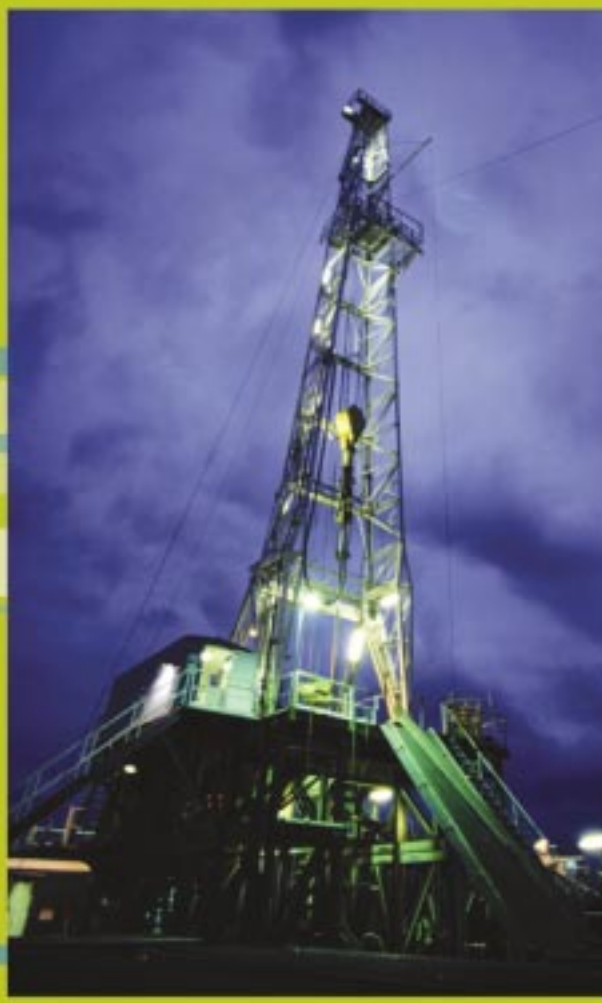
Energy in Ireland 2002

Trends, issues and indicators 1990-2001



SUSTAINABLE ENERGY IRELAND
Energy Policy Statistical Support Unit

Sustainable Energy Ireland

Sustainable Energy Ireland (SEI) is Ireland's national energy agency. Established on May 1st 2002 under the Sustainable Energy Act 2002, SEI has a mission 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. 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 the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan.

SEI manages programmes aimed at:

- 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 (RD&D);
- stimulating preparation of necessary standards and codes;
- publishing statistics and projections on sustainable energy and achievement of targets.

SEI is responsible for advising Government on policies and measures on sustainable energy; implementing programmes agreed by Government and stimulating sustainable energy policies and actions by public bodies, the business sector, local communities and individual consumers.

Energy Policy Statistical Support Unit

Sustainable Energy Ireland 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, advising policy makers, and informing investment decisions. Based in Cork, the Energy Policy Statistical Support Unit 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 analyses of energy services sectors and sustainable energy options;
- Contribute to the development and promulgation of appropriate sustainability indicators.

Report prepared by
Martin Howley, Brian Ó Gallachóir and Brendan O'Loughlin[*]

[*] Department of Communications, Marine & Natural Resources

Energy in Ireland – Highlights

- Over the period 1990 – 2001, Ireland's energy consumption grew by 57%. Growth in 2001 was 5.5% and the average annual growth was 4.2%. This increase in consumption over the period was primarily prompted by annual economic growth (GDP) levels averaging 7.3% during the 1990s.
- GHG (greenhouse gas) emissions in Ireland during 2001 were 27% above 1990 levels. Under the Kyoto Protocol, ratified by Ireland in 2002, our target is to limit annual emissions to 13% above 1990 levels by the period 2008 – 2012.
- Energy production and consumption was responsible for 66% of Ireland's total GHG emissions in 2001, growing from a share of 57% in 1990. Agriculture related emissions fell from 34% to 27% in the same period. This reflects the changing structure of the Irish economy. Energy related CO_2 emissions in 2001 were 44% higher than 1990 levels.
- Energy related CO_2 emissions in transport during 2001 were 120% higher than 1990 levels, with growth in 2001 alone of 8%. Transport accounted for 26% of emissions in 2001, a larger share than industry (25%) but still lower than the residential sector (28%). Although the services sector accounted for a lower share in 2001 (18%), its annual growth rates of 4.3% were higher than either industry (2.5%) or residential (1%) and growth in 2001 was 4.6%.
- Ireland's import dependency has grown from 65% to 87% since 1990. This reflects the declining natural gas resource at the Kinsale field. EU import dependency has remained around 50%.
- Oil remains the dominant energy source and its share of the fuel mix increased from 46% in 1990 to 58% in 2001. Oil consumption almost doubled in absolute terms over this 11-year period. The share of solid fuels (coal and peat) in the fuel mix has declined from 37% to 20% while the contribution from natural gas increased from 15% to 21%. Renewable energy contributed 1.8% in 1990 compared with 1.7% in 2001.
- The efficiency of electricity supply increased towards the end of the decade due mainly to gas increasing its share in the fuel mix from 27% in 1990 to 35% in 2001. Final consumers of electricity received 35% of the energy inputted into power stations in 2001, compared with 33% in 1990. This contributed to a reduction in the carbon intensity of electricity. A unit of electricity consumed was responsible on average for 780 g of CO_2 in 2001 compared with 890 g in 1990.
- The contribution of renewable energy to primary energy supply has remained at less than 2% over the period, most of which was due to traditional biomass and large-scale hydropower.
- Renewable energy's contribution to gross electricity consumption was 5% for most of the period but dropped to 4% in 2001 due to lower hydropower production. Wind energy and landfill gas generation have increased considerably since 1998 but still only accounted for about 1.5% of electricity consumption in 2001.
- Energy intensity of the Irish economy fell by 26.4% between 1990 and 2000. Approximately one third of this reduction can be accounted for by structural changes in the economy.
- Growth has been highest in the transport sector (7.1% per annum), which in 2001 accounted for 30% of Ireland's energy needs. The residential sector has seen slower growth rates (2.4% per annum) but is responsible for 26% of energy consumption. The industrial sector consumed 24% in 2001, a lower share than in 1990 despite annual growth rates of 3%. Significant growth has been seen in the services sector (4.9% per annum), which now consumes 17% of energy in Ireland. The share consumed by agriculture remained about 3% in 2001.
- All sectors, with the exception of transport, showed some degree of decoupling of economic growth from energy consumption. Transport maintains a strong direct coupling with economic growth.
- Industry value added grew by approximately 170% between 1990 and 2000 whereas energy consumption in industry grew by 31%. This resulted in the energy intensity of industry falling by 3.7% per annum. Almost half of this reduction in industrial intensity can be accounted for by structural changes within the industry sector.
- Energy consumption in the residential sector grew by approximately 22.5% between 1990 and 2001 against a growth of approximately 18.8% in the number of permanently occupied dwellings over that period. The energy intensity of the residential sector expressed as average energy consumption per dwelling has remained relatively constant since 1990. Within this pattern, average electricity consumption per dwelling has increased by 38% since 1990 or 3% per annum, whereas over the same period average fuel consumption per dwelling has fallen by 3.6% or an average of 0.3% per annum.
- Overall energy intensity of the tertiary sector has been declining since 1994 and the electricity intensity has started to decline since 1997. This reflects mainly the rate of growth in economic value added in the sector. In terms of energy consumption, this has been the second fastest growing sector, with an increase of approximately 58% between 1990 and 2001.

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1 Introduction

This is the first published report of SEI's Energy Policy Statistical Support Unit, based in Cork. The Unit was established to deliver on the remit of SEI in respect of the development, collation, analysis, publication and maintenance of national energy statistics, indicators and trends.

The report examines energy trends in Ireland since 1990, discusses the underlying causes and relates the trends to Government and EU targets in order to inform the development of the policies and measures employed to meet the targets. The year 1990 is significant as a baseline, not least because, under the Kyoto Protocol and associated EU targets, Ireland's obligations to contain emissions of greenhouse gases, of which the bulk is CO_2 derived from energy utilisation, are referenced against relevant emissions for that year.

The authors are grateful to the Government Departments and Agencies acknowledged at the end of this report for the provision of data.

It should be noted that the energy data for 2001 is provisional.

2 Energy Trends

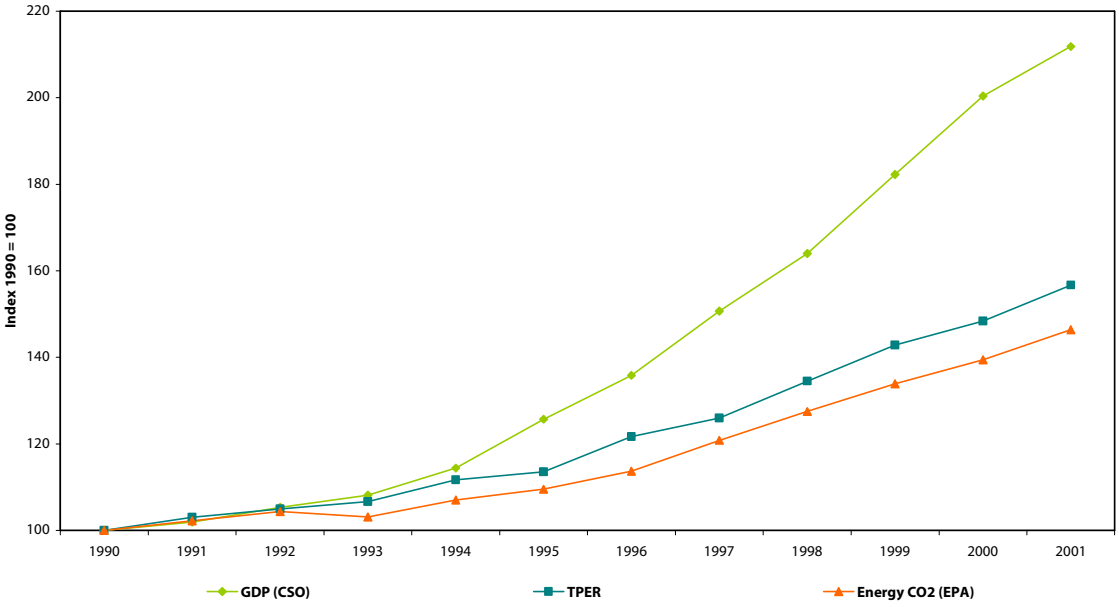
This section provides an overview of energy trends in Ireland, covering the period 1990 – 2001 and with a particular focus on 2001. Ireland's total energy supply (approximating to energy demand or consumption) is examined first, in terms both of the mix of fuels used and consumption by sector. Energy demand, the amount of energy used by final consumers, is then explored. The link between energy consumption and economic activity is also discussed and finally electricity production is examined in its own right.

Energy supply depends on i) the demand for energy and ii) how that demand is delivered. Energy demand in turn is driven primarily by economic activity. Throughout the 1990's economic growth has been particularly strong, especially from 1993 onwards. This resulted in GDP (a measure of economic growth) in 2001 being more than double that of 1990. As highlighted in figure 1, this was achieved with a 57% increase in primary energy consumption and a 46% increase in CO_2 emissions.

GDP growth averaged 2.7%/annum between 1990 and 1993. This rose to 8.6%/annum from 1993 to 1997 and to 10.0%/annum between 1997 and 2000. Over the decade as a whole GDP growth averaged 7.2%/annum, representing a doubling to €83,710 million in 2000 (at constant 1995 prices). Growth slowed to 5.7% in 2001.

Figure 1 shows the extent to which total energy consumption (TPER) has decoupled from economic growth since 1992. This is a result of changes in the structure of the economy and improvements in energy efficiency. To a lesser extent, the decoupling of CO_2 emissions from energy consumption is also evident, particularly since 1993.

Figure 1: Index of Gross Domestic Product, TPER and Energy Related CO_2



2.1 Energy Supply

Ireland's energy supply is discussed in terms of changes to the total primary energy requirement (TPER, also known as gross inland consumption), defined as the total amount of energy consumed within Ireland in any given year. This represents the consumption of energy in all the activities of Irish life and also includes the energy requirements for the conversion of primary sources of energy into forms that are useful for the final consumer, for example electricity generation and oil refining. These conversion activities are not wholly directly related to the level of economic activity that drives energy use but are dependent to a large extent, as in the case of electricity, on the efficiency of the transformation process and the technologies involved. Figure 2 illustrates the trend in energy supply over the period 1990 – 2001, highlighting a progressive shift in the fuel mix.

Figure 2: Total Primary Energy Requirement (Mtoe)

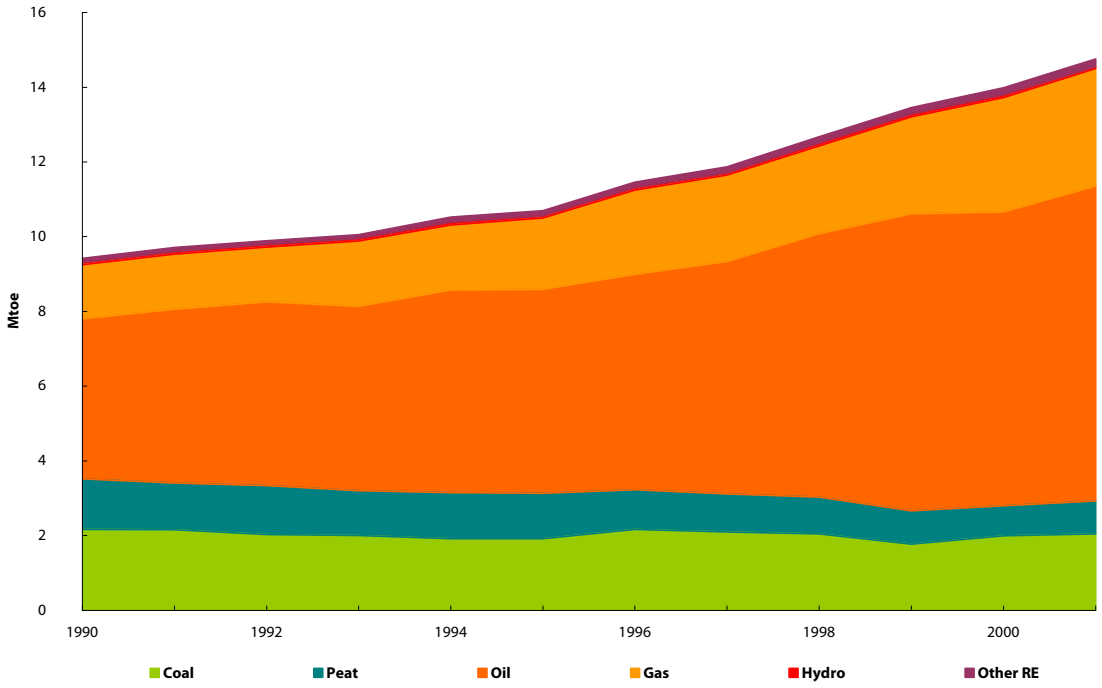


Figure 3 compares 1990 with 2001, showing the contribution by each fuel to energy supply.

Over the period 1990 – 2001 Ireland's total annual energy consumption grew in absolute terms by 56.6% (average annual growth rate of 4.2%) and in 2001 by 5.5%. The fuel mix has changed considerably, with the following being the main trends in national fuel share over the period:

- Oil remains the dominant energy source and with that dominance increasing, from a share of 45.5% in 1990 to 57.2% in 2001. Primary consumption of oil almost doubled over the period (+96.9%) with an average annual growth rate of 6.4%. Its share of energy supply increased from 46% to 58%. In 2001, oil consumption grew by 7.2%.

- The relative share of coal in energy supply declined from 23% to 14%. In absolute terms over the period coal declined by 5.6%, but in 2001 the use of coal increased by 2.6% over the previous year. This increase was for electricity generation as there was a decline in final consumption of coal.

- Peat experienced a decline in absolute terms over the period of 34.9% with its share of national energy supply also falling from 14% to 6%. In 2001 however, peat consumption increased by 10% over the previous year primarily for electricity generation, as there was also a decline in the final consumption of peat.

- Natural gas use increased by 117.1% (7.3%/annum) over the period, its share of energy supply increasing from 15% to 21%. Growth of natural gas consumption in 2001 was 2.6%.

- Hydro production decreased in 2001 and its share in the national primary energy supply has dropped from 0.62% in 1990 to 0.32% in 2001.

- Other renewable sources of energy (wind, biomass, landfill gas etc) increased in absolute terms since 1990 by 89.4%. This resulted in the share of other renewables to TPER rising from 1.16% to 1.41%. The use of other renewables rose by 11.2% over 2000 levels.

Figure 3: Total Primary Energy Requirement by Fuel 1990 and 2001

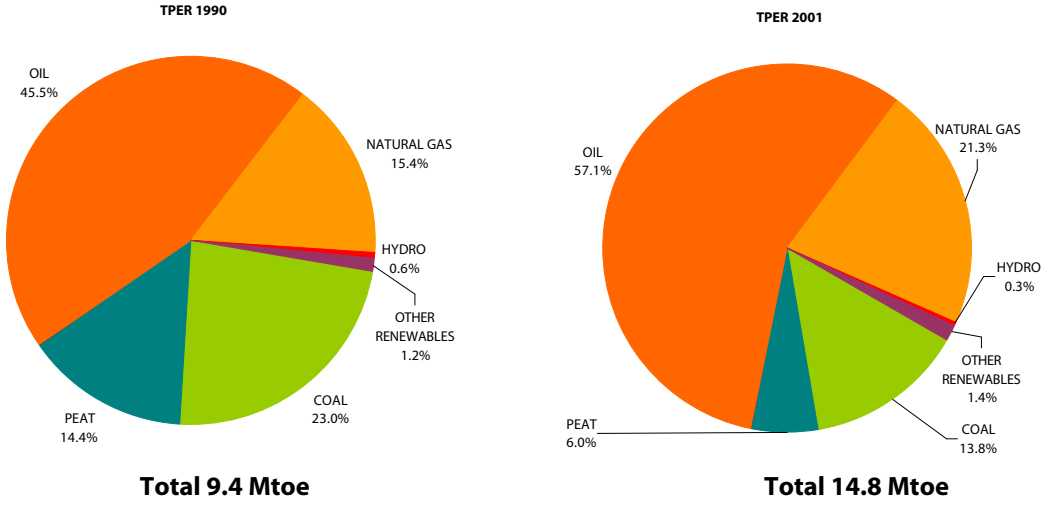
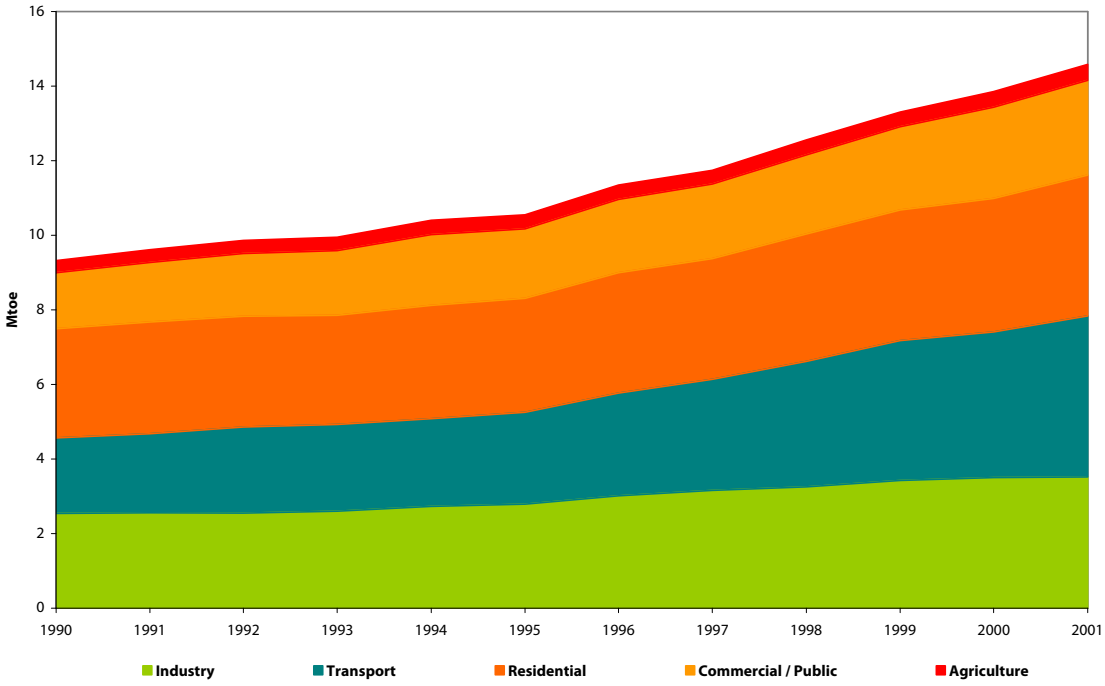


Figure 4 allocates Ireland's energy supply to each sector of the economy, according to their energy demand. Where fuels are used directly by a particular sector this is a straightforward allocation. Regarding electricity, the primary energy associated with each sector's electricity demand is calculated. The energy used directly is then added to the primary energy associated with electricity demand to yield the total energy supply for each sector.

Figure 4: Total Primary Energy Requirement by Sector[1]



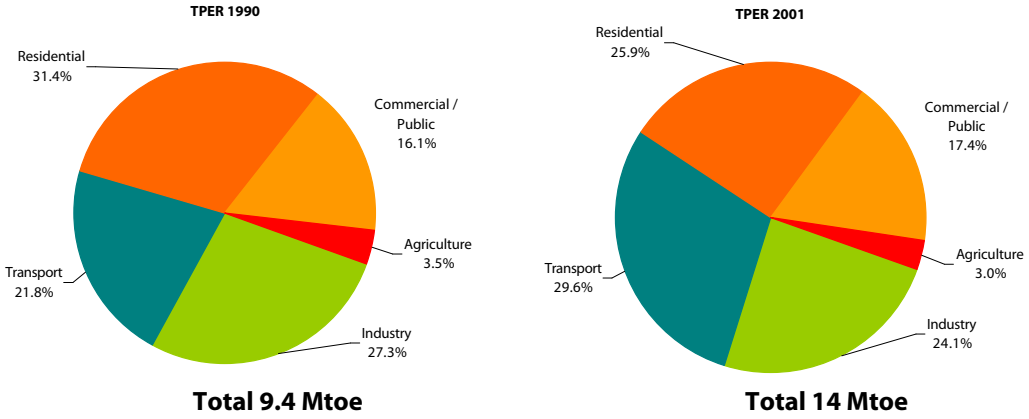
[1] Air transport kerosene is included in the transport sector in these graphs. Later graphs showing CO_2 emissions by sector omits air international transport energy emissions following UN Intergovenmental Panel on Climate Change (IPCC) guidelines.

No estimate is made of the effect of cross border trade and smuggling of diesel and petrol. The Society of the Irish Motor Industry (SIMI) and ESB International (ESBI) estimate this at around 10% of transport energy consumption.

This gives a more complete measure of the impact that each of the sectors has on energy demand and subsequent CO_2 emissions.

Figure 5 illustrates the sectoral share of TPER in 1990 and 2001.

Figure 5: Total Primary Energy Requirement by Sector for 1990 and 2001



It is notable that only the transport and the services or 'tertiary' (private / commercial and public) sectors have increased their share with transport becoming the dominant sector at 30% in 2001. In absolute terms sectoral energy consumption grew as follows:

- Industry energy consumption grew by 38.7% over the period 1990 – 2001 (3.0%/annum). In 2001 energy consumption growth was 0.6%.
- Transport energy consumption grew by 112.7% (7.1%/annum). Growth in 2001 was 10.5%.
- Residential energy consumption grew by 29.2% (2.4%/annum). Growth in 2001 was 5.5%.
- Tertiary consumption of energy grew by 69.5% (4.9%/annum). Growth in 2001 was 4.0%.
- Agriculture energy consumption grew by 31.6% (2.5%/annum). Growth in 2001 was 1.3%.

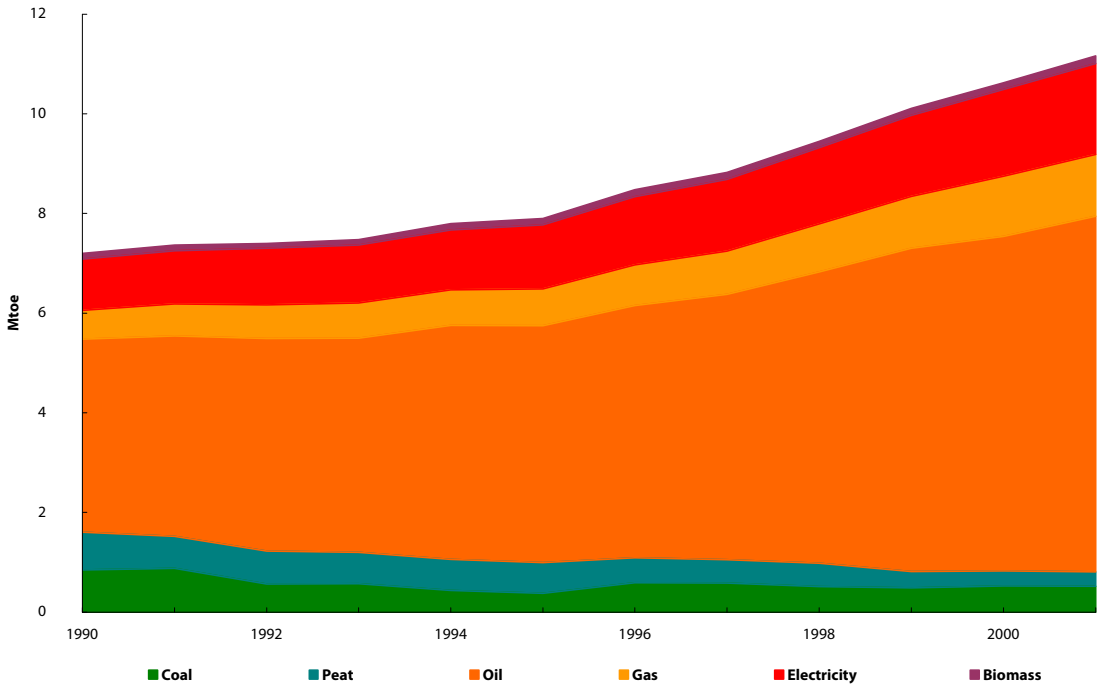
2.2 Energy Demand

Final energy demand is a measure of the energy that is delivered to energy end users in the economy to allow the conduct of 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 consumption 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 6 shows the shift in the pattern of final energy demand by fuel over the period 1990 – 2001.

Ireland's TFC in 2001 was 11.2 Mtoe, an increase of 5.1% on 2000 and 55.2% above 1990 (4.1%/annum). This means that the energy requirements to fuel the economic growth rates throughout the 1990's grew at just over half the rate of the economic growth. It also begs the question 'is the Irish economy more energy efficient now than in 1990?' (see section 2.3).

Figure 6: Total Final Consumption by Fuel, 1990-2001



As can be seen from figure 7, there have been some significant shifts in the mix of fuels in final consumption. These can be summarised as follows:

- Consumption of oil by final consumers grew by 6.4% in 2001. Over the 1990 – 2001 period oil grew by 84.3% (5.7%/annum) and its share in final consumption went from 53.5% to 64%.

- Natural gas has shown the highest growth rate over the 1990 – 2001 period, averaging 7.2% per annum. In absolute terms consumption of gas by final consumers grew by 114.9% over the period, which saw its share rise from 8% to 11.1%. Natural gas consumption grew by 2.9% in 2001.

- The share of electricity in final consumption rose from 14.3% to 16.3% during the 1990 – 2001 period. The consumption of electricity by end users is 76.7% higher at the end of the period (5.3% annual growth). Electricity consumption grew by 4.6% in 2001.

Coal and peat consumption dropped by 39.2% and 61.4% respectively between 1990 and 2001, reflecting a trend away from solid fuels.

Figure 7: Total Final Energy Consumption by Fuel for 1990 and 2001

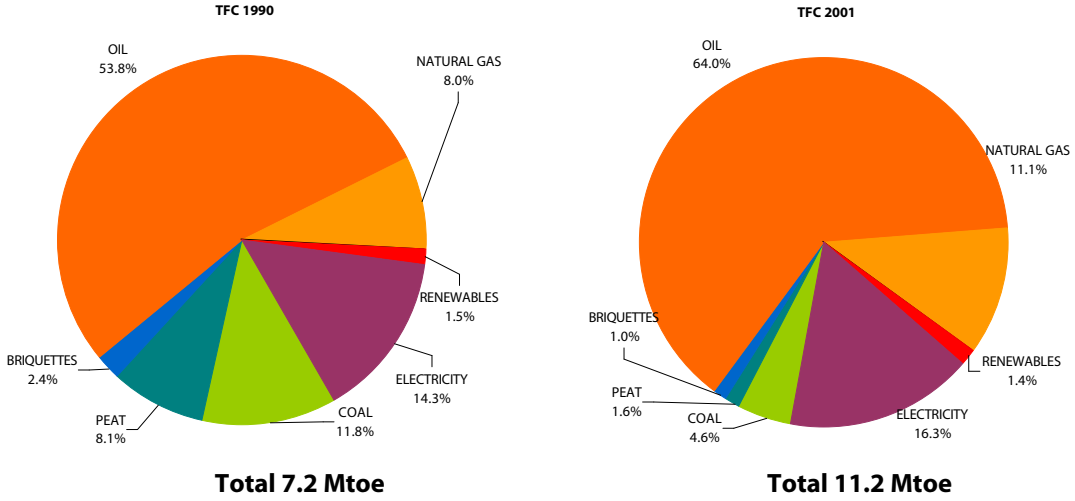
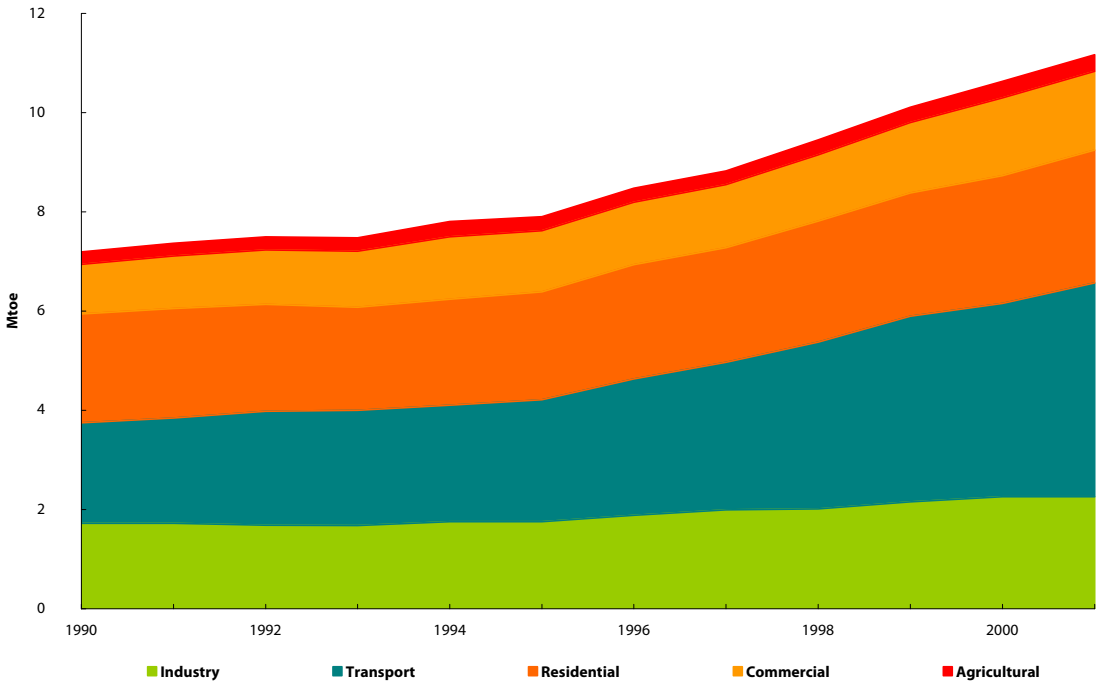


Figure 8 also shows the trend in TFC over the period, here allocated to each of the sectors of the economy.

Figure 8: Total Final Energy Consumption by Sector



Over the period the relative weighting of the sectors has changed. Transport has now become the dominant sector while the share of Industry has decreased. The changes are summarised as follows.

- Transport final energy consumption increased by 112.8% over the period 1990 – 2001, reaching a consumption figure of 4.3 Mtoe in 2001. This represents an average annual growth rate of 7.1% and transport's share of TFC increased from 28.2% to 38.6%. Growth in 2001 alone was 10.5%.

- Final energy consumption in the residential sector during 2001 was 2.7 Mtoe, representing a growth of 22.5% in real terms or a 1.9% average annual growth rate. Growth in the residential sector was 4.3% in 2001. Its share of TFC decreased from 30.4% in 1990 to 24% in 2001.

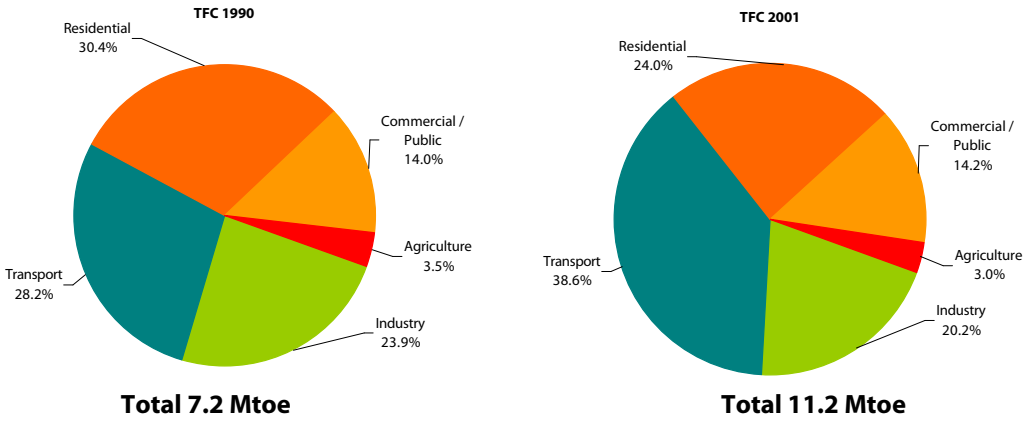
- Industry's final consumption grew to 2.3 Mtoe in 2001 yielding a 30.8% increase from 1990. This represents an average growth rate of 2.5% per annum and its share of TFC dropped from 23.9% to 20.2%. Interestingly, industry experienced a decline in energy consumption in 2001 of 0.03%.

- The commercial-public/tertiary/services sector is the only other sector along with transport to increase its share in final consumption. This increased slightly from 14% in 1990 to 14.2% in 2001. In absolute terms, final energy consumption grew by 57.8% to 1.6 Mtoe (4.3% per annum) over the period. This makes it the second fastest growth sector behind transport in terms of energy use albeit from a lower base. Growth in 2001 was 1.1% in this sector.

- The agricultural sector's relative share also fell from 3.5% in 1990 to 3% in 2001 although final energy consumption grew by 32.6% to 0.3 Mtoe (2.6% per annum). In absolute terms, Agriculture also experienced a small decline of 0.12% in energy consumption in 2001.

The changes in relative share of TFC amongst the different sectors are illustrated in Figure 9.

Figure 9: Total Final Energy Consumption by Sector for 1990 and 2001



2.3 Energy Intensities

Energy intensity is defined as the amount of energy required to produce some functional output. In the case of the economy the measure of output is generally taken to be gross domestic product (GDP)[2].

GDP measured in constant prices is used to remove the influence of inflation.

Figure 10 shows the trend in both primary (TPER/GDP) and final (TFC/GDP) energy intensities (at constant 1995 prices).

The difference between these two trends reflects the energy required in the transformation from primary energy to final energy – primarily in the generation of electricity. Throughout the 1990's there has been a slight convergence of these trends, reflecting the increasing efficiency of the electricity generation sector. With the increase in energy demand, especially electricity, the utilisation of the transformation process becomes more efficient as a result of an increase in load factors (for a power station, annual load factor is a measure of the average proportion of full generation capacity that is being availed of over a period; engineering systems tend to be technically most efficient at high load factors). In addition, newer transformation plant coming on stream tends to be of higher efficiency, such as combined cycle gas turbine generators, which would contribute to increasing the aggregate efficiency of the transformation process. Finally, increasing contributions from renewable sources will also tend to bring the trends closer together.

Figure 10: Primary and Final Energy Intensity

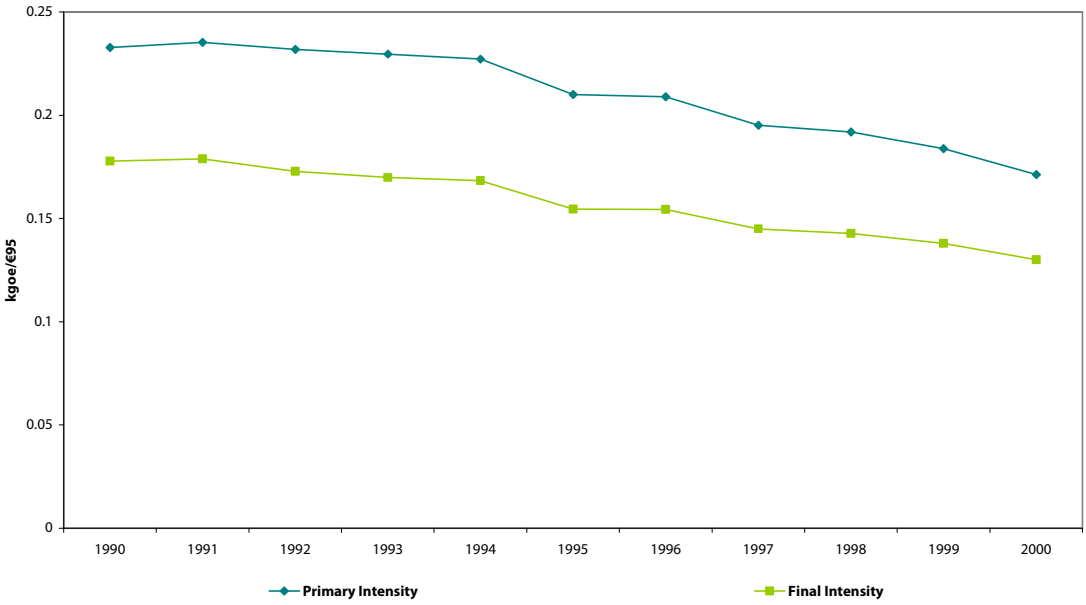


Figure 10 shows that the intensity of both primary and final energy requirements has been falling since 1990. The primary energy intensity of the economy fell by 26.4% between 1990 and 2000 (3% per annum).

In 1990 it required 0.23 kilograms of oil equivalent (kgoe) to produce one euro of GDP whereas in 2000 only 0.17 kgoe was required. This would suggest that the economy is becoming more energy efficient.

There are many factors that contribute to how the trend in energy intensity evolves. These factors include technological efficiency, choice of fuel mix, economies of scale and not least the structure of the economy. In Ireland's case, the economic structure has changed considerably over the past twenty years. The structure of today's GDP has shifted in the direction of higher value added sectors such as pharmaceuticals, electronics and services. Relative to traditional 'heavier' industries, these sectors are not highly energy intensive.

[2] Some commentators would argue that in Ireland's case that gross national product (GNP) should be used 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 makes sense to follow this convention.

Energy intensity will continue to show a decreasing trend if, as expected, the structure of 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 an economy that is more energy efficient but doesn't mean that the actual processes used are energy efficient. There may therefore still be considerable room for improvement.

Figure 11: Final intensity and at constant 1990 sectoral intensities

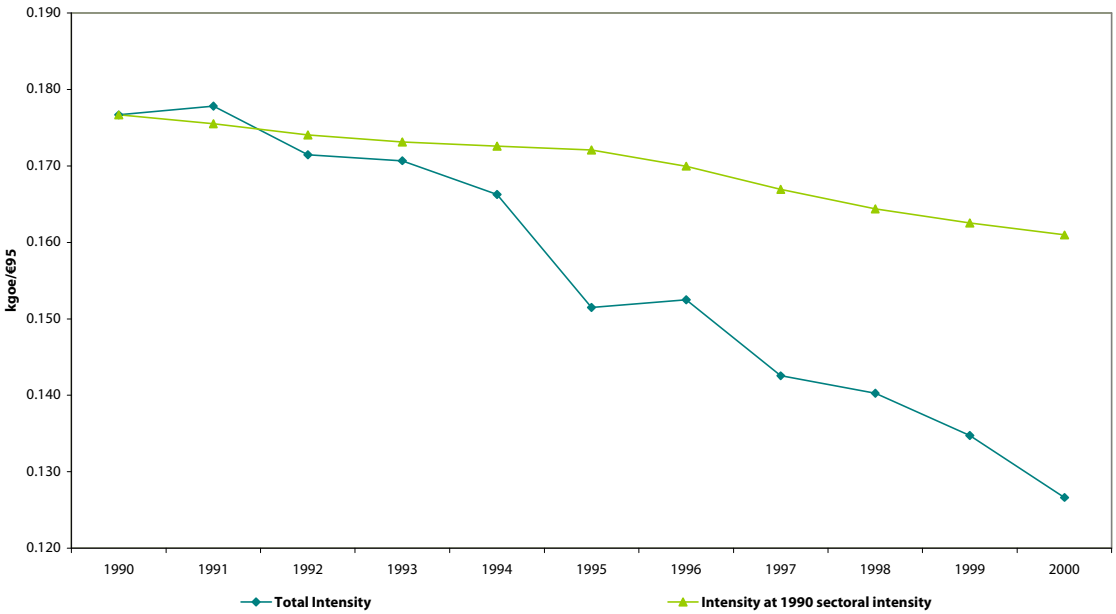


Figure 11 attempts to show what effect the change in the economic structure has had on the evolution of energy intensity. The available energy data doesn't allow for the direct assessment of this structural change but it is possible to assess this indirectly by looking at how the energy intensities have changed over the period. The trace of intensity at constant 1990 sectoral intensities shows what the evolution of intensity would have been had the intensities of the individual sectors remained constant at 1990 values. Had there been no change, then the trace would have been a horizontal line. The amount by which this trace decreases represents the effect of structural changes on the energy intensity of the economy. In this case it can be said that 32% of the decrease in overall intensity can be accounted for by structural changes in the economy.

This would suggest that other effects such as economies of scale, fuel mix and some real energy efficiency has taken place to account for the further decrease in intensity.

2.4 Electricity Generation

The efficiency of electricity supply shown in figure 12 is defined as final consumption of electricity divided by the fuel inputs required to generate this electricity and expressed as a percentage. This takes account of inputs from renewable sources, the generation plants 'own use' of electricity and transmission and distribution losses.

From the mid 1990's onwards the influence of the use of higher efficiency natural gas plants and the increase in production from renewable sources is evident.

Figure 12: Efficiency of Electricity Supply

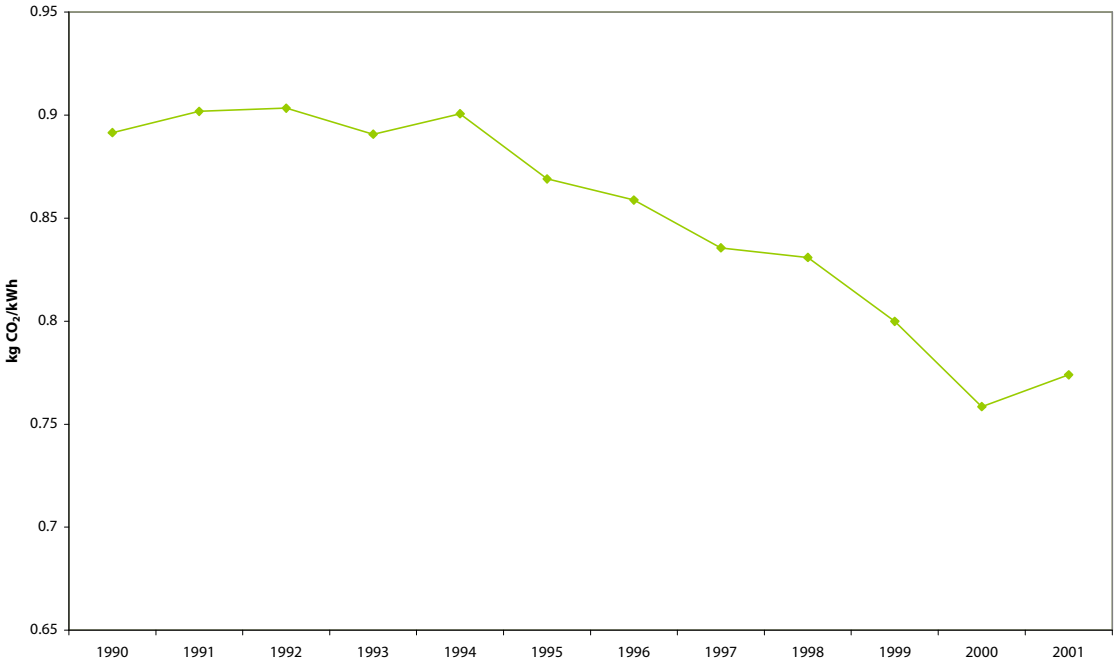
Changes in generating technology and indeed the fuel mix have also resulted in changes in the CO_2 emissions per kWh of electricity generated, as illustrated in figure 13. Since 1990 the share of high carbon content fuels such as coal has been reducing with a corresponding rise in the contributions from the low carbon fuel natural gas and from oil, a relatively low carbon fuel. This resulted in the carbon intensity of electricity dropping from 0.89 kg CO_2/kWh in 1990 to a low of 0.76 kg CO_2/kWh in 2000. However, in 2001 the CO_2 intensity of electricity generated in Ireland showed an increase over the previous year to 0.78 kg CO_2/kWh.

Reasons for the drop in generating efficiency and increase in carbon intensity of electricity in 2001 are:

- A decrease in gas share in electricity generation from 36.8% to 35.4%
- A slight decrease in hydro generation
- An increase in the share of peat generation from 10.2% to 11.1%
- An increase in the share of fuel oil generation from 20.5% to 21.8%.

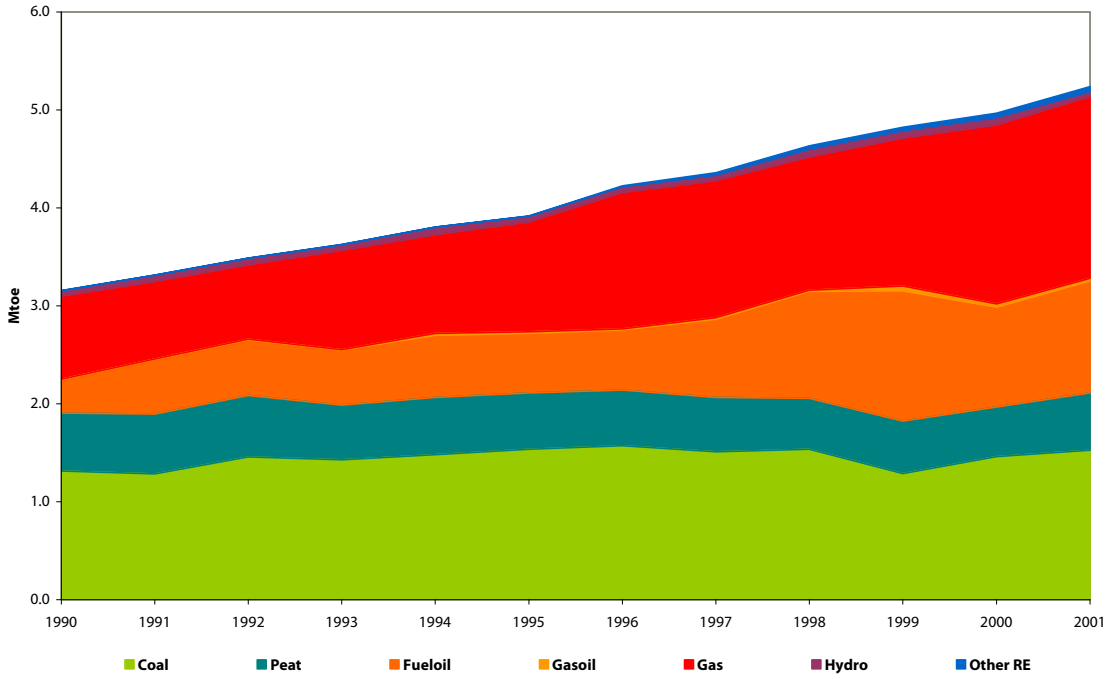
The share of coal in generation fell slightly from 29.4% to 29.1%, which would have had a small counterbalancing effect.

Figure 13: CO_2 Emissions per kWh of Electricity Generated



The trends in the mix of primary fuels employed for electricity generation are shown in figures 14 and 15.

Figure 14: Primary Fuel Mix for Electricity Generation



The primary fuel requirement for electricity generation has grown 66.2% on 1990 figures to 5.2 Mtoe in 2001 (4.7% per annum). In 2001 the growth rate was 5.6%. As a share of national primary energy requirement (TPER) it has grown from 33.5% in 1990 to 35.5% in 2001.

The main shifts in fuel mix over the period have been as follows:

- The share of coal used in electricity generation has reduced from 41.7% in 1990 to 29.1% in 2001. However in absolute terms the consumption of coal has risen by 16.1% over the period (1.4% per annum) to a figure of 1.5 Mtoe. The growth of coal in 2001 was 4.5%.

- The use of peat has fallen by 1.5% since 1990 (an average of -0.1% per annum) to a figure of 0.6 Mtoe in 2001 and its share has gone from 18.8% to 11.1% over the period. However in 2001 the use of peat to generate electricity grew by 15.1% on 2000.

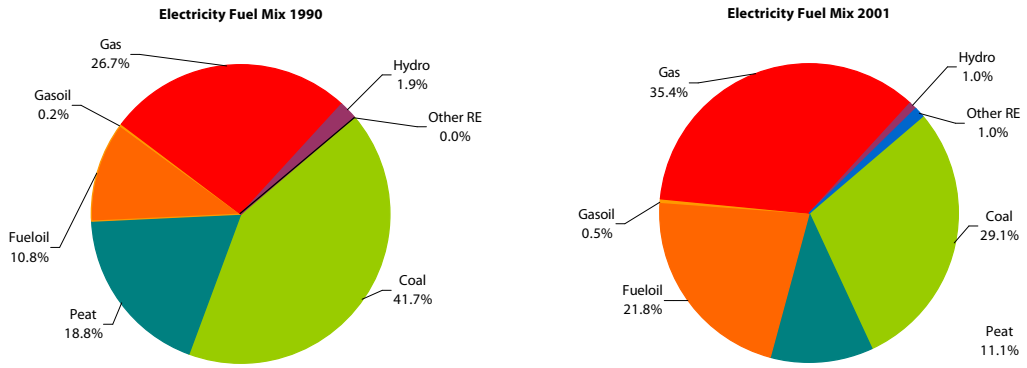
- Fuel oil had a share in electricity generation of 10.8% in 1990; this has risen to 21.8% in 2001. In absolute terms, fuel oil use has grown since 1990 by 236.4% (11.7% per annum) to a figure of 1.1 Mtoe in 2001. The use of fuel oil grew by 12.2% in 2001.

- Natural gas use for the generation of electricity has grown by 120.1% (7.4% per annum) since 1990 to a figure of 1.9 Mtoe in 2001, making it the most significant fuel in electricity generation. Its share has risen from 26.7% to 35.4% over the period. In 2001 the use of gas grew by 1.5%.

- Hydro shows a decrease in share of primary electricity energy from 1.9% to 1.0%. This is due to the fact that no significant new source of hydro generation has come into existence and the output from hydro is relatively constant from year to year, with slight variations depending on rainfall levels.

Hydro is both a primary and a final energy source in that there is no significant loss of energy in the generation process unlike that with fossil fuels. It is therefore common to see the share of hydro reported as a percentage of electricity generated (final consumption of electricity). As such the share of electricity generated by hydro has gone from 5.7% in 1990 (59 ktoe) to 4.2% in 2000 (73 ktoe) and 2.8% in 2001 (51 ktoe).

Figure 15: Electricity Generation Fuel Mix for 1990 and 2001



Figures 16 and 17 illustrate the differences when looking at electricity consumption respectively from the input (primary energy or fuel inputs) and output (final or delivered energy to consumers) sides. Figure 17 shows the final electricity consumption in each of the main sectors. However, because electricity in Ireland is predominately generated from fossil fuels, the real or primary energy requirement is some three times higher. The primary energy required to produce the electricity consumed by the sectors is shown in figure 16.

Figure 16: Primary Electricity Energy by Sector

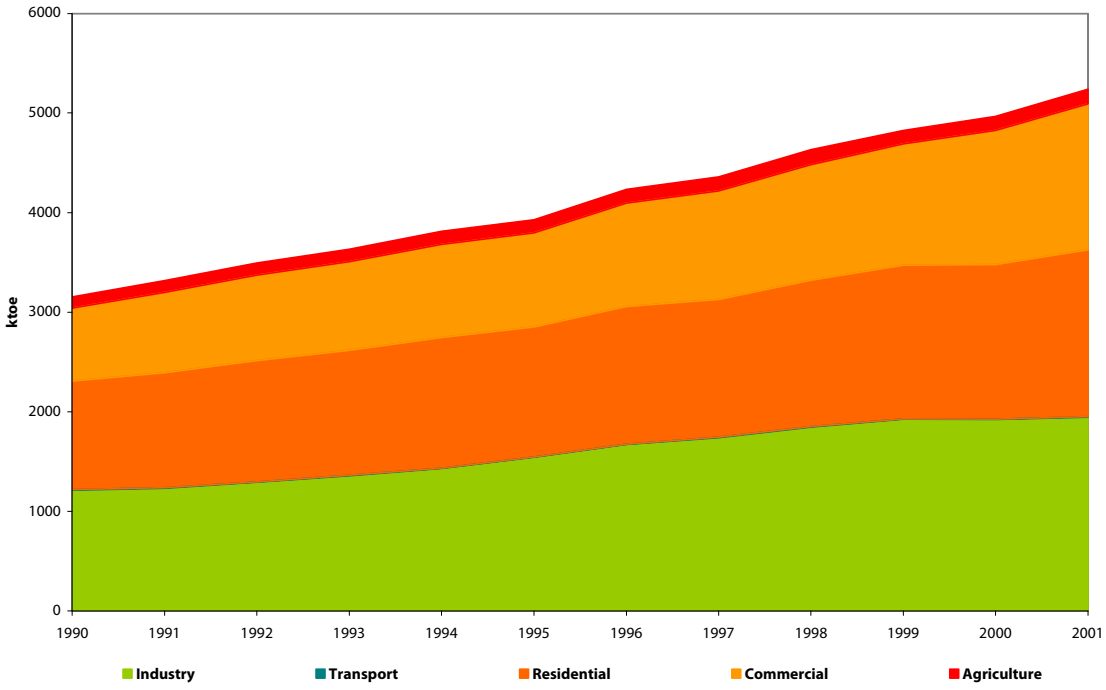
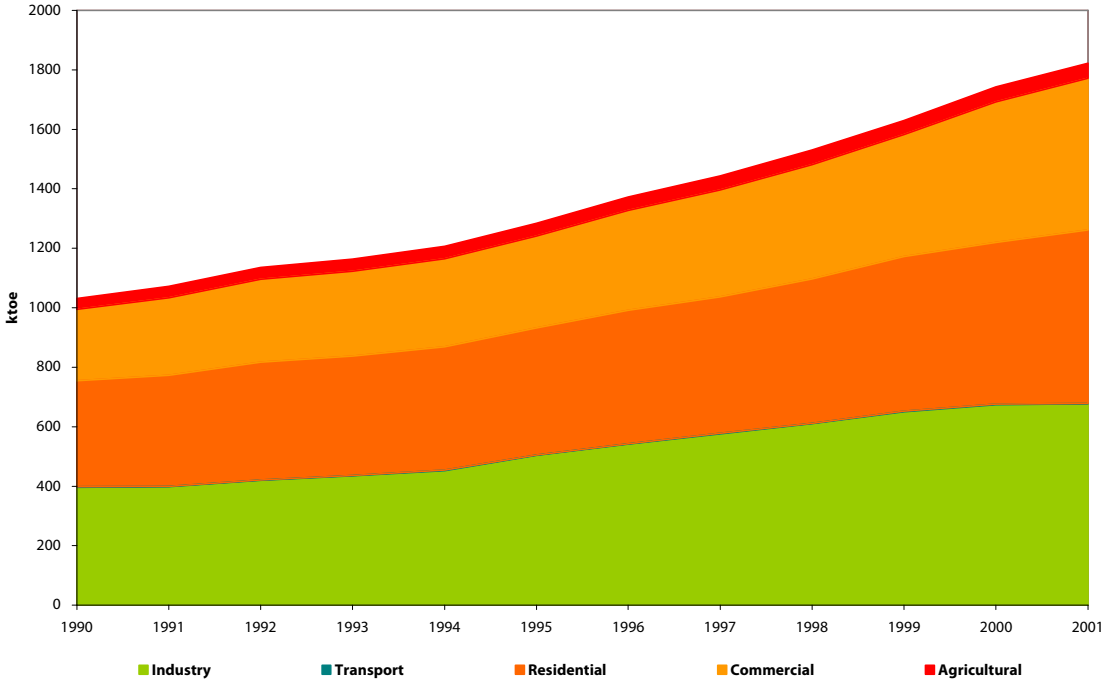


Figure 17: Final Consumption of Electricity by Sector



3 Trends in a Policy Context

Energy trends may be analysed to assess performance with regard to Government policies and targets, in particular those detailed in the Green Paper on Sustainable Energy (1999) and the National Climate Change Strategy (2000). This section presents these trends over the period 1990-2001 in the context of established energy policy objectives, grouped under three pillars of sustainable energy development, namely:

- environmental responsibility
- security of supply
- cost competitiveness.

3.1 Environmental Responsibility

The key policy areas which are discussed under this pillar are:

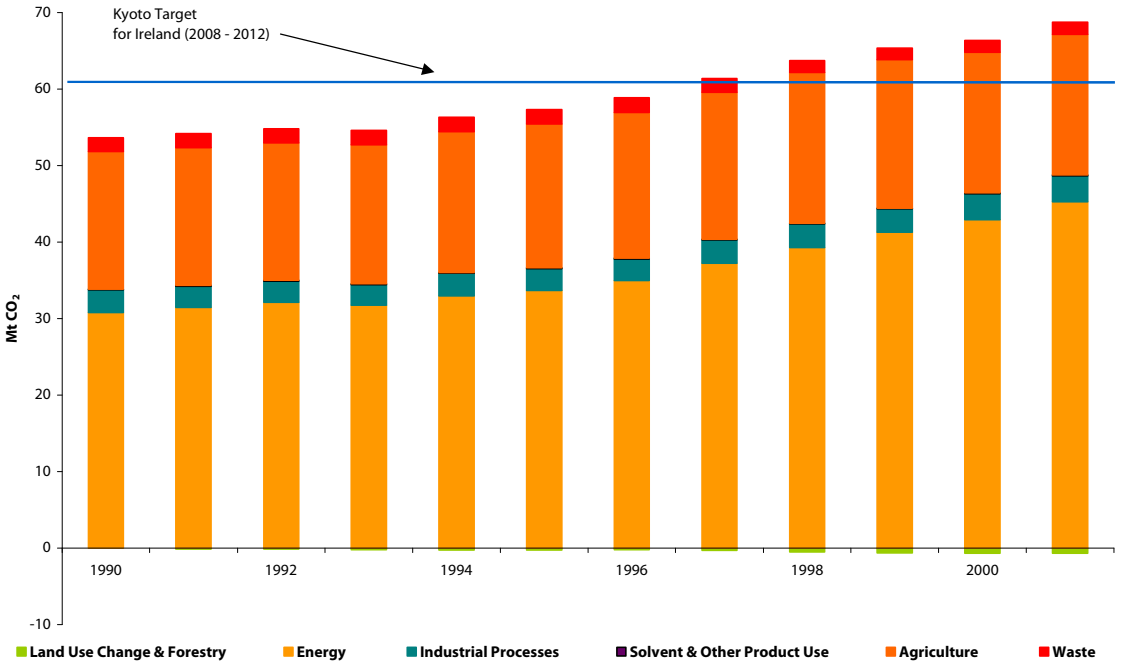
1. limiting energy related greenhouse gas emissions
2. accelerating the deployment of renewable energy.

3.1.1 Greenhouse Gas Emissions

On May 31, 2002 Ireland ratified the Kyoto Protocol, a legally binding international agreement to reduce GHG (greenhouse gas) emissions. Under the Protocol, the EU has committed to reduce its annual GHG emissions to 8% below 1990 levels by the period 2008 – 2012.

In order to achieve this target, the Member States established a burden sharing agreement in 1998. Arising from this, the target for Ireland is to limit emissions to 13% above 1990 levels by the same period. The National Climate Change Strategy has set a target for 2010 of reducing greenhouse gas emissions by 15.4 Mt CO_2 equivalent relative to a projected 'business as usual' rate of emissions.

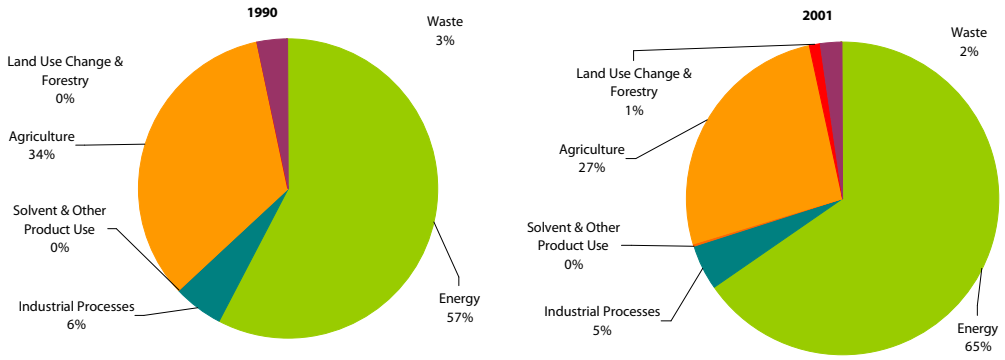
Figure 18: Greenhouse Gas Emissions by Source



Referring to figure 18, this target for the period 2008 – 2012 was breached in 1997. By 2001, annual GHG emissions[3] were 27% above 1990 levels and projections in the National Climate Change Strategy indicate that emissions levels may rise to 37% above 1990 levels by 2010 if the country continues on a 'business as usual' path. It is also evident from figure 18 that the most significant area of growth is in energy related emissions, in particular since 1995.

[3] Based on provisional data for 2001 from EPA and SEI data.

Figure 19: Greenhouse Gas Emissions by Source



The share of GHG emissions arising from energy related activities thus increased from 57% to 66%, as illustrated in figure 19. The share from agriculture dropped from 34% to 27% in the same period. It is interesting to note that for the EU as a whole, energy production and use represented 80% of GHG emissions in 1990[4]. The significant role of agriculture in the Irish economy underlies Ireland's variance from the EU average.

To examine more closely where the growth has been occurring, figure 20 gives a sectoral breakdown of energy related CO_2 emissions (which represent 96% of energy related GHG emissions). Energy related CO_2 emission in 2001 were 44% higher than 1990 levels.

The most significant area of growth is in the transport sector[5], where CO2 emissions in 2001 were 120% higher than those in 1990 (7.4% average annual growth rate) and growth in 2001 alone was 8%. Energy use in transport accounted for 26% of energy related CO2 emissions in 2001.

High growth levels (59% between 1990 and 2001) were also evident in the commercial-public/ tertiary/services sector averaging 4.3% annually (4.6% in 2001). This sector's share of energy related emissions rose from 16.5% to 18.3% as a result.

Industry displayed the lowest growth rate in 2001 at 1.2%, but was still responsible for 25% of emissions. Growth over the period 1990 – 2001 period was 32%.

CO_2 emissions arising from energy use in the residential sector exhibited a low annual growth rate of 1% from 1990 to 2001, representing a total growth of 22.5% over the period. The growth rate in 2001 was 5.2% however. This sector accounted for 28% of energy related CO_2 emissions in 2001 compared with 36% in 1990.

It is clear from figure 20 that there are variations in energy related emissions trends amongst the different sectors of the economy. What is perhaps less clear is the variation in emissions by mode of energy, which is illustrated in figure 21.

Here the emissions are allocated according to whether the energy used is for mobility (transport), in the form of electricity (power) or as thermal energy (for heating). The growth in emissions related to mobility (120% over the period) is again striking. Also clearly evident is the increase in emissions from electricity, which was 53% over the period indicating an average annual growth rate of 4%. In 2001 alone the emissions from electricity consumption grew by 6.8%.

[4] Commission of the European Communities (1998) *COM(98)353 Climate Change – Towards an EU Post-Kyoto Strategy.*
[5] Emissions arising from international air travel are excluded following procedures for reporting under the UN Framwork Convention on Climate Change (UNFCCC) guidelines.

Figure 20: Energy Related CO_2 Emissions by Sector[6]

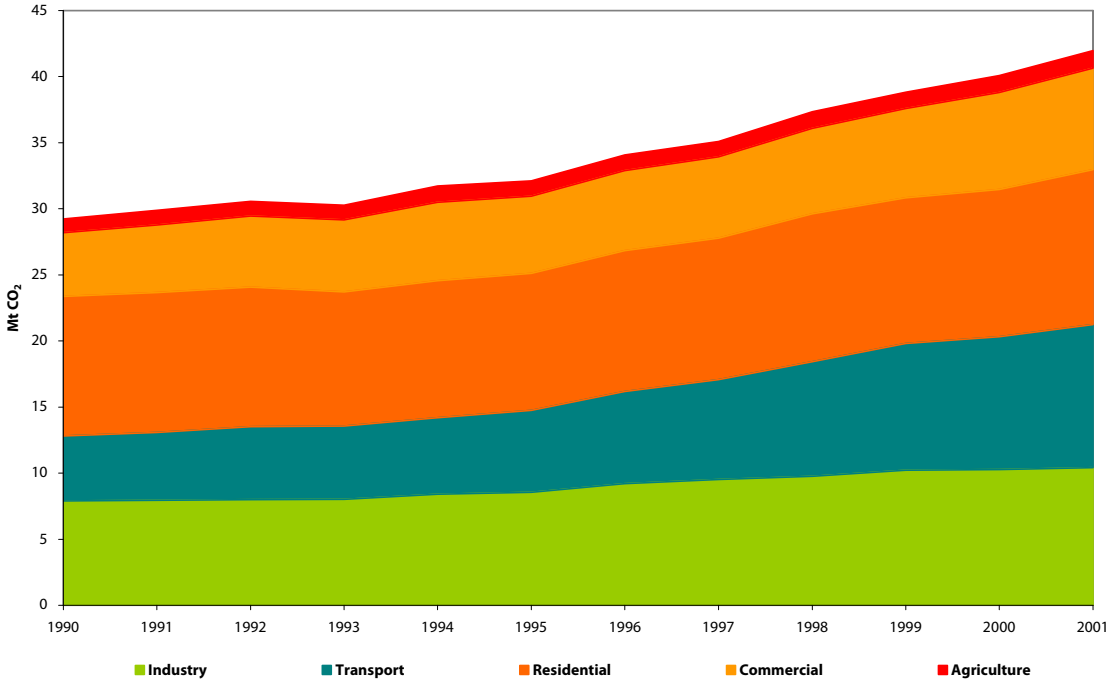
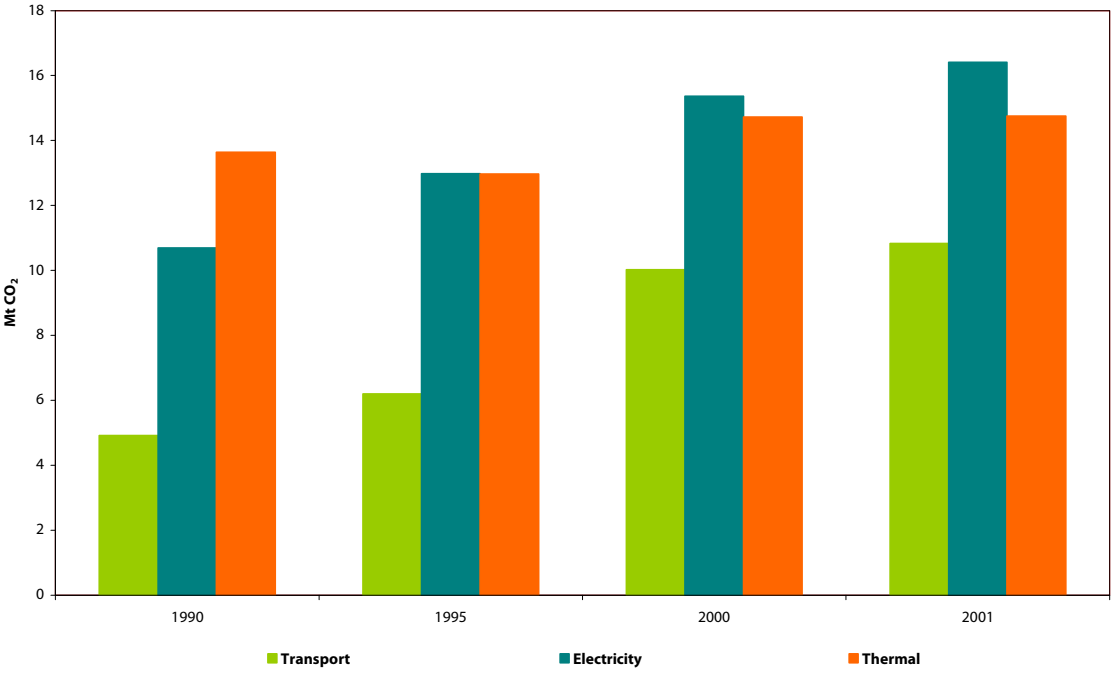


Figure 21: Energy Related CO_2 Emissions by Mode of Energy Application



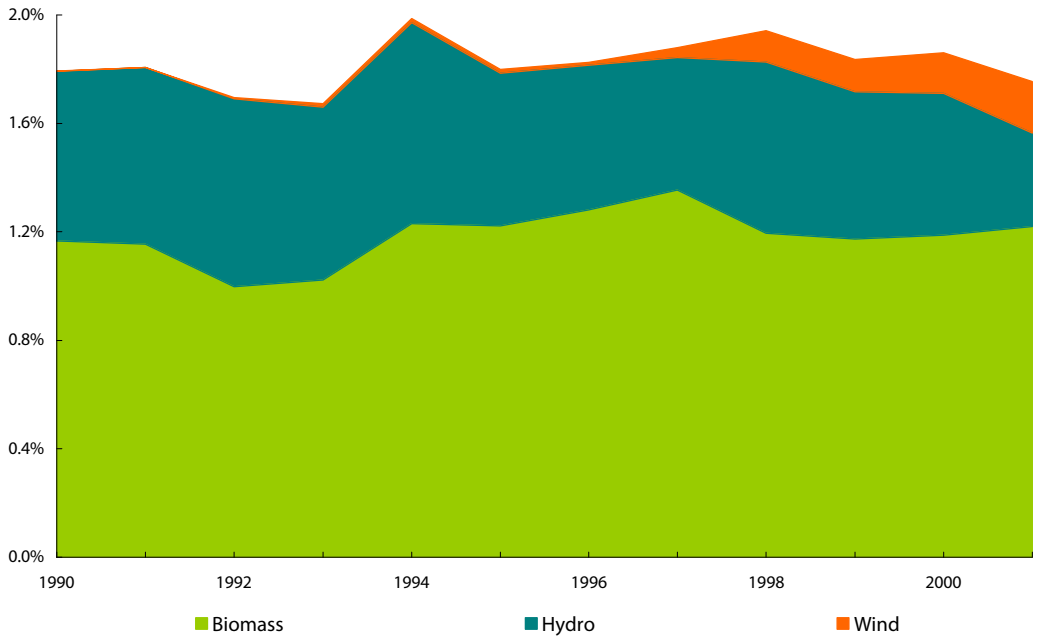
6 Transport sector excludes emissions from kerosene use in air transport.

3.1.2 Renewable Energy

As shown in figure 22, renewable energy has been contributing nearly 2% of Ireland's primary energy supply since 1990. Most of this has been delivered by traditional biomass, waste wood used by the timber processing industry for drying and wood burnt by the residential sector for home heating

The second most significant contribution has been from the large-scale hydro power plants, whose output has varied from year to year depending on rainfall patterns. The growing contribution from wind energy is also evident in figure 22, in particular since 1998. In 2001, biomass contributed 1.27%, hydro power 0.35% and wind energy 0.14% of Ireland's energy requirements.

Figure 22: Renewable Energy Contribution to TPER



In order to stimulate an increase in renewable energy development within the EU, the European Commission published a White Paper on Renewable Energy in 1997[7], which was endorsed by the European Council and European Parliament in 1998. In this document a target was set for the EU as a whole to double the contribution from renewable energy to primary energy supply by 2010 from 6% to 12%. The strategy also detailed the expected contribution from each renewable energy resource and its allocation as electricity, heat production, or as energy use in transport.

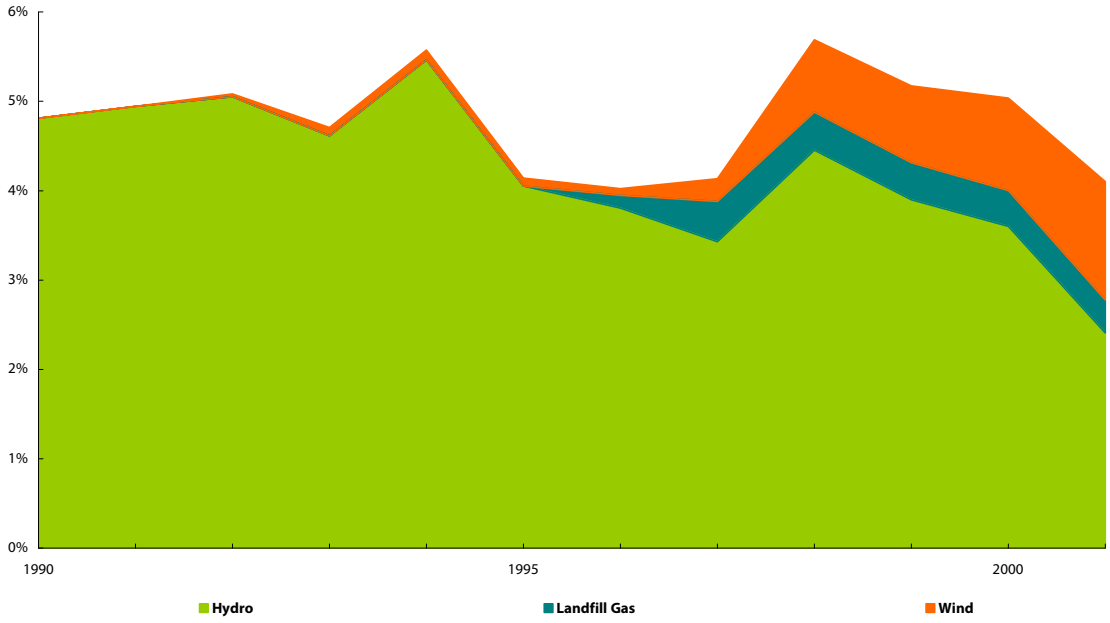
The target and strategy in the area of electricity generation specifically was further detailed in 2001, with the publication of the EU Renewable Energy Directive[8] (2001/77/EC). In this Directive indicative targets for each Member State are provided for the contribution of renewable generated electricity to gross electricity consumption by 2010. These targets are consistent with indicative target contribution of 22.1% to electricity consumption for the EU as a whole, which in turn is consistent with the target contribution of 12% to overall primary energy consumption. The indicative target for Ireland is a 13.2% share of gross electricity consumption by 2010.

The focus of national policy in the area of renewable energy has been in the area of electricity production from renewables, in particular wind energy, due to the size of the wind energy resource in Ireland and the cost competitiveness of the technology. The results of this are evident in figure 23, which shows that wind energy in 2001 accounted for 1% of gross electricity consumption. This contribution represents the combined output of Ireland's 21 wind farms that have a combined installed generating capacity of 125 MW.

[7] Commission of the European Communities (1997) *COM(97)599 Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan.*
[8] European Union (2001) *Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market.*

The trend shown in figure 23 reflects how the contribution to meeting renewable energy targets depends on rainfall, due to the dominant contribution of hydro power. The proportionate hydro contribution will tend to remain flat or decline, due to a relatively fixed large-scale hydro capacity set against an overall growth trend in electricity demand. The contribution from renewables has remained around 5%, although it dropped to 4% in 2001 due to lower levels of hydro power. This is set to change in the coming years if the targets set in the Green Paper on Sustainable Energy are met and wind energy becomes the more prominent renewable source in terms of electricity generation.

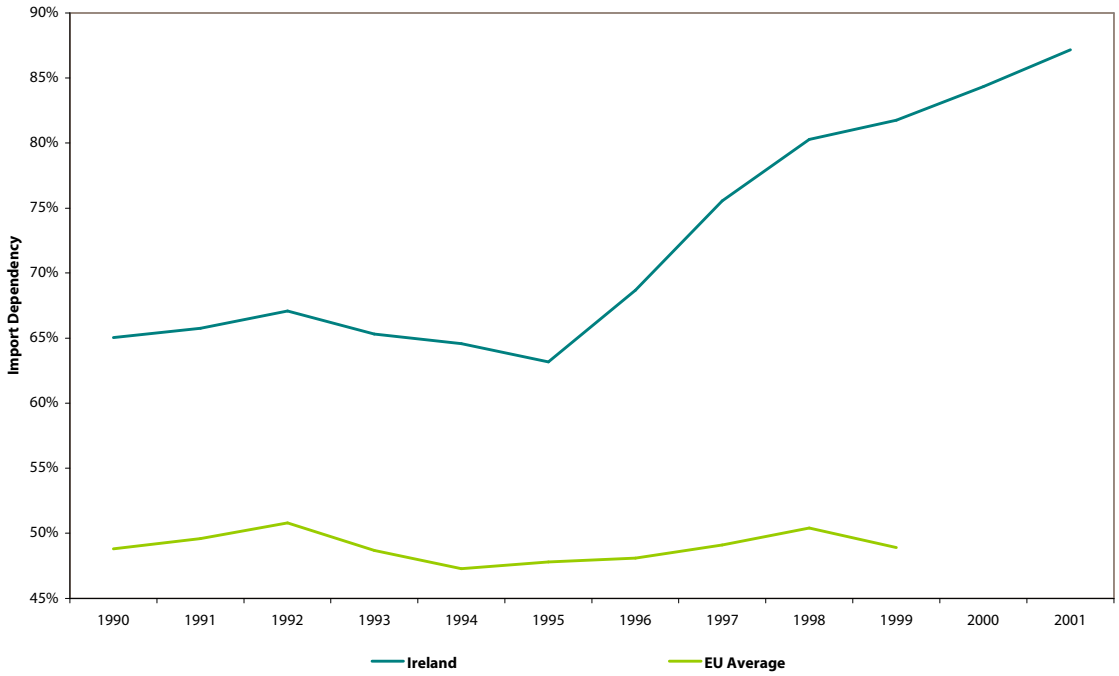
Figure 23: Renewable Energy Contribution to Gross Electricity Consumption



3.2 Security of Supply

Ireland's security of energy supply relates to import dependency and fuel diversity. It is closely linked to EU security of supply, but import dependency is examined here for Ireland in its own right. Figure 24 illustrates the trend over the last decade, comparing it with the EU as a whole.

Figure 24: Import Dependency of Ireland and EU Average



Domestic production accounted for 35% of energy requirements in 1990. However, since the mid-1990's import dependency has grown significantly, due to the decline in indigenous natural gas production at Kinsale since 1995 coupled with decreasing peat production. Imported oil and gas accounted for 74% of TPER in 2001, compared with 45% in 1990. In 2001, Ireland's import dependency reached 87%, increasing from 84% in 2000, and from 65% in 1990. This trend contrasts with that for the EU, where import dependency has remained at between 45% and 50%.This trend reflects the fact that Ireland is not endowed with huge indigenous fossil fuel resources and has to date not harnessed significant quantities of renewable resources.

Figure 25 shows the indigenous energy fuel mix for Ireland over the period. Peak indigenous production in 1995 and the decline since then is again evident.

The share of native gas within the indigenous fuels contribution dropped from 54% in 1990 to 37% in 2001, while peat increased its share from 41% to 49% and renewable energy increased from 5% to 14%.

Some proposed developments are likely to impact on this trend including the plans to extract and utilise gas at the Corrib Gas Field by 2004 and the targets for increasing the deployment of renewable energy to be achieved by 2005.

Figure 25: Indigenous Energy by Fuel

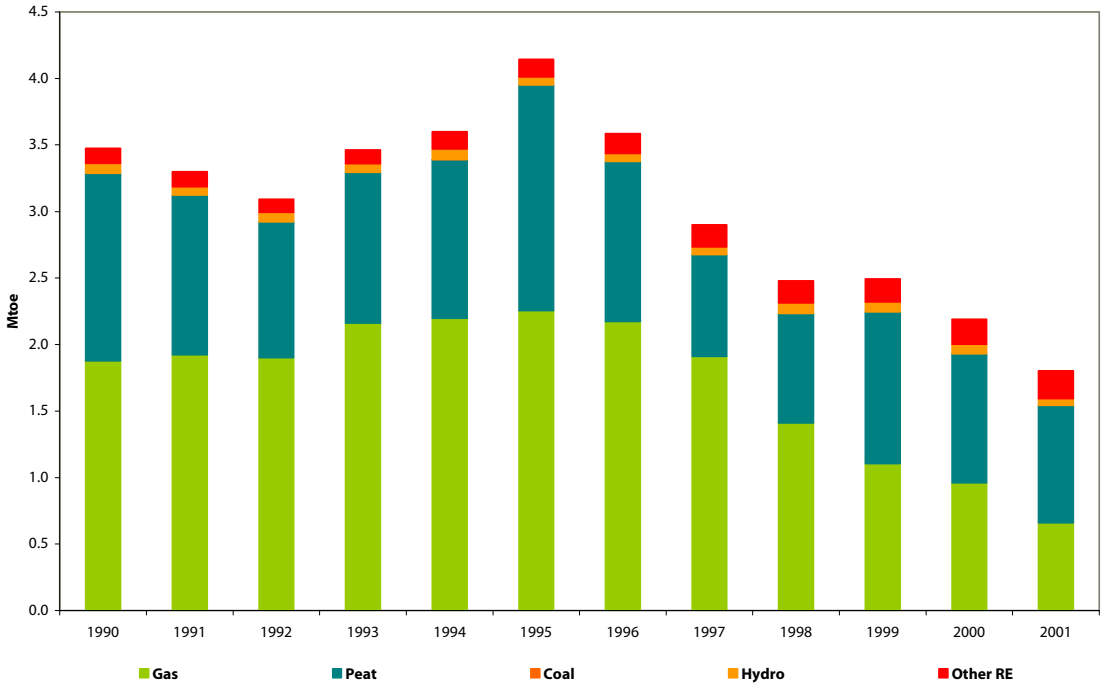
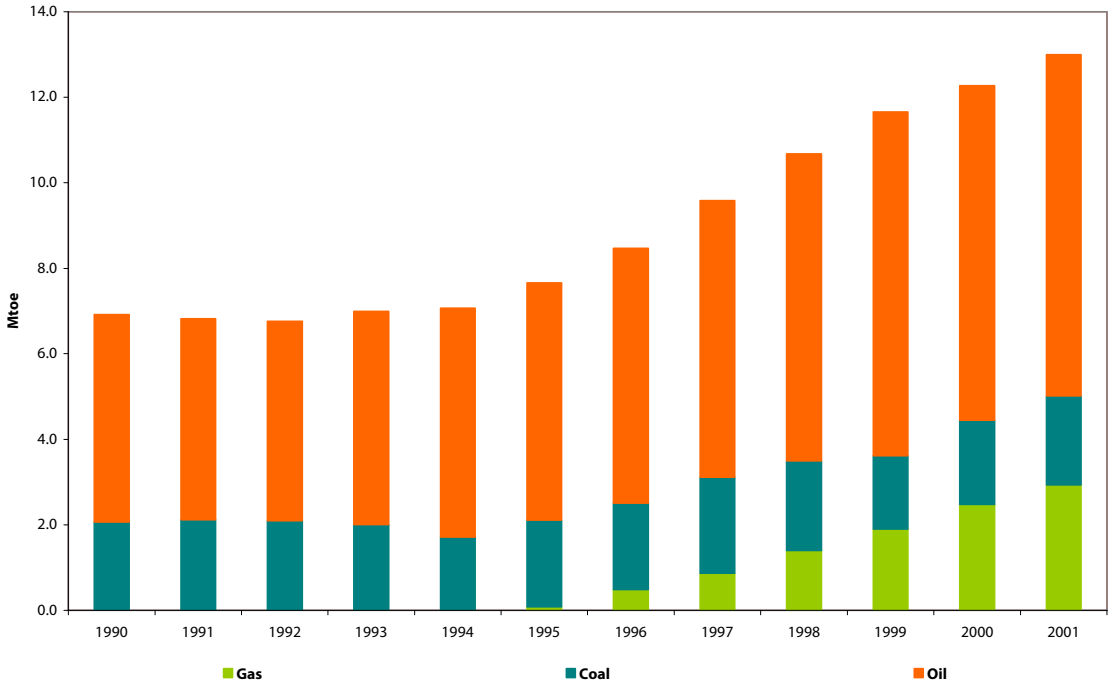


Figure 26 shows the trend for net fuel imports (imports minus exports) over the period 1990 – 2001. The growing dependence on oil due largely to increase in energy consumption in transport is the most striking feature. The decline of indigenous natural gas reserves at Kinsale is also evidenced by the growth in imported natural gas in the latter part of the decade. Coal imports have remained stable over the period reflecting the base load operation of Moneypoint electricity generating plant.

Figure 26: Imported Energy by Fuel



3.3 Cost Competitiveness

Energy is an important component in economic activity and therefore the price paid for this energy is a determining factor in the competitiveness of the economy. This section presents comparisons of the cost of energy in various forms with the EU average. The source of the data presented here is from the EU Commission Directorate-General for Energy and Transport and Eurostat[9].

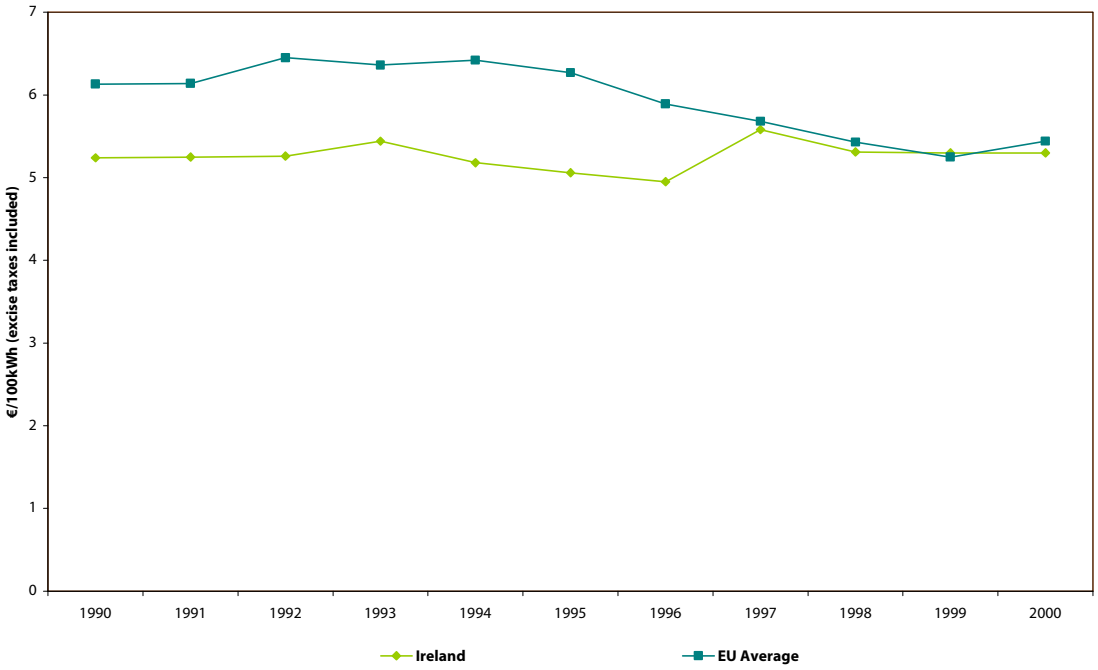
Prices shown are in current money; therefore where prices are similar to 1990 there has been a decrease in costs in real terms.

Between 1990 and 1996 average electricity prices to industry in Ireland were 16.6% below the EU average (figure 27). Since 1997 the prices have converged. Electricity prices to industry in Ireland in 2000 were just 1.2% above 1990 levels (current prices).

Irish industrial fuel oil prices (figure 28) have followed a similar trend to that of the EU average with an average price difference of 3.9% in Ireland's favour between 1990 and 1999. Fuel oil prices to industry in 1999 were 9.8% below 1990 levels (current prices).

Natural gas prices from 1991 onwards for Ireland are unavailable. However the EU average is shown for information (figure 29).

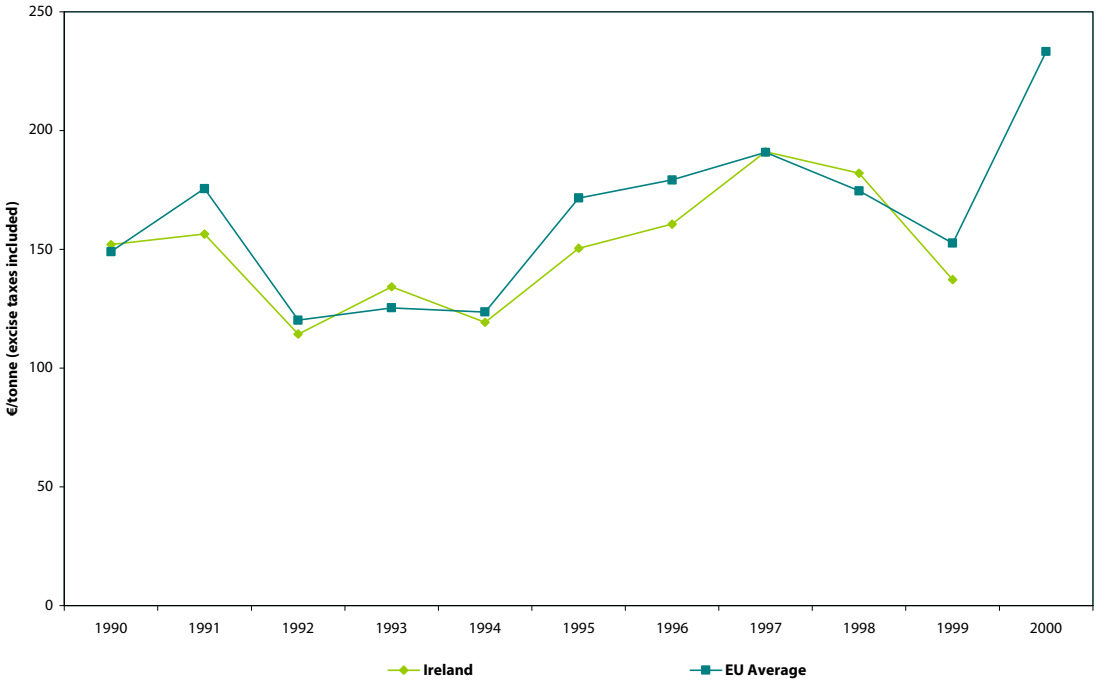
Figure 27: Electricity Prices to Industry



Source: European Commission DGTREN.

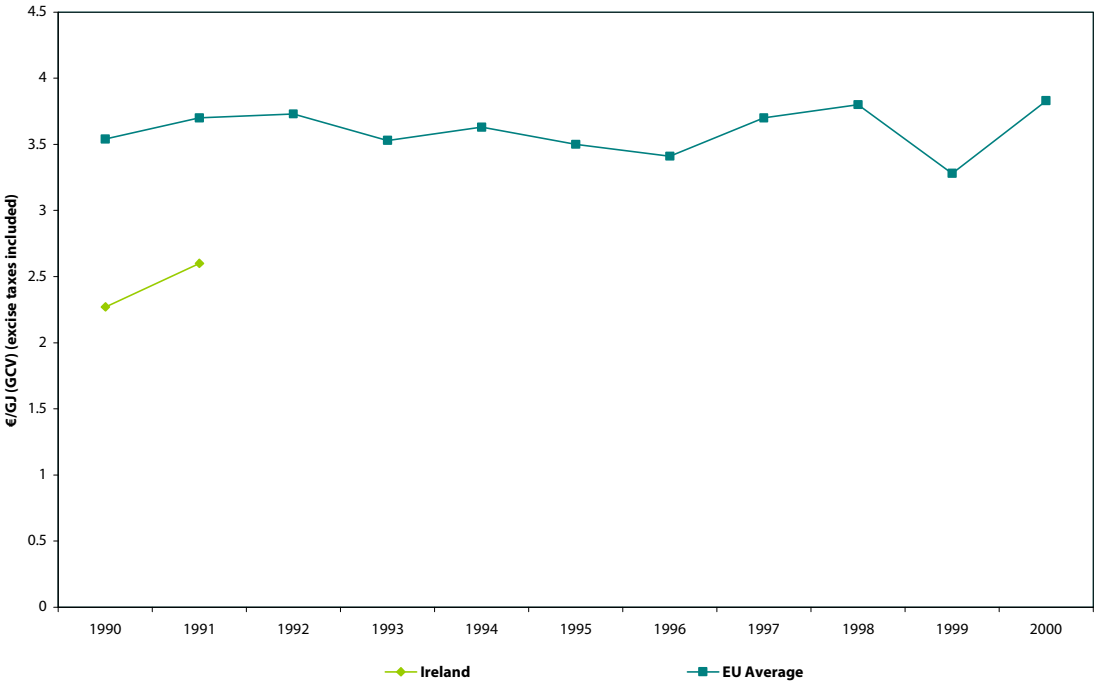
[9] The methodology for calculating fuel prices and detailed comparison with other EU countries can be found at http://europa.eu.int/comm/energy_transport/etif/list_of_tables.html#ENERGY.

Figure 28: Fuel Oil Prices to Industry



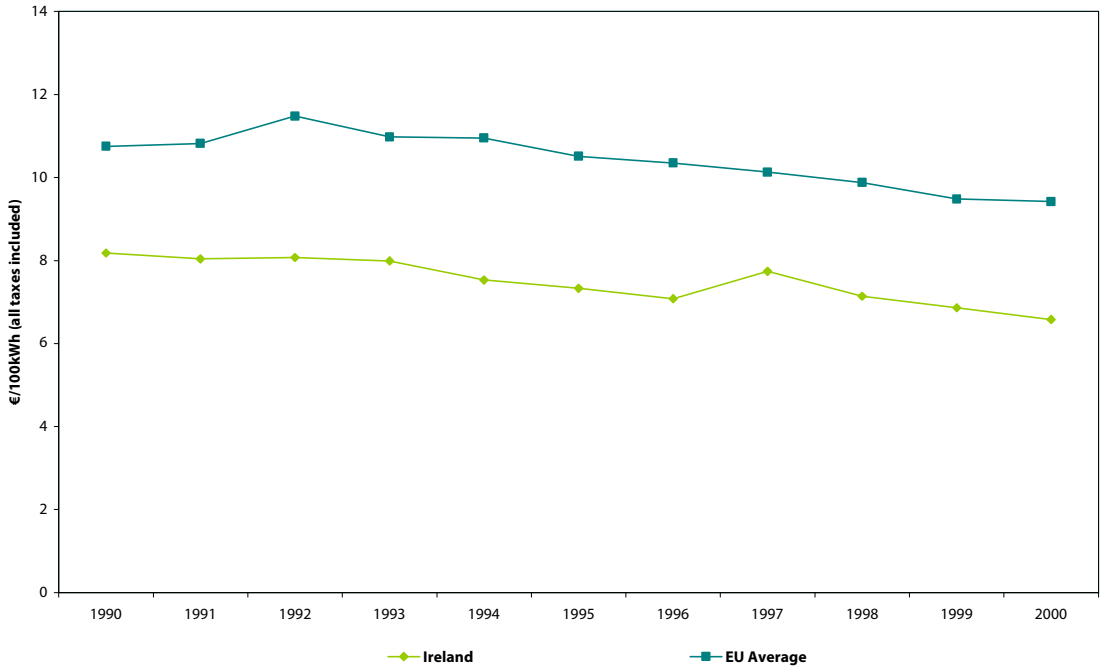
Source: European Commission DGTREN.

Figure 29: Natural Gas Prices to Industry



Source: European Commission DGTREN.

Figure 30: Household Electricity Prices

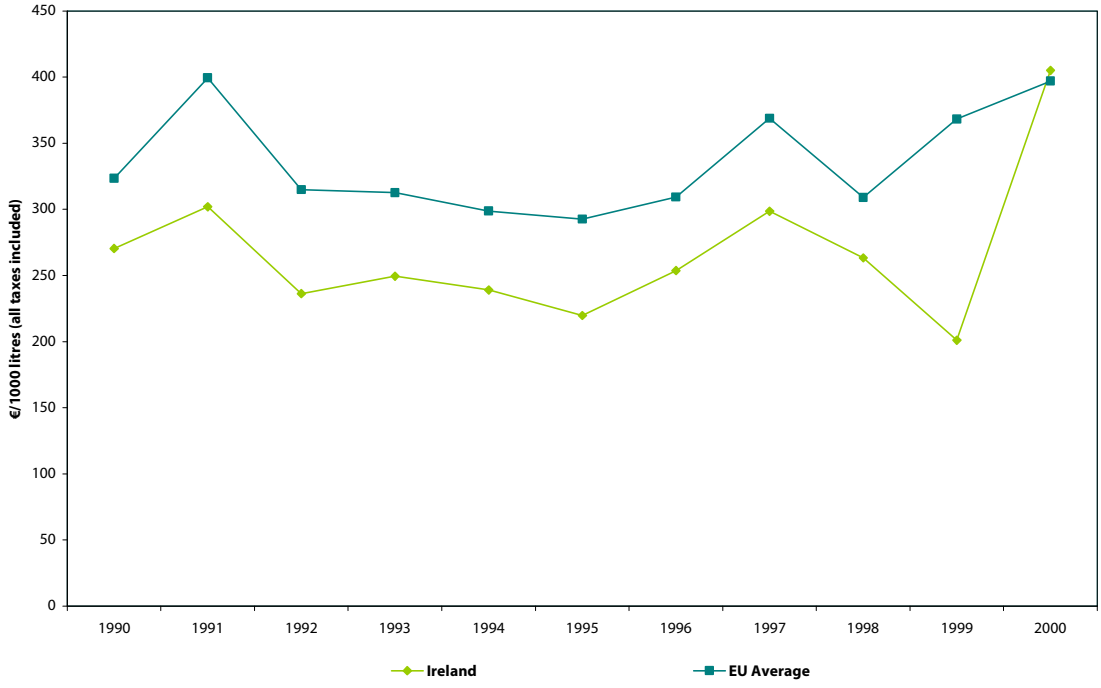


Source: European Commission DGTREN.

Household electricity prices in Ireland are generally lower than the EU average with an average price difference of 28.1% over the period in Ireland's favour.

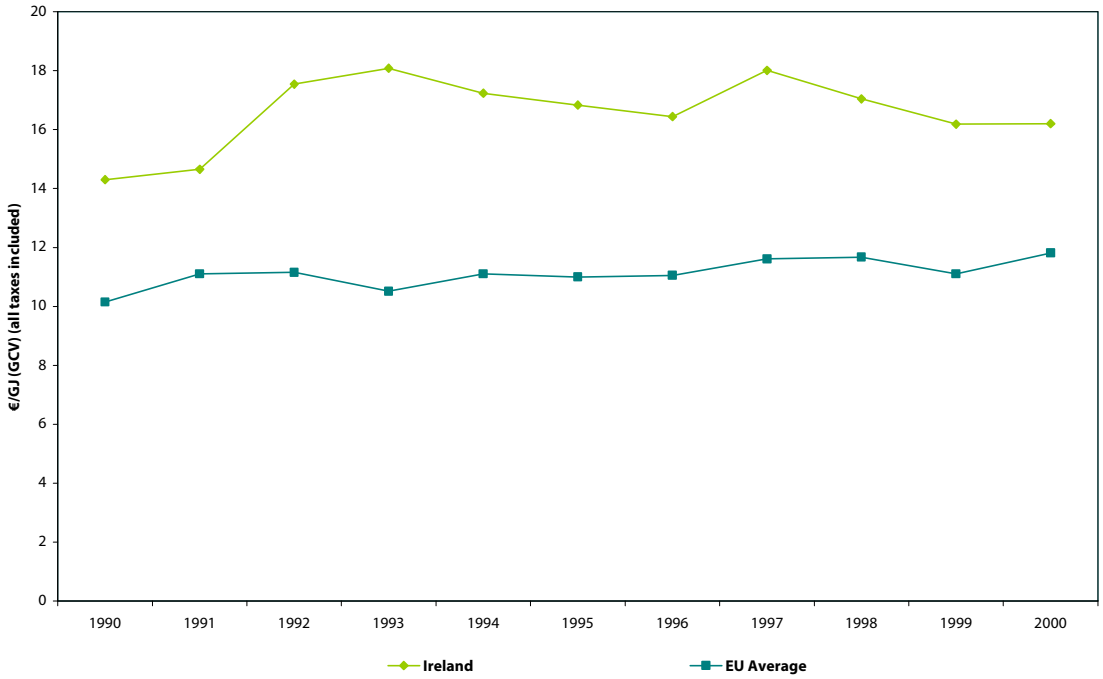
Oil prices rose sharply in 2000 resulting in prices 49.8% above 1990 levels (current prices). The average price of heating oil was 20.5% lower in Ireland than the EU average over the period 1990 – 2000.

Figure 31: Household Heating Oil Prices



Source: European Commission DGTREN.

Figure 32: Household Natural Gas Prices

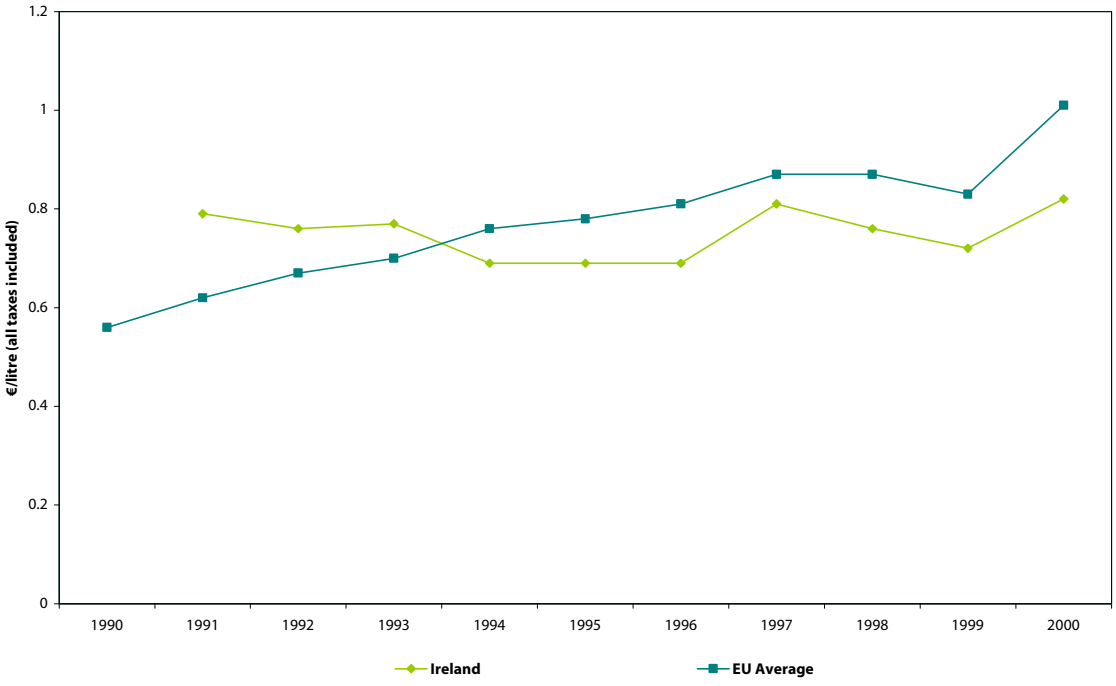


Source: European Commission DGTREN.

Natural gas prices to Irish households were 13.3% higher in 2000 than 1990. The average price of natural gas to Irish households was 49.4% higher than the EU average.

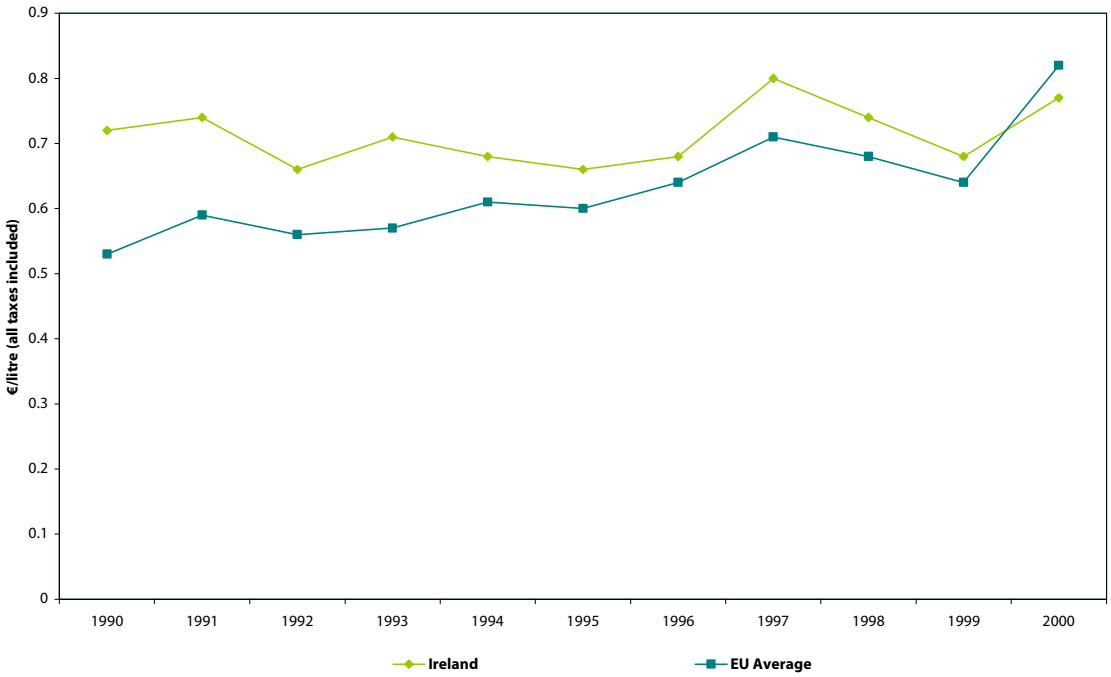
Unleaded petrol prices in 2000 were 3.8% higher than in 1990 (current prices) compared with an increase of 80.4% in the average EU price over the same period.

Figure 33: Retail Unleaded Petrol Prices (95 RON)



Source: European Commission DGTREN.

Figure 34: Retail Road Diesel Prices



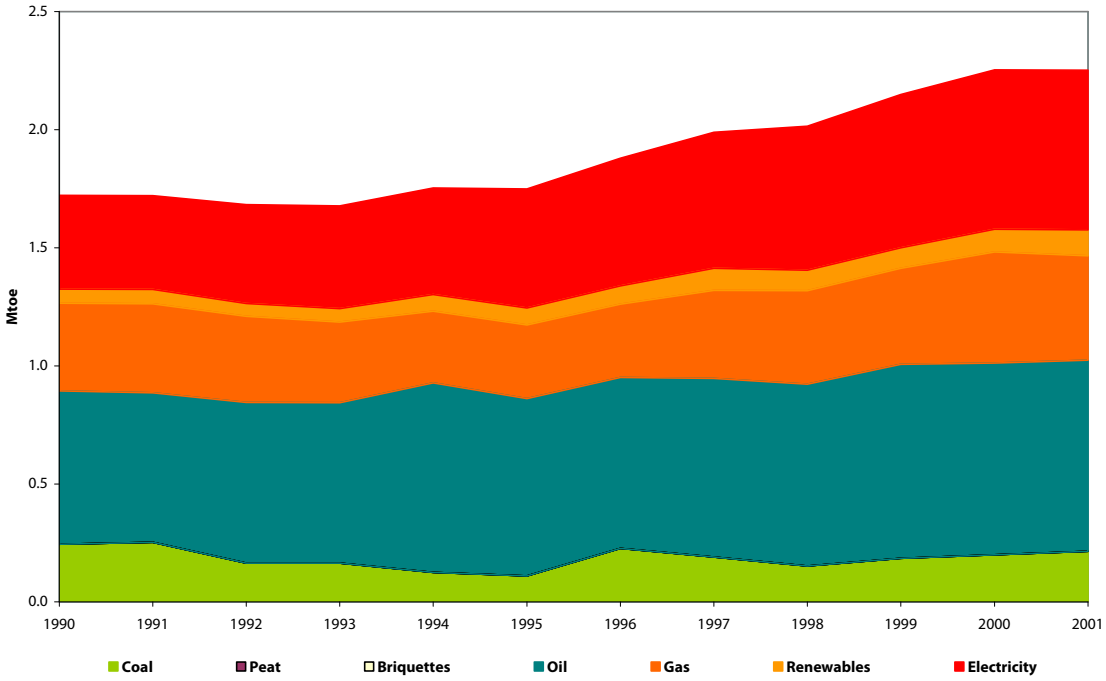
Source: European Commission DGTREN.

The price of automotive diesel in Ireland in 2000 was 6.9% higher than in 1990 (current prices) whereas the EU average has risen at a much higher rate(54.7%) over the same period to converge with Irish prices.

4 Sectoral Indicators

4.1 Industry

Figure 35: Industry Final Energy Use by Fuel



Final energy use in industry (figure 35) has grown by 30.8% to 2.3 Mtoe over the period 1990 – 2001, or on average by 2.5% per annum. Within that period only electricity and renewables have increased their share. The share of electricity has risen from 23.1% to 30.1%, and renewables from 3.5% to 4.8%. The increase in renewables is mainly due to the use of biomass in the wood processing industry.

Electricity is the second most dominant energy form in industry at 30.1% behind oil at 35.9%. However on a primary energy basis, electricity represents 47.8% of energy used in industry compared to 25.5% for oil.

Electricity growth in industry averaged 5% over the period. However, there are some signs of a slow down. Growth rates of electricity consumption in industry in 2000 and 2001 were 3.7% and 0.4% respectively. The decrease in 2001 is as a result of a general slow down in industrial output including, notably, the closure of Irish Ispat steel plant mid year.

Overall final energy growth in industry was flat (-0.03%) in 2001 relative to the previous year, with oil and gas falling by 0.5% and 6.1% respectively.

Industry Energy Intensity

The energy intensity of industry is defined as the amount of energy required to produce one euro of value added. Between 1990 and 2000 the value added of industry grew by some 173% whereas industrial energy consumption grew by 30.8%.

This resulted in the energy intensity of Industry decreasing quite rapidly throughout the decade with a 7.5% per annum decrease over the period 1990-1995 and a 9.5% decrease over the period 1995-2000.

Part of this variation can be explained by changes in the structure of the value added of manufacturing by main branch or sector. The impact of these structural changes can be measured by comparing the variations of the actual intensity with that of a fictitious or notional intensity at constant sectoral intensities (1990 structure as a reference).

Since 1990, there are structural changes towards less energy intensive branches that contributed to decrease the intensity of manufacturing.

Since 1990, structural changes contributed to decrease the intensity by an average 3.7% per annum. This particularly reflects the increasing importance of the IT manufacturing sector and the pharmaceutical and drink concentrates industries. The growth in importance of these relatively low energy consuming, high value added sectors has pushed down the overall energy intensity of the industrial sector. With reference to figure 36, structural changes accounted for approximately half (47%) of the reduction in industrial energy intensity between 1990 and 2000.

Figure 36: Energy Intensity of Industry

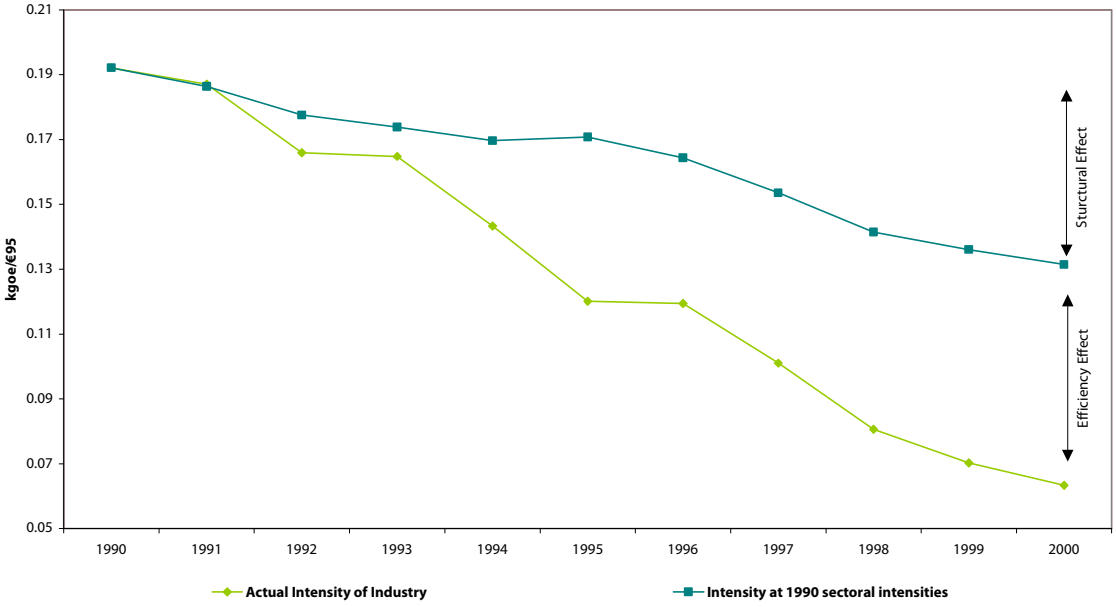


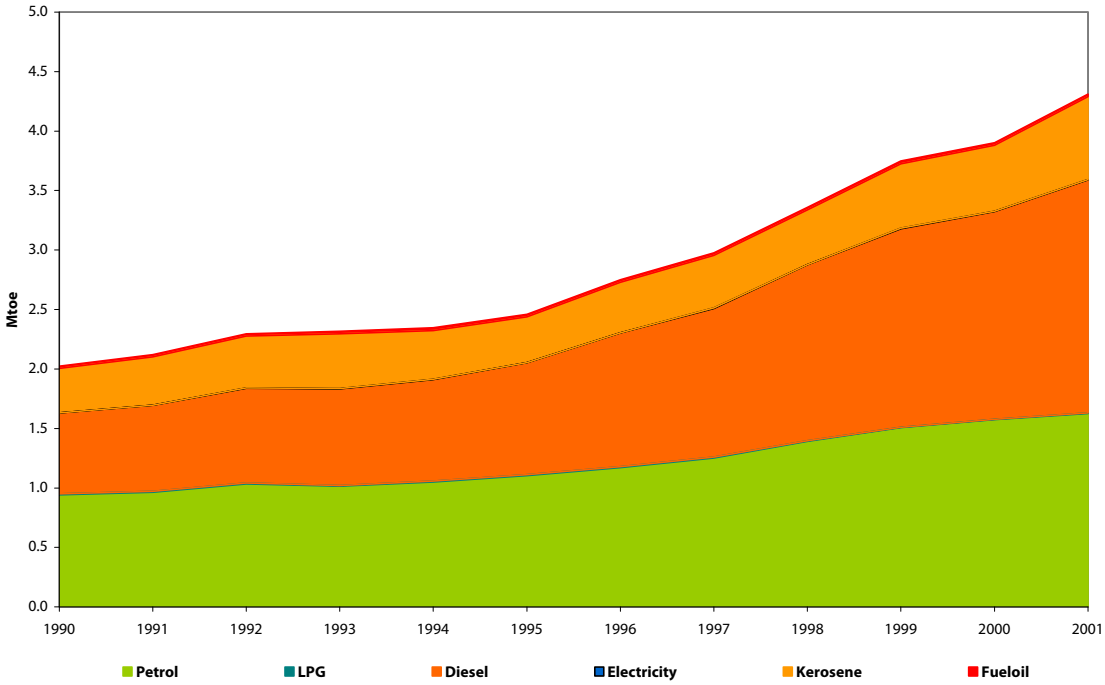
Table 1: Variations of Energy Intensity of Industry (% per annum)

	1990-95	1995-2000	1990-2000
Energy Intensity	-9.0%	-12.0%	-10.5%
Energy Intensity at constant sectoral intensities	-2.3%	-5.1%	-3.7%

As shown in table 1, the rate of decrease of energy intensity of industry has been stronger in the second half of the decade rising from 9% per annum to 12% per annum. Much of this increased rate can be accounted for by structural changes as seen by the increase in the constant sectoral intensities from 2.3% per annum to 5.1% per annum.

4.2 Transport

Figure 37: Transport Final Energy Use by Fuel[10]



Transport energy consumption grew by 112.8% (7.1% per annum) over the period 1990 to 2001 to a figure of 4.3 Mtoe. The growth in 2001 was 10.5%.

In figure 37, kerosene is used primarily for air transport; fuel oil for sea transport and electricity for rail transport on the Dublin DART system. Liquefied petroleum gas (LPG) use in transport has declined to negligible amounts.

Petrol consumption in transport has increased by 72.4% (5.1% per annum) between 1990 and 2001 to a figure of 1.6 Mtoe. Growth slowed slightly in 2001 to 3.2%. The share of petrol in total transport energy declined from 46.6% in 1990 to 37.7% in 2001.

Diesel consumption grew by 188% (10.1% per annum) between 1990 and 2001 to a figure of 2 Mtoe. Growth in 2001 was higher than the average at 12.2%. The share of diesel in transport energy has risen from 33.6% to 45.4% over the period. This reflects the transport requirements of goods in the booming economy and a shift to greater use of diesel in private transport.

Between 1990 and 2001 the total number of vehicles on Irish roads rose by 67.7% to 1.77 million and the number of private cars rose by 73.9% to almost 1.4 million. Figure 38 shows the density of private cars per 1000 of population and while this has been increasing, it is still somewhat below that of the UK and considerably lower than the EU average. This implies that our roads may become even more congested than at present and energy consumption in transport has some growth potential yet.

[10] The effect of cross border trade (fuel tourism) or smuggling is not taken in to account in the figures presented here. The Society for the Irish Motor Industry (SIMI) and ESB International (ESBI) estimate that this is in the region of 10% of final consumption of energy in transport.

Figure 38: Private Cars per 1000 of Population

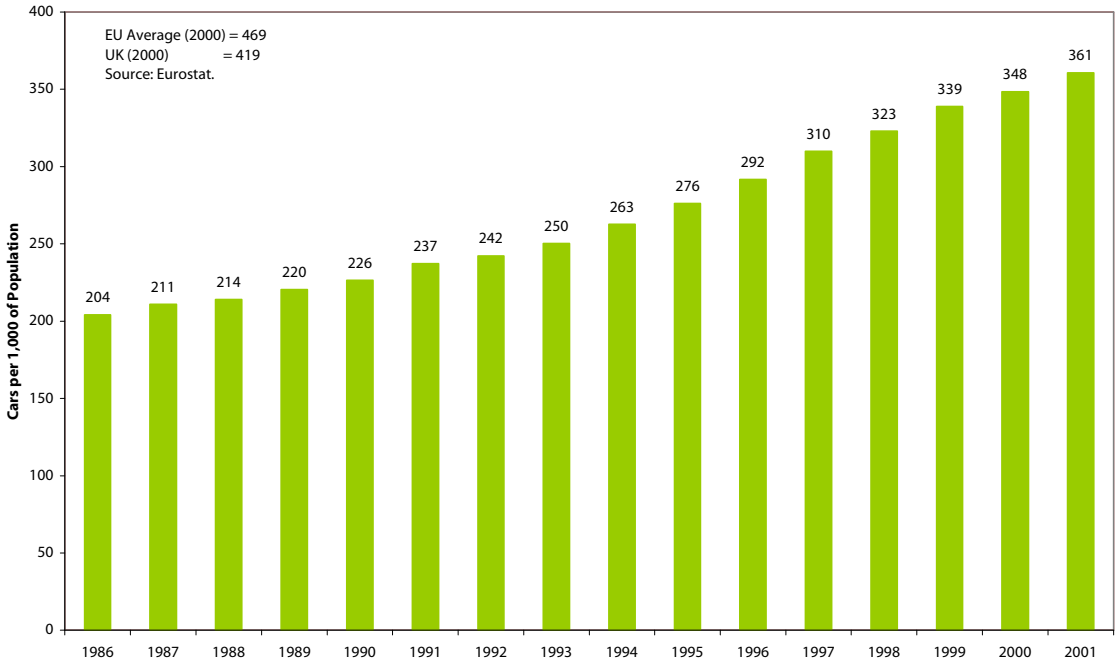


Figure 39: Changes in Car Engine Size

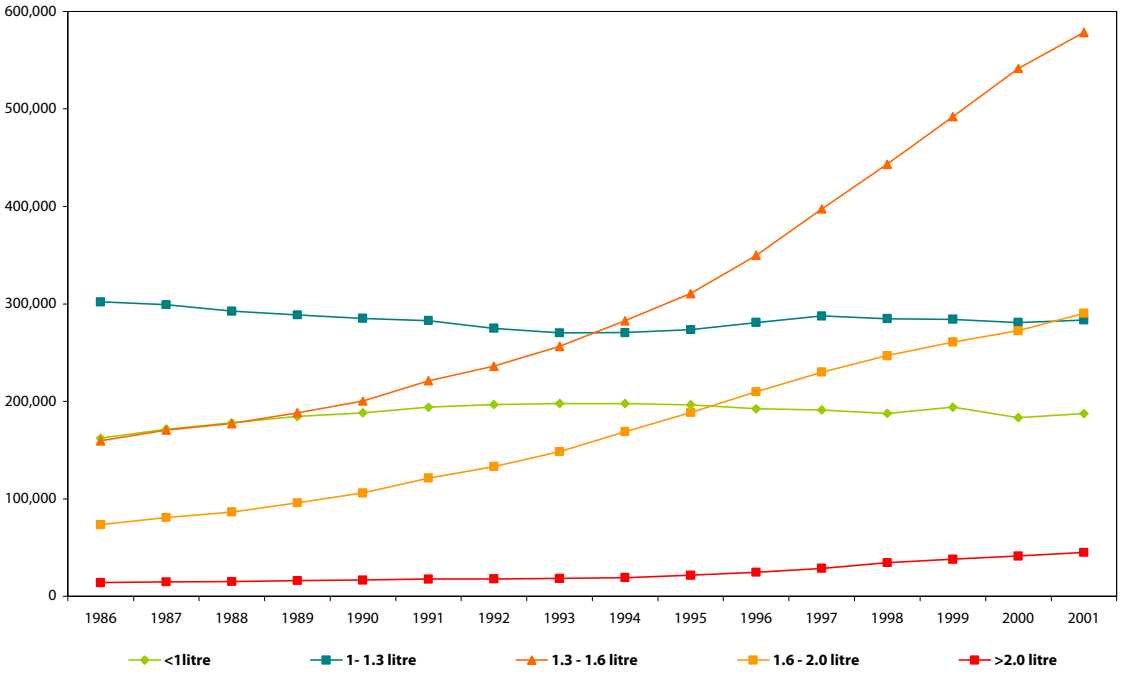


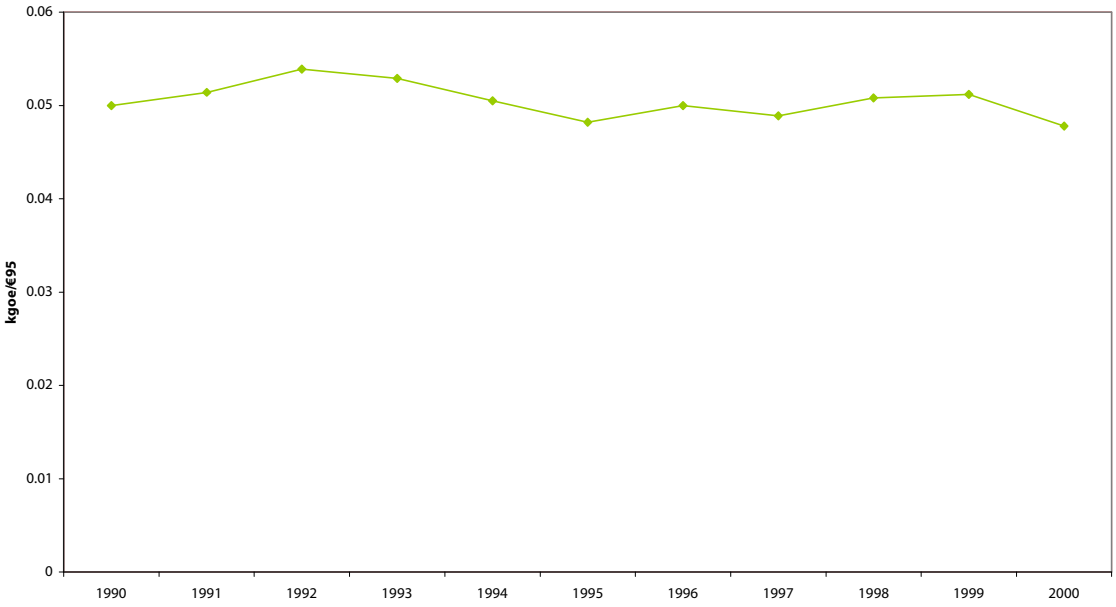
Figure 39 illustrates how the consumer's preference of engine size has changed over time. The less than 1 litre and 1 – 1.3 litre are showing steady or declining numbers whereas the fastest growing range is the 1.3 – 1.6 litre range. The 1.6 – 2.0 litre range is also growing with its share in 2001 overtaking that of the 1 – 1.3 litre range.

Transport Energy Intensity

Energy consumption in transport is affected by activity in all the other sectors (industry, residential, agriculture and tertiary). It is therefore reasonable to relate energy use in transport to gross domestic product (GDP) as a measure of activity. It has been shown in many countries that there is a relatively flat relationship between transport energy and GDP.

That is if there is say a 5% growth in GDP then there will be a corresponding growth of approximately 5% in transport energy use. The energy intensity of transport as shown in figure 40 tracks this relationship throughout the 1990's. One of the challenges of energy/transport policy is to break this relationship so that transport energy use rises slower than economic growth.

Figure 40: Energy Intensity of Transport related to Gross Domestic Product

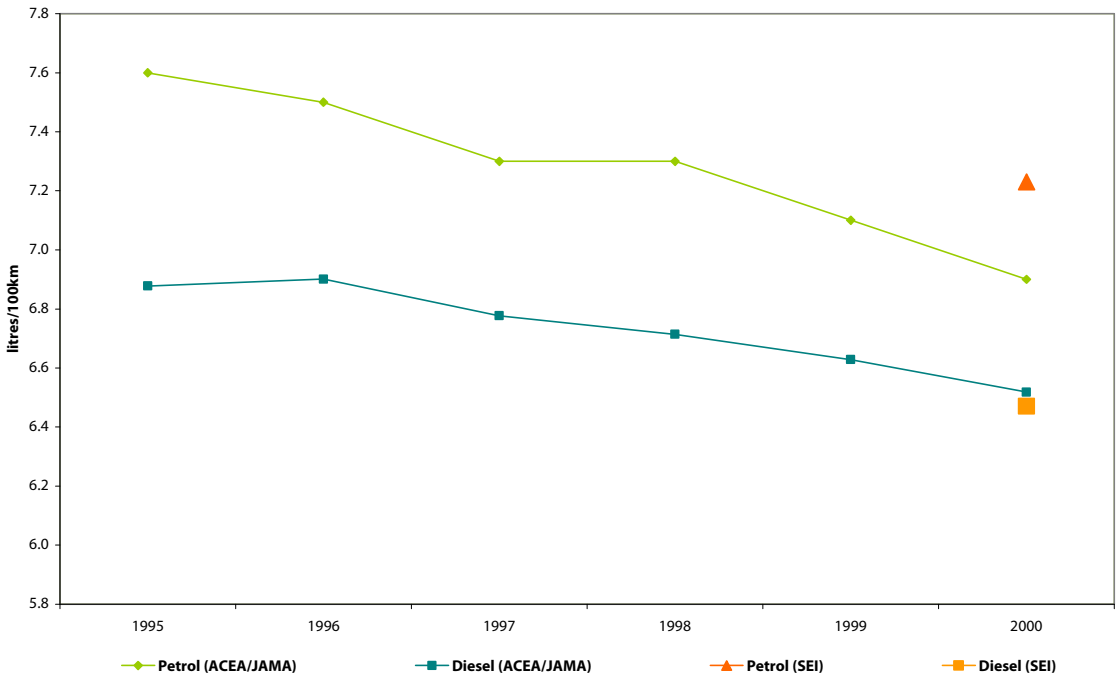


However, energy intensity is not energy efficiency. One way to assess the efficiency of the private car fleet would be to track the average on-road fuel efficiency. This could be done by taking a representative sample of the fleet and tracking the miles per gallon (mpg) or litres per 100 kilometres (l/100km) over a period of time. From this a weighted average could be calculated. Over time this figure would show how the efficiency of the fleet is evolving taking into account changes in engine efficiency, changing proportions of urban/rural mileage and driver behaviour. Surveys such as this are very expensive and very few countries carry them out, France being one exception.

An alternative and complementary method of assessing the progression of the efficiency of the car fleet is to record the efficiency of the new cars entering the fleet and replacing old inefficient models. All new cars have fuel consumption figures (measured under test conditions) quoted for urban, extra-urban and combined driving. It is possible to arrive at an average test efficiency figure for new cars entering the national fleet weighted by the sales figures for each individual model. These figures have been calculated for the first time in Ireland for the year 2000.

Figure 41 presents the weighted average of the fuel consumption of new cars first registered in 2000. These are shown as the orange triangle and red square. This was calculated for the first time by Sustainable Energy Ireland using an extract from the Vehicle Registration Unit's national database and data on fuel consumption of individual models. Historic figures from industry sources are also shown but it is not known if these are weighted by sales. It is envisioned that these new figures will be calculated on an annual basis thereby showing the trend of fuel efficiency of the replacement stock.

Figure 41: Fuel efficiency of New Cars – Industry Data and New National Data

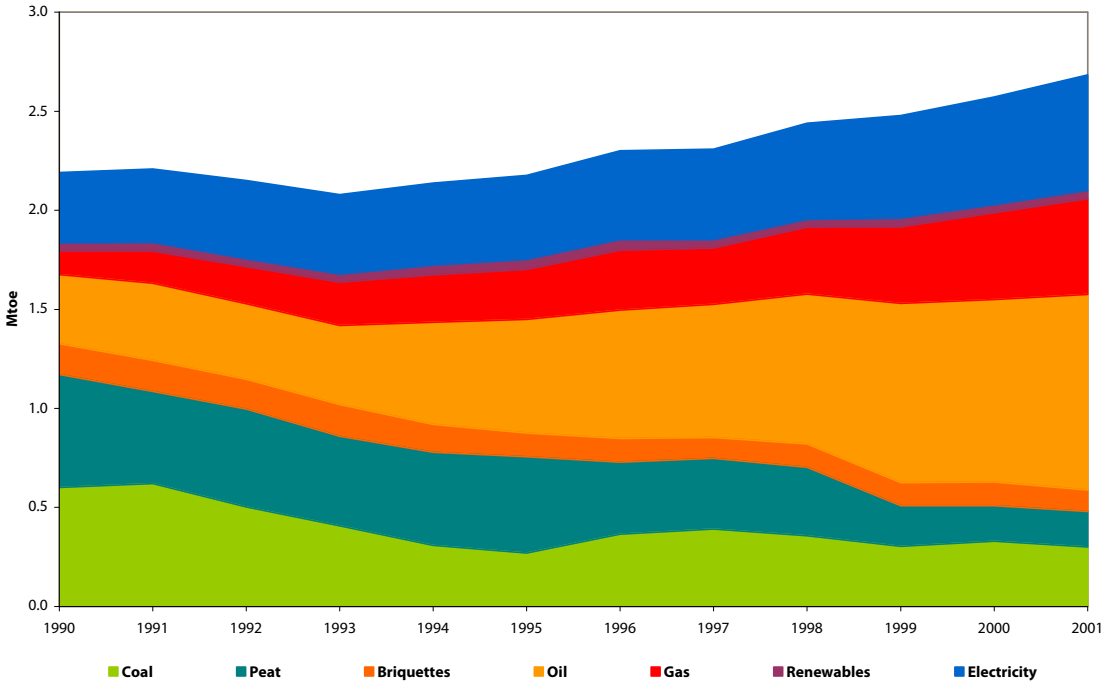


From figure 41, the weighted average consumption for new petrol cars on the road in Ireland in 2000 was 7.2 litres/100km. This compares favourably with an EU average of 8.3 litres/100km for 1999[11]. The comparable figures for diesel cars are 6.5 litres/100km for new cars in Ireland and 8.4 litres/100km for the EU average.

[11] From EU SAVE Project on Energy Efficiency Indicators (Odyssee) Project.

4.3 Residential

Figure 42: Residential Final Energy Use by Fuel



Residential final energy consumption grew by 22.5% (1.9% per annum) over the period 1990 – 2001 to a figure of 2.7 Mtoe. During this time the number of households in the state rose from approx. 1.01 million households to 1.12 million in 1998[12]. No figures are available yet from the 2002 census on household numbers. Residential energy consumption grew by 4.3% in 2001.

Figure 42 shows significant changes in the mix of fuels that have been consumed in the residential sector over the period. This can be explained by the move away from the use of open fires and solid fuel fired back-boiler heating systems that were popular in the seventies and eighties. New homes built in the 1990's predominantly have had oil or gas central heating or perhaps even electric storage heating and there has been a trend to convert existing back-boiler systems to either oil or gas. Increased comfort levels associated with central heating would tend to increase heating demand, for a given standard of insulation, but change to the relatively higher efficiency of the oil and gas heating technologies (or indeed the more efficient types of solid fuel heating technologies) would have had the opposite effect and helped to slow the growth of energy in the sector.

The increase in electricity usage in households can be explained by an increase in the use of appliances, such as washing machines, driers, dishwashers, microwave ovens, computers, televisions etc. in the home.

The salient trends in energy use in the residential sector over the period 1990 – 2001 are as follows:

- Coal usage dropped by 50.1% between 1990 and 2001 to 0.3 Mtoe. The share of coal fell from 27.4% to 11.2%.
- Sod peat usage dropped by 68.5% to 0.18 Mtoe and its share fell from 26% to 6.7%.
- Peat briquette usage dropped by 30% to 0.2 Mtoe and its share fell from 7.1% to 4%.
- Oil usage increased by 182.8% to 1 Mtoe approx. and its share in the residential sector grew from 15.9% to 36.8%.
- Natural gas usage increased by 310.9% to 0.48 Mtoe and its share rose from 5.4% to 18%.
- Renewables (mainly wood) usage increased slightly by 1.2% to 0.04 Mtoe but its share dropped from 1.9% to 1.6%.
- Electricity usage increased by 63% to 0.6 Mtoe and its share increased from 16.2% to 21.7%

[12] Estimate from the Quarterly National Household Survey, Housing and Households 3rd Quarter 1998, Central Statistics Office. Note also that the number of households is not the same as the number of housing units in the State.

Energy Intensity of Residential Sector

The energy intensity, or more correctly the unit consumption of energy, can be measured by the energy consumed per dwelling. Figure 43 shows the trend in unit consumption per dwelling, which grew by 1.2% during the period 1990 – 2000. Climatic corrections are not shown here but it is envisioned that assessment of the effect of varying heating requirement from year to year will be incorporated in future series of this report. Improvements in building standards of new housing and fuel switching to gas and oil from solid fuel should be showing reductions in the unit consumption of dwellings and the application of climatic corrections to the trend will show if this is the case. Average fuel consumption per dwelling has fallen by 3.6% between 1990 and 2001.

Figure 43: Unit Consumption of Energy per Dwelling

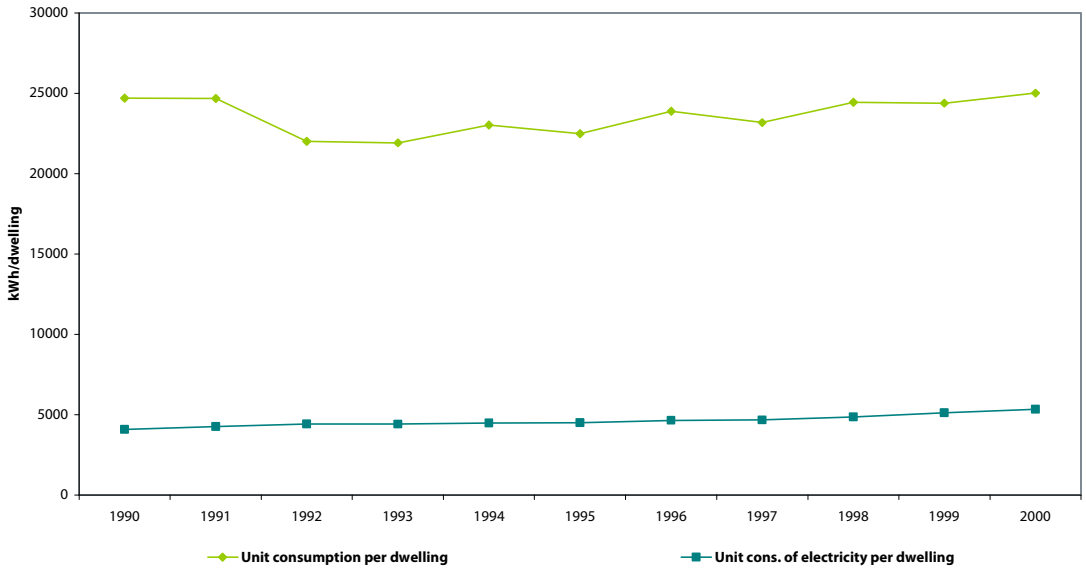
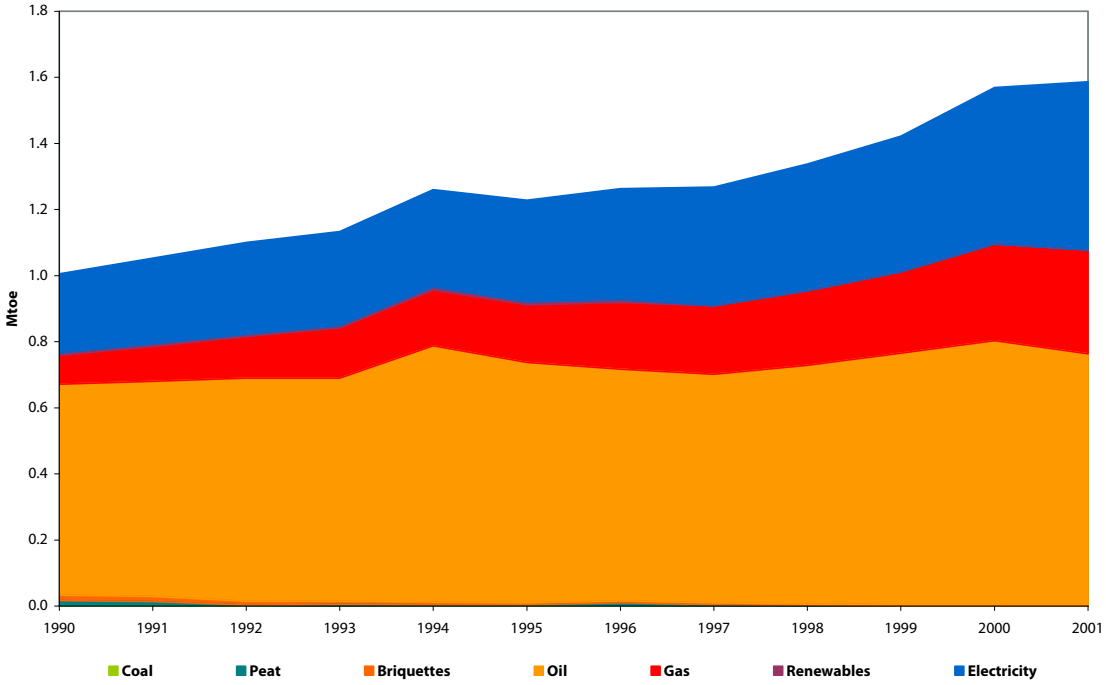


Figure 43 also shows an increasing trend in the unit consumption of electricity in households. This has increased by 38% since 1990. The increasing penetration of household appliances such as washing machines, dishwashers, driers etc and, of late, products such as computers and multiple televisions can account for this increase.

4.4 Tertiary / Commercial and Public Services

Figure 44: Tertiary / Commercial and Public Services Final Energy Use by Fuel



Tertiary sector energy consumption grew by 57.8% over the period 1990 – 2001 (4.2% per annum). Growth in 2001 was 1.1%.

Oil, gas and electricity make up the bulk of energy consumed in the tertiary sector. Coal and peat usage is now negligible.

Oil usage grew by 18.8% (1.6% per annum) over the period 1990 – 2001 to 759 ktoe and its share of tertiary energy consumption fell from 63.5% to 47.8%. In 2001 oil consumption fell by 5%.

Natural gas consumption grew by 262.2% (12.4% per annum) over the period to 314 ktoe. Its share has grown from 8.6% in 1990 to 19.8% in 2001. In 2001 gas consumption grew by 7%.

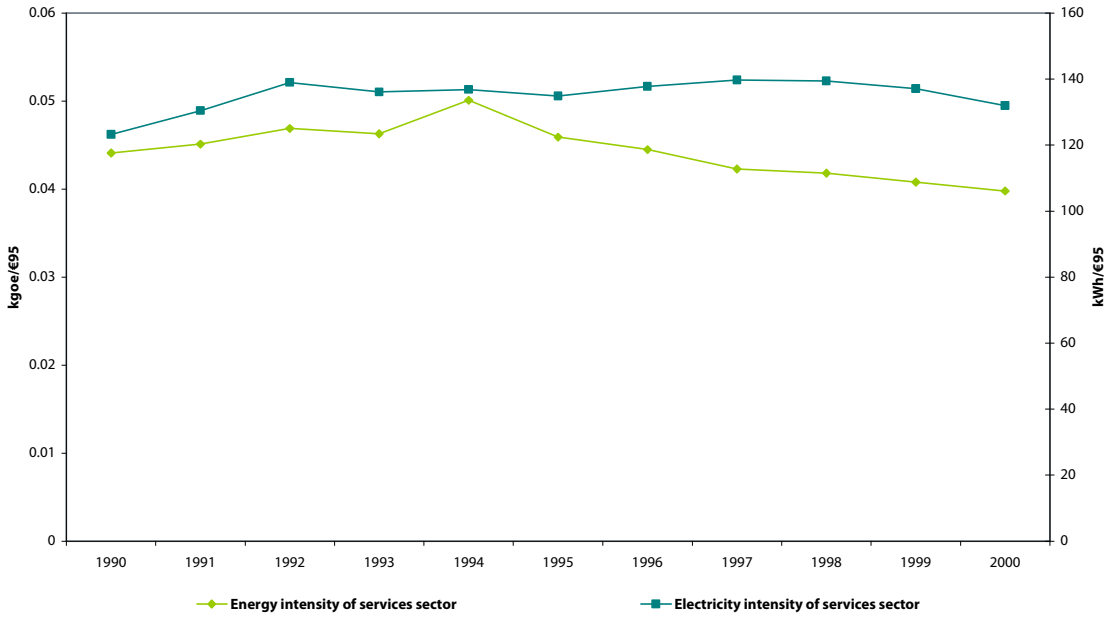
Electricity consumption in tertiary grew by 112% (7.1% per annum) over the period 1990 – 2001. Its share has grown from 23.9% in 1990 to 32.1% in 2001. The growth of electricity in 2001 was 7.7%.

Energy Intensity of the Tertiary Sector

The energy intensity of the tertiary sector is measured against the value added generated by services activities. This intensity is much flatter than that of industry although it is showing a declining trend since 1994. The energy intensity of the services sector was 9.8% lower in 2000 than it was in 1990, principally because of the rapid growth in the value added in the sector.

Also shown is the electricity intensity of the services sector. Electricity is the second most dominant fuel in this sector and more than doubled its consumption over the decade. The electricity intensity of the service sector is 7.1% higher than in 1990, but has been falling since 1997 and was 5.5% lower in 2000 than in 1997.

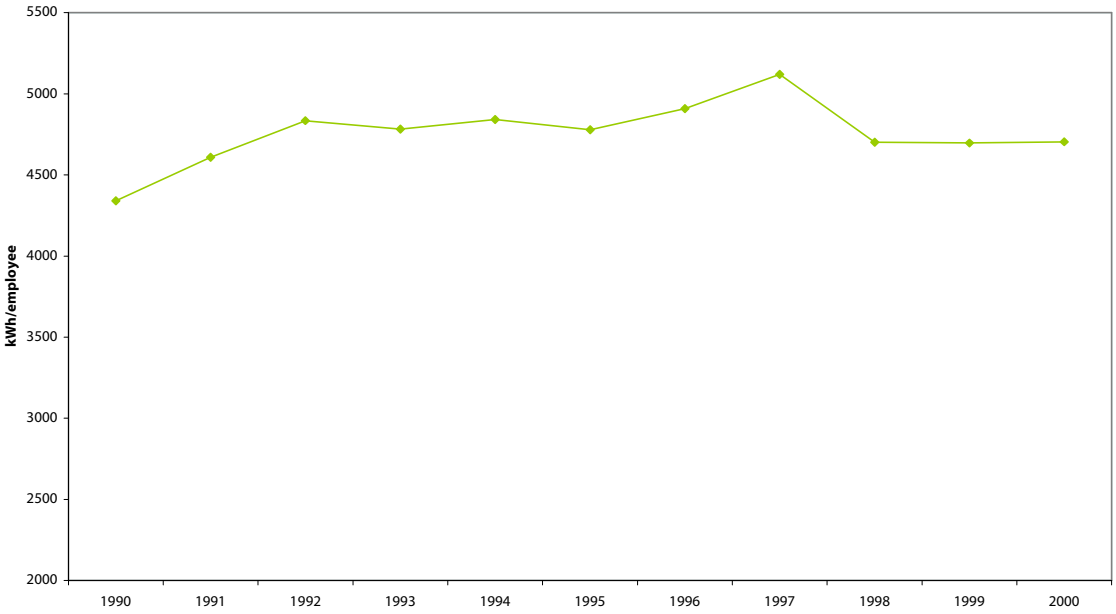
Figure 45: Energy Intensity of Tertiary / Services Sector



Two other measures of intensity in this sector are energy consumption per unit of floor area and per employee. The 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. Unfortunately it is not possible to calculate the intensity per unit of floor area due to an absence of data on floor area in the services sector.

Unit consumption of electricity per employee is used as an indicator of energy use in the services sector because in the main, electricity is affected by the number of people that require light and the number using IT equipment. With reference to figure 46, it can be seen that in the early part of the nineties, the unit consumption of electricity was rising on average by 2.4% per annum, until it peaked in 1997. This can be linked to the increasing use of office equipment, computers, printers, photocopiers etc during this time. Since 1998 it has stabilised at 8.4% above 1990 levels.

Figure 46: Unit Consumption of Electricity per Employee in the Service Sector



Glossary of Terms

Carbon Dioxide (CO_2): A compound of carbon and oxygen formed when carbon is burned. Carbon dioxide is one of the main greenhouse gases. Units used in this report are *t* CO_2 – tonnes of CO_2, *kt* CO_2 – kilo-tonnes of CO_2 (10^3) and *Mt* CO_2 – mega-tonnes of CO_2 (10^6).

Carbon Intensity (kg CO_2/kWh): This is the amount of carbon dioxide that will be released per kWh of energy of a given fuel. For most fossil fuels the value of this is constant, however in the case of electricity it will depend on the fuel mix used to generate the electricity and also on the efficiency of the technology employed. Renewable sources of electricity generation, such as hydro and wind, have zero carbon intensity.

Energy Intensity: The amount of energy used per unit of activity. Examples of activity used in this report are gross domestic product (GDP), value added, number of households, employees etc. Where possible, the monetary values used are in constant prices. When this is the case the intensity is displayed as '€xx' where xx is the base year. So for instance in the case of final intensity the units are *kgoe/€95 – kilograms of oil equivalent per euro in constant 1995 prices*.

Gross and Net Calorific Value (GCV & NCV): The gross calorific value (GCV) gives the maximum theoretical heat release during combustion, including the heat of condensation of the water vapour produced during combustion. This water is produced by the combustion of the hydrogen in the fuel with oxygen to give H_2O (water). The net calorific value (NCV) excludes this heat of condensation because it cannot be recovered in conventional boilers. For natural gas, the difference between GCV and NCV is about 10%; for oil it is approximately 5%.

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

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

Total Final Consumption (TFC): This is the energy used by the final consuming sectors of industry, transport, residential, agriculture and tertiary. It excludes the energy sector such as electricity generation and oil refining etc.

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

Energy Conversion Factors

To : / *From :*	**toe**	**MWh**	**GJ**
	Multiply by		
toe	1	11.630	4.1868×10^{-2}
MWh	0.086	1	3.600
GJ	23.885	0.2778	1

Energy Units:

Joule (J): Joule is the international (S.I.) unit of energy.

Kilowatt hour (kWh): The conventional unit of energy that electricity is measured and charged for commercially.

Tonne of Oil Equivalent (toe): This is a conventional standardized unit of energy and is defined on the basis of a tonne of oil having a net calorific value of 41686 kJ/kg. A related unit is the *kilogram of oil equivalent (kgoe)*, where 1 kgoe = 10^{-3} toe.

Decimal Prefixes:

deca (da)	10^{1}	deci (d)	10^{-1}
hecto (h)	10^{2}	centi (c)	10^{-2}
kilo (k)	10^{3}	milli (m)	10^{-3}
mega (M)	10^{6}	micro (μ)	10^{-6}
giga (G)	10^{9}	nano (n)	10^{-9}
tera (T)	10^{12}	pico (p)	10^{-12}
peta (P)	10^{15}	femto (f)	10^{-15}
exa (E)	10^{18}	atto (a)	10^{-18}

Sources

Central Statistics Office

Department of Communications, Marine and Natural Resources

European Commission DG TREN

Environmental Protection Agency

Eurostat

EU funded SAVE II Odyssee Project

Vehicle Registration Unit

Department of the Environment and Local Government

Sustainable Energy Ireland
Energy Policy Statistical Support Unit
Industry House
Rossa Avenue
Bishopstown
Cork, Ireland
t +353 21 4800212
f +353 21 4800259
e info@sei.ie
w www.sei.ie

Sustainable Energy Ireland
Glasnevin
Dublin 9
Ireland
t +353 1 8369080
f +353 1 8372848
e info@sei.ie
w www.sei.ie

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