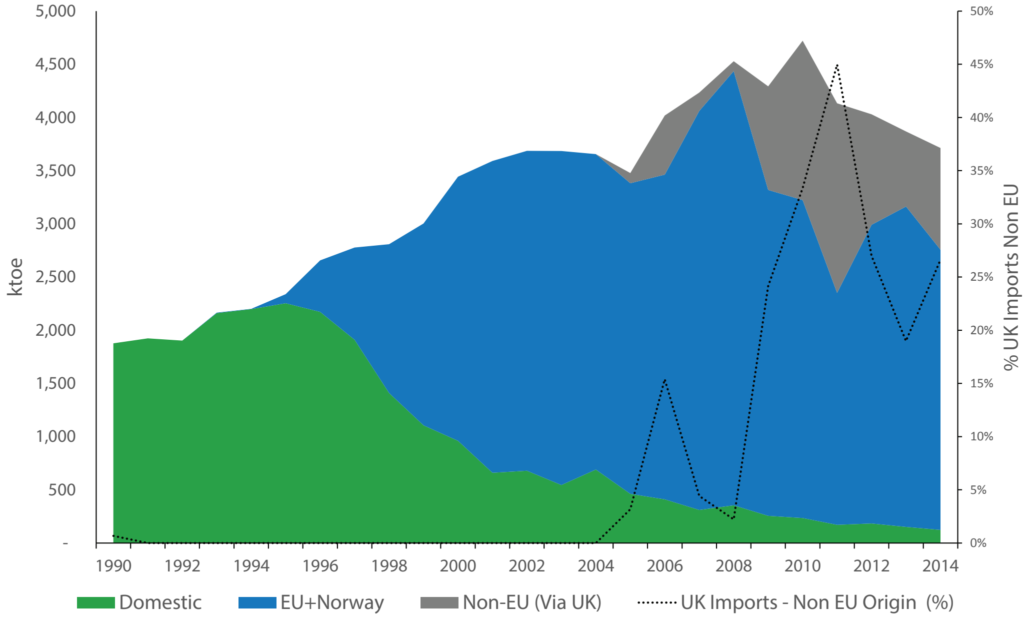
Figure 52 *Irish oil supply by EU and Non-EU supply origin*



Source: Eurostat

Indigenous gas production of 123 ktoe accounted for 3.3% of gas primary energy supply in 2014. The remainder was imported via interconnectors with Scotland and the UK gas transmission system. Gas imports from the UK are also reweighted to account for the proportion of UK supply to Ireland that originated outside the EU, as shown in *Figure 53*.

Figure 53 *Irish gas supply by EU and Non-EU supply origin*

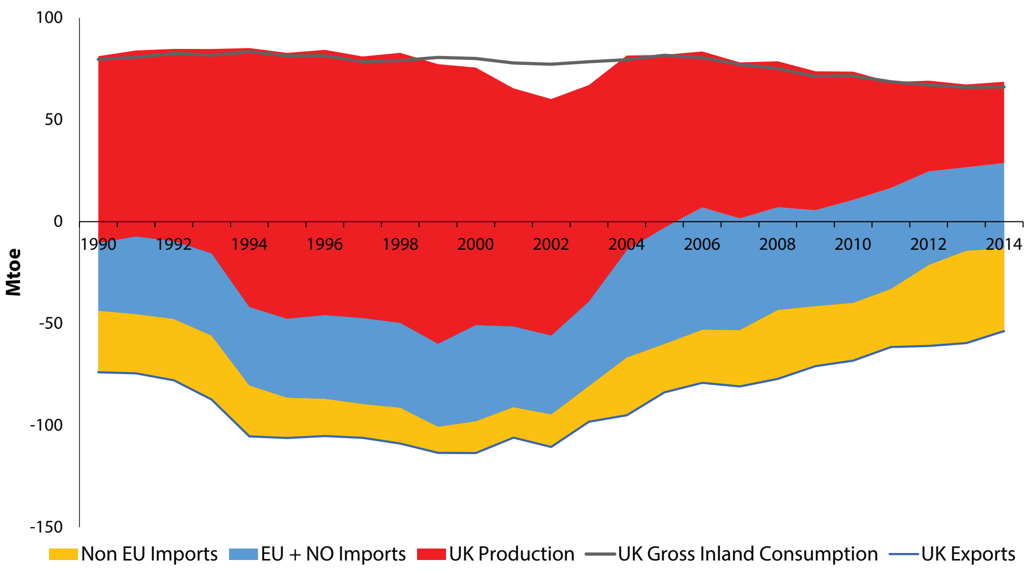


Source: Eurostat

7.3.1.1 UK Primary Energy Supply Balance

The most recent DUKES Chapter 3, points to declining UK crude oil production, declining UK refining capacity, declining UK petroleum product output, and a mismatch between the slate of products produced in the UK and UK product demand. All these factors contribute to the increasing level of non-EU imports of both crude oil and petroleum products to balance UK oil demand. The UK has a legacy overcapacity of refineries, whose demand is not met by domestic oil production. While the UK continues to export large levels of refined oil products, it has been a net oil importer since 2004, requiring increased imports from the EU, and increasingly from further afield, as shown in *Figure 54*. In 2014 UK oil production was 39,698 ktoe, down from the 1999 peak of 137,421 ktoe, with consumption at 69,341 ktoe.

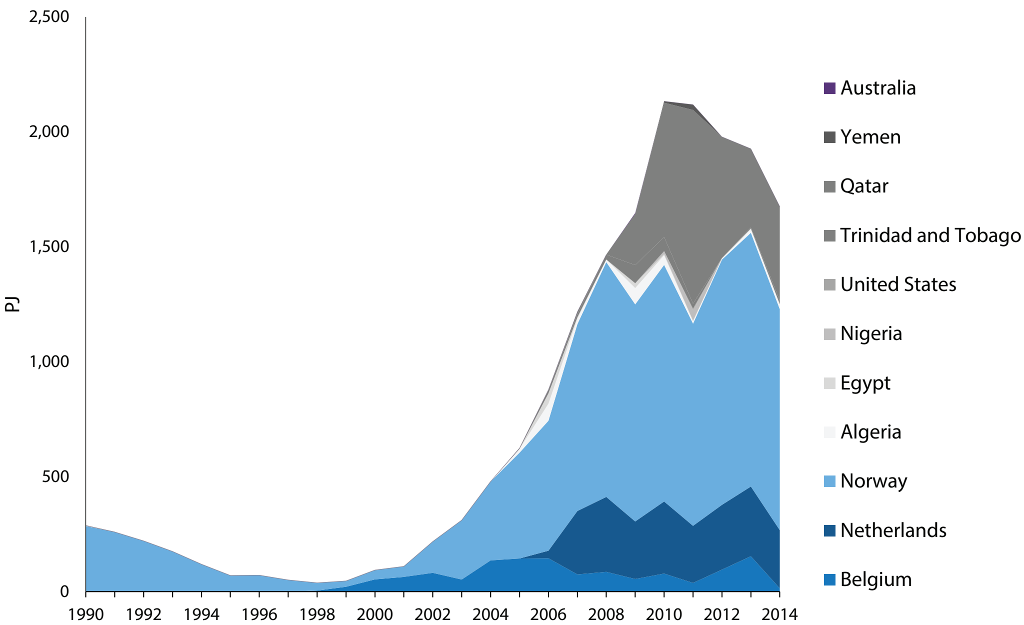
Figure 54 *UK oil supply balance*



Source: Eurostat/DECC/BP

UK gas production peaked at 97,537 ktoe in 2000, thereafter gas production declined at an average rate of 9.2% year on year from 2000 to 2010, while imports rose at 36.7% year on year. UK gas consumption was 87,647 ktoe in 2004 and declined to 60,007 ktoe in 2014, -3.7% year on year over 10 years. In 2014 LNG imports from non-EU countries made up 27% of UK gas imports, as shown in *Figure 55*. The EU-28 as a whole imported 65.3% of its gas in 2013 .

Figure 55 *UK gas imports by origin*



Source: EUROSTAT/DECC

7.3.2 Security of Energy Conversion and Transmission

The C&T element of supply gives dominant weighting to electricity and gas, which are discussed below. The remaining sections of the C&T branch of the S/D index are made up of heat and transport fuels.

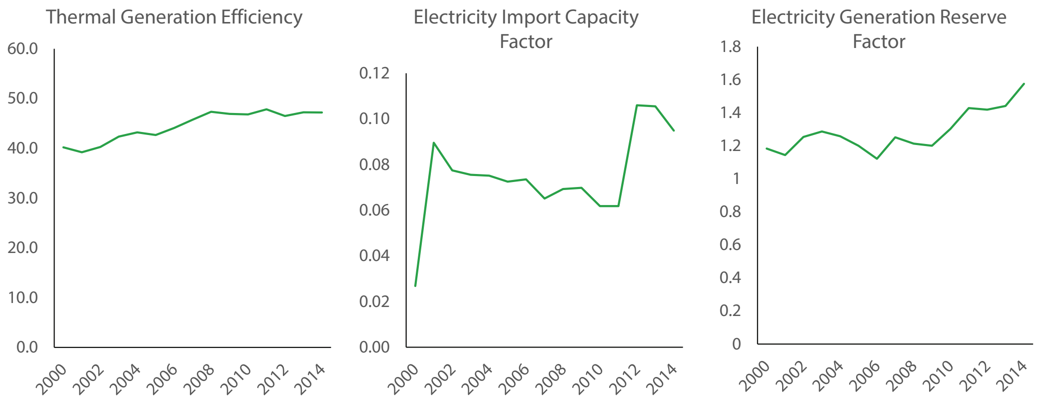
Given the lack of heat C&T in Ireland, heat security is simply scored as the level of electricity generated from CHP plants as a percentage of all electricity generation available for final consumption. In 2014, CHP generated electricity made up 8.3% of electricity available for final consumption.

Transport fuel security is based on the efficiency and reserve capacity of refining capacity in any given year. Whitegate refinery is the only refinery in Ireland, and their production slate is dependent on many variables but, largely, profitability is dictated by the volatility at the margin of crude oil prices. Strategically, Whitegate refinery provides security by maintaining a maximum of 20% reserve capacity for the production of transport fuels. Transport fuel security is calculated as a function of the ratio of the refinery annual output to the maximum capacity. Accordingly it achieves a score in the range of 80%–95% maintaining a reserve margin for strategic security.

7.3.2.1 Electricity

The security of the electricity branch of C&T is scored with multiple data inputs quantifying efficiency, adequacy and reliability. The generation efficiency of conventional electricity thermal generation plants, excluding non-dispatchable renewables, is seen to have stabilised at 47.2% in 2014. This excludes the effects of supply efficiency from own uses, transmissions losses, imports, exports or the input from wind energy. Import capacity factor is calculated as the ratio of import capacity to installed dispatchable capacity. Given the outages in the Moyle Interconnector and the newly commissioned east–west interconnector the import capacity factor has risen accordingly to over 10% recently, having dropped below 10% in 2014 due to new installed capacity, and reduced interconnection capacity due to line faults on both the Moyle and east–west interconnector lines. Generation adequacy is scored relative to the generation reserve factor, which is the ratio of installed dispatchable capacity to peak demand in any given year. A score of 1.2 or above is seen as sufficiently secure.

Figure 56 *Electricity conversion and transmission system security characteristics*



Source: SEAI/EirGrid/Eurostat

7.3.2.2 Gas

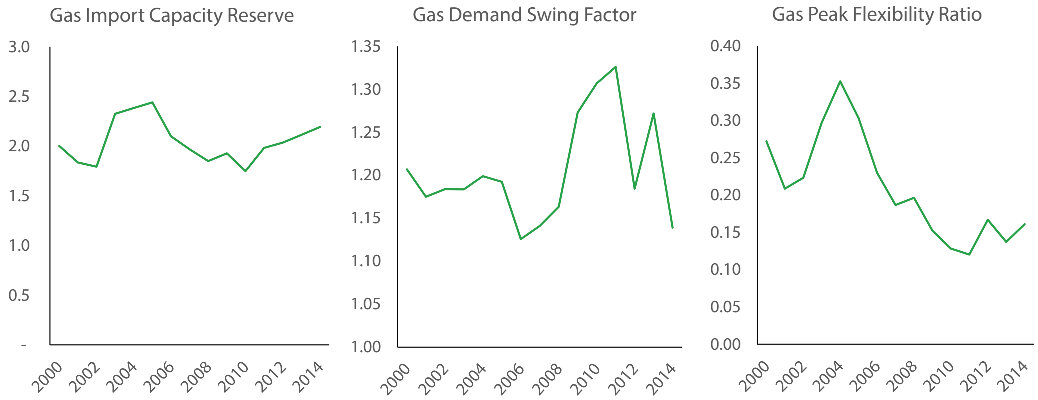
The gas C&T security score is dependent upon the network adequacy and reliability of transmission, storage, and flexible production. Three metrics are used for the S/D index to characterise annual and peak demand trends, as presented in *Figure 57*.

The import reserve factor is the ratio of the import capacity of the Moffat interconnector less the reserved capacity for Northern Ireland to the annual gas imports of the Republic of Ireland. In 2014, there was over 50% reserve capacity on the gas import infrastructure on average over the year.

The demand swing factor is the ratio of monthly peak demand verses the average monthly gas demand in any given year, and it measures the volatility between summer trough and winter peak demand. The unusually cold weather events that occurred in the winters of 2009/10 and 2010/11 caused large demand swings in range of 30% between the average and peak gas demands. This is seen more clearly in *Figure 58* which shows monthly domestic gas demand for the years 2008–2014.

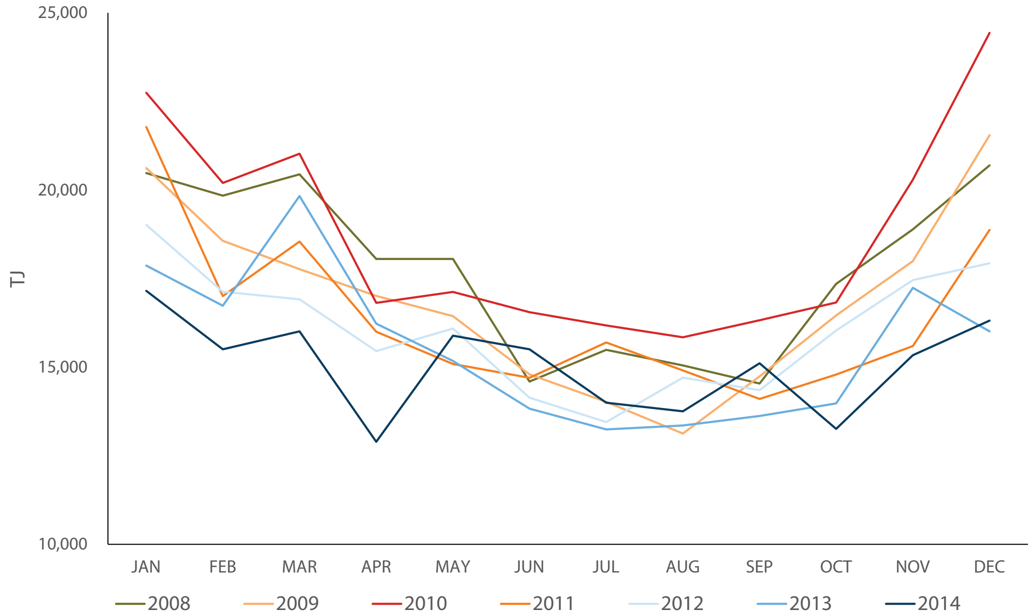
Shorter term gas storage and flexible production is measured as the ratio of monthly peak gas production and peak (underground) gas storage output per month to peak monthly gas consumption in any given year. Domestic gas production from the Kinsale gas field is plotted in *Figure 59*, and, as can be seen, is currently in decline, providing declining seasonal storage services. Flexible production and/or storage in the form of Corrib gas and/or Shannon LNG will improve this metric.

Figure 57 *Gas conversion and transmission system security characteristics*



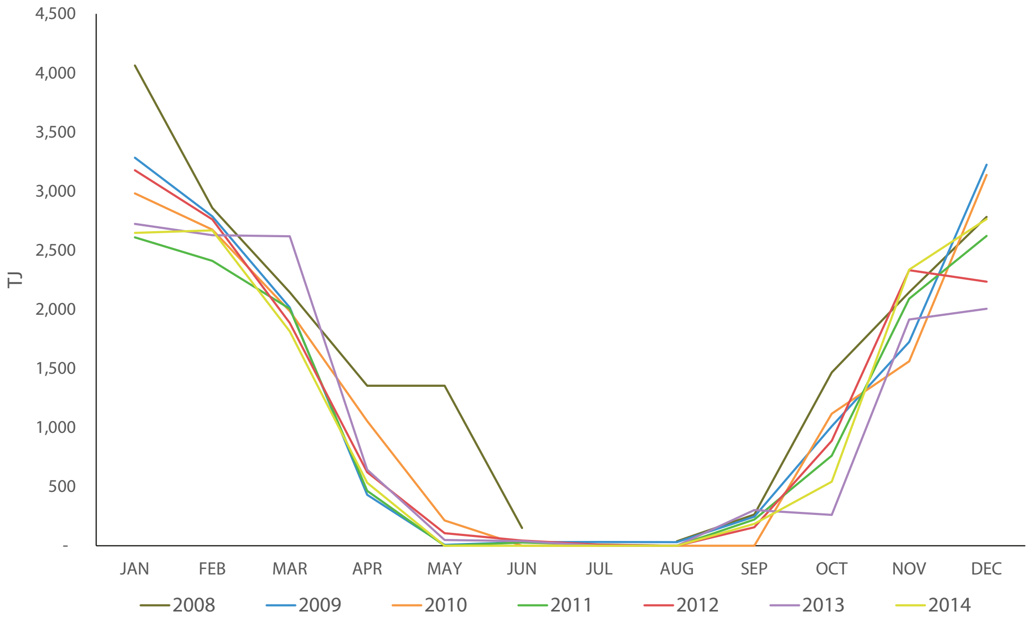
Source: GNI/CER/Eurostat

Figure 58 *Monthly domestic gas consumption*



Source: Eurostat

Figure 59 *Monthly domestic gas production*



Source: Eurostat

7.4 Quantifying Energy Demand Security

Energy demand intensity is bench-marked against the average of the top five EU scores to give a relative score for demand security for each sector. The average of the best demand intensities of the top five EU-15 is used to create the benchmark for all sectors other than the residential sector, where the average of the top five EU-25 Member States creates the benchmark score for residential energy demand intensity. The same EU benchmarks based on 2003 data are used for consistency. The sectoral charts in *Figure 60* show Irish energy demand intensities relative to a time-series of EU benchmarks for each year.

Irish industry in 2014 is seen as having a low energy intensity per value added, of 72.3 toe/M€$_{2005}$GVA, and is lower than the EU benchmark. It therefore receives a high score of 100%, highlighting energy efficiency and the high value added nature of Irish industry.

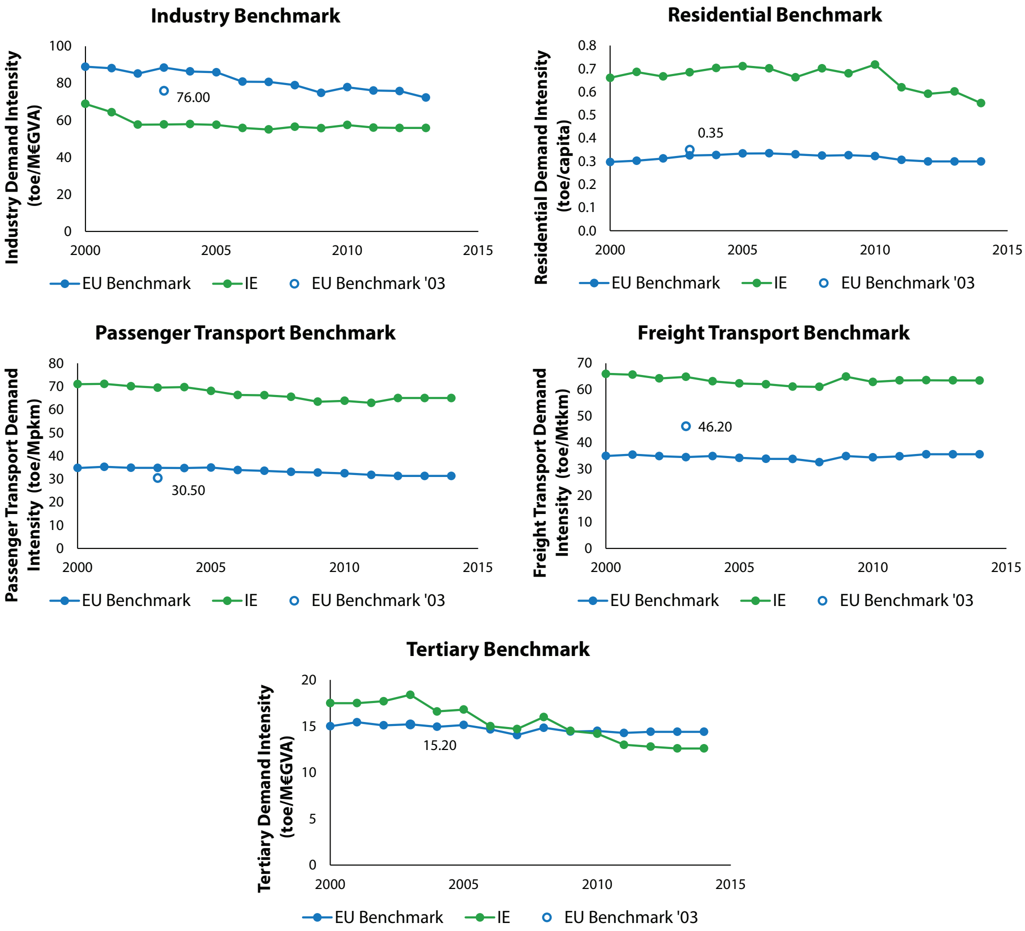
The tertiary sector is seen to be in transition, from higher energy intensity before the great recession, to below the EU benchmark more recently. The tertiary sector energy intensity in 2014 of 14.4 toe/M€$_{2005}$GVA was below the benchmark, and received a 100% score in 2014. All other sectors exhibit higher energy demand intensities relative to the EU benchmarks and are scored accordingly.

The residential sector is reducing in energy intensity on a per capita basis, most notably post 2008. A decomposition analysis is required to parse out the effects of economic recession, energy poverty and housing energy efficiency. In 2014, the residential energy demand intensity dropped to 0.55 toe/capita, but was still above the EU benchmark of 0.29 toe/capita.

Passenger transport had approximately double the demand intensity of the EU benchmark on an energy per passenger-kilometre basis, at 65 toe/Mpkm and 31.6 toe/Mpkm respectively. Post 2008, freight transport demand intensity rose slightly to 63.5 toe/Mtkm, compared with the EU benchmark of 35.7 toe/Mtkm in 2014.

Each of the sectoral demand intensities were weighted by their proportion of TFC in any given year. Transport dominates demand security given its growth from 38% of TFC in 2000, to 43% TFC in 2007, to 42% in 2014.

Figure 60 *Energy demand intensity and European benchmark for each sector of the Index (a) industry, (b) residential, (c) passenger transport, (d) freight transport, (e) tertiary*



Source: ODYSSEE and SEAI

7.5 S/D Index Results

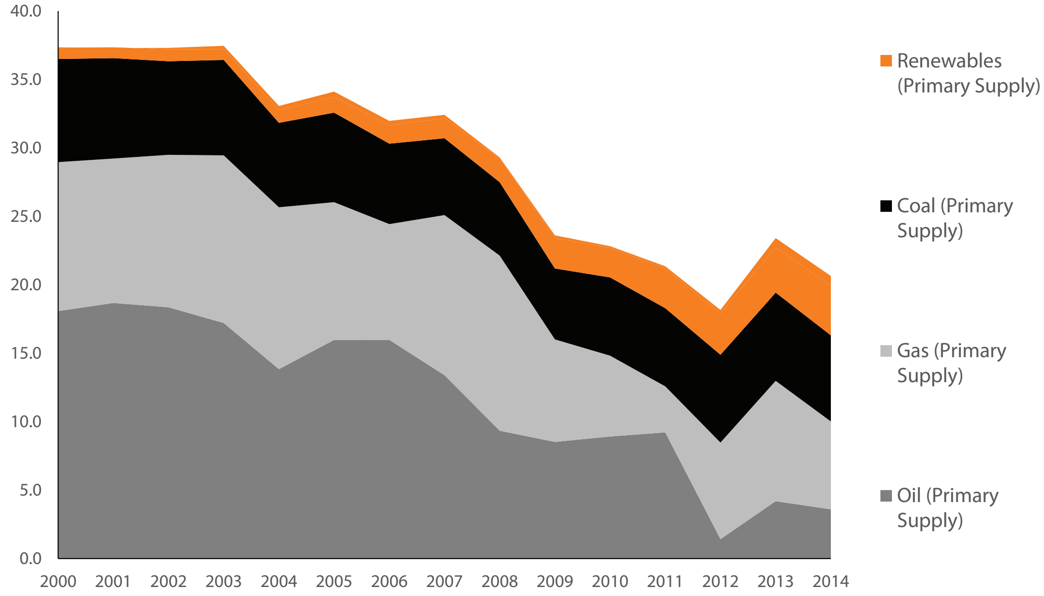
7.5.1 Supply

7.5.1.1 Primary Energy Supply

The annual scores for the security of primary energy supply for the period 2000–2014 are shown in *Figure 61*. The maximum score of the primary energy supply branch of the index is 49 (indicating maximum security). The change in methodology, whereby UK imports have been weighted by the proportion originating within the EU and Norway, or from further afield, has resulted in considerable differences in the primary energy security score when compared to previous updates.

Primary energy supply of crude oil and refined products reduced most considerably, to 3.6 (15.6%) in 2014. It is worth noting that short-term oil security on the island as a result of the increased strategic storage of oil products has improved greatly in recent years to 90 days' strategic oil reserves. However the S/D index aims to take medium-to-long-term trends into consideration, prioritising the perceived risk of the country of origin of primary energy supply. Primary supply of natural gas, following the same re-weighting method for UK imports from outside the EU, shows a declining trend, scoring 6.4 (46.7%) in 2014. The security of coal supply was stable, scoring 6.3 (83.9%) in 2014. Notably, the increasing supply of renewable energy that is produced indigenously, particularly wind and biomass, has improved the security of primary energy supply. Renewable primary energy supply scored 3.6 (96.1%).

Figure 61 *Primary energy supply security scores*

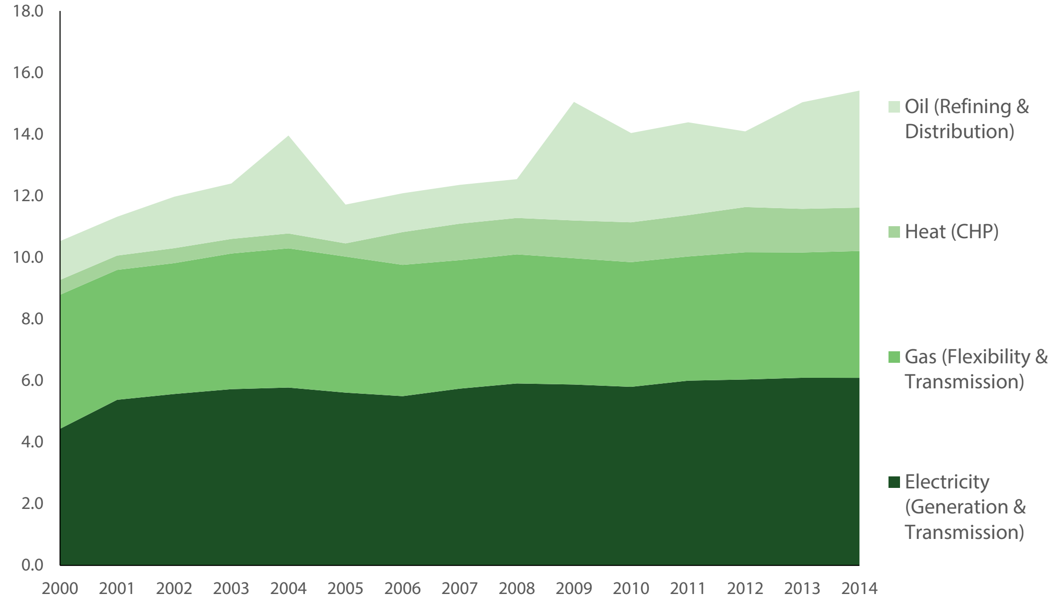


Source: J. Glynn

7.5.1.2 Energy Conversion and Transmission

The annual scores for the security of the energy C&T are shown in *Figure 62*. The maximum score for the C&T branch of the S/D index is 21 (indicating maximum security). Compared with previous updates for 2008, this dataset shows the electricity sector scoring higher than previous assessments while the conversion of transport fuels is considered to be slightly worse. Gas and heat assessments show largely similar results. Given the increased interconnector capacity above the recommended EU threshold, increased thermal efficiency, and reserve capacity above peak demand, the electricity sector received a near maximum score of 6.1 (96.5%). The assessment of gas conversion and transmissions security was reduced as a result of the low levels of flexible production or flexible storage. The Gas C&T branch scores 4.1 (65.4%). Heat is a small proportion of the S/D index. It is governed by the proportion of CHP in the electricity generation mix. Heat C&T scored 1.4 (33.5%). Oil refining for transport fuels saw a growing security score as a result of spare refining capacity providing strategic reserve. Transport fuels in refining and distribution scored 3.8 (90.5%) in 2014, however historically there was volatility in this score, depending on the utilisation factor of the refining capacity in the Whitegate refinery.

Figure 62 *Conversion and transmission supply security*

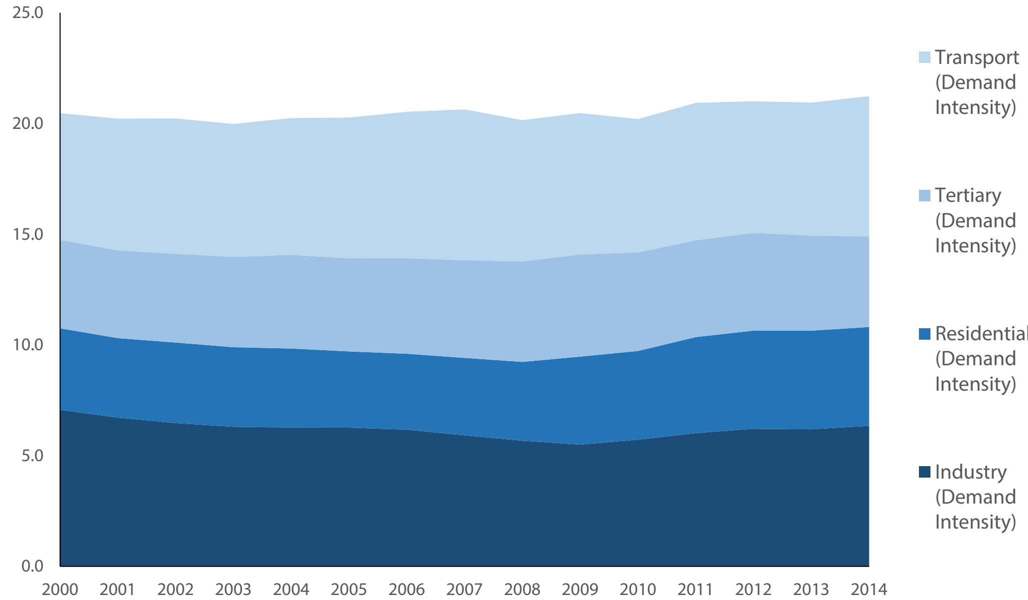


Source: J. Glynn

7.5.2 Demand

The annual scores for energy demand security are shown in *Figure 63*. The maximum score of the demand element of the S/D index in any given year is 30 (indicating maximum security). In 2014 demand security scored 21.2 (70.8%). The long-term demand intensity trend was stable, with a recent reduction in residential demand intensity. The tertiary sector increased its demand security score when these updated data sets are compared to the previous 2008 S/D index update. Industry accounted for 21% of TFC in 2014, and, with an energy demand intensity lower than the top five EU countries, received a maximum score of 6.3 (100%). The residential sector accounted for 23% of TFC, with a score of 4.5 (63.5%). The tertiary sector received a maximum score of 4.1 (100%). Demand security in transport increased, primarily as a result of lower energy demand intensity per passenger-kilometre. Transport consumed 42% of TFC, and received a score of 6.3 (50.5%).

Figure 63 *Demand energy security scores*

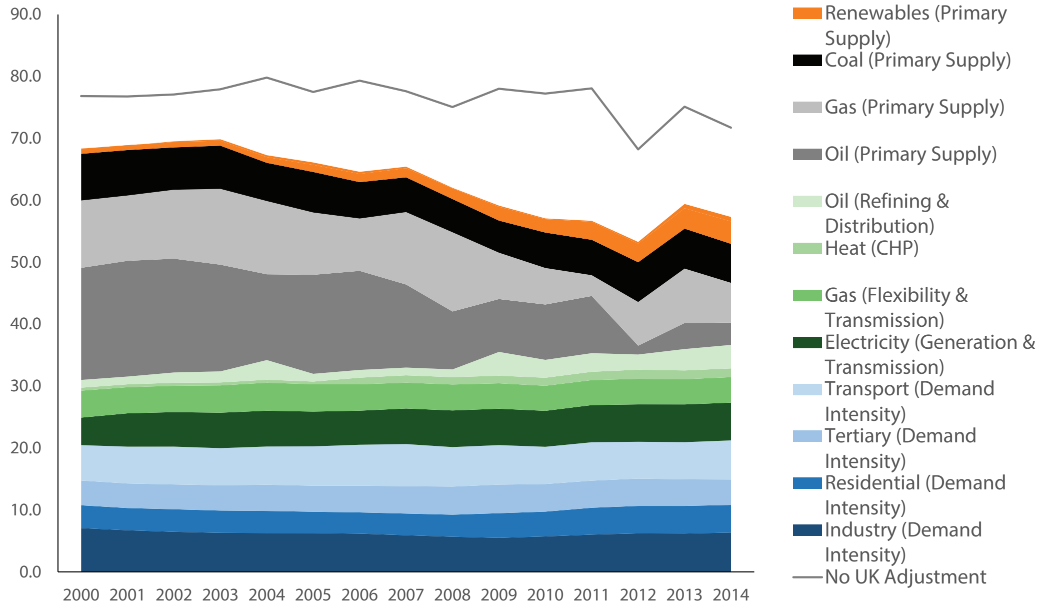


Source: J. Glynn

7.5.3 Overall S/D Index Results

Combining the results of the analysis for primary energy supply, C&T, and energy demand gives the overall result of the S/D index, as shown in *Figure 64*. The case where no adjustment to the primary energy supply for the UK import mix is also presented, for contrast and comparison with previous S/D index updates for Ireland. Overall the elements under domestic control on the demand side and the supply element of C&T are improving. The increasing penetration of domestic renewable energy sources is acting to slow the overall decline in the security of primary energy supply. However, given the weighting for perceived risk that non-EU suppliers of oil and gas receive in this method, the security of Irish primary energy supply is the dominant factor in determining a declining overall security of supply. Energy security has declined in recent years with or without considering the proportion of UK imports that originate from outside the EU.

Figure 64 *Energy security Supply/Demand index*



Source: J. Glynn

Table 3 *Supply/Demand summary results*

	2008			2010			2012			2014		
	Weight	Score	Result	Weight	Score	Result	Weight	Score	Result	Weight	Score	Result
S/D Index			***62***			***57***			***53***			***57***
S/D Index—No UK Adjustment			***75***			***77***			***68***			***72***
Demand Intensity	0.3	***67.2***	20	0.3	***67.3***	20	0.3	***70.0***	21	0.3	***70.8***	21
Industry	0.19	100	5.7	0.19	100	5.7	0.21	100	6.2	0.21	100	6.3
Residential	0.24	50	3.6	0.27	49	4.0	0.25	59	4.4	0.23	63	4.5
Tertiary	0.16	95	4.5	0.15	100	4.5	0.15	100	4.4	0.14	100	4.1
Transport	0.41	51	6.4	0.39	52	6.0	0.40	50	5.9	0.42	50	6.3
Supply	0.7	***60***	41.8	0.7	***53***	36.9	0.7	***46***	32.3	0.7	***52***	36.1
Conversion & Transmission	0.3	***59.7***	12.5	0.3	***66.9***	14.0	0.3	***67.1***	14.1	0.3	***73.4***	15.4
Electricity	0.30	94	5.9	0.30	92	5.8	0.30	96	6.0	0.30	97	6.1
Gas	0.30	67	4.2	0.30	64	4.0	0.30	66	4.1	0.30	65	4.1
Heat	0.20	28	1.2	0.20	31	1.3	0.20	35	1.5	0.20	34	1.4
Oil	0.20	30	1.3	0.20	69	2.9	0.20	58	2.5	0.20	90	3.8
Primary Energy Supply	0.7	***60***	29.3	0.7	***47***	22.8	0.7	***37***	18.2	0.7	***42***	20.6
Oil	0.55	35	9.3	0.50	37	8.9	0.45	6	1.4	0.47	16	3.6
Gas	0.27	95	12.8	0.32	38	5.9	0.30	47	7.1	0.28	47	6.4
Coal	0.14	79	5.4	0.14	85	5.7	0.17	76	6.4	0.15	84	6.3
Renewables	0.04	98	1.7	0.05	96	2.2	0.06	97	3.0	0.08	96	3.6
Other	0.00	70	0.1	0.00	75	0.1	0.01	87	0.3	0.02	78	0.7

Source: J. Glynn

7.6 Acknowledgements

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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 tCO_2 (tonnes of CO_2), $ktCO_2$ (kilo-tonnes of CO_2) and $MtCO_2$(mega-tonnes of CO_2).

Combined Heat & Power Plants: Combined heat and power (CHP) refers to plants which are designed to produce both heat and electricity. CHP plants may be autoproducer (generating for own use only) or third-party owned selling electricity and heat on-site as well as exporting electricity to the grid.

Gross Domestic Product: The gross domestic product represents the total output of the economy over a period.

Gross Final Consumption (GFC): The Renewable Energy Directive (2008/28/EC) defines gross final consumption of energy as the energy commodities delivered for energy purposes to manufacturing industry, transport, households, services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution.

Gross Electrical Consumption: Gross electricity production is measured at the terminals of all alternator sets in a station; it therefore includes the energy taken by station auxiliaries and losses in transformers that are considered integral parts of the station. The difference between gross and net production is the amount of own use of electricity in the generation plants.

Structural Effect: As it affects energy intensity, structural change is a change in the shares of activity accounted for by the energy consuming sub-sectors within a sector. For instance, in industry the structural effect caused by the change in emphasis of individual sub-sectors such as pharmaceuticals, electronics, textiles, steel, etc in their contribution to gross domestic product.

Total Final Consumption (TFC): 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.

Total Primary Energy Requirement (TPER): This is the total requirement for all uses of energy, including energy used to transform one energy form to another (e.g. burning fossil fuel to generate electricity) and energy used by the final consumer.

Appendix 1

Non-synchronous Electricity Generation

In a synchronous AC power system, such as that of the Republic of Ireland and Northern Ireland, all of the conventional generating units are synchronised (that is the waveform 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.

When supply and demand are in balance, the frequency will be exactly 50 Hz. If there is excess generation, the frequency increases; conversely, if there is insufficient generation, the frequency will decrease. The normal operating limits for frequency in Ireland are from 49.9 to 50.1 Hz, and the management of frequency in real time is one of EirGrid and SONI's primary duties. Frequency excursions outside these limits can occur if there is a sudden change in load or generation, or if generation trips out due to a fault. This is managed by maintaining operating reserves, both spinning and static, on the system that can be used to correct the energy imbalance when it occurs.

Electricity from sources such as wind turbines, and the high voltage direct current (HVDC) electricity from interconnectors, is described as non-sychronous and, crucially, does not provide the same inertia as traditional synchronous plants. EirGrid notes[29] that a power system with a high penetration of variable non-synchronous wind generation poses significant challenges for frequency control over multiple time-frames. These challenges can be categorised as follows:

- Rate-of-change-of-frequency (ROCOF) issues—ensuring that generation does not trip for large ROCOF values that come about because of the reduced system inertia in a system with high non-synchronous penetration. This issue is being addressed separately in a dedicated DS3 work-stream;
- Frequency response to large disturbances—ensuring adequate system inertia and a fast-acting response to minimise the chances of load-shedding for system events such as transmission faults or the loss of large in-feeds;
- Voltage induced frequency dips—transmission faults that lead to reduced power output from wind-farms, leading to a frequency dip;
- Frequency regulation—maintaining system frequency within its normal limits, and coping with fluctuations in demand and generation particularly with increased penetration from wind-farms;
- Generation ramping capability—ensuring that the generation portfolio is able to cope with large changes in demand and wind generation over periods from minutes to hours. This is often referred to as the flexibility of plant.

The purpose of the DS3 programme is to address the various challenges to operating the power system that will occur as wind penetration increases. Frequency control is a central plank of the programme, along with voltage control, as it gets to the very heart of how a power system is operated. The various frequency control issues will be addressed as part of the Frequency Control work-stream under the DS3 programme.

29 EirGrid, 2011; DS3: Frequency Control Workstream. Available from www.eirgridgroup.com/

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