Sustainable Energy Ireland

Energy Policy Statistical Support Unit

Security of Supply in Ireland

2007 REPORT

Security of Supply in Ireland 2007

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SUSTAINABLE ENERGY IRELAND

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Sustainable Energy Ireland (SEI)

Sustainable Energy Ireland was established as Ireland's national energy agency under the Sustainable Energy Act 2002. SEI's mission is to promote and assist the development of sustainable energy. This encompasses environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy including public bodies, the business sector, local communities and individual consumers. Its remit relates mainly to improving energy efficiency, advancing the development and competitive deployment of renewable sources of energy and combined heat and power, and reducing the environmental impact of energy production and use, particularly in respect of greenhouse gas emissions.

SEI is charged with implementing significant aspects of government policy on sustainable energy and the climate change abatement, including:

- Assisting deployment of superior energy technologies in each sector as required,
- Raising awareness and providing information, advice and publicity on best practice,
- Stimulating research, development and demonstration,
- Stimulating preparation of necessary standards and codes and
- Publishing statistics and projections on sustainable energy and achievement of targets.

It is funded by the Government through the National Development Plan with programmes part financed by the European Union.

Energy Policy Statistical Support Unit (EPSSU)

SEI 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 to meeting international reporting obligations, for advising policy makers and informing investment decisions. Based in Cork, EPSSU is SEI'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 and
- Contribute to the development and promulgation of appropriate sustainability indicators.

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The authors wish to dedicate this report to the memory of Shimon Awerbuch who died in January 2007. Shimon was a great researcher and innovator in the area of security of supply.

1 Introduction

This report, the third in a series, continues SEI's annual review of energy Security of Supply (SOS) in Ireland. The metrics, or indicators, presented in this report address a wide range of issues relevant to the topic of SOS. They span a range from national to international concerns and across primary fuels and their conversion into energy services. The report, set against the backdrop of a security focused world, is intended to inform debate and provide information to policy makers, energy market participants, investors, and the public. The metrics utilised have been refined since the last publication to provide enhanced focus on the issue of SOS[1].

The complexity in this area of energy policy does not allow for simple solutions or measurement. In 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 SOS. This report attempts to consider the issue holistically and allow stakeholders to respond in an informed manner.

As part of the commitment to develop and improve SOS indicators, SEI in 2007 commissioned new pieces of cutting edge research. These are; an examination of the value of lost load, incorporating risk into power sector investment analysis and a recalculation (with newer data) of the supply/demand index of SOS. This analytical work helps to better underpin our understanding of Ireland's SOS. The previous reports were well received nationally and internationally and it is intended that this series continues to be an innovative resource and model for considering SOS.

The report is structured as follows:

- Section 2 briefly explores recent SOS developments internationally and in Ireland.
- Section 3 examines recent developments with regard to defining measuring SOS.
- Section 4 presents a range of SOS metrics.
- Sections 5 to 7 present the results of new commissioned work on SOS for Ireland.
- Finally, section 8 contains acknowledgements and outlines options for further work.

Energy data drawn from the national energy balance presented in this report are 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 SEI website (www.sei.ie/statistics). A new energy data service is also available at this website, by following the link to Energy Statistics Databank. This service is hosted by the Central Statistics Office with data provided by SEI.

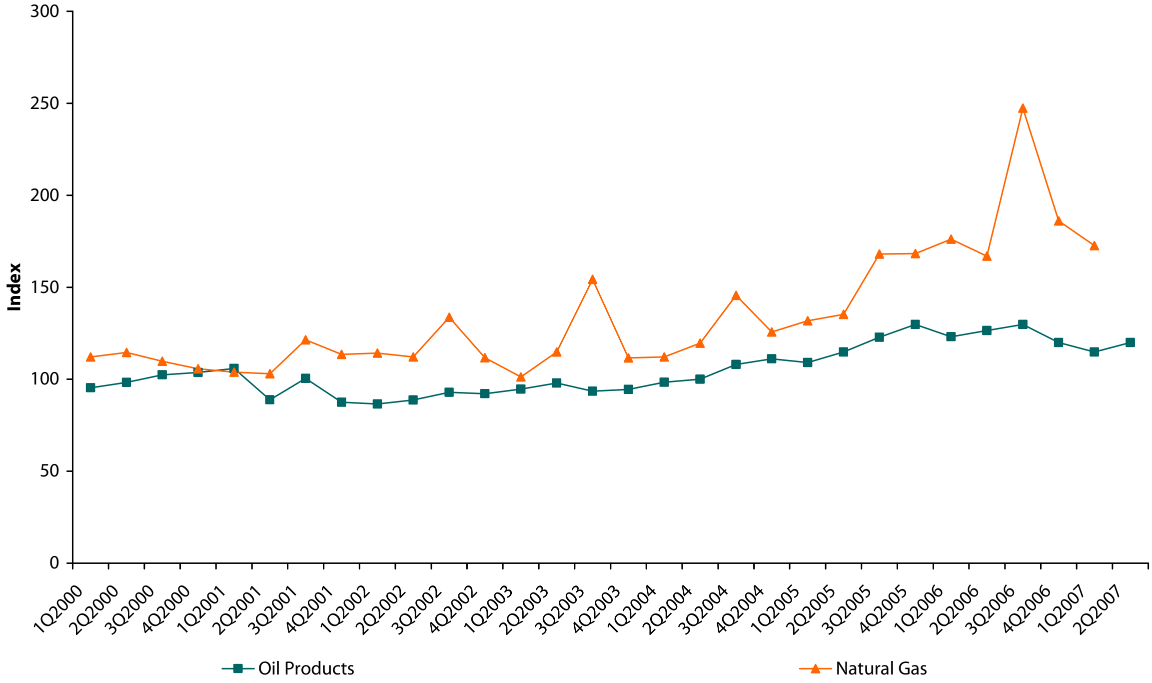
Feedback and comment on the report are welcome and should be addressed by post to the address on the rear cover or by email to EPSSU@SEI.ie.

[1] The first and second SOS reports are available from www.sei.ie/statistics

2 Recent Developments

Oil and gas prices remained high in 2007 and a record high oil price was reached in October 2007. Figure 1[2] presents an index of real oil and gas prices from 2000. These price levels have an effect on all energy services: electricity, thermal energy (heating and cooling) and transport.

Figure 1: Index of Real Oil and Gas Prices in Ireland Q1 2000 to Q2 2007



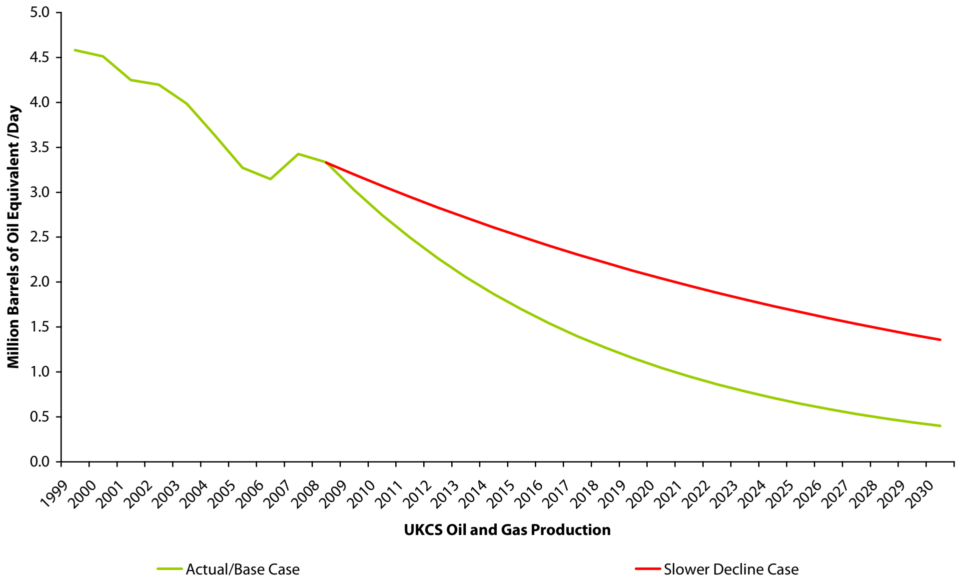
Source: Energy Prices & Taxes © OECD/IEA, 2007

Price is only one vector of SOS however. Regulatory and policy decisions as well as the management of natural resources also impact on SOS. For example, as much of the gas used in Ireland is imported from the North Sea, it is useful to review predictions about its production levels over time as illustrated in figure 2[3].

[2]The data in figure 1 are an index of oil and gas prices charged to households and industry. The nominal prices are adjusted to eliminate the effects of inflation.

[3] Data are sourced from the "UK Energy Review 2006" which is available from http://www.dti.gov.uk/energy/review/page31995.html.

Figure 2: Total UK Continental Shelf (UKC) Oil and Gas Production to 2030



Source: Department of Trade and Industry (UK)

The response to the focus on energy prices and stability led to a large number of policy outputs in 2007. A selection of those efforts and the associated dialogue is included in this section.

The National Development Plan[4] published in January 2007 placed security of energy supply at the core of the €8.5 billion investment in energy over the period 2007 to 2013. The plan allocates funds for direct investment and or research in electricity interconnection, gas storage, renewable energy and energy efficiency with the intention of reducing our dependence on imported fossil fuels. More specific details are contained in the White Paper and the Programme for Government.

An Taoiseach Bertie Ahern TD and Noel Dempsey TD, Minister[5] for Communications, Energy and Natural Resources on the 12th March 2007 launched the Government's Energy White Paper[6]. The White Paper sets out the energy policy directions and targets for Ireland to 2020. It states that "*we live in a world of high energy demand, volatile fossil fuel prices and uncertainty about security of supply*" and that "*energy security and climate change are among the most urgent international challenges*".

The following key targets, relevant to SOS, were set:

- 20% savings in energy usage by 2020, with a further indicative target of 30%,
- 12% of Ireland's thermal energy requirements to come from renewable sources by 2020,
- 33% of Ireland's electricity consumption to come from renewable sources by 2020,
- 10% of Ireland's transport energy requirements to come from renewable sources by 2020,
- delivery of an All-Island single electricity market in 2007,
- doubling North/South interconnection to 680 MW by 2011,
- delivering East/West interconnection of 500 MW no later than 2012,
- increased mid-merit/flexible generation of at least 240 MW by 2009,
- put in place an All-Island strategy by 2008 for gas storage and LNG facilities and
- limit Ireland's relative dependence on natural gas for power generation to approx 50% by 2020.

[4] Available from www.ndp.ie
[5] Eamon Ryan TD was appointed Minister for Communications, Energy & Natural Resources on the 14th June 2007.
[6] The full text of the White Paper is available at http://www.dcmnr.gov.ie/Energy/Energy+Planning+Division/Energy+White+Paper.htm.

A number of other actions were included with regard to SOS relating, inter alia, to improving electricity/gas network infrastructure, putting in place an SOS standard for the natural gas system and exploring further interconnection possibilities for gas and electricity.

The Programme for Government, published in June 2007 contains a number of references to SOS. In the period 2007 to 2012 the Government will:

- ensure that electricity supply consistently meets demand,
- ensure the security and reliability of gas supplies,
- enhance the diversity of fuels used for power generation especially renewables,
- ensure the development of a landbank of state-owned power generation sites to facilitate the entry of new independent generation,
- deliver the East/West and second North/South electricity interconnectors,
- deliver electricity and gas to homes and businesses over networks that are efficient, reliable and secure,
- create a stable environment for hydrocarbon exploration while increasing the return to the State and
- mitigate the impact of any energy supply disruptions by ensuring that contingency measures are in place.

In September 2007 the Department of Communications, Energy and Natural Resources invited tenders to undertake a review of the security of Ireland's access to commercial crude oil and oil products. The objective of the study is to assess over the medium to long term Ireland's security of access to commercial oil, including appropriate risk analysis, and to make recommendations accordingly. In addition, the study will address areas of contingency planning - at the level of commercial oil operations, at the level of State owned strategic oil reserves and in terms of the need, if any, for other State interventions.

The Corrib Gas issue continued throughout 2007. The Corrib field, containing gas with a very high methane content (over 90% by volume), is located approximately 65km off the coast of County Mayo in deep water (approximately 350m). The impact of that gas on demand is included in this report in section 4. There is no further discussion or commentary on the issue outside of a supply/demand evaluation.

The Commission for Energy Regulation (CER) on the 8th October published[7] a consultation on secondary fuelling obligations for licensed generation capacity. The reason being that "*the Commission shall take such measures as it considers necessary to protect security of supply*".

The consultation details the current situation with regard to secondary fuelling and proposes new procedures for natural gas and non-natural gas plant (with a distinction between baseload and mid-merit generating units). For example with respect to natural gas plant, in addition to the exiting arrangements the CER is also considering implementing a minimum generation capacity requirement on the unit's alternative fuel, relative to the unit's capacity on the primary fuel. The proposed minimum is 90%. If implemented, this criterion would be applied to all applications made subsequent to a decision on this policy.

There have also been a number of developments in the international arena since the previous report was published. This list is not meant to be exhaustive, merely an indication of the breadth of the current dialogue at international level.

In September 2006, Dr. Liam Fox MP, the UK Shadow Secretary of State for Defense made a speech entitled "Funding the Threat- a fresh perspective on energy security and national defense"[8]. In the speech Dr. Fox examines the link between increasing oil prices and the wealth shift which this represents, how this wealth is being used and the foreign and security policy implications that arise from it. He states that "*our inability to wean ourselves off our oil habit may be providing us with more immediate threats to our security and wellbeing than the effects that climate change may bring*". He goes on to detail where oil revenues go (Iran, Russia etc.) and to what purpose they are used for, mostly for defense, he argues.

[7] Available from http://www.cer.ie/GetAttachment.aspx?id=bb8f148c-ec38-436e-946f-12e0f867219e
[8] Available from http://www.firstdefence.org/funding_the_threat.doc

In the search for oil SOS the US Government signed an ethanol deal with Brazil[9] which aims to encourage the development of biofuels projects in poor countries, particularly in the Caribbean and Central America, and promote a global biofuels market. Brazil and the US will also cooperate more closely on researching and developing biofuels technology. In 2006 the US produced 18 billion litres of ethanol from 53 million tonnes of corn.

It has been reported[10] in Mexico that, the price of tortillas, a staple, has increased by 100%, triggering protests in January 2007. In response the government struck a deal with tortilla producers to limit price rises; however this agreement expires at the end of April 2008. The current US demand for ethanol pales in comparison to planned future usage. The US Federal Government plans to cut petrol consumption by 20% over 10 years, requiring some 132 billion litres of ethanol. Similarly the European Union is planning to use 20% biofuels by 2020.

In addition the price of durum flour, the main ingredient for Italian pasta, has risen from 0.26 euro per kilogram to 0.45 euro per kilogram over the two month period to September 2007. The growing use of durum wheat as a bio-fuel was blamed for the rise in prices.[11] Consumers' associations in Italy urged people to refrain from buying or eating pasta for a day, as a protest against the price increases.

Cuban President Fidel Castro[12] warned that the increasing use of biofuels by the US and other rich countries will create a global food crisis. There are complex interactions becoming apparent between the various uses of land. These are likely to increase in intensity.

On January 10th 2007 the European Commission proposed[13] a comprehensive package of measures to establish a new energy policy. It is aimed at boosting EU energy security, strengthening competitiveness, and combating climate change. The Commission proposed as a binding target that 20% of the EU's overall energy mix be sourced from renewables by 2020. A commitment of this scale has never been made before. Achieving this target would require massive growth in all three renewable energy sectors: electricity, biofuels, as well as heating/cooling. The effort would be assisted by setting a minimum target for biofuels of 10% of the total, exceeding all past targets for biofuels.

The United Nations Security Council on the 17th April 2007 held its first debate on the relationship between energy, security and climate change. The day-long meeting, called by the United Kingdom, featured interventions from more than 50 delegations. While some speakers praised the initiative, there were reservations from developing countries, which saw climate change as a socio-economic development issue to be dealt with by the more widely representative General Assembly. Many delegations also called for the United Nations to urgently consider convening a global summit on the issue.

Margaret Beckett, UK Foreign Secretary, opened the debate, saying that, "*while there was some doubt about whether the Council was the right forum, the Council's responsibility was the maintenance of international peace and security, and climate change exacerbated many threats, including conflict and access to energy and food. There was also potential economic disruption, which would inevitably have an impact on the world. The international community needed to recognize that there was a security impact from climate change, and begin to build a shared understanding of the relationship between energy, security and climate*".

In closing, Security Council President Emyr Jones Parry said that a record number of delegations had participated in the meeting and stated that "*the overall discussion had highlighted the complexity of the issue and the breadth of the challenge that climate change posed for all nations*".

The G8 annual summit was held at Heiligendamm, Germany in June 2007 and the G8 leaders continued to discuss energy security and climate change following on from the energy security position paper agreed at the St Petersburg summit in 2006. A joint statement[14] by the German G8 Presidency and the Heads of State and/or

[9]Green Left Weekly, 13 April 2007, http://www.greenleft.org.au/2007/706/36657
[10] Ibid.
[11] BBC News, 13 September 2007, http://news.bbc.co.uk/1/hi/world/europe/6992444.stm
[12] Green Left Weekly, 13 April 2007, http://www.greenleft.org.au/2007/706/36657
[13] Full details are available from http://ec.europa.eu/environment/climat/future_action.htm .
[14] Available from http://www.g-8.de/Content/EN/Artikel/__g8-summit/2007-06-07-summit-documents.html

Government of Brazil, China, India, Mexico and South Africa *"recognised the need for closer, more practical and result-oriented regional and international cooperation in the energy sector, especially in ensuring secure and affordable supplies of energy as well as in improving energy efficiency and the access to advanced and affordable energy technologies".*

In addition the G8 leaders[15] *"agreed that the UN climate process is the appropriate forum for negotiating future global action on climate change"* and that they are *"committed to moving forward in that forum"*. Furthermore the G8 leaders concluded that *"technology, energy efficiency and market mechanisms, including emission trading systems or tax incentives, are key to mastering climate change as well as enhancing energy security"*. They *reaffirmed the energy security principles we agreed at St. Petersburg".*

The Association for the Study of Peak Oil (ASPO) held its sixth international conference in September 2007 in Cork[16]. The timing was interesting as crude oil prices reached a record price of $83 per barrel just two days after the conference.

The Conference was opened by Dr James Schlesinger, a former US Secretary of Energy, who declared that the "Peakists" have won, that peak oil is now inevitable and that the debate has matured from if to when the peak will occur.

Dr. Hermann Franssen, President of International Energy Associates (and former chief economist with the International Energy Agency, IEA) discussed the global oil outlook by drawing together the projections of oil demand together with those of oil supply to point to the crux of the problem.

In 2006, Dr. Franssen showed that global oil consumption reached 84 million barrels per day (mbd) on average over the year. Most short term assessments project forward on the basis of oil prices staying within the range $55-$70 per barrel. Based on this, oil consumption is projected to grow at 1.5% - 2% per annum. Global oil demand would reach 96-99 mbd in 2015; 103-110 mbd in 2020 and 111-121 mbd by 2025. The IEA, Energy Information Administration (EIA) and Organization of the Petroleum Exporting Countries (OPEC) project global oil demand at between 116-118 mbd by 2030. According to Dr. Franssen and the general consensus of the ASPO 6 conference, the problem is that oil production will peak at between 90 and 100 mbd, suggesting that we will arrive at this point by 2015.

The first Nobel Laureates Symposium "Global Sustainability: A Nobel Cause[17]" was held in Potsdam, Germany from the 8th to the 10th October 2007. Hans Joachim Schellnhuber, Director of the Potsdam Institute for Climate Impact Research (PIK), invited 15 Nobel Laureates and a number of internationally renowned experts like Sir Nicholas Stern and Rajendra Pachauri to discuss new solutions to meet the challenges of the 21st century.

The participants agreed that energy demand is forecast to grow dramatically in the coming years. In order to attain energy security which is consistent with environmental integrity, an international strategy should include the following factors:

- A systemic efficiency revolution and productivity increase including fuel switching, combined heat power and an energy saving lifestyle.
- A portfolio approach consisting of a systematic exploration of the economic and technological potential of all of the relevant mitigation options.
- A design of investment strategies based on the portfolio approach, e.g., intelligent systems, grid infrastructure, storage technologies, demand-side measures, deployment of renewables such as solar that have huge potential now. Upfront investments, in addition to carbon finance, are needed to support emerging technologies and increase their market share e.g. feed-in law.
- A rapid implementation of demonstration projects for advanced solar energy and carbon capture and storage to foster ingenuity and drive down costs.
- A stabilising of long-term expectations of investors at capital markets and establishing micro-credit institutions in developing countries aimed at financing low-carbon technologies.

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[15] Ibid.
[16] Presentations available from http://www.aspo-ireland.org/index.cfm/page/aspo6
[17] See http://www.nobel-cause.de/ for details.

3 Defining Security of Supply

A broad definition of SOS in used in this series of reports. Based on international experience to date, a country's energy security policy generally comprises measures taken to reduce the risks of supply disruptions below a certain tolerable level. Such measures should be balanced to ensure that a supply of affordable energy is available to meet demand. Security of energy supply thus encompasses both issues of quantity and price. However, time is also a key parameter, as a sudden price hike will have very different effects on both society and the economy compared to those of a long-term price increase. Insecurity in energy supply originates in the risks related to the scarcity and uneven geographical distribution of primary fuels and to the operational reliability of energy systems that ensure services are delivered to end users[18].

This section presents three recent perspectives on defining and measuring SOS.

The IEA on the 28th March 2007 published a report on "Energy Security and Climate Policy - Assessing Interactions"[19] which developed a new methodology in order to quantify the energy security implications of resource concentration. The approach focuses on characterising the price component of energy security. It is based on a method derived from the principles of competition law and consists of two elements of analysis: a measure of market power for international fossil fuel markets, referred to as Energy Security Market Concentration (ESMC), and the level of exposure of a country to such risks. Both are combined into a single, aggregate, Energy Security Index $_{price}$ (ESI_{price}).

This methodology is applied to the energy situation, and possible evolution, of five European countries used as case studies: the Czech Republic, France, Italy, the Netherlands and the United Kingdom.

Results show a worsening trend for both CO_2 emissions and energy security in most of the five countries. Following a reference, "business-as-usual" scenario, the change in CO_2 emissions levels in 2030 compared to 2004 ranges from a reduction of 27% in the Czech Republic to a rise of up to 38% in France. Changes in the price component of energy security also indicate a deterioration. Changes in the indicator range from an increase of 6% in the Czech Republic to 42% in France. In addition, there would be new and growing concerns related to gas imports in the UK between 2004 and 2010 and between 2020 and 2030 in the Netherlands – both countries being still net exporters at present. The same gas-related measure of physical availability would also grow in other countries, by up to 31% in France.

A further perspective on the nature of SOS was provided by Daniel Yergin, Chairman of Cambridge Energy Research Associates (CERA) who, on March 22nd 2007, testified before the US House of Representatives Committee on Foreign Affairs' hearing on "*Foreign Policy and National Security Implications of Oil Dependence*." In his testimony[20], Dr. Yergin discusses the two critical new needs facing energy policymakers:

- to expand the focus of energy security to include the protection of the entire energy supply chain and infrastructure and
- to bring China and India into the global network of trade and investment rather than seeing them tilt toward a mercantilist, state-to-state approach.

Dr. Yergin presented 10 fundamentals of energy security:

1. Diversification
2. Resilience – a "security margin"
3. High-quality and timely information
4. Collaboration among consumers and between consumers and producers
5. Expand "IEA System" to include China and India
6. Include infrastructure and supply chain
7. Robust markets and flexibility

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[18] Blyth and Lefevre (IEA Information Paper), 2004, "Energy Security and Climate Change Interactions". Available from http://www.iea.org/textbase/papers/2004/EnergySecurity_%20ClimateChange_COP10.pdf.
[19] Available from http://www.iea.org/w/bookshop/add.aspx?id=290
[20] The full text is available at http://www.cera.com/aspx/cda/public1/news/articles/newsArticleDetails.aspx?CID=8689

8. Renewed emphasis on efficiency for both energy and climate reasons
9. Investment flows
10. R&D, technological advance, and new technologies

On the 13th April 2007 the Energy Research Centre of the Netherlands (ECN) published a report on "EU Standards for Energy SOS - Updates on the Crisis Capability Index and the Supply/Demand Index Quantification for EU-27"[21]. This analysis was featured in the previous SOS publication and an update is contained in section 6. The report is an update and extension of a similar report, published in June 2006.

It elaborates the proposed concept of energy SOS standards. It explains the role of (novel) indicators in the standards and the process for using and developing them.

The report describes an update of the development of two quantitative indicators that can be used in EU SOS standards. The first one, the Supply/Demand Index is based on a Member State's energy system covering 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 suited for assessing today's energy security as well as energy security in the medium and longer term. The use of this indicator is illustrated with examples for the EU-27 and its 27 individual Member States. Today's index values for these examples vary from 25 to 82 (with a higher score indicating a better SOS position), on a scale of 0 to 100. Indicative 2020 values range from 27 to 83, based on the EC Trends to 2030 scenarios published in 2006. On average, the SOS position worsens from 2005 to 2020 (from 56 to 53). The S/D Index is based largely on objective information contained in energy balances combined with weighing factors and scoring rules, using existing indicators to the extent possible. The most important uncertainties are addressed by sensitivity analyses.

The second indicator is the Crisis Capability Index. With this indicator the capability of a Member State or the EU as a whole to manage and mitigate short-term supply interruptions can be assessed. Finally, the standard includes qualitative considerations concerning the multilateral measures to secure overall producer/consumer relations and safeguarding vulnerable transport routes for oil and gas.

[21] Available at http://www.ecn.nl/publications/default.aspx?nr=ECN-E--07-004

4 Security of Supply Metrics

This section presents a variety of numerical explorations of various aspects of SOS, together forming a coherent picture of this important topic. Metrics are classified into the following categories:

- Overall Economy
- Fuel
- Exploration.

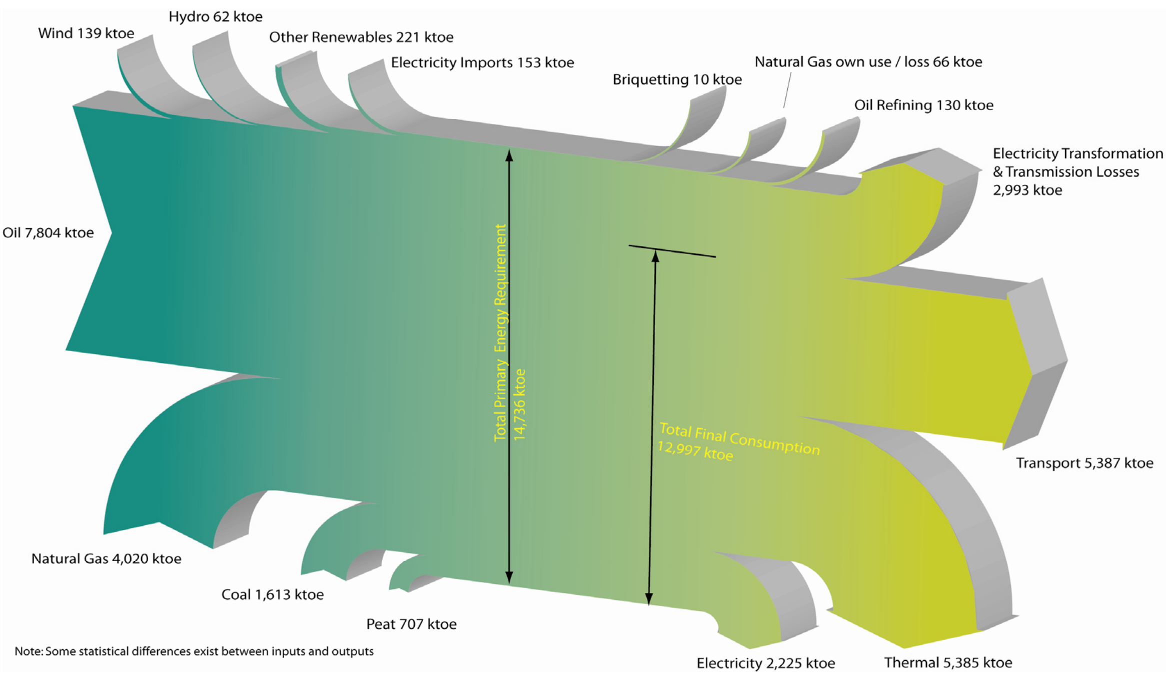
4.1 Security of Supply Metrics - Overall Economy

4.1.1 Supply and Demand

Figure 3 shows the energy balance for Ireland in 2006 as a flow diagram. This provides a useful overview of the energy landscape. Figure 3 illustrates clearly the significance of each of the fuel inputs, 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 due to growing demand in the transport sector. The size of the transport and thermal markets as compared to the electricity market is also significant. In 2006 transport energy demand in Ireland was higher than thermal energy for the first time, reflecting the significant recent growth in transport energy. 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 (20%). Each of these fuels is examined in detail in section 4.2.

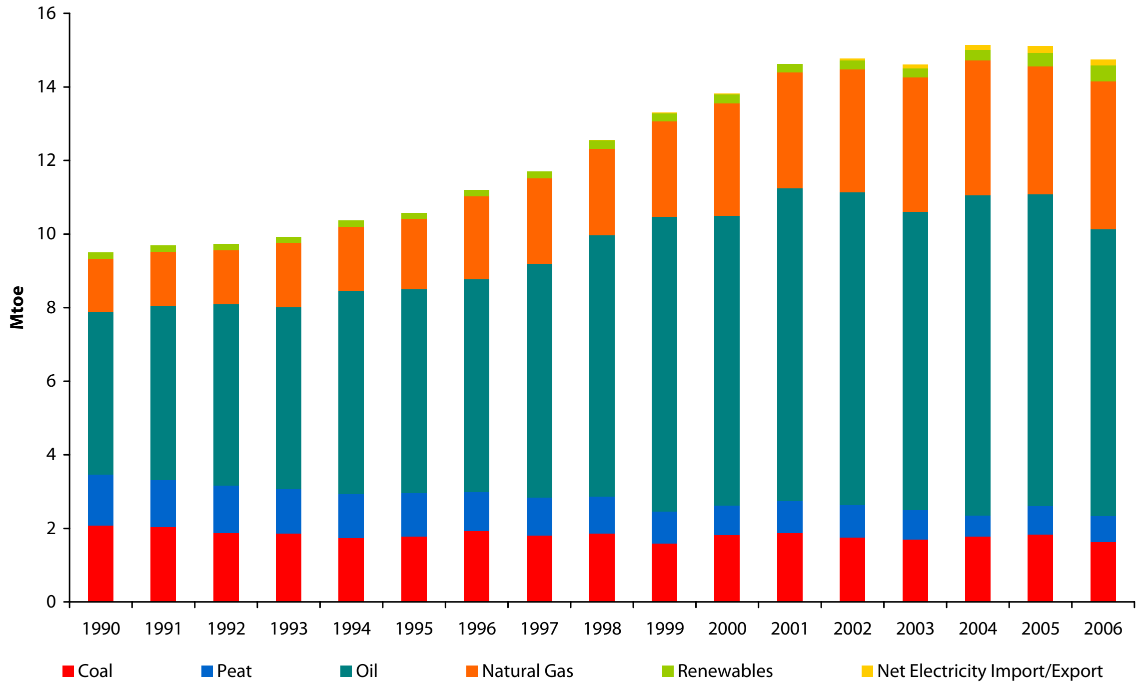
Figure 3: Energy Flow in Ireland 2006



Source: SEI

Total Primary Energy Requirement (TPER) is the barometer used to gauge movements in energy supply. Figure 4 shows that between 1990 and 2006 Ireland's total annual energy requirement grew in absolute terms by 55% (2.8% per annum on average). There was, however, a decrease of 2.4% 2006, despite a 2.7% increase in final energy demand. Oil accounted for 53% of TPER in 2006. Usage of natural gas has increased significantly to the point where its share of energy supply has now reached 27%. It will be noted that natural gas use increased in 2006 by 16% due largely to fuel switching in electricity generation. Solid fuels, coal and peat, have experienced a gradual decline over the period while renewable energy (particularly wind) continues to grow but from a very low base.

Figure 4: TPER 1990 to 2006

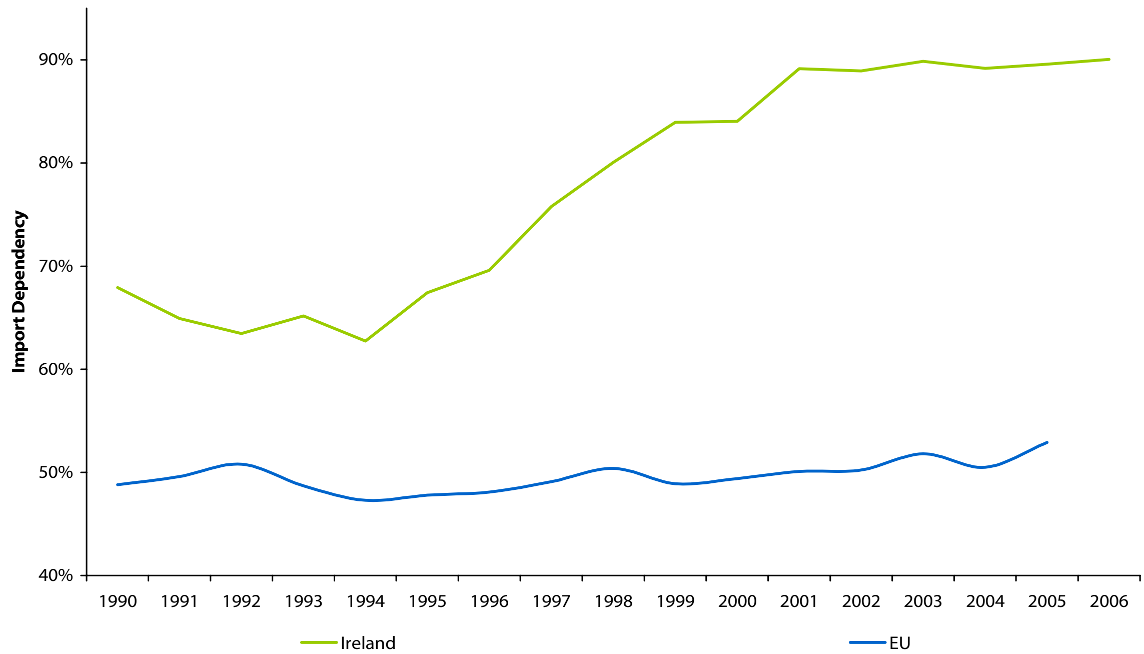


Source: SEI

4.1.2 Import Dependency

Figure 5 illustrates the trend in import dependency since 1990, comparing it with the EU[22].

Figure 5: Import Dependency of Ireland and EU 1990 to 2006



Source: SEI and Eurostat

[22] The EU refers to the total import dependency of the member states for each particular year. From 1990 to 2003 this referred to the EU-15 and in 2004 and 2005 data are for the EU-25. EU data were not available for 2006 at the time of going to print.

Domestic production accounted for 32% of Ireland's energy requirements in 1990. However, since the mid-1990s import dependency has grown significantly, due to the increase in energy use together with the decline in indigenous natural gas production at Kinsale since 1995 and decreasing peat production. Ireland's import dependency was just over 90% in 2006. Table 1 presents the results of a forecast to 2020.

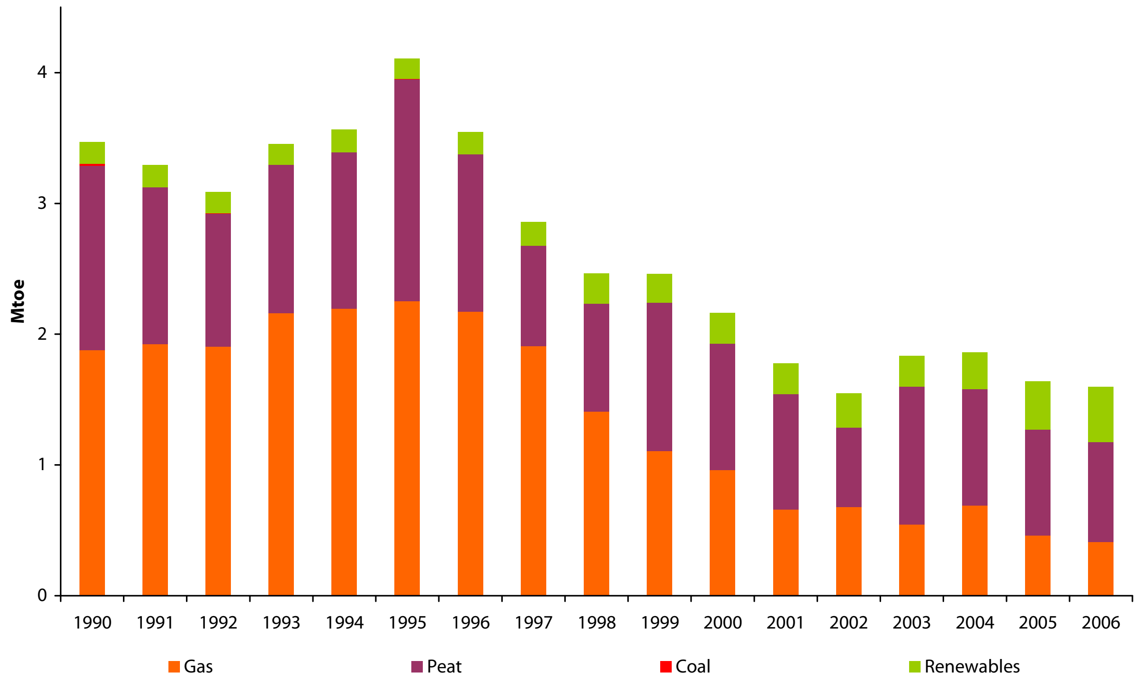
Table 1: Import Dependency Forecasts to 2025

%	2010	2015	2020
EU-27	56	61	64
Ireland	89	88	87

Source: PRIMES (2007)

This trend in figure 5 and table 1 reflects the fact that Ireland is not endowed with significant indigenous fossil fuel resources and has to date not harnessed significant quantities of renewable resources, although there has been strong growth in renewables in recent years from a small base. Figure 6 shows the indigenous energy fuel mix for Ireland over the period 1990 to 2006. The reduction in indigenous supply of natural gas is clearly evident from the graph as is the switch away from peat. Production of indigenous gas decreased by 78% over the period since 1990, peat by 46% while renewable energy in contrast increased by 150%. Indigenous production peaked in 1995 at 4.1 Mtoe and there has been a 61% reduction since then.

Figure 6: Indigenous Energy by Fuel 1990 to 2006



Source: SEI

The share of native gas within the indigenous fuels contribution was 26% in 2006, compared with 54% in 1990. The share of peat increased from 41% in 1990 to 48% in 2006. Renewable energy increased its share from 9% to 26%.

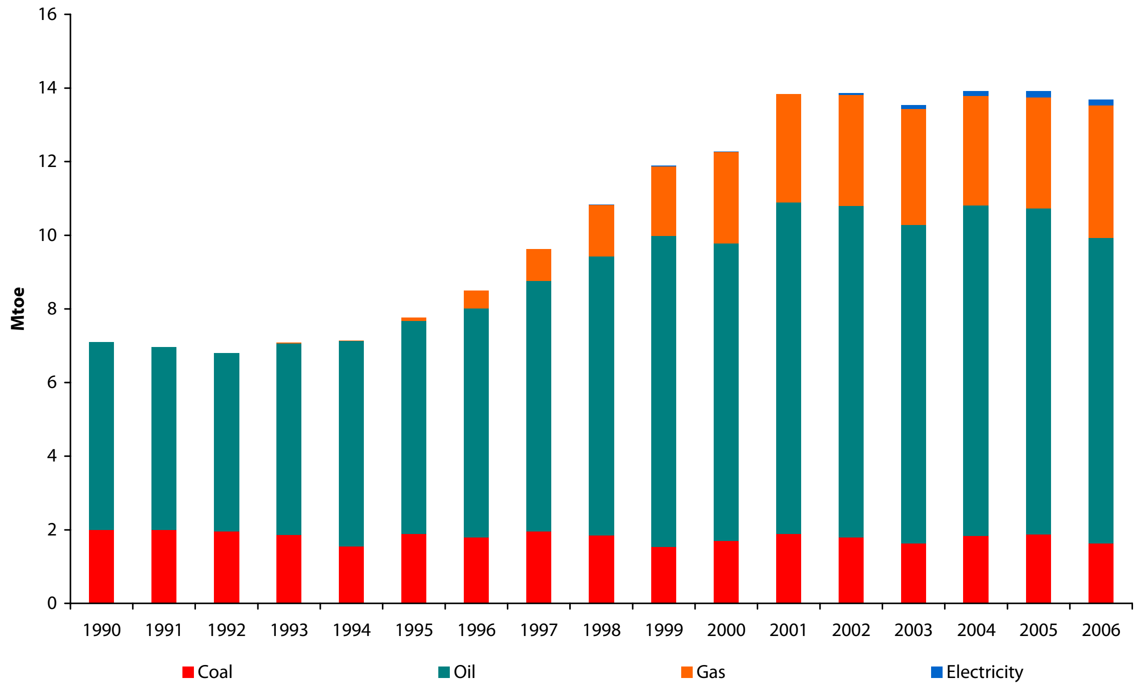
Some proposed developments are likely to impact on this trend including the plans to extract and utilise gas at the Corrib Gas Field and the targets for increasing the deployment of renewable energy to be achieved by 2010 and 2020. Specifically, the Corrib gas field is estimated to contain about 1 trillion cubic feet of gas, enough to satisfy about 60% of Ireland's demand over the 15-year life of the field[23].

[23] The Irish Times, July 06 2007.

Figure 7 shows the trend for net fuel imports (imports minus exports) over the period 1990 to 2006. The growing dependence on oil due largely to increase in energy use in transport is the most striking feature. Total net imports nearly doubled (94%) over the period with a 67% increase in net imports of oil. Imports peaked in 2002 and there has been 1.2% decrease since then.

The decline of indigenous natural gas reserves at Kinsale is also indicated by the growth in imported natural gas in the latter part of the decade and imports increased by 20% in 2006. This is largely the result of increased usage of gas in electricity generation. Coal imports declined by 19% over the period and by 13% in 2006 (due to the switch to gas in electricity generation). In 2006, oil, gas and coal accounted for 64%, 24% and 11% of net imports respectively. Electricity accounted for 1% of net imports in 2006.

Figure 7: Imported Energy by Fuel 1990 to 2006



Source: SEI

4.1.3 Growth in Transport Energy by Mode

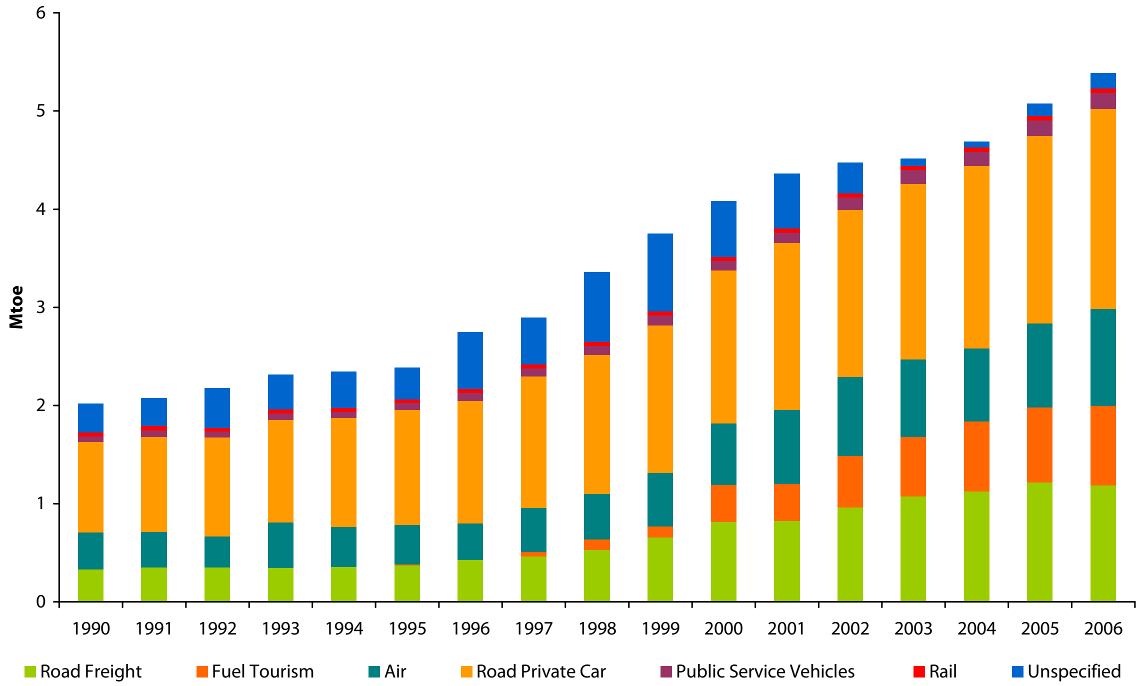
Transport is a key area in terms of Ireland's SOS as it is almost exclusively oil based, all of which is imported, as seen in figure 7.

Fuel consumption in transport is closely aligned to the mode of transport used: kerosene is almost all used for air transport, fuel oil for shipping and electricity is consumed by the Dublin Area Rapid Transport (DART) system and Luas light rail from 2004. Liquefied petroleum gas (LPG) is almost exclusively used for road transport, as is petrol. The bulk of petrol consumption for road transport can be assumed to be 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 consumption is used for freight transportation, public transport in buses and taxis, private car transport and other applications such as agricultural, construction and other machines.

The contribution from each mode of transport to energy demand is shown in figure 8. Data in this section is taken from a report entitled "Energy in Transport"[24] published in November 2007.

[24] Available from www.sei.ie/statistics .

Figure 8: Transport Energy Demand by Mode 1990 to 2006



Source: SEI

During the period 1990 to 2006 overall transport sector energy usage increased by 166% (6.3% per annum on average). The road freight category recorded the largest growth over the period of 255% (8.2% per annum). This is significant because the focus of attention in the sector is often the private car mode. Private car transport remains the dominant mode in energy terms, accounting for 38% of overall transport energy demand in 2006.

The mode with the second largest increase was public passenger services which grew by 187% (6.8% per annum), air grew by 164% 6.3% (per annum), road private car increased by 122% (5.1% per annum) and rail consumption increased by 1.7% (0.1% per annum).

Combined petrol and diesel fuel tourism[25] is also included in figure 8. Only fuel tourism out of the Republic of Ireland (ROI) is included i.e. fuel which is purchased in ROI but consumed elsewhere. Before 1995 the trend was negative i.e. fuel was purchased outside and consumed within the State.

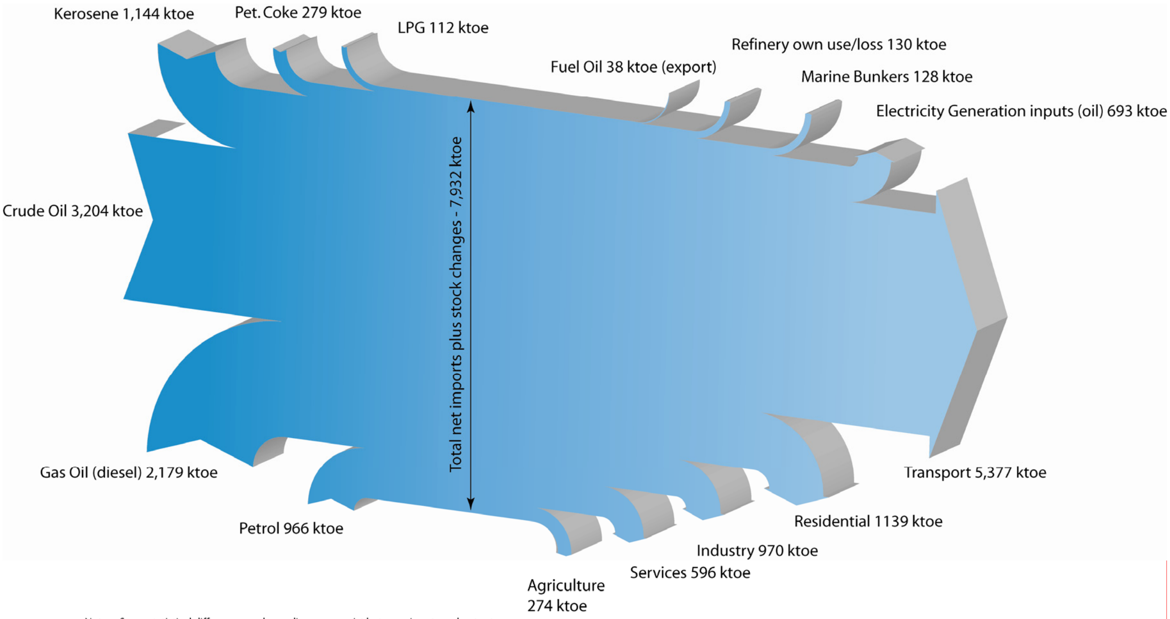
4.2 Security of Supply Metrics – Fuel

4.2.1 Oil Usage

Oil is by far the dominant energy source in Ireland. In terms of TPER, that dominance increased from 47% of the total in 1990 to a peak of 59% in 1999. The share of oil in 2006 was 53% and consumption decreased by 8% over 2005 due mainly to decreased usage in electricity generation. It is worth reiterating that the total amount of oil used in Ireland is imported. Figure 9 presents an energy flow diagram for oil usage in 2006. Inputs on the left are split into oil's various components while outputs on the right are categorised by sector.

[25] Fuel tourism is defined as fuel that is bought within the State by motorists and hauliers but consumed outside the State.

Figure 9: Energy Flow 2006 – Oil



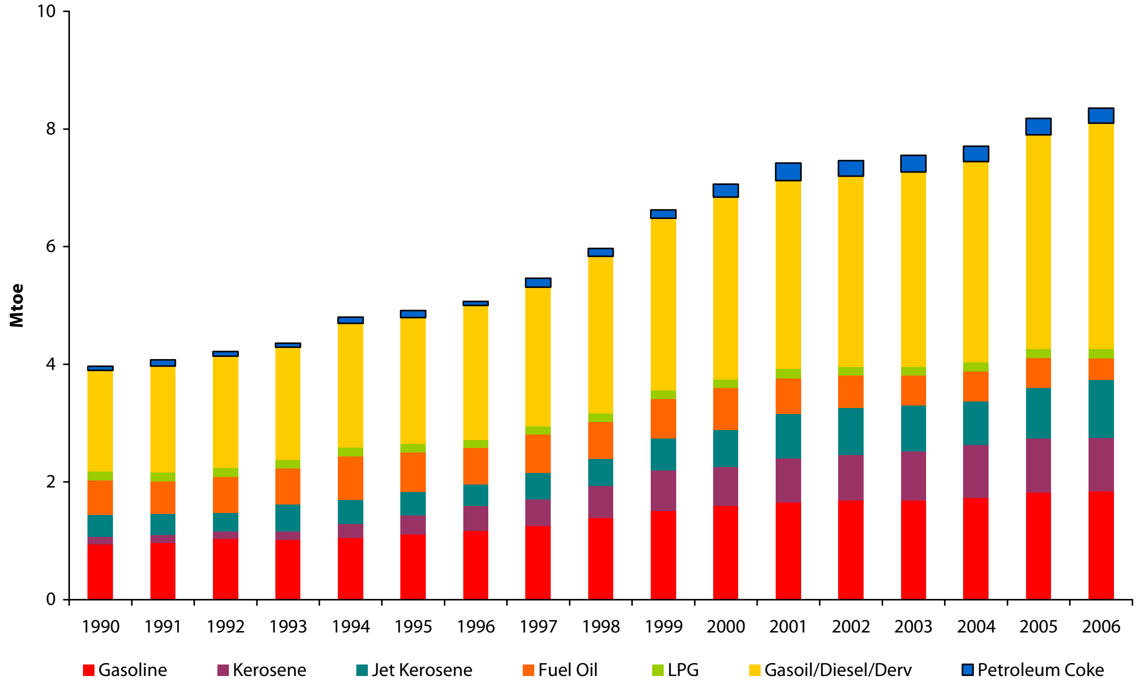
Note: Some statistical differences and rounding errors exist between inputs and outputs
Inputs on the left consist of net imports plus stock changes.

Source: SEI

It can be seen from figure 9 that transport accounts for the largest share of oil usage, approximately 64% in 2006 followed by residential at 14% and industry at 12%. Electricity generation inputs were responsible for 8% of oil consumption.

Figure 10 presents the growth in oil from 1990 to 2006. Over the period, kerosene recorded the largest growth, 649% followed by petroleum coke which grew by 259%. Over the same period, usage of diesel increased by 123% while gasoline rose by 95%.

Figure 10: Final Consumption of Oil 1990 to 2006



Source: SEI

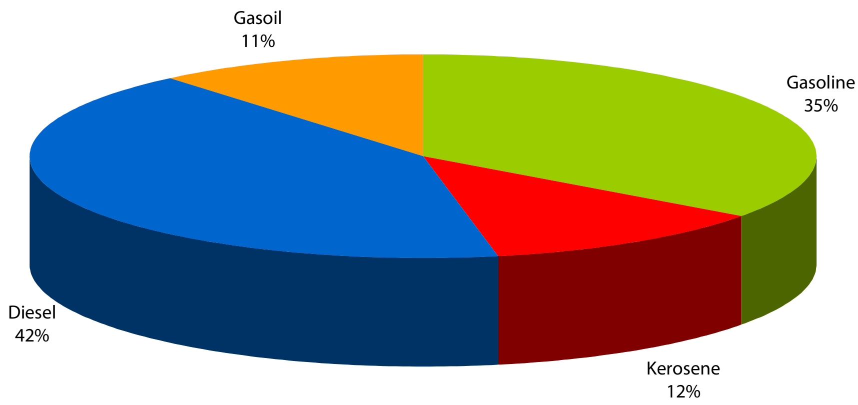
4.2.2 Oil Market

The oil market in Ireland is served by a number of companies, both multi-national and domestic independents.

Ireland has one oil refinery located at Whitegate, Co. Cork which was operated by the Irish National Petroleum Corporation (INPC), a State-owned company, until July 2001 when it was sold to Tosco Corporation. Tosco Corporation was subsequently taken over by Phillips Petroleum, which was acquired by Conoco and is now known as ConocoPhillips. The refinery is now operated by the Irish Petroleum Company Limited (IPCL), a ConocoPhillips subsidiary which also operates the storage terminal at Whiddy Island, within Bantry Bay, on the southwest coast of Ireland.

The latest available production figures indicate that nearly 16 million barrels were refined in 2006. Figure 11 provides a breakdown of production by fuel type.

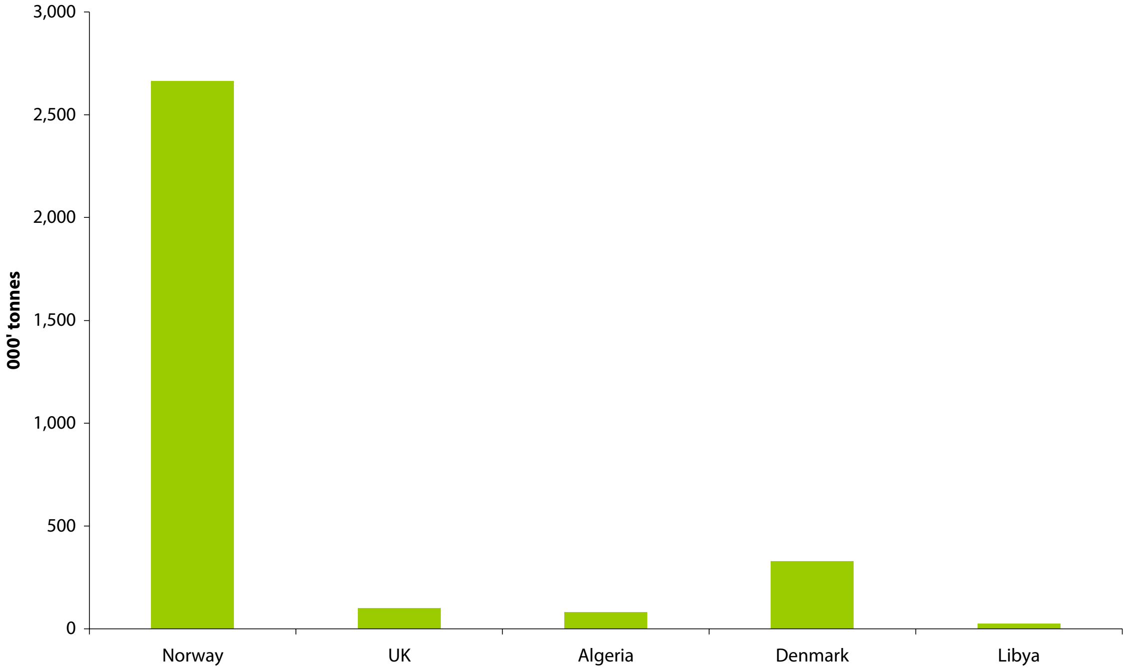
Figure 11: Whitegate Refinery Production 2006



Source: ConocoPhilips

Figure 12 and table 2 illustrate where the crude oil used in Ireland comes from and it can be seen that the majority (83%) is sourced from Norway. Note that other forms of oil are also imported, LPG, petrol, diesel etc. but data was not available at the time of going to print.

Figure 12: Crude Oil Imports by Country of Origin 2006



Source: DCENR

Table 2: Crude Oil Imports by Country of Origin 2006

Country	***000' tonnes***
Norway	2,665
UK	101
Algeria	82
Denmark	329
Libya	26
Total	3,203

Source: DCENR

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.

4.2.3 National Oil Reserves

Ireland's national oil stockholding policy has evolved in response to its international commitments arising from membership of the EU and the IEA. Currently, the EU requires the holding of 90 days stocks based on the previous year's consumption, while the IEA requires 90 days stocks based on previous year's net imports of oil.

Following the "European Communities (Minimum Stocks of Petroleum Oils) Regulations, 1995" responsibility for the management of Ireland's oil stocks was vested in the National Oil Reserves Agency (NORA)[26]. This body acts as an agent on behalf of the Minister for Communications, Energy and Natural Resources (DCENR). The "National Oil

[26] NORA receives no funding from the Exchequer. It is funded by way of a levy of 0.476 cent per litre imposed on oil sales/usage by oil companies and oil consumer companies. This levy has remained unchanged since NORA's establishment in 1995.

Reserves Agency Act 2007"[27] established NORA as a State Agency under the aegis of the DCENR. This Act came into effect on 1st August 2007.

Stock holdings[28] are held either directly by the Agency itself or on its behalf by third parties, either within Ireland or within countries with whom 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.

Table 3 shows the situation as of 1st April 2007 A total of 105 days (based on IEA methodology) worth of stocks were held, of which 65 days were held within Ireland. Ireland's IEA stockholding requirement for 2007 amounts to 2,278,000 tonnes of crude oil equivalent.

Table 3: Number of Days of Oil Stocks Held by Ireland at 1st April 2007

	In Ireland (days)	Abroad (days) *	Total (days)
NORA stocks Wholly owned	33	8	41
Ticketed (Stock Tickets) **	0	32	32
Industry/Consumer Stocks ***	32	0	32
Total	65	40	105

Source: NORA

*Stocks held in other EU countries under cover of Bilateral Agreements whereby the host country guarantees that it would not oppose the transfer of the oil in question to Ireland in the event of an emergency.
** Surplus (i.e. over and above operational stocks) private sector stocks over which NORA has an option to purchase (during the period of the contract) in the event of an emergency.
*** These are operational stocks held at major ports, the Whitegate refinery and by large consumer companies such as the ESB which would be legally and physically amenable to the Government control in the event of an emergency being declared under the Fuels Acts 1971 and 1982. Industry stocks that have already been delivered to filling stations etc. are not included.

The 2007 Energy White Paper[29] has a number of actions which impact upon NORA. It states that the Government will:

- establish the National Oil Reserves Agency (NORA) as an independent statutory body in 2007,
- in light of the recent National Oil Stockholding Policy Review, rebalance the strategic oil reserve by maximising Ireland's wholly-owned stocks of oil and the level of stocks held on the island, subject to increased storage availability and value for money considerations,
- increase the current level of the levy on certain oil products in 2007 in order to underpin our oil stockholding strategy and
- continue to renegotiate existing Bilateral Oil Stockholding Agreements, and to take a proactive approach to the conclusion of new such agreements, so as to ensure diverse and secure contractual sources, having regard to storage availability and value for money considerations.

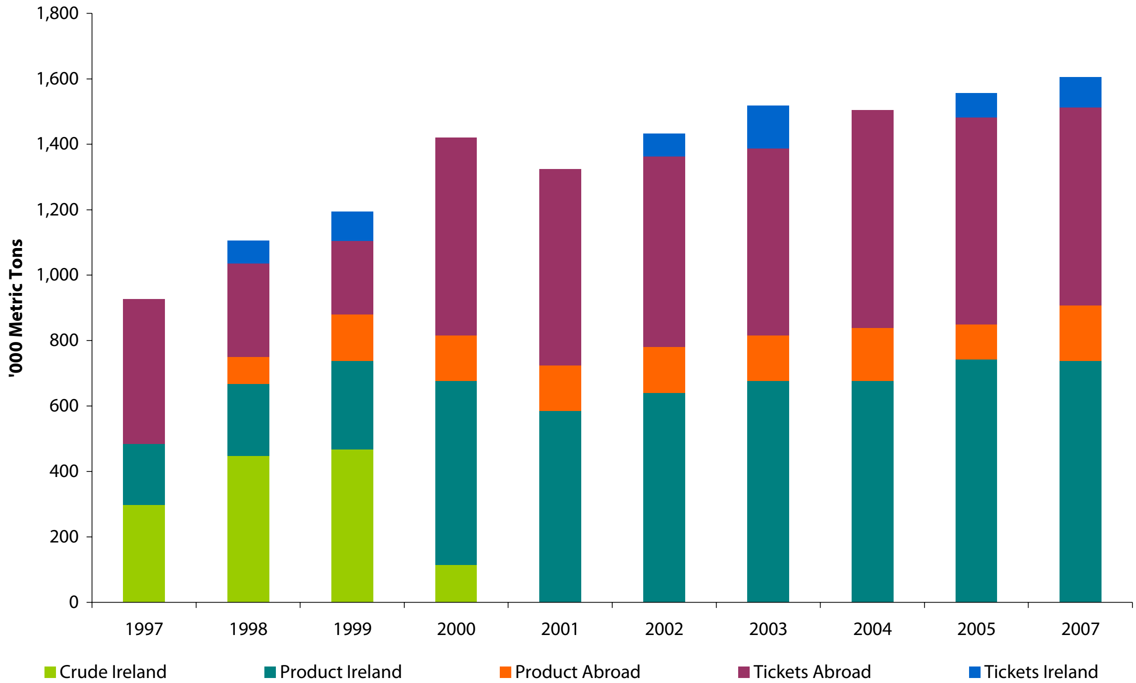
Figure 13 illustrates Ireland's oil stock levels during the period 1997 to 2007. Product refers to holdings of oil products (petrol, diesel, etc) that are held either in Ireland or in other jurisdictions covered by a relevant Oil Stockholding Agreement.

[27] Available from http://www.oireachtas.ie/viewdoc.asp?DocID=7600&CatID=87

[28] To date Ireland has concluded six oil stockholding agreements with the UK, Sweden, Denmark, The Netherlands, Belgium and France.

[29] The full text of the White Paper is available at http://www.dcmnr.gov.ie/Energy/Energy+Planning+Division/Energy+White+Paper.htm.

Figure 13: NORA Oil Stocks 1997 to 2007

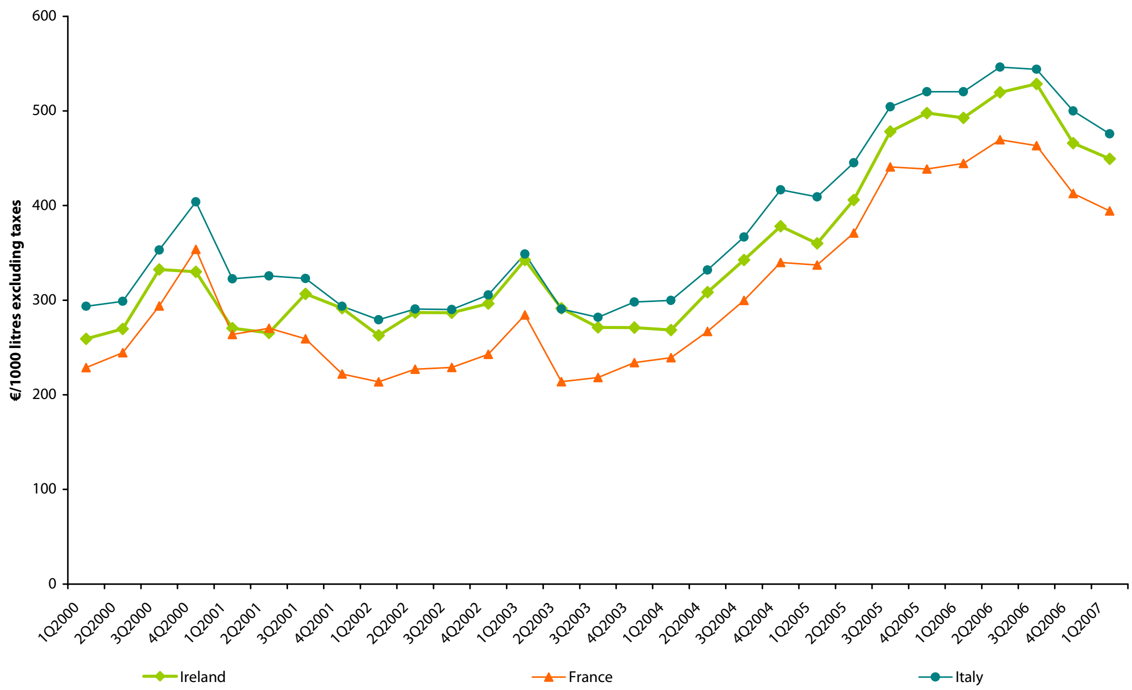


Source: NORA

4.2.4 Oil Prices

Oil prices to industry in Ireland were 45% higher in real terms in mid 2007 than in the year 2000 (figure 14 and table 4). This was the highest increase of any of the countries shown. Looking at nominal prices the increase was in the middle of the range of countries.

Figure 14: Fuel Oil Prices to Industry (Nominal Prices) Q1 2000 to Q2 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

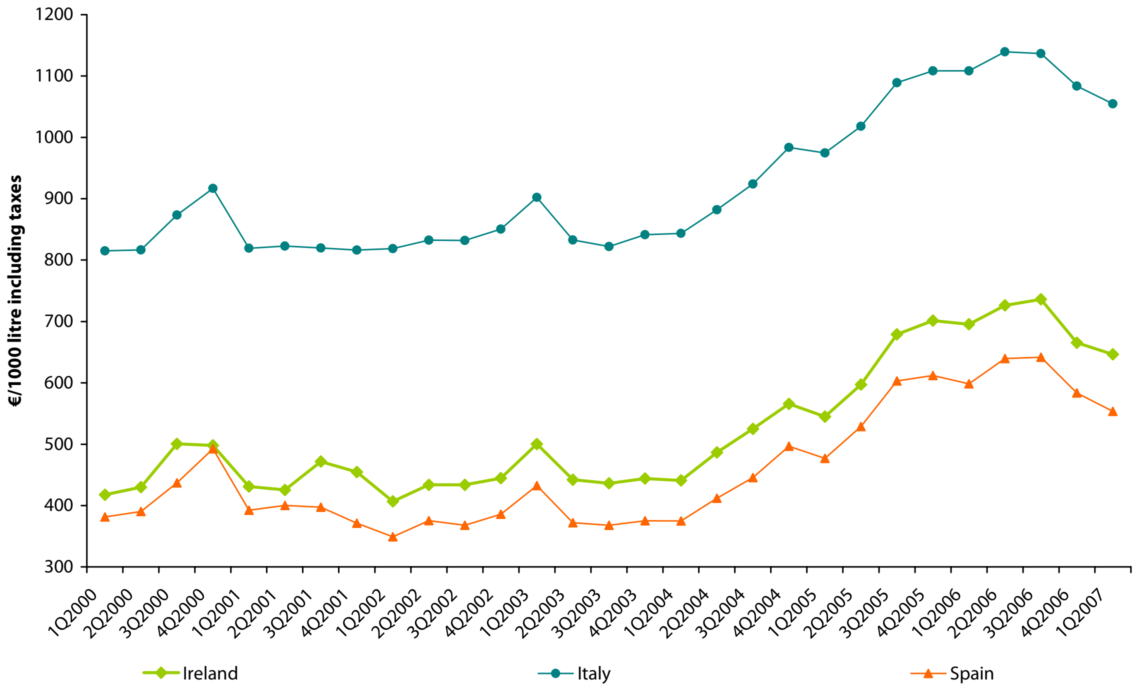
Table 4: Oil Price to Industry Increase Since 2000

Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Oil Prices 2nd qtr 2007 (nominal)	149	102	136	117	122	127	138	136	130	127	132	126	158	135	131	121
Oil Prices 2nd qtr 2007 (real)	114	87	119	102	116	116	123	108	145	106	96	106	136	111	116	108

Source: Energy Prices & Taxes © OECD/IEA, 2007

Nominal heating oil prices to Irish householders (figure 15 and table 5) increased by 23% since 2000 but decreased by 4% when the effects of inflation are removed.

Figure 15: Household Heating Oil Prices (Nominal Prices) Q1 2000 to Q2 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

Table 5: Oil Price to Households Increase Since 2000

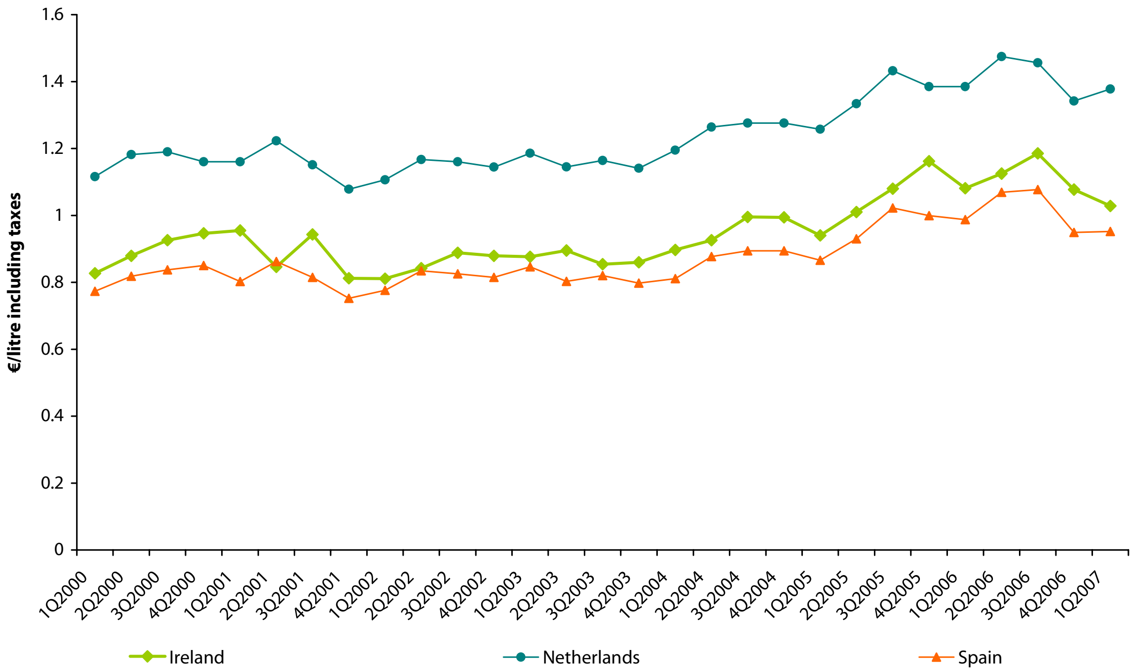
Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Oil Prices 2nd qtr 2007 (nominal)	133	122	142	121	118	122	134	158	123	121	140	129	154	129	129	117
Oil Prices 2nd qtr 2007 (real)	110	107	124	106	107	108	119	126	96	103	120	110	124	103	116	97

Source: Energy Prices & Taxes © OECD/IEA, 2007

Petrol and diesel prices shown here are inclusive of both excise duty and vat.

Figure 16 shows that the decrease in petrol prices in Ireland over the period 2000 to 2007 was the joint largest of the countries shown. Petrol prices in Ireland decreased by 9% in real terms since 2000.

Figure 16: Retail Unleaded Petrol Prices (95 RON[30]) (Nominal Prices) Q1 2000 to Q2 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

Table 6: Petrol Price Increase Since 2000

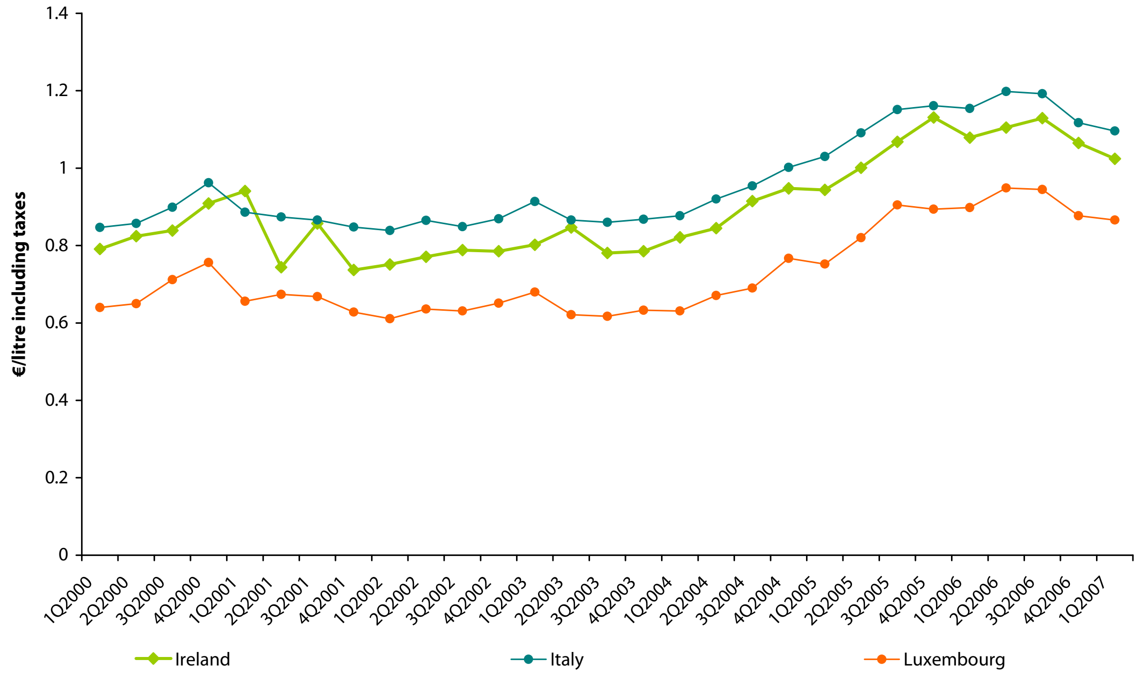
Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Petrol Prices 1st qtr 2007 (nominal)	123	107	124	108	107	109	124	113	115	112	126	119	142	116	115	109
Petrol Prices 1st qtr 2007 (real)	100	95	108	95	98	98	111	92	91	97	108	103	117	95	104	91

Source: Energy Prices & Taxes © OECD/IEA, 2007

Figure 17 shows that the increase in diesel prices in Ireland was in the upper range for the countries shown. Diesel prices in Ireland decreased by 4% in real terms since 2000 whereas there was an 8% average increase for OECD Europe countries.

[30] RON is the research octane number used in Europe to rate the characteristics of petrol.

Figure 17: Retail Road Diesel Prices (Nominal Prices) Q1 2000 to Q2 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

Table 7: Auto diesel Price Increase Since 2000

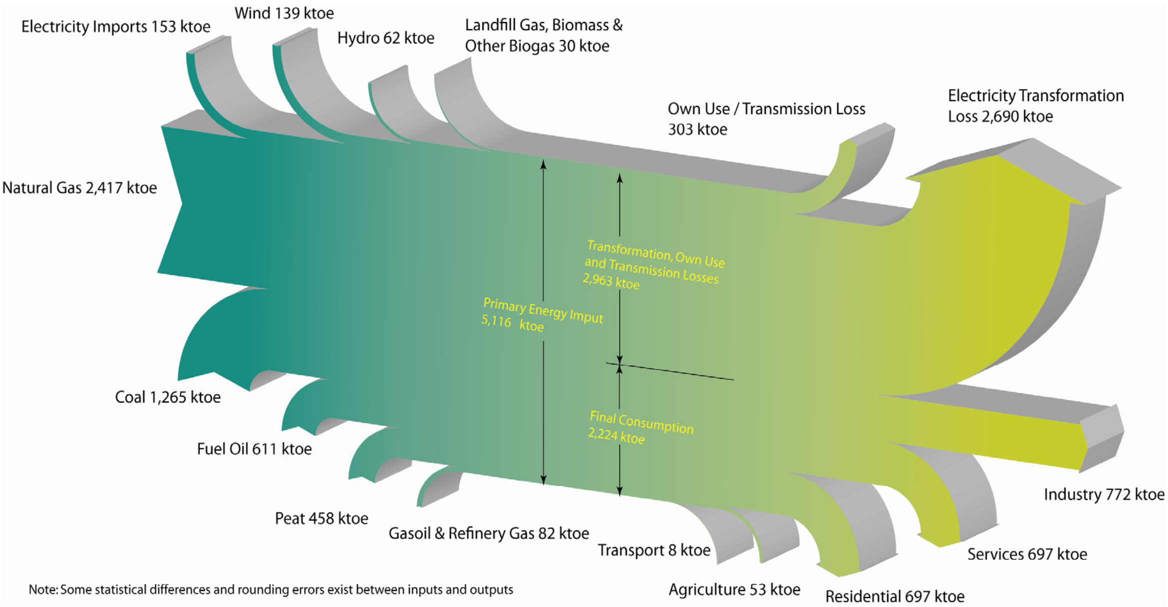
Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Diesel Prices 2nd qtr 2006 (nominal)	138	121	125	108	115	121	135	134	122	123	126	122	154	128	125	112
Diesel Prices 2nd qtr 2006 (real)	108	107	110	95	105	108	121	109	96	106	108	106	127	105	114	94

Source: Energy Prices & Taxes © OECD/IEA, 2007

4.2.5 Electricity Generation and Demand

Figure 18 shows graphically the flow of energy in electricity generation and supply. The relative size of the final electricity consumption and the energy lost in transformation and transmission is striking. These losses represent 59% of the energy inputs. The small, but growing, contribution from renewables is also notable as is the dominance of gas in the generation fuel mix. In 2006, renewables accounted for 4.5% of the energy inputs to generate electricity with wind contributing 2.7% of total inputs. Wind accounted for 60% of the renewable energy used for electricity generation.

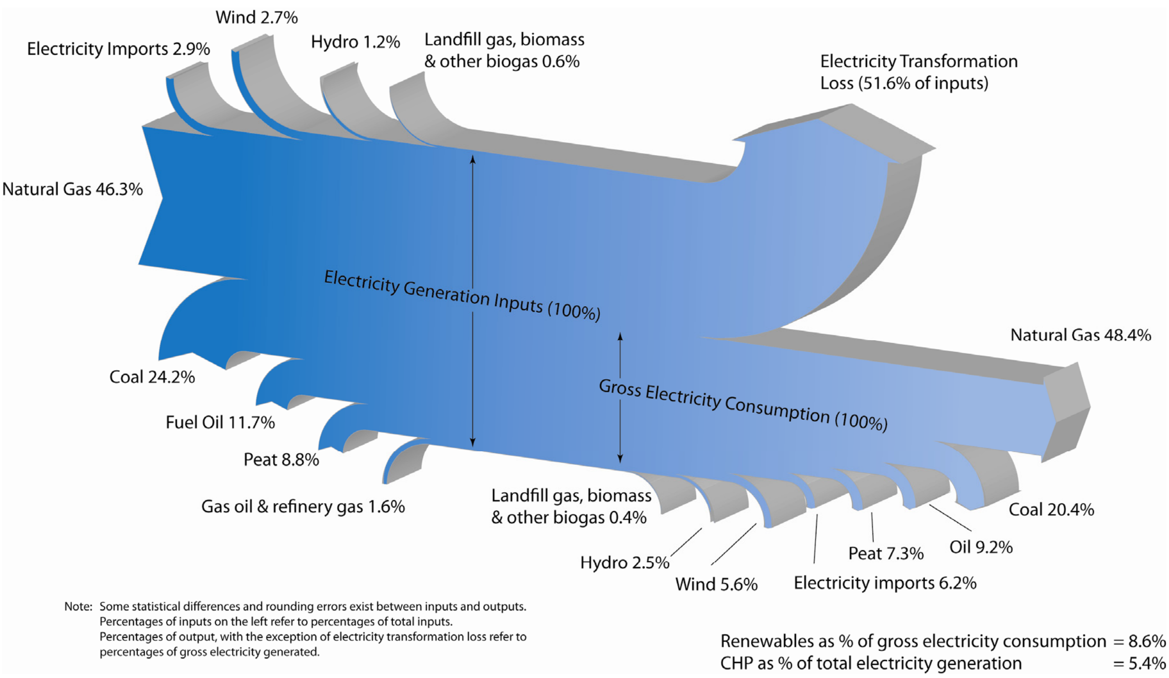
Figure 18: Energy Flow in Electricity Generation and Supply 2006



Source: SEI

Figure 19 shows a similar picture to figure 18 except that the electricity outputs are shown by fuel used to generate the electricity and as percentages for the purposes of comparison with the various targets. Renewable generation makes use of wind, hydro, landfill gas, biomass and other biogas and in 2006 accounted for 8.6% of gross electricity consumption compared with 6.8% in 2005. As mentioned in section 2 there is a target of 15% of electricity to be generated by renewable sources by 2010.

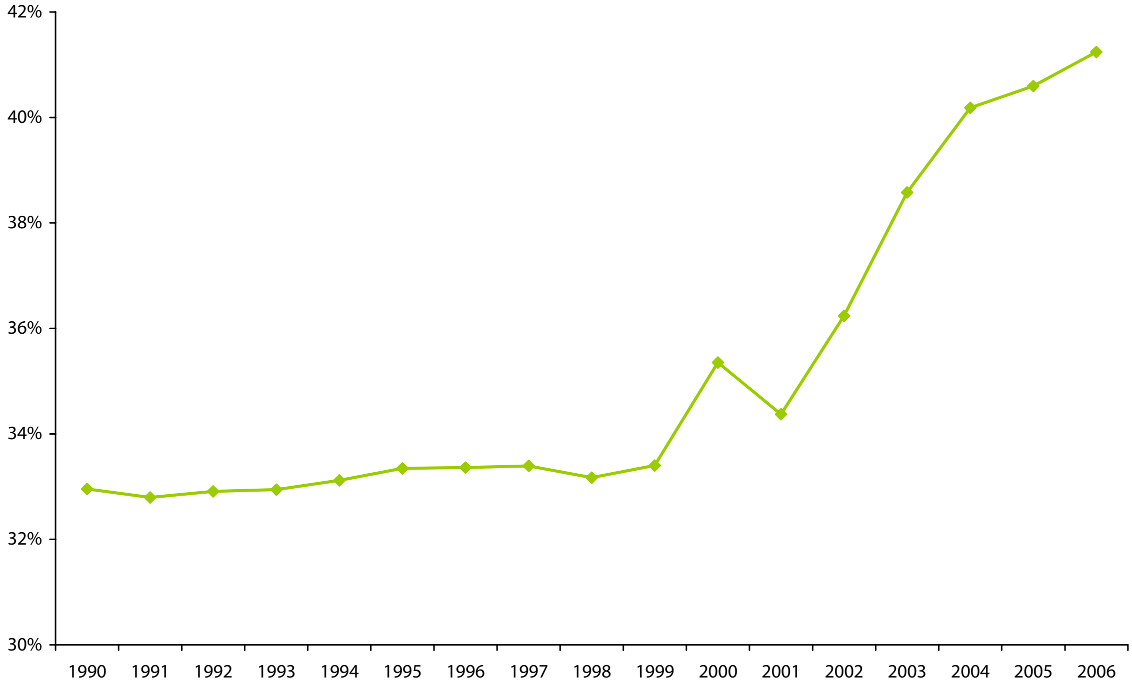
Figure 19: Flow of Energy in Electricity Generation- Fuel Inputs/Electricity Outputs 2006



Source: SEI and Eirgrid

The efficiency of electricity supply shown in figure 20 is defined as final consumption of electricity divided by the fuel inputs required to generate this electricity and expressed as a percentage. The inputs include renewable sources and imports and the final consumption excludes the generation plants' "own use" of electricity and transmission and distribution losses. Hence this is supply efficiency rather than generating efficiency.

Figure 20: Efficiency of Electricity Supply 1990 to 2006



Source: SEI

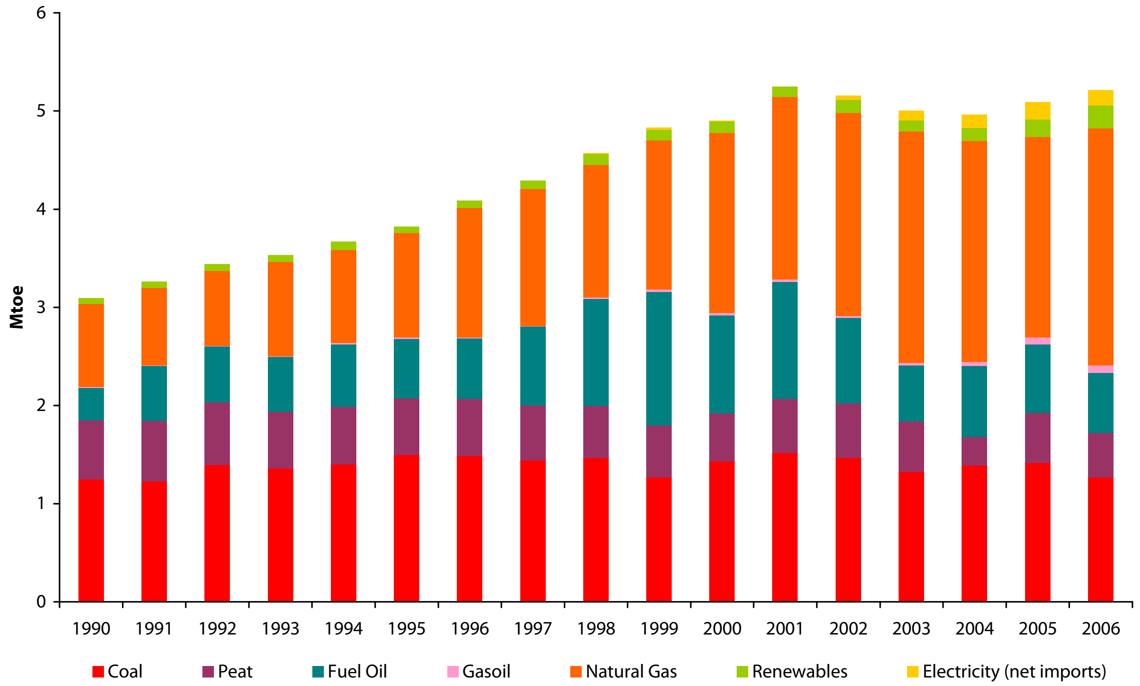
From the mid 1990s onwards the influence of the use of higher efficiency natural gas plants and the increase in production from renewable sources is evident. The sharp rise between 2002 and 2004 (from 35% to 40%) is accounted for, principally, by the coming on stream of new CCGT plant (392 MW in August 2002 and 343 MW in November 2002), an increase in imports of electricity and the closure of old peat fired stations.

The most recent data indicates that an increase in efficiency occurred improving from 40.6% in 2005 to 41.2% in 2006.

Figure 21 shows the primary fuel requirement for electricity generation for the period 1990 to 2006. It grew by 69% from 3.1 Mtoe in 1990 to a high of 5.2 Mtoe in 2001. Between 2001 and 2004 there was a reduction but the trend was revered in 2005 and 2006. Total inputs were 5.2 Mtoe again in 2006.

As a share of total primary energy requirement the inputs to electricity generation were 35% in 2006. Electricity consumption as a share of total final consumption increased from 14% to 17% between 1990 and 2006.

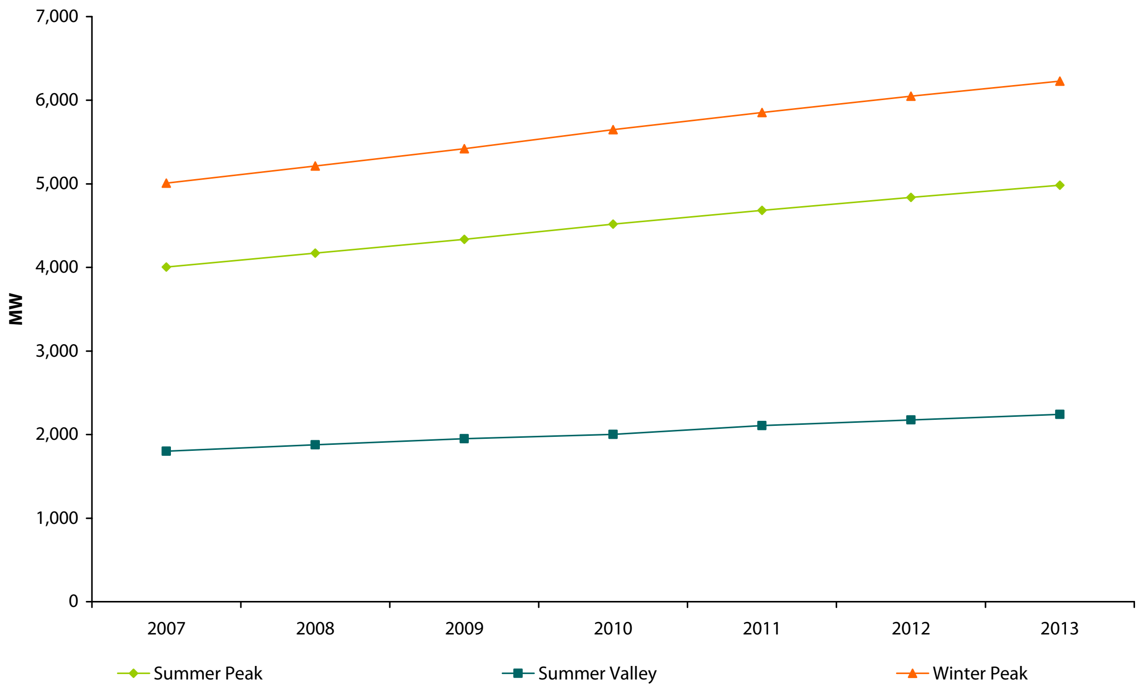
Figure 21: Electricity Primary Fuel Mix 1990 to 2006



Source: SEI

Figure 22 presents the forecasts of transmission demand for the period to 2007 to 2013 from Eirgrid's (the Transmission System Operator) "Transmission Forecast Statement" (TFS)[31].

Figure 22: Transmission Peak and Valley Demand Forecast 2007 to 2013



Source: Eirgrid

[31] Available from http://www.eirgrid.com/EirGridPortal/DesktopDefault.aspx?tabid=Forecast%20Statement%202007-2013

While it is difficult to accurately predict a peak demand figure for a particular year, the forecasts in figure 22 may be taken as indicative of a general trend in demand growth. Three demand values are presented for each year: the winter peak, the summer peak and the summer valley. It can be seen that winter peak and summer peak demand are both projected to increase by 24% over the course of the period.

The winter peak figures represent the expected annual peak demands that are forecast to occur in the October to February winter period of each year, for example the 2007 forecast of 5,008 MW is the maximum demand projected to occur in winter 2007/08. The peak for 2006 was 5,035 MW, achieved on December 19th. These peak forecasts take account of the influence of demand-side management (DSM) schemes, such as Eirgrid's winter peak demand reduction scheme (WPDRS). In winter 2006/07, DSM accounted for approximately 120 MW of a reduction to the peak demand. This amount of DSM is assumed by Eirgrid to continue over the next seven years.

The summer peak refers to the average peak value between March and September. This is typically 20% lower than the winter peak. While the overall grid power flow may be lower in summer than in winter, this may not be the case for flows on all circuits. In addition, the capacity of overhead lines is lower because of higher ambient temperatures, while network maintenance, normally carried out in the March to September period, can weaken the network, further reducing its capability to transport power.

The annual minimum is referred to as the summer valley in the TFS. Summer valley cases examine the impact of less demand and less generation dispatched. This minimum condition is of particular interest when assessing the capability to connect new generation. With local demand at a minimum, the connecting generator must export more of its power across the grid than at peak times. In preparing the forecasts Eirgrid reviewed historical summer valley demand data and the analysis showed a trend over recent years of increasing summer valley demand. Based on this evidence the forecasts of summer valley demands in figure 22 assume a figure of 36% of the annual maximum demand.

4.2.6 Electricity Infrastructure/Investment

Investment in electricity network assets is a critical ongoing part of maintaining a secure system. In terms of electricity infrastructure, Ireland relies on an extensive high-voltage transmission network and a medium- and low-voltage distribution network to transport electricity domestically.

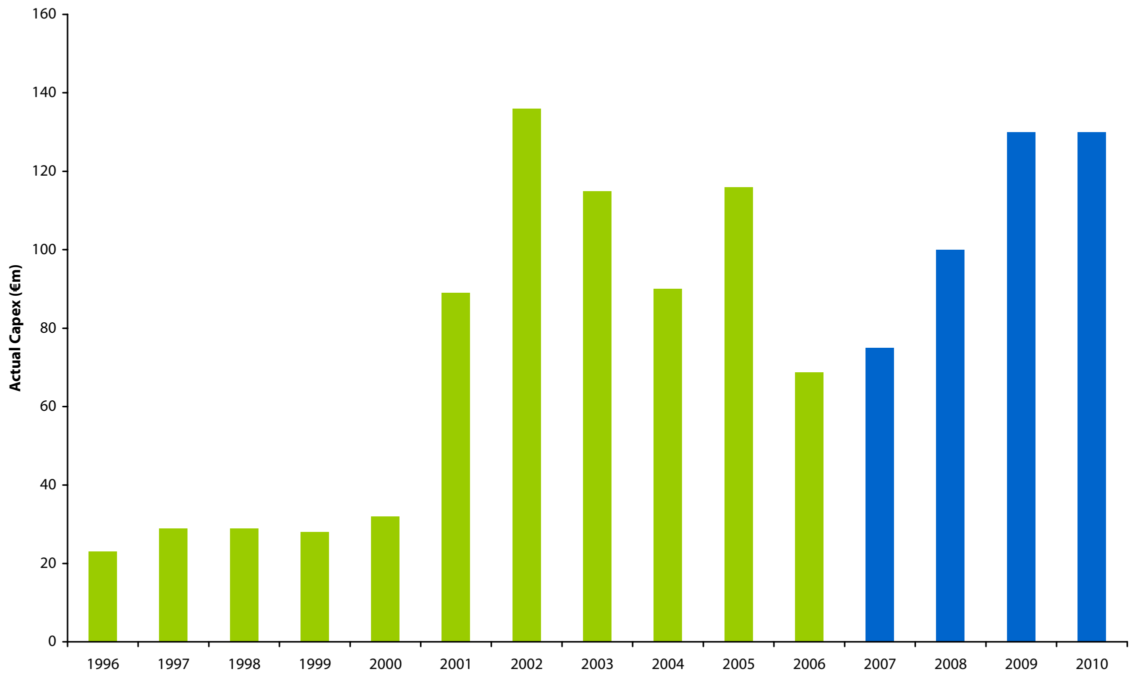
Ireland's electricity transmission and distribution network has experienced a long period of significant under-investment. To address this challenge, a network investment programme worth €4.4 billion, in both transmission and distribution networks, was undertaken between 1996 and 2005. A total investment of €4.9 billion in both transmission and distribution networks is planned up to 2013.

Figure 23 shows the investment in Ireland's electricity network over the last decade. Total transmission investment over the period 1990 to 2006 was €755.8m. The CER in its 2006 to 2010 "Transmission Price Control Review Decision Paper"[32], published on the 9th September 2005, has set a cap on capital expenditure on transmission of €520 million. The planned spend by ESB Networks for the remainder of this period is presented (in blue) on the right of figure 23[33]. The impact of this capital constraint will be continually reviewed as project designs and costs evolve.

[32] Available from http://www.cer.ie/cerdocs/cer05144.pdf.

[33] Note that estimates are provisional and are subject to change, especially as projects may be delayed by the planning processes or by difficulties with way leaves etc. The costs shown are the costs which are expected to be incurred by ESB Networks, and do not include any investment which is paid for directly by third parties (e.g. for line diversions or grid connections).

Figure 23: Electricity Transmission Investment 1996 to 2010



Source: ESB Networks

The electricity network in the Republic of Ireland is interconnected with Northern Ireland. The main interconnector is at the Louth 220 kV station. In addition there are 110 kV connections at Letterkenny in Co. Donegal and Corraclassy in Co. Cavan. The two Transmission System Operators (TSOs) in the Republic of Ireland and Northern Ireland are jointly progressing plans to develop an additional North/South interconnector.

The White Paper on Energy included a number of actions with regard to interconnection. Specifically the Government will:

- support the progressive development of a regional electricity market with UK and North West Europe over the next five years underpinned by new interconnection,
- ensure delivery of the second North/South electricity interconnector by 2011 which will more than double the existing cross border electricity transfer capacity to over 680 MW,
- ensure delivery of the East/West electricity interconnector no later than 2012 which will provide 500MW of capacity and which will remain in State ownership vested in Eirgrid and
- ask Eirgrid to undertake cost benefit analysis and feasibility planning within the next two years for decisions in relation to further interconnection with Britain or potentially with Europe.

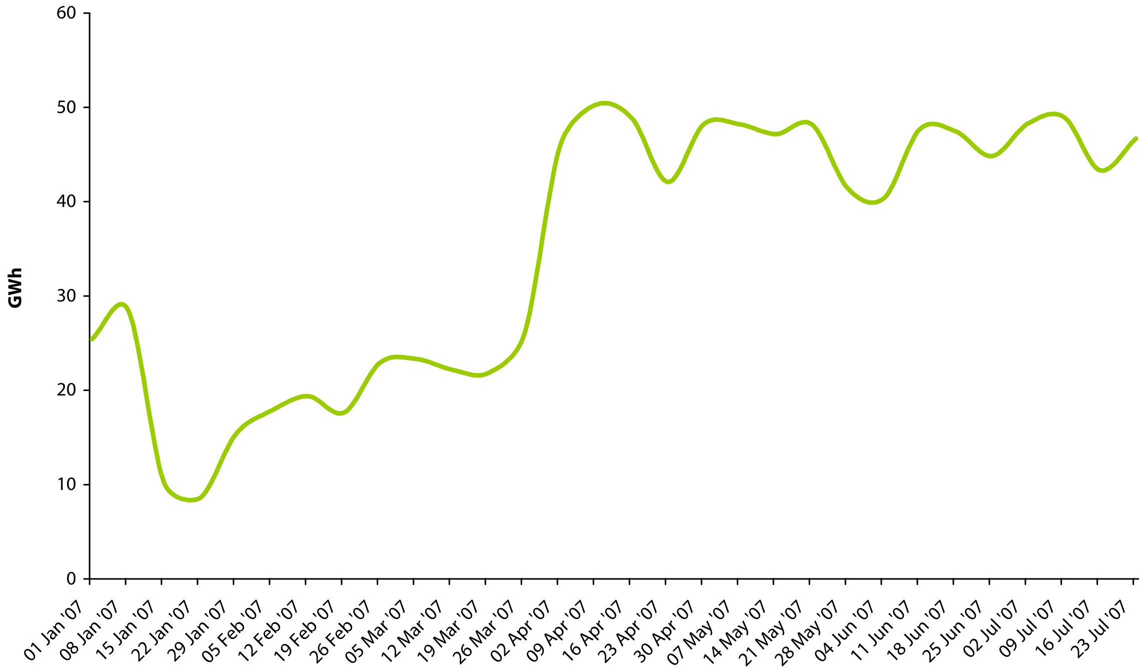
These new interconnectors will enhance Ireland's SOS and competitiveness.

The CER on the 7th September 2007 published a report[34] compiled by Eirgrid on the selection of a connection point for the East/West Interconnector to the Irish Transmission System. The report examines potential connection points and evaluates each one in turn. The report concludes that Woodland is the optimum connection point.

Figures 24 and 25 show that from January to July 2007, over 1,060 GWh of energy was imported over the interconnector from Northern Ireland, with only 4.4 GWh exported in return. The average daily volume of energy imported over the interconnector was in excess of 3.4 GWh.

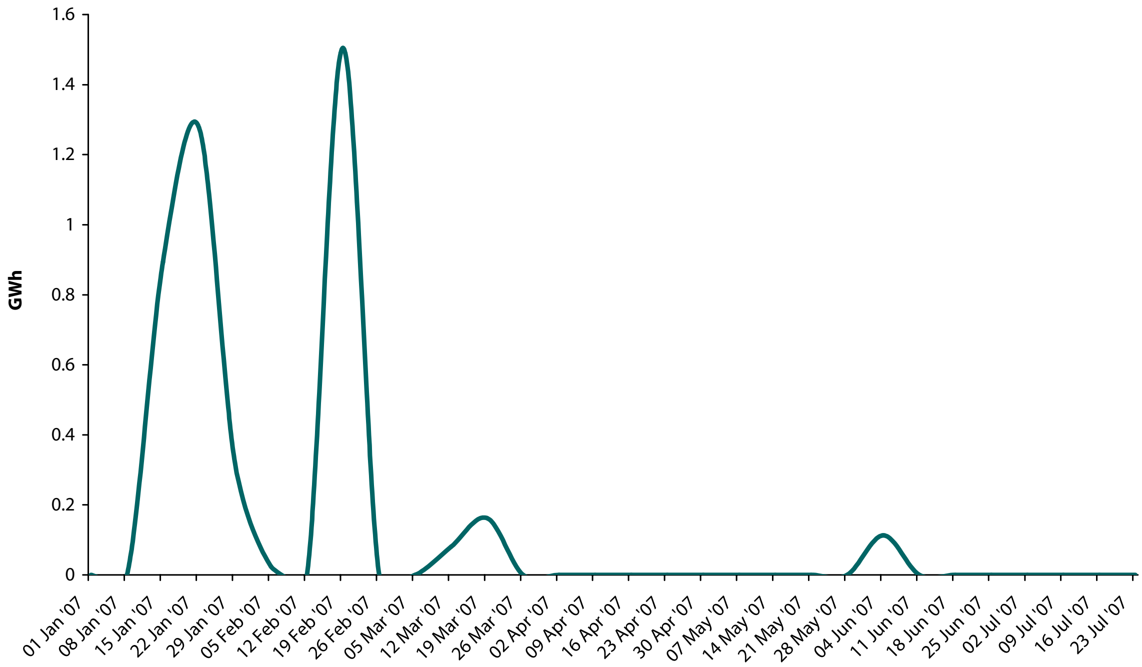
[34] The report is available at http://www.cer.ie/en/electricity-transmission-network-interconnection.aspx?article=cc14e625-43c1-44ec-ac78-ed0ed4962170

Figure 24: Interconnector Trading - Imports January to July 2007



Source: Eirgrid

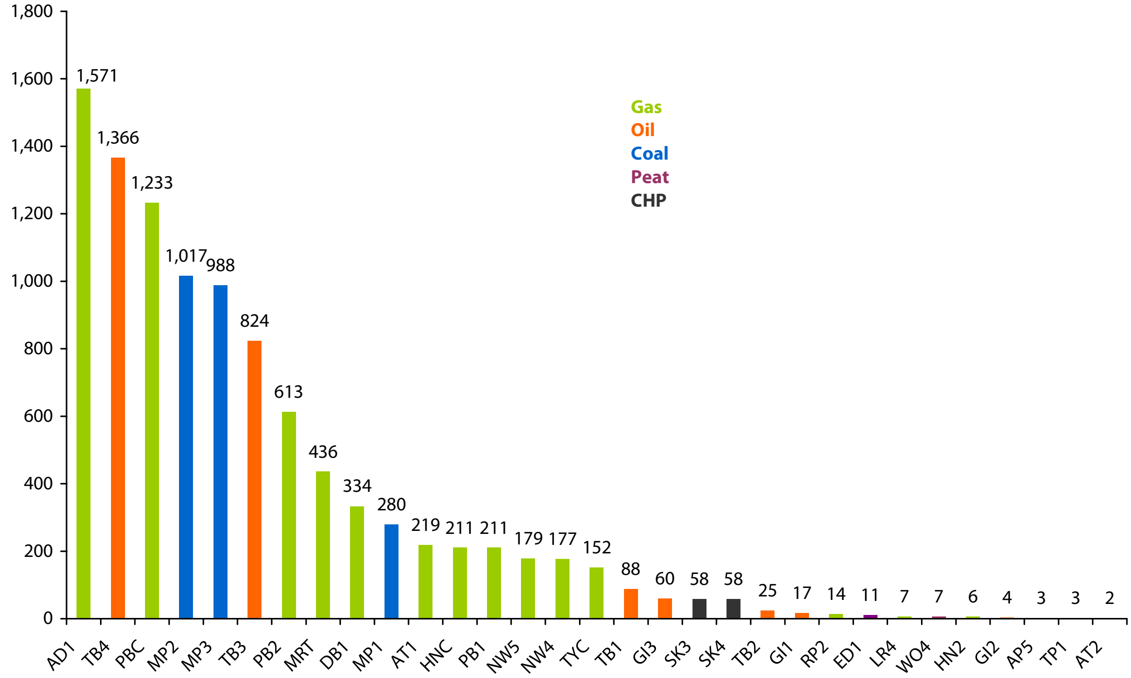
Figure 25: Interconnector Trading - Exports January to July 2007



Source: Eirgrid

Figure 26 shows the generating units setting the spill price from January to July 2007 (i.e. the last generator in each half hour from which electricity is drawn to meet demand). Aghada's gas-fired unit AD1 set the spill price more often than any other unit. Gas (including CHP) is the dominant fuel setting the spill price, followed by oil, coal and peat.

***Figure 26:** Generator Units Setting the Spill Price July to October 2007*



Source: Eirgrid

4.2.7 Public Service Obligation

The "Electricity Regulation Act 1999 (Public Service Obligations) Order 2002 (PSO Order) (S.I. No. 217 of 2002[35])" provides for the imposition on ESB of public service obligations. These obligations require the ESB to produce or buy electricity generated from peat and renewable sources. The requirement is in place to ensure that a percentage of the country's available electricity is produced from indigenous fuel for SOS reasons and to help protect the environment.

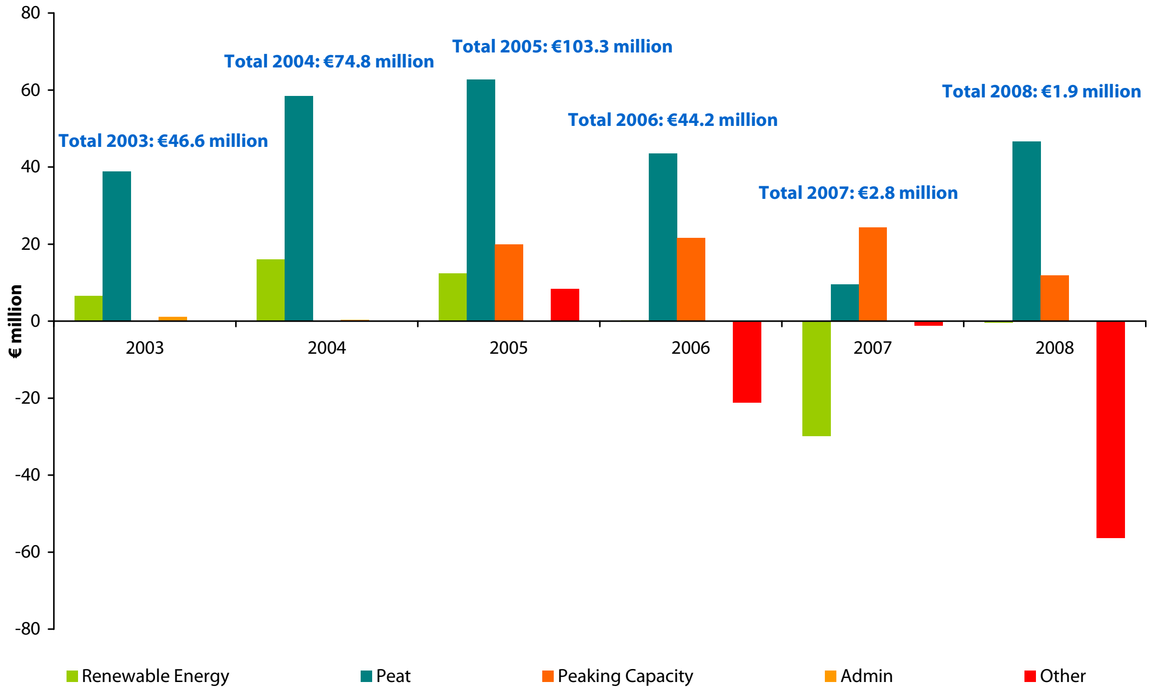
The *Electricity Regulation Act 1999*, is amended by the *Electricity Regulation Act 1999 (Public Service Obligations) (Amendment) (No. 2) Order 2005, (S.I. No. 511 of 2005*[36]), of 5th August 2005 so as to allow for the imposition of a further public service obligation on ESB, in the interest of SOS. This Order places a requirement on ESB to procure temporary peaking capacity to meet short-term peak demand. It also provides for the compensation of ESB for the additional costs incurred in complying with this obligation.

The PSO Order provides for the introduction of a PSO levy to compensate ESB for the additional costs incurred in complying with these public service obligations. The levy, which is approved by the CER, 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 27 shows the cost breakdown for the PSO from 2003 to 2008.

[35] A copy of the legislation is available from http://www.irishstatutebook.ie/ZZSI217Y2002.html.
[36] Available from http://www.dcmnr.gov.ie/NR/rdonlyres/DFAAB159-3681-4F0E-A3E9-6217D1203F34/0/SINo511of2005PSOOrder2005.doc

Figure 27: PSO Cost Breakdown 2003 to 2008



Source: CER

It can be seen that negative values occur in the other and renewable categories. The reasons are explained as follows:

Many of the historic renewable energy contracts have current prices for electricity which are below the proxy benchmark market price for electricity (the "Best New Entrant" price, BNE) which is used in setting the value of the PSO. In such a case rather than ESB Customer Supply being paid for the excess in renewable electricity price the Government receives a credit which is offset against other PSO costs. In 2008 the renewable electricity generation that is supported under the PSO mechanism, primarily wind energy, rather than requiring compensation payment to the relevant supplier, will bring about a surplus of €0.43 million returned to the PSO fund.

The "other" category includes administration costs incurred by the TSO, Public Electricity Supply (PES) and Distribution System Operator (DSO) and other market participants. It also includes the 2006 corrections for over/under recoveries for PES and ESB Power Generation and it can be seen that the total in this category is a negative amount for the third year in a row. This figure also includes the impact of the "Capacity 05" (Aughinish and Tynagh) contracts in 2006 and the estimated impact of Capacity 05 contracts in 2007 which comprises a total credit of €58m. The large credit arising is due to the fall in gas prices since the Best New Entrant price for 2007 was set in July 2006.

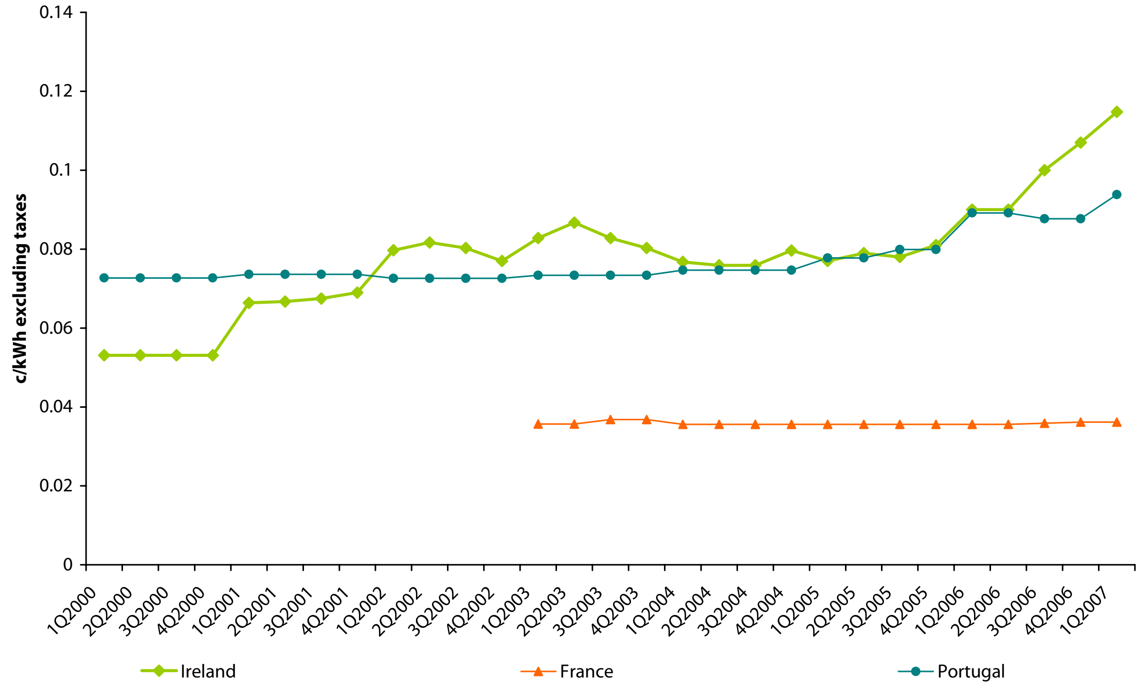
For 2008 the total amount to be recovered through the levy is approximately €1.9 million37. In consideration of the level of costs to be recovered via the PSO levy in 2008 and the resultant very low levy, the Commission decided that the 2008 levy will be set to zero. This is on the basis that the administrative work involved in collecting the levy from all customers would be unduly onerous relative to the costs to be recovered. The PSO costs will be rolled-over to the following year's (2009) allowed PSO costs.

[37] The breakdown of the impact of these costs on various consumer levels can be found in the PSO decision papers (CER/02/152, CER/03/186, CER/04/269, CER/05/125, CER 06/147 CER 07/103) on the CER's website. (www.cer.ie).

4.2.8 Electricity Prices

Electricity prices to Irish industry have risen by 140% in real terms between 2000 and 2007, the largest increase of the countries shown in table 8. The bulk of this increase occurred between the end of 2000 and the second quarter of 2002.

Figure 28: Electricity Prices to Industry (Nominal Prices) Q1 2000 to Q1 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

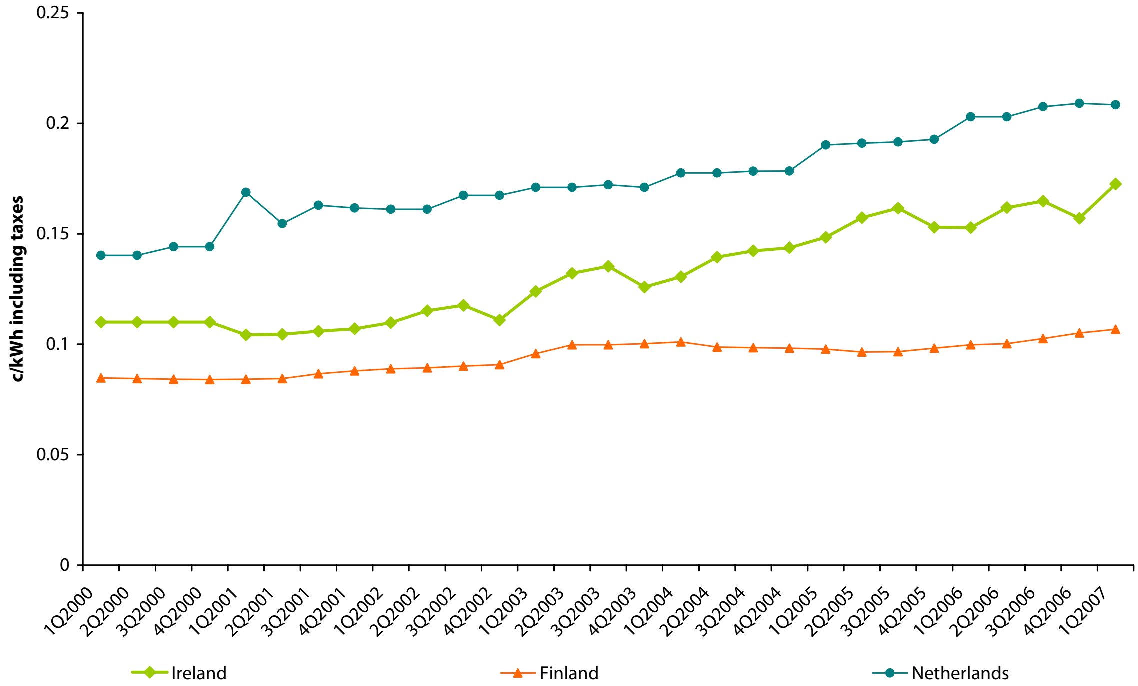
Table 8: Electricity Price to Industry Increase Since 2000

Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Electricity Prices 1st qtr 2007 (nominal)	163	232	130	119	146	105	160	133	216	187	147		129	162	142	193
Electricity Prices 1st qtr 2007 (real)	135	202	116	105	142	97	144	108	240	157	108		112	135	128	174

Source: Energy Prices & Taxes © OECD/IEA, 2007

Electricity prices to Irish householders increased by 24% in real terms since 2000. Of the countries shown in table 9 only the UK, the Netherlands and Sweden experienced higher real growth in household electricity prices.

Figure 29: Household Electricity Prices (Nominal Prices) Q1 2000 to Q1 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

Table 9: Electricity Price to Households Increase Since 2000

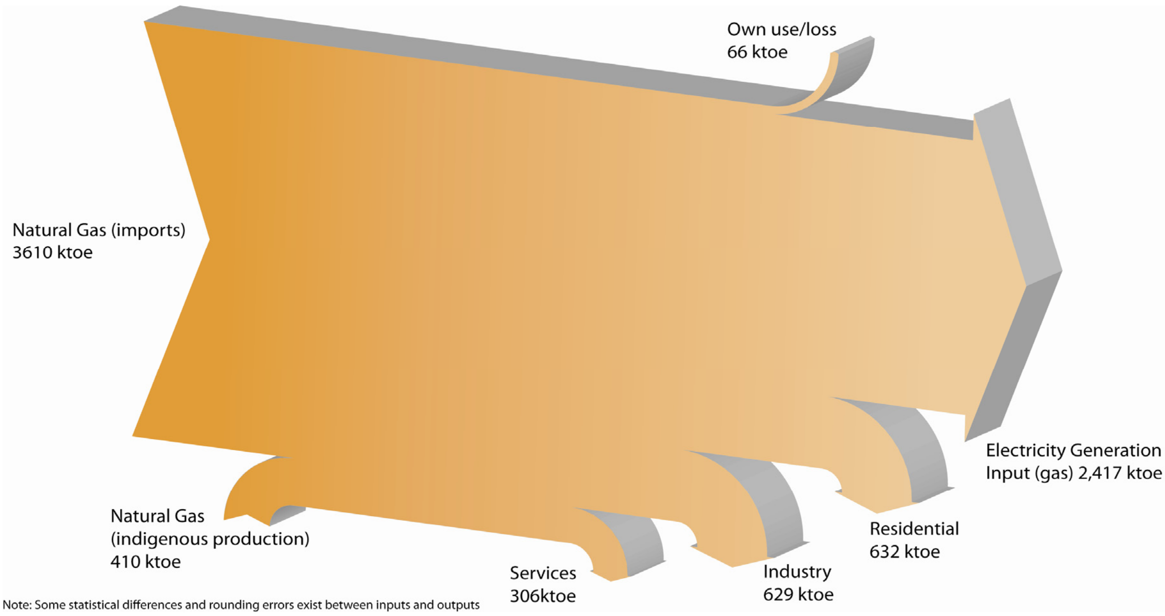
Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Electricity Prices 1st qtr 2007 (nominal)	140	121	109	107	127	105	136	130	157	131	144	147	120	105	142	160
Electricity Prices 1st qtr 2007 (real)	115	107	96	94	116	93	122	105	124	113	124	127	99	86	130	134

Source: Energy Prices & Taxes © OECD/IEA, 2007

4.2.9 Natural Gas

Figure 30 presents an energy flow diagram for gas usage in 2006. The total input, categorised by imported and indigenous is shown on the left while outputs on the right are categorised by sector. It can be seen that the majority of gas is imported (90%) and electricity is responsible for largest share of output (59%).

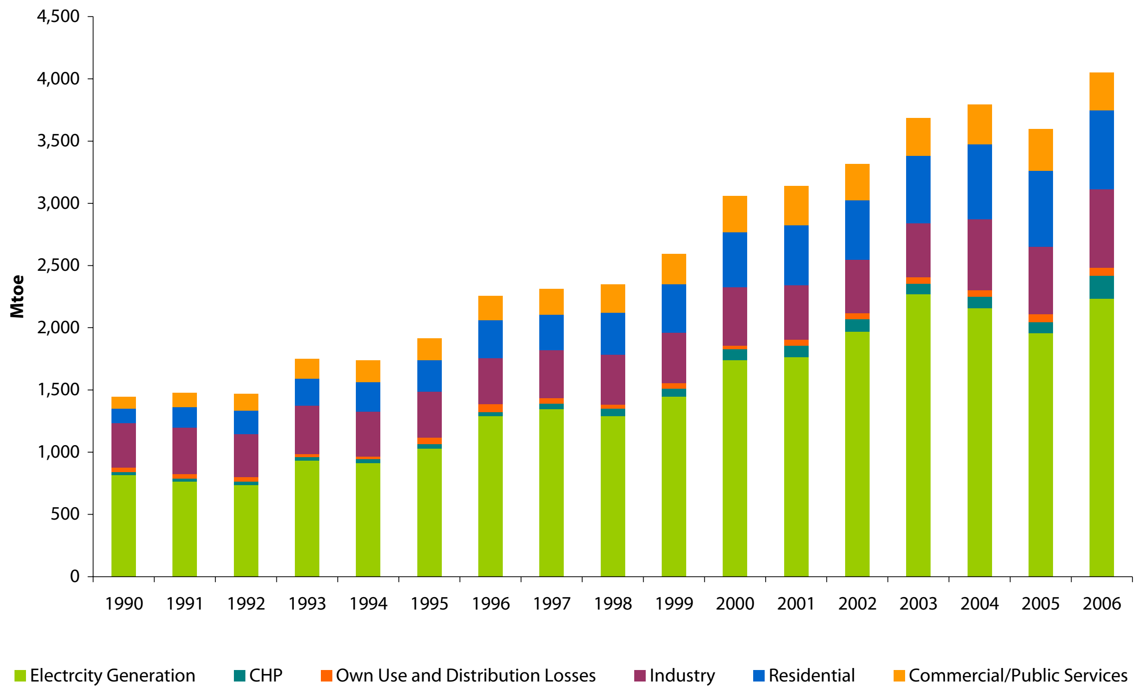
Figure 30: Energy Flow 2006 – Natural Gas



Source: SEI

Gas demand at a sectoral level is shown in figure 31.

Figure 31: Gas Demand 1990 to 2006

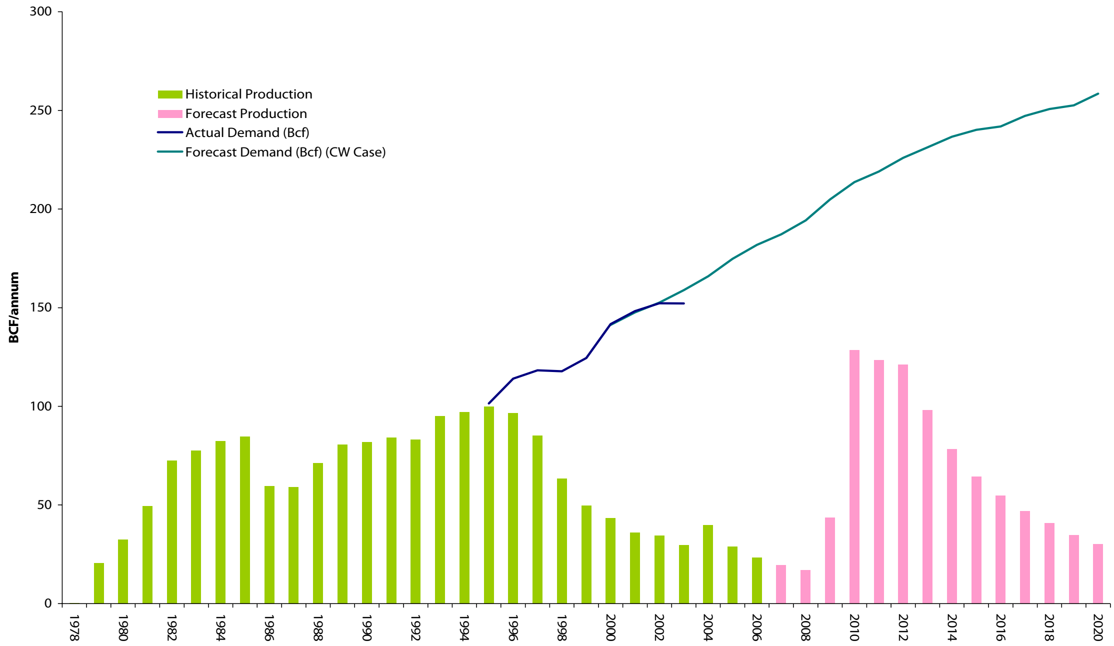


Source: SEI

It can be seen that total gas demand has increased over the period 1990 to 2006 by an average of 6.6% per annum (for a total increase of 178%). Use of gas in the power generation sector in particular has been strong and was 187% or 6.8% per annum over the period. By the end of 2006, 60% of total gas was used for power generation. Natural gas use increased in 2006 by 18% due largely to fuel switching in electricity generation.

Forecast data for indigenous production of natural gas are available from the Petroleum Affairs Division[38] (PAD), a section within DCENR. Data are presented in figure 32 for the period to 2020. It can be clearly seen that the forecasted demand is far in excess of what will be available from indigenous sources.

Figure 32: Forecast Gas Supply and Demand to 2020



Source: DCENR (PAD)

4.2.10 Infrastructure/Investment

The natural gas network in Ireland is operated by Bord Gáis Éireann (BGÉ) a commercial state body. 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. 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 two Ireland-Scotland interconnectors in 2006 provided 90% of the gas supply. The maximum daily import capacity for the interconnectors is imposed by the capability of the compressor stations to deliver high pressure flows into the pipelines. This current limit is 23 million cubic metres per day (mscmd. Further compression power and/or onshore pipeline reinforcement in Scotland could enable the interconnectors to increase to the order of 50 mscmd. In the long term there will be an increasing reliance on the interconnectors to access the European gas sources. The traditional sources of the Dutch and UK sectors of the North Sea are in decline and future gas supplies are projected as being delivered from more distant fields such as the northern Norwegian sector or LNG from outside the EU.

Considerable investment has occurred in the natural gas network in recent years. A total of €1.53 billion was invested in the period 2001 to 2005 and a further €1.7 billion is scheduled for investment by 2013. The network has recently been expanded with the development of the Galway to Mayo pipeline. This will link the Corrib gas field to the Irish market. In addition BGÉ has completed the South/North Pipeline, linking the Irish and Northern Irish markets.

[38] See http://www.dcmnr.gov.ie/Natural/Petroleum+Affairs+Division/ for full details of PAD's work and responsibilities.

The main development that will have a significant impact on the system is the proposed liquefied natural gas (LNG) import terminal on the Shannon Estuary. The CER in the "Gas Capacity Statement"[39] expects that this terminal will be in operation by the winter of 2012/13. The terminal is close to the existing transmission system and would be connected to it by a relatively short length of pipeline.

DCENR commissioned a feasibility study on the construction of a pipeline from the Mayo-Galway Pipeline to Donegal town via Sligo. This provides the possibility that there may be future pipeline projects in this region[40].

Since most of Ireland's is imported it is relevant to examine the situation in the UK. Figure 33 gives an indication of the possible availability of gas to meet annual UK demand over the period to 2014. Data is sourced from the Department of Trade and Industry's (DTI) Joint Energy Security of Supply (JESS) working group report[41].

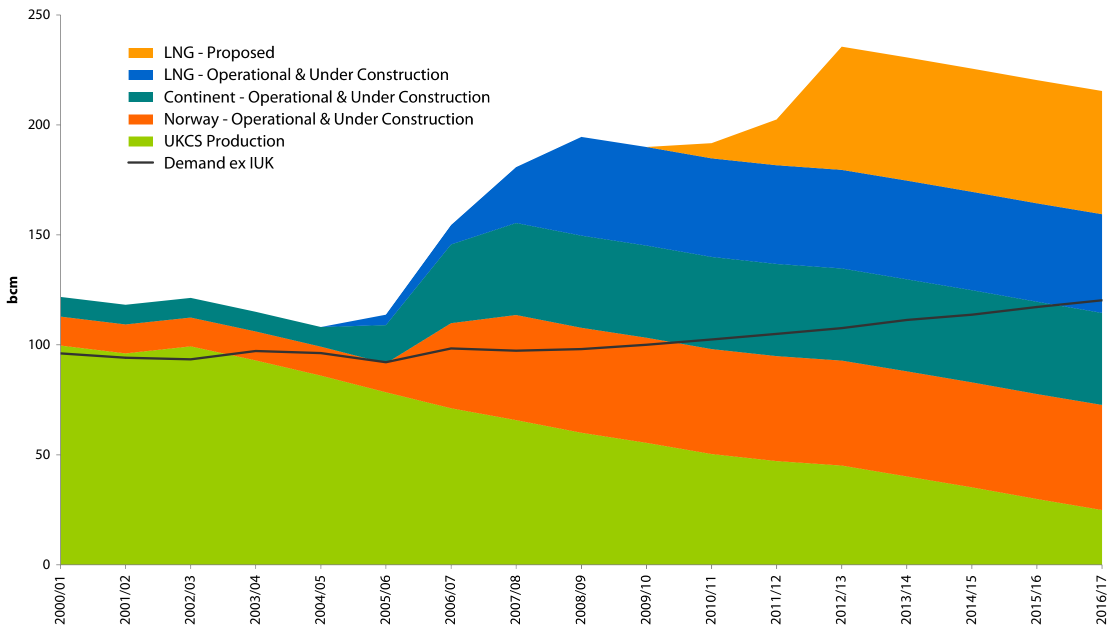
Imports to the UK are currently possible from Continental Europe through the Bacton–Zeebrugge interconnector. However, because seasonal exports are expected to continue at times of low UK demand (i.e. in the summer months), figure 33 assumes no net contribution from the interconnector to annual UK supply (or demand), notwithstanding the expected progressive increase in its import capacity through the installation of additional compression at the Belgian end. There is existing infrastructure in place permitting imports of gas from Norway, principally the Vesterled pipeline to St Fergus. The Norwegian entry on figure 33 also includes the import capacity of projects to bring additional Norwegian gas to the UK, in particular from the large Ormen Lange Field but also from Statfjord and Sleipner.

Figure 33 also shows the capacity of the Balgzand-Bacton Line (BBL, the second gas interconnector) and of the various liquefied natural gas (LNG) import projects being planned. In both cases the chart shows the progressive build up of supplies to the UK these projects would make if they were to go ahead to the fullest extent currently expected. In practice the build up of import capacity and, particularly, of actual gas imports would be more closely matched to the growth of demand.

The (DTI) gas demand projection shown here excludes producers' own use. The demand projection also includes an estimate of non-energy demand for gas (e.g. use for petrochemicals). Demand from Northern Ireland is included but demand from the Irish Republic, around 4 bcm of which is currently met by imports from the UK, is not. As with the production projection, there is great uncertainty attached to the gas demand projection (with industry estimates ranging up to 125 bcm or more by 2015); both should be treated as only indicative.

[39] CER, 2007, "Gas Capacity Statement". Available from http://www.cer.ie/en/gas-capacity-statement.aspx
[40] Ibid.
[41]Full details of the group's activities are available at http://www.dti.gov.uk/energy/energy-reliability/security-supply/jess/index.html.

Figure 33: Annual UK Gas Demand and Potential Supply 1998 to 2015



Source: JESS

Gas production from the UK Continental Shelf (UKCS) peaked in 2000 and has since been declining; that decline is expected to continue. Until the end of this decade, UK demand for gas is expected to be broadly flat and then rise slowly. The implied growing need for imports has implications for import infrastructure and for the underpinning commercial and intergovernmental agreements.

UK gas demand is expected to be broadly flat until the end of this decade and then rise slowly over the next decade or so; the pace of change in demand will depend on a number of factors including absolute and relative energy prices.

Between 1997 and 2003, the UK was a net exporter of gas on an annual basis, mainly via the Bacton–Zeebrugge interconnector. As a result of declining UKCS production, in 2004 the UK was again a net importer of gas and a large and growing import requirement is expected by the end of this decade and beyond. Although reliance on gas imports is not a new feature of the UK energy supply mix, the extent of previous dependence, imports met as much as a quarter of annual UK gas demand in the 1980s, was not on the scale now anticipated (with net imports meeting around 30% of UK annual gas demand in 2010, 60% in 2015 and 80% in 2020).

Were they all to go ahead, the capacity of existing import projects and those currently being considered could meet the annual shortfall in supplies from the UKCS well into the next decade. Imports are likely to come from a range of sources and by a variety of routes, thus contributing to gas supply diversity. There is also some upside potential from UKCS production which, like UK demand, may respond to price signals.

4.2.11 Gas Storage

Ireland's first storage facility commenced operations in 2001 at the Southwest Kinsale Field. The facility enables gas to be injected during the summer and delivered to the Irish market in the winter, when demand is higher. The CER has licensed the facility and it was made available to third parties from 1st June 2006[42].

It is treated as a source of supply on the peak day, but is a demand on the minimum day with injection into storage requiring gas to be moved from the onshore transmission network to the offshore facility.

[42]The licence for the storage facility can be viewed at http://www.cer.ie/CERDocs/cer06101.pdf.

The facility is operated by Marathon Oil Ireland Limited and provides approximately 70 million standard cubic metres (mscm) of space with a summer time injection rate of 0.4 mscm per day and a peak day withdrawal capacity of 2.5 mscm per day. It may be possible to increase output from the storage facility into the transmission system on a short term basis (days) in the event of a supply shortfall from another entry point.

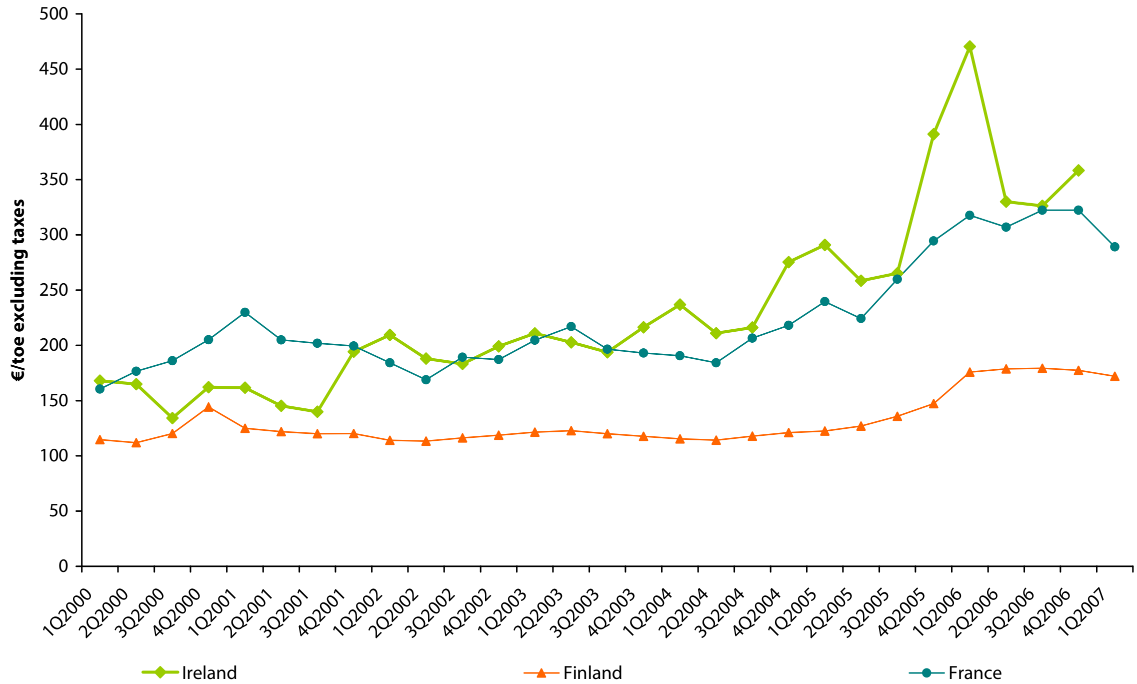
In May 2006 Shannon LNG, an Irish subsidiary of Hess LNG Limited, proposed to build a €400 million liquefied natural gas (LNG) receiving terminal on the Shannon Estuary. This LNG facility will have the capacity to inject up to 22.66 mscm into the Irish natural gas network. The facility is expected to be in commercial operation by 2012.

4.2.12 Gas Prices

Natural gas prices to Irish industry, in real terms (shown in figure 34 and table 10) are almost three times higher than in 2000. Of the countries shown only the UK experienced a higher increase.

Figure 35 shows that there were two distinct periods where gas prices rose dramatically. These were between the third quarter of 2001 and the first quarter of 2002 and then again between the third quarter of 2003 and the first quarter of 2005.

Figure 34: Natural Gas Prices to Industry (Nominal Prices) Q1 2000 to Q1 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

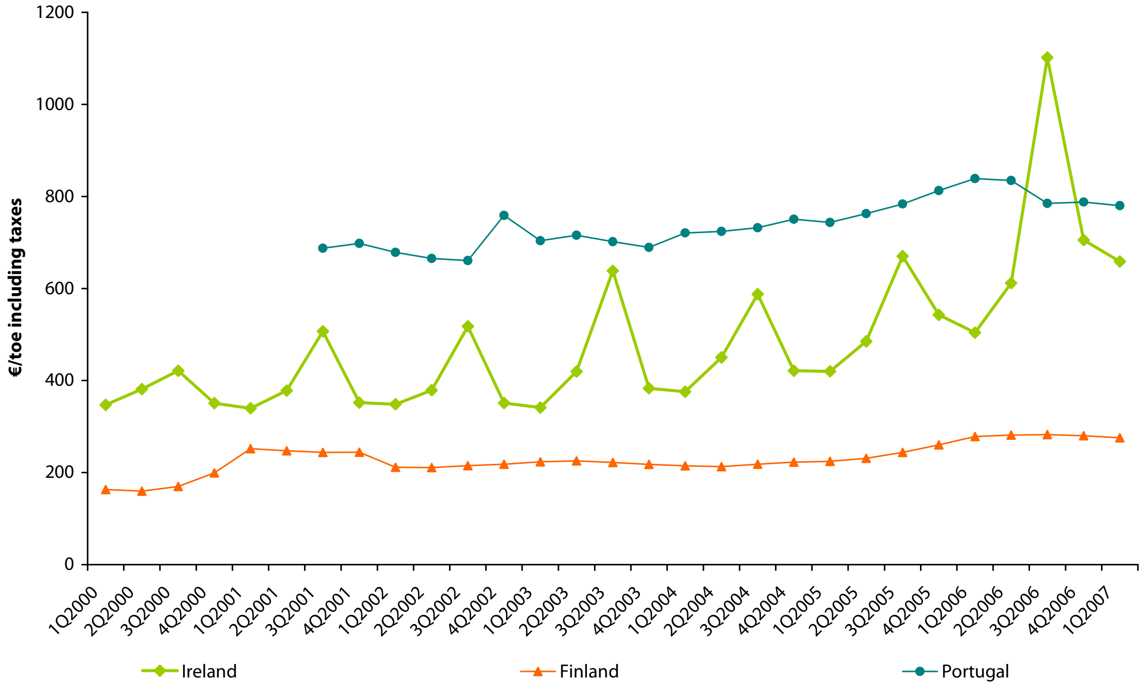
Table 10: Natural Gas Price to Industry Increase Since 2000

Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Gas Prices 1st qtr 2007 (nominal)	175	182	142		135	155	138	146	270	122	147			150		294
Gas Prices 1st qtr 2007 (real)	145	159	126		131	143	124	119	299	102	108			124		265

Source: Energy Prices & Taxes © OECD/IEA, 2007

Up to mid 2007 natural gas prices to Irish households (figure 35 and table 11) had increased, in real terms, by 38% since 2000. This was slightly below the average increase of 40% in the OECD Europe countries. Note that the peaks shown in the Irish gas price in figure 35 reflect fixed standing charges and low consumption during summer months resulting in higher unit prices. Prices have fallen from that peak since then.

Figure 35: Household Natural Gas Prices (Nominal Prices) Q1 2000 to Q1 2007



Source: Energy Prices & Taxes © OECD/IEA, 2007

Table 11: Natural Gas Price to Households Increase Since 2000

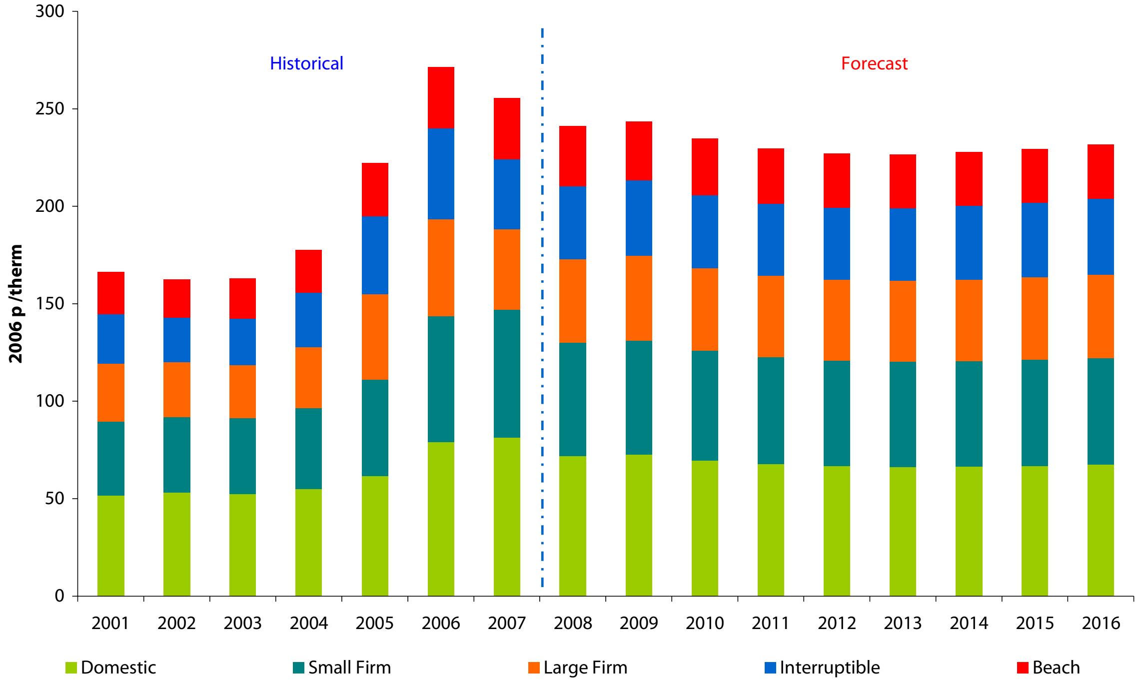
Index 2000 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
Gas Prices 1st qtr 2007 (nominal)	175	182	143	121	159	152	138	177	176	117	147	199		120		212
Gas Prices 1st qtr 2007 (real)	140	161	126	107	146	136	124	144	138	101	126	172		98		177

Source: Energy Prices & Taxes © OECD/IEA, 2007

Data is also available from the UK Gas National Grid[43] which forecasts gas prices to 2016 at the level of the end user (figure 36).

[43] Full details are available from "Development of Investment Scenarios" Available from http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/

Figure 36: ***UK End-User Gas Price Forecast***



Source: UK Transmission National Grid (Gas)

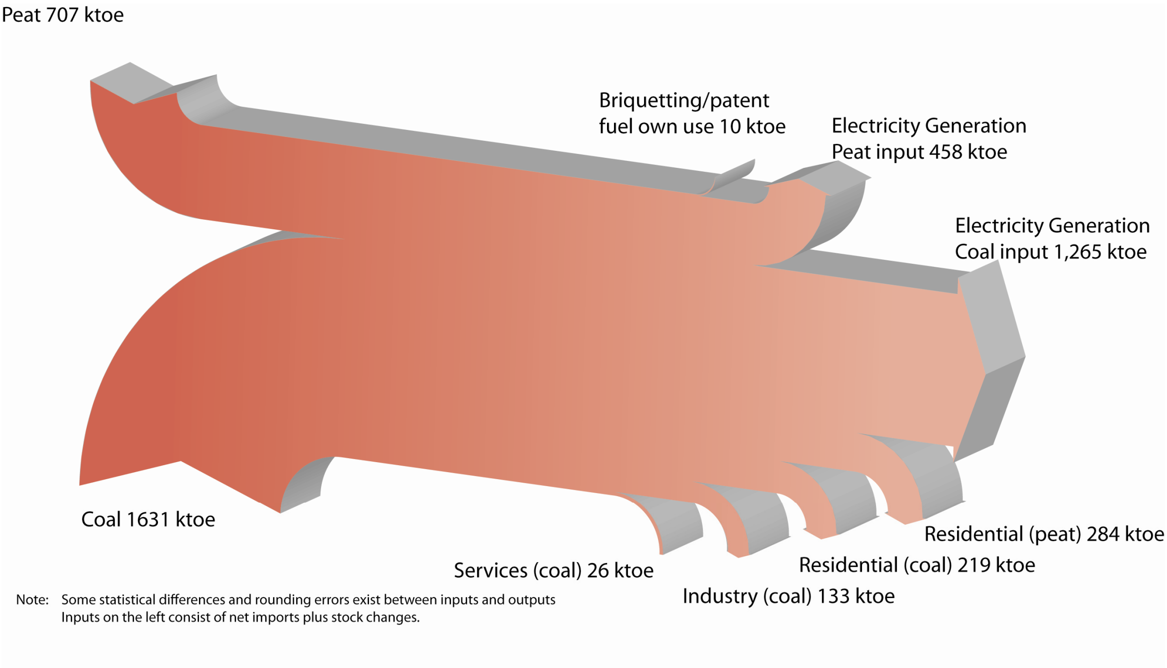
Prices are forecast to increase in 2008 based on an assumption of more normal weather and a reluctance of gas importers to over deliver into a relatively well supplied market during periods of lower demand. The forecast assumes that the UK gas market will remain relatively well supplied throughout the ten-year period, with prices stabilising, albeit at a higher level than that seen before recent increases.

Figure 36 also e forecasts that domestic prices will start to fall in 2008 as the reduction in wholesale prices filters through to this market sector. Prices in the larger DN markets are forecast to have peaked in 2006 as a larger proportion of this price is made up by the wholesale price.

4.2.13 Solid Fuels

Figure 37 presents an energy flow diagram for solid fuels in 2006. Coal and peat inputs are shown on the left while outputs on the right are categorised by sector.

Figure 37: Energy Flow 2006 - Solid Fuels

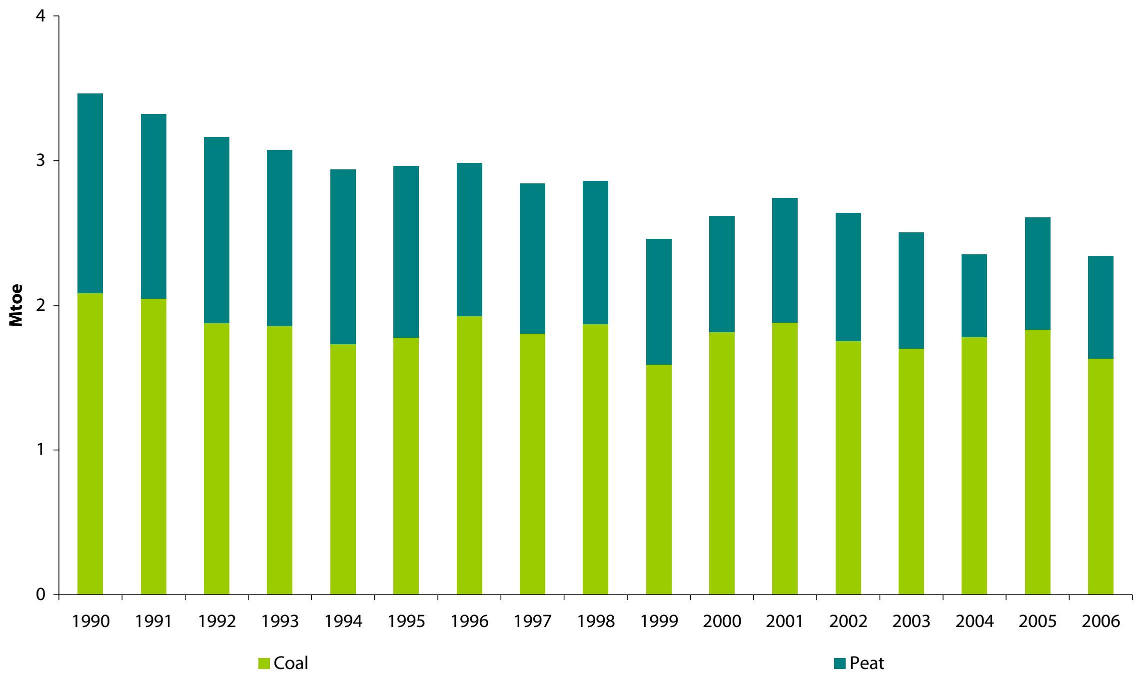


Source: SEI

It can be seen that coal is the dominant fuel accounting for 70% of total solid fuels in 2006. Electricity generation accounts for the largest share of solid fuel usage in 2006 (72%).

Figure 38 illustrates the primary demand for coal and peat over the period 1990 to 2006. Over the period consumption of coal and peat declined by 22% and 49% respectively.

Figure 38: Coal and Peat Consumption 1990 to 2006

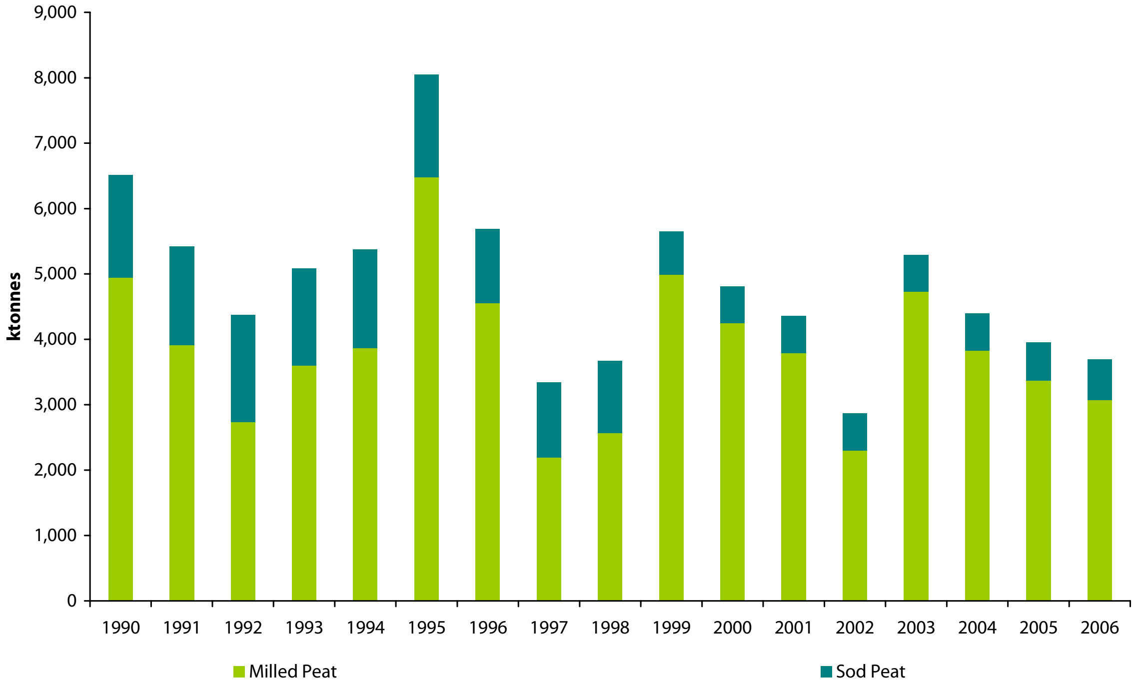


Source: SEI

4.2.14 Peat Production

Figure 39 shows the production of peat during the period 1990 to 2006. Milled peat is produced by Bord na Mona while sod peat is produced by the private sector. Total peat production peaked in 1995 at 8 million tonnes. Total production in 2006 was 3.6 million tonnes of which 83% were milled peat.

Figure 39: Peat Production 1990 to 2006



Source: Bord na Mona

4.2.15. Coal Imports

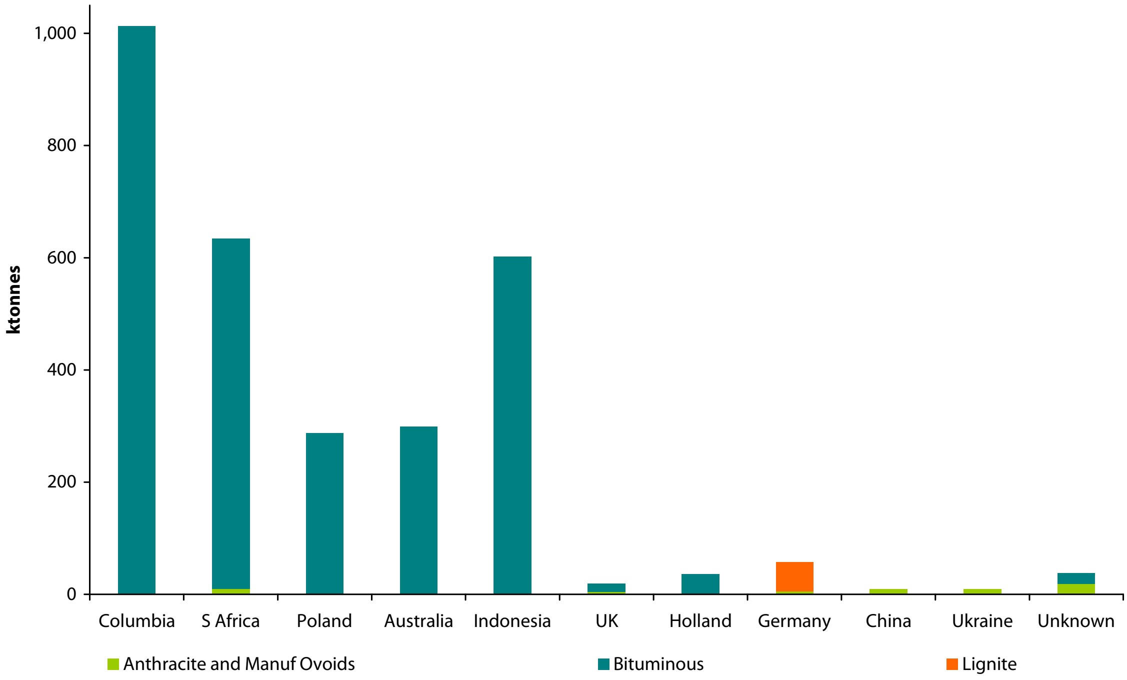
In 2006 coal (which in this case includes lignite, bituminous coal, manufactured ovoids and anthracite) imports into Ireland totalled 2.6 million tonnes. Table 12 and figure 40 illustrate the type and origin of the coal used in 2006. It can be seen that 97% of coal consumption was bituminous. The largest share of Ireland's imports of coal came from Columbia (42%).

Table 12: Coal Imports by Type and Country of Origin 2006

000' tonnes	**Anthracite**	**Bituminous**	**Lignite**	**Manuf Ovoids**	**Total**	***% of Total***
Columbia	-	1,090	-	-	1,090	41.9
Indonesia	-	779	-	-	779	29.9
S Africa	10	365	-	-	375	14.4
Unknown	33	198	-	-	231	8.9
Poland	-	62	-	-	62	2.4
Holland	-	36	-	-	36	1.4
Germany	-	-	13	2	15	0.6
Ukraine	8	-	-	-	8	0.3
UK	5	-	-	-	5	0.2
Total	56	2,531	13	2	2,602	100

Source: SEI

Figure 40: Coal Imports by Type and Country of Origin 2006



Source: SEI

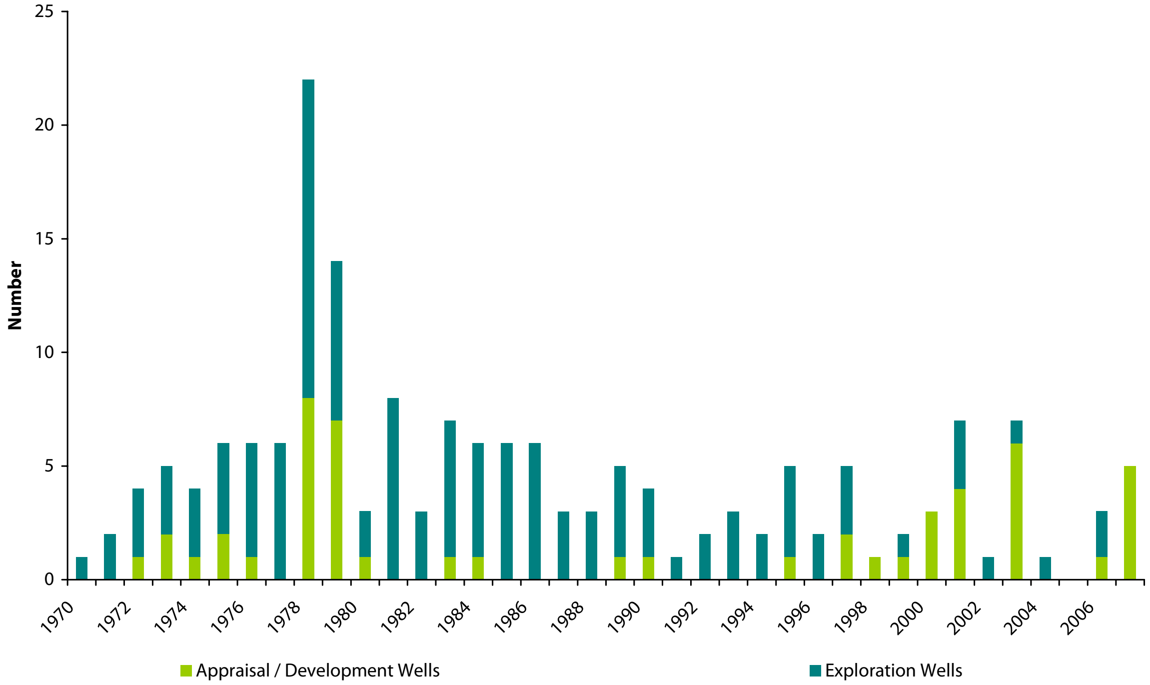
4.3 Security of Supply Metrics - Exploration

In Ireland, the primary gas field over the last decade, Kinsale, is in decline. Also, off of the Cork (South) coast is the Seven Head's field. Ramco, the developer, has stated that the field has proven reserves of 337 billion cubic feet, or 59 million barrels of oil equivalent. Figure 41 shows the amount of exploration for oil and gas taking place in Irish waters. The number of wells drilled is currently very low, reflecting the perceived unattractiveness of Irish waters for mineral exploration. It should be noted that of the 123 exploration wells that have been drilled since 1970, only 9 discoveries have been commercially worthwhile. They are, Kinsale Head, Ballycotton, Seven Heads, Helvick, Connemara, Spanish Point, 35/8-1, Corrib and Dooish.

As mentioned in section 4.1 the Corrib gas field is estimated to contain about 1 trillion cubic feet of gas, enough to satisfy about 60% of Ireland's demand over the 15-year life of the field[44].

[44] The Irish Times, July 06, 2007.

Figure 41: Wells Drilled in Ireland for Exploration 1970 to 2007



Source: DCENR (PAD)

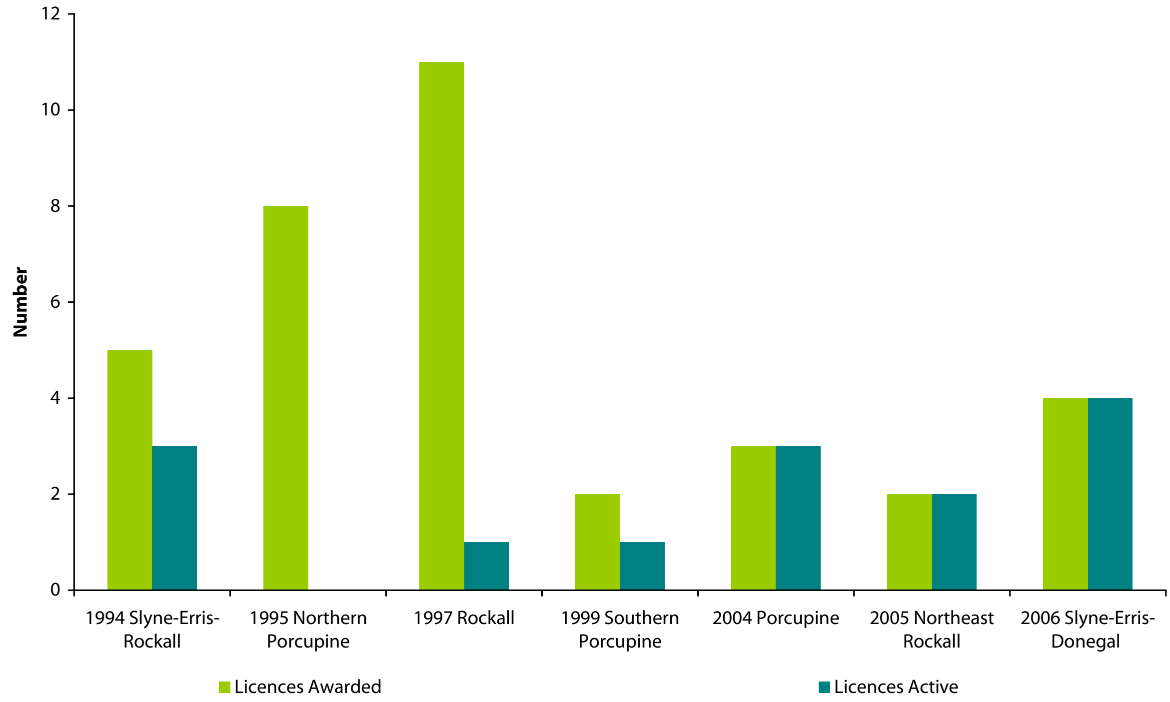
An explanation of the graph legend is as follows:

- Exploration wells are drilled on valid prospects outside the interpreted limits of commercial or potentially commercial discovered hydrocarbons.
- Appraisal wells are drilled subsequent to establishing 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), and
- Development wells are drilled for the purpose of production, injection, observation or disposal of fluid to or from known fields.

The number of licences to explore that have been granted since 1992 and the amount that are currently active are shown in figure 42. The acreage on offer in the most recent licensing round (Slyne-Erris-Donegal) covered approximately 25,000 square kilometres.[45]

[45] Details are available at http://www.dcmnr.gov.ie/Natural/Petroleum+Affairs+Division/Petroleum+Affairs+Division.htm.

Figure 42: Number of Licences 1994 to 2006



Source: DCENR (PAD)

The Minister for Communication, Energy and Natural Resources, Eamon Ryan announced on the 7th October 2007 the terms for a new oil and gas exploration licensing round in the Porcupine Basin[46]. The acreage on offer in the Porcupine Basin to the west of Ireland covers unlicensed blocks in an area of approximately 63,500 square kilometres.

From this round profitable fields will pay up to 40% in taxation to the Exchequer, an increase of 15% for the oil and gas companies involved.

While the above refers to natural gas and oil there may also be reserves of coal. For example, the Kish Bank Basin, offshore of 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[47] in 1986 considered the potential for exploiting this coal. Currently, however, there are no exploration licences covering the area.

[46] Full details are available at http://www.dcmnr.gov.ie/NR/rdonlyres/9ACE7409-FE61-499F-88C4-B3CDED8F697C/0/PorcupineRound2007.pdf

[47] Geological Survey of Ireland, 1986, "Offshore Coal in the Kish Bank Basin: its potential for Commercial Exploitation". http://www.gsi.ie/.

As part of the continuing commitment to develop and improve SOS indicators, SEI in 2007 commissioned new pieces of cutting edge research. Each year SEI works with nationally and internationally well regarded researchers to consider various aspects and to better underpin our understanding of SOS in Ireland.

The following sections include an examination on the value of lost load, incorporating risk into power sector investment analysis and a recalculation (with 2006 data) of the supply/demand index of SOS.

5 New Analysis - Incorporating Risk into Power Sector Investment Analysis

William Blyth
Oxford Energy Associates

5.1 Investment Risks

Capital investment involves making a more-or-less irreversible upfront payment in exchange for a future cash-flow stream. The investor will have expectations about the magnitude of this cash-flow, but because it lies in the future it remains uncertain. In the context of such capital investments, risk can be defined as an event that could lead to a deviation (either positive or negative) from the expected cash flow of the project. Such risks may be hedged to some extent by investing across a portfolio of different projects, but to the extent that risks cannot be diversified away, the greater the risks of a project, the higher the returns will need to be in order to justify investment.

This risk-return relationship is complex, and depends on who ultimately holds the risk from the project. In some market contexts, the investor themselves will absorb the full variations in cash-flow, whereas in other market contexts variations (and risks) may be passed through to consumers.

In the power sector, major sources of risk include price risks (e.g. fuel, electricity, carbon), technical risks (e.g. cost and performance), financial risks (e.g. cost of capital or credit risk) and regulatory risk (e.g. market structure, allocation of CO_2 allowances in the EU emissions trading scheme, EU-ETS). Typically, these risks interact with one another; for example fuel prices and the cost of CO_2 emissions are linked to electricity prices in competitive markets where the wholesale price is determined by the short-run marginal cost of generation.

To the extent that these risks pass through to the expected electricity price, there will be some automatic hedging via a pass through of the price variations to consumers. This hedging is unlikely to be perfect however, and some of the risk will remain with the generation companies. Companies may try to acquire additional information which could help reduce the risks. In the case of uncertainty over climate change policy for example, this could mean that companies would consider waiting for more information before investing; for example, on the likely progress of international climate negotiations, the stringency of national climate change targets, the allocation of allowances into the EU-ETS, the level and design of support mechanisms for renewables and carbon capture and storage etc.

Alternatively, companies might proceed with an investment in the face of these uncertainties if the returns from the project are sufficient to compensate them for taking the associated risks (e.g. as a result of an increase in expected electricity or CO_2 prices).

5.2 Quantifying Risk

Different types of power generation technology will face different risks, and so consideration of risks may affect technology choice. Commercial decision-makers will include the effects of risk (and other strategic factors) in their project appraisals, whereas policy-level analyses often omit these effects. This may lead to a discrepancy between policy-makers' expectations and actual behaviour in response to the introduction of a new policy mechanism that is expected to influence investment patterns.

One example is the introduction of carbon prices to stimulate investment in low-emitting technologies. The price of carbon required to stimulate investment may be calculated by policy-makers based on the expected costs of the new technology. Commercial investors however will factor in the risks surrounding the investment (including risks associated with the carbon price itself), and this will tend to increase the carbon price required to stimulate investment. To quantify this effect, we look at investment in coal-fired generation comparing three different technologies: i) combined-cycle gas turbine (CCGT), ii) pulverised-fuel ultra-supercritical (PF coal), and iii) integrated gasification combined cycle with carbon capture and storage (IGCC+CCS). As a basis for this study, we used the analysis of the two coal-based options for the Moneypoint power plant undertaken in a previous SEI study[48], making the same assumptions about technology costs and performance. One of the key aims of that study was to identify the costs of generating electricity with carbon capture and storage which would dramatically reduce CO_2 emissions compared to a normal coal plant. In this paper, we extend those results to include an assessment of the impact of CO_2 price risk and fuel price risk on the costs of generation.

Gas plant cost assumptions were taken from Blyth et. al. 2007[49]. In addition to fuel price uncertainty, an additional risk factor is considered here for gas plant, namely the risk that companies entering the market may not achieve the full load factors for their plant that they expect. This situation could arise if they take the wrong decision over technology choice and get squeezed out of the market by competitors building cheaper generation plant. Alternatively it could occur in imperfect markets, if for example a dominant player is able to exert market power to distort prices in a way which disadvantages new entrants to the market. To illustrate this situation, in this paper we take an investment in a new gas-fired CCGT plant, and look at the effects of introducing a risk that the load factor could be significantly lower than expected.

5.3 Methodology and Results

The methodology for quantifying risks is to calculate the real option value as described in Blyth et. al. 2007. This quantifies the additional expected return on investment that the project must show in order to justify investing immediately rather than waiting for some resolution of the risks being considered. In the case of the coal plant investments being investigated, the risks introduced into the model include annual random-walk variations of 21% in the gas price (assumed to feed through to the electricity price). This volatility is derived by calculating the annual variations in a geometric Brownian motion random walk process required to meet the high fuel price scenario given in the previous SEI security of supply report[50] which represents an increase in fuel price over 15 years of 108%. For consistency, the same volatility is assumed for the spark spread and the CO_2 price. In addition, the CO_2 price is assumed to undergo a step change at some fixed point in time. This step change is introduced to the model to simulate a policy shift which could either positively or negatively affect CO_2 price. The price of CO_2 is also assumed to feed through to the electricity price assuming a gas-fired plant of 40% efficiency sets the marginal generation cost for the power system. An increase in CO_2 price would therefore be beneficial for the plant with CCS and bad for the stand-alone coal plant, and vice versa for a decrease in CO_2 price.

To represent the load factor risk for a new entrant CCGT plant, a risk factor was introduced to the model whereby in each of the first ten years of operation, there is a 10% chance that the load factor for the CCGT plant drops permanently to half the original expected value for the remainder of its operating life. This was introduced in addition to the other risk factors for CO_2 and fuel price risks described above.

The results are shown in Figure 43.

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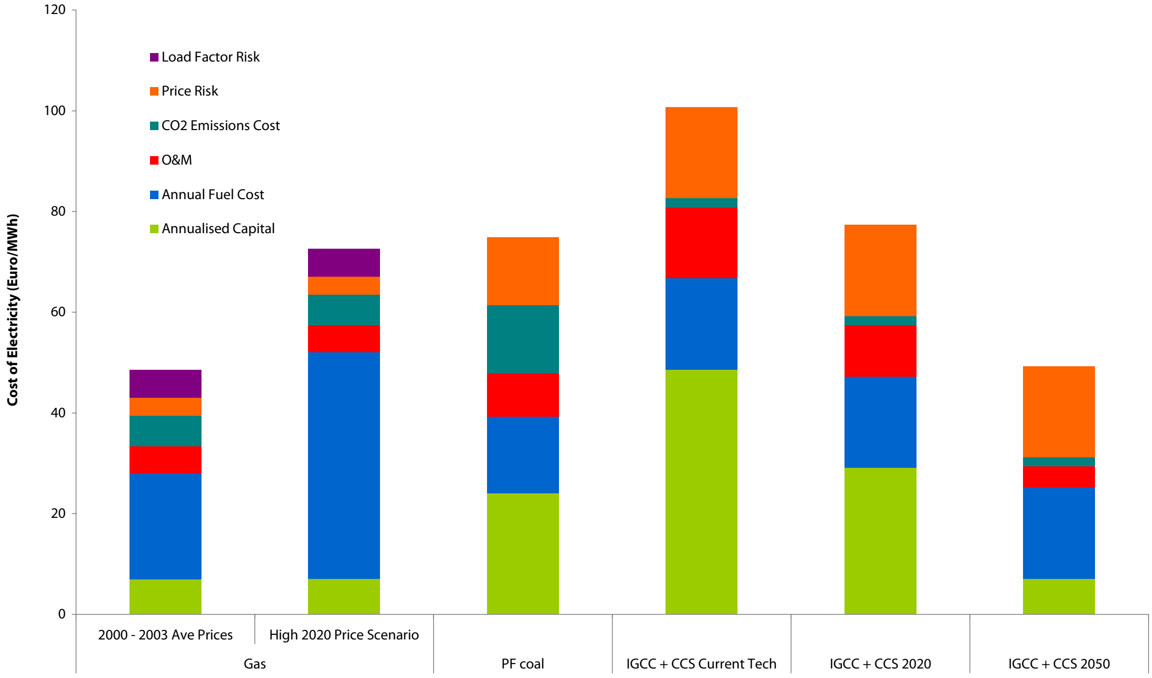
[48] Sustainable Energy Ireland, August 2006, "Carbon Dioxide Capture and Storage in Ireland; Costs, Benefits and Future Potential". Available from http://www.sei.ie/getFile.asp?FC_ID=1850&docID=741

[49] Blyth, W. et. Al, accepted July 2007, "Investment Risks under Uncertain Climate Change Policy". Energy Policy Article in Press.

[50] Sustainable Energy Ireland, December 2006, "Security of Supply in Ireland 2006".

Figure 43: Cost of Electricity Generation



Source: Oxford Energy Associates

The cost of generation for the gas (CCGT) plant is divided into two fuel price scenarios, since this is the major contributor to the overall cost for this technology, and also one of the key sources of uncertainty. The first bar in figure 43 shows the costs assuming a gas price equal to the average level for the period 2000 to 2003 (the latest years for which IEA statistics were available), being €3.33/GJ (or 35c/therm). The second bar applies the growth in prices under the high price scenario in the 2006 SEI SOS publication. This represents a 5.3% per annum growth in price to 2020, taking the gas price to €7.23/GJ (or 76c/therm). The carbon price used for all the technologies is the central price used in the SEI CCS report of €17/tCO_2.

The carbon and fuel price risk element is shown in orange. For the CCGT plant, price risk shows up as only a minor (7%) contribution, despite the strong dependence of the costs of generation on widely varying gas price scenarios. This is because the price of electricity is assumed here to be driven by gas-fired plant. This means that although the cost of generation may be highly variable, the revenue generated by gas-fired plant will vary in step with these cost changes making the overall net cash flows relatively un-risky. This assumption only holds as long as wholesale electricity prices follow gas prices – if this relationship ceases to hold, then gas-fired plant would be much more exposed to gas price risk.

The load factor risk appears slightly more significant, representing about 11% of overall generation costs. This risk factor will scale according to the actual commercial risks faced by new entrants, and is presented as illustrative rather than as a representation of actual risk levels in the Irish energy market.

The costs of generation for pulverised fuel coal and IGCC + CCS in figure 43 are taken directly from the SEI report on CCS, but with the price risk factor added in orange. These price risk figures combine the risks associated with both fuel price and CO_2 price variations. Gas price risk is important in this context, as it is assumed to feed through to wholesale electricity prices (as would be the case in a competitive market), despite the fact that the cost of these technologies is not directly dependent on gas prices. Likewise, the IGCC + CCS plant is exposed to both gas and CO_2 price variations because although it emits very little CO_2 itself, it benefits from high CO_2 prices because they are assumed to feed through to wholesale electricity prices; CCS plant would be exposed to the risk of a drop in CO_2 price. These price risks are quite significant, representing 18% of the costs of generation under current technology price assumptions for both PF coal and IGCC+CCS.

5.4 Conclusions

This paper aims to illustrate the importance of including risk in an analysis of investment. It is suggested that whilst commercial decision-makers will do so as a matter of course, policy-makers tend not to. The risks identified in this paper are illustrative; the assumptions about the scale of the different risks are not referenced to specific investment conditions in the Irish electricity market.

Nevertheless, such an illustrative quantification leads to some useful conclusions:

1. Power generation investment may not proceed according to expectations, since commercial decisions will generally incorporate risk which may be missing from policy analysis.
2. Inclusion of risk in the investment decision may lead to a requirement for higher returns on investment, leading to electricity prices being higher than expected in order to stimulate investment.
3. The choice of technology may be affected by risk, since different types of power generation have different risk exposures.

Policy-makers should therefore take account of risk when designing policies that aim to influence investment in the power sector. This includes policies that specifically aim to influence technology choice (e.g. climate change policies such as emissions trading, or technology support for renewables and carbon capture and storage), as well as more general energy policies relating to market design (e.g. tackling market power of incumbents, or capacity payment mechanisms), which influence the commercial risks faced by investors.

6 New Analysis - SOS Supply/Demand Index Ireland 2006 and 2020

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This S/D Index is one of the three elements proposed as part of an 'EU standard' for the security of energy supply (Scheepers et al, 2007). This paper describes the results of the quantification of the S/D Index for Ireland for the years 2005, 2006 and for 2020. The results are presented in section 6.1. The quantification is based on a new model and data for Ireland. A short description of the essence of the S/D index and results for the EU-27 and its Member States (MS) is presented in section 6.2. The results for the EU-27 MS enable a comparison with respect to the relative position of Ireland. The PRIMES based quantifications as reported in (Scheepers et al., 2007) have been directly used for this comparison. Section 6.3 provides more details on the data assumptions for Ireland.

The 2005 and 2006 quantification is based on a combination of data sources:

- The 2005 and 2006 national energy balances,
- Eurostat (2004, 2006) or PRIMES model results for the year 2005 (EC, 2006) supplemented with information from other sources (for example IEA, 2006).

In addition, ECN has quantified the S/D index for the year 2020 based on two scenarios:

- The 'Trends to 2030' scenario that has been recently updated (EC, 2006) based on PRIMES model results. The results of that quantification have also been reported in (Scheepers et al., 2007) and are summarised here (in section 6.2), mainly for comparison purposes.
- SEI forecast for 2020, in which 30% of the electricity is produced by renewable sources and 6% of the transport fuel by bio-fuels (this forecast was prepared by the Economic and Social Research Institute, ESRI, for SEI in October 2006).

Since the S/D Index model has been modified and improved in certain areas, the results of the previous quantification for Ireland (SEI, 2006) are not comparable to the quantifications presented here. Moreover, the 2005 value was partly based on provisional data for the year 2005. The definite 2005 figures in the most recent SEI energy balance are somewhat different. Therefore, the 2005 quantification is an update in order to enable a sensible comparison with the year 2006 and the forecast for the year 2020.

6.1 Results for Ireland

Five cases have been quantified for Ireland:

IE-2005p Quantification of the year 2005 based on the PRIMES baseline (EC, 2006), supplemented with data from other sources (Eurostat, EC, IEA).

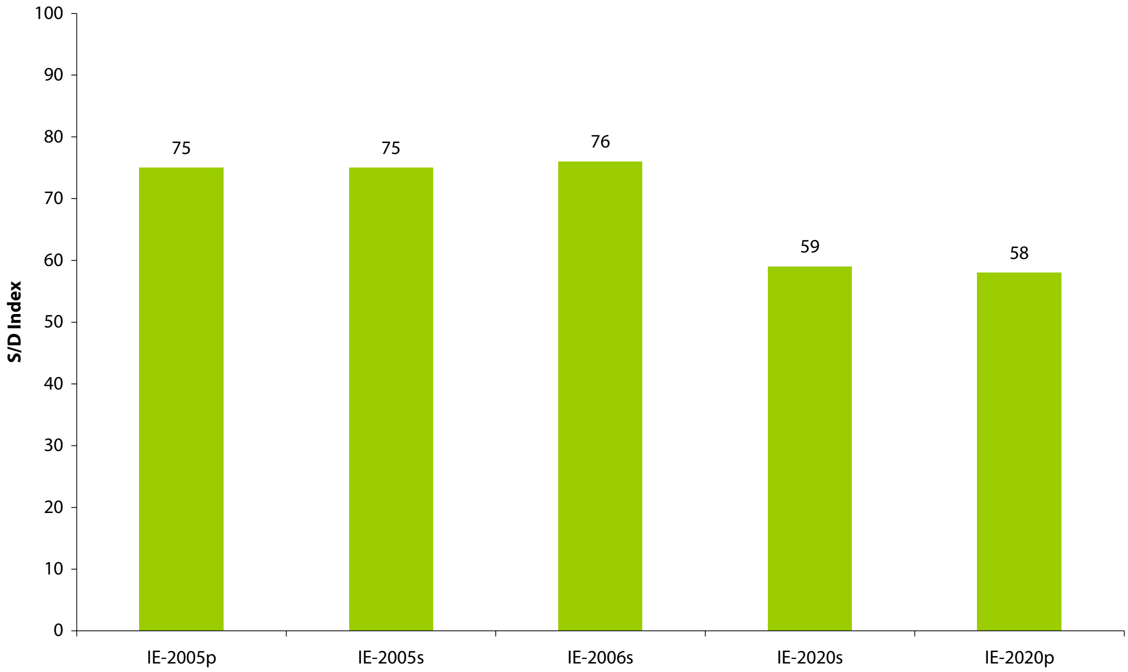
IE-2005s and IE-2006s Quantification of the S/D index for 2005 and 2006 based on the energy balances of these years provided by SEI, supplemented with data from other sources (Eurostat, EC, IEA).

IE-2020s Quantification of the year 2020 based on the SEI forecast, supplemented with data used for the IE-2020p (PRIMES.

IE-2020p Quantification of the year 2020 based on the PRIMES baseline (EC, 2006). Data not provided by the PRIMES baseline are taken equal as in the IE-2005p case (PRIMES).

The results are summarised in the figure 44 and table 13. In addition to the overall S/D index, the table provides the sub-scores and the weighing factors with which the sub-scores are combined into the overall S/D index.

Figure 44: ***S/D Index – Ireland***



Source: ECN

2005 and 2006

The results indicate a score of 75 and 76 for 2005 and 2006, which compares well to the other EU27 MS cases (shown in table 14). Ireland's S/D index is the third best score in comparison to the other EU member states (MS). The difference in the 2005 scores based on the SEI and the PRIMES energy balances is marginal. The changes from 2005 to 2006 are negligible.

The relatively high scores for Ireland are caused by high sub-scores in the PES (primary energy sources). The PES sub-scores are quite high (96-97) as oil and gas are imported from within EU and Norway. The oil and gas scores are therefore 100 (IE-2005s and IE-2006s). The C+T scores are moderate (52 and 55), mainly due to the relatively low CHP share in the electricity production (about 2.2 and 5.4%), which results in a score of only 9 and 22 in the C+T heat part.

2020

It should be noted that the development up to 2020 may be rather scenario specific. The 2020 S/D Index score drops to about 59 (SEI energy balance) or to 58 (PRIMES energy balance). Ireland then drops to the 9th position (see table 14) but is still well above the average score of the 27 MS (53), see table 14.This decrease in the 2020 score is mainly determined by the assumption on the origins of the oil and gas imports. In 2005 (Eurostat, 2007) and 2006 (assumption as for 2005) these imports stem from the UK and Norway.

For MS that are net exporters (e.g. UK) or that have low shares of imports coming from outside EU/Norway (like Ireland) in the year 2005, a generic assumption has been imposed for the year 2020. The main reason is that such origin data are not known from the scenarios. In addition, the expectation is the increased import dependencies in 2020 will also result in larger shares to be imported from outside the EU/Norway. It is assumed that 50% of the imports of oil and gas come from outside the EU/Norway. In 2004 the shares of oil and gas imported from the UK were 30 and 100%, respectively. With the UK moving from a net exporter to a net importer for these fossil fuels, Ireland may have to import substantial portions from outside the EU/Norway on the long term.

If the shares imported from outside EU and Norway increase even more substantially than the generic 50% assumption, a further significant drop in the S/D Index can be expected. This would indicate a considerable increase in exposure to potential SOS disruptions.

Ways to mitigate such exposure could be to decrease the share of oil and gas in the PES mix (76% in 2020 SEI forecast) e.g. by increasing the share from renewable energy sources. A specific example would be to increase the share of renewables (bio-fuels, 6% in the SEI forecast) in the transport sector, at the expense of the oil based fuels. From the cases it can be concluded that Ireland's S/D Index is largely determined by the origin of the imported oil and gas, given the large share of oil and gas in the primary energy mix (81% in 2006 and still 76% in the 2020 SEI forecast). Changes in the origins of these oil and gas imports could cause the S/D Index to worsen on the mid and longer term.

Table 13: S/D Index Ireland

	IE-2005p		**IE-2005s**		**IE-2006s**		**IE-2020s**		**IE-2020p**	
	Weight/ Share	**Score**	**Weight/ Share**	**Score**	**Weight/ Share**	**Score**	**Weight/ Share**	**Score**	**Weight/ Share**	**Score**
S/D index		**74.5**		**75.3**		**75.7**		**59.1**		**57.8**
Demand	0.3	**55.8**	0.3	**57.0**	0.3	**55.8**	0.3	**57.3**	0.3	**55.8**
Industry	0.18	100	0.21	100	0.19	100	0.20	100	0.17	100
Residential	0.24	44	0.23	44	0.23	44	0.19	40	0.23	40
Tertiary	0.18	62	0.16	62	0.15	62	0.17	66	0.19	66
Transport	0.40	40	0.40	40	0.42	40	0.44	42	0.41	42
Supply	0.7	**82.5**	0.7	**83.5**	0.7	**84.2**	0.7	**59.9**	0.7	**58.6**
C+T	0.3	**53.7**	0.3	**52.2**	0.3	**55.0**	0.3	**56.0**	0.3	**58.0**
Electricity	0.3	70	0.3	67	0.3	68	0.3	71	0.3	78
Gas	0.3	71	0.3	71	0.3	71	0.3	71	0.3	71
Heat	0.2	11	0.2	9	0.2	22	0.2	22	0.2	21
Tr. Fuels	0.2	45	0.2	45	0.2	45	0.2	45	0.2	45
PES	0.7	**94.9**	0.7	**96.3**	0.7	**96.7**	0.7	**61.5**	0.7	**58.9**
Oil	0.57	97	0.58	100	0.54	100	0.52	50	0.54	50
Gas	0.24	100	0.23	100	0.27	100	0.24	59	0.29	59
Coal[51]	0.16	78	0.17	78	0.16	79	0.12	74	0.10	74
Nuclear	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
Ren. ES	0.03	100	0.02	100	0.03	100	0.11	100	0.07	100
Other	0.00	100	0.00	100	0.00	100	0.01	100	0.00	100

Source: ECN

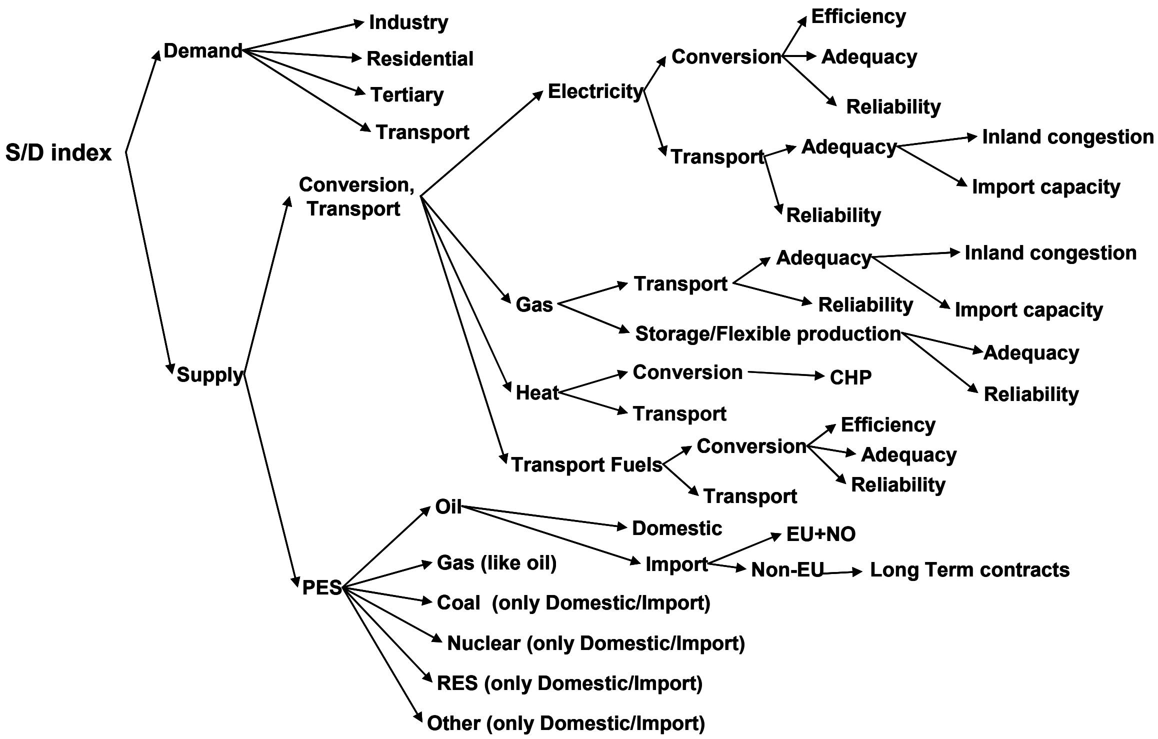
6.2 Description of the S/D Index and Results for the EU-27

Supply/Demand Index

The S/D index aims at review and assessment of energy SOS in the medium and longer run. The S/D Index covers final energy demand, energy conversion and transport and primary energy sources (PES) supply. It uses four types of inputs, two objective types and two types of a more subjective nature. The objective inputs concern the shares of different supply and demand types (i.e. for demand: industrial use, residential use, tertiary use and transport use; for supply: oil, gas, coal, nuclear, RES and other) and the values characterizing capacity and reliability in conversion and transport based on the secondary energy carriers (electricity, gas[52], heat and transport fuels). Figure 45 displays the conceptual model of the elements considered in the overall S/D Index.

[51] Includes Peat. The category including coal and peat is often listed as 'Solids' in energy balances.
[52] The updated S/D Index model now has a separate branch for the secondary energy carrier Gas.

Figure 45: The S/D Index Model Structure



Source: ECN

The subjective inputs concern the weights that determine the relative contribution of the different components in the Index (such as the relation between supply and demand outputs in the Index, or the relation between EU imports and non-EU imports) and the scoring rules for determining various Index values reflecting different degrees of perceived vulnerabilities.

Quantitative Results for the EU-27 and its Member States

The use of the S/D Index is illustrated with examples for the EU-27 and its Member States for they years 2005 and 2020. The examples are based largely on objective information contained in energy balances, derived from mainly Eurostat (Eurostat, 2006) and IEA statistics (IEA, 2006) and the 'EU Trends to 2030 - update 2005' baseline scenario (EC, 2006). The S/D Index model combines that information with weighing factors and scoring rules, using existing indicators where possible. The most important uncertainties are scrutinised by some sensitivity analyses. The base case and indicative results for the year 2005 and 2020 are displayed in table 14, respectively, ordered by SOS position: the higher the S/D index value, the better the SOS position.

Table 14: S/D Index, EU-27 and Member States 2005 and 2020 PRIMES Based, EU Trends to 2030

	2005 Index 0-100			2020 Index 0-100
Denmark	82		**Denmark**	83
United Kingdom	80		**Sweden**	71
Ireland	75		**Netherlands**	70
Sweden	70		**United Kingdom**	67
Romania	70		**France**	66
Netherlands	69		**Germany**	63
EU 27	65		**EU 27**	62
Czech Republic	64		**Romania**	61
France	64		**Czech Republic**	61
Germany	63		**Ireland**	58
Poland	60		**Belgium**	55
Bulgaria	59		**Poland**	55
Belgium	57		**Austria**	54
Austria	57		**Bulgaria**	54
Estonia	55		**Finland**	54
Hungary	55		**Spain**	50
Finland	53		**Hungary**	50
Slovenia	52		**Slovenia**	49
Spain	51		**Italy**	49
Slovak Republic	51		**Estonia**	49
Italy	50		**Slovak Republic**	47
Portugal	47		**Portugal**	45
Lithuania	45		**Lithuania**	43
Greece	44		**Greece**	42
Latvia	40		**Latvia**	41
Malta	30		**Malta**	32
Luxembourg	28		**Luxembourg**	32
Cyprus	25		**Cyprus**	27

Source: ECN

2005 Scores

The average value of the S/D index in 2005 is about 56. The range is from 82 (Denmark) to 25 (Cyprus). The differences between MS are mostly caused by differences in the PES (Primary Energy Sources) parts, caused by both the relatively large spread in the PES sub-index (ranges from 0 to 97, average of 53), see table 15, and the relative high weight of the PES sub-index (0.49) in the total S/D Index. MS with high import dependencies for oil and gas, combined with high shares of these imports originating from outside the EU/Norway, have a relatively low score, i.e. an S/D Index below 50. Such MS include: Cyprus, Luxembourg, Malta, Latvia, Greece, Lithuania and Portugal. On the other hand, MS that are net exporting for gas and/or oil have a relatively high score, i.e. an S/D Index of 60 or higher. Examples are Denmark (82) and the United Kingdom (80). In addition, MS that are net importers but import mainly from within EU/Norway also get high scores. An example is Ireland (75), and to a lesser extent Sweden (70). The Netherlands (69) has a high score due to being a net gas exporter. Romania (70) has relatively low import dependencies for oil and gas, added to moderate shares of coal/nuclear in its PES mix. France (64), Czech Republic (64), Germany (63) and Poland (60) have high scores due to their large shares of nuclear and/or coal in the PES mix. As most of the largest MS (Germany, France, United Kingdom) are part of the best scoring MS, the EU-27 aggregate score is also relatively high (65).

Table 15: S/D Index and Sub-Indices, EU-27 and Member States PRIMES Based

	S/D Index	Primary Energy Sources	Conversion and Transport	Demand
EU-27-2005	65.4	65.3	75.1	58.7
EU-27-2020	62.1	56.1	82.7	57.4
BG-2005	59.0	60.4	74.6	45.8
BG-2020	53.9	51.4	82.1	38.3
AT-2005	56.6	44.6	85.5	55.8
AT-2020	54.1	39.0	89.7	53.9
BE-2005	57.2	61.9	61.1	46.9
BE-2020	55.1	51.8	73.3	47.7
CY-2005	25.1	4.4	42.5	46.7
CY-2020	27.0	5.8	43.5	50.0
CZ-2005	64.4	68.3	89.9	40.2
CZ-2020	60.9	60.9	92.2	38.9
DE-2005	62.7	64.9	60.0	60.8
DE-2020	62.9	59.7	71.7	62.0
DK-2005	82.1	93.6	79.0	65.6
DK-2020	82.9	95.9	79.9	63.7
EE-2005	54.8	63.9	48.4	44.6
EE-2020	48.9	49.7	54.4	43.8
EL-2005	43.9	34.1	48.4	56.7
EL-2020	41.8	29.5	53.6	53.7
ES-2005	51.0	37.2	73.8	57.6
ES-2020	50.1	34.5	79.4	54.9
FI-2005	53.4	61.5	51.5	41.6
FI-2020	53.6	61.9	51.5	41.6
FR-2005	63.8	67.8	57.4	61.8
FR-2020	65.7	69.5	61.3	62.5
HU-2005	54.8	49.0	78.3	47.8
HU-2020	49.5	39.9	80.3	43.5
IE-2005	74.5	94.9	53.7	55.8
IE-2020	57.8	58.9	58.0	55.8
IT-2005	49.5	29.3	67.8	69.8
IT-2020	49.0	31.1	67.3	65.6
LV-2005	40.2	31.6	51.8	46.1
LV-2020	40.6	35.0	55.1	39.7
LT-2005	45.1	25.5	60.3	66.6
LT-2020	43.0	22.9	65.7	60.0
LU-2005	28.2	11.2	67.7	28.2
LU-2020	31.7	15.9	70.5	30.2
MT-2005	30.4	0.2	31.8	78.6
MT-2020	32.2	2.5	33.5	79.9
NL-2005	69.4	72.9	90.0	49.2
NL-2020	70.4	75.0	91.4	48.2
PL-2005	60.2	68.5	55.9	49.6
PL-2020	54.8	58.1	60.6	45.4
PT-2005	46.6	27.3	70.7	61.3
PT-2020	45.2	26.8	74.1	55.1
RO-2005	69.9	77.1	86.2	46.9
RO-2020	61.0	63.2	86.3	39.7
SE-2005	70.4	87.5	49.0	57.3
SE-2020	70.6	79.1	64.0	61.2

SI-2005	52.2	49.5	73.0	41.8
SI-2020	49.1	42.9	75.4	40.7
SK-2005	50.6	47.5	80.4	34.8
SK-2020	47.0	42.1	82.3	30.1
UK-2005	79.6	97.0	66.2	60.5
UK-2020	67.4	69.4	72.4	60.8

Source: ECN

2020 Scores Using the Updated DG TREN Baseline Scenario

On average, the S/D Index decreases by almost 3 points compared to 2005 (from 56 to 53), mainly caused by a decrease in the PES sub-index (decrease of 6 points). So, the SOS position is somewhat less in 2020 than in 2005. The division into low/intermediate/high scoring MS does not really change when compared to today's situation (table 14). In an absolute sense, Ireland and the UK observe the largest decrease in S/D Index (drop of 17 and 13 points, respectively), but both remain as relatively high scoring MS in 2020[53]. PES sub-index scores decreases are generally caused by higher import dependencies in 2020 and higher shares of imports from outside EU/Norway. For some MS, a combination of increasing shares of gas and decreasing shares of coal/nuclear also contribute to a decrease in the PES sub-index, and hence in the S/D Index. Some examples of this latter effect are Belgium, Estonia and Poland. The C+T (Conversion and Transport) sub-index increases on average (almost 5 points) due to the improved overall efficiency of electricity generation and higher shares of CHP in electricity production. Changes in the Demand sub-indices are moderate, which on the one hand reflects a 'moving' benchmark value based on the best performing MS, and on the other hand, a stand-still of the residential energy intensity benchmark. On average, a decrease of 2 point is observed, mainly due to a higher value of the residential energy intensity.

Use of Other Scenarios

It should be noted that the development up to 2020 may be rather scenario specific. Quantification of the policy scenarios, e.g. the "Scenarios on energy efficiency and renewables", (EC, 2006b) rather than the baseline "Trends to 2030" (EC, 2006) scenario may give somewhat different results.[54] In the previous report (Scheepers et al., 2006) other examples of the impact of using other (country specific) scenarios have been presented (for the Netherlands and the UK). The first application of the S/D Index for Ireland (based on the old S/D Index model) is another example (SEI, 2006).

Use of the S/D Index as a Benchmarking or Policies Comparison Tool

The S/D Index model can be used for benchmarking and comparison purposes, for historic recent years (statistics) or for the future (scenarios). For the purpose of an inter MS comparison (benchmarking of MS against each other or e.g. against an average or benchmark value), comparison of future situations will only make sense if the same overall scenario is used for all MS. For the purposes of assessing the possible impact of different policies as resulting in different future developments of the energy system, comparisons for a specific MS or for the EU aggregate make sense. In that case, national MS specific scenarios can be used to observe the effects of changes in the energy system over time, and to assess how policy induced changes may have an effect on the energy system and how different policy options compare to each other. Moreover, changes in S/D index values can be compared to other effects, e.g. the CO_2 reduction over the respective time period (2005-2020).

6.3 Data Assumptions for Ireland

2005 and 2006

For the 2005 and 2006 quantifications, the SEI energy balances were used to the extent possible, resulting in estimates for:

- Final energy demand shares (weights for demand scores),

[53] For MS that are net exporters (e.g. UK) or that have low shares of imports coming from outside EU/Norway (Ireland) in the year 2005, a generic assumption has been imposed for the year 2020, as such origin data are not known from the scenario. It is assumed that 50% of the imports of oil and gas come from outside the EU/Norway. For the other MS, the origins of these imports have been assumed equal for 2005 and 2020.

[54] For the EU-25 as an aggregate, five of these policy scenarios have been quantified for the previous version of the S/D index model (Groenenberg and Wetzelaer, 2007).

- Shares of primary energy sources (weights for PES scores) and
- Import dependencies (used in scoring PES).

It should be noted that the 2006 energy balance contains provisional data.

Other information provided by SEI includes:

- CHP share in electricity production (used in scoring C+T heat part),
- Average efficiency of thermal electricity production (used in scoring electricity).

Eurostat data have been used for the import origin of oil and gas, in particular the share of the imports coming from outside the EU and Norway. In 2005, these shares were 0% (In 2004, these were 2.8 and 0%, respectively, including oil imports from Libya).

The most recent PRIMES scenario data (EC, 2006) have been used as basis for estimates of the final (sectoral) energy intensities.

For the electricity reserve margin and import connection, EC Benchmarking reports have been used, resulting in 10.4% (domestic capacity in relation to peak demand) and 6% (import connection as fraction of domestic capacity), respectively. The CHP shares were provided by SEI and equal 2.2% and 5.4%, for 2005 and 2006, respectively. The most recent PRIMES value for 2005 presents 2.8% for the CHP share.

Values of 40.6% and 41.2% were used for the efficiency of electricity production.

2020

From the SEI forecast of the year 2020, the following parameters have been used:

- Final energy demand shares,
- Shares of primary energy sources,
- Average efficiency of thermal electricity production (44.0%).

The CHP share was taken equal to 2006 value (5.4 %). PRIMES had 5.2%.

Other parameters have been assumed to be equal as in the PRIMES case.

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7 New Analysis – The Value of Lost Load

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7.1 Introduction

The value of lost load (VoLL) is the average willingness to pay of electricity consumers to avoid an additional period without power. The VoLL is a useful yardstick for decisions on the total capacity of the power supply (e.g., Sanghvi, 1983). In the efficient solution, the marginal cost of additional capacity, which is roughly equal to the wholesale peak price, is equal to the VoLL. In a regulated market like the Irish one, customers cannot express their willingness to pay, and suppliers cannot reveal their marginal costs. Therefore, the VoLL has to be inferred. This is particularly relevant for Ireland as the electricity supply is rapidly expanding and being restructured, and the prospect of supply shortages is real (Bazilian *et al.*, 2006; Lyons *et al.*, 2007; Malaguzzi Valeri and Tol, 2006).

There are three groups of methods for doing so, if the preferred method (based on preferences revealed in market behaviour) fails. The first alternative is based on stated preferences (e.g., Beenstock *et al.*, 1998). It relies on surveys of customers, who answer hypothetical questions. This method is the most common one, but this may be because it is academically the most challenging method. Stated preference methods suffer from substantial biases. No Irish data are available. There is substantial empirical evidence that using estimates from other countries is inappropriate. The second alternative is to use cost estimates from black-outs or brown-outs in the past (e.g., Corwin and Miles, 1978). This avoids the biases of the survey methods, but one needs to assume that the future and the past are similar. Ireland has changed rapidly.

The third alternative is based on estimates of the production function, which relates electricity use to output. This is the method used here. See Section 7.2 for an elaboration.

CER & NIAUR (2007a) use a tautological method for estimating the VoLL. They use the estimated peak price of electricity for the planned capacity. In this circular reasoning, planned capacity automatically equals desired capacity, and future decisions are justified by reference to past decisions.

7.2 Data and Methods

If there are no disaggregated data on the demand for electricity at peak hours, as is the case for Ireland, one can instead use a production function. Production functions imply demand functions. However, this method is one step removed from the variable of interest, and additional assumptions (e.g., rationality of economic agents, divisibility of goods and services) are required. Furthermore, typical production functions are estimated for a year as a whole, and may not be appropriate for an assessment of the impact of an event such as electricity interruptions for a few hours. Nonetheless, the production function approach is adopted here as the only viable option given data availability.

The method used here is identical to that used in de Nooij *et al.* (2007). Specifically, the production function is assumed to be linear. That is, the value of electricity to a particular industry equals annual electricity use over annual value added. The crucial assumption is that companies are able to shift production in the year, so that the exact time of the black-out does not matter. This assumption is a reasonable one for most activities. Another assumption is that the duration of a black-out does not matter, which is again reasonable for a relatively short brown-outs that could occur in Ireland.

Electricity use by sector can be found in the energy balances of the SEI for the years 1990 to 2005 (SEI, 2006). Operating hours are as in de Nooij *et al*. (2007). Production data for the same period are taken from the ESRI Databank (Bergin and Fitz Gerald, 2006). The time series gives some idea of the evolution over time.

For residential electricity use, de Nooij *et al*. (2007) similarly assume that all activity stops when there is no electricity – essentially, an hour of time is lost for every hour without electricity. This seems large, but risk and annoyance are not counted. The opportunity cost of leisure time is assumed to be equals to average wage, here assumed to equal the average GDP per working hour, after tax. For those who do not work, the opportunity costs are half the average wage. The cost per kWh follows from dividing the total value of leisure production by total residential electricity consumption, both by time of day and week.

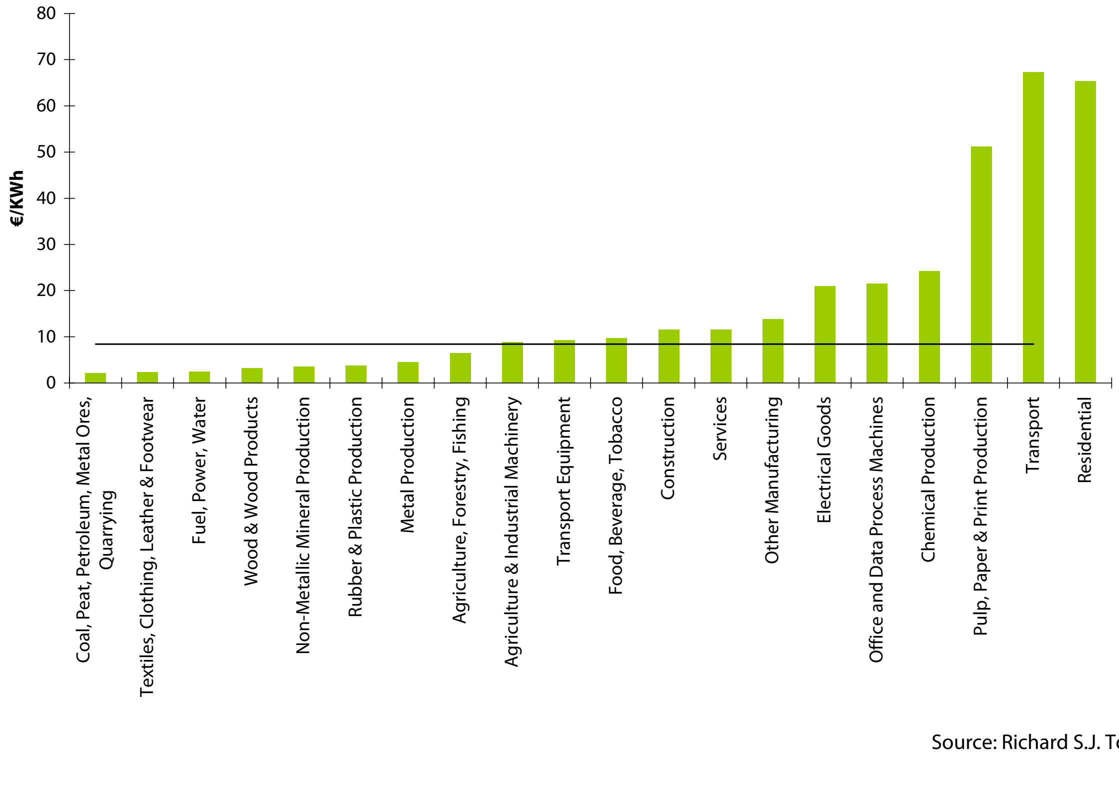
Data on GDP, size of the population and labour force, and number of working hours are taken from GDDC (2007). The average labour tax rate is taken from OECD (2007); it falls from 40% in 1990 to 26% in 2005. As an alternative, we use the average income tax rate from Bergin and Fitz Gerald (2006), which is roughly constant around 20% -- the two tax numbers are consistent if one considers the increase in the labour participation rate. Exelon (2007) shows that 44% of domestic electricity is used during the day, 35% in the evening, and 20% at night. These numbers are for Great Britain, but used here as such data are not available for Ireland.

7.3 Results

Figure 46 shows the VoLL for the different sectors in 2005. There are substantial differences. In "traditional" manufacturing sectors, the VoLL is only a few euro per kWh, but this goes up to some €20/kWh in the manufacturing of electronic and chemical products. Transport is exceptional, as it uses little electricity. The average value is €8/kWh. Residential electricity use is by far the most valuable among the large users.

The pattern shown in Figure 46 was very different in 1990. The largest differences are for mining, where the VoLL has fallen by 7% per year on average between 1990 and 2005; and other manufacturing, where the VoLL has increased by an annual 14%. The average has grown by 2% per year. The VoLL for households has increased by almost 3% per year. Although wage growth has only slightly exceeded the increase in residential electricity use, the value of leisure time was substantially increased by the fall in labour taxes.

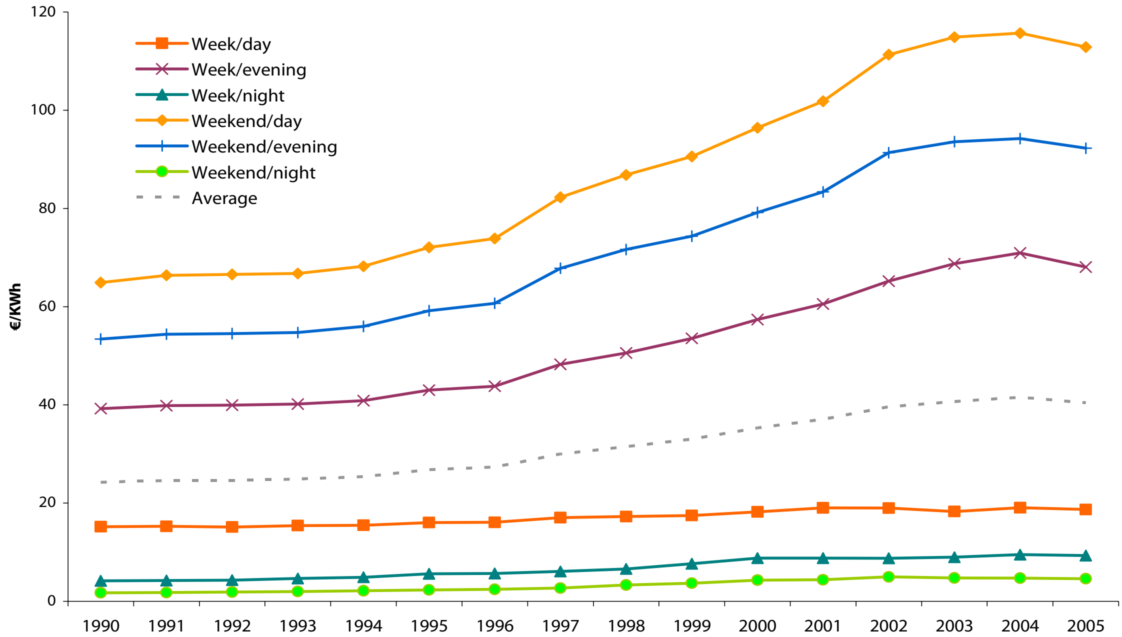
Figure 46: Value of Lost Load 2005



Source: Richard S.J. Tol

Figure 47 shows the VoLL for 1990 to 2005, split by time of week. The VoLL grew by some 3.5% per year over this period, but growth was more rapid for 1997 to 2004. The recent deceleration is largely due to the household VoLL, which is driven by a deceleration in labour productivity growth and a saturation of the employment ratio. The stabilisation of wage taxes is also important. If the average income tax is used rather than the average wage tax, the VoLL increased by only 1% per year.

Figure 47: Value of Lost Load 1990 to 2005



Source: Richard S.J. Tol

The VoLL differs substantially between week days and the weekend, and between times of day. For production, electricity is most valuable in week nights, and least valuable in weekend nights. This is because industries with the lowest VoLL tend to work either on Monday to Friday from 9 till 5, or 24-7. For households, electricity is more valuable in the weekend than during the week. During the week, electricity is more valuable in the evening than during the day; the opposite is true for the weekend. As the value of electricity is so much greater to households than to companies, the household VoLL dominates the average VoLL.

The average VoLL is around €40-43/kWh, which is considerably higher than the €10/kWh set by CER & NIAUR (2007b). The lower number uses the wage tax, the higher number the income tax. At week days during the evening, when brown-outs are most likely, the value goes up to €68-74/kWh. This suggests that the regulators aim for less power generation capacity than is socially desirable, and that the probability of a brown-out is too large. At present, during a brown-out, it is policy to shut off electricity in residential areas first, and in industrial estates later. As the household VoLL is much larger than the company VoLL, this policy may be reconsidered.

7.4 Conclusions

In this paper, a simple version of the production function approach to estimate the VoLL is used in the Republic of Ireland for the period 1990 to 2005. The estimate suffers from lack of detailed data on residential electricity use. The VoLL has grown considerably over the last 15 years, as wage growth outstripped electricity demand, and the Irish economy shifted towards production that has a higher value added per amount of electricity used. In 2005, the VoLL is about €40/kWh, which is considerably higher than the regulator assumes it to be.

7.5 Acknowledgements

John Fitz Gerald, Laura Malaguzzi Valeri and Edgar Morgenroth had useful comments on an earlier version of the paper. Financial support by the ESRI Energy Policy Research Centre is gratefully acknowledged.

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8 Conclusions and Next Steps

This report, the third in a series, continues SEI's annual review of energy SOS in Ireland. The metrics, or indicators, presented in this report address a wide range of issues relevant to the topic. SOS continues to be at the centre stage of energy policy and this publication continues to strive to help inform debate and policy formation in this key area.

This document will continue to be developed and refined on an annual basis. SEI is actively seeking national and international partners to co-operate with, in terms of accessing and developing new data and analysis. In 2008, SEI hopes to formulate the Crisis Capability Index (developed by the Research Centre of the Netherlands and the Clingandael Centre for Strategic Studies) for Ireland. The index combines an assessment of a Member State's risk to be confronted with sudden supply interruptions and its potential impacts (Risk Assessment: RA) and the capability of that country to mitigate these impacts (Mitigation Assessment: MA). If the risk is high, more weight should be put on effective crisis capabilities than when this risk is low.

In addition, it is hoped that the links to the UK JESS report will be refined and improved. It is also planned to consider the issue of peak oil in more detail, specifically in terms of its impacts for Ireland.

Comments are welcome on how best to improve the document, and suggestions for concerted collaboration in this area nationally and abroad are welcomed.

The authors wish to express their gratitude to those who provided data and analysis and those who commented on the first two versions of this report.

Data Sources

Bord Na Mona

Commission for Energy Regulation

Department of Communications, Energy and Natural Resources

Department of Trade and Industry (UK)

Economic and Social Research Institute

Eirgrid

Eurostat

ESB Networks

International Energy Agency

Joint Energy Security of Supply Working Group (UK)

National Oil Reserves Agency

Petroleum Affairs Division - Department of Communications, Energy and Natural Resources

UK Transmission National Grid (Gas)

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