SUSTAINABLE ENERGY IRELAND

Energy Policy Statistical Support Unit

Energy Efficiency in Ireland

2007 REPORT

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Report prepared by
Fergal O' Leary, Martin Howley and Dr. Brian Ó Gallachóir

September 2007

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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;
- 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;
- Contribute to the development and promulgation of appropriate sustainability indicators.

Highlights

Overall Economy

- The observed ODEX, a measure of energy efficiency, shows that between 1995 and 2005 there was an 8.1% (0.8% per annum) decrease, which means an 8.1% improvement in energy efficiency.
- To separate out the influence of behavioural factors, a technical[1] ODEX is calculated and used to better assess the technical energy efficiency progress. Technical efficiency improved by 15% (1.6% per annum) from 1995 to 2005.
- The primary energy intensity of the economy fell by 35% between 1990 and 2005 (2.9% per annum on average).
- Over the period 1990 to 2005 final energy usage for the economy as a whole increased by 72% (3.7% per annum) while energy intensity decreased by 32% (2.6% per annum). Over the period 2005 to 2020 final energy consumption is forecast to increase by a further 34%.
- The efficiency of thermal electricity generation was 38.3% in 1990 and had improved to 43.3% in 2005
- Over the period 1990 to 2005 total final energy usage per capita increased by 46% (2.6% per annum).

Industry

- The ODEX for industry decreased from 100 in 1995 to 85 in 2005 indicating a 15% improvement in energy efficiency.
- In the industry sector, over the period 1990 to 2005 final energy usage increased by 44% (2.5% per annum) while energy intensity decreased by 54% (5.1%).
- Structural changes in the makeup of Irish industry between 1995 and 2005 accounted for just over two thirds of the reduction in industrial energy intensity.

Residential

- The observed ODEX for the residential sector decreased by 8.2% over the period 1995 to 2005 (0.8% per annum).
- The technical ODEX decreased by 22% (2.4% per annum) and implies that significant efficiency gains were made but a rebound effect (increased energy usage) negated some of the gains.
- Final energy usage in the residential sector increased by 27% (1.6% per annum) over the period 1990 to 2005 while average energy use per dwelling decreased by 16% (1.1%).

[1] Technical efficiency gains arise from the use of more energy efficient technologies whereas behavioural gains are the result of how technologies are used.

Transport

- The transport observed ODEX fell by 0.8% over the period 1995 to 2005 while the technical ODEX decreased by 6.3% (0.6% per annum). Additional efficiency gains would have been made if not for behavioural effects, for example the purchase of larger cars.

- In the transport sector intensity remained fairly constant with only a 1% decrease over the period (0.1% per annum). In other words, transport energy use grew almost at the same pace as GDP which increased by 151% (6.3% per annum) over the period 1990 to 2005.

Services

- Final energy usage in the services sector increased by 72% (3.7% per annum) while energy intensity decreased by 17% (1.3%).

International Comparison

- For the period 1995 to 2004 Ireland experienced improvement in efficiency of 8.2% as measured by the overall ODEX compared with a 5.6% improvement for the EU-15.

- Where data is available for EU-15 countries (and Norway), Ireland recorded the largest per annum reduction in primary intensity over the period 1990 to 2004. Only Luxembourg and Norway experienced a slightly greater reduction in final intensity.

- With regard to thermal electricity generation Ireland has improved its ranking from 8th highest efficiency (36.6%) in 1990 to 5th (41.3%) in 2004. All countries with the exception of Sweden, Norway, Finland and the Netherlands improved their efficiency.

- Examining the change in final energy intensity in industry, Ireland had the second largest decrease over the period 1990 to 2004 (5.4% per annum) while the intensity for the EU-15 average declined by 0.9% per annum. Note that structural changes are not taken into account in these figures.

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1 Introduction

The Government of Ireland, in the White Paper on Energy[2], set a target for a 20% reduction in energy usage across the whole economy by 2020. This moves energy efficiency to the centre of Government energy policy. The scale of the task ahead is highlighted by the fact that between 1990 and 2005 final energy demand increased by 64%.

This is the first SEI/EPSSU report that focuses exclusively on Energy Efficiency in Ireland. The purpose of the report is to provide timely and comprehensive data on energy efficiency and intensity, in order to provide context and background to discussions regarding future policy options.

The analysis in this report has benefited greatly from SEI/EPSSU's involvement in the pan European Odyssee project[3]. The project was set up in 1993 through a joint collaboration between ADEME, the SAVE programme of the General Directorate of the European Commission in charge of energy and all energy efficiency agencies in the EU-15 and Norway. The project was designed to collect and improve data relating to energy usage drivers, energy efficiency and CO_2 related indicators. The Odyssee project is co-ordinated by ADEME with the technical support of ENERDATA[4] and the Fraunhofer Institute for Systems and Innovation Research [5].

A key development within the Odyssee project has been the formulation of a new set of energy efficiency indicators, known as ODEX. ODEX indicators provide an alternative to the usual energy intensities used to assess energy efficiency changes at the sectoral or economy level, as they include factors only related to energy-efficiency and exclude the changes in energy use due to other effects such as climate fluctuations, changes in economic and industry structures, lifestyle changes etc.

In particular, SEI/EPSSU gratefully acknowledges the contribution of Bruno Lapillonne of ENERDATA for his assistance in developing specific energy efficiency indicators for Ireland presented in this report.

The report is structured as follows:

- To provide context for the analysis, recent trends in energy usage are discussed in **section 2**.
- **Section 3** explores the major policy developments which have, or are intended to have, an impact on energy efficiency in Ireland.
- **Section 4** examines energy efficiency and intensity at the economy level.
- Energy efficiency and intensity are analysed at the sub-sectoral level for industry, residential, transport and services, respectively, in **sections 5 to 8**.
- Using forecast data future energy usage and intensity are examined from 2005 to 2020 in **section 9**.
- In **section 10** trends in the Ireland are compared with trends internationally.
- Finally, **section 11** presents conclusions and outlines the next steps required to expand the available statistics and to shed further light on the trends.

The national energy balance data presented in this report are the most up-to-date at the time of writing. The national energy balance is updated whenever more accurate information is known. To obtain the most up-to-date figures visit the statistics section of the SEI website[6]. A new energy data service is available at www.sei.ie/statistics, follow the links for 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".

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

[3] http://www.odyssee-indicators.org/

[4] http://www.enerdata.fr/enerdatauk/

[5] www.fraunhofer.de

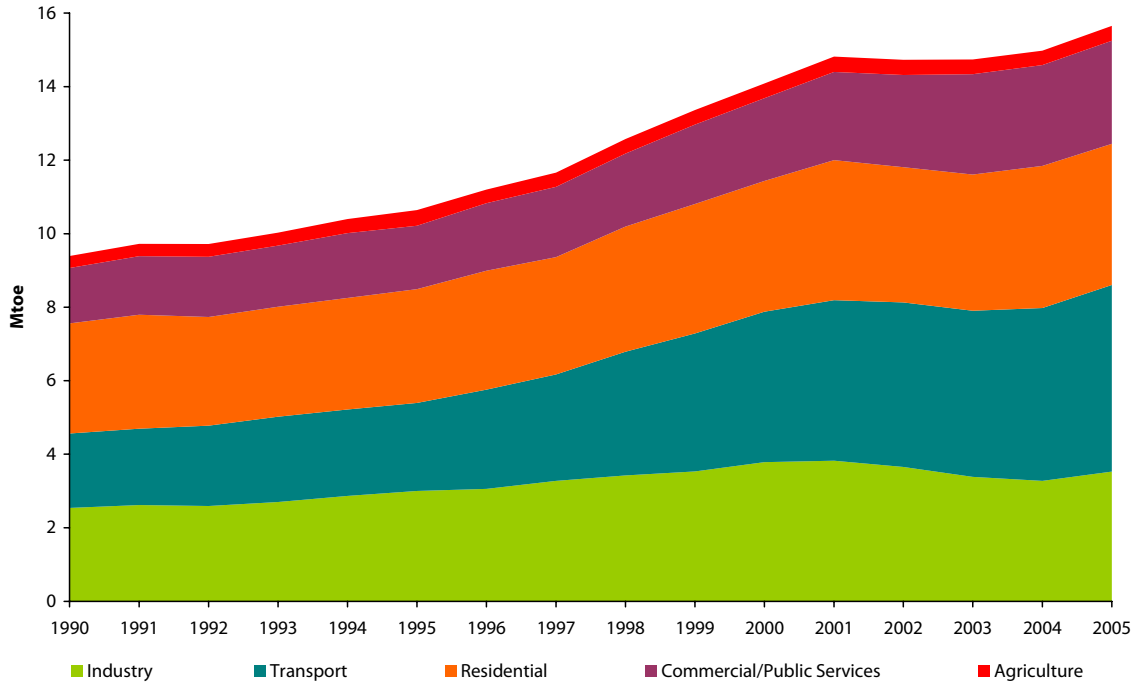
[6] www.sei.ie/statistics

2 Energy Trends

This section provides a brief overview of energy trends in Ireland to provide context and background to the analysis of energy efficiency. A detailed analysis of energy trends over the period 1990 to 2005 is available in a separate SEI publication[7].

Ireland's energy supply is discussed in terms of changes to the total primary energy requirement (TPER), defined as the amount of energy used within Ireland in a given year. Figure 1 shows the TPER[8] of the five principal sectors of the economy in Ireland for the period 1990 to 2005. The average annual growth rate in energy usage during this period was 3.4%. Total growth over the period was 64%. Table 1 presents growth rates of shares of the different sectors over the period.

Figure 1 Total Primary Energy Requirement by Sector 1990 - 2005



Source: SEI

[7] SEI ,2006, *Energy in Ireland 1990–2005. Trends, issues, forecasts and indicators.*
Available from http://www.sei.ie/index.asp?locID=70&docID=-1.

[8] Primary energy usage includes all the fuels used directly by each sector plus the primary energy used to generate electricity attributed to each sector in proportion to its electricity demand.

Table 1 Growth Rates and Shares of TPER by Sector

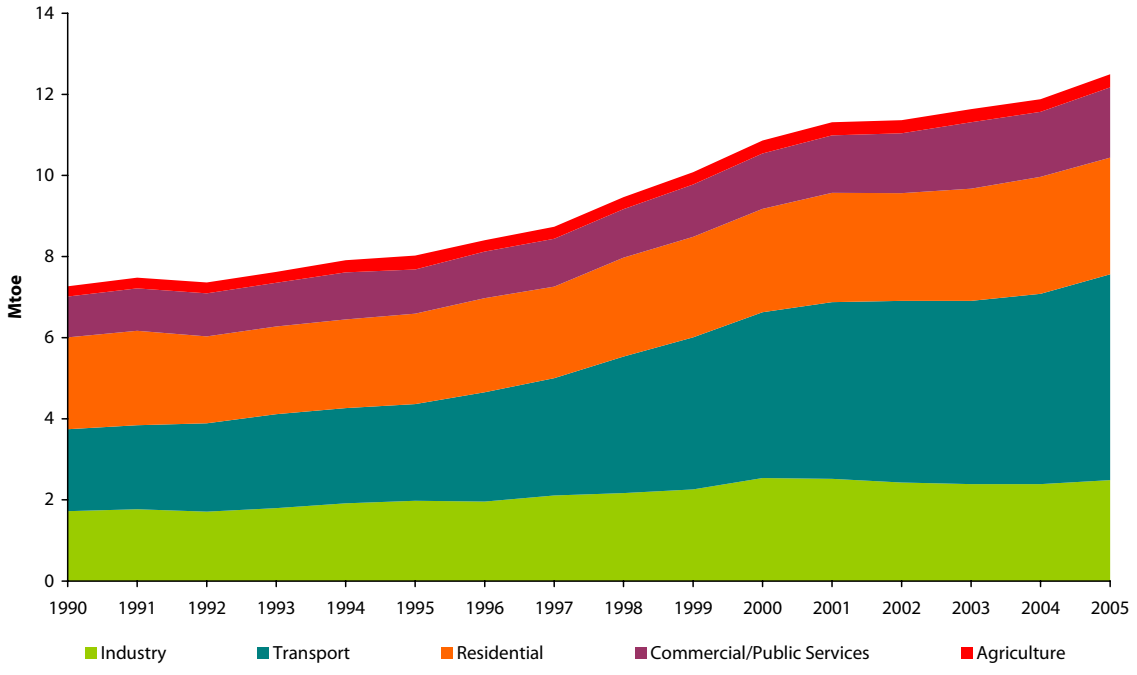
	Actual Values ktoe[9]	Growth %	Average Annual Growth Rates%					Shares %	
	2005	**1990 – '05**	**1990 – '05**	**1990 – '95**	**1995 – '00**	**2000 – '05**	**2005**	**1990**	**2005**
Industry	3,493	37.6	2.2	3.4	4.8	-1.6	5.1	27.0	22.4
Transport	5,087	150.9	6.3	3.4	11.3	4.4	8.2	21.6	32.6
Residential	3,835	28.1	1.7	0.7	2.8	1.5	-0.8	31.9	24.5
Commercial / Public	2,803	86.3	4.2	2.7	5.5	4.5	4.6	16.0	17.9
Agriculture	405	23.6	1.4	5.4	-0.9	-0.1	3.0	3.5	2.6
Total	15,623	64.3	3.4	2.2	5.5	2.5	3.0		

Source: SEI

Final energy demand is a measure of the energy that is delivered to energy end users in the economy to undertake activities as diverse as manufacturing, movement of people and goods, essential services and other day-to-day energy requirements of living. This is also known as Total Final Consumption (TFC) and is essentially total primary energy less the quantities of energy required to transform primary sources such as crude oil into forms suitable for end use consumers such as refined oils, electricity, patent fuels etc. (Transformation, processing or other losses entailed in delivery to final consumers are known as "energy overhead".)

Figure 2 shows the trend in TFC over the period, here allocated to each of the sectors of the economy. The changes in growth rates are tabulated in Table 2.

Figure 2 Total Final Energy Consumption by Sector 1990 - 2005



Source: SEI

Transport has continued to increase its dominance (since the mid 1990s) as the largest energy consuming sector (on a final energy basis) with a share of 41% while the share of industry and residential have decreased. It is worth noting that transport final energy use is larger than that of both industry and commercial/public services combined.

[9] Kilo tonne of oil equivalent.

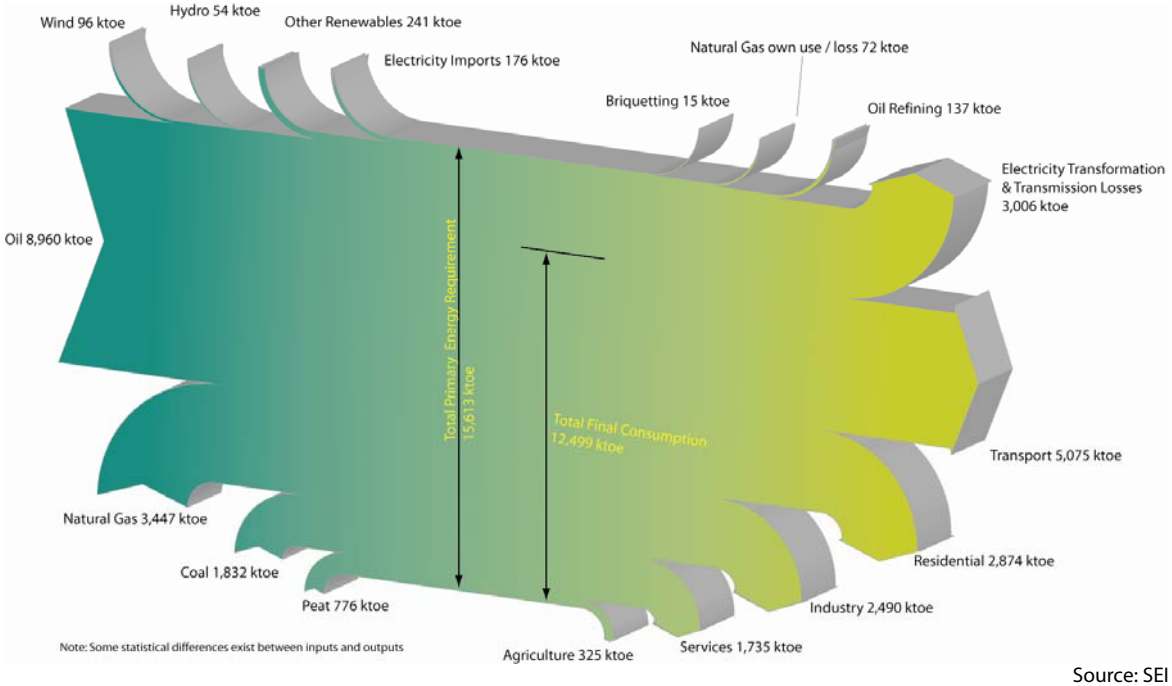
Table 2 Growth Rates and Shares of TFC by Sector

	Actual Values ktoe	Growth %	Average annual growth rates %					Shares %	
	2005	**1990 – '05**	**1990 – '05**	**1990 – '95**	**1995 – '00**	**2000 – '05**	**2005**	**1990**	**2005**
Industry	2,490	44.5	2.5	2.8	5.2	-0.4	4.1	23.7	19.9
Transport	5,075	150.9	6.3	3.4	11.3	4.4	8.2	27.8	40.6
Residential	2,874	27.1	1.6	-0.3	2.7	2.4	-0.3	31.1	23.0
Commercial / Public	1,735	72.3	3.7	1.6	4.6	4.9	8.1	13.9	13.9
Agriculture	325	29.0	1.7	6.2	-1.4	0.5	3.6	3.5	2.6
Total	12,499	72.0	3.7	2.0	6.2	2.9	5.2		

Source: SEI

Figure 3 shows the energy balance for Ireland in 2005 as a flow diagram. Primary fuel inputs are shown on the left while TFC outputs, by sector, are illustrated to the right. Figure 3 illustrates clearly the significance of each of the fuel inputs as well as showing how much energy is lost in transformation.

Figure 3 Energy Flow in Ireland 2005[10]



Source: SEI

Oil dominates as a fuel, accounting for 57% of the total requirement. Oil consumption increased by 2.8% in 2005. Renewables is divided into wind, hydro and other renewables. Transport continues to be the largest of the end use sectors using 41% of the final energy demand in Ireland in 2005. Transport also experienced the highest final consumption growth (8.2%) in 2005.

Losses associated with the transformation of primary energy to electricity were 19% of TPER or 3,006 ktoe in 2005, down 1% point since 2004.

[10] All energy inputs shown here represent the sum of indigenous production plus, where applicable, net imports i.e. imports minus exports.

3 Energy Efficiency – The Policy Context

There is increasing scientific evidence regarding the contribution of energy use to climate change. This coupled with the growth in energy demand and related emissions have prompted governments and policy makers to respond by introducing policies and measures designed to manage energy more effectively.

This section briefly identifies the major policy developments relevant to energy efficiency in Ireland.

3.1 National Development Plan

The reference document for policy implementation in Ireland is the National Development Plan[11] (NDP). The NDP, published in January 2007, details Government spending for the period 2007 to 2013. The NDP states that: *"Increasing energy efficiency will be key in reducing demand across the island and decoupling economic growth from increased energy demand"*. The NDP has a target of 1% per annum saving of energy use across the economy over the lifetime of the plan.

The NDP allocates an investment of €276 million to fund the large-scale development of wind energy capacity and the development of alternative sources of energy such as biomass and biofuels, ocean energy and solar and geothermal technologies.

3.2 The Energy End-Use Efficiency and Energy Services Directive

Directive 2006/32/EC[12] of the European Parliament and of the Council on energy end-use efficiency and energy services (ESD) was signed into law on 5th April 2006. The Directive stipulates that Member States shall adopt and aim to achieve an overall national indicative energy savings target of 9% over the 9 year period from 2008 to the end of 2016. Member States are required to submit a first Energy Efficiency Action Plan to describe the measures set to meet the 9% target.

The target energy savings are referenced against the average primary energy requirement over the most recent five year period for which official data are available. It excludes energy used by enterprises involved in the EU Emissions Trading Scheme (ETS) and aviation and marine bunker fuels. Table 3 contains a summary of the directive.

Table 3 Main Contents of the Energy Services Directive[13]

Relevant to	Providers of energy efficiency measures including distribution/retailing; final customers; military.
Exceptions	Small suppliers / energy retail sales firms; EU-ETS installations; marine bunker fuels.
Status of the Target	Non-binding target (energy saving indicative target).
The Target	National energy saving indicative target: for the ninth year of the Directive's application: 9 %. Intermediate target for the third year of application of the Directive.
Calculation of the Target:	Mean value of the annual domestic final energy consumption of all energy consumers covered by the directive in the last five years before implementation of the directive for which official data exist.
Public Sector	Not a higher target but simply an exemplary role for the public sector.
Measurability of the Target	Harmonised calculation model with a combination of top-down and bottom-up calculation methods. At first, 20-30 % of the end use energy demand under the ESD to be evaluated using bottom-up methods; "significantly higher percentage" from 2012.
Early Action Included	From 1995, in specific cases from 1991.
Sectors Affected	All final consumption sectors without undertakings participating in greenhouse gas emission allowance trading and without defence related parts of the armed forces' energy consumption.

[11] See www.ndp.ie for the full text of the NDP.

[12] Full details are available at http://ec.europa.eu/energy/demand/legislation/end_use_en.htm.

[13] Fraunhofer Institute, 2006, *Statistical and Methodological issues in connection with the EU Directive on energy End-Use Efficiency and Energy Services*. Available from http://www.isi.fraunhofer.de/e/projekte/berichte-pdfs/BMWi26-05_Summary.pdf

3.3 National Energy Efficiency Campaign

The Government launched a National Energy Efficiency Campaign in September 2006 entitled the *Power of One*.[14]

The main aims of the campaign are:

- to build awareness on types and sources of energy, costs and environmental impacts,
- to inform consumers about the impact that inefficient energy use has on costs and the environment,
- to encourage individual responsibility and change in behaviour in small ways and
- to empower individuals to recognise their role in the challenge and to use their power to collectively make the difference.

It is planned to make the *Power of One* an All–Island campaign in 2007.

3.4 EU Council Presidency Meeting - March 2007

The European Council Presidency met on the 8th / 9th March 2007 and agreed on the need to integrate policies on climate change and energy. The Council committed itself to unilaterally reducing EU greenhouse gas emissions to 20% below 1990 levels by 2020. It further endorsed a reduction to 30% below 1990 levels subject to securing agreement on comparable reductions elsewhere.

The Council also adopted an Energy Action Plan based on the European Commission's communication *An Energy Policy for Europe*[15] that integrates energy policy with these climate change targets. In particular, the European Council *"stressed the need to increase energy efficiency in the EU so as to achieve the objective of saving 20% of the EU's energy consumption compared to projections for 2020.*

The 20% energy efficiency target applies to all sectors, including those involved in the Emissions Trading Scheme[16] (ETS). The reference against which the target savings are set is projected energy requirements in 2020 rather than average historical energy trends.

3.5 Energy White Paper – Delivering a Sustainable Energy Future for Ireland

On the 12th March 2007, An Taoiseach Bertie Ahern TD and Noel Dempsey TD, Minister[17] for Communications, Marine and Natural Resources launched the Government's Energy White Paper[18]. The White Paper sets out the energy policy directions and targets for Ireland to 2020.

The following key targets were set:

- 20% savings in energy usage by 2020, with a further indicative target of 30%, the means to achieve this 20% saving will be contained in the Energy Efficiency Action Plan,
- 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 and

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[14] www.powerofone.ie

[15] Commission of the European Communities, 2007, *An Energy Policy for Europe*.
Available from http://ec.europa.eu/energy/energy_policy/documents_en.htm

[16] http://ec.europa.eu/energy/demand/legislation/end_use_en.htm

[17] Eamon Ryan TD was appointed Minister for Communications, Energy & Natural Resources on the 14th June 2007.

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

- 10% of Ireland's transport energy requirements to come from renewable sources by 2020.

The White paper lists a number of programmes which will assist in achieving these targets. The Government, inter alia will:

- continue to support the National Energy Efficiency Campaign (see 3.3),
- continue to promote the adoption of the Irish Standard for Energy Management in all workplaces,
- give priority to expanded cost-effective demand side management initiatives for industry and consumers from 2008 under a fully costed comprehensive DSM Plan to be finalised by the end of 2007,
- initiate steps in 2007 in conjunction with Commission for Energy Regulation, SEI and energy suppliers, to roll-out the provision of real time energy displays for households which have demonstrable potential to reduce energy bills,
- oversee the introduction over the next five years of smart meters for all electricity customers, (new and existing housing stock) informed by the Dundalk Pilot Project and a technical economic and cost review to be completed in 2007,
- in the context of the last point, review the most appropriate funding mechanism to meet the cost of installation; support targeted research and development and innovation in energy efficiency and technology conversion under the Energy RTDI Programme 2007 to 2013,
- lead by example setting a target of 33% for energy savings across the public sector. This will be achieved by introducing comprehensive Energy Efficiency Programmes (targets and standards) for Government Departments, State Agencies, Local Authorities, the Health Service and the public sector overall,
- revise and update existing social housing design guidelines to ensure that all new capitally funded housing schemes are socially, environmentally and economically sustainable, achieving energy efficiency,
- continue to support and expand as necessary the SEI Energy Efficiency Programmes in the built environment, the Large Industry Programme and the new targeting of the SME sector in conjunction with the National Energy Efficiency Campaign.

3.6 National Climate Change Strategy 2007 - 2010

The National Climate Change Strategy[19] (NCCS) 2007 to 2012, published on the 2nd April 2007 follows on from the first national strategy, published in 2000 and reviewed in 2002. The Strategy details the measures by which Ireland will meet its Kyoto 2008 to 2012 commitment. It also outlines how the measures will position Ireland for the post - 2012 period.

Specifically, with regard to the energy efficiency the NCCS states that: *"through innovation, energy efficiency and more sustainability in our personal choices, we can achieve the necessary lowering of the carbon intensity of our economy without sacrificing competitiveness, economic performance or quality of life"*.

As part of an energy efficiency strategy the NCCS mentions the Energy Efficiency Programme with target of a 33% energy savings across public sector by 2020, energy efficiency measures to be funded in social housing programmes and the Energy Efficiency Action Plan.

[19] Available from http://www.environ.ie/en/PublicationsDocuments/FileDownLoad,1861,en.pdf.

3.7 Programme for Government

The Programme for Government was published in June 2007 and contains a number of references to Energy Efficiency. In the period 2007 to 2012 the Government will:

- set a target of a reduction of 3% per year on average in our greenhouse gas emissions,
- improve the energy efficiency of new Irish homes by up to 40% or more,
- require the public sector to lead the way on energy efficiency with a mandatory programme of efficiency measures including the sole use of energy-efficient lighting and heating in offices, schools and hospitals and other public buildings to produce 33% energy savings by 2020,
- require all street lighting and traffic lighting systems to be energy-efficient and replace inefficient systems and
- prioritise energy efficiency and eco-design in new school buildings.

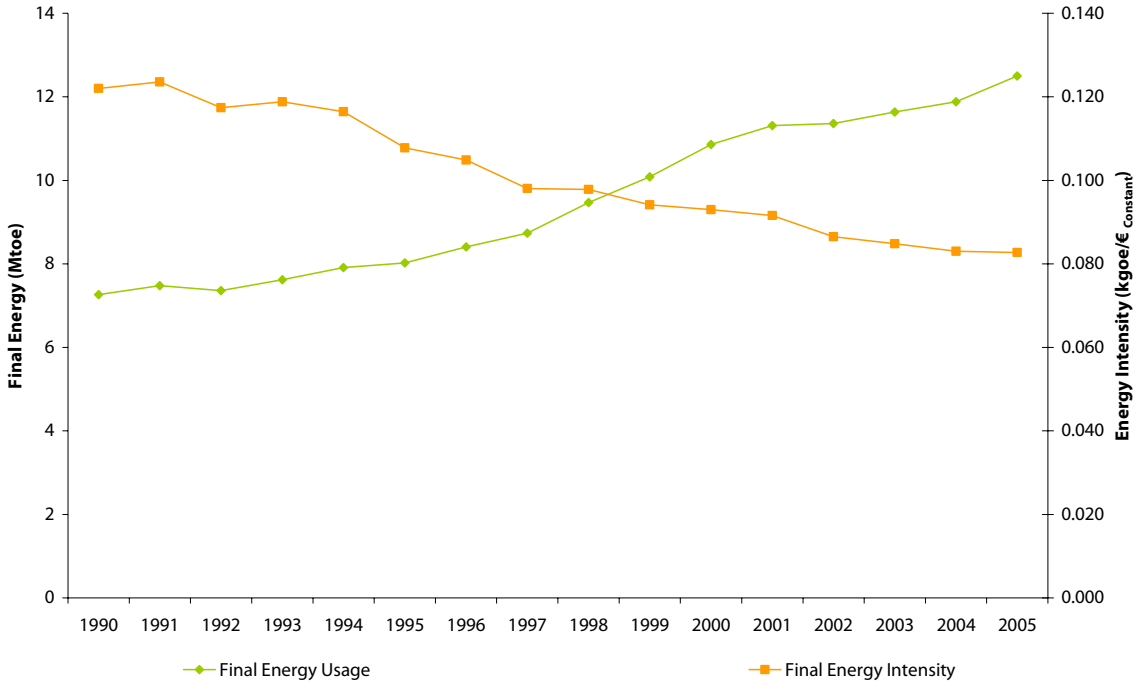
4 Energy Intensity and Efficiency – Economy Level

Energy intensity is defined as the amount of energy required to produce some functional output. It represents the inverse of energy productivity. In the case of the economy, the measure of output is generally taken to be gross domestic product (GDP[20]). GDP measured in constant prices is used to remove the influence of inflation.

Figure 4 graphs final energy usage and final energy intensity over the period 1990 to 2005 for the economy as a whole. Final energy usage increased by 72% (3.7% per annum on average) to 12,499 ktoe while energy intensity[21] decreased by 32% (2.6% per annum on average) to 0.083 kgoe /€ $_{\text{constant 2003}}$. Note that falling energy intensity equates to increasing energy productivity.

Examining these metrics in isolation implies that a significant improvement in energy productivity has occurred over the period. This improvement in energy intensity, however, may be due to any number of factors such as fuel mix, structural changes in the economy and /or as a result of energy efficiency improvements.

Figure 4 Final Energy Usage and Intensity 1990 - 2005



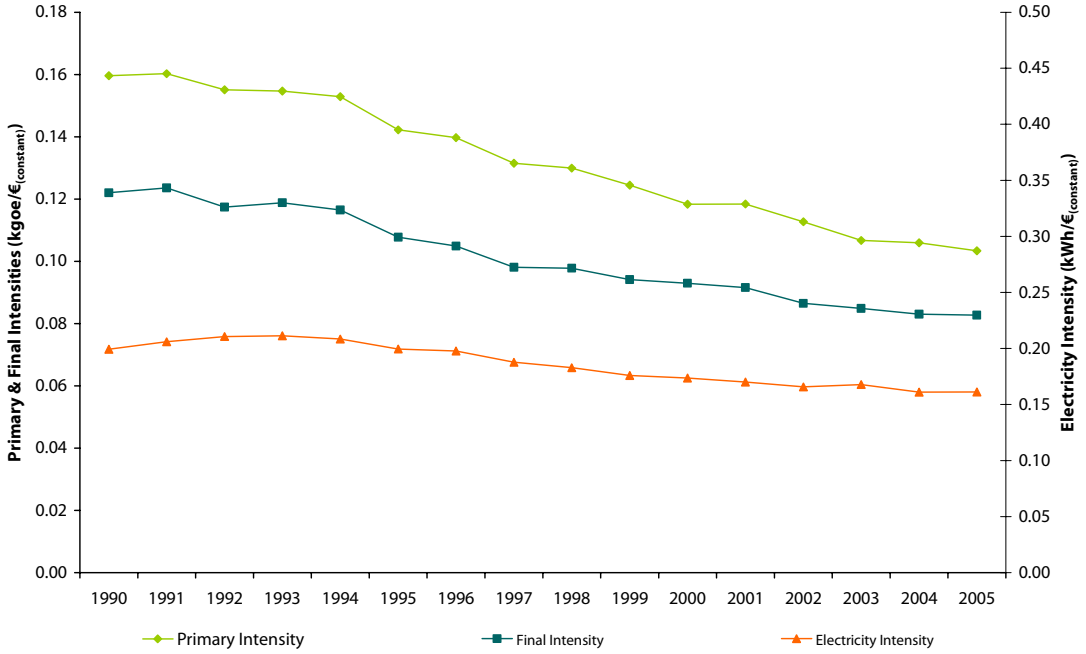
Source: SEI

[20] It can be argued that in Ireland's case, gross national product (GNP) should be used to address the impacts due to the practice of transfer pricing by some multinationals. The counter argument is that energy is used to produce the GDP and by using GNP some of the activity would be omitted. The practice internationally is to use GDP, so for comparison purposes it is sensible to follow this convention.

[21] Intensity as measured by the ratio of final energy usage to GDP in constant 2003 money value. This is expressed as kilograms of oil equivilant per euro of GDP (kgoe /€ $_{\text{constant 2003}}$).

Examining intensities in more detail, it can be seen from Figure 5 that the intensities of primary energy, final energy and electricity have been falling (improving in terms of energy productivity) since 1990.

Figure 5 Primary, Final and Electricity Intensity 1990 - 2005



Source: SEI

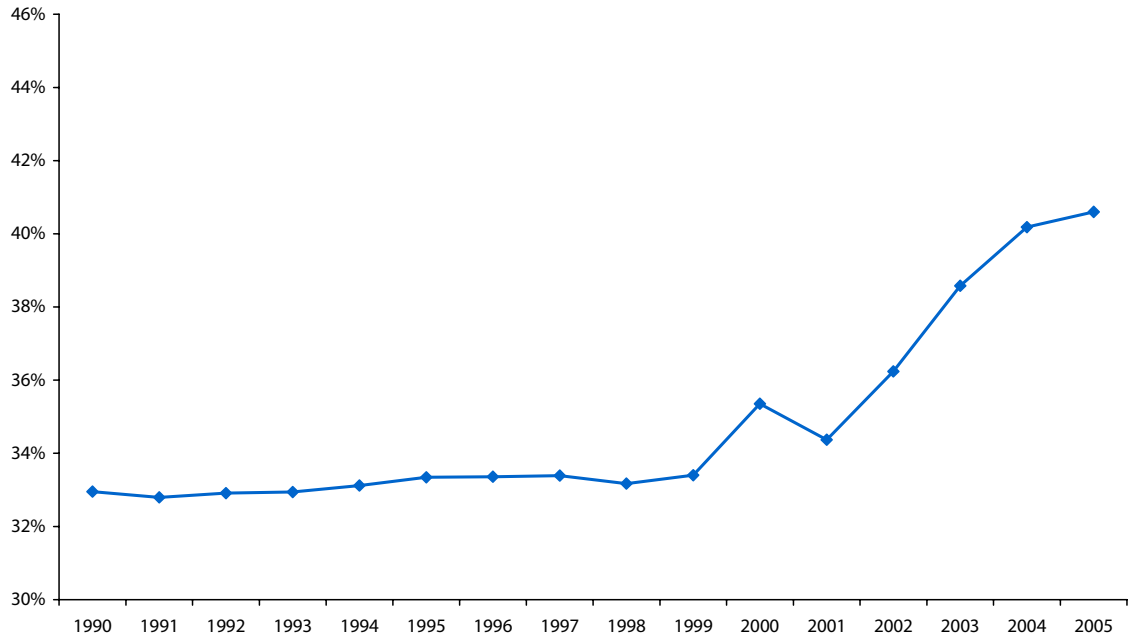
The primary energy intensity of the economy fell by 35% between 1990 and 2005 (2.9% per annum). In 1990 it required 0.16 kgoe to produce one euro of GDP whereas in 2005 only 0.10 kgoe was required.

The difference between primary and final intensity reflects the amount of energy required in the transformation from primary energy to final energy – largely used for electricity generation. The efficiency improvement in the electricity transformation sector is illustrated from 2001 onwards when primary intensity fell at a faster rate than final intensity (see Figure 6). The decrease in primary intensity since 2001 was 13% whereas for final intensity the decrease was 9.7%.

Final electricity intensity of the economy has not been falling as fast as primary or final energy intensities. Over the period 1990 to 2004 the electricity intensity fell by 19% and in the period 2001 to 2005 by 5.3%. This is attributed to the shift towards increased electricity consumption in energy end use. While electricity consumption has increased by 105% since 1990, final energy demand increased by 72%.

The efficiency of electricity supply, shown in Figure 6, is defined as the final consumption of electricity divided by the fuel inputs required to generate this electricity, expressed as a percentage. The inputs include renewable sources and imports. This consumption excludes the generation plant's 'own use' of electricity as well as transmission and distribution losses.

Figure 6 Efficiency of Electricity Supply 1990 - 2005



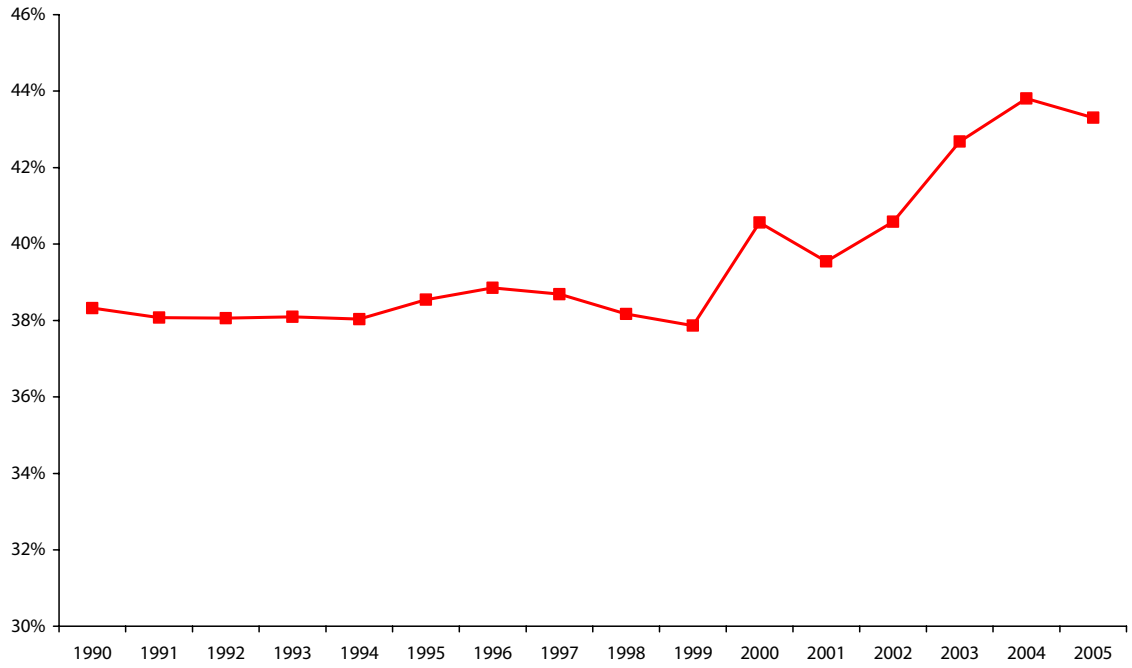
Source: SEI

Newer transformation units coming on stream, such as combined cycle gas turbine generators (CCGT), tend to be of higher efficiency and this has contributed to increasing the aggregate efficiency of the transformation process. In August 2002, the 392 MW Dublin Bay Power CCGT plant was commissioned, thus improving 2002 generating efficiency. Huntstown's 343 MW CCGT plant also contributed late in 2002 and these developments had full effect in 2003 with both plants operational all year. In addition, increasing contributions from renewable sources, imports and the closure of old peat fired stations have increased the efficiency of electricity supply and helped bring the trends in primary and final energy intensity (Figure 5) closer together.

In 2005 the electricity generation efficiency was 40.6%. This was a small increase on 40.2% in 2004 due partly to increased wind generation and higher electricity imports.

Figure 7 shows the efficiency of thermal electricity generation. This relates only to combustible fossil fuels. This efficiency was 38.3% in 1990 and had improved to 43.8% in 2004 and 43.3% in 2005 due to a reduction in gas generation and increased coal and peat generation (Ireland's thermal electricity efficiency is compared with trends in the EU-15 in section 10).

Figure 7 Efficiency of Thermal Electricity Generation 1990 - 2005

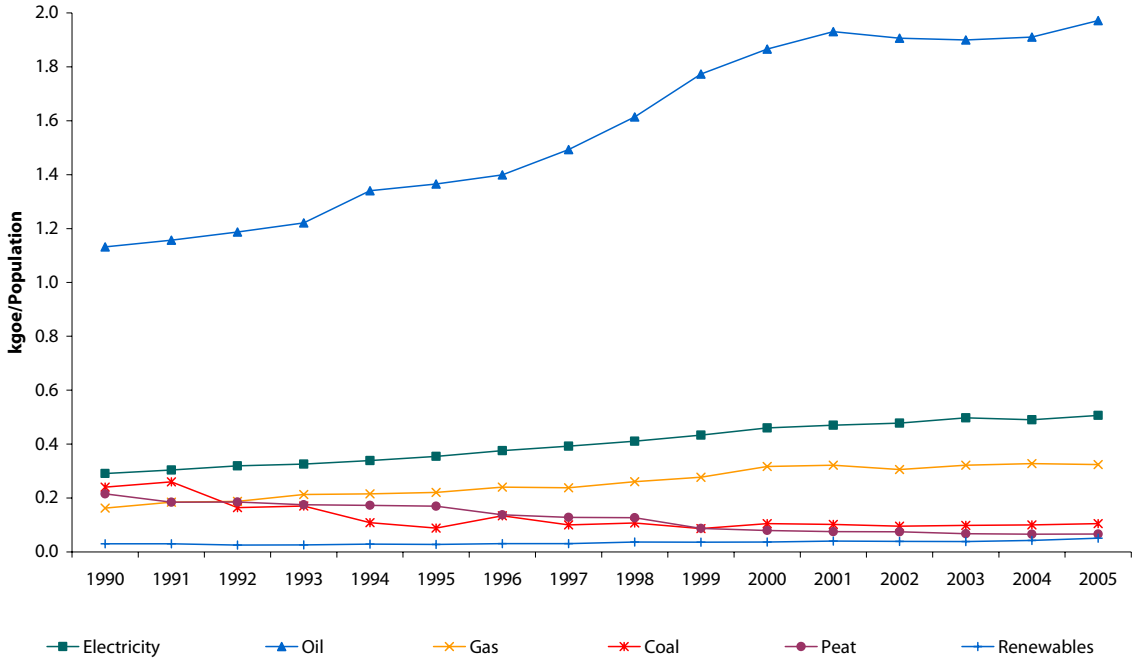


Source: SEI

Another relevant indicator is per capita energy usage. Over the period 1990 to 2005 total final energy usage per capita increased by 46% (2.6% per annum on average).

Figure 8 shows the trend for a number of fuels for the same period. Gas recorded the largest per capita increase (in relative terms) with an increase of 100% (4.7% per annum) followed by electricity (74%, 3.8% per annum), oil (74%, 3.8% per annum) and renewables (66% (3.5% per annum).

Figure 8 Final Consumption per Capita 1990 - 2005



Source: SEI and CSO

Over the same period per capita final usage of peat declined by 69% (7.6% per annum) while use of coal declined by 69% (7.6% per annum).

Referring back to Figure 5, there are many factors which contribute to how trends in energy intensities evolve. These factors may be, inter alia, technological efficiency, behavioural effects, choice of fuel mix, economies of scale and changes in the structure of the economy. In Ireland economic structure has changed considerably over the past twenty years. There has been a shift from energy intensive industries, such as fertilizer and steel production to the high value added sectors such as pharmaceuticals, electronics and services. In general, these sub-sectors are less energy intensive than traditional manufacturing industries. The industry sector is examined in more detail in section 5.

Energy intensity will continue to show a decreasing trend if, as expected, the economy continues to move away from low value-added high energy consuming sectors to one that is dominated by high-value added low energy consuming sectors. This results in a more productive economy from an energy perspective but does not necessarily mean that the actual processes used are more energy efficient.

It can be understood, therefore, that energy intensity in this form is a crude indicator and variation may be a result of many factors such as economic, structural, technical, behavioural issues, or because real energy efficiency gains have been made.

In order to better understand the trends and to clarify the role of the energy-related factors an approach focussing on techno-economic effects is required to clean or remove changes due to economic or structural effects[22]. This also facilitates analysis on the results of specific energy-efficiency policy measures.

This type of analysis has been developed since 1993 through the Odyssee[23] project, which includes Irish involvement through SEI/EPSSU. A set of in indicators have been developed which measure achievements in energy efficiency at the level of the main end-uses.

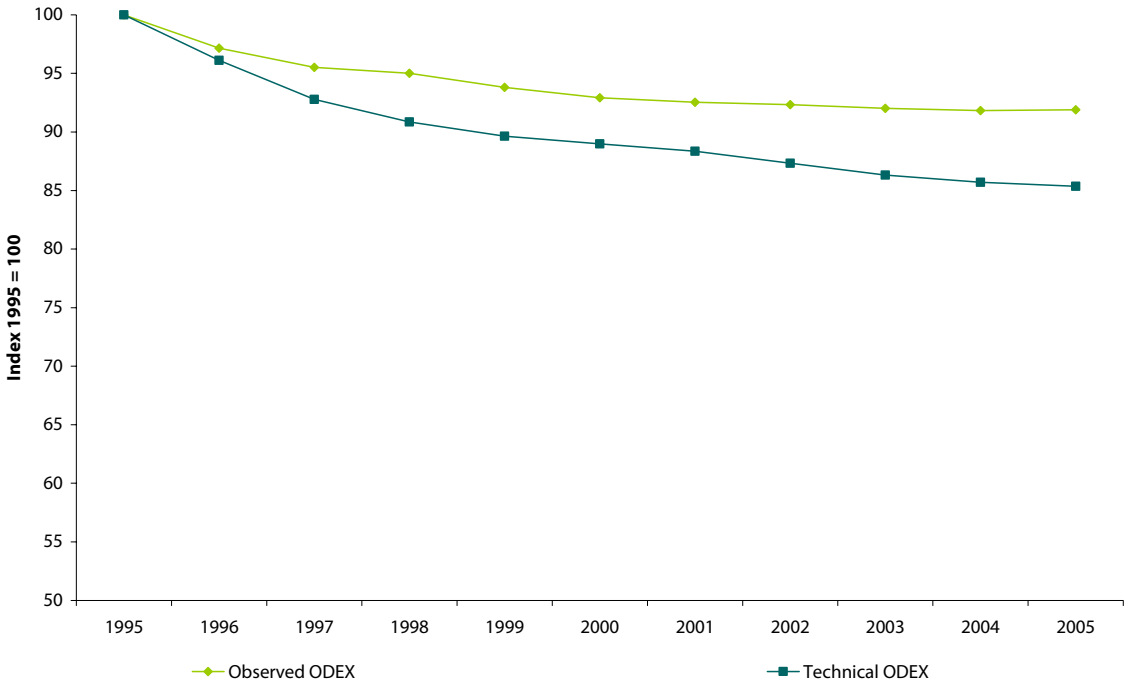
[22] Bosseboeuf D. et al, 2005, *Energy Efficiency Monitoring in the EU-15* both published by ADEME and the European Commission. Available from www.odyssee-indicators.org

These include ODEX indicators which are referenced in the Energy End-use Efficiency and Energy Services Directive (ESD)[24]. They are innovative compared to similar indices as they aggregate trends in unit consumption by sub-sector or end-use into one index per sector based on the weight of each sub-sector/end-use in the total energy consumption of the sector. The sectoral indicators can then be combined into an economy wide indicator.

The indices provide an alternative to the usual energy intensities used to assess energy efficiency changes at the sectoral level or at the level of the whole country, as they include effects only related to energy-efficiency and exclude the changes in energy use due to other effects (such as climate fluctuations, changes in economic and industry structures, lifestyle changes etc) at the economy or sectoral level.

Figure 9 presents two ODEX indicators for Ireland for the period 1995 to 2005.

Figure 9 Ireland ODEX 1995 - 2005



Source: SEI

The observed ODEX shows that between 1995 and 2005 there was an 8.1% (0.8% per annum on average) decrease, which means an 8.1% improvement in energy efficiency. To separate out the influence of behavioural factors, a technical ODEX is calculated and used to better assess the technical energy efficiency progress. As shown in Figure 9, technical efficiency improved by 15% (1.6% per annum) from 1995 to 2005.

The difference between the two indicators is the effect of behavioural effects[25] i.e. Ireland would have achieved the greater reduction in energy efficiency but for the increases in energy usage due to behaviour. Note that ODEX indicators are calculated as a 3 year moving average to avoid short term fluctuations due, for example, to imperfect climatic corrections, behavioural factors, business cycles etc.

[23] For full details of the project go to www.odyssee-indicators.org

[24] See http://ec.europa.eu/energy/demand/legislation/end_use_en.htm for details and a copy of the Directive.

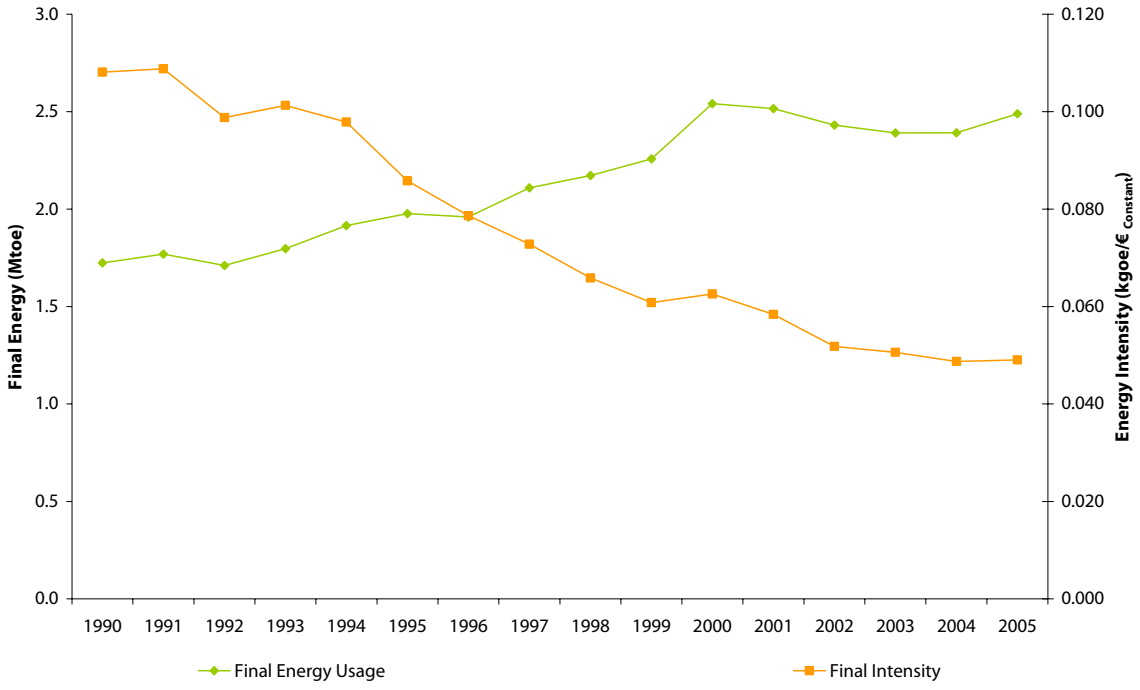
[25] Technical efficiency gains arise from the use of more energy efficient technologies whereas behavioural gains are the result of how technologies are used.

5 Energy Intensity and Efficiency – Industry

A more detailed discussion of energy trends in the industry sector is contained in the report *Energy in Industry - 2007 Report* which is available from the "Statistics" section of www.sei.ie.

Figure 10 graphs final energy usage and final energy intensity for the industry sector over the period 1990 to 2005. Final energy usage increased by 44% (2.5% per annum on average) to 2,490 ktoe while energy intensity[26] decreased by 54% (5.1%) to 0.049 kgoe /€ $_{\text{constant 2003}}$.

Figure 10 Industry - Final Energy Usage and Intensity 1990 - 2005



Source: SEI

As mentioned in section 4 energy intensity in this form is a crude indicator and variation may be the result of many factors, particularly structural changes in the case of Ireland. To eliminate the effects of structural changes an index of energy intensity at constant structure [27] is also shown in Figure 11.

[26] Intensity as measured by the ratio of final energy usage to Gross Value Added (GVA) in constant 2003 money value. This is expressed as kilograms of oil equivilant per euro of GDP (kgoe /€ $_{\text{constant 2003}}$).

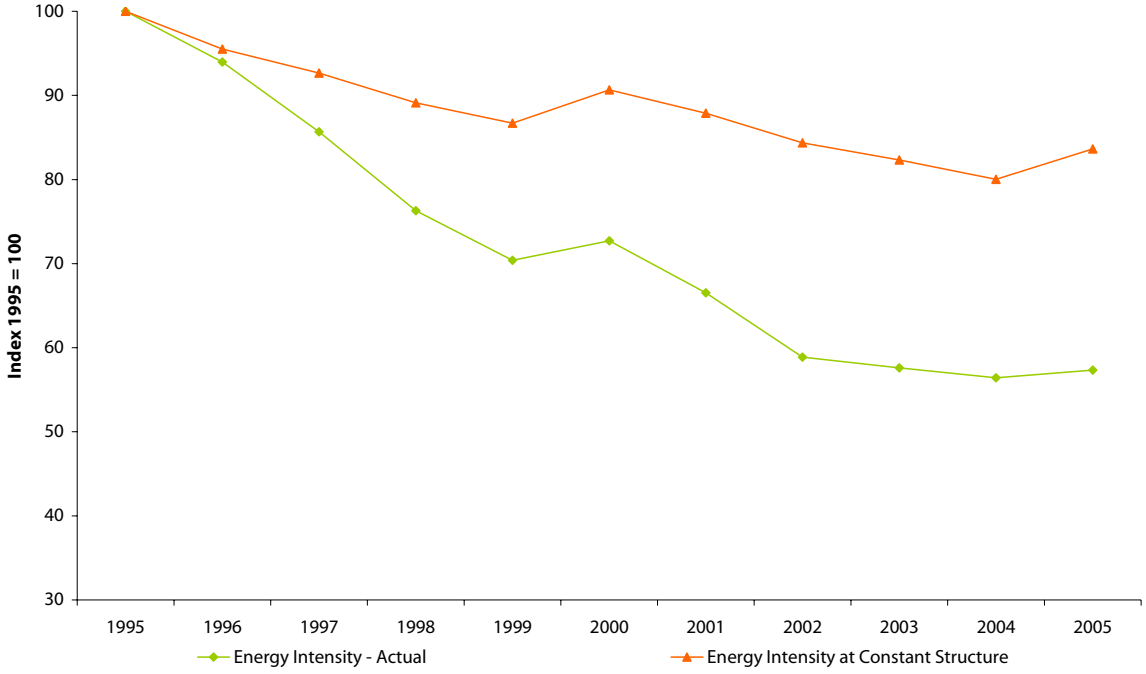
[27] This section draws on methodology developed under the Odyssee project. See Bosseboeuf D. et al, 1999, *Energy Efficiency Indicators – The European Experience and* Bosseboeuf D. et al, 2005, *Energy Efficiency Monitoring in the EU-15* both published by ADEME and the European Commission. http://www.odyssee-indicators.org/

This indicator measures the impact of structural changes in industry by comparing the variations of the actual intensity with that of a fictitious or notional intensity at constant structure (using 1995 structure as a reference). It can be seen that structural changes have had a significant effect but other factors are also responsible for the improvement in energy productivity.

The green line in Figure 11 is the trend in energy intensity in industry. Over the period 1995 to 2005 intensity of industry declined by 43% (5.4% per annum).

The orange line in Figure 11 represents the evolution of industrial energy intensity had the structure not changed over time. As mentioned in section 4, the structure of industry did change, resulting in lower energy intensity. These structural changes were brought about by global economic influences and Irish industrial policy. Over the period, industrial policy concentrated on moving the sector up the value chain to manufacture high value goods such as pharmaceuticals, electronics and value added foodstuffs. This resulted in increased economic efficiencies, contributing to the further reduction in intensity shown in Figure 11.

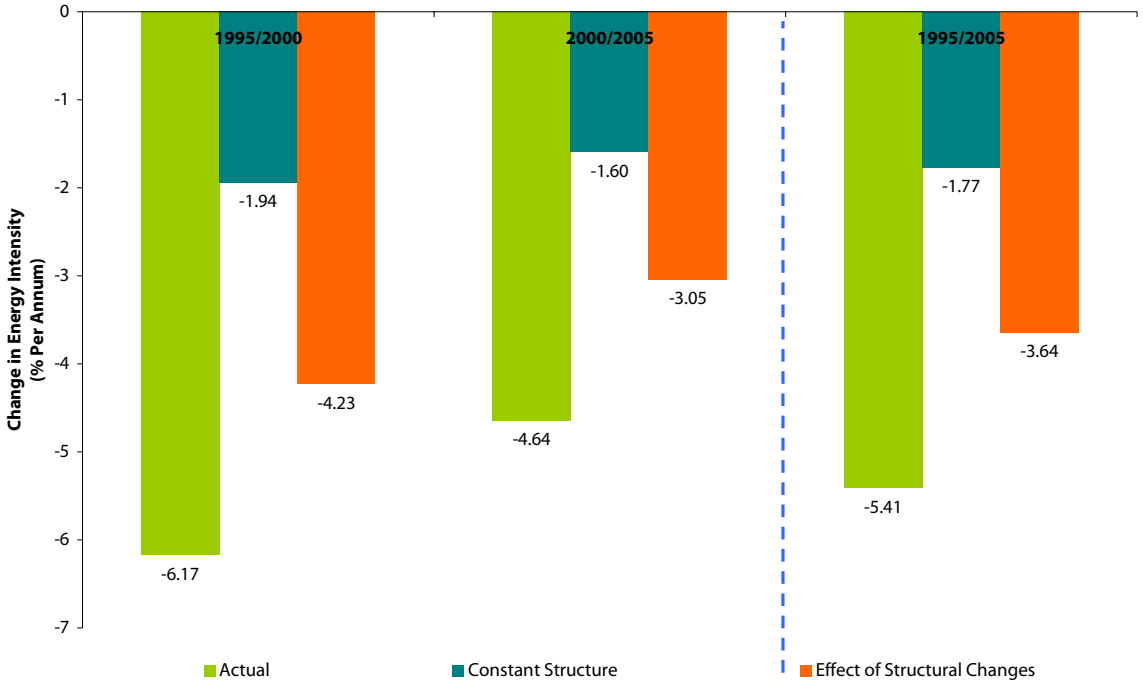
Figure 11 Index of Energy Intensity of Industry 1995 - 2005



Source: SEI

The contribution of structural changes is examined further in Figure 12. For three periods (1995 to 2000, 2000 to 2005 and 1995 to 2005) the changes in final energy intensity are compared with those of the intensity at constant structure. The difference between the intensities shows the influences of structural changes in the sector.

Figure 12 Intensity Trends in Industry: The Role of Structural Changes



Source: SEI

It can be seen that structural changes were significant in the three periods.

In other words, changes in the makeup of Irish industry between 1995 and 2005 accounted for just over two thirds of the reduction in industrial energy intensity[28]. The remainder of the change in intensity is due to other effects such as change in fuel mix, quantity effects (economies of scale), other behavioural effects and real efficiency gains.

To examine which sectors were responsible for the structural component, it is useful to consider the industrial intensity at a sub-sectoral level. Three time periods are again covered.

The total reduction in energy intensity due to structural changes is shown to the left of the dotted line in Figure 13 with the contribution of each sub-sector[29] illustrated to the right. Sub-sectors registering a positive change contributed to decrease the energy productivity of industry whereas a negative value implied an increase in energy productivity.

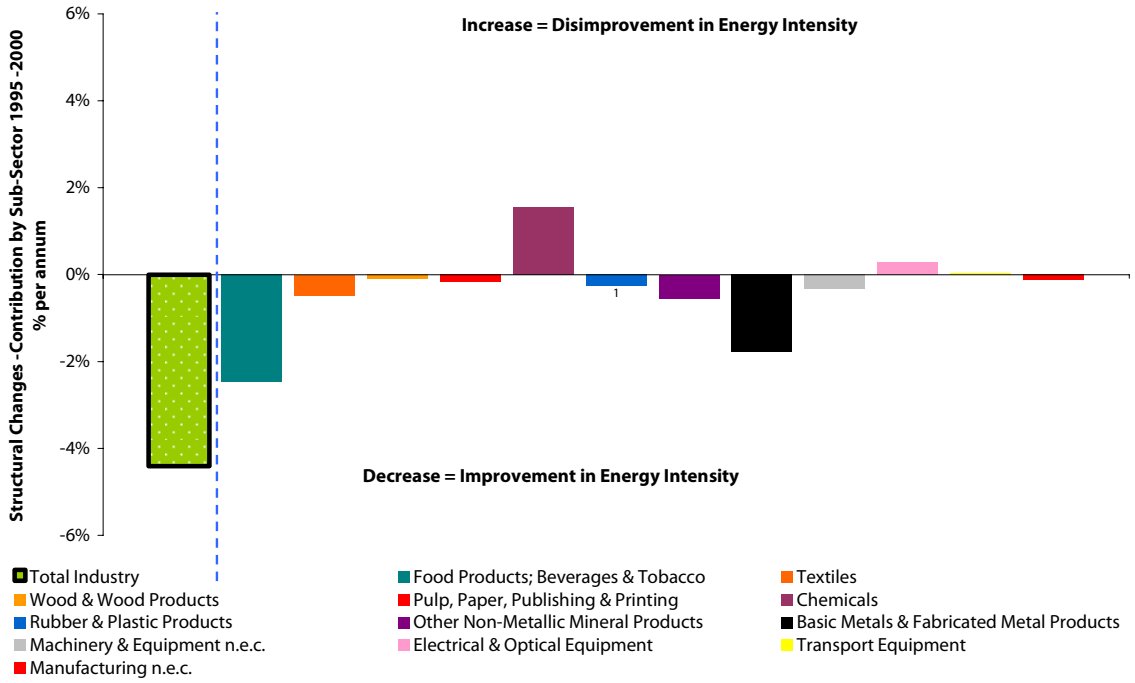
The contribution of the food products and basic metals sub-sectors were the most significant over the period 1995 to 2000 with food products contributing 56%[30] of the decrease due to structural changes and metals 40%. The non-metallic mineral products (which include cement) and optical sectors experienced an increase in energy intensity but this effect was outweighed by the decreases in the other sectors.

[28] Structural changes accounted for 67% of total changes between 1995 and 2005, 69% between 1995 and 2000 and 66% between 2000 and 2005.

[29] Full definitions of the sub-sectors used can be found on page 60.

[30] This means that out of the total variation due to structural changes, food contributed 56%.

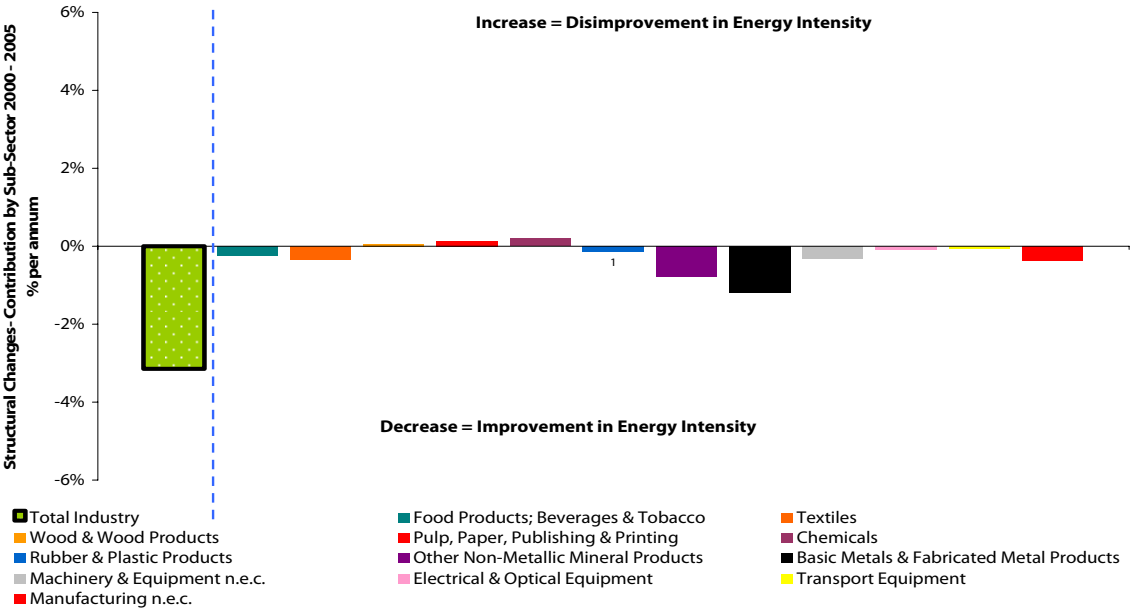
Figure 13 Variation in Energy Intensity due to Structural Changes – Contribution by Sub- Sector 1995 - 2000



Source: SEI

Figure 14 examines the period from 2000 to 2005. The sub-sectors which contributed most to the overall variation were basic metals (responsible for 38%) and non-metallic mineral products (25%).

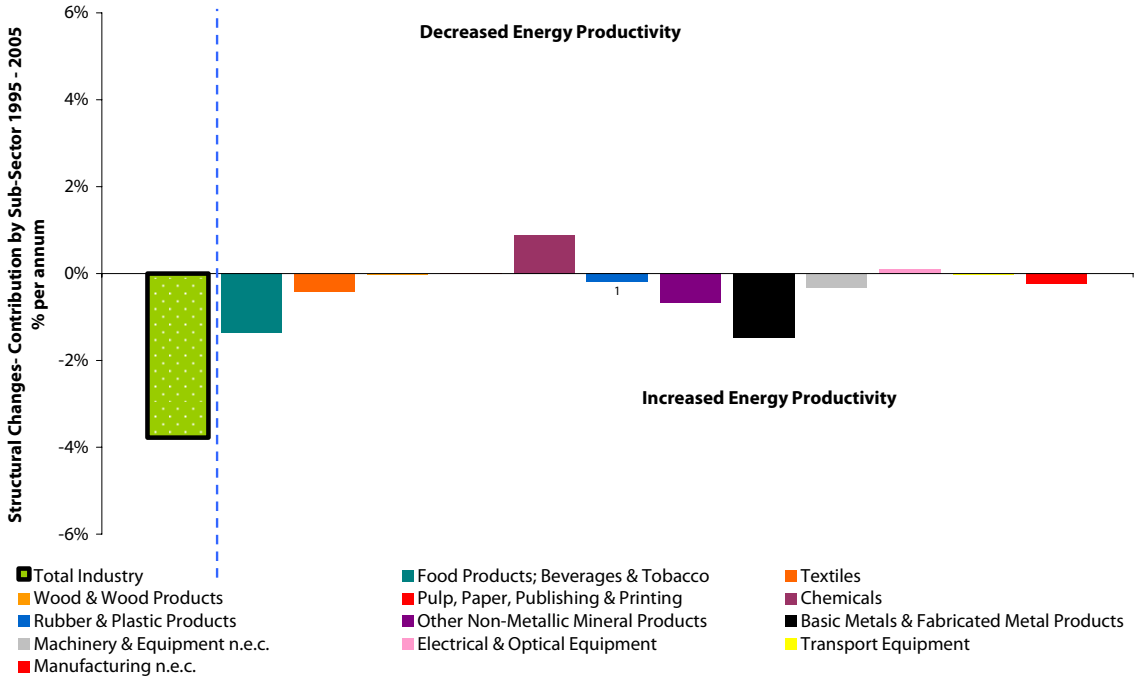
Figure 14 Variation in Energy Intensity due to Structural Changes – Contribution by Sub- Sector 2000 - 2005



Source: SEI

Figure 15 looks at the period as a whole: 1995 to 2005.

Figure 15 Variation in Energy Intensity due to Structural Changes – Contribution by Sub- Sector 1995 - 2005



Source: SEI

The basic metals sub-sector was the most significant accounting for 39% of the variation followed by the food sub-sector, responsible for 36%.

Table 4 Variation in Structural Energy Intensity –Contribution to Overall Change by Sub-Sector

	1995 - 2000		2000- 2005		1995 - 2005
Food Products; Beverages & Tobacco	56%		8%		36%
Textiles	11%		11%		11%
Wood & Wood Products	2%		-2%		1%
Pulp, Paper, Publishing & Printing	4%		-4%		0%
Chemicals	-35%		-6%		-23%
Rubber & Plastic Products	6%		4%		5%
Other Non-Metallic Mineral Products	12%		25%		18%
Basic Metals & Fabricated Metal Products	40%		38%		39%
Machinery & Equipment n.e.c.	7%		10%		8%
Electrical & Optical Equipment	-6%		3%		-3%
Transport Equipment	-1%		2%		1%
Manufacturing n.e.c.	3%		11%		6%

Source: SEI

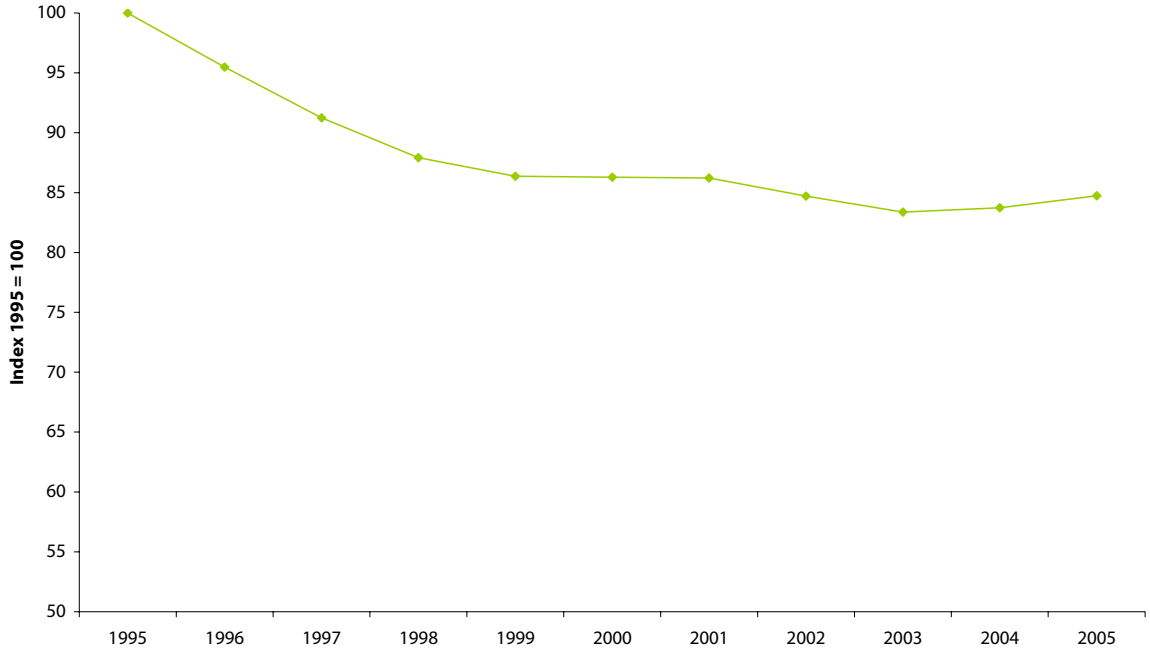
To remove non-efficiency effects an ODEX indicator for industry in Ireland has been constructed over the period 1995 to 2005 that takes into account twelve industry sub-sectors, shown in Figure 16.

The graph clearly shows the improvements in energy efficiency over the period.

The ODEX indicator is based on unit consumption expressed in terms of energy used per unit of physical output (where data are available) and production indices for the other sub-sectors relative to that in the base year (in this case 1995). It is important to note that, for some sub-sectors the trends also include some non-technical changes, especially in the chemical industry as a result of the shift to light chemicals. Data for this sector are currently not available at a sufficiently disaggregated level.

The index decreased from 100 in 1995 to 85 in 2005 indicating a 15% improvement in energy efficiency.

Figure 16 Industry ODEX 1995 - 2005

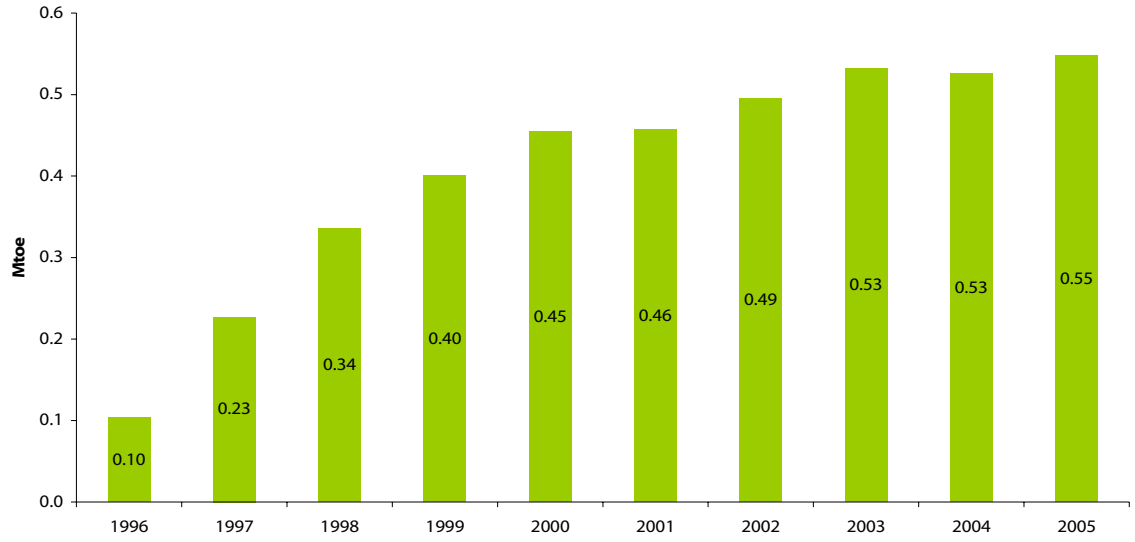


Source: SEI

This methodology also allows for the quantification of energy savings as a result of energy efficiency improvements, shown in Figure 17.

Total energy savings in 2005 due to such improvements were 0.6 Mtoe.

Figure 17 Energy Savings in Industry 1996 - 2005



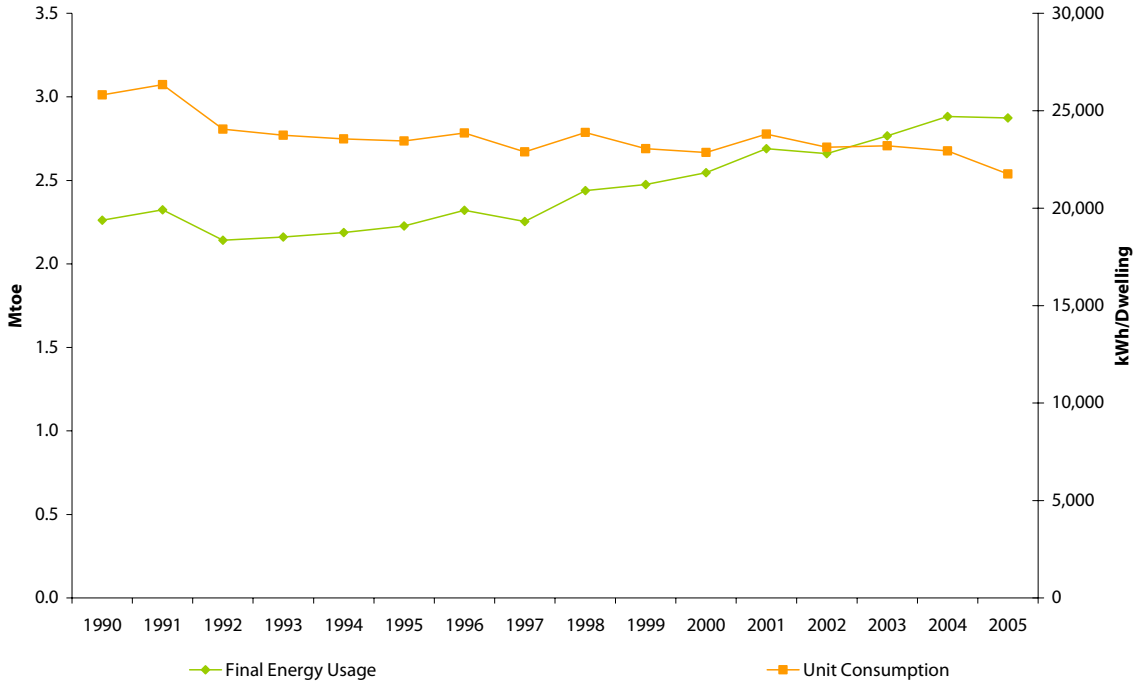
Source: SEI

6 Energy Intensity and Efficiency – Residential

A more detailed discussion of energy trends in the residential sector is contained in the report *Energy Consumption and CO_2 Emissions in the Residential Sector* which is available from the "Statistics" section of www.sei.ie.

Figure 18 graphs final energy usage and unit consumption[31] for the residential sector over the period 1990 to 2005. Final energy usage in the sector increased by 27% to 2,874 ktoe (1.6% per annum on average) while average energy use per dwelling decreased by 16% (1.1%) to 21,755 kWh per dwelling.

Figure 18 Residential - Final Energy Usage and Unit Consumption 1990 - 2005



Source: SEI

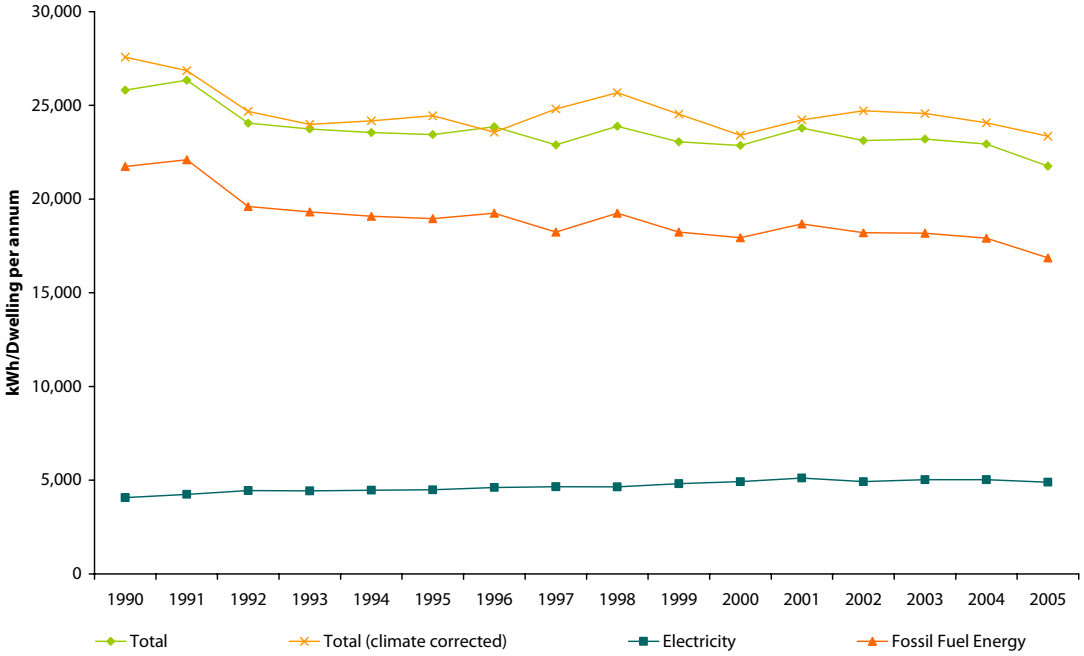
Over the period 1990 to 2005 the number of households[32] in the State increased by 52% from approximately 1.01 million to 1.54 million. Figure 19 shows the trend in unit consumption per dwelling (actual values and climate corrected), with a distinction between electricity and fossil fuels.

[31] The energy intensity of the residential sector is measured using unit consumption, defined as energy usage per dwelling.

[32] Defined as the number of private households in permanent housing units.

While overall energy use per dwelling has decreased, Figure 19 shows an increasing trend in electricity consumption per dwelling. This has increased by 20% since 1990. The increasing penetration of household electrical appliances such as dishwashers, clothes driers, personal computers, games consoles and multiple televisions etc. is likely to have contributed to this increase. In contrast, fossil fuel consumption per dwelling has deceased by 22% over the period. This is associated with the switch from stand alone heating systems fired by solid fuels to central heating systems which generally use gas, oil or more recently wood pellets. Another important factor is the improvement in the building stock (through the increased efficiency standards of new houses and retrofitting of the existing stock).

Figure 19 Unit Consumption of Energy per Dwelling (Permanently Occupied) 1990 - 2005



Source: Based on SEI, CSO and Met Éireann data

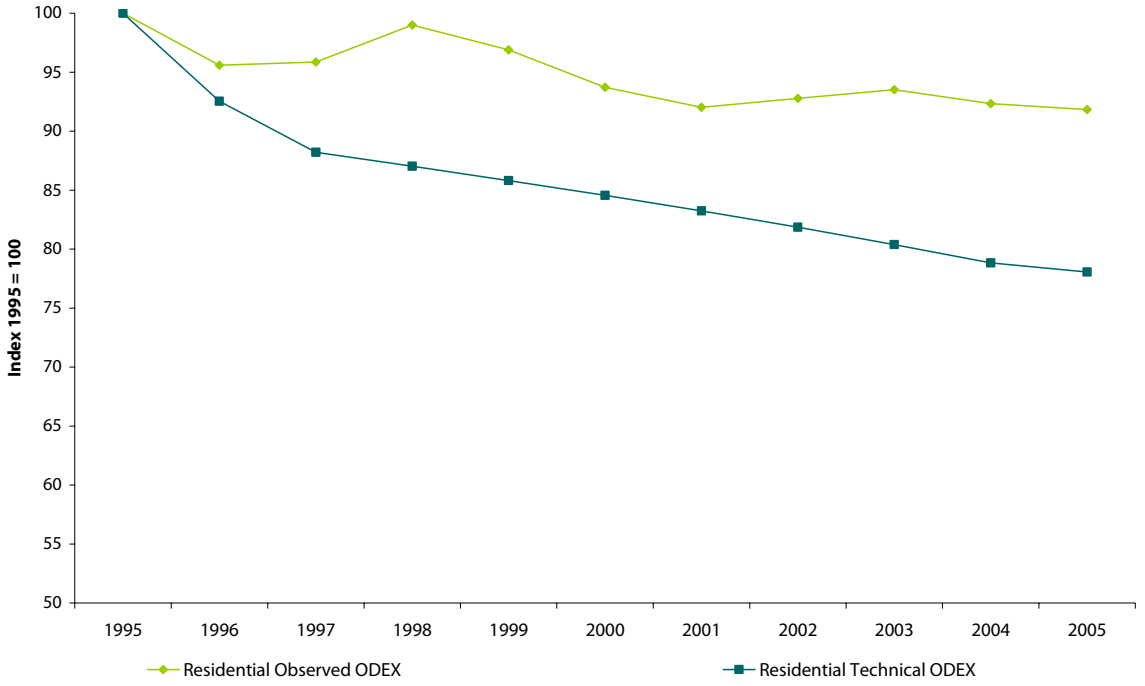
As stated above, in 2005 the "average" dwelling consumed a total of 21,755 kWh of energy based on climate corrected data. This comprised 16,865 kWh (78%) in the form of direct fossil fuels and the remainder (4,890 kWh) as electricity.

Figure 19 also shows overall unit energy use per dwelling, corrected for climate variations. Looking at this it can be seen that the decrease in climate corrected energy use per dwelling over the period was 15.3% while the uncorrected energy use decrease was 16%. It can be seen that most of the improvement occurred during the early 1990s and again from 2001.

Two ODEX indicators are shown in Figure 20 for the household sector. The observed ODEX decreased (indicating an improvement in energy efficiency) by 8.2% over the period (0.8% per annum). To remove the influence of behavioural or lifestyle factors a technical ODEX is also calculated. Technical efficiency gains arise from the use of more energy efficient technologies whereas behavioural gains are the result of how technologies are used.

The technical ODEX decreased by 22% (2.4% per annum). This implies that significant additional efficiency gains would have been made if not for the change in behaviour i.e. efficiency gains were made but a rebound effect negated some of the gains. This rebound effect is the result of increased energy usage through higher comfort levels, the move towards whole house heating, larger dwellings, use of power showers etc.

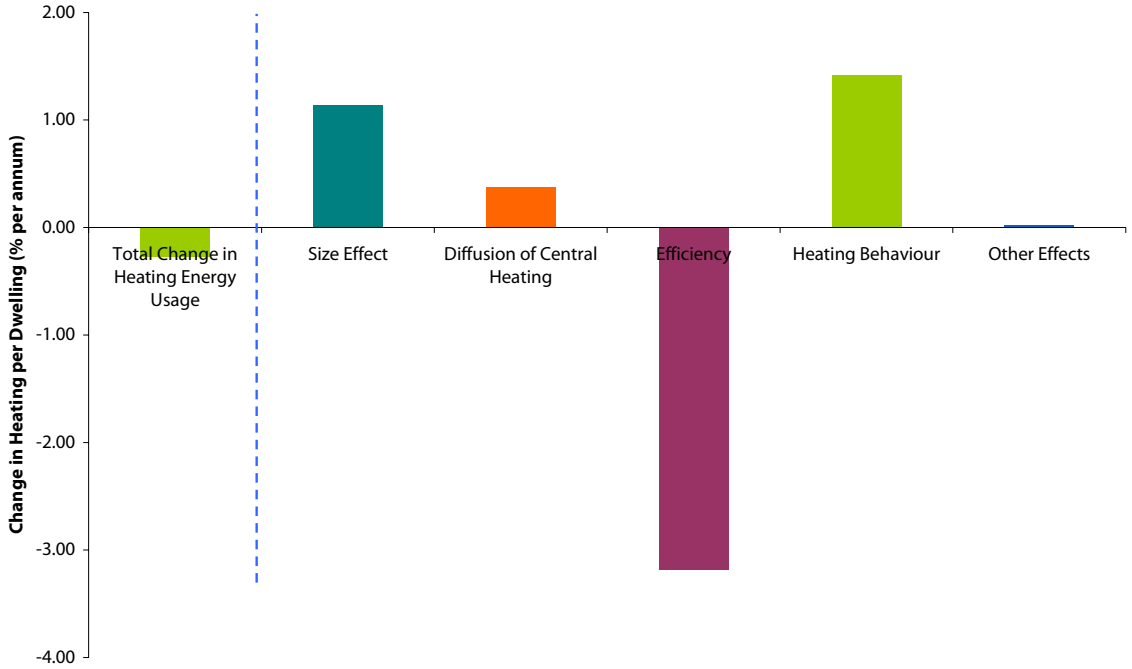
Figure 20 Household ODEX 1995 - 2005



Source: SEI

As stated previously, variations in energy use per dwelling may be the result of a number of factors. Figure 21 and Table 5 examine these factors over the period 1995 to 2005.

Figure 21 Drivers of Change in Heating Consumption per Dwelling 1995 - 2005



Source: SEI

The total per annum reduction in heating consumption per dwelling is shown to the left of the dotted line with the contributory factors illustrated to the right. Over the period as a whole, larger dwellings (size effect) have increased the average consumption per dwelling by 1.1% per annum and the diffusion of central heating contributed a 0.4% increase per annum. These factors have been more than offset by the decrease in heating consumption brought about by dwellings becoming more efficient (3.2% increase per annum).

An important contributing factor in overall increased efficiency is the number of new dwellings constructed since 1992. These newer dwellings, as a result of various iterations of the Building Regulations, are subject to increased efficiency standards. In all, 43% of the current stock (approximately 650,000 dwellings) have been built since 1992. In addition, efficiency improvements (such as adding insulation, double glazing etc.) have been made to a subset of the stock[33].

Table 5 Drivers of Variation in Heating Consumption per Dwelling 1995 - 2005

% Per annum	1995-2005		2000-2005	2000-2004	2004-2005
Total Change in Heating Energy Usage	-0.27		0.83	1.6	-2.3
Size Effect	1.14		1.12	1.0	1.6
Diffusion of Central Heating	0.38		0.38	0.41	0.26
Efficiency	-3.19		-2.29	-2.21	-2.60
Heating Behaviour	1.42		1.62	2.42	-1.50
Other Effects	0.02		0.01	-0.01	0.07

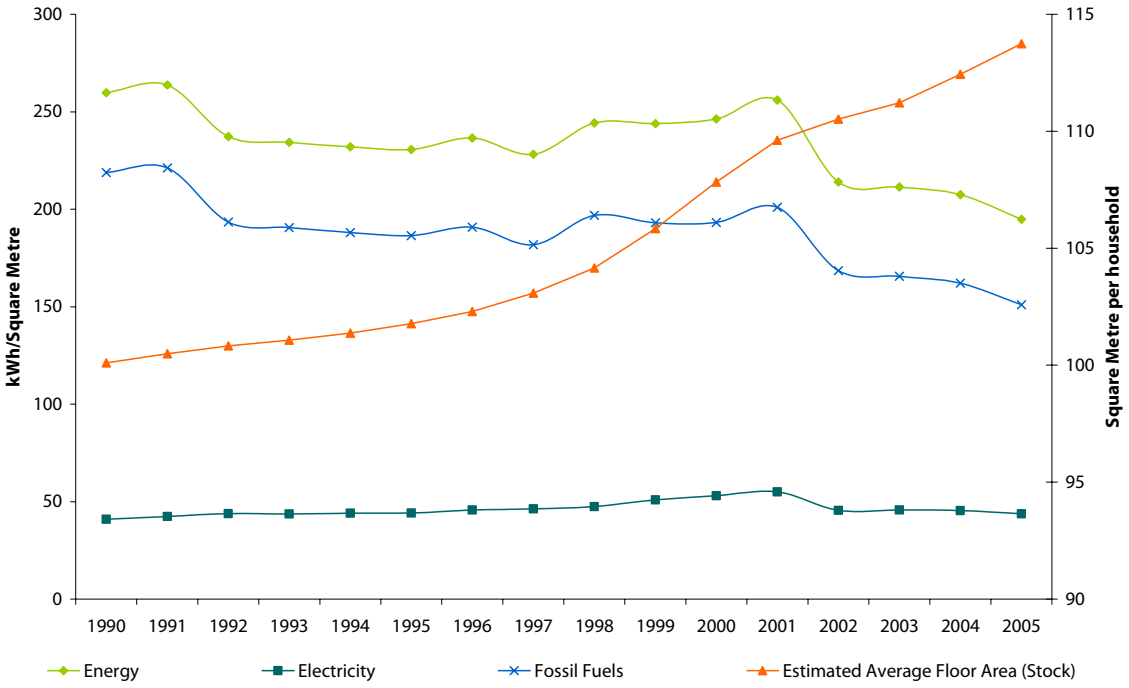
Source: SEI

[33] Economic and Social Research Institute, 2003, *Irish National Survey of Housing Quality*.
A full copy of the report can be downloaded from
http://www.environ.ie/DOEI/DOEIPub.nsf/0/96ffd2d2ffab95f880256f0f003dbcf6?OpenDocument

Figure 22 shows the trend in energy, electricity and fossil fuels per estimated square meter[34] for the residential sector.

Over the period 1990 to 2005 energy usage per square meter fell by 25% (1.9% per annum), fossil fuel usage decreased by 31% (2.4%) while electricity usage increased by 7.0 (0.4%). Over the same period, average floor area is estimated to have increased by 14% (0.9%).

Figure 22 Estimated Energy Usage per Square Meter 1995 - 2005



Source: SEI and CSO

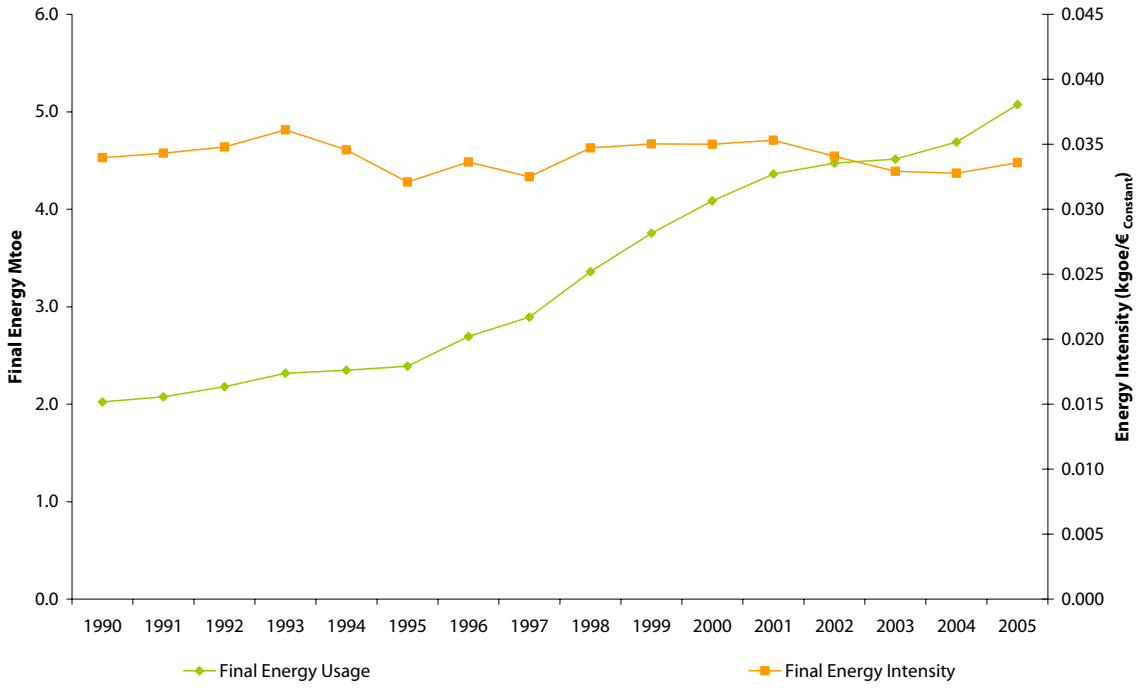
[34] The methodology for estimateing the floor area of the stock is conatin in *Energy Consumption and CO_2 Emissions in the Residential Sector*, available from the "Statistics" section of www.sei.ie

7 Energy Intensity and Efficiency – Transport

A more detailed discussion of energy trends in the transport sector is contained in the report *Energy in Transport* which is available from the "Statistics" section of www.sei.ie.

Figure 23 graphs final energy usage and final energy intensity[35] for the transport sector over the period 1990 to 2005. It can be seen that intensity remained fairly constant with only a 1% decrease to 0.034 kgoe /€ $_{\text{constant 2003}}$ in 2005 (0.1% per annum). In other words, transport energy use grew almost at the same pace as GDP. Transport energy usage was 5,057 ktoe in 2005, an increase of 151% (6.3% per annum) on 1990.

Figure 23 Transport - Final Energy Usage and Intensity 1990 - 2005



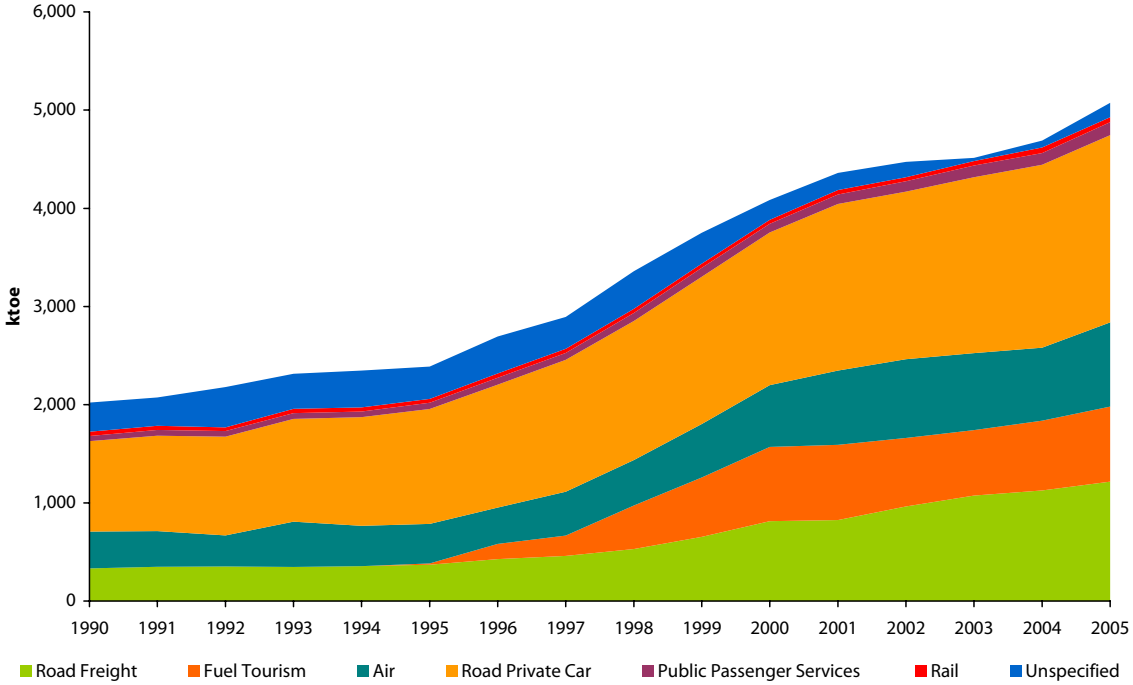
Source: SEI

The contribution from each mode of transport to energy demand is shown in Figure 24[36].

[35] Intensity as measured by the ratio of final energy usage to GDP in constant 2003 money value. This is expressed as kilograms of oil equivilant per euro of GDP (kgoe /€ $_{\text{constant 2003}}$).

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

Figure 24 Transport Energy Demand by Mode 1990 - 2005

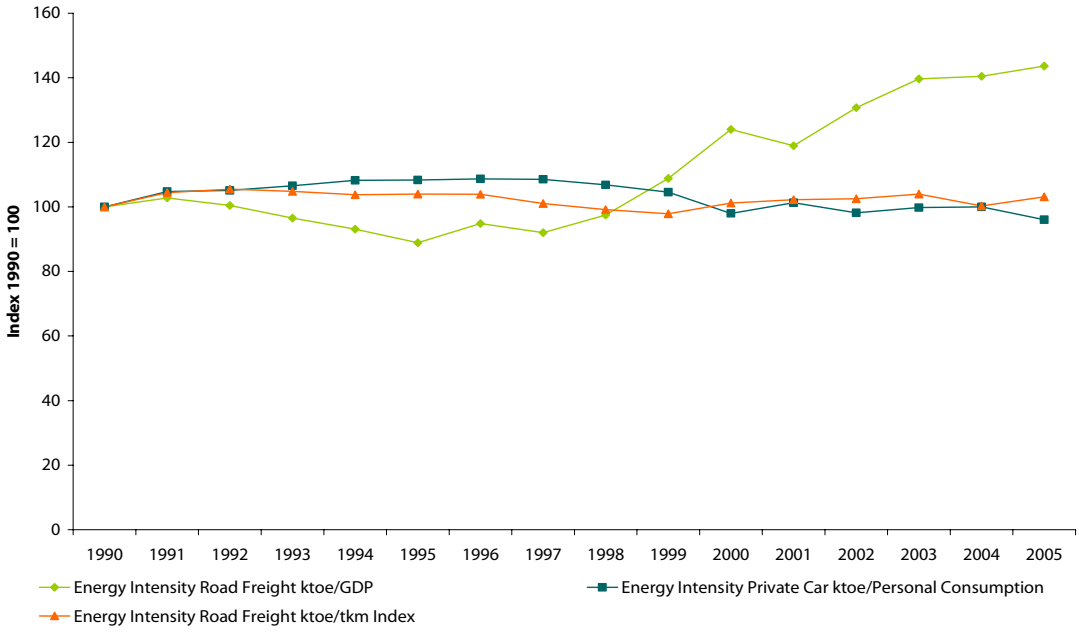


Source: SEI

It can be seen that the largest sub-sectors are road freight and road private car responsible for 24% and 38% respectively of the total. Over the period 1990 to 2005 energy usage by private cars increased by 107% (5% per annum on average) while fuel usage by road freight increased by 264% (9% per annum).

Figure 25 shows three intensity indicators for the period 1990 to 2005 .

Figure 25 Road Freight and Road Private Car Final Energy Intensity 1990 - 2005



Source: SEI

Road freight is measured against GDP while private car final energy is compared with personal consumption of goods and services.

Looking first at the energy intensity of road freight, it can be seen that there has been an increase of 44% (2.4% per annum) in the index since 1990 indicating a deterioration in energy intensity.

It is likely that this is influenced by the large and increasing amount of transport for construction purposes (especially road building) that has been experienced in recent years i.e. large quantities of heavy, relatively low value goods are being transported. The latest Road Freight Survey[37] backs up this assertion as it states that in 2006, 62% of the total weight of goods carried was in the group "Crude and Manufactured Minerals, Building Materials" up from 49% in 1999.

Also shown in Figure 25 is the ratio of fuel usage of road freight and tonne kilometres. It can be seen that the ratio increased by 3% (0.2% per annum). This suggests that energy efficiency (i.e. the amount of energy required to transport a given quantity of goods) has remained relatively constant over the period.

Finally in Figure 25, the ratio of fuel consumption of private cars and personal consumption of goods and services is shown for the period 1990 to 2005. There was 4% (0.3% per annum) reduction in energy intensity over the period.

It is also possible to examine efficiencies of the private cars in more detail.

In recent years the number of private cars has been increasingly rapidly in Ireland. The number of vehicles on Irish roads exceeded two million[38] for the first time in 2004 reaching 2,138,680 vehicles by the end of 2005. Of these there were 1.66 million private cars (78% of the total).

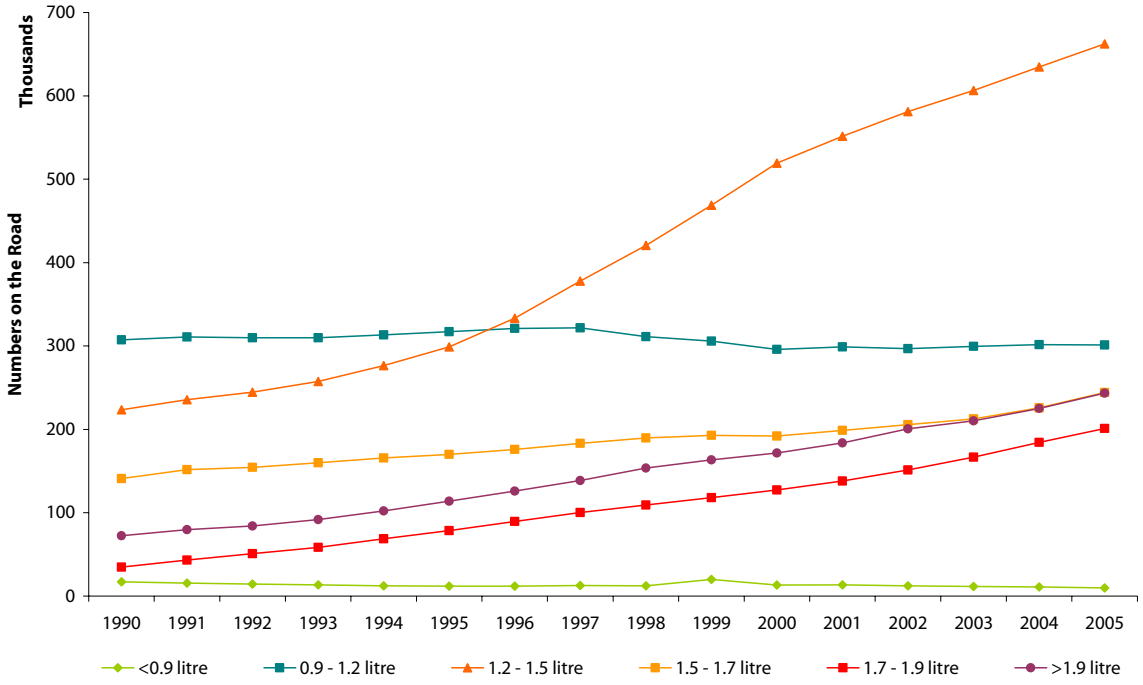
While the numbers of cars have been increasing there has also been a purchasing trend towards larger cars (in terms of engine size). Figure 26 show how purchasing patterns with respect to engine size have changed over time.

Figure 26

[37] Central Statistics Office, Various Years. *Road Freight Surveys.* Available from www.cso.ie.

[38] Vehicle Registration Unit (Department of the Environment, Heritage & Local Government, DEHLG), various years, *Irish Bulletin of Vehicle and Driver Statistics.*

Change in Car Engine Size 1990 - 2005

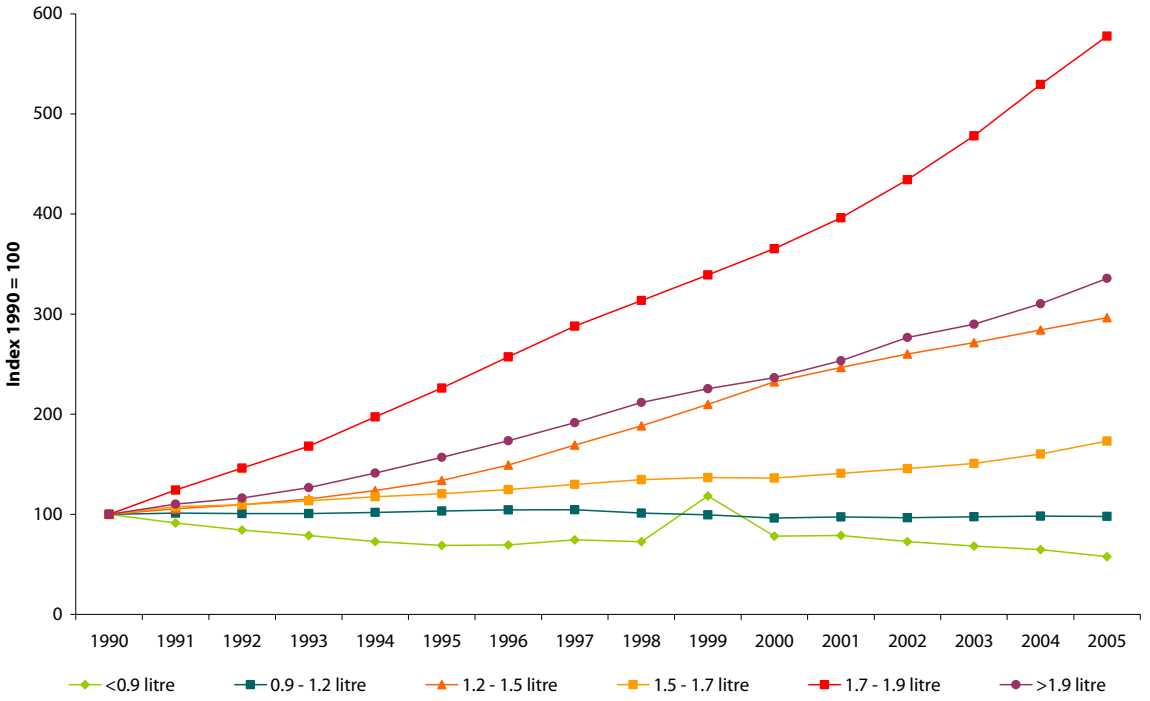


Source: Based on DEHLG Data.

Cars with an engine size of 1.2 litres or less are showing steady or declining numbers whereas the numbers of cars with engine size of larger than 1.2 litres are all showing increasing trends. The 1.2 to 1.5 litre engine size has the largest share of private cars, 39% of the total in 2005. This was over twice the share of the second most popular class, the 0.9 to1.2 litre band which accounted for 18% of the total. In 1990 the 0.9 to 1.2 litre engine size had the largest share of private cars, 39% of the total. It is also interesting to note that cars with an engine size of greater than 1.9 litres have increased their share of the total, from 9% in 1990 to 15% in 2005.

Figure 27 presents the same data but in this case expressed as an index, with 1990 as the reference year.

Figure 27 Change in Car Engine Size 1990 – 2005 (Index)

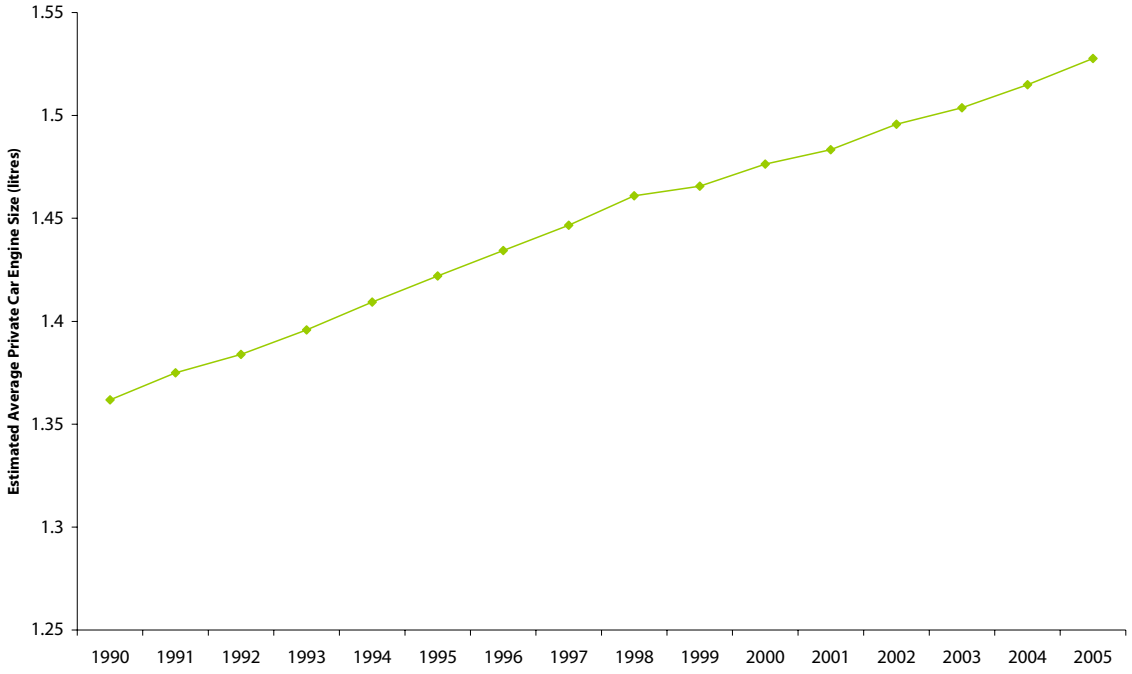


Source: Based on DEHLG Data.

This gives a clearer indication of the rate of increase of the differing size classes. Cars with engines less than 0.9 litre and 0.9 to 1.2 litre are showing steady or declining numbers whereas the other classes are showing an increase with the fastest growing range being the 1.7 to 1.9 litre category and the greater than 1.9 litre the second fastest. This clearly shows a changing preference towards larger cars. The number of cars in the 1.7 to 1.9 litre range grew by 478% since 1990 and those in the greater than 1.9 litre range grew by 236%.

Estimates of the average car engine size for the period 1990 to 2005 are shown in Figure 28.

Figure 28 Estimated Average Private Car Engine Size 1990 - 2005



Source: Based on DEHLG Data.

The estimates assume that the median value for each engine size range is 0.1 litres below the maximum limit of the band. While this may not be the case for all engine size bands it does allow for a comparison to be made. Therefore in Figure 28 the trend is more important that any actual yearly value. Over the period 1990 to 2005 the average engine size of the private car stock has steadily increased by 0.8% per annum (12% in total).

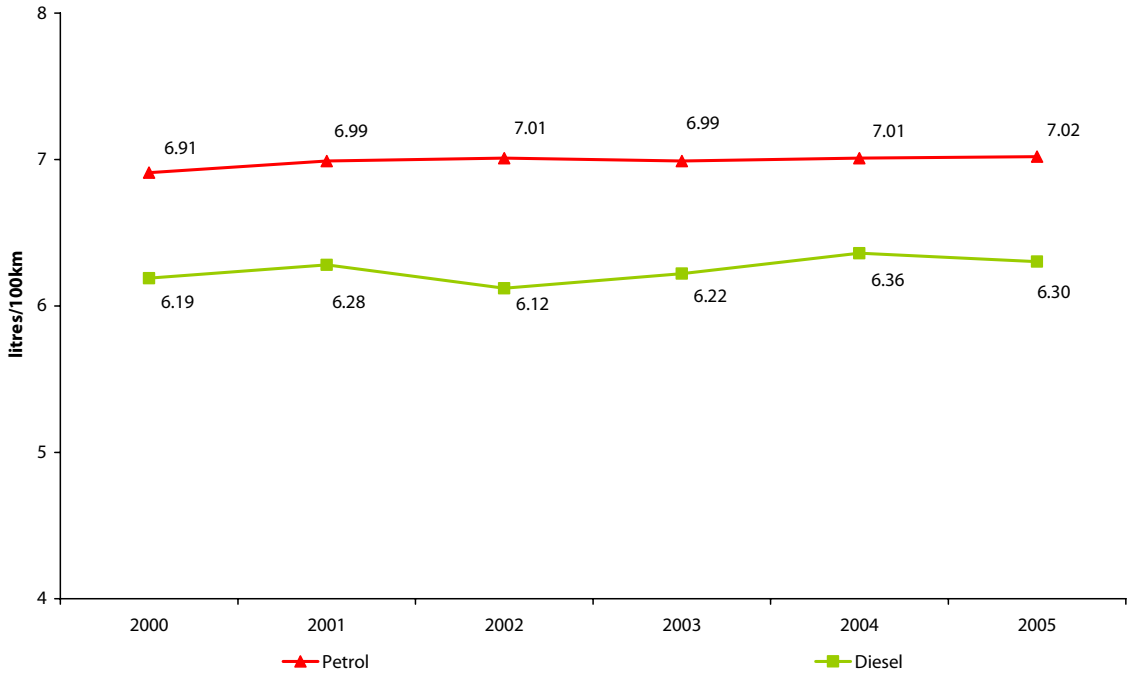
As a result of improved engine design, newer cars entering the Irish fleet have higher efficiency levels. The purchasing trend towards larger engine sizes as demonstrated is however, negating the impact on these efficiency benefits as shown in the following analysis.

All new cars have fuel consumption figures[39] associated with them (measured under test conditions) quoted for urban, extra-urban and combined driving. An average specific fuel consumption figure for new cars entering the national fleet may be calculated by weighting the test values by the sales figures for each individual model. If the voluntary agreements with car manufacturers are being effective, over time a gradual reduction in the weighted average fuel efficiency of new cars being registered should be seen.

Figure 29 presents the weighted average specific fuel consumption (combined urban and extra urban test values) of new private cars first registered in the years 2000 to 2005. This was calculated using an extract from the Vehicle Registration Unit's national database and data on fuel consumption of individual models.

[39] Fuel consumption and CO_2 emissions data were sourced from the Vehicle Certification Agency. The database can be downloaded at http://www.vca.gov.uk/fcb/new-car-fuel-consump.asp.

Figure 29 Specific Fuel Consumption of New Cars Litres /100 km 2000 - 2005

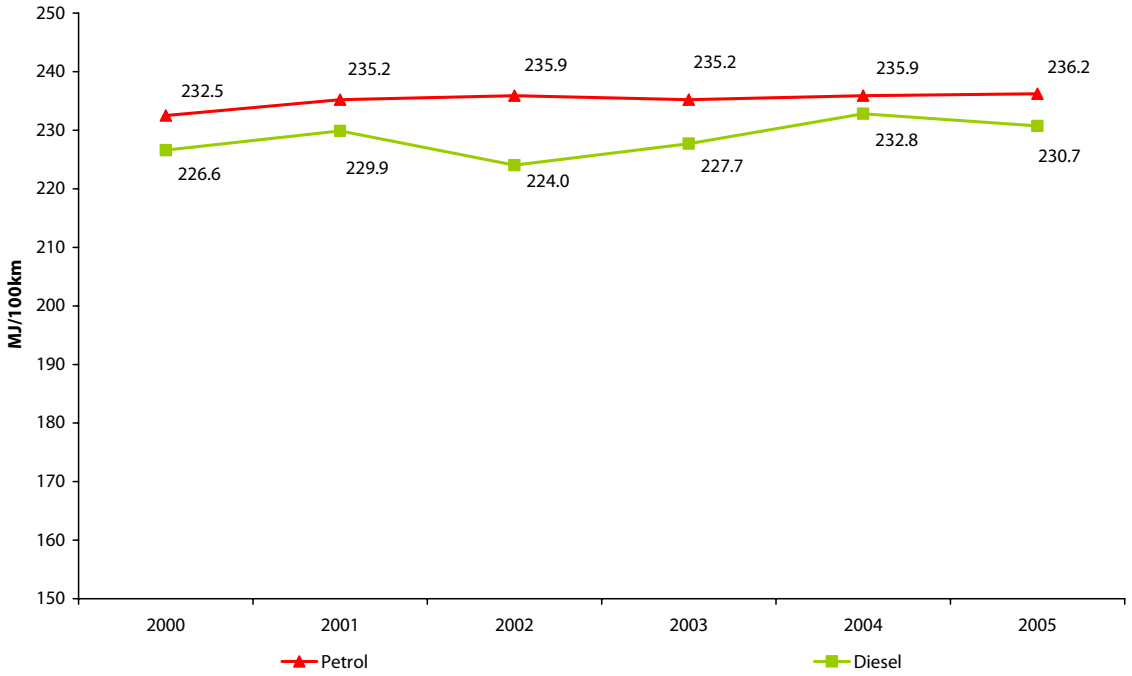


Source: Based on DEHLG Data

The specific fuel consumption for new petrol cars on the road in Ireland in 2005 was 7.0 litres/100km (40 miles per gallon, mpg). This represents an increase of 1.6% (decrease in fuel efficiency) on the average consumption in 2000 and indicates that, overall, the weighted average of newly purchased petrol cars is becoming less fuel efficient. The comparable 2005 figure for new diesel cars was 6.3 litres/100km (45 mpg), which was 1.8% higher than in 2000.

An indicator which removes the difference in energy content between petrol and diesel is mega joules per 100 kilometre (MJ/100 km), shown in Figure 30.

Figure 30 Specific Fuel Consumption of New Cars MJ/100km 2000 - 2005

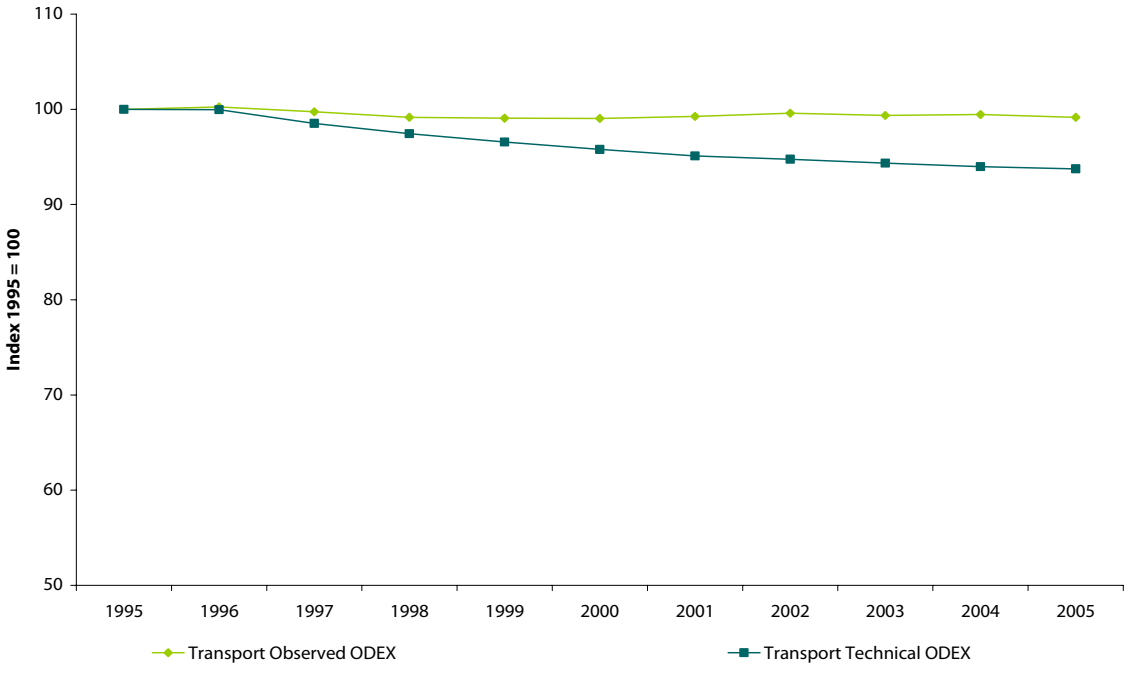


Source: Based on SEI and DEHLG Data

Here the trends are closer together for example in 2005 new petrol cars, measured in litres per 100km, consumed 11% more than diesel cars. When measured using MJ/100km petrol cars consumed just 2.3% more than diesel cars. It should be noted however that, on average, diesel cars purchased in Ireland tend to be larger than petrol cars.

Finally, the individual ODEX indicators for each mode are combined into two overall ODEX indicators for the transport sector and they are shown in Figure 31. Note that air transport is not included as per the ESD.

Figure 31 Transport ODEX 1995 - 2005



Source: SEI

The transport observed ODEX fell by 0.8% over the period 1995 to 2005 while the technical ODEX decreased by 6.3% (0.6% per annum). Additional efficiency gains would have been made if not for behavioural effects, for example the purchase of larger cars.

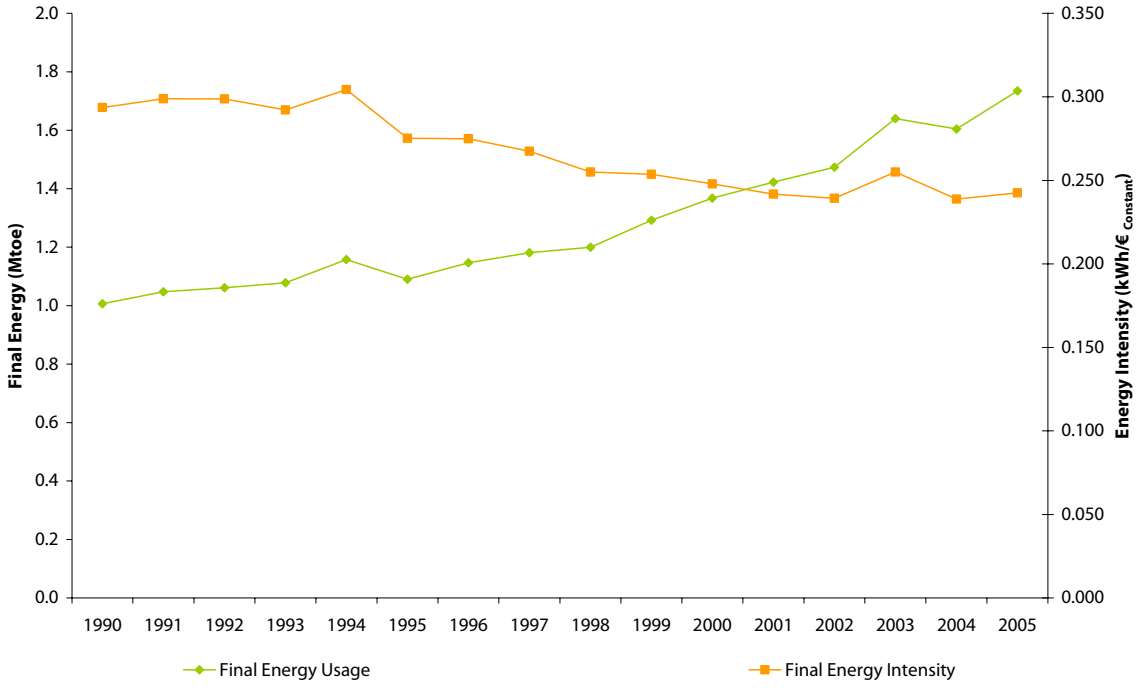
Another contributing factor to the improvement in efficiency is in the area of road transport of goods. Trucks and light vehicles are running fuller i.e. they have a higher load factor, as a result of better economic conditions. Between 1995 and 2005 the load factor of trucks and light vehicles increased by 5% per annum on average.

8 Energy Intensity and Efficiency – Services

A more detailed discussion of energy trends in the services sector is contained in the report *Profiling Energy and CO_2 Emissions in the Services Sector* which is available from the "Statistics" section of www.sei.ie.

Figure 32 graphs final energy usage and final energy intensity[40] for the services sector over the period 1990 to 2005. In 2005 final energy usage in the sector was 1,735 ktoe, an increase of 72% (3.7% per annum on average) on 1990. Over the same period energy intensity decreased by 17% (1.3%) to a figure of 0.243 kWh /€ $_{\text{constant 2003}}$ in 2005.

Figure 32 Services - Final Energy Usage and Intensity 1990 - 2005



Source: SEI

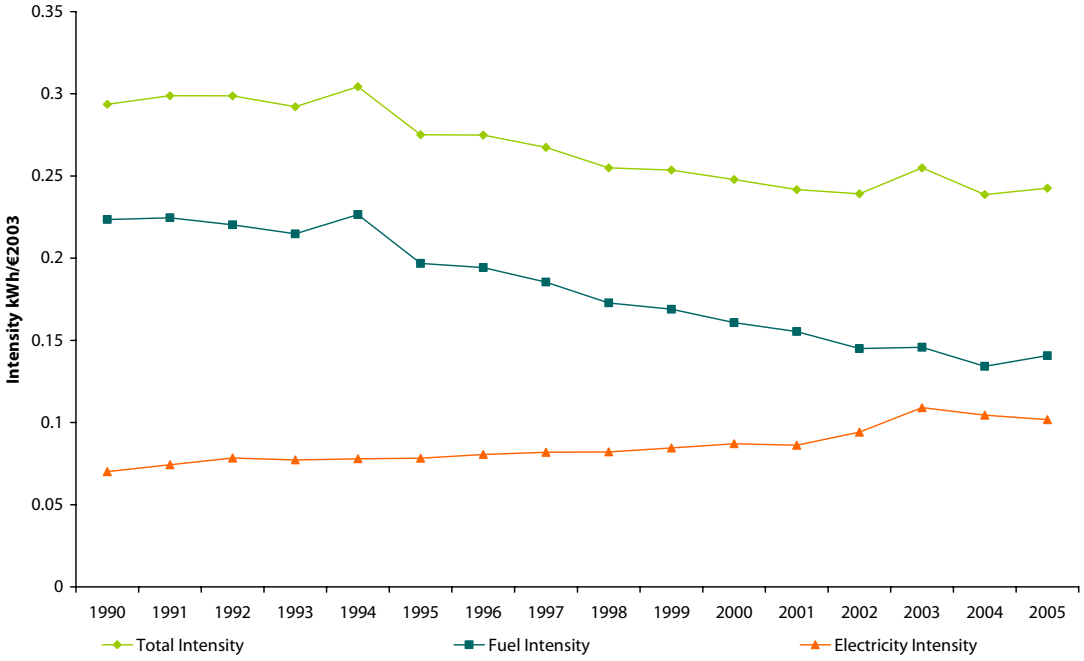
The decrease in energy intensity is partly attributable to the rapid growth in the value added of the sector.

Overall energy intensity is separated into fuel and electricity intensity in Figure 33.

[40] Intensity as measured by the ratio of final energy usage to GVA in constant 2003 money value. This is expressed as kilograms of oil equivilant per euro of GDP (kgoe /€ $_{\text{constant 2003}}$).

It can be seen that the fuel intensity continued to fall until 2004 and was 40% lower in 2004 than in 1990. There was a reversal of the trend in 2005 when the fuel intensity of services increased by 4.9%. Electricity intensity on the other hand increased by 56% up to 2003, however, it has decreased by 6.7% since.

Figure 33 Energy Intensity of Services Sector 1990 - 2005



Source: SEI

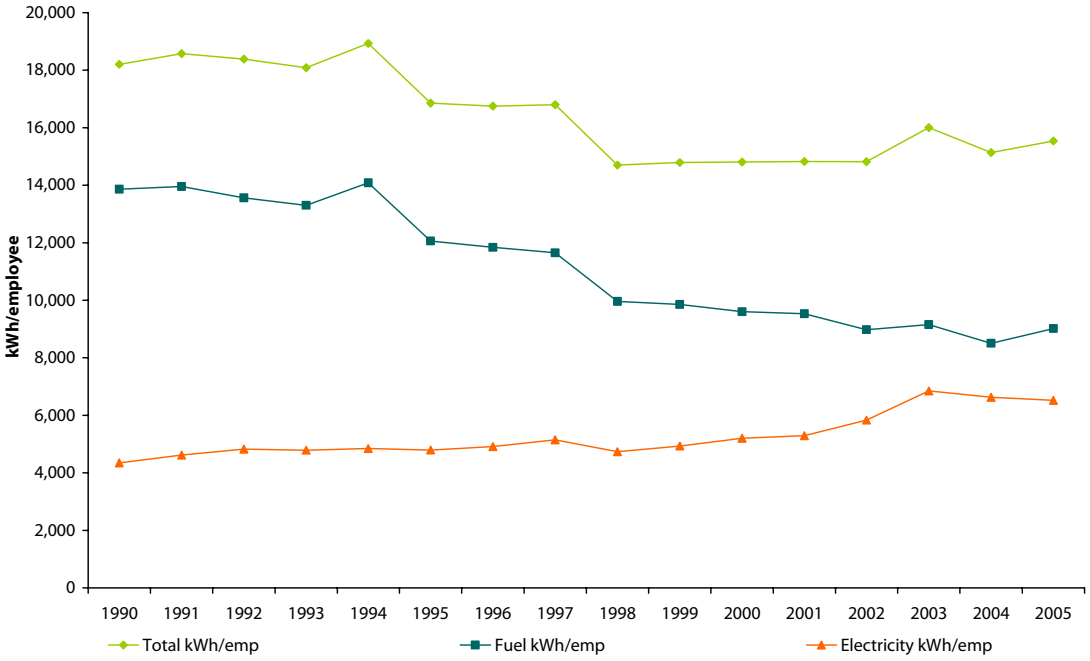
Two other indicators can be used to measure energy efficiency in this sector, energy use per unit of floor area and per employee. The rationale is that consumption of oil and gas is mainly for heating purposes and is related to the floor area heated and not directly related to the number of people occupying a building at a given time. It is not currently possible to calculate the consumption per unit of floor area due to an absence of data on floor area in the sector.

Unit consumption of electricity per employee is used as an indicator of energy use in the services sector because in the main, there is a correlation between electricity use and the number of employees.

With reference to Figure 34 it can be seen that unit consumption of electricity was rising steadily since 1990. By 2003 it was 58% higher than in 1990 but has fallen back to 50% in 2005. This can be linked to the increasing use of office equipment, computers, printers, photocopiers etc during this time.

By contrast, the fuel consumption per employee has declined by 35% since 1994.

Figure 34 Unit Consumption of Electricity per Employee in the Service Sector 1990 - 2005



Source: SEI

It should be noted that energy statistics relating to fuel consumption for the services sector in Ireland are calculated as a residual. This approach is unsatisfactory, not least because the energy use in the services sector is affected by uncertainties in all other sectors.

As a result of the heterogeneous nature of the services sector it is difficult to assess the amount of energy that is consumed in this sector (this is the reason why ODEX indicators have not been constructed for the sector). The increasing number of energy suppliers in the liberalised market makes this task all the more difficult.

9 Energy and Intensity Forecasts to 2020

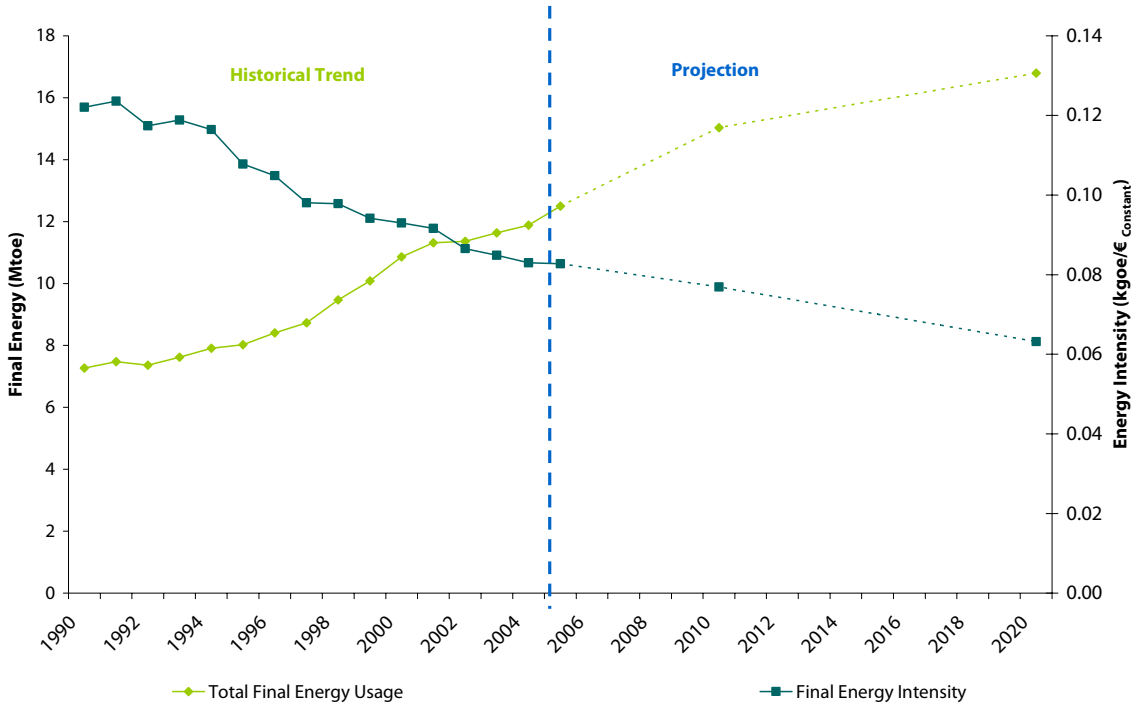
This section presents forecasts of energy and intensity trends for Ireland for the period 2005 to 2020. The energy forecasts were prepared for SEI/EPSSU by the Economic and Social Research Institute (ESRI) in October 2006. The GDP and GVA data are from the latest ESRI Medium Term Review[41]. ESRI prepare two scenarios in the Medium Term Review relating to high and low economic growth paths. In this section, following advise from ESRI, the high growth path is used to 2010 and low growth to 2020. Energy forecast data is only available for 2010 and 2020 therefore values for the intervening years should not be inferred from the graphs.

Energy intensity projections are calculated in the same way as the historical projections in previous sections. In the case of the residential sector the future housing stock is the number of permanently occupied dwellings in 2005 plus the projected number of dwelling completions from the Medium Term Review. It is acknowledged that not all new dwellings will be permanently occupied and that there will a number of dwellings lost from the stock each year through demolitions but it is believed that this shouldn't alter the results significantly.

Figure 35 graphs final energy usage and final energy intensity over the period 1990 to 2020 for the economy as a whole. As stated in section 4, over the period 1990 to 2005 final energy usage increased by 72% (3.7% per annum on average) while energy intensity decreased by 32% (2.6%).

Over the period 2005 to 2020 final energy usage is forecast to increase by 34% (2%) while energy intensity is expected to decrease by 24% (1.8%).

Figure 35 Final Energy Usage and Intensity 1990 – 2020



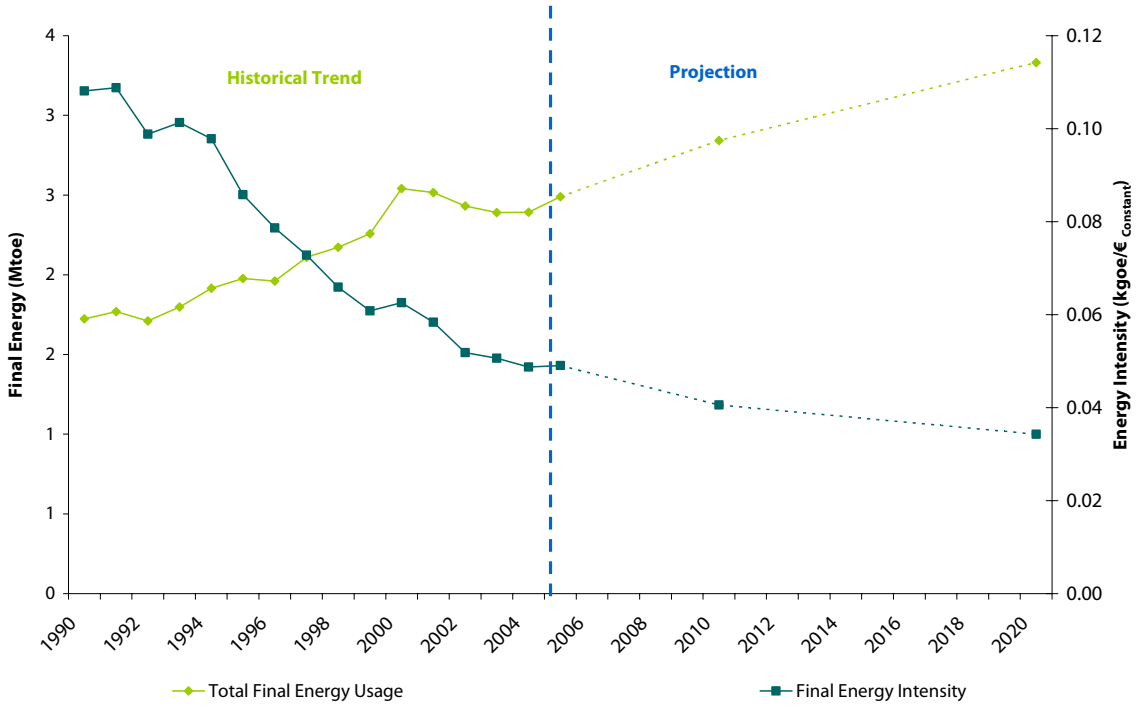
Source: SEI, CSO and ESRI

[41] ESRI, 2005, *Medium-Term Review: 2005-2012, No. 10* Available from www.esri.ie

In the industry sector, Figure 36, over the period 1990 to 2005 final energy usage increased by 44% (2.5% per annum) while energy intensity decreased by 55% (5.1%).

Over the period 2005 to 2020 final energy usage is forecast to increase by 34% (2%) while energy intensity is expected to decrease by 30% (2.4%).

Figure 36 Industry Final Energy Usage and Intensity 1990 – 2020

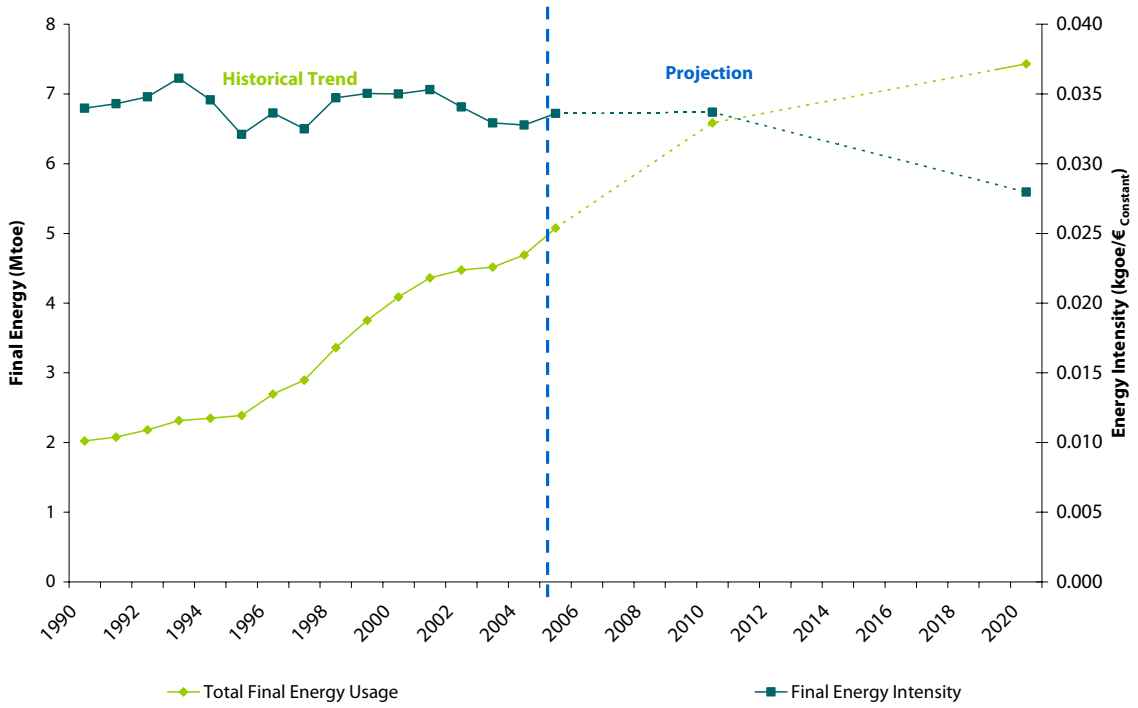


Source: SEI, CSO and ESRI

In the transport sector, Figure 37, over the period 1990 to 2005 final energy usage increased by 151% (6.3% per annum) while energy intensity decreased by 1% (0.1%).

Over the period 2005 to 2020 final energy usage is forecast to increase by 46% (2.6%) while energy intensity is expected to decrease by 17% (1.2%).

Figure 37 Transport Final Energy Usage and Intensity 1990 – 2020

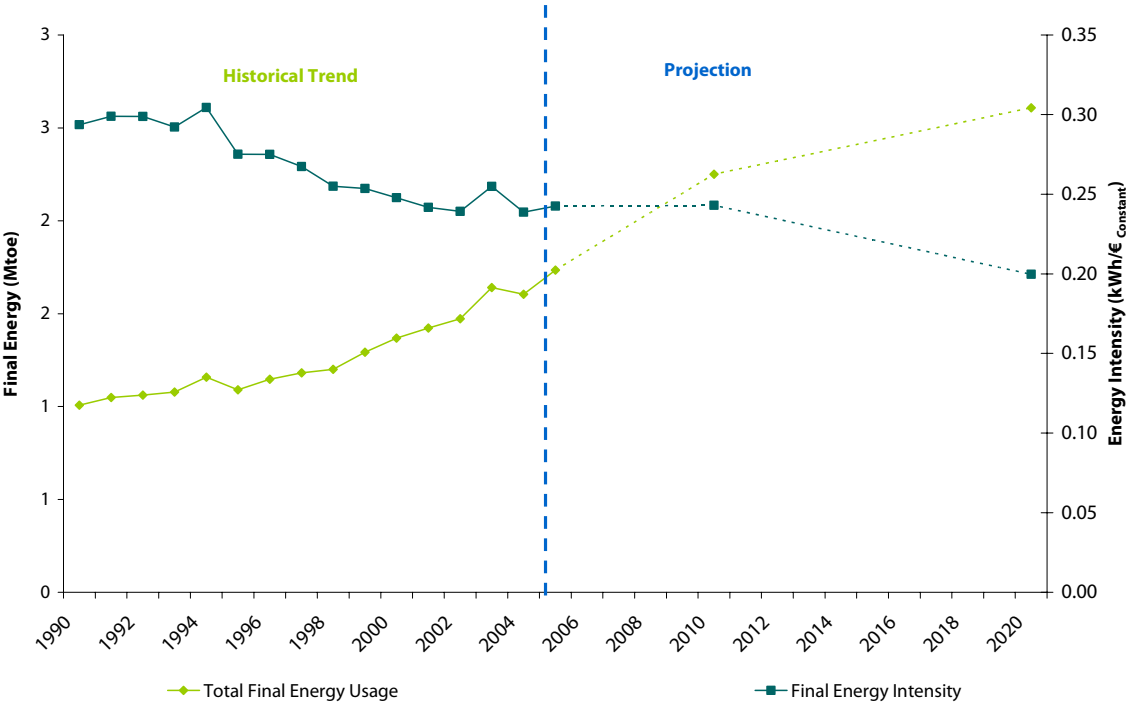


Source: SEI, CSO and ESRI

In the services sector, Figure 38, over the period 1990 to 2005 final energy usage increased by 72% (3.7% per annum) while energy intensity decreased by 17% (1.3%).

From 2005 to 2020 final energy usage is forecast to increase by 50% (2.8%) while energy intensity is expected to decrease by 18% (1.3%).

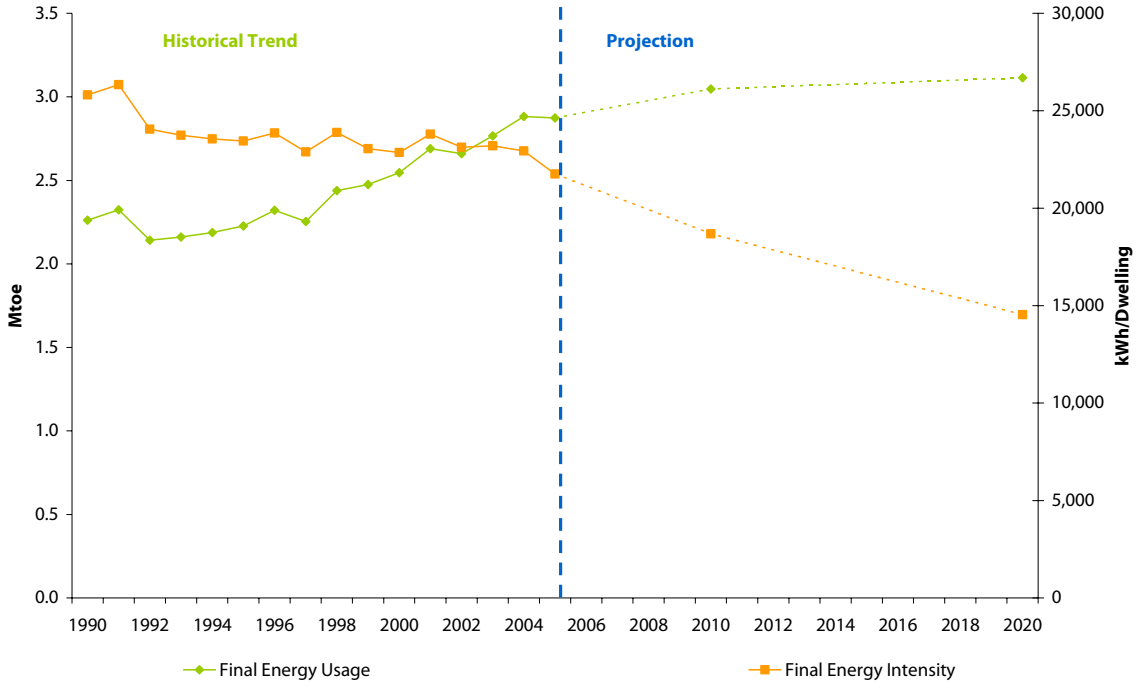
Figure 38 Services Final Energy Usage and Intensity 1990 – 2020



Source: SEI, CSO and ESRI

Finally, in the residential sector, Figure 39, over the period 1990 to 2005 energy usage increased by 27% (1.6% per annum) while average energy use per dwelling decreased by 16% 1.1% per annum. From 2005 to 2020 growth in energy usage is forecast to be 8% (0.5% per annum) while energy intensity is expected to decrease by 33% (2.6% per annum).

Figure 39 Residential Final Energy Usage and Intensity 1990 – 2020



Source: SEI, CSO and ESRI

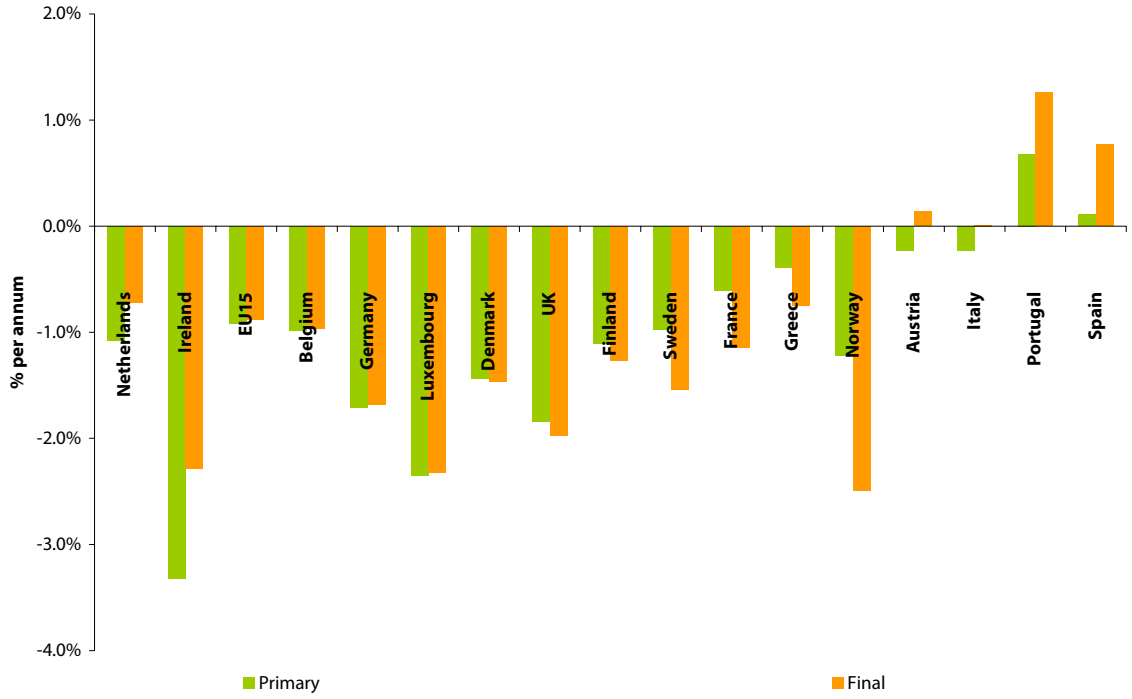
The increases in sectoral energy usage shown in this section, aggregating to an overall 34% increase by 2020, indicate the scale of the task required to achieve the 20% reduction in energy usage target from the White Paper on Energy.

10 International Comparison

In this section trends in Ireland are compared with trends internationally, using data from the EU Odyssee[42] project. For comparison purposes data for Ireland may be different to that presented earlier in this report[43]. It also should be noted that the period examined in this section is 1990 or 1995 to 2004, as opposed to 2005 elsewhere.

Figure 40 and Table 6 illustrate the per annum change in primary and final energy intensity for EU-15 countries and Norway over the period 1990 to 2004. It can be seen that Ireland recorded the largest per annum reduction in primary intensity over the period. Only Luxembourg and Norway experienced a slightly greater reduction in final intensity.

Figure 40 Variation of Energy Intensity in EU-15 Countries and Norway 1990 - 2004



Source: Odyssee

For 6 countries (Ireland, Netherlands, Austria, Italy, Portugal and Spain) primary energy intensity has decreased faster (or increased slower) than final intensity indicating an overall improvement in the efficiency of electricity generating power plants. This has been achieved by the increasing use of combined cycle gas, combined heat and power and wind. The other countries (and the EU-15 as a whole) either recorded similar trends or final intensity decreased at a faster rate than primary intensity. This was the trend for all countries before the advent of new electricity generating technologies.

[42] Odyssee is a cross European project which develops and maintains a database of energy efficiency indicators. More information can be found at http://www.odyssee-indicators.org/.

[43] The values taken from the Odyssee data base for Ireland have been revised recently by SEI. These revised values were used in the first part of the report. The Odyssee database will be updated later in 2007.

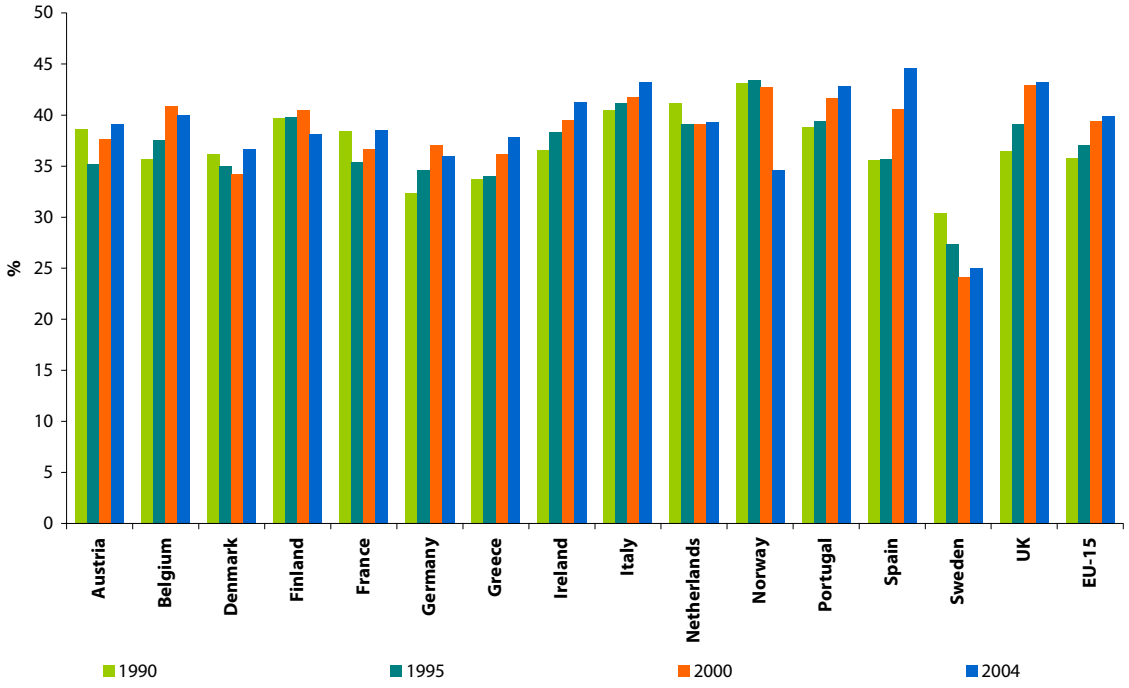
Table 6 Variation of Energy Intensity in EU-15 Countries and Norway 1990 - 2004

	Primary Intensity %	Final Intensity %
Ireland	-3.32	-2.29
Luxembourg	-2.35	-2.32
UK	-1.84	-1.97
Germany	-1.71	-1.68
Denmark	-1.44	-1.47
Norway	-1.22	-2.49
Finland	-1.11	-1.27
Netherlands	-1.08	-0.72
Belgium	-0.99	-0.97
Sweden	-0.98	-1.54
EU 15	-0.92	-0.88
France	-0.61	-1.15
Greece	-0.39	-0.75
Austria	-0.23	0.14
Italy	-0.23	0.01
Spain	0.11	0.77
Portugal	0.68	1.26

Source: Odyssee

Figure 41 and Table 7 show the efficiency of electricity generation from fossil fuels

Figure 41 Efficiency of Electricity Generation from Fossil Fuels 1990, 1995, 2000 and 2004



Source: Odyssee

Table 7 Efficiency of Electricity Generation from Fossil Fuels 1990, 1995, 2000 and 2004

	1990 %	1995 %	2000 %	2004 %
Spain	35.6	35.7	40.6	44.6
Italy	40.5	41.2	41.7	43.2
UK	36.5	39.1	43.0	43.2
Portugal	38.8	39.5	41.7	42.8
Ireland	36.6	38.3	39.5	41.3
Belgium	35.7	37.6	40.9	40.1
EU-15	35.8	37.1	39.4	39.9
Netherlands	41.2	39.1	39.1	39.3
Austria	38.6	35.2	37.7	39.1
France	38.5	35.4	36.7	38.5
Finland	39.7	39.8	40.5	38.2
Greece	33.7	34.1	36.2	37.9
Denmark	36.2	35	34.3	36.7
Germany	32.3	34.7	37.1	35.9
Norway	43.1	43.4	42.8	34.6
Sweden	30.4	27.4	24.1	25.1

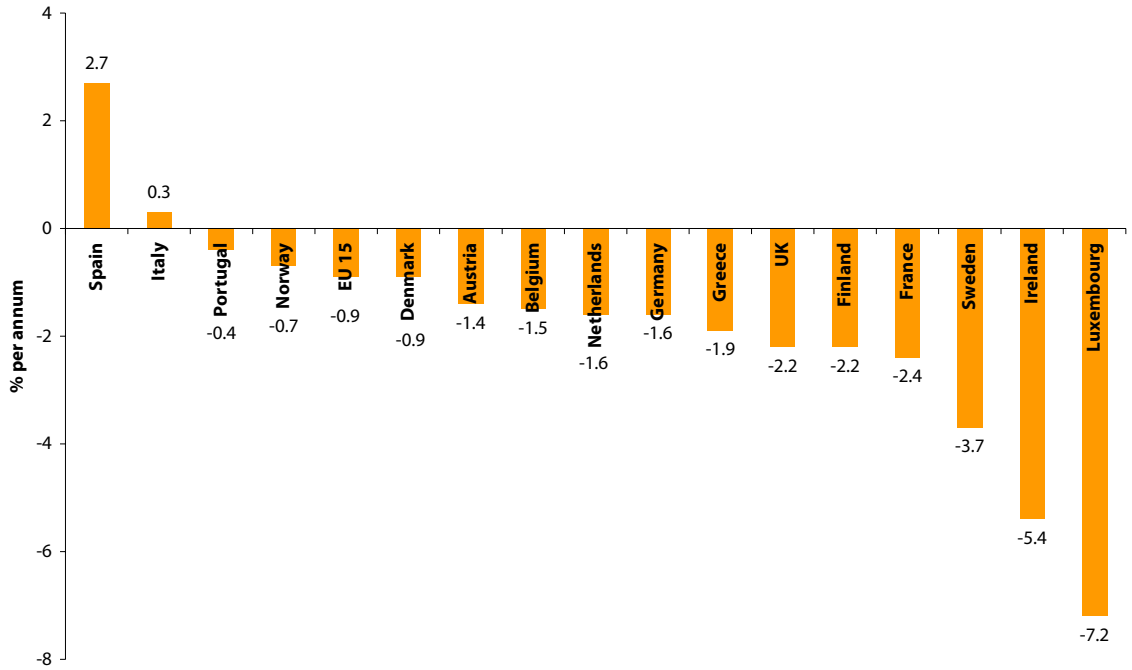
Source: Odyssee

Ireland has improved its ranking from 8th highest efficiency (36.6%) in 1990 to 5th (41.3%) in 2004. All countries with the exception of Sweden, Norway, Finland and the Netherlands improved their efficiency. Spain recorded the largest improvement (9%) over the period 1990 to 2004 followed by Ireland[44]. Over the same period the EU-15 average increased from 35.8% to 39.9%.

The change in energy intensity in industry is shown in Figure 42. The wide range is evident with Spain's intensity increasing by 2.7% per annum while industry intensity in Luxemburg decreased by 7.2% per annum. Ireland had the second largest decrease over the period (5.4% per annum) while the intensity for the EU-15 average declined by 0.9% per annum. Note that structural changes are not taken into account, also the data for Ireland are based on an older methodology, not that seen in section 5. Data is included in this form here for comparison purposes.

[44] Note that the figures for France, Sweden and Norway are less relevant as thermal electricity represent less than 10% of the electricity production in these countries.

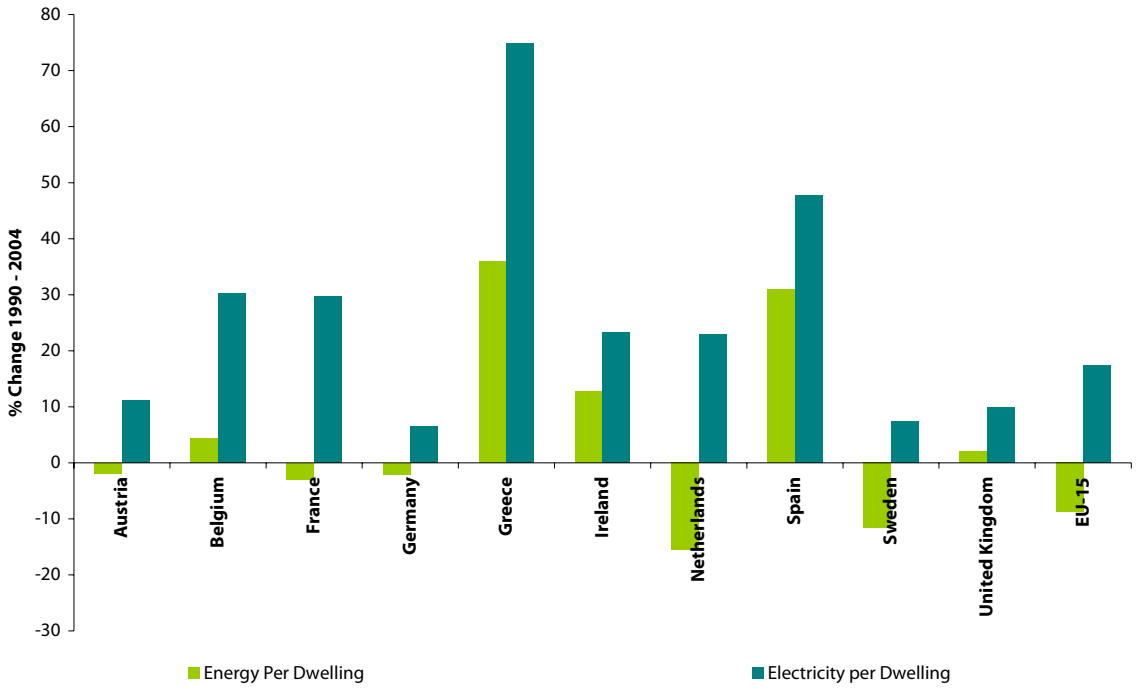
Figure 42 Variation in Industry Energy Intensity 1990 - 2004



Source: Odyssee

Figure 43 and Table 8 show the change in energy and electricity per dwelling over the period 1990 to 2004. Only EU-15 countries which have a full dataset are included. Energy usage per dwelling data are climate corrected.

Figure 43 Variation in Energy and Electricity per Dwelling 1990 - 2004



Source: Odyssee

Table 8 Variation in Energy and Electricity per Dwelling 1990 – 2004

	Energy per Dwelling %	Electricity per Dwelling %
Austria	-1.9	11.2
Belgium	4.4	30.3
France	-3.0	29.8
Germany	-2.1	6.5
Greece	36.0	74.9
Ireland	-12.7	23.3
Netherlands	-15.6	23.0
Spain	31.0	47.7
Sweden	-11.7	7.4
United Kingdom	2.1	9.8
EU-15	-8.8	17.3

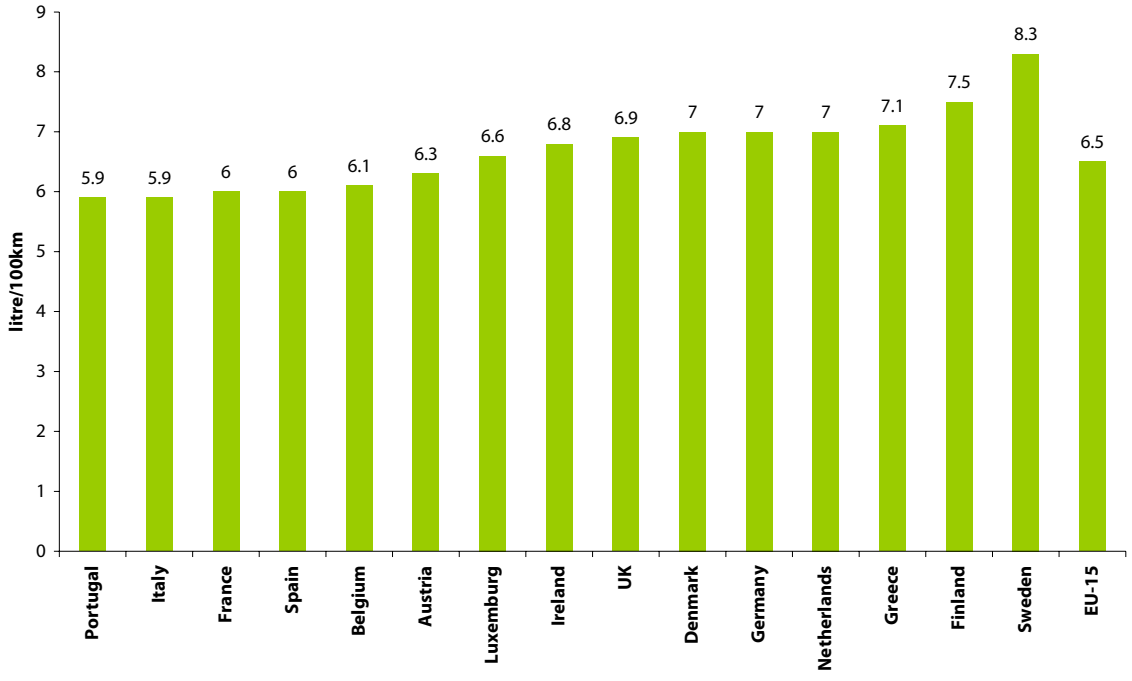
Source: Odyssee

It can be seen that all the countries shown have experienced an increase in electricity per dwelling over the period. Greece and Spain recorded the largest increases (75% and 48%). The increasing use of air conditioning is one reason for this. Ireland increased its electricity usage per dwelling by 25% while the EU-15 average increased by 17%.

The trends in energy usage per dwelling are more mixed. Greece (36%), Spain (31%) and the UK (2.1%) recorded an increase. Energy per dwelling fell in the other counties with the Netherlands showing the largest decrease (16%) followed by Sweden (12%) and Ireland (13%). The average for the EU-15 fell by 9%.

Figure 44 illustrates the specific consumption of new cars in the EU-15 for 2004. The range between the lowest and highest is 2.4 litres /100km. Ireland (6.8 litres /100km) is in the middle of the range slightly above the EU-15 average (6.5 litres /100km).

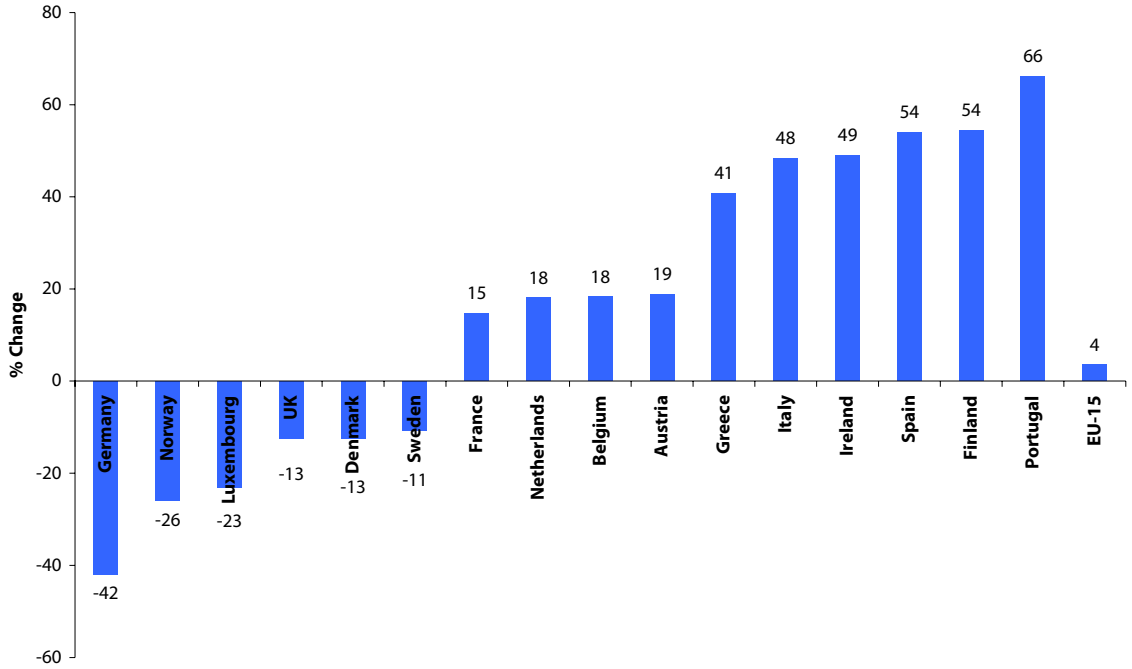
Figure 44 Specific Consumption of New Cars 2004



Source: Odyssee

Figure 45 shows the change in services sector electricity consumption for the period 1990 to 2004.

Figure 45 Variation in Services Sector Electricity Intensity 1990 - 2004



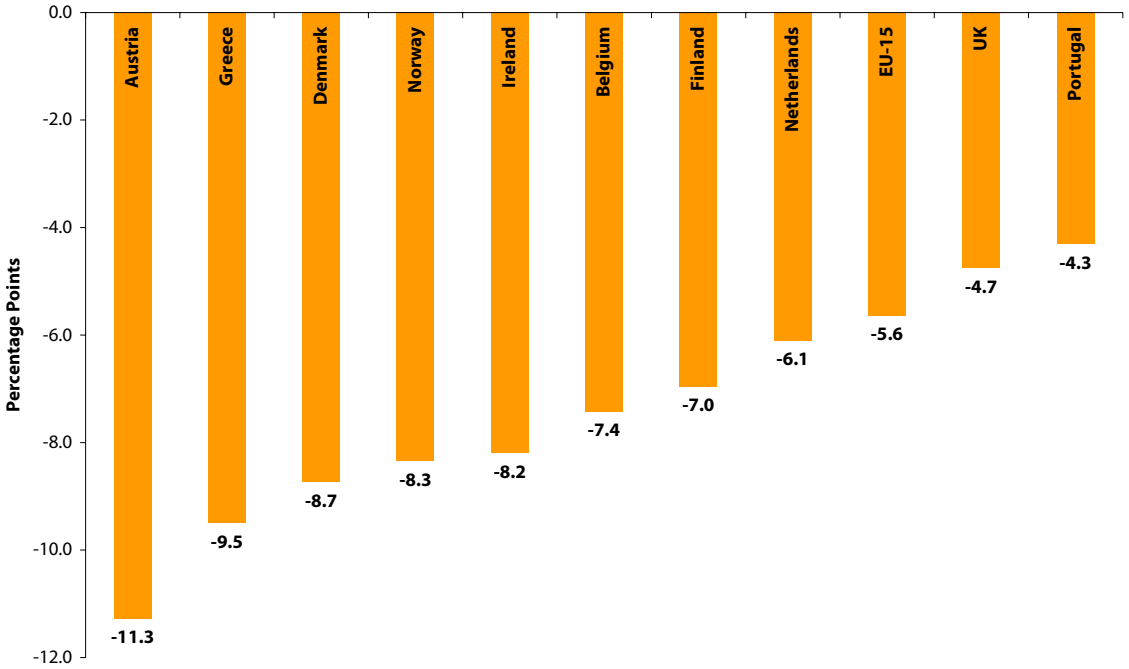
Source: Odyssee

Again, a wide range between countries is evident. Germany recorded the largest reduction (42%) while Portugal experienced an increase of 66%. Ireland had the 4th largest increase (49%). The EU-15 average in creased by 4%.

As seen in section 4 any change in energy intensity may be due to a number of factors not necessarily energy efficiency, therefore when examining energy efficiency trends it is more correct to compare ODEX indicators across countries.

Figure 46 shows the change in the observed ODEX for the EU-15 and a selection of countries[45] for the period 1995 to 2004. It can be seen that Ireland experienced the 5th largest reduction of the counties shown. Much of the improvement comes from industry[46] as we have seen for Ireland (section 5).

Figure 46 Variation in ODEX for EU-15 and Selected Countries 1995 - 2004



Source: Odyssee

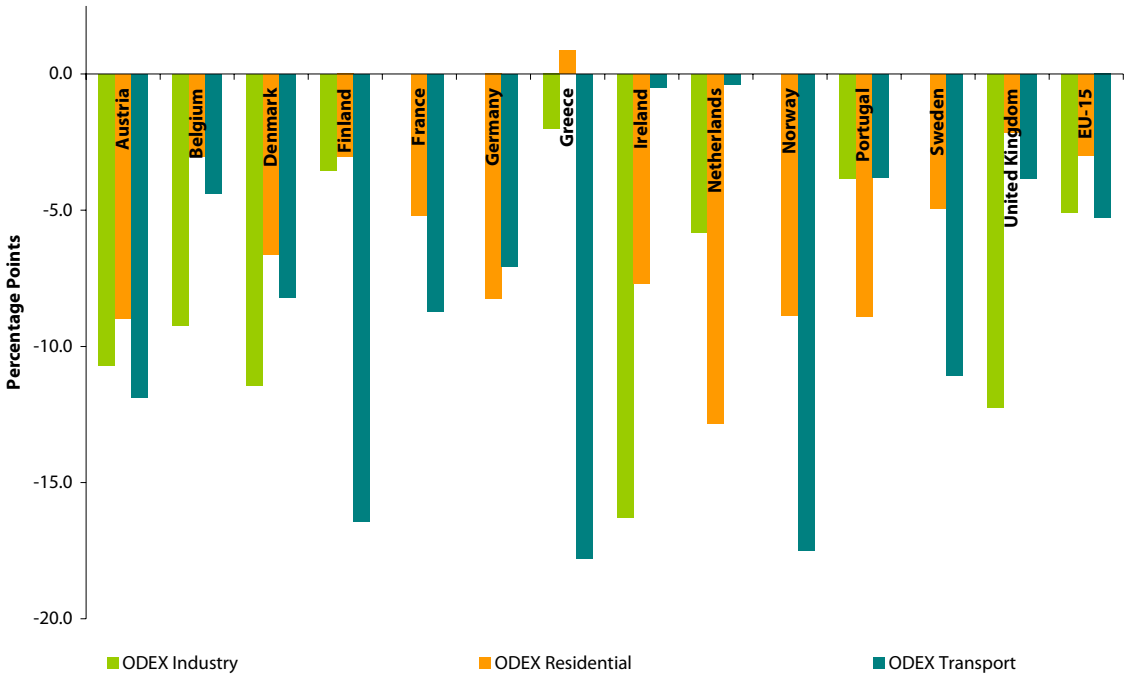
Figure 47 and Table 9 show the change since 1995 in sectoral ODEX (observed) indicators for the EU-15 and Norway.

[45] Where data is available for the whole period.

[46] Bosseboeuf D. et al, 2005, Energy Efficiency Monitoring in the EU-15. Published by ADEME and the European Commission. Available from http://www.odyssee-indicators.org/Publication/publications.php.

For countries where all three indicators are available it can be seen that industry has experienced the greatest improvement in energy efficiency in Belgium, Denmark, Ireland and the UK. For the EU-15 transport showed a slightly higher increase.

Figure 47 Variation in Industry ODEX for EU-15 and selected Countries 1995 - 2004



Source: Odyssee

Table 9 Variation in Sectoral ODEX 1995 - 2004

	ODEX Industry % Point Change	ODEX Residential % Point Change	ODEX Transport %Point Change
Austria	-10.7	-9.0	-11.9
Belgium	-9.2	-3.0	-4.4
Denmark	-11.4	-6.6	-8.2
Finland	-3.5	-3.1	-16.4
France		-5.2	-8.7
Germany		-8.3	-7.1
Greece	-2.0	0.9	-17.8
Ireland	-16.3	-7.7	-0.5
Netherlands	-5.8	-12.8	-0.4
Norway		-8.9	-17.5
Portugal	-3.8	-8.9	-3.8
Sweden		-4.9	-11.1
United Kingdom	-12.2	-2.1	-3.8
EU-15	-5.1	-3.0	-5.3

Source: Odyssee

The industry and residential ODEX for Ireland compares well with the other EU-15 countries but not so well in the transport sector.

11 Conclusions and Next Steps

The 20% energy savings target by 2020 from the White Paper is challenging when compared with 64% growth in primary energy that has occurred over the period 1990 to 2005 and the forecasted 34% increase in final energy usage by 2020.

This report examines energy usage, intensity and efficiency in order to provide context and background to discussions regarding future policy options. It is the first SEI/EPPSU report to focus exclusively on this topic.

The report finds that while energy intensity in Ireland has decreased by 32% from 1990 to 2005, much of this is due to structural changes particularly in the make up of the industry sector. This reduction, however, does not necessarily equate to an improvement in energy efficiency. Therefore an analysis based on ODEX indicators has been developed to measure energy efficiency in Ireland.

As measured by ODEX, at the economy level, energy efficiency improved by 8.1% from 1995 to 2005. Over the same period there has been a 15% gain in energy efficiency in the industry sector. There has been an 8.2% improvement in the residential sector, most of which is attributable to the improved efficiency standards of new dwellings. In the transport sector a slight improvement in efficiency (0.8%) has been recorded as a result of cars becoming more efficient and improved load factor of goods vehicles.

The ODEX indicators indicate that behavioural[47] effects are a significant driver in increasing energy usage in Ireland (particularly in the residential and transport sectors). Ireland would have experienced a greater improvement in energy efficiency were it not, inter alia, for the purchase of larger cars, larger dwellings and increased heating in these dwellings. This is, therefore, a key area where future efficiency gains can be made. Overall, the significant reduction in energy intensity that has occurred in recent years is largely the result of technical factors.

The ODEX indicators will be refined in future iterations of this report as the datasets used require continuous improvement. In addition, SEI and EPA are co-funding a Research Fellowship that will contribute to the efforts in modelling and forecasting of both medium and long term energy demand and energy efficiency policies.

This report is intended to be a first step in an on-going process to develop and improve energy efficiency indicators. The report is presented as a discussion document and comments from the energy, environment, enterprise and economic policy community are most welcome.

SE/EPSSUI gratefully acknowledges the assistance of Bruno Lapillonne of ENERDATA for his assistance in developing specific energy efficiency indicators for Ireland.

[47] Technical efficiency gains arise from the use of more energy efficient technologies whereas behavioural gains are the result of how technologies are used.

Data Sources

Central Statistics Office

Economic and Social Research Institute

Department of Environment, Heritage and Local Government

Met Éireann

Odyssee

Vehicle Certification Agency (UK)

NACE Classification

Section A Agriculture, hunting and forestry

01	Agriculture hunting and related service activities
02	Forestry logging and related service activities

Section B Fishing

05	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing

Section C Mining and quarrying

10	Mining of coal and lignite; extraction of peat
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
12	Mining of uranium and thorium ores
13	Mining of metal ores
14	Other mining and quarrying

Section D Manufacturing

15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c.
37	Recycling

Section E Electricity, gas and water supply

40	Electricity, gas, steam and hot water supply
41	Collection, purification and distribution of water

Section F Construction

45	Construction

Section G Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods

50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel

51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods

Section H Hotels and restaurants

55	Hotels and restaurants

Section I Transport, storage and communication

60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications

Section J Financial intermediation

65	Financial intermediation, except insurance and pension funding
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation

Section K Real estate, renting and business activities

70	Real estate activities
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computer and related activities
73	Research and development
74	Other business activities

Section L Public administration and defence; compulsory social security

75	Public administration and defence; compulsory social security

Section M Education

80	Education

Section N Health and social work

85	Health and social work

Section O Other community, social and personal service activities

90	Sewage and refuse disposal, sanitation and similar activities
91	Activities of membership organisations n.e.c.
92	Recreational, cultural and sporting activities
93	Other service activities

Section P Private households with employed persons

95	Private households with employed persons

Section Q Extra-territorial organisations and bodies

99	Extra-territorial organisations and bodies

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Sustainable Energy Ireland
Energy Policy Statistical Support Unit
Building 2200
Cork Airport Business Park
Co. Cork
Ireland

T. +353 21 4547050 | epssu@sei.ie
F. +353 21 4547059 | www.sei.ie

Sustainable Energy Ireland
Glasnevin
Dublin 9
Ireland

T. +353 1 8369080 | info@sei.ie
F. +353 1 8372848 | www.sei.ie

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