SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Energy in the Residential Sector

2013 Report

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Sustainable Energy Authority of Ireland

The Sustainable Energy Authority of Ireland was established as Ireland's national energy authority under the Sustainable Energy Act 2002. SEAI's mission is to play a leading role in transforming Ireland into a society based on sustainable energy structures, technologies and practices. To fulfil this mission SEAI aims to provide well-timed and informed advice to Government, and deliver a range of programmes efficiently and effectively, while engaging and motivating a wide range of stakeholders and showing continuing flexibility and innovation in all activities. SEAI's actions will help advance Ireland to the vanguard of the global green technology movement, so that Ireland is recognised as a pioneer in the move to decarbonised energy systems.

SEAI's key strategic objectives are:

- Energy efficiency first – implementing strong energy efficiency actions that radically reduce energy intensity and usage;
- Low-carbon energy sources – accelerating the development and adoption of technologies to exploit renewable energy sources;
- Innovation and integration – supporting evidence-based responses that engage all actors, supporting innovation and enterprise for our low-carbon future.

The Sustainable Energy Authority of Ireland is financed by Ireland's EU Structural Funds Programme co-funded by the Irish Government and the European Union.

Energy Policy Statistical Support Unit (EPSSU)

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

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

Highlights

General Status

- The residential sector accounted for just over a quarter (27%) of all primary energy used in Ireland in 2011 and was the second largest energy using sector, after the transport sector.
- The residential sector was responsible for 27% (10.5 million tonnes) of energy related CO_2 emissions in 2011.
- The principal sources of energy supply to the sector are oil, electricity and natural gas, respectively accounting for 36%, 25% and 20% of energy end use in 2011.

Trends 2006 to 2011

- In the five year period from 2006 to 2011, the number of permanently occupied dwellings grew by 13%.
- However, over the same period, overall residential sector energy consumption fell by 4.4% (0.9% per annum) and, when adjusted for weather effects, fell by almost twice that amount (7.8%, or 1.6% per annum).
- Average weather corrected energy use per household fell by 18% since 2006.
- Residential sector CO_2 emissions fell by 11% (2.3% per annum) between 2006 and 2011, significantly faster than the fall in energy consumption. When adjusted for weather effects, CO_2 emissions fell by 14% (3% per annum).
- Average weather corrected energy-related CO_2 emissions per dwelling fell by 24% since 2006.

Trends 1990 to 2011

- The number of permanently occupied dwellings grew by 64% between 1990 and 2011 to reach 1.65 million. The average floor area per dwelling grew by 19% over the same period.
- Notwithstanding this growth, energy consumption in the sector only grew by 26%. Moreover, the sector's energy-related CO_2 emissions fell by 2.7%, highlighting the effect of the changing fuel mix on energy related emissions.
- Direct (combustible) fuel usage in the sector grew by only 10% and associated CO_2 emissions fell by 8.8% over the period.
- While electricity consumption in the sector doubled over the same period, associated CO_2 emissions grew by just 9%. This reflects the significant fall in CO_2 intensity of electricity.

Household Energy Use 2011

- On a weather corrected basis, the "average"[1] dwelling in Ireland consumed almost 20,000 kWh of energy in 2011. This comprised approximately 5,000 kWh of electricity and almost 15,000 kWh of non-electrical consumption.
- On this basis, households on average consumed 166 kWh per square metre per annum (242 kWh primary energy equivalent) – comprising 124 kWh non-electrical (136 kWh primary energy equivalent) and 42 kWh electricity (102 kWh primary energy equivalent).
- Household energy usage per square metre in Ireland was 20% below the UK average and 9% below the EU-27 average in 2010.
- The average dwelling was responsible for emitting 6.4 tonnes of energy-related CO_2 emissions in 2011. Of this, 3.9 tonnes CO_2 (61%) came from direct fuel use and the remaining 2.5 tonnes arose indirectly from electricity use.

Energy Efficiency

- The average energy efficiency in Irish housing improved by 34% over the period 1995 to 2011 (2.5% per annum). The average annual rate of improvement grew from 1.4% between 1995 and 2006 to 4.9% between 2006 and 2011.
- At least 12% of the 2011 housing stock had energy efficiency upgrades carried out since 2006, including through grant support schemes. It is estimated that such schemes saved over 900 GWh in year 2011, equating to annual cost savings of over €55 million.

Energy Spend

- Total energy spend in the sector in 2011 was €3 billion, an increase of 10% on 2006.
- Average spend per household fell by 2.3% between 2006 and 2011, even though the weighted average fuel price increase in that period was 37%.
- The average proportion of household disposable income spent on fuel and power was 4% in 2009/2010. This compares with 3.6% in 2004/2005, 4% in 1999/2000 and 6.9% in 1987.

1 Total residential energy divided by the number of permanently occupied dwellings.

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1 Introduction

This report provides a profile and analysis of Irish energy use in the residential sector, updated from the Energy in the Residential Sector – 2008 Report.[1] It broadly follows the format of the previous report but also introduces new information from additional data sources developed since that report was published, such as the Building Energy Rating (BER) database and the findings of a national Smart Metering Trial. The 2008 report examined energy consumption in the residential sector to 2006. The most up to date residential energy data in this report is for 2011, and a particular focus of this report is on trends in the five year period from 2006 to 2011.

In addition to examining overall residential sector energy usage and CO_2 emissions trends this report presents an updated profile of the housing stock using new data from the 2011 Census and the 2009/2010 Household Budget Survey. New indicators of energy efficiency have been added, as well as forecasts of residential sector energy use to 2020. The report also points to key data gaps and suggests areas for further study and development.

The residential sector accounted for just over a quarter (27%) of all energy[2] used in Ireland in 2011 and after transport it was the second largest energy using sector. It was responsible for 27% (10,479 kt CO_2)[3] of energy-related CO_2 emissions in 2011.

Energy use in the sector includes energy for heating, hot water, cooking, cleaning, washing, drying, lighting, cooling and entertainment. The sector has experienced rapid growth in the past two decades, with the number of permanently occupied dwellings increasing by 64% (2.4% per annum) over the period 1990 to 2011 to reach 1.65 million. As a result, there has been a recognised need by policy makers to implement programmes and measures that reduce the sector's demand for energy and a purpose of this report is to provide context and background to discussions regarding future policy options.

This report is intended to be a further step in an ongoing process of developing and improving energy statistics in the residential sector and is structured as follows:

- The relevant trends in energy usage and CO_2 emissions are outlined in section *2*, and provide a context for the subsequent analyses of energy use in the sector.
- Section *3* details Government targets which relating to the residential sector and summarises the policy measures and programmes that have been introduced to meet these targets.
- Section *4* profiles the residential sector and analyses the underlying factors influencing its energy usage.
- Section *5* examines energy intensity and energy efficiency trends.
- In section *6* trends in Ireland's residential sector are compared with trends internationally.
- Finally, section *7* examines new datasets which have become available since the 2008 report or will become available in the near future which can contribute to or facilitate more detailed analysis of residential energy consumption. Key data gaps in the residential sector are also identified in the discussion.

The energy balance data presented in this report are from the national energy balance published by the Sustainable Energy Authority of Ireland (SEAI) on 5th October 2012. The most up-to-date balance figures are available in the statistics publications section of the SEAI website. An energy data service is available at http://www.seai.ie/statistics; follow the links for Energy Statistics Databank. This service is hosted by the Central Statistics Office with data provided by SEAI.

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

1 SEAI, 2008, Energy in the Residential Sector - 2008 Report. Available from http://www.seai.ie/Publications/Statistics_Publications

2 The total primary energy requirement (TPER), this is the total requirement for all uses of energy, including energy used to transform one energy form to another(e.g. burning fossil fuel to generate electricity) and energy used by the final consumer.

3 kilo tonnes carbon dioxide.

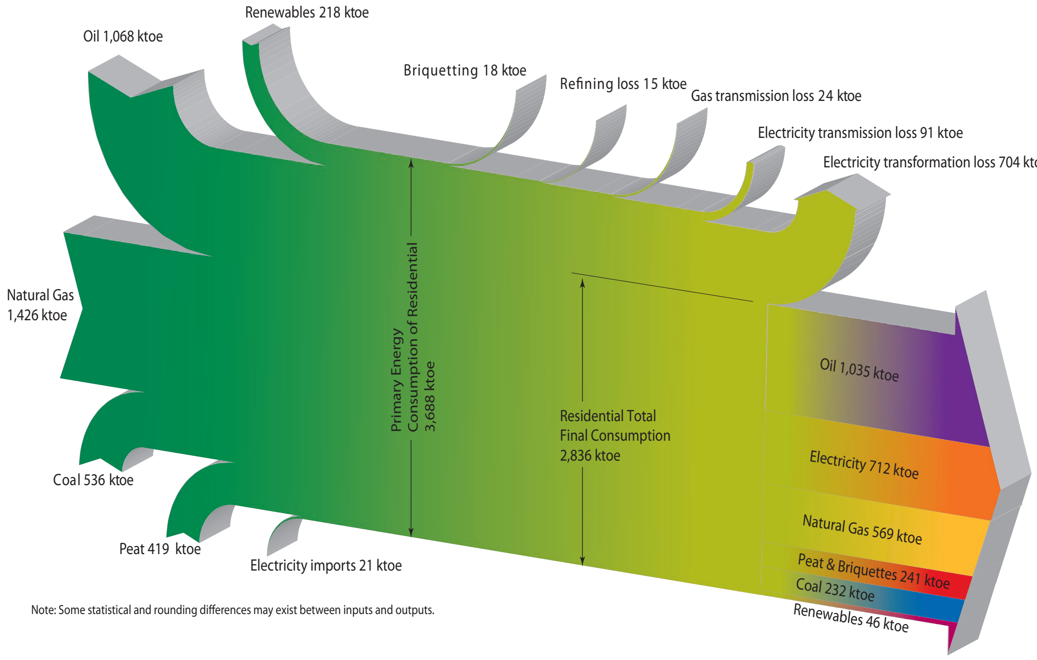
2 Energy and Environmental Context

This section provides an overview of residential sector energy trends and the sector's share of total energy usage in Ireland, over the period 1990 to 2011. A more detailed discussion of overall energy trends in Ireland is available in the latest edition of Energy in Ireland[4].

The total amount of primary energy (TPER) used by the residential sector was 3,688 ktoe[5] (42,889 GWh) in 2011. While the residential sector's energy usage has increased by 26% since 1990, its share of total primary energy usage fell from 32% in 1990 to 27% in 2011.

Figure 1 shows Ireland's residential sector energy balance for 2011 as an energy flow diagram. Fuel inputs on the left totalled 3,688 ktoe and include the fuels[6]used – on a pro-rata basis – to generate the electricity consumed by the sector. The energy transformation losses (mostly electricity generation) amounted to 852 ktoe (9,911 GWh or 23% of residential TPER) resulting in the final energy consumption of the sector in 2011 being 2,836 ktoe (32,982 GWh). This represents a quarter (25%) of Ireland's Total Final Consumption[7] (TFC), and is the amount of energy for which households within the sector are billed directly. The significant dependence on oil (36% of residential sector TFC) and electricity (25%) is noticeable, accounting for more than 60% of the total residential consumption.

Figure 1 *Residential Sector Energy Balance 2011*



Source: SEAI

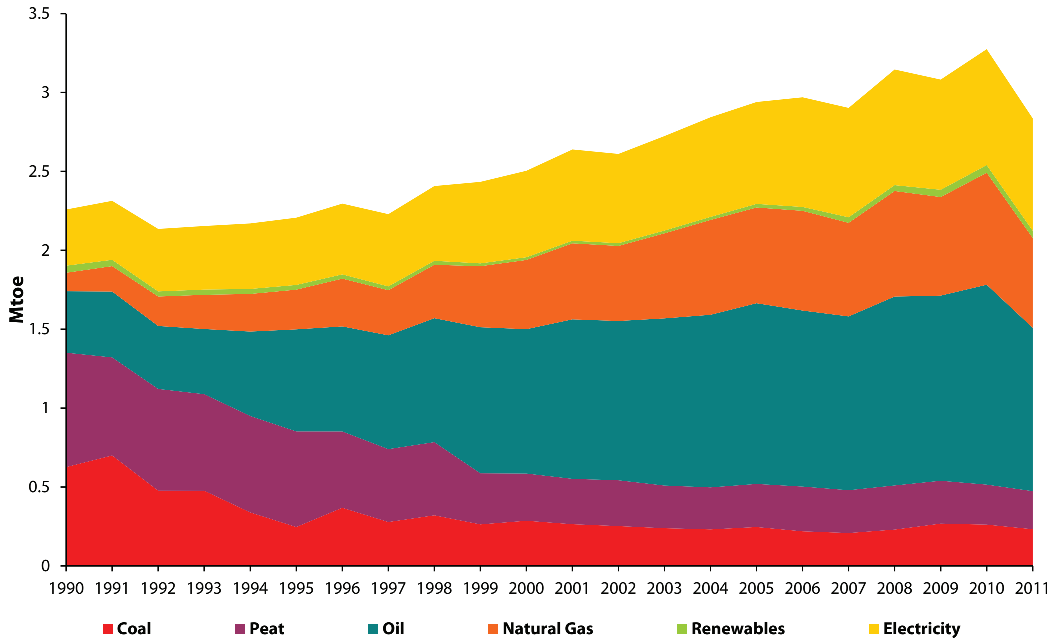
Figure 2 shows the fuel mix contributing to the overall energy bill of the residential sector for the period 1990 to 2011. Residential final energy use grew by 26% (1.1% per annum) over the period 1990 to 2011. As can be seen from *Figure 2* and *Table 1* natural gas experienced the biggest growth rate over the period (7.8% per annum on average) followed by oil (4.8% per annum) and electricity (3.4% per annum). Solid fuels (coal, peat and briquettes) all declined over the period. This reflects a significant change in the fuel mix since 1990.

Table 1 also contains the breakdown of consumption by fuel type for 1990 and 2011. In 1990 coal and peat were responsible for 28% and 32% respectively or almost 60% collectively of total energy usage in the residential sector. By 2011 coal and peat had declined to 8.2% and 8.5% respectively of TFC. Meanwhile the shares of oil and gas increased from 17% and 5.2% respectively to 36% and 20% in 2011. Electricity also increased its share of residential sector TFC from 16% in 1990 to 25% in 2011.

4 Available from www.seai.ie/statistics
5 kilo tonnes of oil equivalent.
6 The total of each individual fuel used for electricity generation and oil refining is apportioned to each end use sector according to the final consumption of electricity and oil by that sector.
7 TFC is essentially TPER less the quantities of energy required to transform and distribute primary sources such as crude oil into forms suitable for use by consumers such as refined oils and electricity.

In the five year period from 2006 to 2011 residential energy consumption fell by 4.4% (0.9 % per annum) but when adjusted for weather effects it fell by almost double that amount, (7.8% or 1.6% per annum).

Figure 2 *Residential Sector Total Final Energy Consumption by Fuel 1990 to 2011*



Source: SEAI

Table 1 *Growth Rates, Quantities and Shares of Final Consumption in Residential Sector*

	Growth %	Average annual growth rates %				Quantity (ktoe)		Shares %	
	1990 – 2011	'90 – '11	'00 – '05	'05 – '10	'06 – '11	1990	2011	1990	2011
Fossil Fuels (Total)	11.9	0.5	3.1	1.9	-1.5	1,857	2,078	82.2	73.3
Coal	-62.9	-4.6	-3.0	1.2	1.2	626	232	27.7	8.2
Peat	-66.7	-5.1	-1.8	-1.5	-3.2	725	241	32.1	8.5
Briquettes	-49.3	-3.2	-5.5	-0.5	-2.2	155	79	6.9	2.8
Oil	165.8	4.8	4.4	2.2	-1.4	389	1,035	17.2	36.5
Gas	385.5	7.8	6.7	3.2	-2.1	117	569	5.2	20.1
Renewables	2.3	0.1	5.6	16.4	13.3	45	46	2.0	1.6
Combustible Fuels (Total)	10.4	0.5	3.1	2.0	-1.5	1,902	2,100	84.2	74.1
Electricity	100.0	3.4	3.3	2.6	0.5	356	712	15.8	25.1
Total	**25.6**	**1.1**	**3.2**	**2.2**	**-0.9**	**2,258**	**2,836**		
Total Weather Corrected	**18.6**	**0.8**	**3.8**	**-0.7**	**-1.6**	**2,378**	**2,819**		

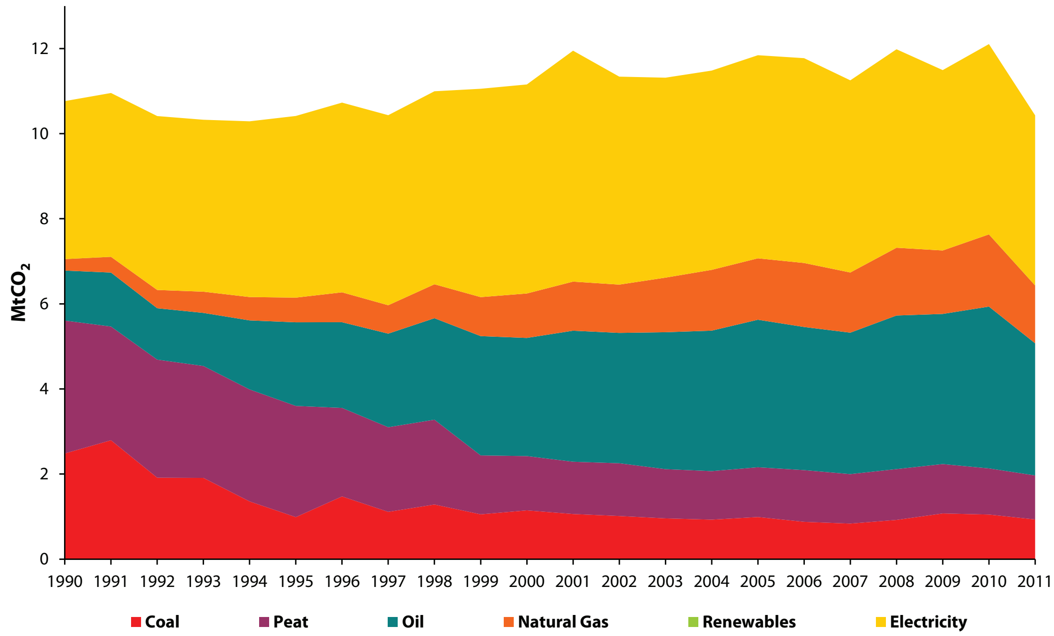
Source: SEAI

Differences in energy conversion efficiencies associated with the different fuels, coupled with the differences in carbon content of fuels utilised, have resulted in energy use in the residential sector becoming increasingly less CO_2 intensive since 1990. There was a shift from heating homes with coal and peat used in open fires, with or without back boilers, to more efficient oil and gas central heating, thus resulting in less carbon intensive fuels being used at a greater efficiency.

Similarly, the decarbonisation of electricity generation in Ireland and the introduction of more efficient generating stations between 1990 and 2011 helped to reduce the emissions associated with electricity use in the residential sector.

The residential sector is examined in more detail with respect to energy-related CO_2 emissions in *Figure 3* and *Table 2*. While final energy use in the sector increased by 26% over the period, its energy-related CO_2 emissions fell by 2.7%, illustrating the effect of the changing fuel mix on energy-related emissions.

Figure 3 *Residential Energy-related CO_2 by Fuel*



Source: SEAI

Table 2 *Growth Rates, Quantities and Shares of Energy-Related CO_2 Emissions in Residential Sector*

	Growth %	Average annual growth rates %				Quantity (kt)		Shares %	
	1990 – 2011	'90 – '11	'00 – '05	'05 – '10	'06 – '11	1990	2011	1990	2011
Coal	-62.4	-4.6	-2.9	1.1	1.3	2,484	933	23.1	8.9
Peat	-66.9	-5.1	-1.7	-1.5	-3.2	3,123	1,034	29.0	9.9
Briquettes	-49.3	-3.2	-5.5	-0.5	-2.2	642	325	6.0	3.1
Oil	164.3	4.7	4.3	2.1	-1.5	1,175	3,106	10.9	29.6
Gas	403.9	8.0	6.7	3.3	-2.0	270	1,359	2.5	13.0
Renewables	-	-	-	-	-	-	-	0.0	0.0
Combustible Fuels (Total)	-8.8	-0.4	2.4	1.6	-1.5	7,052	6,432	65.5	61.4
Electricity	9.0	0.4	-0.6	-1.1	-3.4	3,713	4,047	34.5	38.6
Total	**-2.7**	**-0.1**	**1.1**	**0.6**	**-2.3**	**10,764**	**10,479**		
Total Weather Corrected	**-7.5**	**0.4**	**1.7**	**-2.0**	**-2.6**	**11,210**	**10,364**		

The residential sector was the second largest source of energy-related CO_2 emissions in 2011, after transport (34%). The residential sector's share of total CO_2 emissions[8] fell from 35% in 1990 to 28% in 2011 to reach 10,479 kt CO_2. Absolute emissions from the residential sector fell by 2.7% over the period. If upstream emissions associated with electricity use are excluded, the CO_2 emissions from direct fossil fuel use in the residential sector fell by 8.8% compared with 1990.

In particular in *Table 2*, it is interesting to note that the emissions associated with electricity use in the residential sector only increased by 9% between 1990 and 2011, even though the electricity consumption doubled over the same period. This is due to the falling CO_2 intensity of electricity in Ireland.

Since 1990 the share of high carbon content fuels such as coal and oil being used in electricity generation has been falling with a corresponding rise in the relatively lower carbon natural gas, and zero carbon renewables. "For the purposes of reporting emissions under the Kyoto Protocol, imported electricity is also considered zero carbon, as emissions are counted in the jurisdiction in which they are emitted. This resulted in the carbon intensity of electricity dropping by 45% from 896 g CO_2/kWh in 1990 to a low of 489 g CO_2/kWh in 2011.

In the five year period from 2006 to 2011 residential CO_2 emissions fell by 11% (2.3% per annum), compared to a 4.4% fall in energy use (0.9% per annum). When adjusted for weather effects, CO_2 emissions fell by 14% (3% per annum). Emissions associated with combustible fuels fell by 7.4% (1.5% per annum) in line with a drop in energy consumption of 7.2% (1.5% per annum). Electricity emissions fell by 16% (-3.4% per annum) even though the energy demand grew by 2.5% (0.5% per annum). So, most of the emissions savings in the residential sector between 2006 and 2011 arose from the reduction in the carbon intensity of electricity over the period.

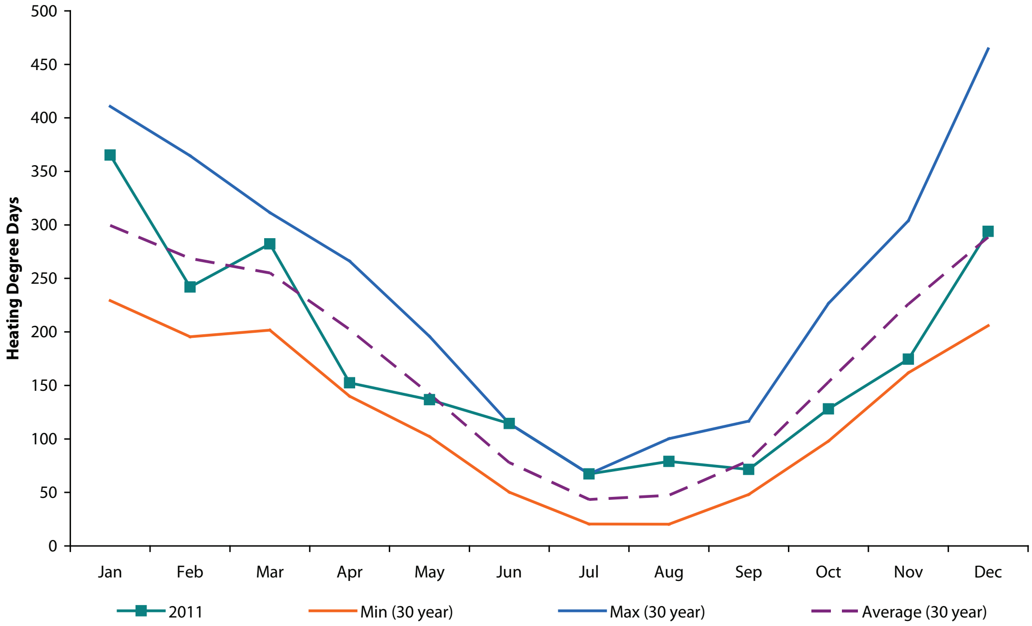
8 Measured as kilo tonnes of carbon dioxide (kt CO_2).

2.1 Weather Effects - Heating Degree Days

Weather variations from year to year can have a significant effect on energy demand and in particular on the portion of the energy demand associated with space heating. A method to measure the weather or climatic variation is through the use of degree days. "Degree Days" is the measure or index used to take account of the severity of the weather when looking at energy use in terms of heating (or cooling) "load" on a building. A "Degree Day" is an expression of how cold (or warm) it is outside, relative to a day on which little or no heating (or cooling) would be required. It is thus a measure of cumulative outdoor temperature deficit (or surplus) relative to a neutral target temperature (base temperature). It should be noted that the larger the number of heating degree days, the colder the weather and that the typical heating season in Ireland is October to May. If, for example, the outdoor temperature for a particular day is 10 degrees lower than the base temperature (15.5 degrees), this would contribute 10 degree days to the annual or monthly total.

Met Éireann calculates degree day data for each of its synoptic weather stations. SEAI calculates a population weighted average of these data to arrive at a meaningful degree day average for Ireland that is related to the heating energy demand of the country.

Figure 4 *Population weighted average heating degree day trend 2011*

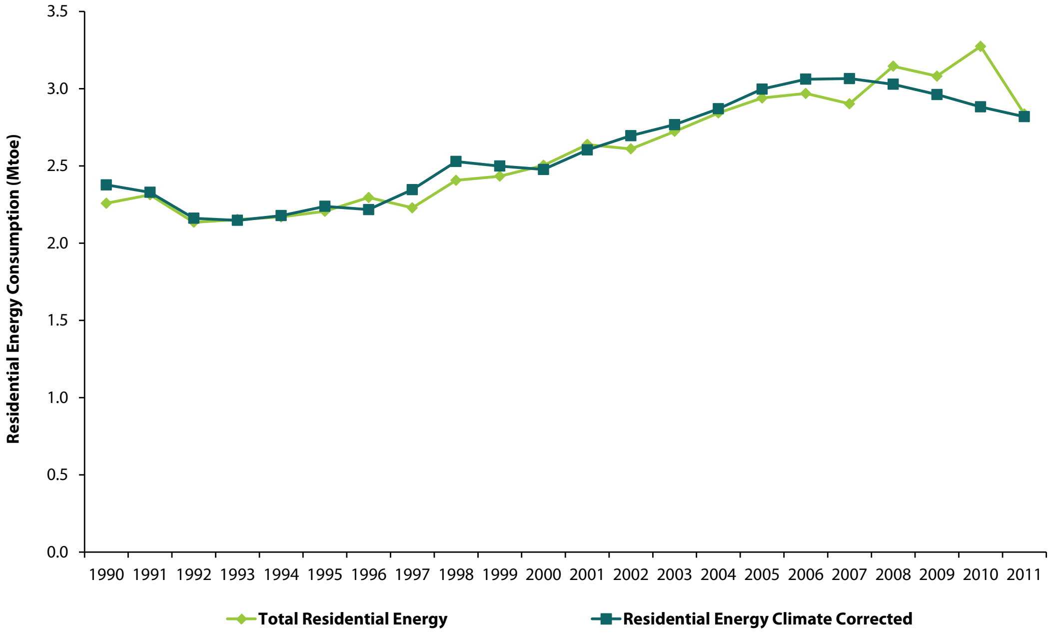


Source: Met Eireann & SEAI

Figure 4 shows the minimum, maximum and average degree days for each month for the last 30 years together with the monthly degree days for 2011. As shown in *Figure 4* it was colder than average in January and March but warmer in February and April. Later in the year, October and November were warmer than average and December was very slightly colder than average. For the year as a whole, there were just 1.2% more degree days in 2011 than the 30 year average. In terms of space heat requirements that are weather dependent, 2011 could be considered average.

When the climate correction is applied to the residential energy consumption it smooths out the trend in energy consumption as shown in *Figure 5*. The climate correction yields a lower normalised energy consumption in cold years, (for example 2008 - 2011), and yields a higher normalised consumption in mild years, (such as 1990, 1997 to 1999).

Figure 5 *Climate Corrected Residential Energy Consumption*



Source: SEAI

2.2 Forecasts of Residential Energy Use

In order to inform policy formulation the SEAI Energy Modelling Group, in conjunction with ESRI, produced[9] forecasts which examine energy usage out to 2020. Two sets of forecasts were prepared in 2012[10]. The first, the Baseline forecast, includes all policy measures legislated for up to the end of 2010 and represents a hypothetical future scenario in which no further policy actions or measures have been taken. It provides a basis for comparison with the other scenarios in which the expected additional effects of government policy and measures to 2020 are modelled. The second scenario, the *NEEAP/NREAP* forecast, builds on the Baseline forecast, with additional assumptions introduced to incorporate the measures and targets contained in the *Energy White Paper*, the *National Energy Efficiency Action Plan (NEEAP)* and the *National Renewable Energy Action Plan (NREAP)*.

The NEEAP/NREAP forecast assumes that the 20% energy efficiency improvement by 2020 and the 16% overall RES target, required by the EU Renewable Energy Directive (based on achievement of the 40% renewable electricity, 12% renewable heat and 10% renewable transport targets), are achieved.

As shown in *Table 3*, an overall decrease in residential energy demand to 2020 is forecast (16%). With the exception of renewables and electricity, demand for all other energy sources is expected to fall. The greatest decrease is expected for coal at approximately 7% per annum, followed by natural gas at 3% per annum, peat at 2.5% per annum and oil at between 2% and 3% per annum. Oil will still have the highest share in final residential energy consumption in 2020 but electricity will overtake natural gas to have the second largest share in the sector.

Table 3 *Residential Final Energy Demand by Fuel 2010[11] to 2020 (NEEAP/NREAP Scenario)*

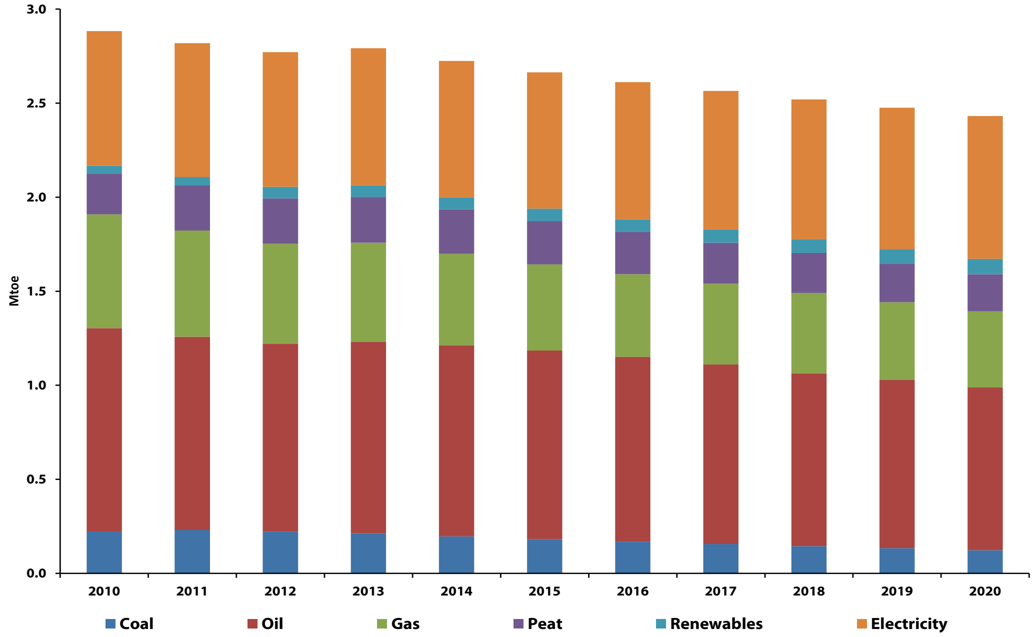
Sector (ktoe PEE)	Total Final Demand (ktoe)				Growth %	Average Annual Growth Rate %			Fuel Shares %			
	2010	2012	2015	2020	10 - '20	10 - '20	12 - '20	15 - '20	2010	2012	2015	2020
Coal	223	222	182	123	-45	-5.8	-7.1	-7.5	8	8	7	5
Oil	1081	999	1003	865	-20	-2.2	-1.8	-2.9	37	36	38	36
Natural Gas	606	531	458	405	-33	-3.9	-3.3	-2.4	21	19	17	17
Peat	216	242	230	198	-8	-0.9	-2.5	-3.0	8	9	9	8
Renewables	41	61	66	81	96	6.9	3.6	4.2	1	2	2	3
Electricity	716	716	725	760	6	0.6	0.7	0.9	25	26	27	31
Total	**2883**	**2771**	**2665**	**2432**	**-16**	**-1.7**	**-1.6**	**-1.8**				

Source: SEAI

9 These forecasts were originally published in Energy in Ireland 1990 – 2006. Available from www.seai.ie/statistics
10 Full details on the 2012 forecasts are available from: http://www.seai.ie/Publications/Energy_Modelling_Group_/Energy_Forecasts_for_Ireland/
11 Climate corrected figures are used for 2010 as it was an exceptionally cold year, so using actual values would distort the figures.

The *NEEAP/NREAP* forecast for the residential sector is shown in *Figure 6*. The projected residential sector share of total final demand in 2020 is 21%.

Figure 6 *Residential Final Energy Demand by Fuel 2010 to 2020 (NEEAP/NREAP Scenario)*



Source: SEAI

Inherent in the *NEEAP/NREAP* scenario is the underlying assumption that all measures in the White Paper will result in the corresponding targets being met. These forecasts highlight the significant scale of challenge associated with achieving these targets.

2.2.1 SEAI Residential Energy Roadmap to 2050

The SEAI Residential Energy Roadmap to 2050 sets out a number of possible trajectories for energy consumption and CO_2 emissions for Ireland's existing and future housing stock. In the Roadmap[12] (2010 to 2050) six different scenarios set out a number of possible trajectories. Key outcomes of the analysis are that total energy demand for the residential sector could be reduced by as much as 50% by 2050 and CO_2 emissions by up to 90%. This could be achieved with an extensive programme of energy efficiency retrofit, deployment of renewable energy and low or zero carbon (LZC) technologies combined with decarbonisation of the electricity grid.

12 SEAI, 2011, Residential Energy Roadmap. Available from: http://www.seai.ie/Renewables/Residential_Energy_Roadmap.pdf

3 Energy in the Residential Sector – the Policy Context

Irish residential energy policy is framed in the context of European legal obligations specified in various Directives and Regulations, as well as other international and national targets. This section outlines the key policy targets relevant to residential energy use in Ireland and new policy developments since the publication of the 2008 report.

The residential sector accounted for just over a quarter of all the energy used in Ireland in 2011 and was the second largest energy using sector after transport. In 2011 the residential sector was responsible for 28% of all energy-related CO_2 emissions and 45% of non-Emissions Trading Scheme emissions. As a result, there is a clear motive for policy makers to put in place programmes and measures which reduce the sector's demand for energy.

3.1 International Cooperation

Ireland's target under the **Kyoto Protocol**[13], an international legally binding agreement to reduce GHG (greenhouse gas) emissions, was to limit the growth in annual emissions to 13% above 1990 levels in the period 2008 to 2012.

The **EU Energy and Climate Change Package,** agreed at the European Council in December 2008[14], set out targets of a 20% efficiency improvement, 20% renewable energy penetration and 20% greenhouse-gas emissions reduction by 2020. These targets resulted in two specific pieces of GHG emissions legislation affecting Ireland:

- **Directive 2009/29/EC**[15] requiring emissions trading scheme (ETS) companies to reduce their emissions by 21% below 2005 levels by 2020;
- **Decision 2009/406/EC**[16] requiring Ireland to reduce non-ETS emissions by 20% below 2005 levels by 2020.

The target for Ireland in the European **Renewable Energy Directive (2009/28/EC)**[17] is a 16% share of renewable energy in gross final consumption by 2020. At a national level there are targets for renewable energy use in electricity generation (RES-E), in transport energy (RES-T) and for thermal energy purposes (RES-H). While there is no specific target for residential sector, the sector accounts for a third of total electricity demand, 16% of total thermal energy demand and just over a quarter of all energy use and emissions, therefore it will be required to make a proportional contribution in order to achieve the overall targets.

The **EU Energy Services Directive (ESD)** [18] set an indicative target for Member States to achieve a 1% per annum energy-efficiency improvement, resulting in a cumulative target of a 9% improvement in energy efficiency by 2016. The ESD is an overarching directive that seeks to promote cost-effective energy efficiency in the EU member states through various promotional, awareness and support measures and through the removal of institutional, financial and legal barriers. Unlike the 2020 energy-efficiency target, the ESD target excludes energy used by enterprises involved in the EU Emissions Trading Scheme (ETS)[19] and also international aviation.

In fulfilling its requirements under the ESD, the Irish Government submitted its first **National Energy Efficiency Action Plan (NEEAP)** to the European Commission in September 2007[20], and its second in June 2011[21] while an update is due in 2014 to further detail Ireland's progress toward the ESD target of 9% savings by 2016. The plan details the current package of energy-efficiency policies and measures that will contribute to both the national 20% savings target for 2020, and the EU ESD 9% energy-savings target for 2016. A complete list of all the existing and committed-to measures that will contribute towards meeting Ireland energy-efficiency targets is contained in the NEEAP. A summary of NEEAP measures which relate to the residential sector is given in Appendix 1: National Energy Efficiency Action Plan.

To give fresh momentum to energy efficiency, on 8 March 2011 the EU Commission put forward a new **Energy Efficiency Plan (EEP)**[22] setting out measures to achieve further savings in energy supply and use. An associated Directive[23] was proposed in 2011 which would supersede the ESD and transform certain aspects of the EEP into binding measures. The finalised **Directive on Energy Efficiency**[24], published in October 2012, reaffirmed and

13 More information available from: http://unfccc.int/kyoto_protocol/items/2830.php
14 Available from: http://www.consilium.europa.eu/uedocs/cmsUpload/st17215.en08.pdf
15 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:en:PDF
16 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF
17 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF
18 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0085:EN:PDF
19 European Union Emissions Trading Scheme *http://ec.europa.eu/environment/climat/emission/index_en.htm*
20 Available from: http://ec.europa.eu/energy/efficiency/end-use_en.htm
21 Ibid.
22 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0109:FIN:EN:PDF
23 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0370:FIN:EN:PDF
24 Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF

strengthened the provisions of the ESD and seeks to set a common framework to promote energy efficiency in the Union beyond 2020.

The European **Energy Performance of Buildings Directive (EPBD)** was adopted into Irish law as Statutory Instrument S.I. No. 666 of 2006. This is a cross-sectoral measure encompassing energy efficiency in the built environment as a whole. This directive included a common methodology for calculating the integrated energy performance of buildings; minimum standards on the energy performance of new buildings and existing buildings that are subject to major renovation; systems for the energy certification of new and existing buildings, and for public buildings; and regular inspection of boilers and air-conditioning systems in buildings.

As part of the EPBD, a **Building Energy Rating**[25] (BER) certificate, which is effectively an energy label for buildings, has been at the point of sale or rental of a building, or on completion of a new building since 2008. Since January 2009 this labelling system applies to existing buildings as well as new domestic and non-domestic buildings in Ireland. Member States are also required by the EPBD to review their mandatory energy performance requirements for buildings at least every 5 years.

The EPBD was superseded by the **Recast EPBD (Directive 2010/31/EU)**[26] in 2010, transposed into Irish law as **S.I. 243 of 2012 European Union (Energy Performance of Buildings) Regulations 2012**[27] which came into effect on 9th January 2013. This recast includes a requirement for Member States to move to "near zero-energy buildings" (NZEB) by 2020.

Ireland is also committed to the implementation of the following EU Directives relating to the **energy efficiency of products**[28] which impact on energy use in the residential sector:

- **Energy Labelling of Domestic Appliances Directive (2003/66/EC)** – to ensure the provision of consistent, detailed information to consumers on the energy use of domestic appliances;
- **Eco-design of Energy-Using Products Directive (2009/125/EC)** – to set minimum energy performance standards for a broad range of energy usage and related technologies;
- **Directive 2010/30/EU** on the indication, by labelling and standard product information, of the consumption of energy and other resources by energy-related products.

3.2 Irish Policies

3.2.1 Building Regulations (Part L Amendments) Regulations

There have been two substantive revisions to Ireland's Building Regulations (Part L – Conservation of Fuel and Energy) aimed at progressively improving energy efficiency standards towards low to zero carbon buildings.

New regulations[29], detailed in Technical Guidance Document L - Conservation of Fuel and Energy, came into effect on 1st July 2008 for new dwellings, setting an energy performance target improvement of 40% relative to the previous standards set in 2002. Subsequent regulations revised this further, to a 60% improvement level with effect from 1st December 2011.

Since July 2008, all new domestic buildings are also required to have the following contribution from renewable energy:

- 10 kWh/m^2/annum contributing to energy use for domestic hot water heating, space heating or cooling, ***or***
- 4 kWh/m^2/annum of electrical energy, ***or***
- A combination of these which would have the equivalent effect.

Since 31st March 2008, when installing a replacement oil or gas boiler, it has been a requirement that the boiler be condensing, where practical (Section L3, Building Regulations Part L amendment – **S.I. No. 854 of 2007**[30]).

25 Building Energy Rating www.seai.ie/Your_Building/BER/
26 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). Available from: http://www.eceee.org/buildings/EPBD_Recast/EPBD_recast_19May2010.pdf
27 Statutory Instrument No. 243 of 2012. Available from: http://www.irishstatutebook.ie/home/html
28 Details available at: www.europa.eu/scadplus/leg/en/s14003.htm
29 Building Regulations (Part L Amendment), 2008. Available from: www.environ.ie/en/Legislation/DevelopmentandHousing/BuildingStandards/FileDownLoad,17840,en.pdf
30 Statutory Instrument No..854 of 2007. Available from: http://www.irishstatutebook.ie/home/html

These revisions to the regulations also prescribe strengthened standards for:

- Insulation levels in building fabric
- Ventilation and air infiltration
- Thermal bridging reduction
- Heating and hot water system controls
- Insulation of hot water storage vessels, pipes and ducts

3.2.2 Carbon Tax

A carbon tax at a rate of €15 per tonne of carbon dioxide (CO_2) was introduced on fossil fuels in the 2010 budget[31]. The tax was applied to petrol and auto-diesel with effect from midnight, 9th December 2009; and from 1st May 2010 it applied to kerosene, marked gas oil, liquid petroleum gas (LPG), fuel oil and natural gas. The rate was increased to €20 per tonne of carbon dioxide produced in the 2012 budget. The carbon tax liability per unit of energy is detailed in *Table 4*. Exemption from the tax apply only to participants in the EU Emissions Trading Scheme (ETS) in respect of fuels so covered. On that basis, electricity is not subject to the carbon tax. One of the consequences of the carbon tax on fossil fuels is to improve the cost competitiveness of renewables.

The application of the tax on coal and commercial peat was announced in the 2013 Budget on 5th December 2012, extending the carbon tax to solid fuels on a phased basis over two years. A rate of €10 per tonne applied effective from the 1st of May 2013 and this rate will increase to €20 per tonne on the 1st of May 2014.

Table 4 *Carbon Tax*

Fossil Fuel	Unit	€	Current Rate Effective from	Introduced
Petrol	litres	0.034	7 December 2011	9 December 2009
Auto-diesel	litres	0.046	7 December 2011	9 December 2009
Kerosene	litres	0.043	7 December 2011	1 May 2010
Marked Gas Oil	litres	0.035	7 December 2011	1 May 2010
LPG	litres	0.013	7 December 2011	1 May 2010
Fuel Oil	litres	0.044	7 December 2011	1 May 2010
Natural Gas	kWh	0.041	1 May 2012	1 May 2010
Peat Briquettes	Bale	0.24	1 May 2013	1 May 2013
Coal	kg	0.028	1 May 2013	1 May 2013

Source: Department of Finance

3.2.3 Smart Metering

The main strategic objectives of the National Smart Metering programme, covering both electricity and natural gas and led by the Commission for Energy Regulation, are to: encourage energy efficiency, facilitate peak load management, support renewable and micro generation, enhance competition and improve customer experience, improve network services and review and realise synergies with water metering.

The National Smart Metering Programme Phase 1 commenced in late 2007. Its objective was to set up and run smart metering trials and assess their costs and benefits, in order to inform decisions relating to the full rollout of an optimally designed universal National Smart Metering Programme. The trial included over 5,000 domestic electricity consumers. The electricity and gas smart metering trials findings reports and cost-benefit analyses reports were published in 2011[32]. The CER decided[33] to proceed to Phase 2 of the National Smart Metering Programme on foot of the positive findings of those reports. Phase 2 involves planning, requirement definition, procurement and selection and is expected to take less than 2 years.

31 Details available from http://www.budget.gov.ie/Budgets/2010/2010.aspx and http://www.environ.ie/en/Publications/Environment/Atmosphere/
32 Available from: http://www.cer.ie/en/information-centre-reports-and-publications.aspx?article=1c6fdd02-da48-44b8-8703-7f0916c2de7a
33 CER, 4th July 2012, Decision on the National Rollout of Electricity and Gas Smart Metering. Available from: ibid.

3.3 Government Programmes

The Irish Government, through SEAI, encourages people to improve the energy performance of their homes by incentivising the installation of various upgrade measures. A pilot **Home Energy Savings Scheme** was introduced in 2008 to reduce energy and CO_2 emissions from the existing housing stock. The subsequent full national Home Energy Saving Scheme[34] was launched on 8th February 2009, with a budget of €50 million (in 2009). The scheme supported the upgrade of 25,000 homes.

A follow-on to the Home Energy Savings scheme, the **Better Energy Homes Scheme**, was launched in 2011. It aims to stimulate energy-efficiency actions to reduce energy usage by homeowners and the general public. SEAI currently grant-aids householders to make their homes more energy-efficient by providing incentives towards the implementation of measures including attic and wall insulation, and heating controls with efficient boilers. Solar heating is also included when combined with other energy efficiency measures. As of end of December 2012, €147 million has been paid in grant support towards 346,000 upgrade measures in 136,000 homes[35]. Energy savings of greater than 21% per dwelling have been verified for a sample of the upgraded homes[36]. There is also a noted continued downward trend in the typical cost of works, particularly in the case of wall insulation.

The **Warmer Homes Scheme** targets vulnerable and fuel poor homes and provides funding for the installation of domestic energy efficiency upgrades via regional not-for-profit organisations and private contractors. The scheme is running since 2000 and has now been incorporated into the Better Energy Homes scheme. Energy efficiency improvement measures include: attic insulation, draught proofing, lagging jackets, energy efficient lighting, cavity wall insulation and energy advice. As there can be a high level of comfort taking (a form of 'rebound' effect) associated with retrofitting low income households, the projected energy savings are assumed to be 70% of the energy efficiency gains. Since 2000 over €82 million has been paid in grant support towards upgrading 95,000 homes.

SEAI currently has a Voluntary Agreements programme with key energy utilities, fuel importers and named energy market players, who agree to meet specified energy saving targets as part of a multi-annual programme.

The Minister for Communications, Energy and Natural Resources has proposed that the current suite of Exchequer-funded grants for energy efficiency (excluding the Better Energy Warmer Homes Scheme) be replaced by a comprehensive national energy efficiency scheme. In this regard, the **Better Energy Financing** project is a Government initiative towards transitioning from Exchequer-funded grants to a market-orientated approach for realising energy efficiencies. This project is staffed by resources from across industry and the utilities and will provide a design for a financial solution for consumers wanting to upgrade their homes and avail of the resulting energy efficiency saving. The scheme will involve participating energy suppliers, both network connected and non-network connected, who have already signed up to the voluntary agreements programme to meet energy efficiency targets. It will also focus on quality assurance relating to assessments, installations, workmanship and products.

3.4 Types of energy efficiency policy measures in the residential sector

The MURE (Mesures d'Utilisation Rationnelle de l'Energie)[37] project provides information on energy efficiency policies in EU Member States and enables the simulation and comparison at a national level of the potential impact of the various types of energy efficiency measures.

The main categories of measures used in the Irish residential sector are information/education, legislative and financial. A summary of such measures is given in Appendix 2: Energy Efficiency Policy Measures, as well as *Figure 57* which classifies the policy measures as informative or educational, cooperative, legislative (informative or normative)[38], financial (e.g. grants), fiscal or tariffs, or cross-cutting measures which impact on more than the residential sector (e.g. Carbon Tax). This highlights a significant increase in policy activity since 2005.

34 Sustainable Energy Ireland Home Energy Savings Scheme: www.sei.ie/Grants/Home_Energy_Saving_Scheme/
35 Figures from the start of the scheme to December 2012.
36 Jim Scheer, Matthew Clancy and Sadhbh Ní Hógáin, 2012, Quantification of energy savings from Ireland's Home Energy Savings scheme: an ex-post billing analysis. Energy Efficiency DOI 10.1007/s12053-012-9164-8
37 Details on the MURE project are available from: http://www.muredatabase.org/index.htm
38 Legislative informative measures are legislative measures which only require information to be displayed, e.g. energy labels for appliances or dwellings. They introduce standards or require a certain performance, such as minimum efficiency of appliances or building regulations.

4 Energy Consumption and CO_2 Emissions – Underlying Factors

A number of factors shape the patterns of energy usage seen in section *2*. This section analyses the significant variables which underlie the trends in residential sector energy usage and CO_2 emissions. Some of the variables such as the number of dwellings will be expected to increase the demand for energy while other factors such as the strengthened Building Regulations will be expected to reduce demand.

The variables are examined in this section, under 4 headings as illustrated in *Figure 7*:

Figure 7 *Drivers of Energy Usage and CO_2 Emissions*

The Housing Stock
- **Number of dwellings**
- **Type of dwelling**
- **Period of construction**
- **Floor area**
- **Energy rating (BER)**

Space Heating
- **Penetration of central heating**
- **External and internal temperatures**
- **Fuel used**
- **Building regulations**
- **Insulation**
- **Heating controls**
- **Appliance efficiency**

Economic Factors
- **Disposable income**
- **Housing tenure (i.e. renting/ownership)**
- **Employment status**
- **Household size**
- **Age of occupants**
- **Number of children**
- **Energy prices**

Other Factors
- **Location (proximity to gas grid)**
- **Household occupancy**
- **Penetration & efficiency of electrical appliances**
- **Intensity of use of electrical appliances**
- **Prevalence of energy saving features**
- **Behavioural factors**
- **Information (e.g. Smart Meters)**

Source: SEAI

4.1 The Housing Stock

As consumption of energy in the residential sector is dependent on the characteristics of the total stock of dwellings, it is therefore useful to examine these characteristics.

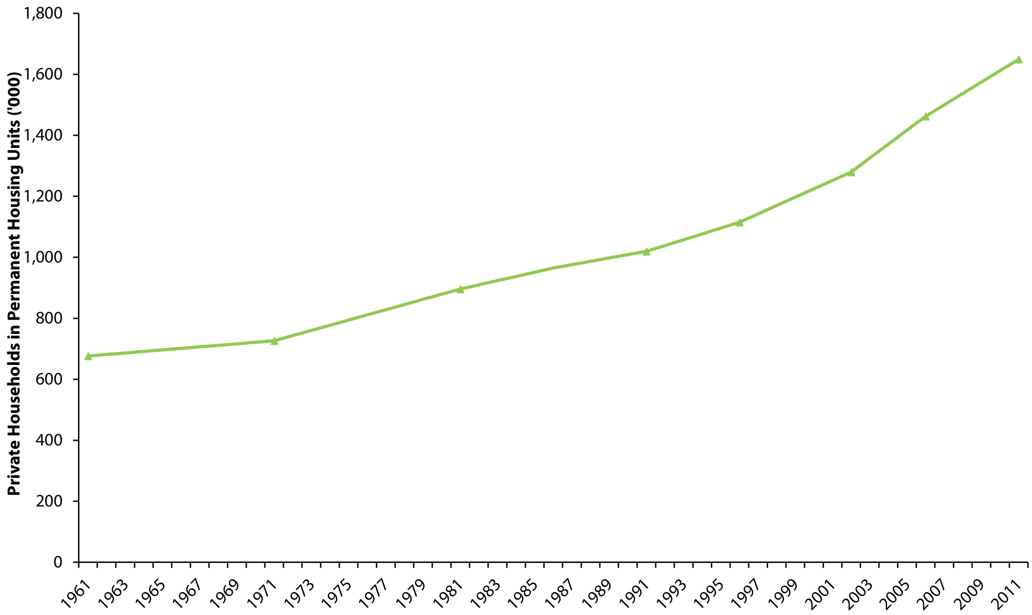
4.1.1 Number of Dwellings

There are many variables that can be used to track trends in the housing stock, for example number of housing units, number of houses built, number of private households, number of private households in permanent housing units etc. The latter is one of the measures used in the Census of Population and is considered for the purposes of this report to be the indicator that best tracks the actual number of households in the country and is the most useful in terms of impact on energy usage changes. The measure does not include temporary dwellings, holiday homes that are only occupied for part of the year and non-private households, defined as group of persons situated in boarding houses, hotels, prisons or ships, etc[39].

39 More details can be found in volume 6 (Housing) of the Census. Available from www.cso.ie

The most recent Census, carried out in April 2011, stated that there were 1,649,408 private households in permanent housing units[40]. The trend from Census data since 1961 is presented in *Figure 8* and *Table 5*.

Figure 8 *Private Households in Permanent Housing Units (Selected Census Years)*



Source: CSO

Over the period 1961 to 2011 the number of private households in permanent housing units increased by 144%, by 62% from 1991 to 2011, by 29% from 2002 to 2011 and by 13% from 2006 to 2011. Also shown in *Table 5* is the average annual growth between periods. The acceleration in the trend in the last decade is clearly evident.

Table 5 *Private Households in Permanent Housing Units (Selected Years)*

Year	Number	Average Annual Growth Rate Between Periods (%)
1961	676,402	
1971	726,332	0.71
1981	896,054	2.12
1991	1,019,723	1.30
1996	1,114,974	1.80
2002	1,279,617	2.32
2006	1,462,296	3.39
2011	1,649,408	2.44

Source: CSO

4.1.2 Type of Dwelling

In addition to the number of households, a key variable impacting on energy consumption in the residential sector is the type of dwelling. Flats and apartments are typically expected to have the lowest heat loss (as a result of their smaller size and generally less exposed surface area) while detached houses have the largest, as a result of having a larger exposed surface ratio. It has been estimated that up to 25% of the heat from a dwelling can be lost through its walls[41]. It follows that a dwelling with a larger exposed surface area are typically expected to have a greater potential for heat loss. A higher proportion of flats and apartments in the stock has the effect of reducing energy intensity.

40 Note that these figures have made allowance for the number of homes which are vacant based on CSO figures. In Census 2011 the number of housing units in the State was recorded as 1,994,845

41 Source SEAI. See http://www.SEAI.ie/index.asp?locID=4&docID=-1 for more details.

Data on accommodation type is available from a number of sources such as the Census of Population and the CSO Quarterly National Household Survey (QNHS). For this report the Census data was used as it is the most recent.

Table 6 illustrates that the most common house type in Ireland in 2011 was the detached house, which accounted for 42% of the total.

Table 6 *Stock of Private Households in Permanent Housing Units – Type of Accommodation*[42]

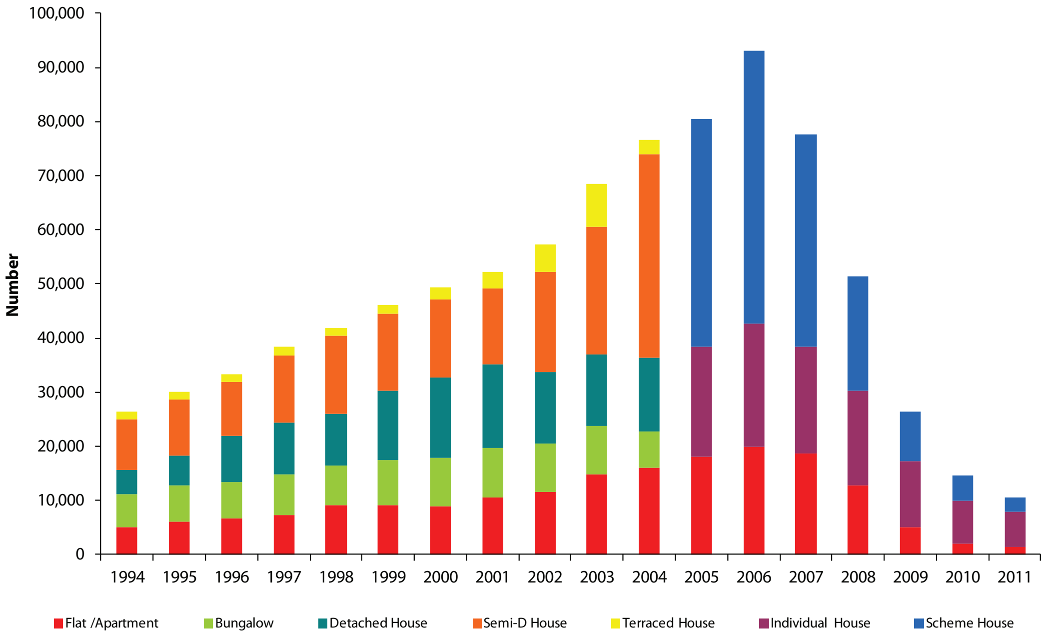
Dwelling Type	2011 Number	Share of Total
Detached house	699,869	42.%
Semi-detached house	456,651	28%
Terraced house	281,825	17%
Flat or apartment in a purpose-built block	149,921	9%
Flat or apartment in a converted house or commercial building	27,666	1.7%
Bed-sit	5,695	0.3%
Caravan, mobile or other temporary structure	4,800	0.3%
Not stated	27,781	1.7%
Total	1,654,208	

Source: SEAI

Data are also available for the number of newly completed dwellings by type. *Figure 9* illustrates the number of house completions by type from 1994 to 2011, 1994 being the earliest year data are available. Data are sourced from the Department of the Environment, Community and Local Government (DECLG), which in turn are obtained from dwellings connected to the electricity supply. A comparable dataset is not available before 1994 and the methodology for categorising dwellings changed in 2005[43].

While this precludes an analysis of dwelling type over the full period it can be seen that apartments have increased their share of annual new dwellings from 19% in 1994 to 25% in 2008. The total number of dwellings completed per year increased by 252% (11% per annum on average) from 1994 to 2006. There was an 89% reduction in the number of completions between 2006 and 2011.

Figure 9 *New Dwellings Completed by Type 1994 to 2011*



Source: DECLG

42 Percentage totals in this report may not sum to 100 as a result of rounding.

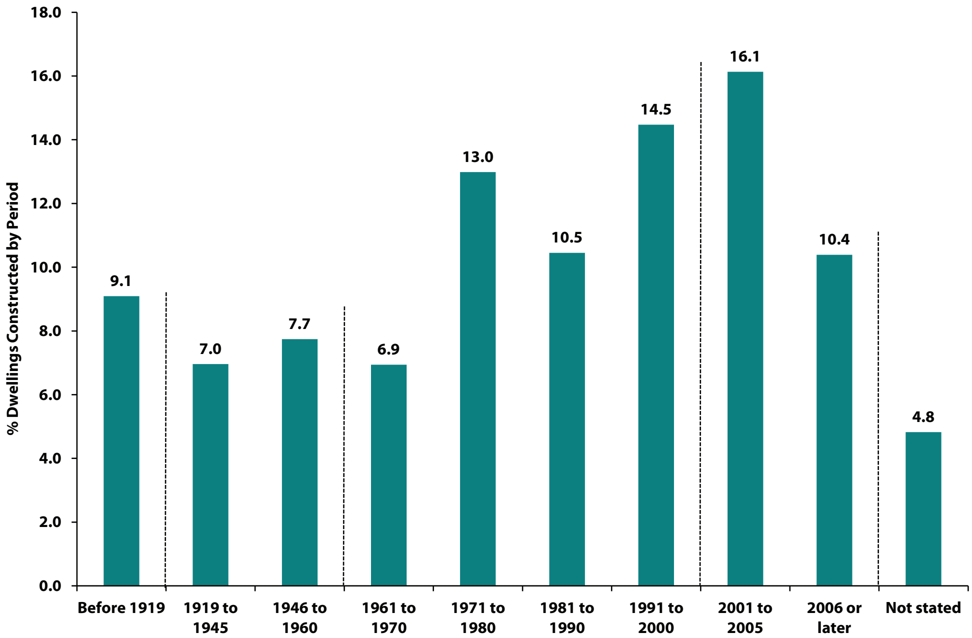
43 New dwellings completed since 2005 are classified as follows: "Individual House" is where connection is provided to a separate detached house. "Scheme House" is where connection is provided to two or more houses. "Apartments" is where all customer metering for the block is centrally located.

4.1.3 Period of Construction

A key factor in determining the energy profile of the housing stock is the period of construction. Newer houses must conform to stricter energy efficiency standards and therefore they will be expected to use less energy per square metre than older dwellings. However, improvements in insulation standards of older houses through retrofitting offset some of the energy losses that would otherwise have occurred.

Figure 10 and *Table 7* illustrate the age profile using data from the 2011 Census. It can be seen that 26% of the total housing stock has been built since 2000. These dwellings should be more energy efficient as they have been subject to more stringent Building Regulations.

Figure 10 *Private Households in Permanent Housing Units – Period of Construction*



Source: CSO

By contrast 44% of the stock was built before the first thermal insulation requirements came formally into effect in 1979[44]. It can be reasonably assumed that pre-1980 housing stock has a poorer standard of insulation than that built after the introduction of the thermal building requirements. According to the European Housing Review, 2007[45], Ireland has the youngest dwelling stock in the EU.

Table 7 *Private Households in Permanent Housing Units – Period of Construction*

Period in which Built	Number	Share of Total
Before 1919	149,939	9%
1919 to 1945	114,817	7%
1946 to 1960	127,691	8%
1961 to 1970	114,510	7%
1971 to 1980	214,197	13%
1981 to 1990	172,413	11%
1991 to 2000	238,724	14%
2001 to 2005	266,110	16%
2006 or later	171,397	10%
Not stated	79,610	5%
Total	1,649,408	

Source: CSO

44 It can be seen that data are shown to 1980 as opposed to 1979 but this shouldn't significantly alter the point. In addition there were some elementary building thermal energy requirements from 1976.

45 Royal Institution of Chartered Surveyors, 2008. European Housing Review. Available from www.rics.org

4.1.4 Estimated Floor Area

A dataset is published by the CSO which shows the average floor area of granted planning permissions for flats and houses. Not all dwellings that are granted planning permission are built but the figures provide a plausible proxy for the trend in new flat and house size. The trend is shown in *Figure 11* for the period 1990 to 2011 with percentage growth rates shown in *Table 8*.

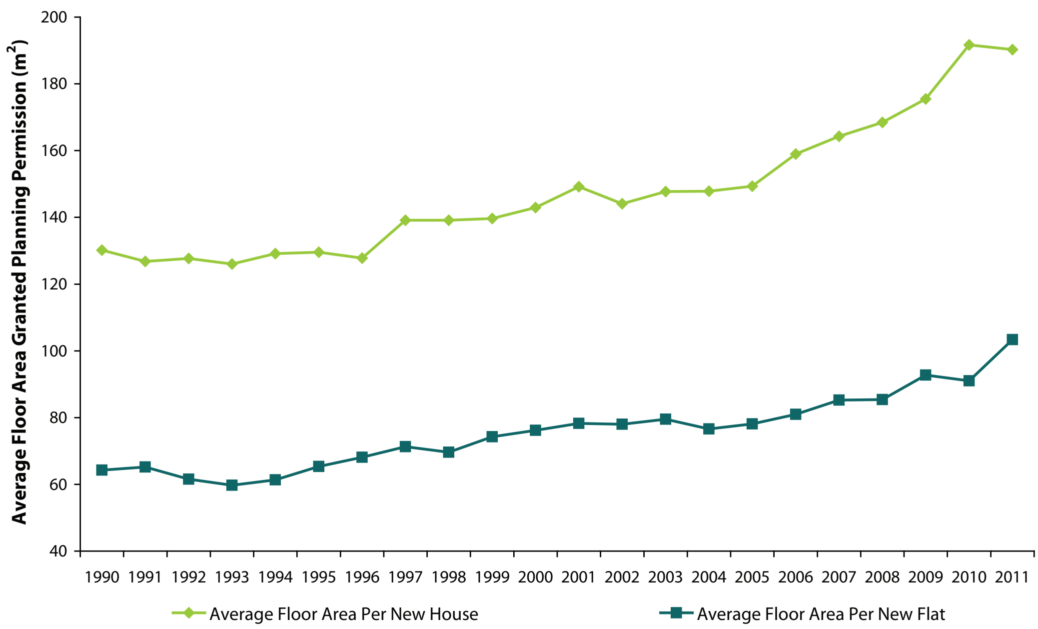
Table 8 *Growth Rates of Average Residential Floor Areas per New Dwelling*

	Growth %	Average annual growth rates %					
	1990 – 2011	1990 – '11	1990 – '95	1995 – '00	2000 – '05	2005 – '10	2011
New Houses	46.2	1.8	-0.1	2.0	0.9	5.1	-0.7
New Flats	60.9	2.3	0.3	3.1	0.5	3.1	13.6

Source: CSO and SEAI

Average floor areas of new houses grew from 130 square metres in 1990 to 190 square metres in 2011 (an increase of 46%). The average declined slightly in the early 1990s and then grew at a rate of 2% per annum in the latter half of the decade. Average floor areas of houses decreased by 0.7% in 2011. Average floor areas of new flats showed a stronger growth over the period from 64 square metres to 103 square metres (61%). The average floor area of flats increased by 14% in 2011. The ratio of new houses to new flats built in 1990 was approximately 25 to 1 whereas in 2011 it was approximately 6.8 to 1. The 2006 Census[46] notes that in 1991, 6.5% of the housing stock consisted of apartments or flats, whereas in 2011 the share was 10%.

Figure 11 *Average Floor Areas of New Flats and New Houses 1990 to 2011*



Source: CSO and SEAI

While the above only refers to new dwellings it is also possible to estimate the trend in the stock as a whole using the CSO dataset and a model of the stock of dwellings derived using, inter alia, data from DECLG studies in the mid 1990s. Data from this model is updated incrementally, using planning permission data from the CSO and an estimate of the rate of demolitions[47]. *Table 9* summaries the growth rates of average floor area during the period. Over the period 1990 to 2011 the estimated average floor area of the stock of dwellings increased from 100 square metres to 119 square metres (1,281 square feet) in 2011, as shown in *Figure 12*.

Table 9 *Growth in Average Floor Area – Stock of Dwellings*

	Growth %	Average annual growth rates %					
	1990 – 2011	1990 – '11	1990 – '95	1995– '00	2000 – '05	2005 – '10	2011
Average Floor Area	19.3	0.8	0.3	1.1	1.1	0.9	0.3

Source: CSO and SEAI

46 CSO (2007), *2006 Census of Population – Volume 6 – Housing*.

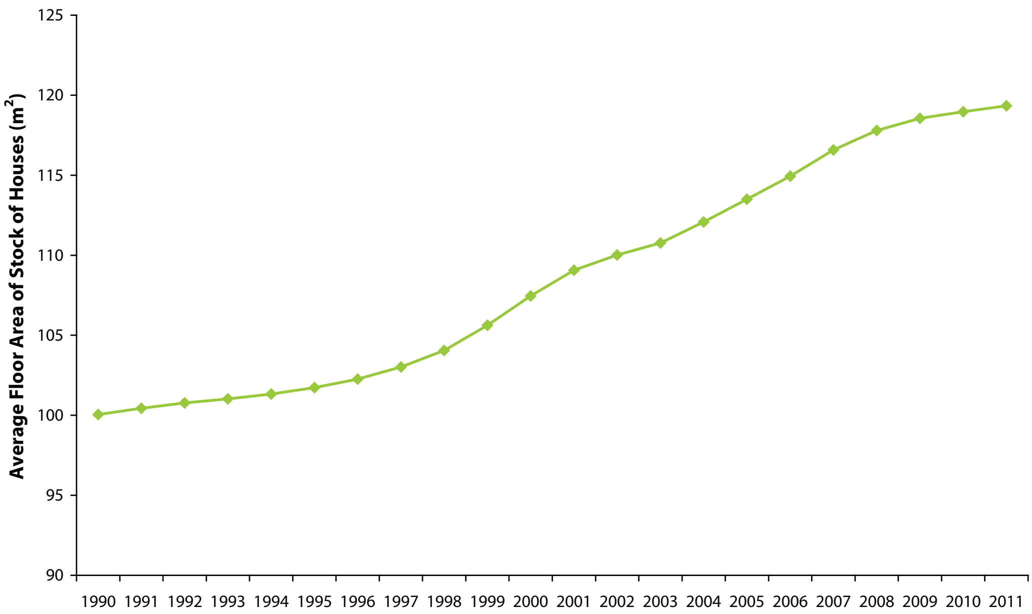
47 ESRI has estimated in the Irish National Survey of Housing Quality that 0.06% of the housing stock is lost through demolitions each year.

Average floor area has increased steadily over the period as larger dwellings are added to the stock. Growth of 0.3% was recorded in 2011. The increasing trend in floor area has been offset somewhat by the growing number of flats and apartments. However, the dominant driving force is the number and size of large one off or non-estate dwellings that have been built in recent years. In 2011, the average floor area of non-estate houses granted permission was 249 square metres, compared to 135 square metres for houses in estates and 103 square metres for flats and apartments[48].

In 2007, 52% of the units granted planning permission were estate dwellings, 22% non-estate and 26% were apartments. In 2011 these ratios were 42%, 36% and 22% respectively.

The evidence suggests that there has been a trend towards larger dwellings (although estate houses' floor area has remained stable since 2008). Taken in isolation, this should have had a significant impact on the amount of energy demanded in the residential sector as bigger dwellings tend to have a larger demand for heating as they have a proportionally greater wall surface area and therefore higher heat loss. This has been offset somewhat by the increasing insulation standards introduced through progressive revisions to the building regulations. Other variables such as the changing fuel mix, more efficient heating systems, falling occupancy levels and the declining average number of persons per household have also had an impact.

Figure 12 *Average Floor Area of the Housing Stock 1990 to 2011*



Source: CSO and SEAI

4.1.5 Household Size and Occupancy

While the number of dwellings and the average size of these dwellings have been increasing in recent years *Table 10* shows that the number of persons making up a household is declining. This is important as, other things being equal, two people living in two separate households will typically consume more energy than two people living in the same household, but the per household consumption should decrease. *Table 10* presents the average household size for selected years from 1961 to 2011.

Table 10 *Average Number of Persons per Household – Census Years*

	1961	1971	1981	1991	2002	2006	2011
Occupancy	4.0	3.9	3.7	3.3	3.0	2.8	2.7

Source: CSO

The average number of persons per household declined by 31% over the period 1961 to 2011, by 18% from 1991 to 2011 and by 7% from 2002 to 2011. In addition, CSO Census data reveals that the proportion of one person households has increased from 13% in 1961 to 24% in 2011.

48 CSO (2012), *Planning Permissions – Quarter 1 2012*. Available at www.cso.ie.

By international standards the average household size in Ireland remains high. For example, in 2011 in Germany and Denmark the average was 2.0 persons per household and in the UK the average was 2.3, while the EU 27 average was 2.4[49]. Even though net migration remained positive (net inward migration) between 2006 and 2011, the number of people emigrating from Ireland more than doubled over the period, largely due to the economic recession. This emigration may also have impacted on the average household size.

Another factor which affects the demand for energy in the residential sector is occupancy. Dwellings which are empty for extended periods during the day should require less energy for heating and lighting than those which are constantly occupied. Occupancy tends to be highest in households where there are small children, people who are sick or have poor health, people with a disability and older people.

Data on occupancy is not directly available. Traditionally the rate of female participation in the workforce was used as a proxy and in recent years there has been a significant increase in the number of women working. In 1997 the employment rate for women of working age was 42%. By quarter 4, 2011 this had increased to 53%[50].

A counter to the increase in women working and a resulting decrease in residential occupancy hours is the recent rise in the rate of unemployment. Unemployed people are likely to spend more hours in their home thus requiring more energy for heating, lighting and appliances. Since 2007 the rate of unemployment[51] increased from 4.5% to 14.4% in 2011.

The number of vacant dwellings is also on the increase. In 1991, 12.7% of dwellings were not occupied (on the night of the Census)[52]. In 2006 there were 266,000 vacant dwellings representing 15% of the total housing stock. In 2011 there were 289,451 vacant dwellings also representing 15% of the total housing stock. Of these, 168,427 were houses, 61,629 were flats and 59,395 were classified as holiday homes[53].

4.1.6 Occupier Status

Table 11 illustrates the ownership profile of dwellings in 1991, 2006 and 2011, with data sourced from the censuses in those years. Owner-occupiers include those that are owned outright or are in the process of being purchased. In 2011 the majority of dwellings (70%) were either owned outright or were in the process of being purchased (mortgaged), representing a decrease on the 1991 proportion of 79% and the 2006 proportion of 75%. There have been historically high levels of ownership in Ireland compared to other European countries. For example, in Austria the proportion of owner occupied dwellings was 51% in 2004 and for the UK it was 69%[54].

Table 11 *Private Households in Permanent Housing Units –Ownership 1991, 2006 and 2011*[55]

	1991	% of 1991 Total	2006	% of 2006 Total	2011	% of 2011 Total
Own Outright	387,278	38.0	498,432	34.1	566,776	34.4
Mortgaged	421,107	41.3	593,513	40.6	583,148	35.4
Local Authority Renter	98,929	9.7	105,509	7.2	129,033	7.8
Private Renter	81,424	8.0	145,317	9.9	305,377	18.5
Other	21,589	2.1	72,181	4.9	40,378	2.4
Not Stated	9,396	0.9	47,344	3.2	24,696	1.5
Total	**1,019,723**	**100**	**1,462,296**	**100.0**	**1,649,408**	**100.0**

Source: CSO

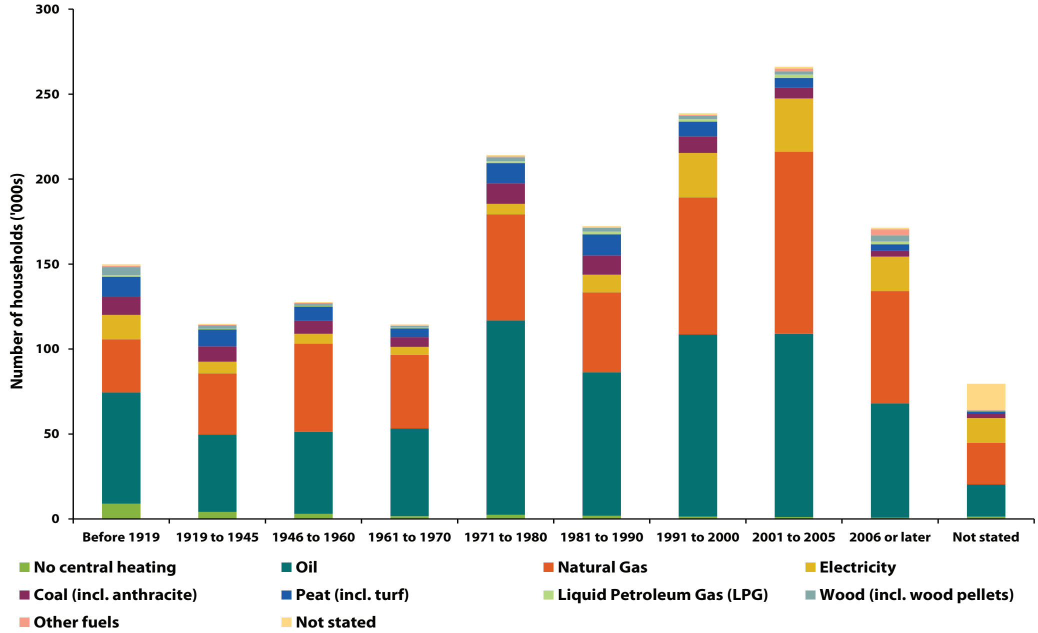
Research has shown that owner occupiers have a greater incentive to invest in energy saving measures than either the landlords or tenants in rented accommodation[56]. This point is borne out by data from the 2005 CSO Quarterly National Household Survey[57] which details the presence of a number of energy saving items. For example in 2005, 82% of owner occupiers had double glazing (including partial) installed whereas the proportion was 69% for rented dwellings. A more recent paper using Household Budget Survey microdata[58] also found that owner occupiers are still much more likely to have double glazing than those living in rented accommodation. Another study using data from the ESRI National Survey of Housing Quality[59] found that owner occupiers have significantly more energy saving features than renters.

49 Eurostat EU-Statistics on Income and Living Conditions, 2011, Survey on Income and Living Conditions. Available from http://epp.eurostat.ec.europa.eu
50 CSO, various years, Quarterly National Household Survey. See www.cso.ie
51 Central Statistics Office, 2012, Seasonally Adjusted Annual Average Standardised Unemployment Rates by State and Year . Available from www.cso.ie
52 Fitzgerald, John. 2005. The Irish Housing Stock: Growth in Number of Vacant Dwellings. Available from www.esri.ie
53 CSO, 2007, Census Volume 6. Available from www.cso.ie
54 Ministry of Infrastructure of the Italian Republic, 2006. Housing Statistics in the EU 2006. Available from www.federcasa.it/news/housing_statistics/Report_housing_statistics_2005_2006.pdf
55 Other includes those occupying the accommodation rent-free and renting in the voluntary sector.
56 IEA, 2007. Mind the Gap – Quantifying Principal-Agent Problems in Energy Efficiency. Available from www.iea.org
57 CSO, Quarter 3 2005. Recycling and Energy Conservation. Available from www.cso.ie
58 Leahy, E. and Lyons, S., 2010, Energy Use and Appliance Ownership in Ireland, Energy Policy 38, 4265–4279.
59 O'Doherty, J., Lyons, S. and Tol, R.S.J., 2008, Energy-using appliances and energy-saving features: Determinants of ownership in Ireland, Applied Energy 85 (2008) 650–662

4.1.7 Census 2011 Housing Stock by Fuel

The addition of a question on the type of fuel used by each household in the 2011 Census allows for a more detailed analysis of the housing stock by fuel and period of construction, by fuel and location and also by fuel type and age of occupant. Detailed figures of the housing stock by fuel and period of construction are available in Appendix 5: Residential Wood Consumption.

Figure 13 *All Household by Heating Fuel Type and Period of Construction*



Source: CSO

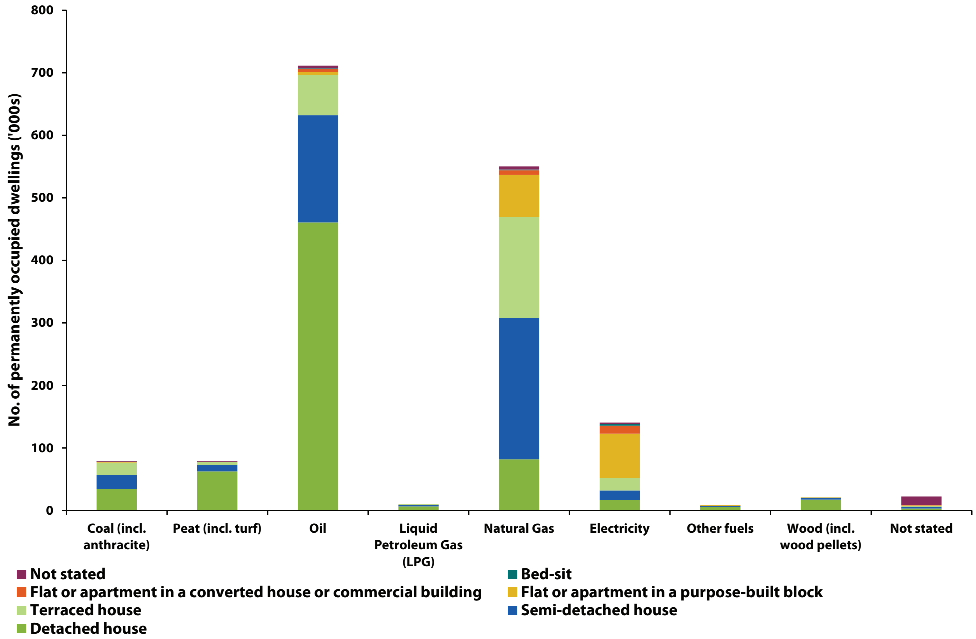
Figure 13 shows all household types grouped by fuel type and period of construction. The majority of households in Ireland rely on oil for heating; however houses constructed since 2000 have a higher share of natural gas for heating than oil. The trend is explained by the large number of scheme houses constructed during the building boom in urban areas with access to the gas grid. The dramatic rise in oil prices over the decade, concerns about peak oil and growing environmental awareness may also have influenced the choice of main heating fuel type over the period.

Interestingly, both the share of electricity and solid fuels (coal and peat) used for heating were significantly underestimated in the 2009/2010 Household Budget Survey (HBS). In fact the census places electricity as the third most popular heating fuel when the solid fuel category is split into both coal and peat. The number of households which rely on coal and peat is declining while the increase in electricity consumption for space heating is mainly in apartments (purpose built and conversions) and bedsits, but can also be attributed to the use of heat pumps by other dwelling types.

It is likely that there has been some retrofitting of heating type into homes built in the last century. In particular, houses that were built before 1980 would have upgraded from solid fuels to central heating with either oil or natural gas. As the natural gas grid was expanded many homes in urban areas converted to natural gas central heating.

Figure 14 examines which house type use the different residential fuels. Most detached houses use oil, whereas most semi-detached and terraced houses use natural gas. This reflects the rural and urban split between house types and the available fuels. Most detached houses are located in rural areas that do not have access to the gas grid.

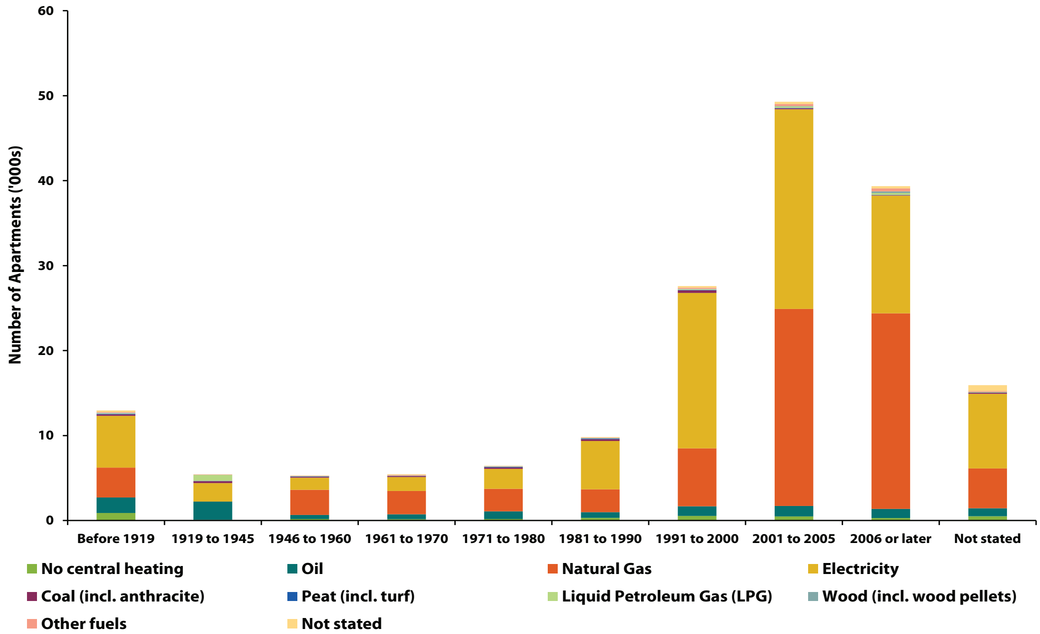
Figure 14 *Residential Heating Fuel Type by Type of House*



Source: CSO

The growth in the popularity of electricity for heating, primarily driven by the recent growth in the number of apartments, is evident in *Figure 14*. *Figure 15* shows the trend for both purpose built flats and apartments as well as those in converted residential or commercial buildings and displays a significant change in fuel types over time. As with the trend in the overall housing stock it is likely that those flats or apartments constructed between 1946 and 1980 were not originally heated by natural gas but were more likely to be located in cities or urban areas and were converted to natural gas when the gas grid arrived in those areas. The dominant fuel type for space heating in apartments built between 1981 and 2000 is electricity. Since 2000 there has been a dramatic shift to natural gas being the fuel of choice for apartments. Just over a quarter of all apartments constructed pre-2000 were fuelled by natural gas. In the period 2001 - 2005 the share of gas fuelled apartments doubled to represent half of all apartments. This share further increased to three quarters of all apartments if constructed in 2006 or later.

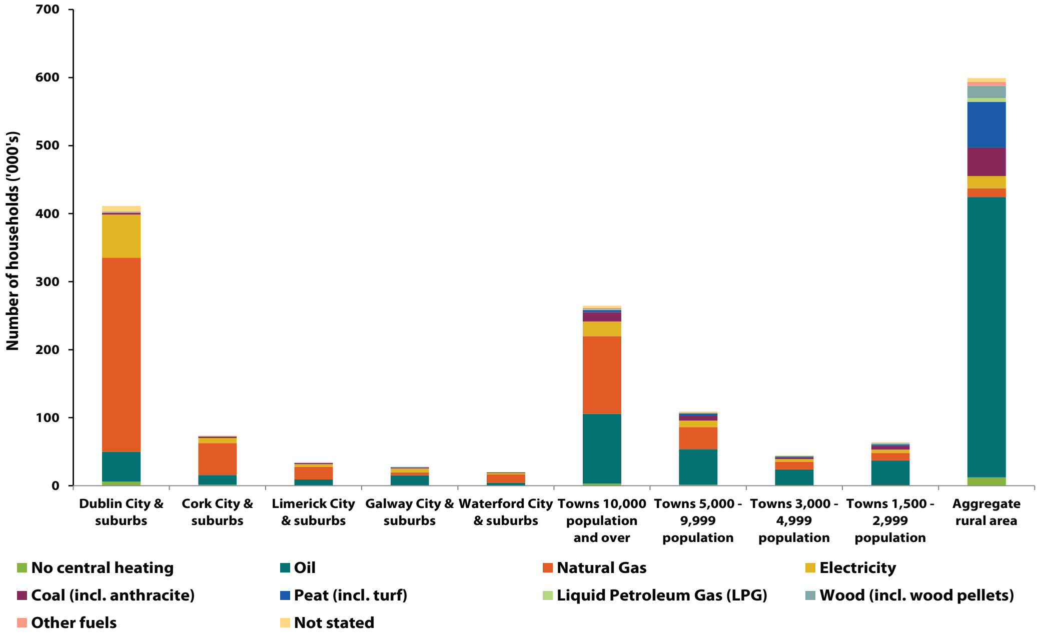
Figure 15 *Purpose-built Apartments and Flats by Heating Fuel Type and Period of Construction*



Source: CSO

It can be seen from *Figure 16* that most urban households rely on natural gas. The notable exception is Galway City and suburbs, because the gas grid connection to Galway City was completed in 2002 and there wasn't a history of town gas in the city. Just over 15% of all households in Galway City and suburbs are fuelled by gas. The majority (53%) of households there are fuelled by oil. The second most popular fuel type in Galway City and suburbs is electricity, with just over 20% or a fifth of all households using electricity.

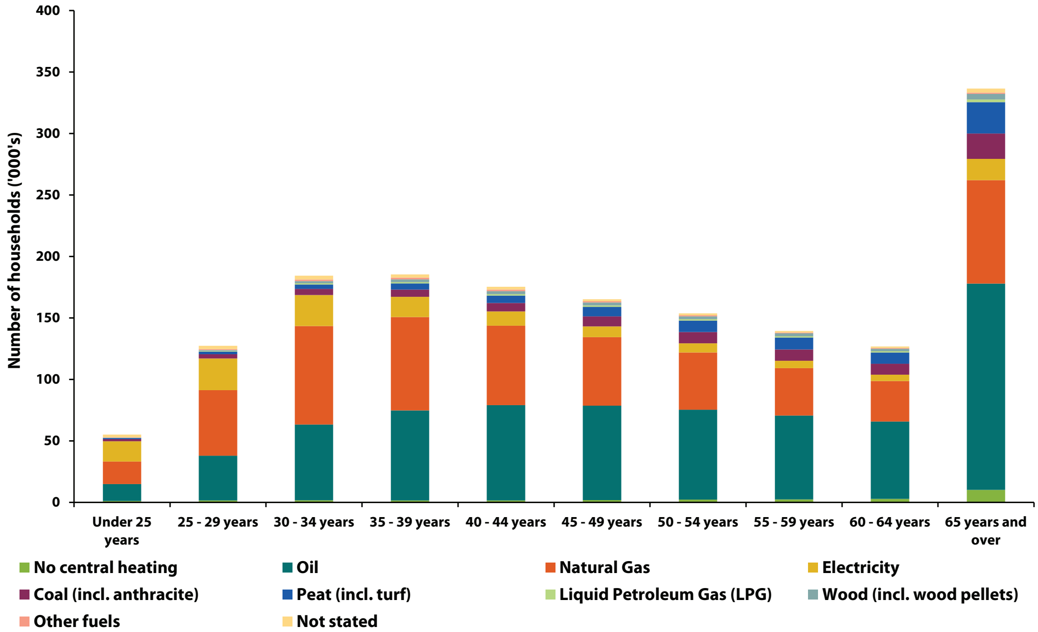
Figure 16 *Households by Heating Fuel Type and Broad Location*



Source: CSO

Figure 17 examines the type of fuel by the age of the household's primary occupant. Where the primary occupant is under 40 years of age they are most likely to live in a gas household. However over 40 year olds are more likely to rely on oil. This is related to the urban and rural divide, with under 40 year olds more likely to live in urban areas with access to the gas grid. Older people living in urban areas are more likely to live in older houses that may not have been retrofitted with gas.

Figure 17 *Households by Heating Fuel Type and Age of Primary Occupant*



Source: CSO

4 Drivers of Residential Energy Consumption

4.2 Space Heating

Another significant factor in residential sector energy usage is the system of space heating. Central heating systems are typically more energy efficient than individual room heating appliances and/or open fires (with or without back boilers), so for a given requirement of space heating less energy would be expected to be used.

On the other hand, a considerable increase in the level of comfort, in the form of higher temperatures and a move towards whole house heating, is often associated with the introduction of central heating. There is also greater convenience in using timer controls, particularly with oil and natural gas fired systems, which has the potential to result in greater usage. Therefore, an improvement in energy efficiency associated with a switch to central heating can be offset somewhat by increased energy usage through greater convenience and comfort levels.

4.2.1 Building Regulations

Table 12[60] presents a basic comparison of normalised heating energy usage of different age cohorts of Irish housing arising from progressive improvements in thermal standards introduced by the Government since 1976, accompanied by the installation of more efficient heating systems. Almost half of all dwellings in the current housing stock were built before the introduction of energy specific building requirements (see *Table 7*). Some of the older dwellings will have been improved thermally by retrofitting insulation or energy efficient systems.

Table 12 *Impact of Building Requirements*[61]

Date of Introduction	Change	Cumulative Change	Fuel Use for Heating, Relative to Base 1976	Energy Performance Coefficient (EPC)[60]
1976	-	-	100%	-
1981	-44%	-44%	56%	-
1991	-14%	-58%	42%	-
1997	-13%	-71%	29%	-
2002	-5%	-76%	24%	-
2005	-	-76%	24%	1
2008	-60%	-86%	14.%	0.6
2011	-33%	-91%	9%	0.4

Source: Dept. of Environment

It can be seen that there has been a significant decrease in the amount of energy required for heating over the period. It should be noted that this does not mean that dwellings constructed to the 2011 building regulations use 91% less energy that those built before 1976. The figures in *Table 12* refer only to the technical improvements relating to energy requirements for heating. The aim, as stated in Ireland's Second National Energy Efficiency Action Plan (NEEAP), is to achieve a nearly zero energy houses by 2020.

It is important to note that while thermal standards have been improved, the actual amount of energy savings may be less than that stated in the Building Regulations due to factors such as increased comfort levels, non-energy conscious behaviour and non-compliance. While increased comfort levels may results in increased energy use, the social and health benefits arising from increased household comfort and convenience are some of the reasons why the building regulations are regularly reviewed and updated.

4.2.2 Fuels Used for Space Heating

Figure 18 and *Table 13* show the percentage of dwellings with central heating from 1987 to 2010 using data from iterations of the CSO Household Budget Survey (HBS)[63]. It can be seen that the proportion of homes with central heating has increased from 52% in 1987 to 97% in 2010. It has been estimated that in 1974 less than 25% of the 740,000 households in the country had central heating[64]. For comparison, in the UK in 2008, 98%[65] of homes used some form of central heating compared to 31% in 1970.

60 SEAI, 2002. Home Energy Rating Scheme Programme Strategy, Consultation Draft.

61 There were further regulations issued in 2005 but these were concerned with the specific heat loss rate and therefore it is not appropriate to compare them with the older regulations.

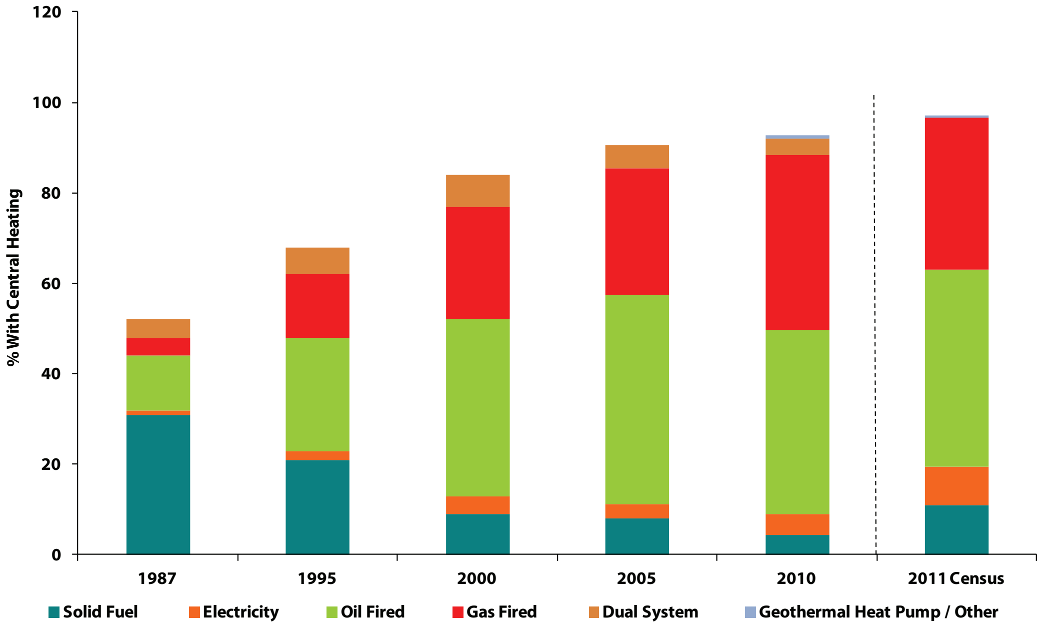
62 The energy performance coefficient (EPC) of a proposed building is the calculated primary energy consumption of the proposed building divided by that of the reference building.

63 CSO, Various Years. Household Budget Survey. www.cso.ie

64 SEAI, 2008, Energy in the Residential Sector. Available from www.seai.ie/Publications/Statistical_Publications

65 UK Department of Energy and Climate Change, 2012, Great Britain's housing energy fact file 2011. Available from http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/en_effic_stats/dom_fact/dom_fact.asp

Figure 18 *Penetration of Central Heating - Selected Years*



Source: CSO

Table 13 *Penetration of Central Heating by Fuel Type*

Fuel Type %	1987	1995	2000	2005	2010	2011 Census
Solid Fuel	31	21	9	8	4.3	10.9
Electricity	1	2	4	3	4.8	8.5
Oil Fired	12	25	39	46	40.6	43.8
Natural Gas Fired	4	14	25	28	38.6	33.4
Dual System	4	6	7	5	3.8	
Geothermal Heat Pump/Other				0	0.6	0.5
Partial				3	1.8	
Total Central Heating	52	68	83	91	97	97

Source: CSO

According to the Household Budget Surveys, the share of solid fuel has declined from 31% of homes in 1987 to just 4.3% in 2010, while central heating systems fired by oil and natural gas have increased from 16% to almost 80%. It is worth noting that the Economic and Social Research Institute (ESRI) in the Irish National Survey of Housing Quality (INSHQ)[66] state that over 80% of dual[67] systems use oil. In the coming years, however, it is anticipated that solid fuel prevalence may increase again due to increasing use of biomass systems.

For comparison, in the UK the predominant form of central heating is natural gas which increased from 10% of homes in 1970 to over 81% in 2008. By contrast the use of solid fuels fell from 30% to 1.2% over the same period[68].

Census 2011 was the first census to include questions on the type of household heating. It paints a different picture to the results of the 2009/2010 HBS. The census results are more reliable than the HBS results as the 2009/2010 HBS is based on a sample of the population, with the survey results weighted to agree with the number of private households in the 2006 census of population. Thus, changes in population and the number and type of households that occurred between 2006 and 2010 are not reflected in the 2009/2010 HBS.

66 ESRI, 2003. Irish National Survey of Housing Quality. A full copy of the report or an executive summary can be downloaded from http://www.environ.ie/DOEI/DOEIPub.nsf/0/96ffd2d2ffab95f880256f0f003dbcf6?OpenDocument.

67 The INSHQ defines dual systems as central heating systems which can be run from either solid fuel or oil, or two separate systems.

68 UK Department of Energy and Climate Change, 2012, Great Britain's housing energy fact file 2011. Available from http://www.decc.gov.uk/en/content

4.2.3 Diffusion of Central Heating

The relationship between unit consumption (usage of energy per dwelling) and the penetration of central heating is examined in *Figure 19* (for more on unit consumption see section *5*). Only thermal (fuel) usage is shown, i.e. electricity is excluded, as it constitutes a relatively small proportion of central heating. The consumption data is climate corrected, using degree day[69] data, to filter out the variations due to hot and cold years. Central heating penetration data are only available in this series for 1987, 1995, 2000, 2005 and 2011 so the comparison with energy usage is limited to these years. *Figure 19* suggests that the increase in the penetration of central heating and the associated increase in comfort and energy use was more than offset by gains made through energy efficiency. This is illustrated by the decrease in thermal unit consumption (climate corrected) from 1987 until 2000.

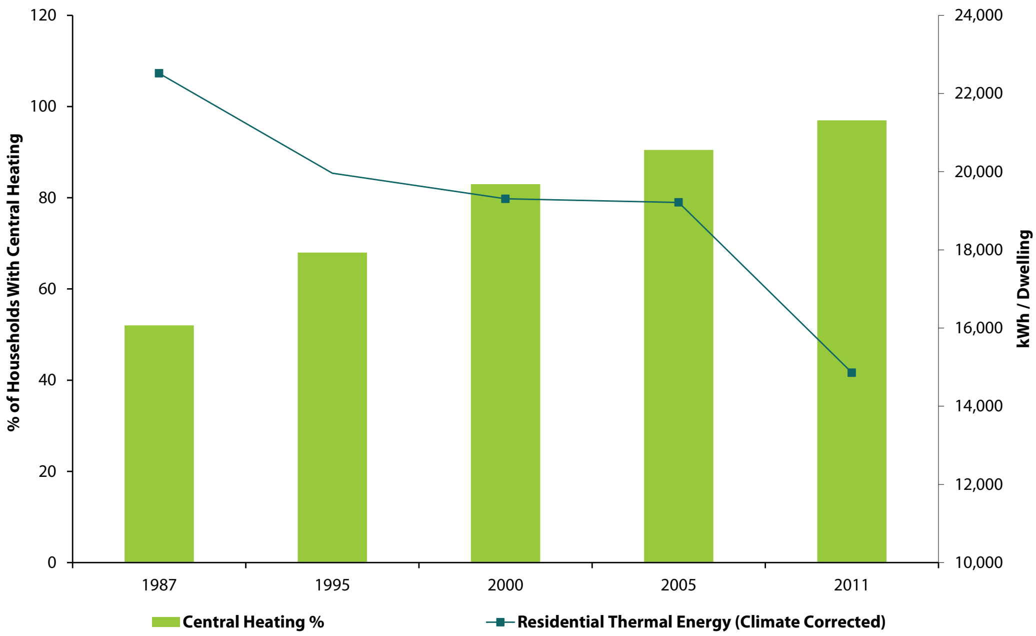
This decrease in energy usage between 1987 and 2000 is due, in part, to the switch from the use of solid fuels in open fires and back boilers to more efficient oil and natural gas central heating, as seen in Figure 10. A number of other factors such as the increased insulation standards arising from revisions of the Building Regulations in 1991 will also have had an impact through improvements in building fabric performance.

The trend of decreasing energy use per dwelling stalled between 2000 and 2005 when the increase in the penetration of larger dwellings, central heating and associated increase in comfort and energy use, was no longer offset by gains made as a result of energy efficiency improvements. This coincided with increased household disposable income during the Celtic Tiger years. This is known as a comfort effect whereby the convenience of automated controls, whole house heating, larger houses and higher internal temperatures outweigh lower energy consumption gains achieved as a result of fuel switching to cleaner fuels.

There was a sharp acceleration of energy savings per dwelling between 2005 and 2011. There are a number of reasons for the energy efficiency improvements including an increased penetration of newer houses built to higher energy efficiency standards and heating control requirements as specified in the various revisions to the building regulations. A number of national residential energy efficiency upgrade schemes also contributed to energy efficiency improvements of the existing housing stock. The details of the schemes are discussed in section *7.5.1*. Other factors contributing to the decrease in energy use per household include increasing public awareness of environmental and sustainability concerns associated with energy use and significant energy price increases at a time of decreasing household disposable income.

In summary, *Figure 19* suggests that significant residential energy efficiency improvements can be achieved with continuous policy focus on improving the energy efficiency of the residential building stock, by improving the building regulations for new houses and promoting energy efficiency upgrades of the existing stock.

Figure 19 *Central Heating / Thermal Unit Consumption – Selected Years*



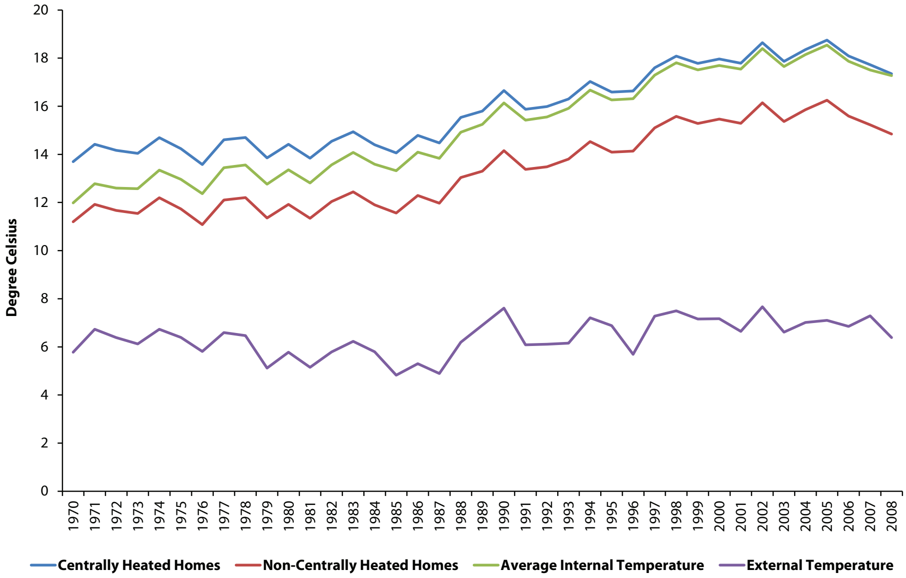
Source: CSO & SEAI

69 Data are climate corrected using degree days where degree days are a measure or index used to take account of the severity of the weather when looking at energy consumption in terms of heating (or cooling) "load" on a building. A degree day is an expression of how cold (or warm) it is outside, relative to a day on which little or no heating (or cooling) would be required. It is thus a measure of cumulative temperature deficit (or surplus) of the outdoor temperature relative to a neutral target temperature (base temperature) at which no heating or cooling would be required.

4.2.4 Residential Internal Temperatures

Data on comfort levels or internal temperature is currently not available for Ireland but estimates are available for the UK and are presented in *Figure 20*. Data are sourced from the Building Research Establishment (BRE)[70] which is published by the UK's Department of Energy and Climate Change (DECC) in *Great Britian's Housing Energy Fact File 2011*[71]. Their data indicates that homes heated by central heating tend to be 2.5˚ Celsius warmer than those heated by stand alone room heating systems.

Figure 20 *Modelled UK Internal Temperatures 1970 to 2008*



Source: BRE

The increase in internal temperature for both centrally heated and non-centrally heated dwellings over the period 1970 to 2008 was 3.6˚C in the UK, but the weighted average temperature rose by 5.3˚C because of the increasing numbers of dwellings which have central heating. In 1970, the average internal temperature in homes with central heating was estimated at 13.7°C but thirty-eight years later, this estimate had risen to 17.3°C. In recent years the internal temperature has stabilised at approximately 18°C.

It may be reasonable to assert that there has been a similar increase in Ireland given the comparable increase in central heating. However the actual internal temperature levels may be different between Ireland and the UK.

Space heating in winter normally raises the indoor temperature from approximately 8–10˚C to 18–21˚C. In recent years the increase in internal energy has started to stabilise at approximately 18˚C, or by approximately 10˚C in total. Therefore it is estimated that a 1% drop in the internal temperature could save 10% in energy.

70 Building Research Establishment, www.bre.co.uk

71 UK Department of Energy and Climate Change, 2012, Great Britain's housing energy fact file 2011. Available from http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/en_effic_stats/dom_fact/dom_fact.aspx

4.3 Energy Prices

Price is an important factor when discussing energy usage. Global oil prices have fluctuated dramatically in recent years. This has particular effect in Ireland due to our high dependence on oil. In addition, there is the knock-on impact that oil prices have on other energy prices, in particular on natural gas prices, and as a consequence, electricity prices. Average oil prices rose steadily during the second half of 2010 and peaked at $127/barrel at the start of May 2011. During the second half of 2011 the average price of crude oil was $111/barrel. This compares with an average price in 2008 of $97/barrel and €80/barrel in 2010. The average price of crude oil did not change significantly from that of the second-half of 2011 during 2012, with an average price of $112/barrel for the year.

Residential consumption of energy tends not to be sensitive to energy prices, especially in the short run. This relationship is examined using data from Ireland in a recent paper[72], which estimates that a 10% per cent increase in electricity prices is associated with only about a 0.7% decrease in consumption. The price elasticity of residential demand for other fuels is also very low. This means that it takes relatively large increases in fuel or carbon taxes to bring about significant reductions in consumption, and also that fuel price increases tend to lead to higher expenditure by households rather than decreases in demand.

4.3.1 Price Directive on Electricity and Gas Prices

SEAI publishes biannual reports titled *Understanding Electricity and Gas Prices in Ireland*[73] based on the methodology for the revised EU Gas & Electricity Price Transparency Directive[74] which came into effect on the 1st January 2008. The reports focus specifically on gas and electricity prices and are a useful reference on cost-competitiveness. The methodology for collecting household data was changed under the revised Directive so the prices are not directly comparable with those collected under the previous methodology.

For households, prices include all charges payable including: energy consumed, network charges, other charges (capacity charges, commercialisation, meter rental, etc.), all netted for any rebates or premiums due. Initial connection charges are not included.

- Prices reported by Ireland under the Directive represent weighted average prices of the full market, using the market share of the various suppliers as weighting factors.
- Market shares are based on the quantity of gas or electricity invoiced by suppliers to household end-users. The market shares are calculated separately for each energy consumption band.

Three levels of prices are required: prices excluding taxes and levies, prices excluding VAT and other recoverable taxes, prices including all taxes, levies and VAT. For the purpose of assessing household spend on electricity and gas the most relevant price category is the prices including all taxes, levies and VAT.

4.3.1.1 Residential Electricity Prices

Figure 21 shows graphically the position of the all tax-inclusive electricity price to households during the second semester of 2012 relative to the average EU and Euro Area prices. Residential electricity prices were almost 7% above the EU average in the most significant consumption band (DD), which accounts for half of all residential customers, and 16% above the EU average for another 32% of consumers.

When comparing prices of goods across countries it is important to not only correct for differences in currencies but also for the differences in income and living standards. This is of particular importance when comparing prices paid by residential consumers. As part of the data collection process non-euro country prices are converted into euro at the prevailing exchange rates but this does not take into account the varying purchasing powers in each country. To correct for this Eurostat also publishes prices in purchasing power parities.

When purchasing power parities (PPP) are applied, Ireland is 1% below the average in consumption band DD. In band DC, the second most significant consumption band with over 32% of all residential consumers, Ireland is 8% above the average.

Table 14 details Ireland's position with respect to the EU average and the PPP EU average. The final column in *Table 14* shows Ireland's ranking in the EU in euro terms for the tax-inclusive price paid by householders for electricity. A ranking of 1 indicates the most expensive jurisdiction. Ireland was ranked 5th most expensive in band DC (the band for which Eurostat reports) during the second semester of 2012, up from 6th position in the previous semester. In consumption band DD, Ireland's ranking remained at 7th most expensive of 30 countries, for all of 2012.

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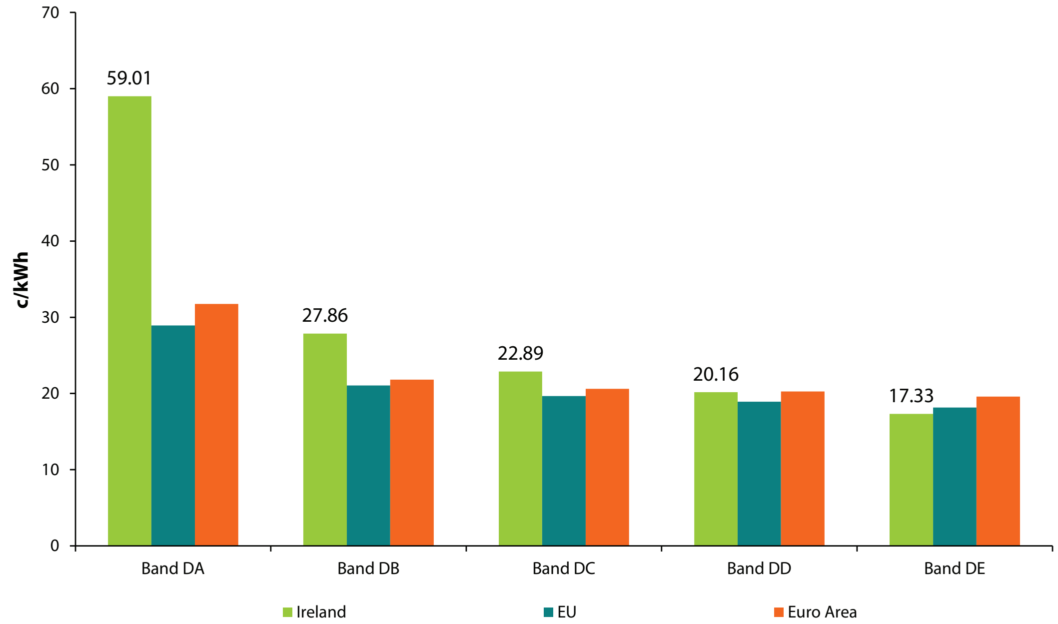
72 Di Cosmo, V. and Hyland, M., 2013, Carbon tax scenarios and their effects on the Irish energy sector, Energy Policy 59, 404-414.

73 Sustainable Energy Authority of Ireland (various dates), *Understanding Electricity and Gas Prices in Ireland*, www.seai.ie.

74 http://europa.eu/legislation_summaries/energy/internal_energy_market/l27002_en.htm

Figure 21 *Residential Electricity Prices 2nd Semester 2012*



Source: Eurostat

Table 14 *Categories for Residential End Use of Electricity Prices*

Household end-user	Annual electricity consumption (kWh) Lowest	Highest	Share of residential electricity market in Ireland S2 - 2012	Price c/kWh	% change since last semester	Relative to EU avg. 2012-S2	PPP Relative to EU avg. 2012-S2	Ranking out of 30 countries 2012-S2
Very small (DA)		<1,000	1.1%	59.01	8.0%	204%	189%	1
Small (DB)	1,000	2,500	8.3%	27.86	6.4%	132%	122%	4
Medium (DC)	2,500	5,000	31.5%	22.89	6.2%	116%	108%	5
Large (DD)	5,000	15,000	50.1%	20.16	7.1%	107%	99%	7
Very large (DE)	≥15,000		9.0%	17.33	6.0%	95%	88%	9

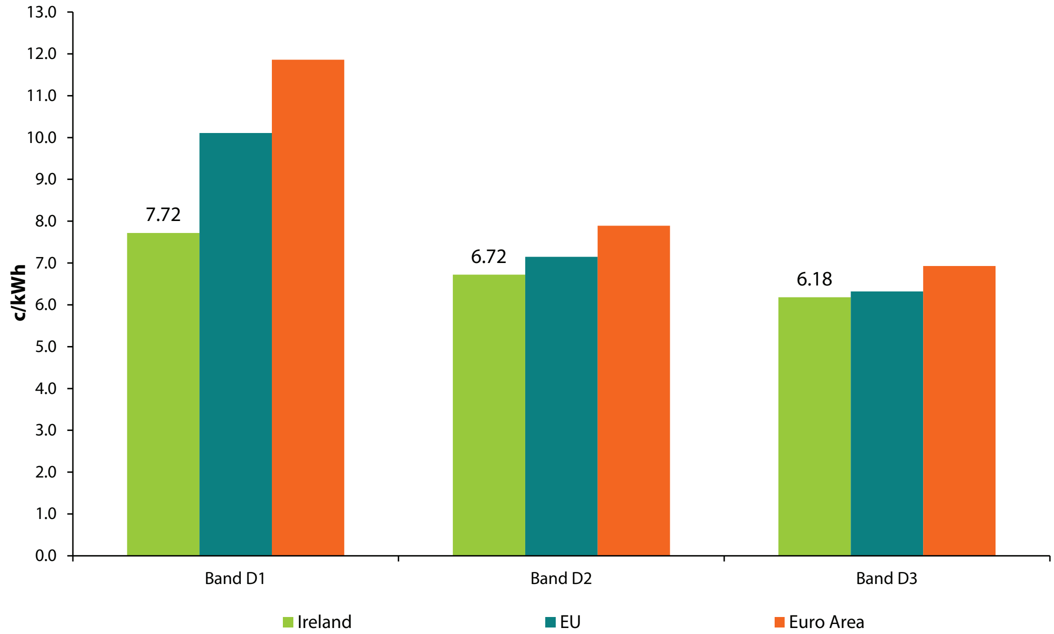
4.3.1.2 Residential Gas Prices

Figure 22 shows graphically the position of the all tax-inclusive gas price to households during the first semester of 2012 relative to the average EU and Euro Area prices. With regard to consumption bands the most relevant for the majority (94%) of residential consumers is the medium band (20 – 200 GJ per annum or 5,556 kWh to 55,556 kWh) referred to as D2. In the lower consumption bands the average price per kWh is higher because the standing charges and network charges form a larger proportion of the annual costs.

During the second semester of 2012 all consumption bands were below the EU average with bands D1, D2 and D3 at 24%, 6%, and 2% below respectively.

When purchasing power parities are applied, Ireland is below the EU average in all gas consumption bands for residential consumers, ranging from 10% to 29% below. In band D2 Ireland was 10% below the EU average in the first semester of 2012 in purchasing power parity terms.

Figure 22 *Residential Gas Prices 2nd Semester 2012*



Source: Eurostat

Table 15 details Ireland's position with respect to the EU average and the PPP EU average. The final column in *Table 15* shows Ireland's ranking in the EU in euro terms for the tax-inclusive price paid by householders for gas. A ranking of 1 indicates the most expensive jurisdiction. Ireland was ranked 11th most expensive of 25 countries in band D2 (the band for which Eurostat reports and the band that represents 94% of residential use in the country) during the second semester of 2012, a deterioration of 2 places on the previous semester, but the same ranking as in semester 2 2011.

Table 15 *Categories for Residential End Use of Gas Prices*

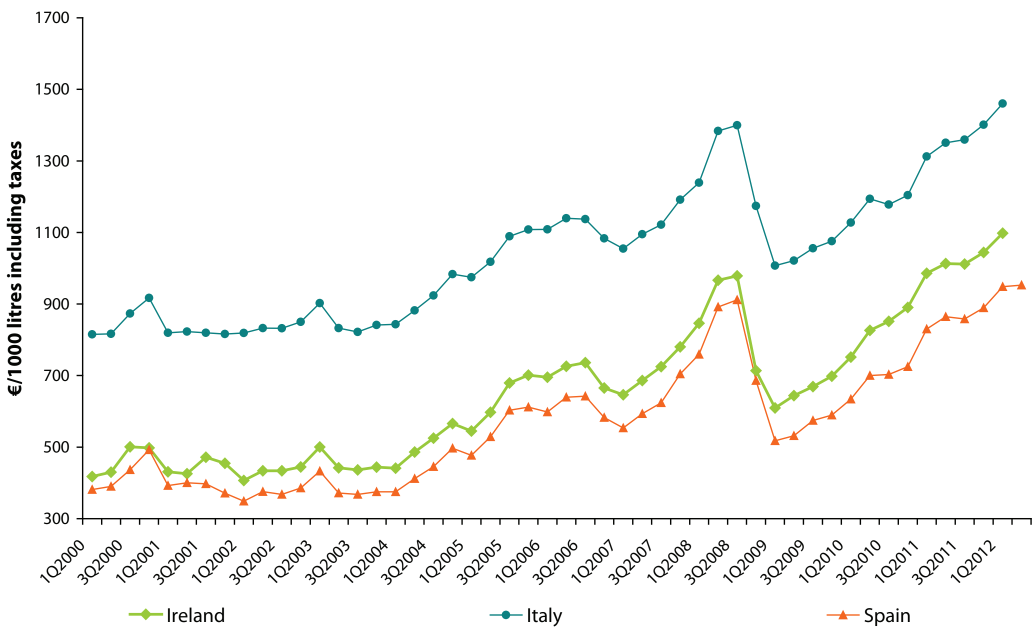
Residential end-users	Annual gas consumption (kWh)		Share of residential gas market in Ireland S1 - 2012	Price c/kWh	% change since last semester	Relative to EU average 2012-S1	PPP Relative to EU average 2012-S1	Ranking out of 25 countries 2012-S1
	Lowest	*Highest*						
D1 - Small	0	< 5,556	3.8%	7.72	13.9%	76%	71%	16
D2 - Medium	5556	< 55,556	93.8%	6.72	9.4%	94%	87%	11
D3 - Large	≥ 55,556		2.3%	6.18	6.6%	98%	90%	11

4.3.2 IEA Energy Prices and Taxes - Household Oil and Summary

This section presents comparisons of the cost of energy in various forms in Ireland with that in selected EU countries. The source of the data presented here is the International Energy Agency (IEA) Energy Prices and Taxes. This data source was chosen because it is produced quarterly and the latest complete data is available for the first quarter of 2012. Prices shown are in current (nominal) money[75].

Graphical comparisons with other countries in money terms are restricted to euro-zone countries (subject to data availability) to avoid difficulties in adjusting for exchange rates. To avoid confusion in the graphs, only data for Ireland and the highest and lowest price countries (as of the 1st quarter 2012) are presented. Relative price increases since 2005, however, are tabulated for all the EU-15 countries in index format in both nominal and real terms.

Figure 23 *Household Heating Oil Prices*



Source: Energy Prices & Taxes © OECD/IEA, 2012.

Table 16 *Oil Price to Households Increase since 2005*

Index 2005 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom
1st qtr 2012 (nominal)	151	151	154	143	147	147	147	196	**160**	148	146	131	146	155	139	160
1st qtr 2012 (real)	128	131	131	122	126	131	130	157	**143**	127	123	116	126	130	124	127

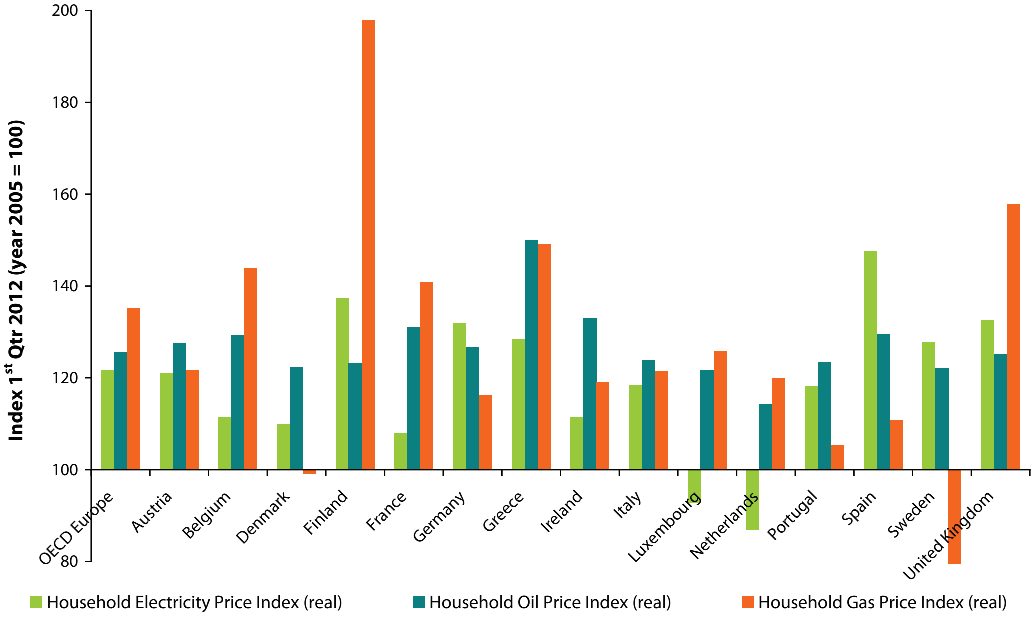
Source: Energy Prices & Taxes © OECD/IEA, 2012.

Heating oil prices to Irish householders increased in real terms by 43% since 2005, the second largest amongst the EU-15 countries as detailed in *Figure 23* and *Table 16*. Greece had the largest increase at 57%. On average in Europe the price of oil to households increased by 28% in real terms.

The IEA publishes separately an overall energy index (real) for households that shows that overall energy prices to Irish households increased by 24% between 2005 and the first quarter of 2012; this was similar to the OECD Europe increase of 25% over the same period.

75 Nominal and Real Values: Nominal value refers to the current value expressed in money terms in a given year, whereas real value adjusts nominal value to remove effects of price changes and inflation to give the constant value over time indexed to a reference year.

Figure 24 *Real Energy Price Change to Households since 2005 in EU-15 (index)*

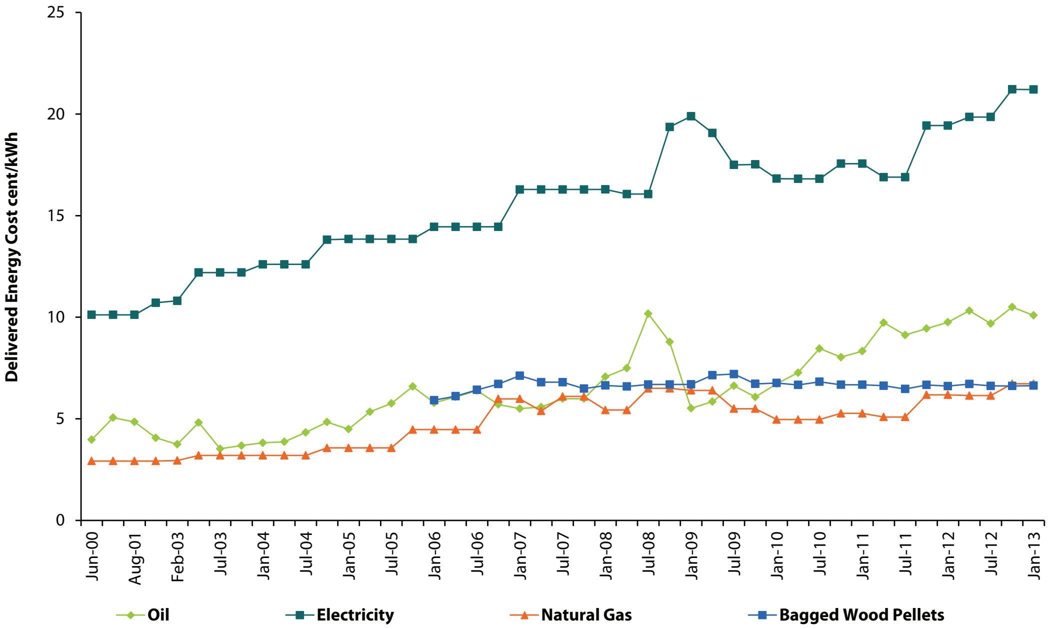


Source: Energy Prices & Taxes © OECD/IEA, 2012.

4.3.3 SEAI Fuel Cost Comparison

Figure 25 presents the trend in residential energy prices (current prices) for electricity, natural gas, heating oil (kerosene), and wood[76]. These were chosen as these fuels are used in the central heating systems present in 91% of dwellings. The different fuels are compared by examining delivered costs in cents per kilowatt hour (kWh). The doubling of the price of electricity between 2000 and 2013 is striking. It can also be seen that from January 2006 to October 2011 the price of kerosene rose by 63%. Household natural gas prices increased by 38%, electricity prices increased by 34% and the price of bagged wood pellets increased by 13% over the same period. The weighted average price increase from 2006 to 2011, as applied to the average household fuel mix in 2011, is estimated at 37%.

Figure 25 *Fuel cost comparison*



Source: SEAI

76 Data are sourced from Fuel Cost Comparison sheets – available from www.seai.ie/statistics. For simplicity only one tariff per fuel is presented, electricity band DD (as it is heating that is being compared in this case), natural gas Band D2, and oil (kerosene). Note that discounts are available by purchasing oil and wood in bulk quantities.

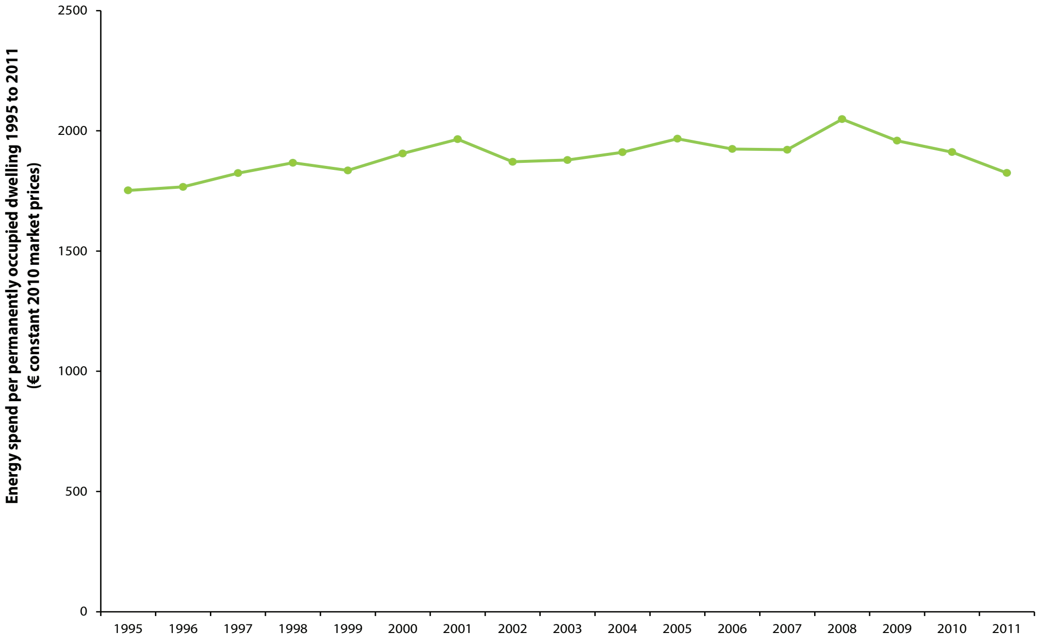
4.4 Residential Expenditure on Energy

According to the CSO's National Income and Expenditure (NIE) accounts, in 2011 the total spend on energy[77] by households was approximately €3 billion, an increase of 57% on 1995 and 10% on 2006. This contrasts with significantly higher rates of energy price increase during those periods: 124% between 1995 and 2011 and 37% between 2006 and 2011 (based on the average household fuel mix in 2011).

Figure 26 presents a calculated average spend on energy per permanently occupied dwelling (in constant 2010 prices) from 1990 to 2011. There is a notable change in the spending pattern per household since 2008 with a year on year decrease since then. Oil prices spiked in the first half of 2008, which is the likely cause of the spike in that year, but then dropped dramatically in the second half of that year. Since 2009, oil prices have continued to rise, although they have not yet reached the high prices seen in early 2008.

As seen in the previous section, prices for residential energy have risen since 2009, therefore an increase in energy spend per household would be expected. Factors contributing to the decrease in energy spend per household since 2008, as seen in *Figure 26,* include the economic recession forcing households to reduce their energy spend, energy efficiency improvements resulting in lower energy demand and a greater effort by householders to reduce their energy demand due to environmental concerns.

Figure 26 *Average Spend on Energy per Permanently Occupied Dwelling 1995 to 2011*[78]



Source: CSO National Income and Expenditure

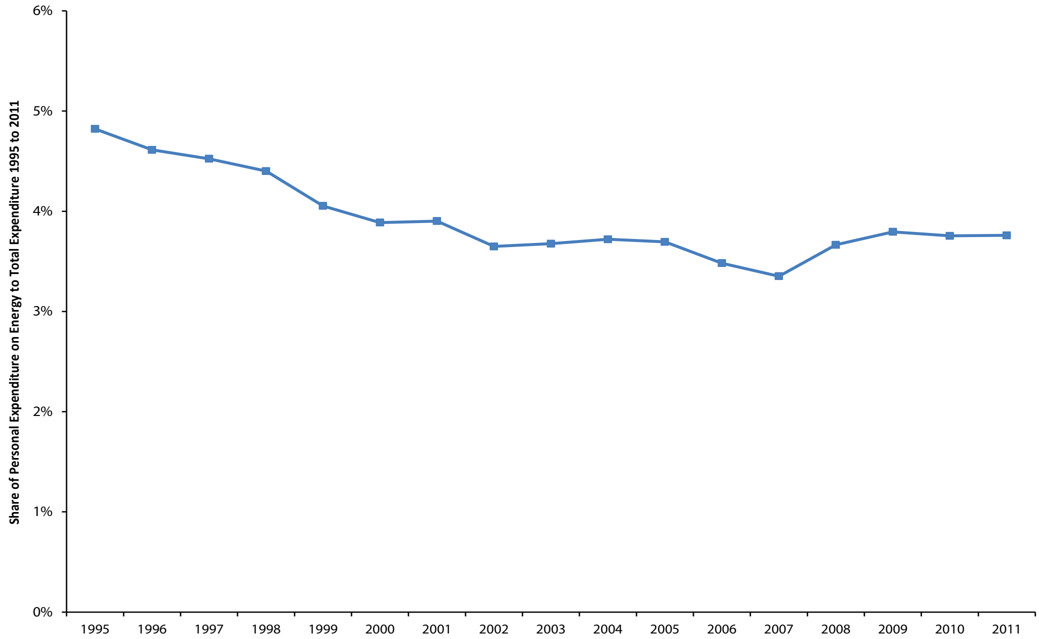
Average spend per household fell by 2.3% between 2006 and 2011, even though the weighted average fuel price increase in that period was 37%.

Viewing *Figure 26* in isolation could lead to the interpretation that improvements in energy efficiency and energy saving measures by households since 2008 have counteracted any energy price increases over the period. However, it should be noted that there has been a significant drop (18%) in the overall expenditure per permanently occupied dwelling since 2008 due to the economic recession.

The proportion of total expenditure[79] spent on fuel and power decreased over the period 1995 to 2011, as illustrated in *Figure 27.* The direction of the trend changed dramatically in 2008, which coincided with the economic recession, and has been relatively flat since 2009. In 1995 the average spend on energy was 4.8% of total household expenditure, this dropped to 3.4% in 2007 but has since risen to a share of 3.8% in 2011. While discretionary spending can be cut in an economic recession there is less scope to reduce the overall spend on energy, hence the increase in expenditure on energy as a proportion of the overall household expenditure.

77 The category labels in the Central Statistics Office National Income and Expenditure tables are fuel and power excluding motor fuel.
78 Cental Statistics Office, 2012, National Income and Expenditure 2011. Available from www.cso.ie
79 Total expenditure is defined as personal consumption of goods and services less taxes on personal income and wealth.

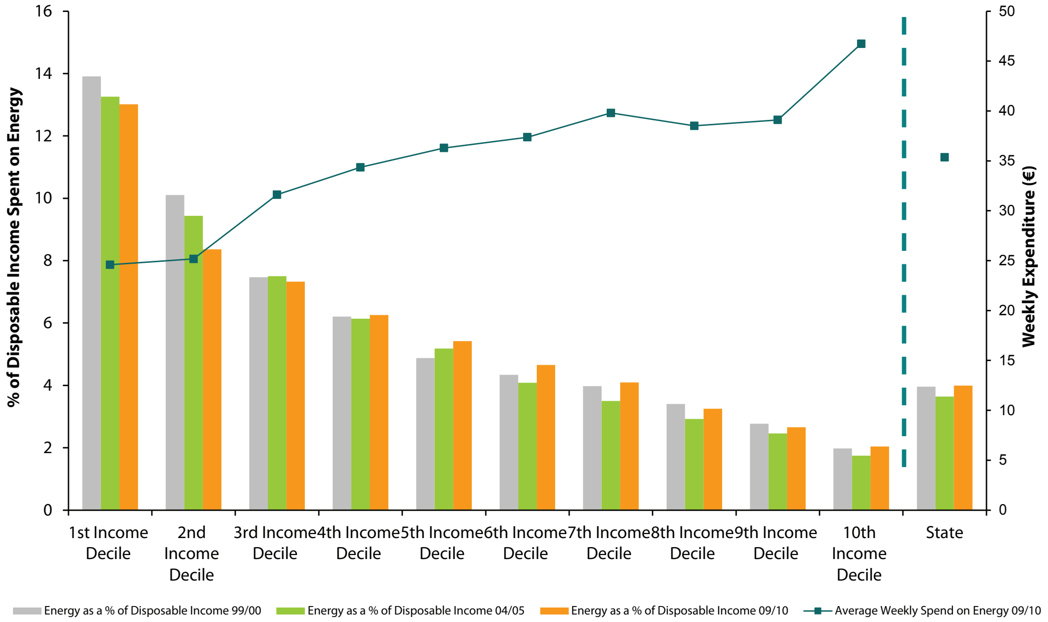
Figure 27 *Share of Expenditure on Energy to Total Expenditure 1995 to 2011*



Source: CSO

The Household Budget Survey (HBS) defines disposable household income as gross income less direct taxation. *Figure 28* examines expenditure on energy[80] as a percentage of disposable income in 2009/2010 for the income deciles in the HBS. The income deciles are constructed by ranking all incomes and then grouping them into ten equal groups. For example, the lowest income decile contains the households with the lowest 10% of incomes.

Figure 28 *Weekly Expenditure on Energy as a Proportion of Disposable Income - Selected Years*



Source: CSO

It can be seen from *Figure 28* that as income decreases there is an increase in the proportion of disposable income spent on energy. In 2009/2010, those in the lowest or 1st income decile (weekly income < €238), spent on average 13% (compared with 13.3% in 2004/2005 and 14% in 1999/2000) of their disposable income on energy while the highest earners spent 2% (compared with 1.7% in 2004/2005 and 2% in 1999/2000). The average proportion of total disposable income spent on energy for Ireland as a whole was 4% in 2009/2010 (compared to 3.6% in 2004/2005, 4% in 1999/2000 and 6.9% in 1987), which is similar to the values calculated from the NIE accounts as shown in *Figure 27.*

80 The variable in the HBS is expenditure on fuel and light (excluding motor fuels) here, referred to as energy.

4.4.1 Energy Affordability

Energy affordability has important implications for health, quality of life and energy efficiency. Households experiencing 'energy poverty' may do so for a variety of reasons, including low income, poor insulation standards, relatively inefficient heating system and personal circumstances (e.g. age, disability, health, unemployment) entailing spending long periods confined in the home.

Energy poverty has been defined as the *"inability to heat one's home to an adequate, i.e. safe and comfortable, temperature owing to low income and poor, energy inefficient housing"*[81]. A quantitative definition often used[82] is the need to spend more than 10% of net household income on fuel to achieve an acceptable level of comfort and amenity.

The results of the Household Budget Survey (HBS) indicate that in the decade 1999/2000 to 2009/2010 there was a progressive decrease in the average spend on energy for the first and second deciles for each iteration of the HBS, as shown in *Figure 28*. This would suggest that the share of households in fuel poverty in those deciles had been decreasing over that period.

The absolute number of households in fuel poverty cannot be assessed using decile averages. Accordingly, the ESRI examined the anonymised data file for the 2009/2010 HBS, the results of which are shown in *Table 17*. After the first three deciles, people are more likely to use lots of energy as opposed to being in energy poverty.

Table 17 *Share of households by disposable income decile spending over 10% of disposable income on heat & lighting*

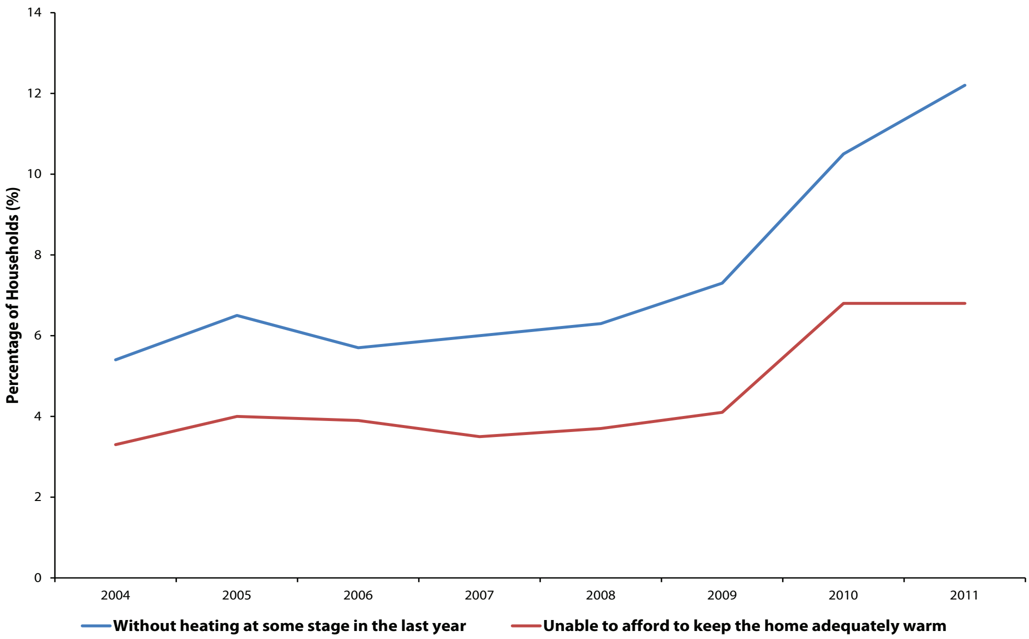
Disposable Income Decile	1	2	3	4	5	6	7	8	9	10
Share of households in energy poverty (%)	52.1	29.2	21.6	13.5	6.4	4.3	2.5	1.1	0.2	0.0

Source: ESRI analysis of the CSO Household Budget Survey 2009/'10 anonymised data file

It is difficult to quantify the absolute number of households in energy poverty but such analyses would suggest a possible incidence in the range of 10–13% in 2009/2010.

The EU Survey on Income and Living Conditions[83] (SILC), which is carried out by the CSO each year, includes two qualitative energy related questions, the results of which are shown in *Figure 29*. The impact of the economic recession can be clearly seen in *Figure 29*, where both energy related deprivation indicators can be seen to have been relatively stable before the recession and deteriorated sharply after 2008.

Figure 29 *Timeseries of the energy related deprivation indicators in the annual SILC*



Source: CSO

4 Drivers of Residential Energy Consumption

81 SEAI, 2003. A Review of Fuel Poverty and Low Income Housing. Available from www.SEAI.ie/getFile.asp?FC_ID=873&docID=263
82 Ibid.
83 CSO, annually, Survey on Income and Living Conditions. More information available from: http://www.cso.ie/en/silc/releasesandpublications/

The SILC asks householders whether they have gone without heating at least once over the previous year, due to lack of money. The most recent survey figures available indicate that in 2011, some 12.2% of households in Ireland went without heat at some stage during the year, an increase on 2010 (10.5%) and 2009 (7.3%).

The SILC also asks whether householders can afford to keep their home adequately warm. This indicator has also increased recently, with 6.8% of householders saying they could not adequately heat their homes in 2011 and 2010, up from 4.1% in 2009 and 3.7% in 2008.

The Department of Communications, Energy and Natural Resources published '*A Strategy for Affordable Energy in Ireland*' in 2011[84]. In that document it is estimated, using an expenditure based method, that 20% of all households, or approximately 317,000 households, experienced energy poverty in 2009, based on figures from the Department of Social Protection.

It is estimated that over 151,000 households were experiencing severe energy poverty, whereby a household spent more than 15% of its disposable income on energy services in the home, and that 83,000 were experiencing extreme energy poverty, whereby a household spent more than 20% of its disposable income on energy services in the home.

The factors associated with the highest risk of energy poverty were identified as:

- Low income, particularly where a household falls within the lowest income decile or where the household falls within the 'working poor' group, i.e. where the head of the household is employed but the household income is below 60% of the national average (median) household income.
- Households occupied by older people, in particular those living alone or where the main breadwinner is widowed
- Households renting from a local authority
- Households in accommodation built prior to 1945

The strategy identified five priority work packages in order to address energy poverty, namely;

- Improving the energy efficiency of the stock by addressing thermal efficiency standards
- Energy suppliers to use disconnections as a last resort and to work with customers to find alternative payment arrangements
- Develop an area based approach to mitigating energy poverty
- Monitoring the number of households in energy poverty and developing a comprehensive measure of energy poverty
- Effective communications, with the timely provision of energy efficiency information and a review of the existing referral system

As well as the work packages identified, the strategy also highlighted other key actions, including ensuring greater access to energy efficiency improvement measures for those at risk of energy poverty, reforming the eligibility criteria for energy efficiency schemes and a review of the National Fuel Scheme and the Household Benefits Scheme to align income supports with the energy efficiency and income of the home.

84 Department of Communications, Energy and Natural Resources, 2010, Warmer Homes: A Strategy for Affordable Energy in Ireland. Available from: http://www.dcenr.gov.ie/Energy/Energy+Efficiency+and+Affordability+Division/Affordable+Energy.htm

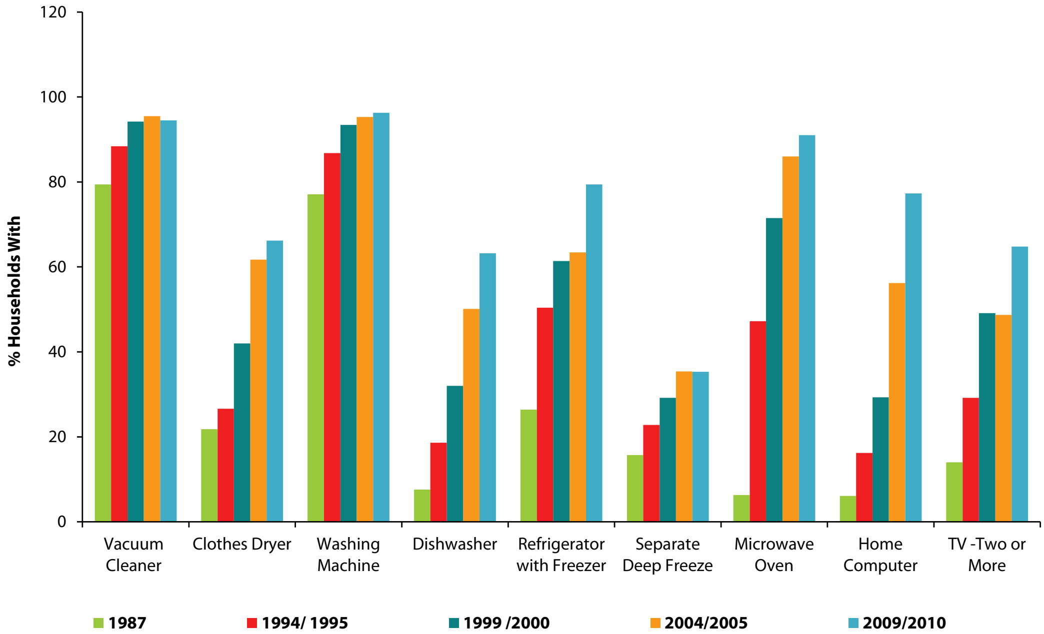
4.5 Residential Electricity

At an individual household level electricity accounts for approximately a quarter of consumption. As electricity costs between 1.5 and 2 times as much as other residential fuels it accounts for between 30% and 40% of total household energy spend, depending on what other fuels are being used. In addition to running various appliances, televisions, washing machines, clothes dryers, computers etc., electricity provides a number of different services to households, such as space and water heating, lighting and cooking.

4.5.1 Appliances

The penetration of electricity appliances can be tracked using data from the CSO HBS. Thirteen different appliances were included in the 2009/2010 survey. Those with the highest growth in ownership are included in *Figure 30*. The proportion of households with one TV are not included because they were widespread at the beginning of the period, so little useful information can be gathered by tracking their development. However, the survey also collects data on the number of households with two or more TV's and this is included in the analysis in *Figure 30* and *Table 18*.

Figure 30 *Penetration of Electrical Appliances – Various Years*



Source: CSO

Table 18 *Penetration of Electrical Appliances – Various Years*

Appliance %	1987	1994/1995	1999/2000	2004/2005	2009/2010	% Increase 1987-2009/2010
Vacuum Cleaner	79.4	88.4	94.2	95.5	94.5	19
Clothes Dryer	21.8	26.6	42	61.7	66.2	204
Washing Machine	77.1	86.8	93.4	95.3	96.3	25
Dishwasher	7.6	18.6	32	50.1	63.2	732
Refrigerator with Freezer	26.4	50.4	61.4	63.4	79.4	201
Separate Deep Freeze	15.7	22.8	29.2	35.4	35.3	125
Microwave Oven	6.3	47.2	71.5	86	91	1,344
Home Computer	6.1	16.2	29.3	56.2	77.3	1,167
TV- Two or More	14.0	29.2	49.1	48.7	64.8	363

Source: SEAI

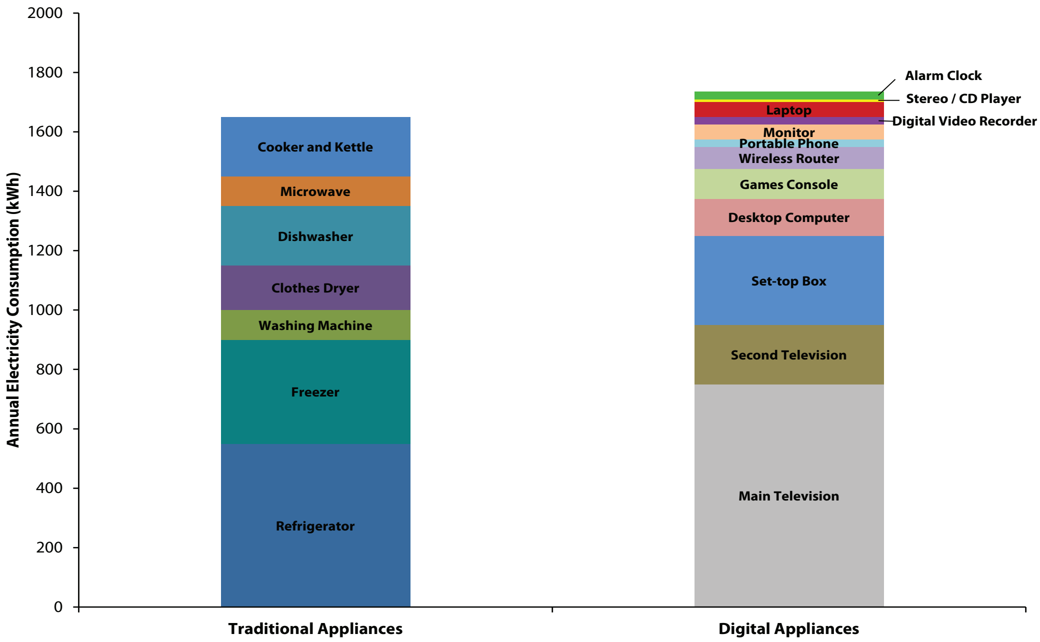
The data does not take account of newer appliances such as satellite/cable set top boxes, DVD players, games consoles or the wide range of convenience products such as electric blenders, coffee machines, etc. but it does provide a useful trend which can be tracked over time.

It can be seen that the penetration of all of the electrical appliances shown in *Table 18* has increased over the period, with microwave ovens showing the largest increase (91% in 2009/2010 compared with 6.3% in 1987). While it could be argued that microwave ovens are a more energy efficient form of cooking, when compared to cooking on a hob or oven, but the significance is that the increase points towards a proliferation of convenience electrical appliances.

The digital revolution of the last decade resulted in a large increase in the number of digital appliances. Ownership of home computers increased by 1,167% and the number of households with two or more TV's points grew by 363%. Most digital appliances use small amounts of energy, with the exception of televisions, set-top boxes and similar items that are on continuously, making them more significant energy users than occasional use items. Digital appliances are now consuming more than traditional appliances in many household in the OECD, according to the IEA[85].

It can be reasonably assumed that the increasing penetration of appliances has had a significant effect on the demand for electricity. Furthermore, anecdotal evidence suggests that there has been an increase in the size of a number of traditional appliances, in particular televisions and refrigerators, which have also increased electrical demand. Some efficiency gains have been made through technical improvements and the labelling of appliances by energy usage has also helped inform purchasing decisions and contributed to a decrease in energy demand in some appliances. While it is not currently possible to quantify these effects on electricity consumption in Ireland (due to data limitations), the consumption is likely to be similar to that detailed in *Figure 31*, which represents typical OECD household electricity appliance consumption, as estimated by the International Energy Agency.

Figure 31 *Typical OECD household electricity consumption of major traditional and digital appliances*



Source: Gadgets and Gigawatts, IEA

It should be noted that the average consumption of refrigerators and freezers in Ireland of approximately 380 kWh per annum [86] appears to be significantly less than the estimate of 550 kWh for the OCED average.

Traditional appliances which are constantly on, such as refrigerators and freezers, have a significant share in the overall annual appliance consumption. The introduction of mandatory labelling of traditional appliances (or white goods), which rate the energy efficiency of these items, has helped reduce the consumption of these appliances.

Recent papers have examined the domestic ownership of energy using appliances and energy saving features[87] in Ireland using the ESRI National Survey of Housing Quality[88] and the Household Budget Survey[89]. Households with higher incomes and those living in newer and larger homes tend to have both more appliances and more energy saving features. Given the long term growth in average floor area noted earlier and likely future growth in

85 IEA, 2009, Gadgets and Gigawatts, ISBN 978-92-64-05953-5
86 Based on estimates from the UK Energy Savings Trust and stock data from the Household Budget Survey
87 For example, insulation, double glazing, energy efficient lighting or advanced heating controls.
88 O'Doherty J., Lyons, S. and Tol, R.S.J., 2008, Energy-using appliances and energy-saving features: Determinants of ownership in Ireland. Applied Energy 85 (2008) 650-662.
89 Leahy, E. and Lyons, S., 2010, Energy Policy 38, 4265-4279

real household incomes, these relationships represent potentially important drivers of future household energy demand and efficiency.

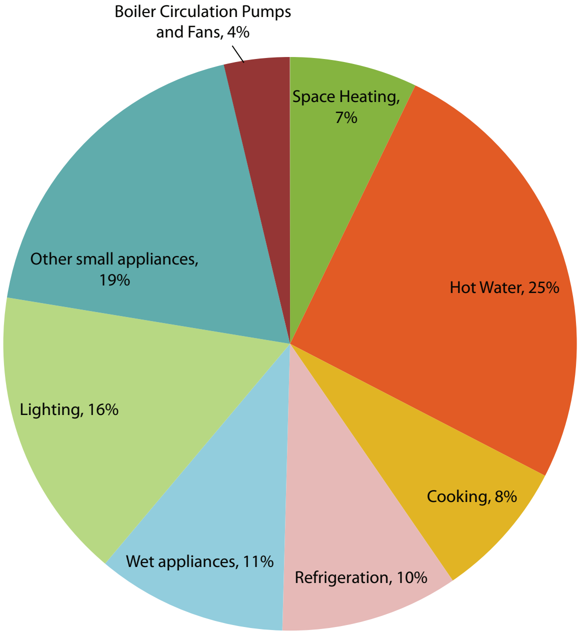
Other socio-demographic influences on appliance ownership and use highlighted by this research include housing tenure, dwelling type, period of residency and family composition. In particular, households in rental accommodation and those living in apartments tend to have fewer appliances. Both of these categories have grown sharply in recent years as shown by the 2011 Census[90]. Declining average household size may also serve to moderate the growth in numbers of appliances somewhat, since larger households tend to have significantly more appliances.

90 Central Statistics Office, Profile 4: The roof over our heads, August 2012. Available from http://www.cso.ie/en/census/census2011reports/

4.5.2 Residential Electricity End Use

It has been previously shown (*Table 1)* that residential electricity demand has been increasing in recent years. One of the reasons for this is the increasing demand for electrical appliances. To provide further understanding it is useful to examine the demand for all residential electricity services. Robust data is not available but estimates were made by SEAI. The data in this section is more tentative than elsewhere in this report but it is based on the best information currently available. The results of the analysis are presented in *Figure 32* and the details of how the shares were estimated is available in Appendix 6: Residential Electricity End Use.

Figure 32 *Residential sector estimated electricity end use 2011*



Source: SEAI

The largest end use category in Ireland is hot water, with a quarter of all electricity use in households estimated to be for heating water. The second largest category is the small appliances category, which includes TVs and other digital appliances, as well as any errors in the estimated consumption of the rest of the categories. The consumption of wet appliances[91] at 11% and refrigeration at 10% were estimated from unit consumption data sourced from the UK Energy Savings Trust[92], usage for wet appliances from the smart metering trial and stock data from the HBS. The electricity consumption per household for cooking was also estimated from the HBS and the number of households relying on electricity for cooking was taken from the smart metering trial. Consumption for the lighting, hot water, space heating and boiler circulation pumps and fans categories was estimated from the BER research database and Census 2011 data.

Table 19 *Electricity end-use[93]*

Appliance %	Ireland (2011)	EU (2009)	United States (2010)
Space Heating	7	19	6
Space Cooling	N/A*	5	22
Hot Water	25	9	9
Cooking	8	7	2
Refrigeration	10	15	8
Wet appliances	11	10	7
Lighting	16	10	14
Other small appliances	19	21	29
Boiler Circulation Pumps and Fans	4	4	3

Source: SEAI

* Any electricity use for space cooling is currently included in the other small appliances category

91 The category of wet appliances refers to washing machines, dishwashers and clothes dryers.

92 UK Energy Savings Trust, 2012, Powering the Nation: Household electricity-using habits revealed. Available from: http://www.energysavingtrust.org.uk/Publications2/Corporate/Research-and-insights/Powering-the-nation-household-electricity-using-habits-revealed

93 These figures are for the sector as a whole and will vary significantly between individual households, depending on whether electricity is used for space heating and cooking in individual circumstances

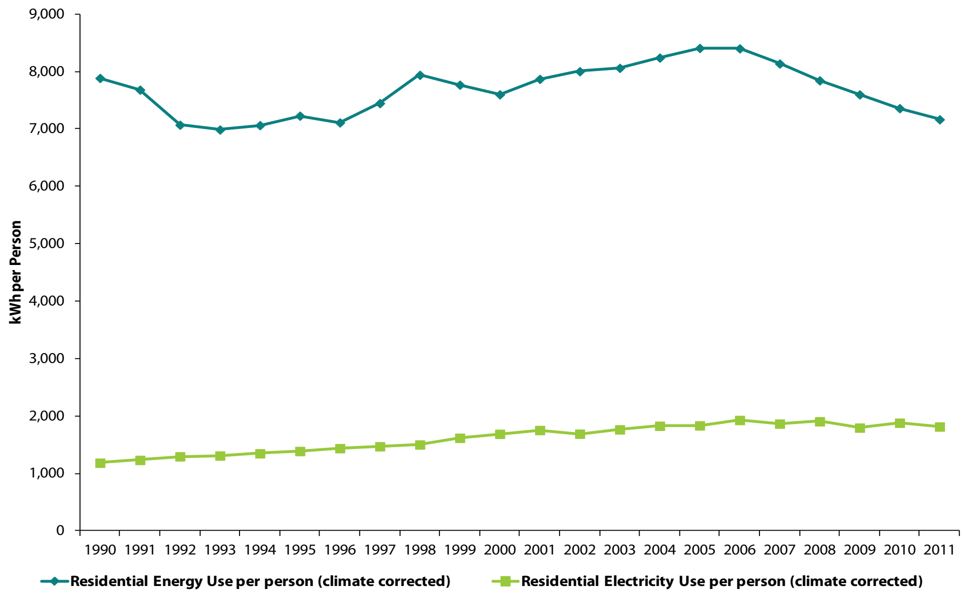
5 Energy Intensity and Efficiency

Following the examination of overall energy usage trends and the structure of the housing stock as well as the main underlying factors behind energy usage, this section presents a number of energy intensity and energy efficiency indicators. These indicators can be used to link the energy trends and underlying factors. Intensity in the residential sector can be measured by relating energy to, amongst other things, population and the number of dwellings.

5.1 Energy Intensity

Figure 33 presents residential electricity and fuel usage per person for the period 1990 to 2011. Residential electricity use per person in 2011 was on average 1,815 kWh while total climate corrected household non electrical energy use per person was 7,165 kWh.

Figure 33 *Climate Corrected Residential Energy Usage per Person 1990 to 2011*



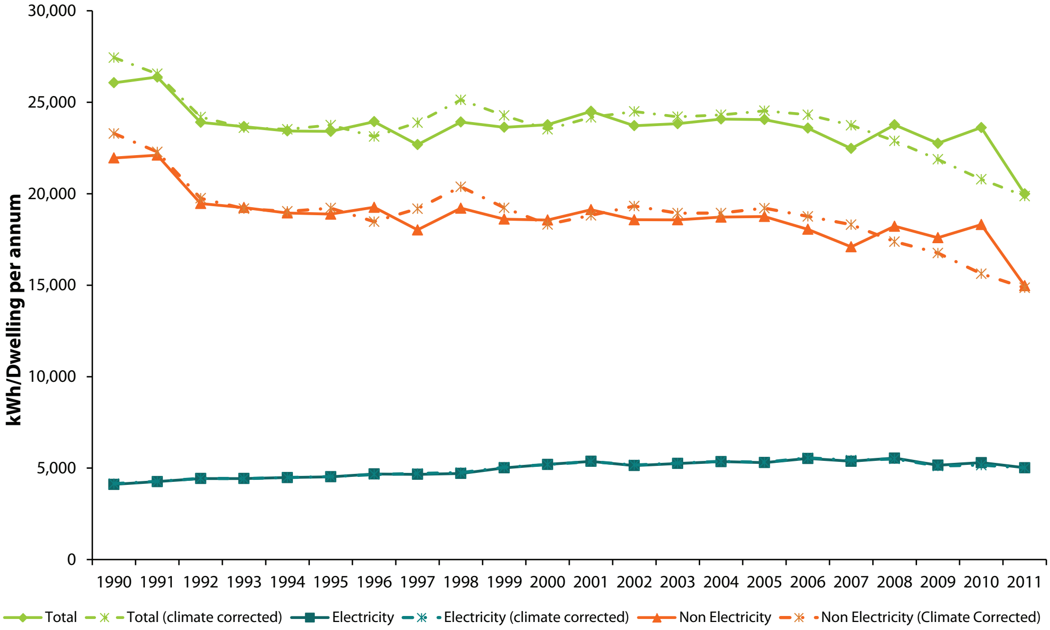
Source: SEAI and CSO

Over the period as a whole, residential electricity demand per person increased by 53% (2.1% per annum). This can be partly explained by the increasing use and size of appliances, as discussed in section *4.5.1*. Total energy use per person fell by 9% between 1990 and 2011 (-0.5% per annum). This is largely the result of fuel switching, from solid fuels to more efficient oil and gas central heating systems and improved thermal efficiency of dwellings.

Looking at *Figure 34,* climate corrected energy consumption per dwelling fell by 28% (-1.5% per annum) over the period 1990 to 2011. This implies that the stock of dwellings has become less energy intensive, partly as a result of the large number of new dwellings, improved insulation standards and the drop in the average number of persons per household.

While overall unit energy use per dwelling has decreased, *Figure 34* and *Table 20* show an increasing trend in climate corrected electricity consumption per dwelling. This has increased by 21% since 1990. The increasing penetration and size of household electrical appliances such as washing machines, dishwashers, clothes driers, computers and multiple televisions, as well as convenience appliances, is believed to have contributed to this increase. Another factor is the increase in the number of electrically heated dwellings since 1990. By contrast, non-electrical energy consumption per dwelling decreased by 36% over the period.

Figure 34 *Unit Consumption of Energy per Dwelling (permanently occupied) 1990 to 2011*



Source: SEAI and CSO

In 2011, the "average" dwelling consumed 19,875 kWh of energy, based on climate corrected data, 4.4% below the 2010 level. This comprised 14,858 kWh (75%) direct fossil fuels and 5,016 kWh (25%) of electricity.

Figure 34 also shows overall unit energy use per dwelling, corrected for climate variations. Looking at this in conjunction with *Table 20,* it can be seen that the decrease in climate corrected energy use per dwelling over the period was 28%, while the uncorrected energy use decrease was 23%. Most of the improvement in climate corrected energy use per dwelling occurred during the early 1990s and again from 2006 onwards, with the increasing penetration of new housing stock and improved energy performance of these new houses. Some of the improvements are also due to improvements in the existing housing stock resulting from schemes such as the Greener Homes Scheme, the Home Energy Saving Scheme and the Warmer Homes Scheme.

Table 20 *Growth Rates and Quantities of Residential Unit Energy Consumption and Unit CO_2 Emissions*

	Growth %	Average annual growth rates %				Quantity (kWh)	
Unit Energy Consumption	**1990 – 2011**	**'90 – '11**	**'00 – '05**	**'05 – '10**	**2011**	**1990**	**2011**
Total Energy per dwelling	-23.3	-1.3	0.2	-0.4	-15.4	26,068	19,992
Non Electrical Energy per dwelling	-31.8	-1.8	0.2	-0.5	-18.3	21,956	14,971
Electrical Energy per dwelling	22.1	1.0	0.4	0.0	-5.3	4,112	5,022
Unit Energy Consumption Climate Corrected						**Quantity (kWh)**	
Total Energy Climate Corrected per dwelling	-27.6	-1.5	0.9	-3.3	-4.4	27,443	19,875
Non Electrical Energy Climate Corrected per dwelling	-36.2	-2.1	1.0	-4.0	-4.9	23,295	14,858
Electrical Energy Climate Corrected per dwelling	20.9	0.9	0.5	-0.6	-2.9	4,148	5,016
Unit Energy-Related CO_2 Emissions						**Quantity (t)**	
Total Energy CO_2 per dwelling	-40.5	-2.4	-1.8	-2.0	-15.7	10.7	6.4
Non Electrical Energy CO_2 per dwelling	-44.3	-2.7	-0.5	-1.0	-17.6	7.0	3.9
Electricity CO_2 per dwelling	-33.4	-1.9	-3.4	-3.6	-12.5	3.7	2.5

Source: SEAI

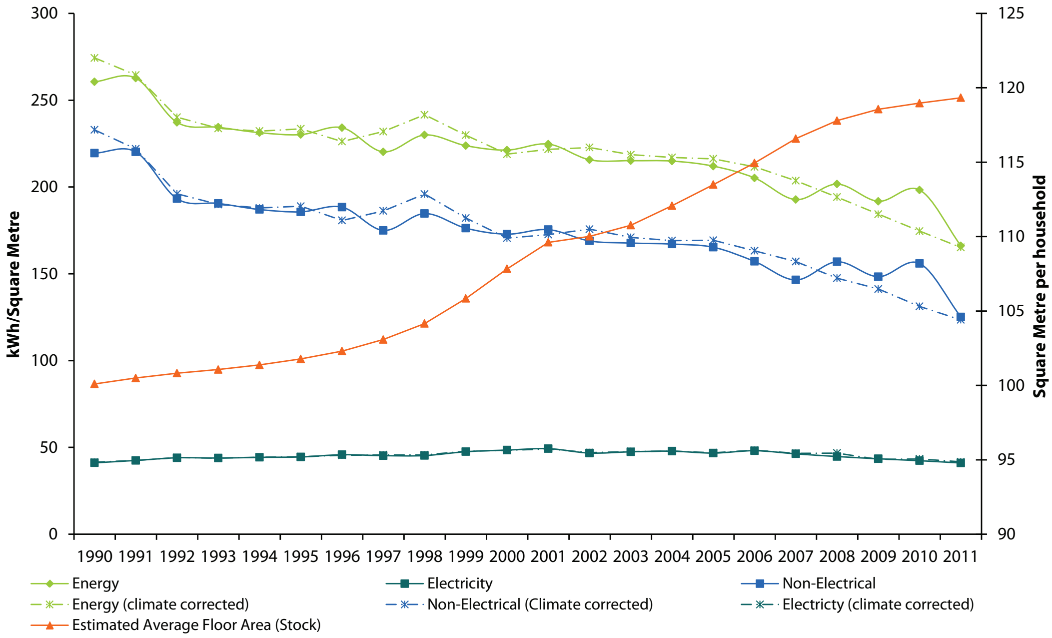
In 2011, the "average" dwelling was responsible for emitting approximately 6.4 tonnes of energy-related CO_2. A total of 3.9 tonnes CO_2 (61%) came from direct fuel use and the remainder indirectly from electricity use. Overall CO_2 emissions per dwelling have fallen by 41% since 1990, and by 21% since 2006 (24% when weather corrected).

Another indicator of intensity is energy use per unit of area. *Figure 35* and *Table 21* show the trend in total energy, electrical energy and non-electrical energy per estimated square metre[94] for the residential sector. Over the period 1990 to 2011, energy usage per square metre fell by 36% (2.1% per annum) to 166 kWh per square metre per annum

94 The methodology for estimating the floor area of the stock is outlined in section *4.1.4*.

(242 kWh primary energy equivalent[95]), non-electricity energy usage decreased by 43% (2.6% per annum) to 124 kWh per square metre per annum (136 kWh primary energy equivalent), while electricity usage fell by 0.2% (0.01% per annum) to 42 kWh per square metre per annum (107 kWh primary energy equivalent). Over the same period, the average floor area of the stock is estimated to have increased by 19% (0.8% per annum).

Figure 35 *Estimated Energy Usage per Square Metre 1990 to 2011*



Source: SEAI and CSO

Table 21 *Growth Rates and Quantities of Estimated Energy Usage per Square Metre 1990 to 2011*

	Growth %	Average annual growth rates %				Quantity (kWh/m²)	
Usage per Square Metre	**1990 – 2011**	**'90 – '11**	**'00 – '05**	**'05 – '10**	**2011**	**1990**	**2011**
Total Energy	-36.2	-2.1	-0.85	-1.33	-16.2	260.6	166.2
Electricity	-0.21	-0.01	-0.72	-1.96	-3.10	41.1	41.0
Non Electrical Energy	-43.0	-2.6	-0.89	-1.16	-19.75	219.5	125.1
Est. Average Floor Area Stock	19.2	0.8	1.03	0.95	0.31	100.1	119.3
Climate Corrected Usage per Square Metre	**1990 – 2011**	**'90 – '11**	**'00 – '05**	**'05 – '10**	**2011**	**1990**	**2011**
Energy Climate Corrected	-39.8	-2.4	-0.25	-4.19	-5.37	274.4	165.2
Electricity Climate Corrected	0.52	0.03	-0.61	-1.56	-3.84	41.5	41.7
Non Electrical Energy Climate Corrected	-47.0	-3.0	-0.15	-4.97	-5.88	232.9	123.5

Source: SEAI and CSO

95 The primary energy equivalent in this case includes an energy overhead for the extraction, processing and transport of fuels. For most fuels a primary energy factor of 1.1 is used. The factor for electricity changes annual. In 2011 the electricity factor was 2.54.

5.2 Energy Efficiency

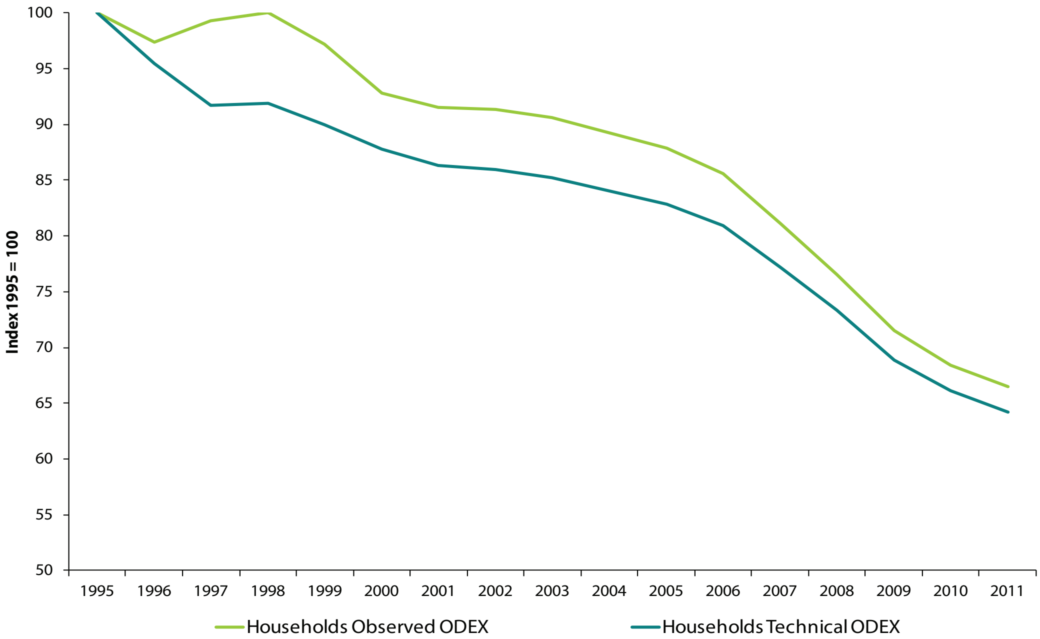
In order to better understand intensity trends and to clarify the role of the energy-related factors a methodology is required to isolate and disregard changes due to economic or structural effects[96]. In 2006, SEAI produced a new set of metrics for Ireland, known as ODEX indicators, to examine the evolution in energy efficiency in Ireland. This type of analysis has been developed since 1993 through the ODYSSEE[97] project, which includes Irish involvement through SEAI/EPSSU.

ODEX indicators are referenced in the Energy End-use Efficiency and Energy Services Directive (ESD)[98]. 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, etc.) at the economy or sectoral level.

A residential observed ODEX is calculated based on actual energy consumption and a residential technical ODEX is also calculated to remove the influence of behavioural factor. Technical energy efficiency gains arise from the penetration of more energy efficient technologies, whereas behavioural gains are the result of how technologies (for example heating systems and appliances) are used. The technical energy efficiency index is calculated using theoretical consumption figures based on building regulations.

Figure 36 presents two ODEX indicators for Ireland for the period 1995 to 2011. Both indices are corrected for climatic variations; however, as a result of the methodology employed, there may be over-correction in mild years. This can be seen in the 1998 ODEX value for example, as 1997 to 1999 were relatively mild years. Both indices are calculated as a three year moving average.

Figure 36 *Residential ODEX 1995 to 2011*



Source: SEAI

The observed ODEX decreased by 34% over the period (2.5% per annum), indicating an improvement in energy efficiency. As the ODEX is a "top-down" energy efficiency indicator it provides a measurement for gross energy efficiency savings in the residential sector but cannot be linked directly to specific energy efficiency measures or programmes. The average annual rate of improvement grew from 1.4% between 1995 and 2006 to 4.9% between 2006 and 2011. The technical ODEX decreased by 36% (2.7% per annum).

It can be seen that the observed ODEX is approaching the technical ODEX, indicating an overall energy efficiency improvement, but energy efficiency gains can be negated by rebound effects. Rebound effects are where there is increased energy usage through higher comfort levels, longer heating hours, the move towards whole house heating, larger dwellings and non-compliance with the Building Regulations.

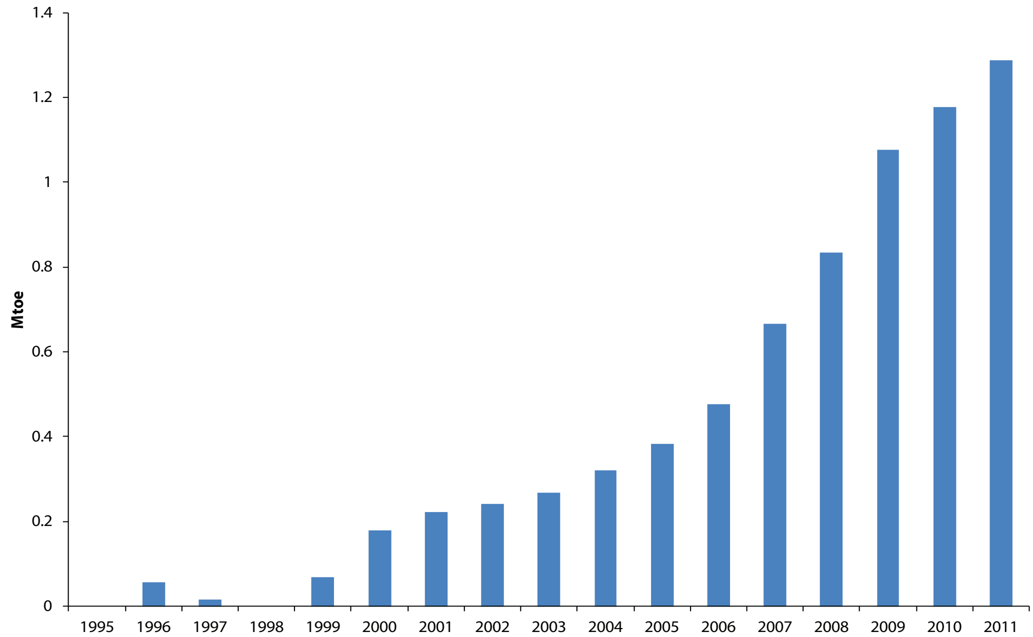
96 Bosseboeuf D. et al, 2005, Energy Efficiency Monitoring in the EU-15, published by both ADEME and the European Commission. Available from www.odyssee-indicators.org

97 For full details of the project go to www.odyssee-indicators.org

98 See ec.europa.eu/energy/demand/legislation/end_use_en.htm for details and a copy of the Directive.

The ODEX methodology also allows for calculation of the amount of savings due to energy efficiency, as shown in *Figure 37*. The savings in any particular year are a result of cumulative energy efficiency gains from 1995 to that particular year. The annual amount of energy saved relative to 1995 had grown to 1.3 Mtoe by 2011. It is important to note that the energy savings calculated using the ODEX methodology include a number of factors. In addition to energy efficiency savings due to specific policies and measures, savings due to price effects and improvements that would have occurred in the absence of the policies and measures are also included.

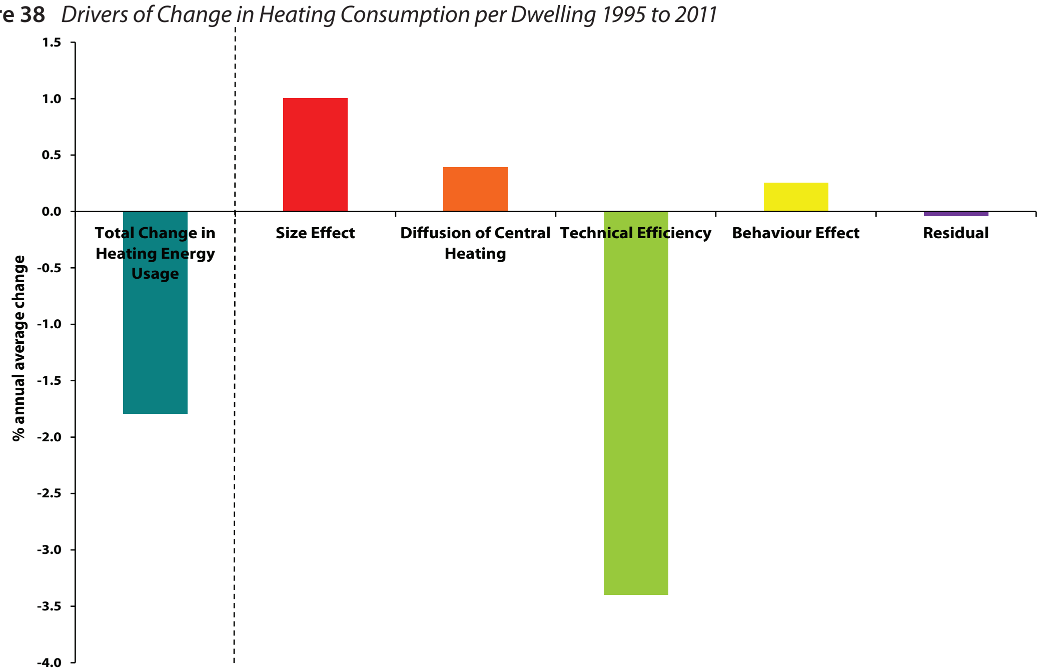
Figure 37 *Residential Energy Savings 1995 to 2011*



Source: SEAI

Using the ODEX methodology, it is also possible to quantify variations in energy use associated with individual factors. *Figure 38* examines the factors influencing home heating only over the period 1995 to 2011.

Figure 38 *Drivers of Change in Heating Consumption per Dwelling 1995 to 2011*



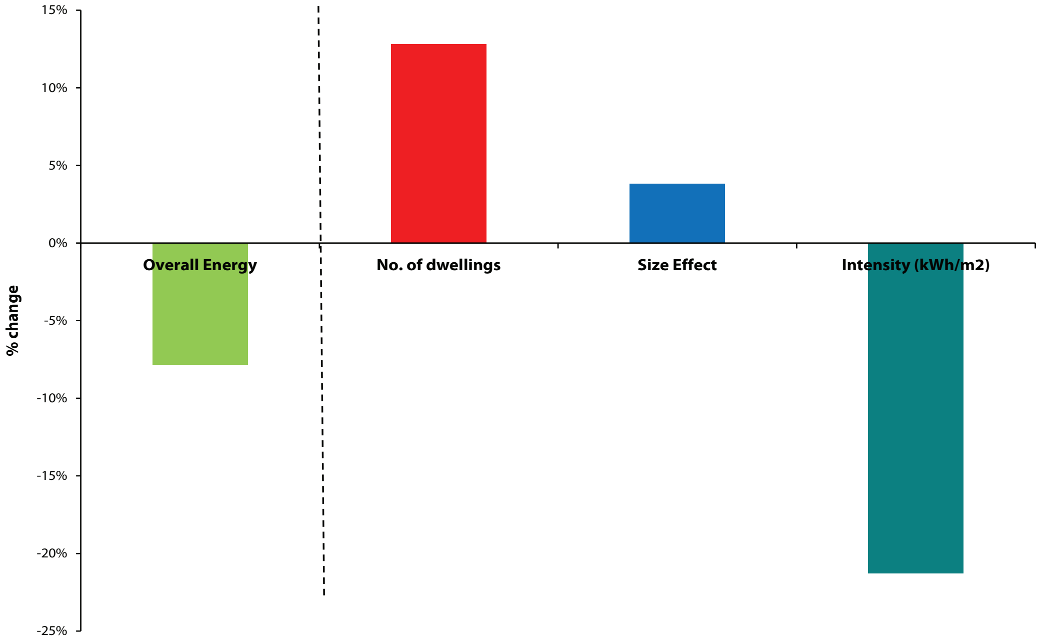
Source: SEAI

The total average annual 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% 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 (3.4% increase per annum). The residual column in *Figure 38* refers to other factors not accounted for elsewhere.

Given the dramatic improvement in energy consumption per household since 2006, as shown in *Figure 34*, the factors influencing total residential energy consumption in this period were also examined in detail in *Figure 39*. In relation to the intensity improvement, further data and research is required to establish definitively the contributions of the individual factors influencing the change in intensity (energy per square meter) between 2006 and 2011. These factors include:

- The impact of improved new build standards arising from revised building regulations;
- The impact of retrofit upgrading to existing dwellings (both grant-aided and other measures);
- The impact of improved awareness and information among consumers;
- The impact of energy prices (including carbon taxes);
- The impact of reduced incomes on energy use.

Figure 39 *Decomposition of climate corrected total energy use in the residential sector 2006 to 2011*



Source: SEAI

In the 2006 census the share of the stock built after 2001 was 9%, and by 2011 that share had increased to 20%. Therefore over the period 2006 to 2011 the number of dwellings built to more stringent building regulations (from 2002 onwards) doubled.

Apart from an increase of 1.5% in the share of apartments in the stock there wasn't a significant change in the type of housing stock. Between 2006 and 2011 the share of oil in the stock increased by 4.6%, the share of natural gas by 4.5% and that of electricity by 1.4%. Heating systems based on all of these are more efficient than solid fuel heating systems and this fuel switching contributed to an improvement in the efficiency of the dwelling stock.

Also, over 16% of the building stock built prior to the introduction of the 2002 building regulations underwent energy efficiency upgrades during the period 2006 to 2011 (over 200,000 dwellings).

It is possible that a portion of the improvement may be due to an increase in the consumption of sod peat (turf) and wood that is not accounted for in the official energy statistics. There has always been some unaccounted consumption in the residential energy use statistics. It can equally be argued that the overall impact of increased use of non-traded wood logs and sod peat is likely to be small.

More detailed data than is currently available is required in order to calculate a full decomposition analysis on the whole residential sector in Ireland.

6 International Comparison

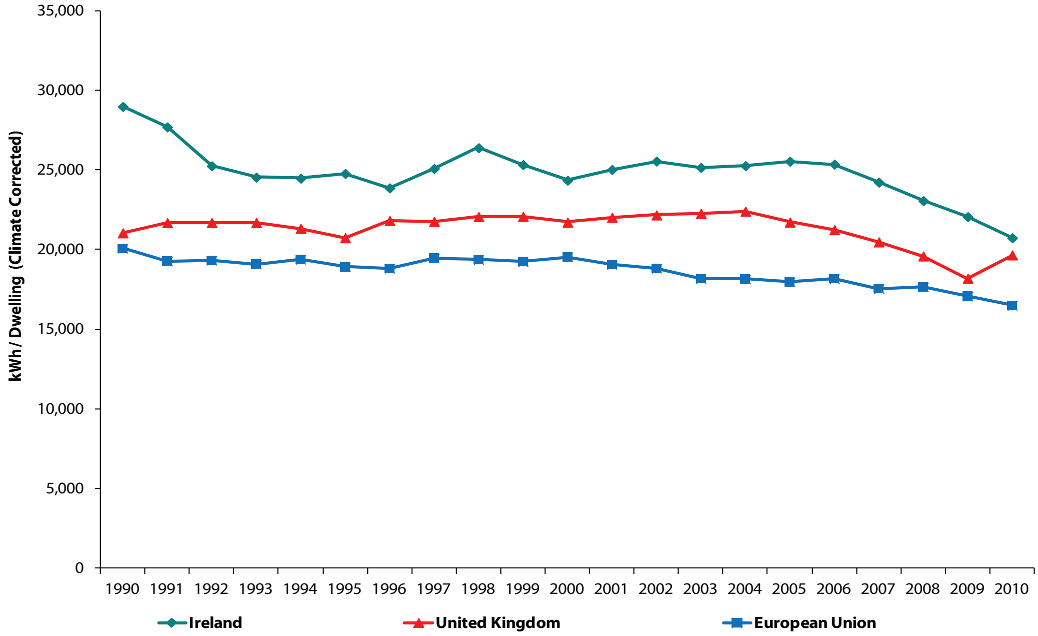
Section *5* presented the consumption of energy per dwelling for Ireland. It is possible using the ODYSSEE database[99] of energy efficiency indicators to compare the situation in Ireland with that in the EU (15 and 27) average and the UK. Data in this section is not directly comparable with that presented for Ireland earlier in this report due to differing methodologies and emission factors used in ODYSSEE. It is useful, however, for cross country comparisons. The emphasis on a comparison with the UK is because its climate is most similar to Ireland's.

In this section it can be seen that Ireland is well above the EU and UK averages for energy consumption, electricity consumption and CO_2 emissions per dwelling. This is the result of a number of factors:

- Larger average dwelling size in Ireland – the average dwelling size in Ireland is 39% above the average for the EU 27 and 31% above the average for the UK (in 2010).
- District heating – other EU countries have significant district heating networks, for example, the share of total heating supplied by district heating is 60% in the Czech Republic, 59% in Sweden, 58% in Denmark[100]. Losses and CO_2 emissions in district heating are accounted for in the transformation sector, whereas in Ireland losses and CO_2 emissions for direct fuel use are attributed directly to the residential sector.
- Differences in the fuel mix – for example, there is a higher proportion of solid fossil fuel use in Ireland than in most other EU member states, see *Figure 42*.

Energy usage per dwelling (climate corrected) is presented in *Figure 40* for Ireland, the UK and the average for the European Union 27. It can be seen that in 2010 Ireland was 5% above the UK and 26% above the EU-27 average (compared to 36% above in 2006). As Ireland has, on average, larger dwellings than the EU and UK it is not surprising that the energy usage per dwelling is higher.

Figure 40 *Energy Usage per Dwelling Climate Corrected*



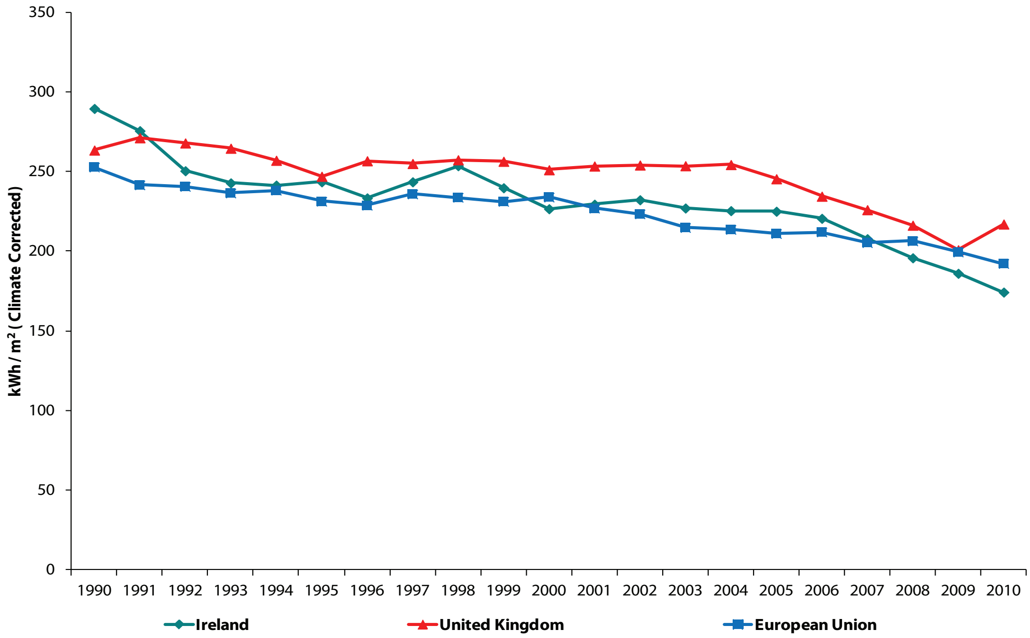
Source: ODYSSEE

A different picture emerges when the comparison is based on energy usage per square metre (climate corrected), as presented in *Figure 41* for Ireland, the UK and the EU-27. In 2010 Ireland was 20% below the average for the UK and 9% below the EU-27 average.

99 ODYSSEE is a cross European project which develops and maintains a database of energy efficiency indicators. More information can be found at www.odyssee-indicators.org/

100 Total district heat sales in any particular year as a percentage of the total heat demand in that year. The Czech Republic and Danish shares quoted are for 2011, while the Swedish share refers to 2009. Data sourced from www.euroheat.org

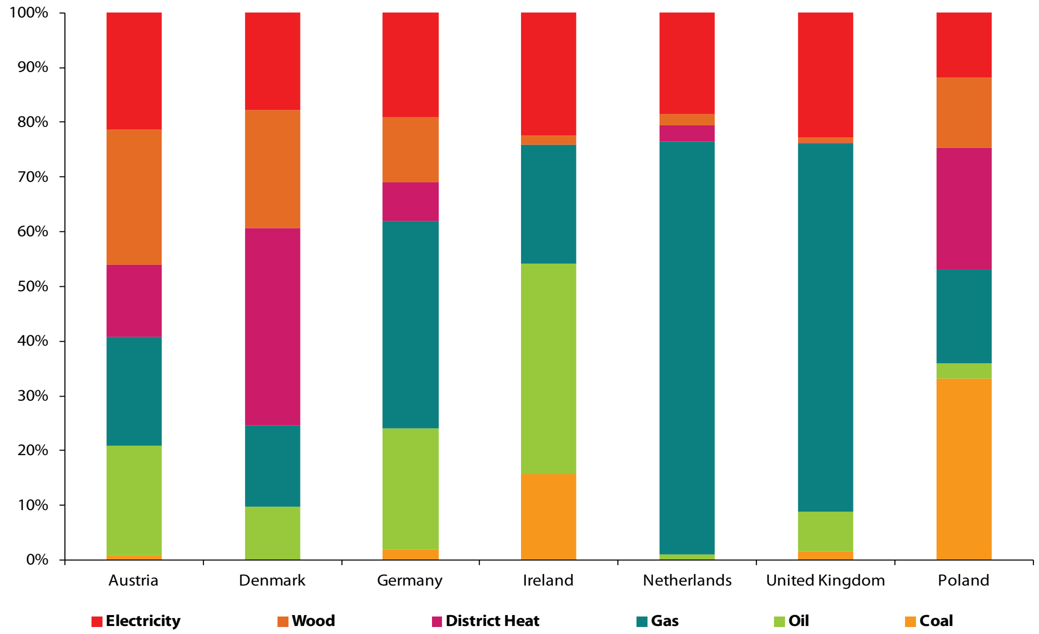
Figure 41 *Energy Usage per Square Metre Climate Corrected*



Source: ODYSSEE

Figure 42 and *Table 22* present the fuel mix (final energy usage) for a select number of EU countries.

Figure 42 *Final Energy Usage - Fuel Mix 2011*



Source: ODYSSEE

It can be seen from this selection of countries that Ireland's fuel mix has a higher proportion of oil use (39% of the total) than any of the other countries. There is only a negligible amount of district heating in Ireland, the use of wood is low (1.8%) and the share of coal (16%) is second only to Poland (33%). In Ireland's case, the coal category here refers to both coal and peat, whereas for all other countries it is just coal.

The fuel mix helps to explain why Ireland is shown to have higher energy usage and higher CO_2 emissions per dwelling than the EU average. Fuels such as coal and oil are typically consumed at lower efficiencies than gas and are more carbon intensive than wood and natural gas. In addition, losses associated with district heating (as well as electricity) are attributed to the energy transformation sector.

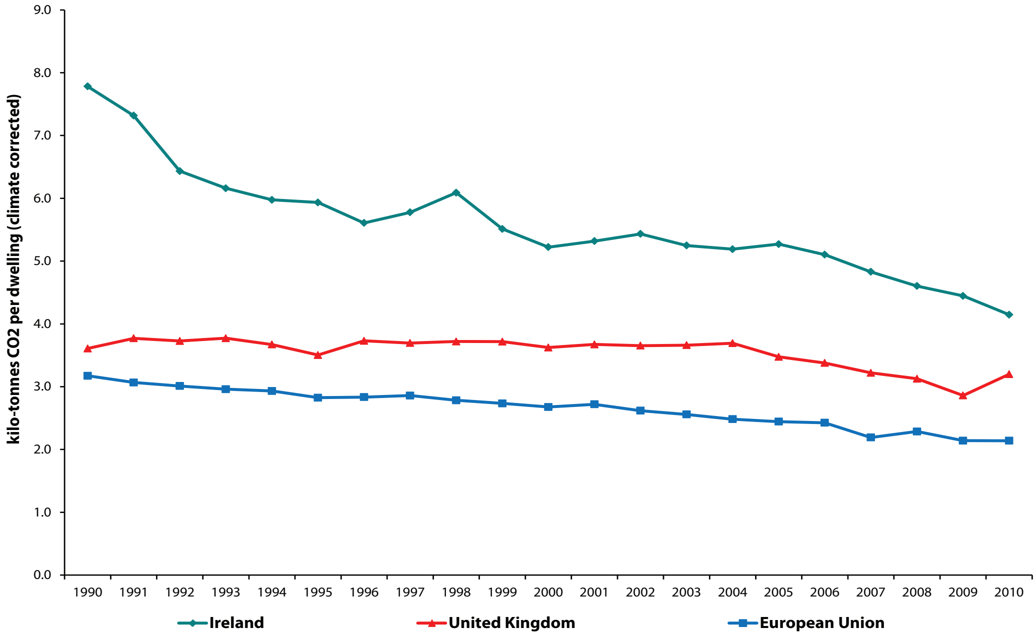
Table 22 *Residential Final Energy Usage – Fuel Mix 2011*

% of Total	Coal	Oil	Gas	District Heat	Wood	Electricity
Austria	0.8%	20.2%	19.7%	13.3%	24.6%	21.4%
Denmark	0.0%	9.7%	14.9%	36.1%	21.6%	17.7%
Germany	2.0%	22.1%	37.9%	7.1%	11.8%	19.1%
Ireland	15.7%[103]	38.6%	21.6%	0.0%	1.8%	22.4%
Netherlands	0.0%	0.9%	75.6%	3.0%	1.9%	18.6%
UK	1.5%	7.2%	67.4%	0.1%	1.0%	22.8%
Poland	33.1%	2.8%	17.0%	22.3%	12.9%	11.8%

Source: ODYSSEE

Figure 43 illustrates CO_2 emissions per dwelling for Ireland, the UK and the EU - net of emissions associated with electricity generation. The average Irish dwelling in 2010 emitted 30% more CO_2 than the average dwelling in the UK, and emissions were 94% more than the average for the EU-27. Two important reasons for this are the larger dwelling size in Ireland and the prevalence of high emitting fuels (peat, coal & oil) in the residential fuel mix. The substantial improvements for Ireland over the period coincide with revisions of the Building Regulations, see *Table 12*.

Figure 43 *CO_2 Emissions per Dwelling climate corrected*



Source: ODYSSEE

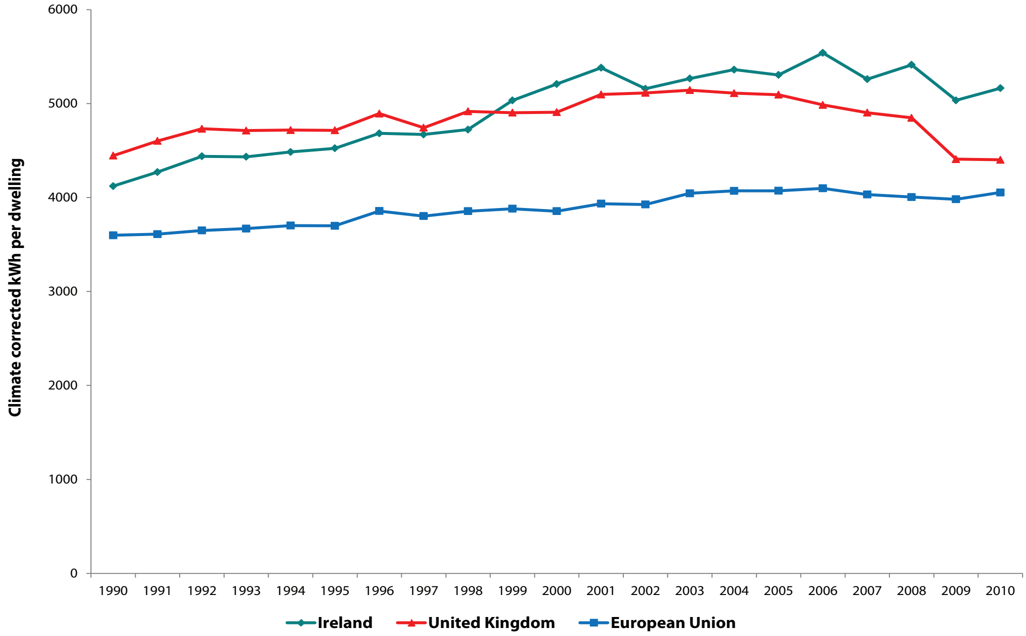
Figure 44 presents electricity consumption per dwelling (climate corrected), and it can be seen that since 2000 Ireland's electricity usage has been above that of the UK and of the EU average. The acceleration in the demand growth for Ireland coincided with high economic growth when the increased demand for appliances (and their increased size) was driven by the new homes market in particular. Another factor influencing increased electricity usage has been the greater use of electricity for space heating, for example in apartments. In 2010, Ireland's climate corrected electricity consumption per dwelling was 15% above the UK average and 21% above the EU average.

It should be noted that the climate correction is only applied to the known space heating portion of electricity consumption. The consumption of supplementary electric heaters, such as portable oil filled heaters, are not climate-corrected, hence there is some variation due to extreme weather, such as in 2008 and 2010 in Ireland.

It should also be noted that the larger dwelling size in Ireland relative to other European countries as well as a high prevalence of electric cooking is why there is greater than average electricity consumption per dwelling in Ireland. Examining the climate corrected electricity consumption per square meter in 2010 reveals that Ireland's consumption was 9% below the EU average and 12% below the UK average.

101 Coal and peat is included in this category for Ireland.

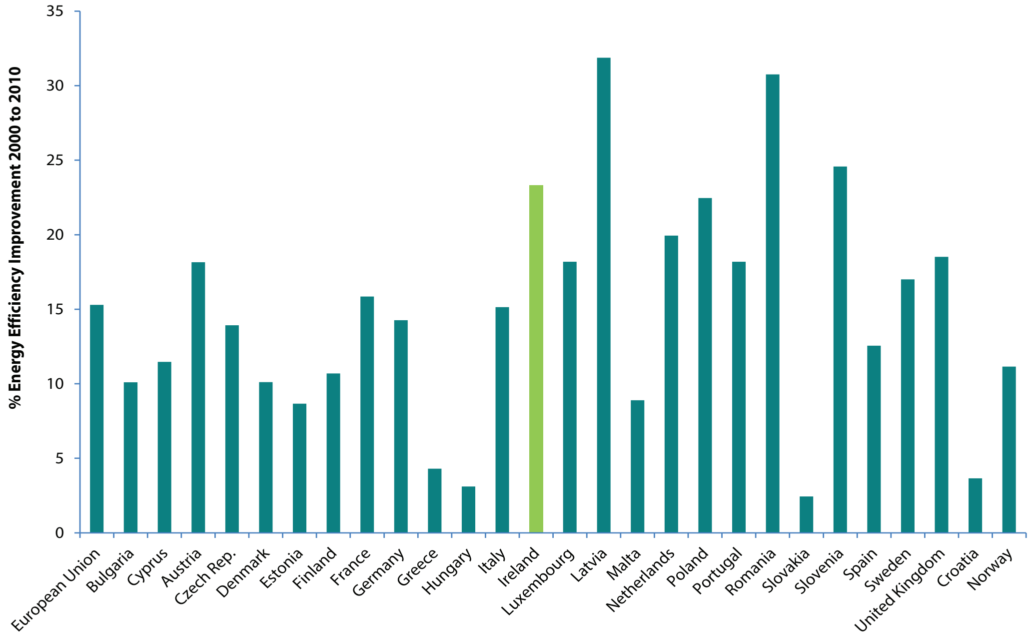
Figure 44 *Electricity Consumption per Dwelling climate corrected*



Source: ODYSSEE

Figure 45 shows the variation in the residential sector ODEX over the period 2000 to 2010 for countries where data is available.

Figure 45 *Residential Sector ODEX – Variation 2000 to 2010*



Source: ODYSSEE

Ireland recorded the fourth largest improvement in energy efficiency between 2000 and 2010 with a 23% improvement in energy efficiency, as measured by ODEX. Latvia experienced the largest improvement over the decade at 31%, while Slovakia recorded the lowest improvement of 2.4%. There was a 15% improvement for the EU-27 and a 19% improvement in the UK over the same period.

7 New Data Sources and Further Development

The residential sector accounted for just over a quarter of all the energy used in Ireland in 2011 and was the second largest energy using sector after transport. As a result, there is a clear motive for policy makers to put in place programmes and measures which reduce the sector's demand for energy.

7.1 Data Gaps

One of the purposes of this report is to inform and underpin policy decisions in Ireland. The current data available in Ireland does not allow for a full understanding of energy use in the residential sector. However, there have been some improvements since the 2008 report, most notably arising from the inclusion of new questions on energy in the 2011 Census and the growth of the BER database to contain detailed information on the energy performance of over 20% of the national housing stock.

There will be a mandatory legal requirement on Ireland to provide more detailed residential energy end-use data from 2014 under the Energy Statistics Regulation (1099/2008). There are also very strong policy drivers for better data, including those related to energy poverty and affordability, energy efficiency, emissions savings, fuel switching and deployment of renewable energy.

Combining anonymised data from the BER database with information from the 2011 Census survey and other surveys, such as the TABULA project[102], will facilitate detailed bottom up modelling of the housing stock. It is envisaged that the rollout of smart meters for electricity and gas will provide a data source on energy usage and appliance usage, which is possibly the largest remaining unknown relating to energy in the residential sector.

The data gaps remaining are:

- Dwelling floor areas
- Occupancy
- Dwelling condition, linked to income and energy usage (for assessing energy affordability)
- Data on internal temperatures, number of heating hours, proportion of the home heated etc. (required in order to quantify both the savings from energy efficiency upgrades and any increases in comfort)
- Usage of supplementary or occasional space heating
- The amount of non-traded biomass and peat usage
- The diffusion of energy efficiency heating equipment, in particular the number of stoves replacing open fires
- Hot water usage patterns
- Electricity use for hot water (by electrical immersion heater in summer and by electrical water heating showers)
- Estimates of electricity end use
- The market share and sales of appliances by energy rating label category
- Usage of appliances, including an insight into the usage of digital appliances such as televisions, set-top boxes, wireless routers etc.

SEAI/EPSSU is currently pursuing a number of avenues to fill some of these data gaps through its internal work programme and by funding external public-good research.

102 The EU Tabula project. More information available from: www.building-typology.eu/tabula

7.2 Energy Statistics Regulation Residential Energy End-Use Data

The proposed Energy Efficiency Directive has increased focus on energy efficiency and energy use at EU level and requires more detailed residential energy end use data. The Energy Statistics Regulation EC No. 1099/2008 is being extended to incorporate a requirement for more detailed statistics on energy consumption in households. A Comitology procedure started in early 2013 and an addendum of statistical data to its existing scope is expected to enter into force by early 2014.

The extension to the regulation will require energy consumption in households to be split by end use for main fuels for the following categories:

- Space heating
- Space cooling
- Water heating
- Cooking
- Electricity only: other electrical appliances

Only a crude split of residential energy end-use into the proposed categories is currently possible for Ireland, due to a lack of detailed data. The energy end-use split is based on broad assumptions about the purposes for which the various fuels are used, as detailed in *Table 23*. Note that space cooling is not separated from electricity consumption in Ireland.

Table 23 *Existing crude split of fuel by end-use*

	Peat	Coal	Gasoil or Kerosene	LPG	Natural Gas	Elec	Wood Products	Wood logs	Heat Pumps	Solar Thermal	All Fuels
Heating (Weather Corrected)	85%	85%	85%	65%	76%	15%	85%	85%	95%	0%	67%
Water Heating	15%	15%	15%	25%	19%	22%	15%	15%	5%	100%	16%
Cooking	0%	0%	0%	10%	5%	12%	0%	0%	0%	0%	4%
Lighting and Appliances	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	13%

Source: SEAI

Further data will be required in order to refine the model. Additional data sources include responses to new energy questions in the Q2 2014 CSO Quarterly National Household Survey (QNHS), the Smart Metering data (when available) and the growing BER database, which is becoming more representative of the entire housing stock.

In advance of the requirement for more detail on residential energy end-use data, Eurostat grant aided Statistics on Energy Consumption in Households (SECH) projects in 17 countries[103]. The results are available on the Eurostat website[104]. A general finding of the surveys across the countries involved was that there is a widespread significant underestimation of non-traded wood/fire wood consumption.

103 Ireland did not avail of the Eurostat grant or run a survey on energy consumption in households.
104 https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp

7.3 Building Energy Rating Database

The Dwelling Energy Assessment Procedure (DEAP) is the Irish official procedure for calculating and assessing the energy required for space heating, ventilation, water heating and lighting (less savings from energy generation technologies). DEAP calculates the annual delivered energy consumption, primary energy consumption and carbon dioxide emission for standardised occupancy. The DEAP methodology and software are used to generate "Building Energy Rating" (BER) certificates and BER Advisory Reports, as required under the EPBD[105]. The BER scheme and database is audited and administered by SEAI.

A BER makes the energy performance of the building visible and comparable, allowing buyers and tenants to take energy performance into consideration in their decision to purchase or rent a building. A home's BER is similar to the energy rating on appliances, with A rated homes being the most energy efficient (and likely to have lower energy bills) and G rated homes being the least energy-efficient. A seller or landlord must provide a BER to prospective buyers or tenants when a home is offered for sale or rent. BER details must be included in commercial advertisements related to the sale or rental. A BER is also required for a new home before it is first occupied and when availing of energy efficiency upgrade grants. A BER for a dwelling is valid for 10 years from the date of issue, unless there is a material change in the building which could affect its energy performance – for example an extension to the building, a significant change to the building fabric or a change in the heating system or fuel used. At the end of March 2013, approximately 350,000 dwellings – or just over 20% of the residential housing stock had been assessed and were included in the BER database.

A BER is an asset rating, based on calculated energy use under standardised occupancy conditions. DEAP uses the building fabric and heating system details to calculate the dwelling energy use and assumes the dwelling is used by standard, notional or typical occupants and is not affected by the current occupants; that is, the heating system operating hours and temperature set points are fixed. A BER does not cover electricity used for purposes other than heating, lighting, pumps and fans; i.e. cooking, refrigeration, laundry and other appliance use is not included. Therefore a BER is only an indication of the energy performance of a house (represented as $kWh/m^2/annum$). Actual energy performance of a dwelling will depend on household size and composition, individual heating patterns and temperatures as well as ownership and efficiency of particular domestic electrical appliances.

As a BER is based on primary energy consumption the result cannot be directly comparable to the final residential energy consumption in the energy balances. A energy overhead is assumed for extracting, processing and transport of fuels DEAP calculations. An overhead of 10% is applied to most fossil fuels delivered to the dwelling, thus the primary energy factor used in 1.1. A primary energy factor of 2.42 was calculated for the electricity factor in 2011. This reflects the electricity grid efficiency of 41% and a 5% energy overhead to account for the processing and transport of fossil fuels to electricity generating stations[106].

A sample BER certificate in included in Appendix 3: Building Energy Rating Certificate. The most efficient rating is an "A1" rating, which represents annual energy consumption of less than 25 kWh/m^2. There are three sub-categories within the A, B and C bands with an increment of 25 $kWh/m^2/annum$ between each sub-category down to a "D1" rating (corresponding to an annual consumption of less than 225 kWh/m^2). There are two sub-categories within the D and E band, separated by increments of 40 $kWh/m^2/annum$ down to an F band (annual consumption between 380 and 450 kWh/m^2) and a final G band for annual consumption of greater than 450 kWh/m^2.

7.3.1 Online BER Research Tool

The BER Research Tool[107] gives researchers access to anonymised micro data from the Building Energy Rating (BER) scheme. The tool provides access to information on all aspects of dwelling construction that affect energy performance. The data for the research tool is updated nightly, so search results represent an up-to-date summary of certified residential Building Energy Ratings and results can be viewed on screen or downloaded in the form of a Microsoft Excel spreadsheet.

Over a fifth of the residential dwelling stock is currently included in the BER database. There are, however, biases in this sample, as it only represents houses sold, rented or built since 2008, or houses which have availed of a grant for an energy efficiency upgrade. In the medium term it will be possible to model the entire stock based on the BER database, when the BER database is statistically representative of the entire building stock and, in the long term, it will provide a census of all residential dwellings.

105 A BER is a requirement of the EU Directive on the Energy Performance of Buildings (2002/91/EC of 16 December 2002), which was transposed in Ireland by the European Communities (Energy Performance of Buildings) Regulations 2010 (S.I. No. 243 2012).

106 A detailed explanation is available here: http://www.seai.ie/Your_Building/BER/BER_FAQ/FAQ_DEAP/Results/DEAP_elec_factors_FAQ_Q42012.pdf

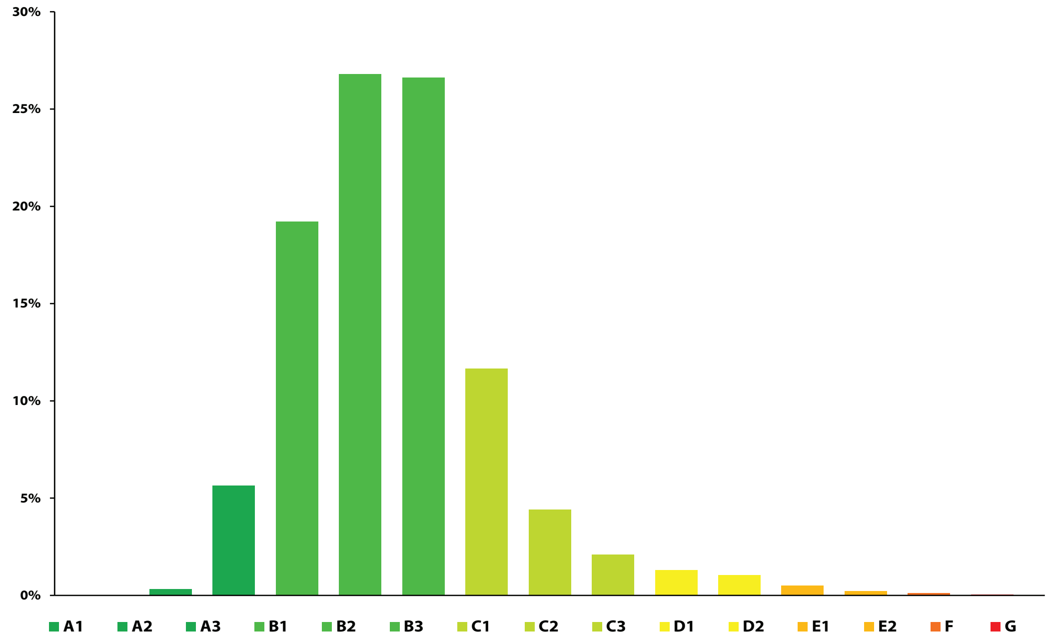
107 The BER Research Tool administered by SEAI is available from: https://ndber.seai.ie/BERResearchTool/ber/search.aspx

7.3.2 Energy Performance of New Houses

The distribution of BERs for houses constructed to the 2008 building regulations or later is shown in *Figure 46*. The 2008 building regulations came into effect on 1st July 2008 however; there was a transitional period allowed where the work, material alteration or the change of use commences or takes place on or before 30 June 2008, or where planning approval or permission was applied for on or before 30 June 2008, and substantial work was completed by 30 June 2010, the work can be completed to the 2006 building regulations. Therefore a lag would be expected between the date the building regulations came into effect and when houses meeting those building regulations are completed and occupied.

As of the end of 2012, 30,000 BERs had been issued for new builds of which approximately 17,000 BERs were for dwellings which were subject to the 2008 or 2011 revisions to the building regulations. The Department of the Environment, Community and Local Government housing statistics show 26,420 new homes were completed in 2009, 14,602 in 2010 and 10,480 in 2011.

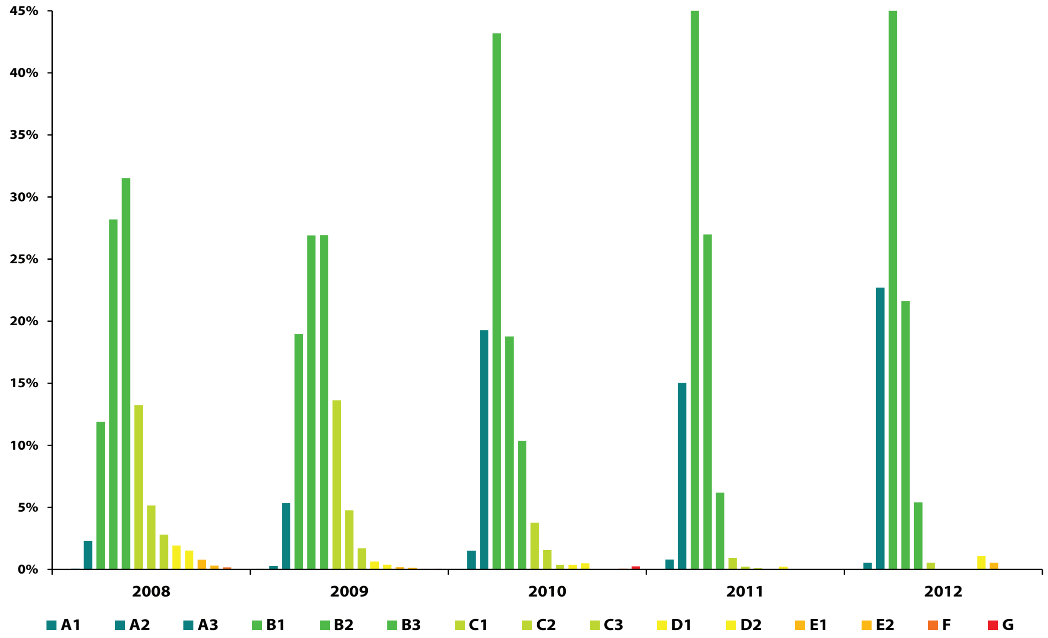
Figure 46 *Distribution of BER certificates for all new homes constructed in 2008 or later*



Source: SEAI

Figure 47 compares of distribution over time of BER certificates for new houses completed in 2008, 2009, 2010, 2011, 2012. A gradual change in the distribution can be seen, with more efficient houses in 2012 than in 2008. In 2008 approximately three quarters (74%) of all new houses had a BER of B3 or better, whereas since 2010 the share of A or B rated new houses increased to over 90%, albeit of a smaller number of house completions.

Figure 47 *Comparison of distribution of BER certificates for all new homes constructed each year since 2008*

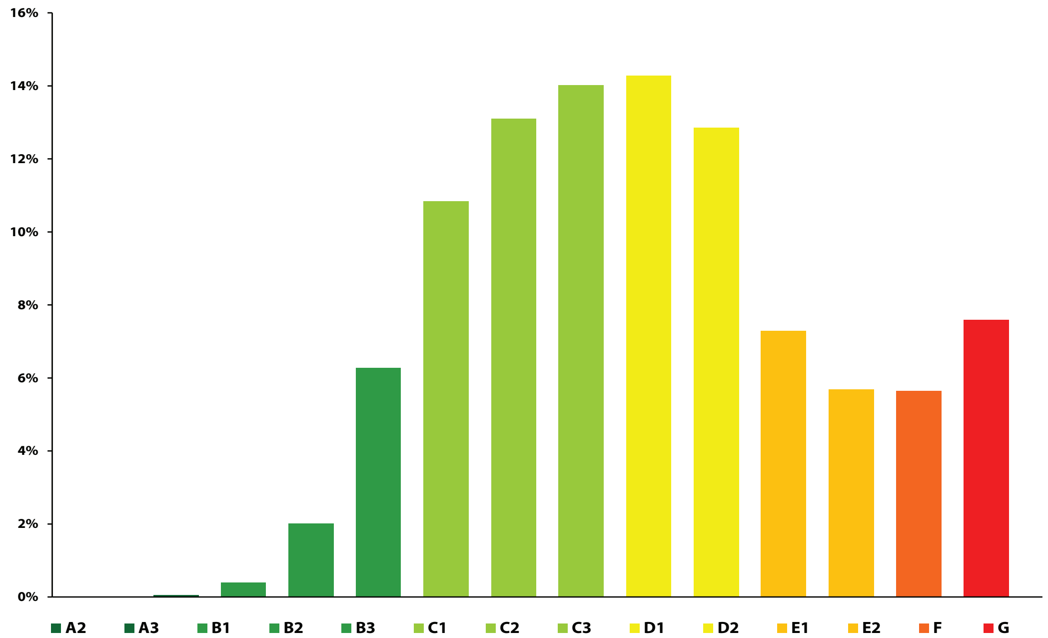


Source: SEAI

7.3.3 Energy Performance of Existing Houses

Figure 48 presents the distribution of BERs for existing dwellings, i.e. houses that have been sold or rented or upgraded since 2007. There are just over 295,000 records for existing dwellings in the BER database, with the most frequently occurring being "D1" or "C3", both categories accounting for 14% of all the existing dwellings. Average dwelling consumption calculated from the energy balances equates to a "C1". This would suggest that actual heating periods, temperature levels or hot water usage in Irish homes may be below the standardised regimes applied in the DEAP software calculations used to generate BER certificates.

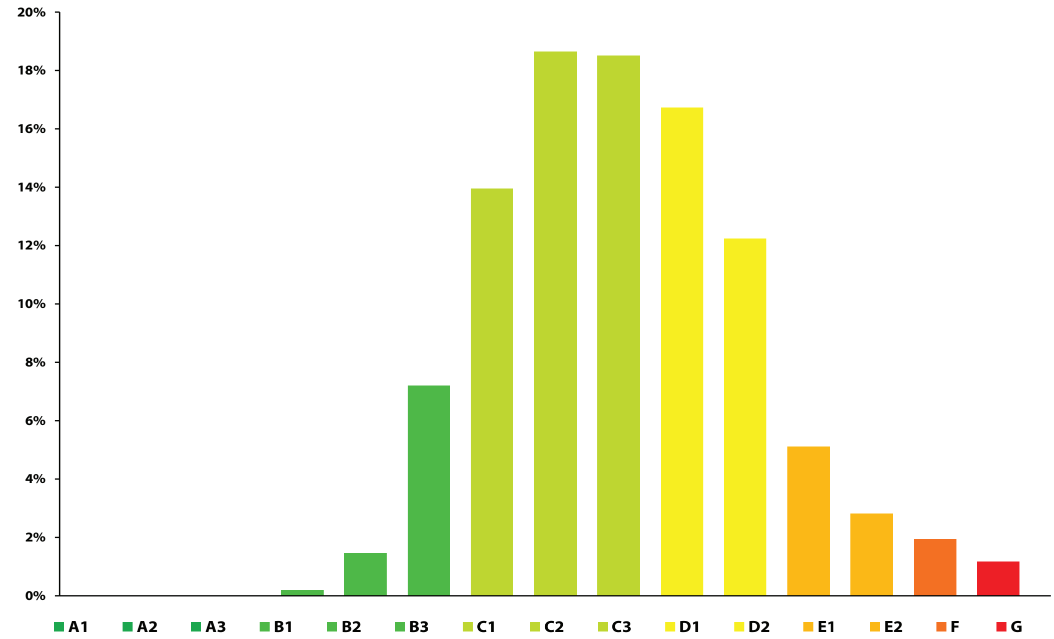
Figure 48 *Distribution of BER certificates for all existing dwellings in the BER database*



Source: SEAI

Included in the existing dwellings in *Figure 48* are the 99,000 dwellings which received grants for energy efficiency upgrading. *Figure 49* presents the distribution of the upgraded dwellings only, which have a greater concentration of dwellings in the C and D and significantly less dwellings in the E, F and G categories than is the case with existing dwellings in general.

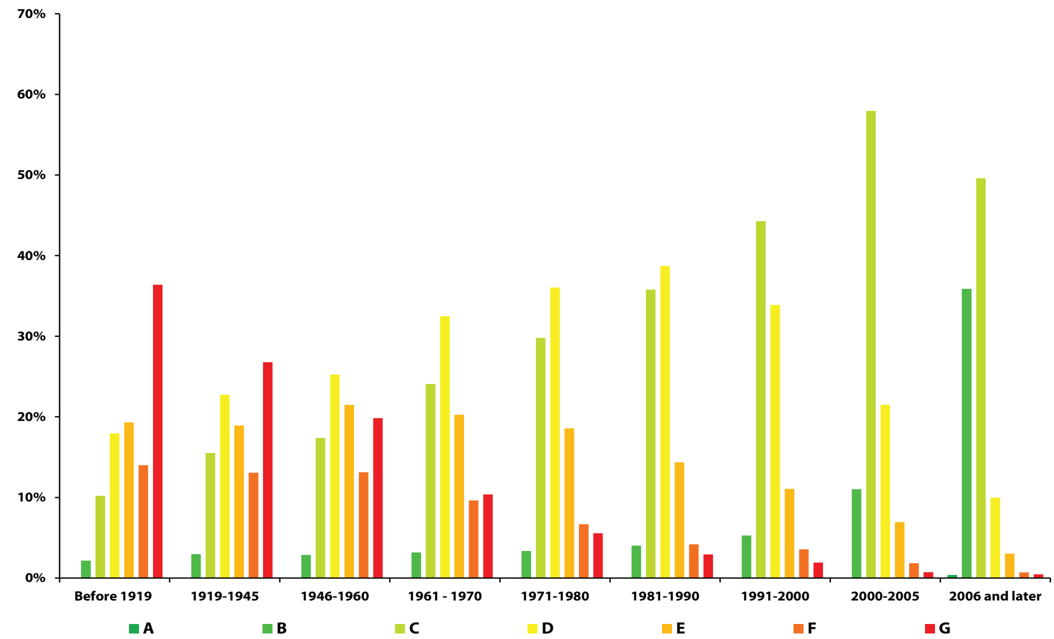
Figure 49 *Distribution of BER certificates for all existing grant aided dwellings in the BER database*



Source: SEAI

The profile of BERs by period of construction is shown in *Figure 50*. The results are as expected with older dwellings having higher frequency in the lower category BERs i.e. less efficient than newer dwellings.

Figure 50 *Distribution of BER certificates for all existing dwellings in the BER database by period of construction*

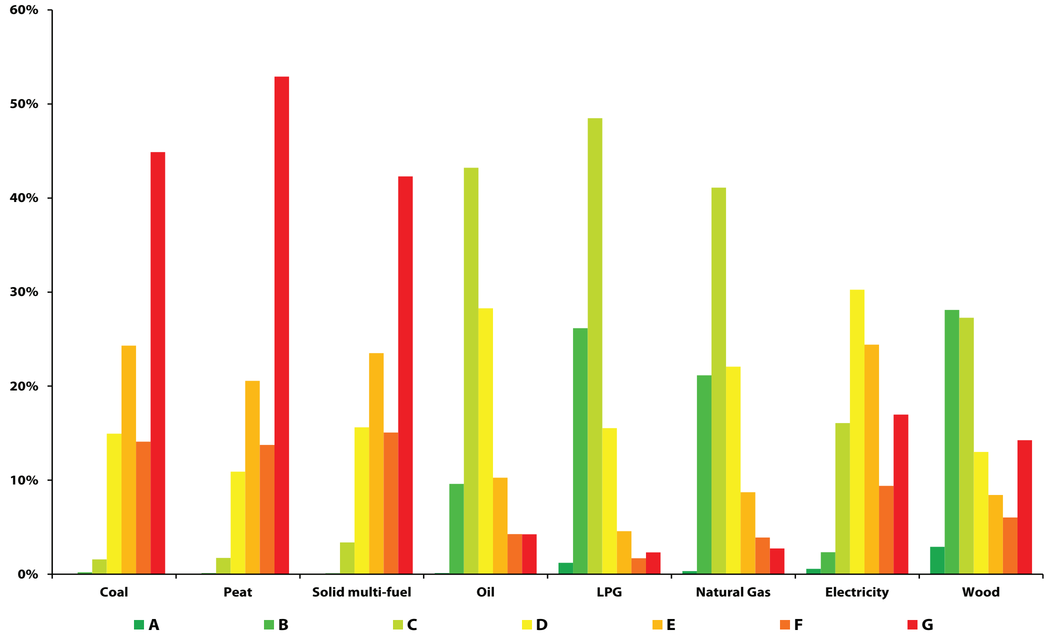


Source: SEAI

The profile of BERs by main space heating type are shown in *Figure 51*. Solid fuel, coal and peat dwellings are less efficient than other fuel types. Dwellings using oil as the main space heating fuel type have an average rating of a "C3", LPG dwellings have an average rating of a "C2" and natural gas dwellings have an average rating of a "C1". Dwellings using wood fuel as the main heating source have "B3", "C1" and "G" ratings occurring most frequently;

depending on the type of wood fuel used in which appliances, e.g. logs in open fire or wood pellet boiler there can be a significant spread in the efficiency of wood fuels.

Figure 51 *Distribution of BER certificates by main space heating types*

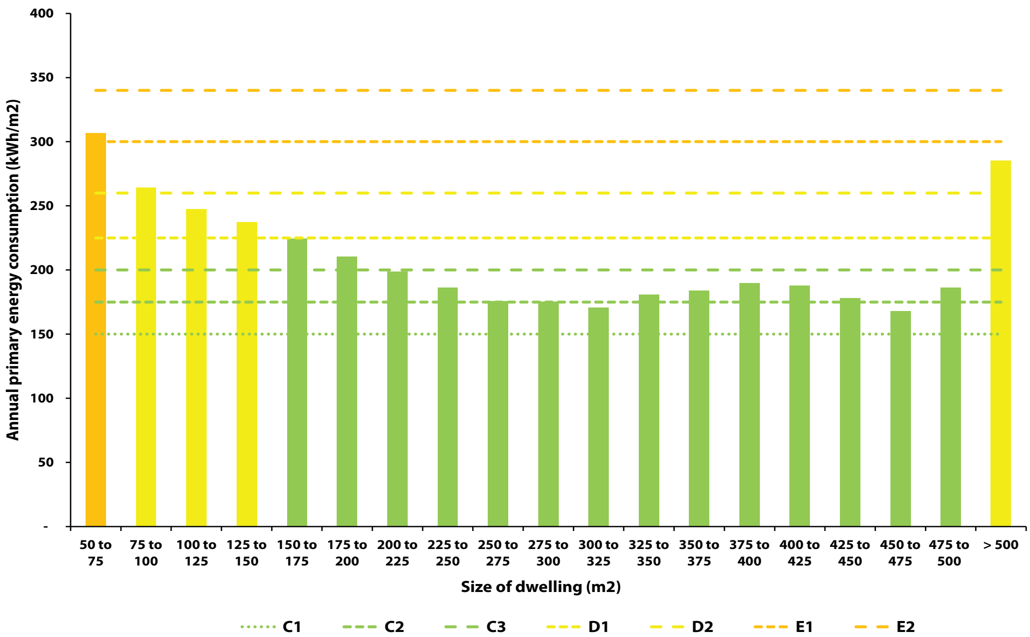


Source: SEAI

As the BER rating is based on primary energy consumption, the DEAP calculated electricity final demand is multiplied by a factor (2.42 currently), equal to the inverse of the electricity grid generation efficiency in order to get the primary energy consumption of dwellings using electricity.

A surprising finding is that bigger houses are not necessarily less efficient. This is because bigger houses are generally newer and therefore constructed to higher efficiency standards. Interestingly, the average floor area of dwellings in the BER database is currently 111 square meters (1,195 square feet), which is less than the 119 square meters estimated from planning permissions. As the BER database is a biased sample of the entire building stock it is not envisaged to use the BER database figure to represent the average floor area of the stock.

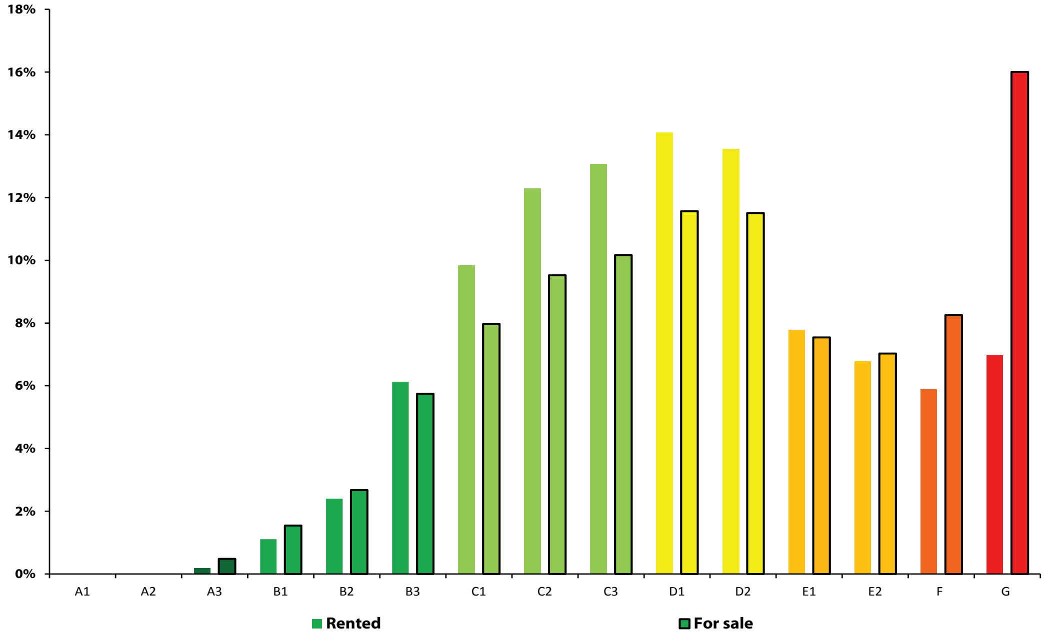
Figure 52 *Annual energy consumption of dwellings by floor area*



Source: SEAI

Another surprising finding is that dwellings which are for rent are not less efficient than dwellings for sale, as shown in *Figure 53*. Even though energy efficiency upgrading is less likely for rented dwellings than for owner occupier dwellings, the cohort of rented dwellings is generally more efficient than the general housing stock. This is probably because rented dwellings are generally smaller than the average dwelling, usually being scheme houses and also they are more likely to have been constructed more recently than the average stock dwelling.

Figure 53 *Comparison of BER distribution of dwelling by purpose of carrying out energy rating*



Source: SEAI

7.4 Case Study: Quantifying Energy Savings from Grant Schemes

SEAI researchers examined changes in energy use by households that participated in the Home Energy Savings Scheme (since renamed the Better Energy Homes Scheme) in an academic peer-reviewed paper[108]. The paper quantified the energy savings realised by a sample of participants of the scheme through an ex-post billing analysis. Typically 30-35% of the energy efficiency improvements costs are grant aided to participants in the grant schemes. The study compared the metered gas consumption of a sample group of households to a closely matched control group of metered gas consumers from the general population.

The energy efficiency improvements of the sample group included insulation upgrades (wall and/or roof), installation of high efficiency boilers and/or improved heating controls. As part of the energy efficiency upgrades a BER rating was carried out on the houses before and after the energy efficiency improvements.

The SEAI research team set out to find the answers to two questions:

- How much energy savings were realised by people who had made energy efficient home improvements under the Better Energy Homes scheme?
- How close were the actual energy savings realised to the technical savings potential[5] forecast when the Better Energy Homes scheme was set up?

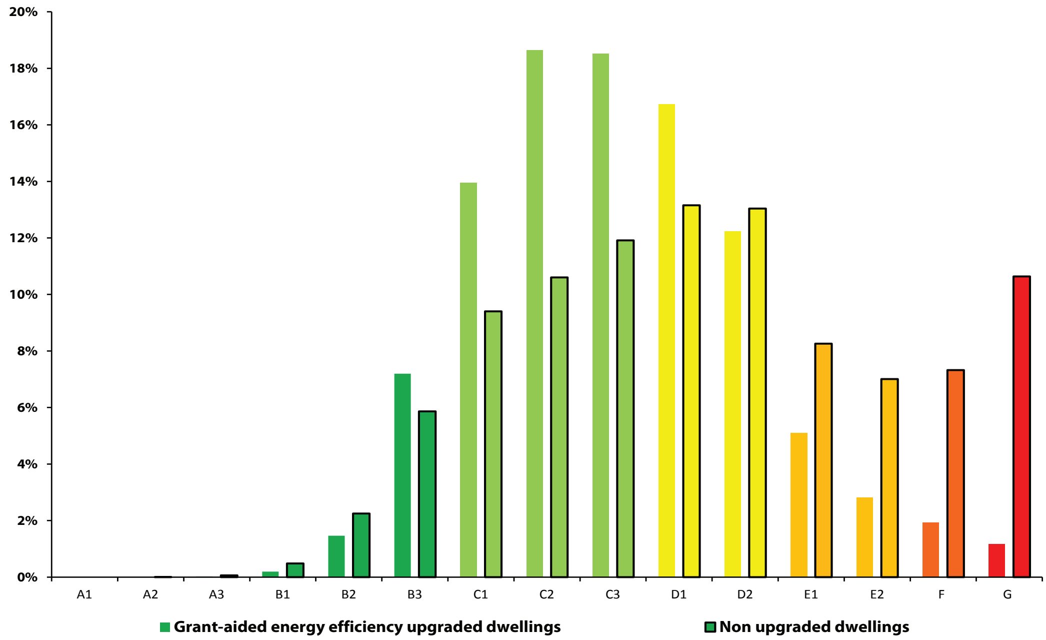
The key findings[109] of the analysis were that participants in the Better Energy Homes scheme:

- Saved an average of 21% on their annual gas bill
- Enjoyed considerable lifestyle improvements – warmer, more comfortable houses
- Saw substantial improvements in the Building Energy Rating of their homes

Before the improvements just under 17% of homes in the sample had a C3 BER rating or better, while after the improvements this share increased to 60%. This shift in the distribution of the ratings can be seen in *Figure 54.*

The paper also quantified a shortfall of approximately 35% (+/- 8%) between the technical savings forecast and the measured savings. The technical savings potential is calculated from engineering calculations that consider the theoretical changes to U-values and heat loss areas (walls, roofs, etc.) following insulation upgrades and efficiency improvements in heating systems. The shortfall is a result of both direct and indirect rebound effects, such as: increased comfort, achieved U-values and variations in the ex-ante assumptions.

Figure 54 *Comparison of upgraded dwellings to existing dwellings in the BER database*



Source: SEAI

108 Jim Scheer, Matthew Clancy and Sadhbh Ní Hógáin. 'Quantification of energy savings from Ireland's Home Energy Saving scheme: an ex post billing analysis'. Available at: http://www.springerlink.com/content/2736846l3206j34r/?MUD=MP

109 SEAI, 2012, Better Energy Homes Impact Report Billing Analysis. Available from : http://www.seai.ie/Publications/Energy_Modelling_Group_/Energy_Modelling_Group_Publications/Better_Energy_Homes_Impact_Report_Billing_Analysis.pdf

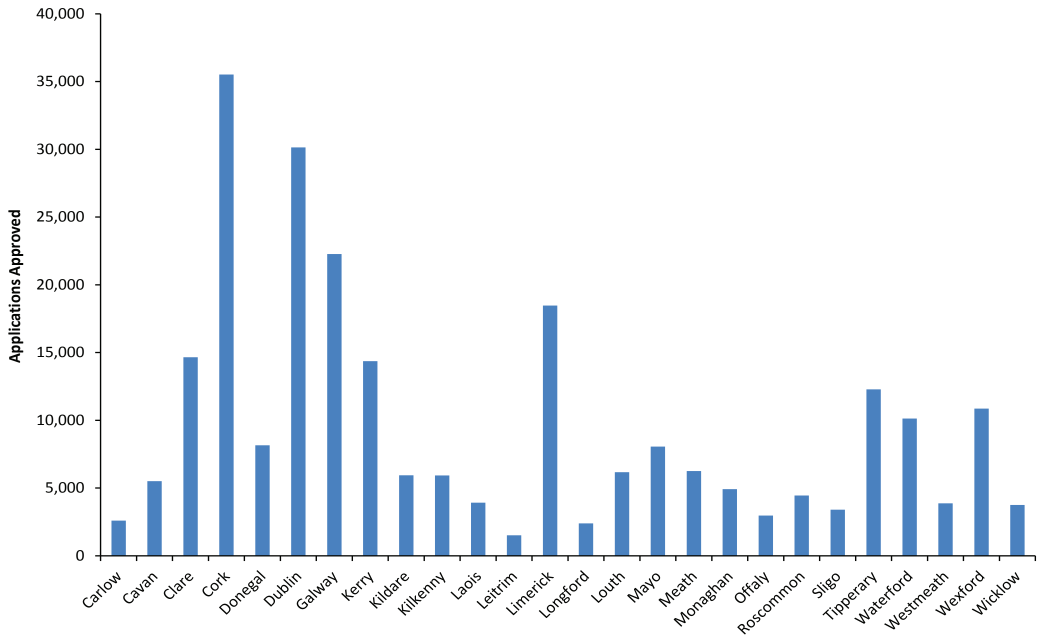
7.5 Grant Scheme

7.5.1 Better Energy Homes

The Better Energy Homes scheme was established by the Government as an incentive to encourage people to improve the energy performance of their homes, making them more energy efficient, reducing greenhouse gas emissions, and improving comfort levels in homes. The scheme provides cash grants to subsidise homeowners who invest in energy efficiency improvements in one or more of the following areas: roof insulation, wall insulation, installation of a high efficiency (> 90%) gas or oil fired boiler, heating control upgrades and solar panels.

The scheme is administered by the SEAI, and grants totalling almost €160 million were taken up by approximately 136,000 householders between 2008 and the end of 2012 for more than 346,000 upgrade measures. It is estimated that annual savings from the scheme had reached 751 GWh (65 ktoe)[110] in 2011, thus directly avoiding approximately €47 million on energy costs[111].

Figure 55 *Better Energy Homes Grant Scheme Applications by County*



Source: SEAI

Table 24 details the energy savings, frequency and expenditure for the various energy efficiency upgrade measures.

Table 24 *Summary of the Better Energy Homes Scheme*

Energy Efficiency Measures	Typical Net BER Improvement[104]	% of total measures	% of total grant spend
Cavity Insulation	15 -20%	23%	22%
Roof Insulation	10 -20%	28%	16%
Dry-Lining Insulation	25 - 30%	3%	13%
External Insulation	25 -30%	3%	24%
High Efficiency Gas Boiler with Heating Controls Upgrade	25 -30%	5%	8%
High Efficiency Oil Boiler with Heating Controls Upgrade	25 -30%	5%	6%
Heating Controls Upgrade only	15 - 25%	2%	2%
Solar Heating	8-16%	1%	2%
Integral BER	N/A	25%	5%
Before/After BER	N/A	3%	1%

Source: SEAI

110 Assuming energy savings of 5,500 kWh per dwelling
111 Avoided energy costs are calculated using prices from the SEAI Domestic Fuel Cost Comparison Archives
112 The typical improvement in BER rating that could be expected from each individual measure, done in isolation. Note that in estimating the total potential BER improvement, if the full range of measures is installed, the potential BER improvements for each measure should not be added together.

7.5.2 Warmer Homes Scheme

The Warmer Homes Scheme (WHS) aims to improve the energy efficiency and comfort conditions of homes occupied by vulnerable households in receipt of the National Fuel Allowance Scheme through the installation of draught proofing, attic insulation, lagging jackets, low energy light bulbs and cavity wall insulation where appropriate. The scheme is administered by the SEAI and grants totalling almost €82 million were taken up by more than 95,000 householders between 2000 and March 2013. While thermal energy consumption has decreased per dwelling, total energy savings are liable to be reduced by the chosen uptake of increased comfort. In this regard the social and health benefits arising from increased household comfort and convenience are as important as the overall energy savings for low income households.

7.5.3 Greener Homes Scheme

SEAI's Greener Homes Scheme (GHS) supported householders who were installing or replacing their heating system to install a renewable energy heating technology, including wood pellet/chip stoves and boilers, solar panels and geothermal heat pumps. The aim of the programme was to facilitate the wider deployment of renewable energy heating technologies in the residential sector and the development of a sustainable market. The Greener Homes scheme commenced in 2006 and finished in 2011. It supported the installation of over 33,067 renewable energy technologies.

Table 25 *Summary of GHS technology installations*

Technology	Split by Volume	Total Payment
Heat Pump	18%	€19,034,595
Biomass	18%	€24,730,059
Solar	63%	€30,621,899
Wood gasification	0.5%	€358,000

Source: SEAI

7.5.4 Summary Grant Scheme Savings

In the 5 year period from 2006 to 2011,the above schemes supported energy efficiency upgrading of over 200,000 dwellings, representing over 12% of the housing stock in 2011. It is estimated that these schemes saved over 900 GWh (77 ktoe) in 2011, achieving annual savings to the value of €56 million on energy costs for householders.

7.6 National Smart Metering Trial

One aspect of the National Smart Metering Programme has been to assist improved primary energy efficiency by empowering consumers with more detailed, accurate and timely information regarding their energy consumption and costs, thus helping consumers reduce any unnecessary energy usage and shift any discretionary usage away from peak consumption times. This allows electricity system operators to limit using inefficient peaking generation plants. Smart meters enable greater use of indigenous low carbon renewable energy sources.

Smart meters can offer a range of benefits for both the electricity and gas consumer and the installation of smart metering will allow electricity and gas suppliers to create innovative pricing arrangements that can be offered to customers to support the efficient use of electricity and gas, such as time-of-use tariffs.

The changes in electricity usage by participating households during the smart metering trial are summarised in *Table 26*, showing an overall saving of 3% on electricity bills.

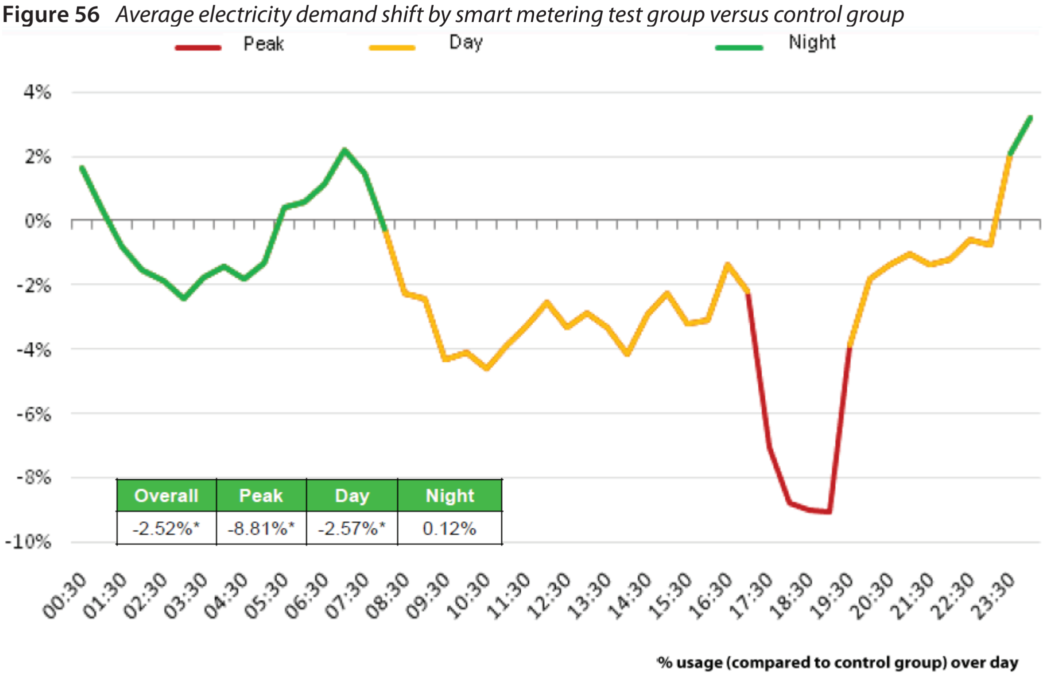
Table 26 *Change recorded during the Smart Meter Trial*

	Overall Bill	Overall Consumption	Peak Consumption	Night Consumption
Average recorded change during the trial	-3%	-1.4%	-7.58%	**+2.3%**

Source: SEAI

Changes to consumption behaviour which shift consumption from the peak consumption period, between 17.30 and 19.30 on weekdays, to other times, in particular towards night time consumption (19.30 to 08.00) are possibly more important measures of the success of smart meters than a reduction in the overall consumption. The shift should help to avoid the least efficient electricity generating plants being called upon to meet peak demand. *Figure 56* shows the average shift in consumption of the smart meter test group relative to a 'control group', over the course of a typical weekday.

Figure 56 *Average electricity demand shift by smart metering test group versus control group*



Source: SEAI

7.7 Residential Traded and Non-traded Wood Consumption

A significant number of households in Ireland use wood as a secondary or supplementary heating source in open fires, stoves and ranges. The quantities used are difficult to monitor as a lot of wood used for residential heating is non-traded wood or not officially traded. Sources of non-traded wood/firewood include fallen trees, discarded furniture, housing rubble and wood purchased in the grey market.

Traded wood in the residential sector mostly refers to newer wood products such as wood pellets, wood chips, wood briquettes and manufactured wood logs but also includes officially purchased firewood and kindling.

7.7.1 Trends in Residential Wood Consumption

The most significant change in residential space heating since 1990 has been the switch from solid fuel room heating to central heating. Given the dramatic shift it is reasonable to assume that there has also been a significant reduction in non-traded wood / firewood over the period, as open fires shifted from being constantly used to occasional use. It is reasonable to assert that for most of the 1990's and for a significant portion of the last decade the trends in non-traded wood consumption and that of other, officially traded, solid fuels would have been similar.

In contrast with this is the more recent trend of 'new biomass' in homes, i.e. dwellings that use wood pellets and wood chips as the penetration of biomass boilers and stoves increased. Since 2000 there was significant growth in wood burners in homes, driven by environmental and sustainability concerns associated with fossil fuel usage, as well as the Government Greener Homes Scheme[113] technology grants and the renewable energy requirement for all new houses built to 2008 Building Regulations standard or later. During the period of operation of this grant scheme between 2006 and 2010, new wood energy use in homes increased from 27 ktoe to 52 ktoe (18% per annum). These biomass boilers tend to use 'new' wood energy sources such as wood pellets or wood chips; they are unlikely to have changed the pattern of non-traded wood consumption. Thus assuming that the non-traded wood consumption followed the trend in other solid fuels seems reasonable.

In the last five years however, fuel price increases coupled with a heightened awareness of energy efficiency, have resulted in a significant increase in the number of solid fuel and wood burning stoves replacing open fires. It is reasonable to assume that more wood logs are consumed in stoves than in open fires[114]. Therefore this may possibly decouple the consumption trend of the non-traded wood consumption from that of residential coal and peat consumption.

7.7.2 Existing Non-Traded Wood Estimation Methodology

The existing estimate of non-traded wood included in the national energy balance assumes that the trend in residential wood consumption follows the same trend as residential coal and peat consumption. This is a reasonable assumption as most open fires use a mix of coal and/or peat and wood logs. This methodology relies on the estimate for 1990 being accurate. At best the 1990 estimate would have been an expert guess, as there was not any survey data available for that year. A particular advantage of this methodology is that a consistent time series of firewood consumption is available from 1990. Using this methodology gives a non-traded wood consumption of 15 ktoe in 2011. This scenario contributes to an overall share of renewable heat (RES-H) of 4.8%.

7.7.3 Adjusted Non-Traded Wood Estimates from the Existing Methodology

Adjusting the existing methodology seems a quick fix for estimating the total wood consumption, but deciding on what share of total wood consumption is covered by the existing estimate is not a simple task. Recent surveys in Finland[115] and Denmark[116] suggest an assumption that only 20% of total wood log consumption is purchased, so choosing that estimate is a worst case starting point for the analysis of Ireland. This is more conservative than the findings of the EU Concerted Action on Renewables[117] which found that in countries where supply and consumption figures exist for wood energy the supply accounts for between 30% and 50% of the total wood consumption.

Assuming that only 20% of all non-traded wood is currently covered in the existing methodology and adjusting the total wood figure accordingly results in an estimated consumption of 75 ktoe for total wood consumption. This scenario would contribute to an overall share of renewable heat (RES-H) of 6.1%.

113 Greener Homes is a capital grant support scheme administered by SEAI for home renewable energy heating systems. See http://www.seai.ie/greenerhomes for details.

114 As wood logs sparking is no longer a problem with stoves and wood logs are a more convenient and clean fuel to use in stoves than peat or coal.

115 https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp

116 Ibid

117 http://www.ca-res.eu/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/dam/ca_res/public_downloads/working_group_summary/WG2_Summary_Report_CA_RES_2012.pdf&t=1360346303&hash=f112497adb73e8c8e271ebcd231bbbf3

7.7.4 Census 2011

As already discussed in section *4.1.7* the 2011 Census included questions which allow for households to be classified by period of construction, type of house and type of space heating fuel. There follows three different methodologies used to estimate the non-traded wood fuel consumption from the 2011 Census.

7.7.4.1 Estimates from Coal and Peat Consumption

The census specifies the number of households relying on each fuel type, which allowed for bottom up calculations of energy consumption to be compared with the energy balance total. Estimates were calculated for consumption of coal and peat in households where they are the main heating consumption. Assuming a fossil fuel consumption of 15,000 kWh per solid fuel household per annum[118] allows calculations of an estimate of the total coal and peat consumption of those houses. When this consumption is subtracted from the total residential coal and peat consumption in the national energy balance, the households primarily relying on coal and peat accounted for approximately 44% of the total residential fossil fuel consumption. Therefore it is assumed that 56% of both residential coal and peat consumption is used for supplementary heating.

Two estimates of wood consumption can be calculated from the estimated coal and peat used for supplementary heating. The first method is a conservative estimate that provides an upper limit for firewood/wood log consumption. This conservative estimate assumes that the same energy content as the coal and peat used for supplementary heating is consumed as wood energy. Using this methodology gives a firewood consumption of 270 ktoe. Given that wood is a less dense source of energy and it is more problematic if used in an open fire, often causing 'sparking', it is highly unlikely that there is equivalent consumption of wood energy as the total coal and peat consumption used for supplementary heating.

The second method assumes that the wood energy share of an open fire is only approximately 28% of the total energy input (see "A5.4 Firewood/Wood Log Energy Share of Open Fire/Stove"). Therefore the total residential firewood/wood log consumption is 28% of the fossil fuel consumption for supplementary heating. Using this methodology gives a firewood consumption of 76 ktoe.

7.7.4.2 Unit Estimates of Wood Consumption

The third method of estimating firewood consumption from the 2011 Census assumes that the average consumption of wood for supplementary heating in either open fires or stoves as detailed in "A5.6 Assumptions for Calculating Firewood/Wood Log Consumption from Census 2011", an overall weighted average of 1,838 kWh per annum per dwelling (entire stock of dwelling whether or not a fire/stove is in the dwelling) or 2,395 kWh per dwelling with an open fire or stove. The estimated wood consumption in supplementary heating is 262 ktoe. All apartments and bedsits were excluded for the total number of households using open fires/stoves and a further 3% exclusion rate was used, estimated from the BER dataset.

7.7.5 Traded Wood or 'New Wood' Fuels Consumption

In recent years there has been significant growth in biomass for the residential sector. The supply of wood pellets, chips and briquettes as well as some wood logs consumption is reported to SEAI through responses to the annual renewables questionnaire sent out to wood suppliers. The quantities are included as traded wood in the energy balance and have an energy content of approximately 10 ktoe in the 2011 energy balance.

An interesting result of the analysis of the 2011 Census results and a unit consumption estimate of consumption in wood fuelled houses, in particular houses constructed since 2000, is that the traded wood figure of 10 ktoe accounts for over 84% of the consumption of those houses. This gives confidence that the SEAI survey on wood pellet, wood chip and wood briquettes is providing significant coverage of the 'new wood' or traded wood market. The assumptions of coverage of wood fuel survey are detailed in *Table 27.* The overall coverage of the SEAI traded wood survey is estimated at 73% in 2011 based on the survey responses and market shares of the individual wood products in the 2011 Energy Balance.

118 A household using solid fuels is likely to have less than the average household non-electricity consumption of 15,000 kWh per annum as they are less likely to heat the whole house to the same indoor temperature.

Table 27 *Assumed coverage of wood fuel types in the SEAI annual renewable energy survey*

	Market Share in 2011 Energy Balance	Assumed Survey Coverage	Corrected Market Share
Wood pellets	83%	80%	70%
Wood chips	1%	60%	1%
Wood briquettes	14%	40%	23%
Wood logs	2%	20%	6%
Overall Coverage		**73%**	**100%**

Source: SEAI

7.7.5.1 Household Budget Survey

The Household Budget Survey (HBS) conducted at 5 yearly intervals by the CSO includes a question on fuel spend disaggregated by fuel type. The results of the survey can be used to estimate the consumption of traded wood. As a significant portion of residential firewood consumption is non-traded the results of these surveys are likely to underestimate residential wood log consumption.

The spend on wood products such as wood pellets, wood briquettes and wood chips is estimated using the quantities reported in the SEAI annual wood fuel survey and the unit prices reported for the SEAI fuel cost comparison survey. As detailed in "A5.7 Assumptions for Calculating Wood Energy Use from Household Budget Survey" it was assumed that the remaining spend was for wood logs.

The estimated quantity of wood logs from the HBS is therefore approximately 24 ktoe. This represents a fraction of the total wood log consumption. Based on the experience of other European countries it is assumed that the HBS represents 20% of all non-traded wood. Therefore the total firewood/wood log estimate based on the HBS is 120 ktoe, giving a non-traded firewood consumption of 96 ktoe.

7.7.6 Comparison of Wood Consumption Estimates

A summary of the different methodologies used to estimate firewood consumption is given in *Table 28*. The adjusted non-traded wood estimates were combined with conservative estimates for coverage of the SEAI traded wood surveys in order to calculate a revised residential wood energy contribution to overall renewable heat.

Table 28 *Comparison of different estimates for non-traded residential firewood*

	Existing Methodology	Adjusted Estimate (80%)	Household Budget Survey Estimate	Census 1: wood equals 28% of excess solid fuel	Census 2: bottom up consumption estimates	Census 3: wood equals all of excess solid fuel
Non traded wood Consumption (ktoe)	15	75	120	76	263	270
Non traded wood Consumption (solid cubic metres)	67,625	338,124	545,865	342,927	1,190,068	1,224,738
Non traded wood Consumption (tonnes)	47,608	238,040	384,289	241,420	837,808	862,216
Non traded wood energy share of excess coal and peat for supplementary heating open fires/stoves	6%	28%	45%	28%	97%	100%
Conservative traded wood estimate (ktoe)	10	15	15	15	15	15
Wood share in total residential consumption	0.9%	3.2%	4.8%	3.2%	9.8%	10.0%
RES-H	4.8%	6.1%	7.0%	6.1%	9.7%	9.9%

Source: SEAI

The last two scenarios are highly unlikely, as the non-traded wood consumption is unlikely to have a similar energy content to the excess coal and peat consumption. As quantified in *Table 28* the share of non-traded wood in total residential energy consumption is unlikely to change the merit order of the fuels used in the residential sector. As non-traded wood is only a small part of the total solid biomass consumption, the relative variation in estimates is small relative to the overall total solid biomass consumption and therefore does not significantly impact on the overall calculation of renewable heat (RES-H).

While the analysis in this section points to an underestimate of non-traded wood in the existing national energy balance, in the absence of a household energy use survey it is not intended to change from using the existing methodology in the national energy balance. The advantage of the existing methodology is that it provides a consistent time series. If the adjusted method was to be adopted it would also require calculations for other years. The results of the 2011 Census enable calculations for 2011 but a lot more detailed analysis is required before the conclusions for 2011 can also be assumed correct for other years.

A survey on residential wood energy is required prior to estimating or revising the existing non-traded wood estimates in the national energy balances. The advice from the Concerted Action Renewable Energy Sources Directive[119] group is that given wood fuel consumption in Ireland in less than 10% of applicable renewables there is a lowest level of importance for Ireland to survey for wood fuels for the purpose of meeting the Directive target. They suggest two survey cycles should be available by 2020, with a frequency of between 5 and 10 years on the survey. The sampling error, with 95% confidence, should not exceed +/- 30%, so that the maximum influence of the sampling error on the reported share is less than +/- 3%.

119 Concerted Action Renewable Energy Sources Directive (Working Group 2: Methodology), 2012, Quality standard for statistics on wood fuel consumption of households. Available from www.ca-res.eu

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 (103 tonnes) and Mt CO_2 – mega-tonnes of CO_2 (106 tonnes).

Climate Correction: Annual variations in climate affect the space heating requirements of occupied buildings. Climate correction involves adjusting the energy used for space heating by benchmarking the climate in a particular year with that of a long-term average measured in terms of number of degree days.

Energy Intensity: The amount of energy used per unit of activity. Examples of activity used in this report are number of households, square metres etc.

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%.

Heating Degree Days: "Degree Days" is the measure or index used to take account of the severity of the weather when looking at energy use in terms of heating (or cooling) "load" on a building. A "Degree Day" is an expression of how cold (or warm) it is outside, relative to a day on which little or no heating (or cooling) would be required. It is thus a measure of cumulative temperature deficit (or surplus) of the outdoor temperature relative to a neutral target temperature (base temperature) at which no heating or cooling would be required.

Legislative informative measures: Legislative informative measures are legislative measure which only require information to be displayed, e.g. energy labels for appliances or dwellings.

Legislative normative measures: Legislative normative measures introduce standards or require a certain performance, such as minimum efficiency of appliances or building regulations.

Nominal and Real Values: Nominal value refers to the current value expressed in money terms in a given year, whereas real value adjusts nominal value to remove effects of price changes and inflation to give the constant value over time indexed to a reference year.

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

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Department of the Environment, Community and Local Government, Custom House, Dublin 1. www.environ.ie

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EU funded ODYSSEE Project www.odyssee-indicators.org/

EU funded MURE Project www.muredatebase.org/

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SEAI Building Energy Rating Research Tool www.seai.ie/Your_Building/BER/National_BER_Research_Tool/

SEAI Modelling Team www.seai.ie/Publications/Energy_Modelling_Group

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Residential Sector Final Energy Use 1990 to 2011

Residential kilo tonnes of oil equivalent (ktoe)	1990	2000	2005	2007	2008	2009	2010	2011
Coal	**626**	**286**	**246**	**208**	**230**	**268**	**261**	**232**
Bituminous Coal	608	210	163	142	164	185	184	154
Anthracite + Manufactured Ovoids	0	59	59	60	56	70	67	67
Coke	0	0	0	0	0	0	0	0
Lignite	18	17	24	6	10	12	10	11
Peat	**725**	**299**	**273**	**271**	**280**	**272**	**254**	**241**
Milled Peat	0	0	0	0	0	0	0	0
Sod Peat	570	179	183	186	174	169	165	163
Briquettes	155	120	90	85	106	103	88	79
Oil	**389**	**915**	**1,136**	**1,095**	**1,194**	**1,173**	**1,267**	**1,035**
Crude	0	0	0	0	0	0	0	0
Refinery Gas	0	0	0	0	0	0	0	0
Gasoline	0	0	0	0	0	0	0	0
Kerosene	105	570	795	789	878	915	1,010	799
Jet Kerosene	0	0	0	0	0	0	0	0
Fuel Oil	0	0	0	0	0	0	0	0
LPG	69	57	53	47	40	30	37	34
Gasoil / Diesel/ DERV	197	244	256	230	252	214	206	193
Petroleum Coke	19	44	33	29	23	15	13	9
Naphta	0	0	0	0	0	0	0	0
Bitumen	0	0	0	0	0	0	0	0
White Spirit	0	0	0	0	0	0	0	0
Lubricants	0	0	0	0	0	0	0	0
Natural Gas	**117**	**439**	**607**	**593**	**669**	**625**	**710**	**569**
Renewables	**45**	**17**	**23**	**35**	**37**	**46**	**49**	**46**
Hydro	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0
Biomass	45	17	16	23	20	27	27	23
Landfill Gas	0	0	0	0	0	0	0	0
Biogas	0	0	0	0	0	0	0	0
Wastes	0	0	0	0	0	0	0	0
Solar	0	0	0	1	3	4	6	8
Geothermal	0	0	6	11	14	15	15	15
Non-Renewable (Wastes)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Electricity	**356**	**548**	**646**	**693**	**733**	**699**	**735**	**712**
Total	**2,258**	**2,504**	**2,931**	**2,896**	**3,142**	**3,082**	**3,275**	**2,836**

More detailed data is available on the SEAI website at www.seai.ie/statistics.

Balance

Appendix 1: National Energy Efficiency Action Plan

Table 29 lists the expected energy and emissions savings in 2020 for the various energy efficiency policy measures.

Table 29 *NEEAP 1 submission*

	GWh PEE	$ktCO_2$
Building Regulations 2002—improved energy performance of residential buildings	1,015	266
Building Regulations 2008—40% improvement on energy performance of residential buildings relative to current building regulations	2,490	615
Building Regulations 2010—60% improvement of residential buildings relative to current building regulations	1,100	272
Low Carbon Homes 2016—70% improvement of residential buildings relative to current building regulations	395	98
House of Tomorrow programme—developer support for buildings exceeding existing building regulations	30	7
Warmer Homes Scheme	170	42
Home Energy Saving Scheme—improving current residential building stock in Ireland	600	157
Smart meter installation—estimated efficiency gains among domestic users	690	120
Greener Homes Scheme	265	64
Lighting Efficiency Standard	1,200	210
Efficient Boiler Standard	2,400	585

Source: DCENR and SEAI

Table 30 details the expected energy and emissions savings in 2020 as detailed in the NEEAP 2 submission. The most obvious and significant change from *Table 29* is the addition of the Better Energy Homes Scheme.

Table 30 *NEEAP 2 submission*

	GWh PEE	$ktCO_2$
Building Regulations 2002—improved energy performance of residential buildings	1,280	312
Building Regulations 2008—40% improvement on energy performance of residential buildings relative to current building regulations	2,110	514
Building Regulations 2010—60% improvement of residential buildings relative to current building regulations	835	203
Low Carbon Homes 2016—70% improvement of residential buildings relative to current building regulations	225	55
House of Tomorrow programme—developer support for buildings exceeding existing building regulations	30	7
Warmer Homes Scheme	120	33
Home Energy Saving Scheme—improving current residential building stock in Ireland	365	90
Smart meter installation—estimated efficiency gains among domestic users	625	126
Greener Homes Scheme	120	28
Lighting Efficiency Standard	1,200	242
Efficient Boiler Standard	1,200	293
Better Energy Homes Scheme	6,000	1,476

Source: DCENR and SEAI

Appendix 2: Energy Efficiency Policy Measures

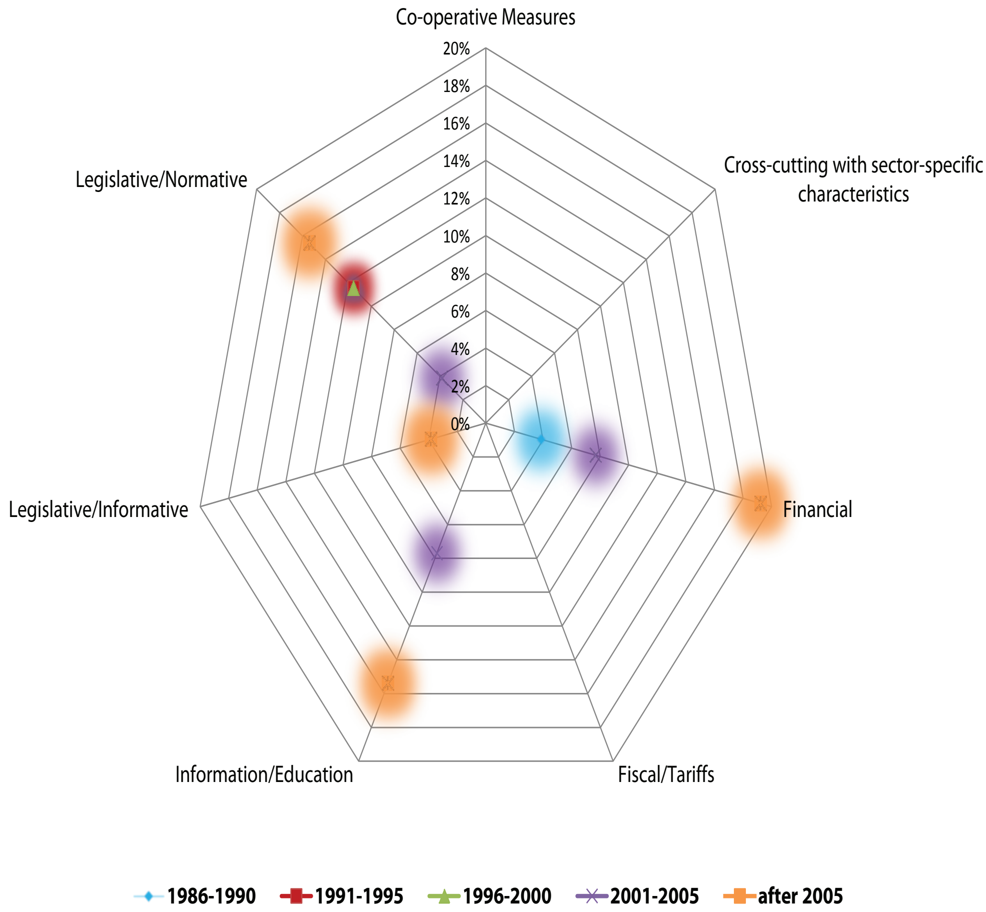
Table 31 details the energy efficiency policy measures that have been introduced to the residential sector.

Table 31 *Energy Efficiency Policy Measures in the Residential Sector*

Measure	Start date	Status	Measure Type	Semi-Quantitative Impact
Programme "Energy Action" in Dublin	1988	Ongoing	Financial	Low
Building Regulations 1991	1992	Completed	Legislative Normative	High
Minimum Efficiency Standards for Boilers	1995	Ongoing	Legislative Normative	Medium
Mandatory labelling of electrical appliances	1995	Ongoing	Legislative Normative	Unknown
Building Regulations 1997	1998	Completed	Legislative Normative	High
Minimum Efficiency Standards for Appliances and Lighting	1999	Ongoing	Legislative Normative	Medium
House of Tomorrow	2001	Completed	Financial	Low
Warmer Home Scheme (Low Income Housing Strategy)	2002	Completed	Financial	Medium
Sustainable Energy Ireland	2002	Ongoing	Information/ Education	High
Energy efficient communities through spacial and planning policies	2002	Ongoing	Unknown	Medium
Energy Conservation Standards for New Dwellings (Revised Building Regulations) 2002	2003	Completed	Legislative Normative	High
The Greener Homes Scheme	2006	Completed	Financial	Medium
Power of One – Information Campaign	2006	Ongoing	Information/ Education	Medium
Low Carbon Homes Scheme	2006	Completed	Financial	Low
EU-related: Energy Performance of Buildings (Directive 2002/91/EC) - Irish Response to the Energy Performance of Buildings Directive	2007	Ongoing	Legislative Informative	High
Best Practice Design for Social Housing	2007	Ongoing	Information/ Education	Medium
Boiler Efficiency Campaign	2007	Ongoing	Information/ Education	Low
Building Regulations 2008	2008	Ongoing	Legislative Normative	Medium
Condensing Boilers - Minimum Boiler Efficiency	2008	Ongoing	Legislative Normative	High
EU-related: Recast Ecodesign Directive for Energy-related Products (Directive 2009/125/EC) - Energy Efficient Lighting	2009	Ongoing	Legislative Normative	High
Upgrade of Older Housing Stock - Home Energy Savings Scheme & Housing Aid for Older People Scheme	2009	Completed	Financial	High
Building regulations 2011	2011	Ongoing	Legislative Normative	High
Better Energy Homes (Residential Retrofit)	2011	Ongoing	Financial	High
Micro CHP	2012	Proposed (medium/ long-term)	Financial	Unknown
Periodic Mandatory inspection of Boilers	2012	Proposed (medium/ long-term)	Legislative Normative	Unknown
Smart Metering	2016	Ongoing	Information/ Education	High
Building Regulations - Nearly Zero Energy Homes	2016	Proposed (medium/ long-term)	Legislative Normative	High

Source: DCENR and SEAI

Figure 57 *Summary of Irish energy efficiency measures with classifications from the MURE database*

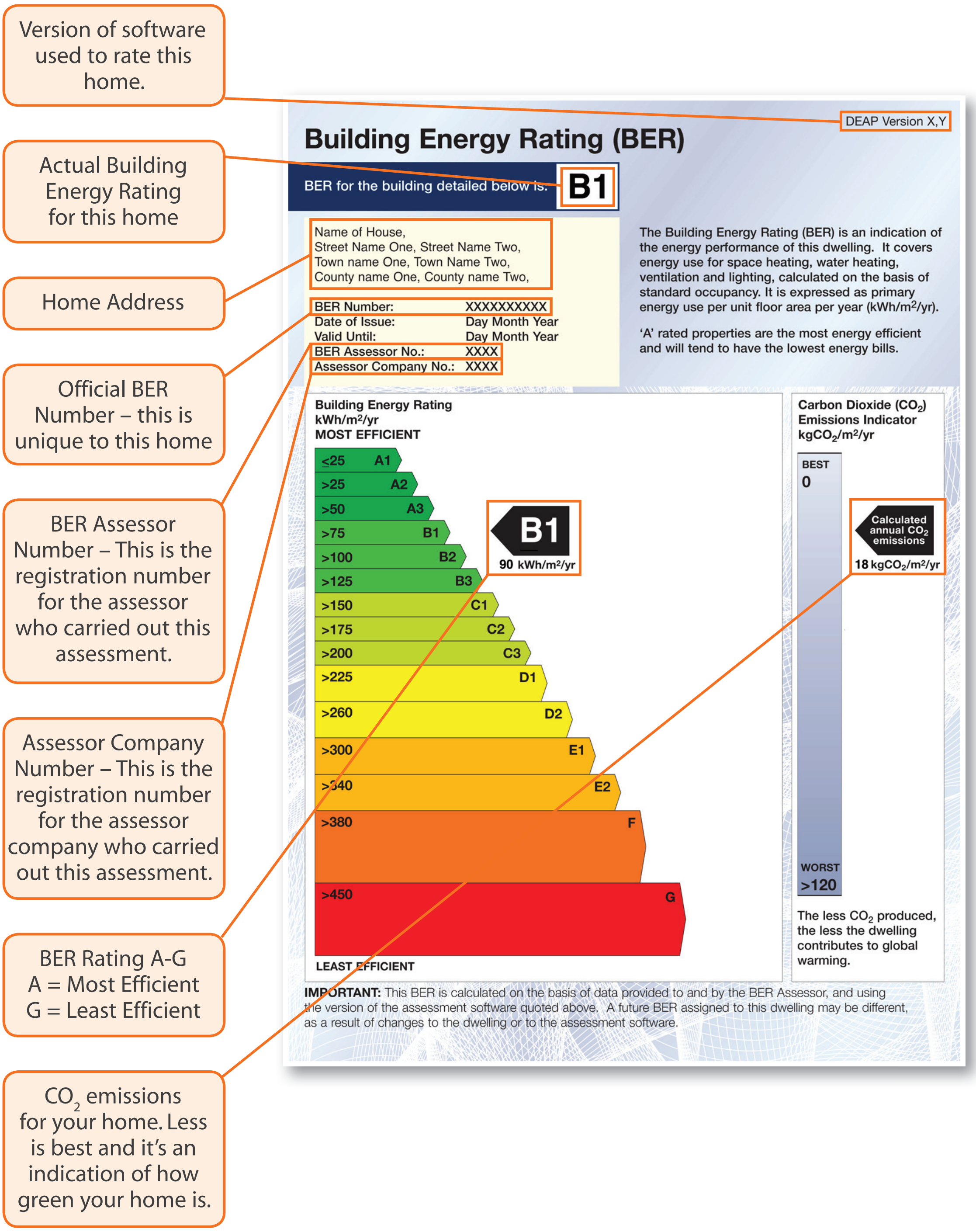


Source: MURE and SEAI

Appendix

Appendix 3: Building Energy Rating Certificate

Sample Building Energy Rating Certificate



Appendix 4: Analysis of Census 2011 Data

This appendix contains more detailed analysis of the Census 2011 data. It disaggregates the housing stock by the different house type categories included in the Census (detached, semi-detached, terrace, purpose built flats and apartments, converted flats or apartments, bedsits, not stated). These categories do not exactly match those in the BER database but in order to provide an indicative efficiency of the stock of houses by house type a BER distribution for a sample of a similar house types is also included in each section. *Table 32* details which categories of BER house types are compared to the Census 2011 house type categories in this appendix.

Table 32 *Census and BER house type categories and numbers comparison*

Census House type	Census Numbers	BER house type	BER number	% of stock with BER
All Households	1,649,408	All Households*	311,822	19%
Detached house	699,869	House & Detached house	113,850	16%
Semi- detached house	456,651	Semi- detached house	77,790	17%
Terraced house	281,825	Terraced house (mid & end)	61,268	22%
Flat or apartment in a converted house or commercial building	27,666			
Flat or apartment in a purpose- built block	149,921	Apartments, ground-floor, mid-floor, top-floor apartment & Maisonettes	65,490	
Bed-sit	5,695			

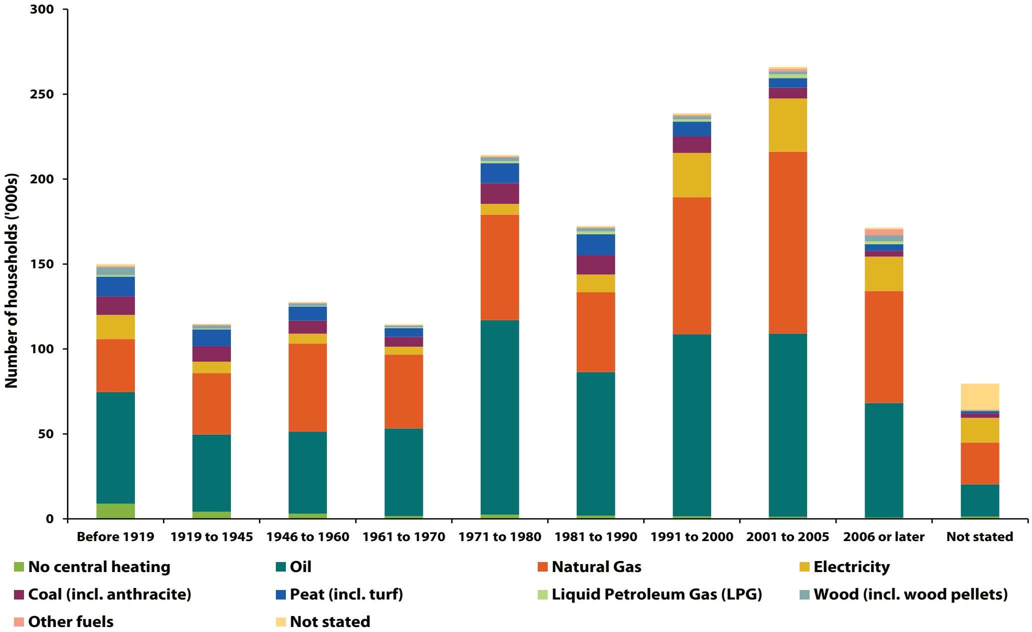
Source: CSO & SEAI

* Not all dwellings require a BER certificate; historical houses or protected structures and dwellings less than 50m^2 are exempt from requiring a BER certificate.

Appendix

All Households

Figure 58 *All households by heating type by period of construction*



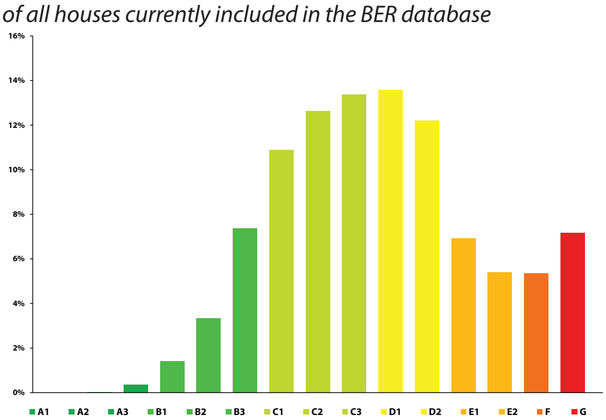
Source: CSO Census 2011

Table 33 *All Households by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	1.6%	6%	4%	2%	1%	1%	1%	1%	0%	0.5%	2%
Oil	43.1%	44%	40%	38%	45%	53%	49%	45%	41%	39.3%	24%
Natural Gas	33.4%	21%	31%	41%	38%	29%	27%	34%	40%	38.5%	31%
Electricity	8.5%	10%	6%	5%	4%	3%	6%	11%	12%	11.8%	18%
Coal (incl. anthracite)	4.8%	7%	8%	6%	5%	6%	7%	4%	2%	1.9%	3%
Peat (incl. turf)	4.8%	8%	9%	6%	5%	5%	7%	4%	2%	2.3%	2%
Liquid Petroleum Gas (LPG)	0.6%	1%	0%	0%	0%	1%	1%	1%	1%	1.0%	0%
Wood (incl. wood pellets)	1.3%	3%	2%	1%	1%	1%	1%	1%	1%	2.1%	0%
Other fuels	0.5%	0%	0%	0%	0%	0%	0%	0%	1%	2.1%	0%
Not stated	1.4%	1%	0%	0%	0%	0%	0%	0%	0%	0.5%	19%
Period of construction (%)		9%	7%	8%	7%	13%	10%	14%	16%	10%	5%

Source: CSO Census 2011

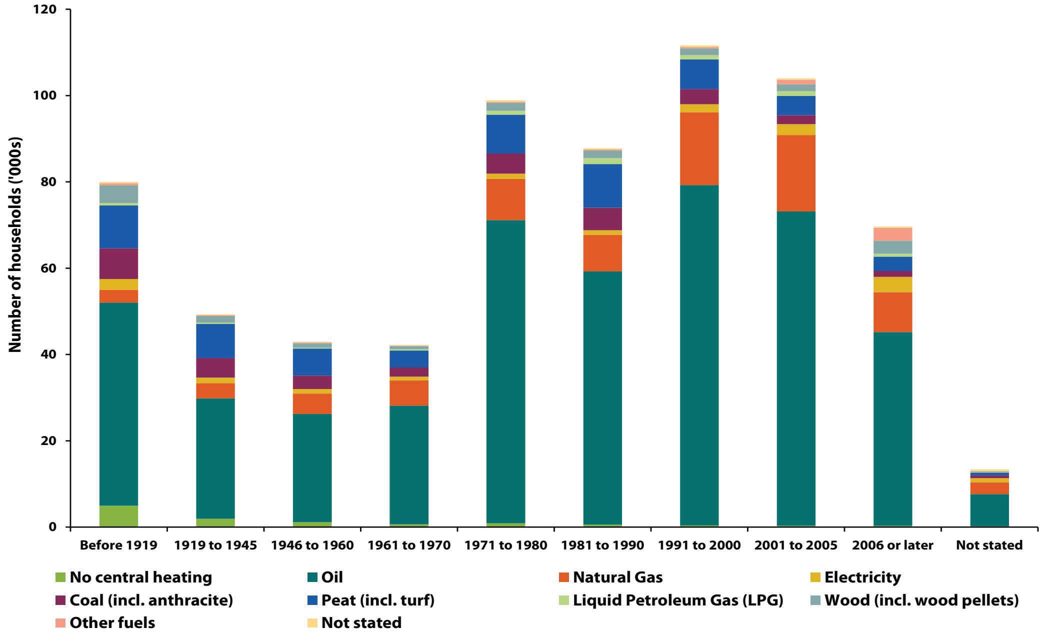
Figure 59 *BER distribution of all houses currently included in the BER database*



Source: SEAI

Detached Houses

Figure 60 *Detached households by heating type by period of construction*



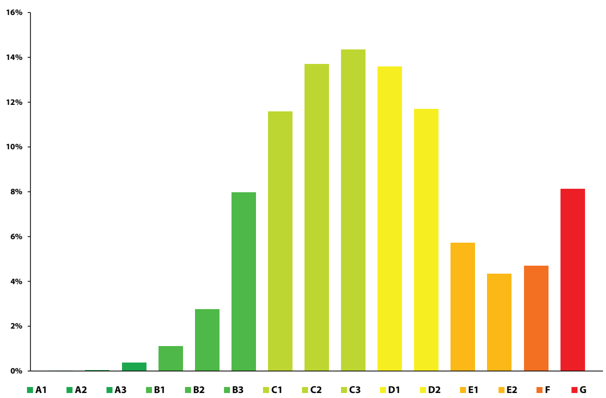
Source: CSO Census 2011

Table 34 *Detached Households by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	2%	6%	4%	3%	2%	1%	1%	0%	0%	0.4%	1%
Oil	66%	59%	57%	58%	65%	71%	67%	71%	70%	64.5%	56%
Natural Gas	12%	4%	7%	11%	14%	10%	10%	15%	17%	13.3%	21%
Electricity	2%	3%	3%	2%	2%	1%	1%	2%	2%	5.1%	7%
Coal (incl. anthracite)	5%	9%	9%	7%	5%	5%	6%	3%	2%	1.9%	5%
Peat (incl. turf)	9%	12%	16%	15%	9%	9%	12%	6%	4%	4.8%	5%
Liquid Petroleum Gas (LPG)	1%	1%	1%	1%	1%	1%	2%	1%	1%	1.0%	1%
Wood (incl. wood pellets)	2%	5%	3%	2%	2%	2%	2%	1%	2%	4.4%	2%
Other fuels	1%	1%	0%	0%	0%	0%	0%	0%	1%	4.3%	0%
Not stated	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.4%	3%
Period of construction (%)		11%	7%	6%	6%	14%	13%	16%	15%	10%	2%

Source: CSO Census 2011

Figure 61 *BER distribution of detached houses in the BER database*

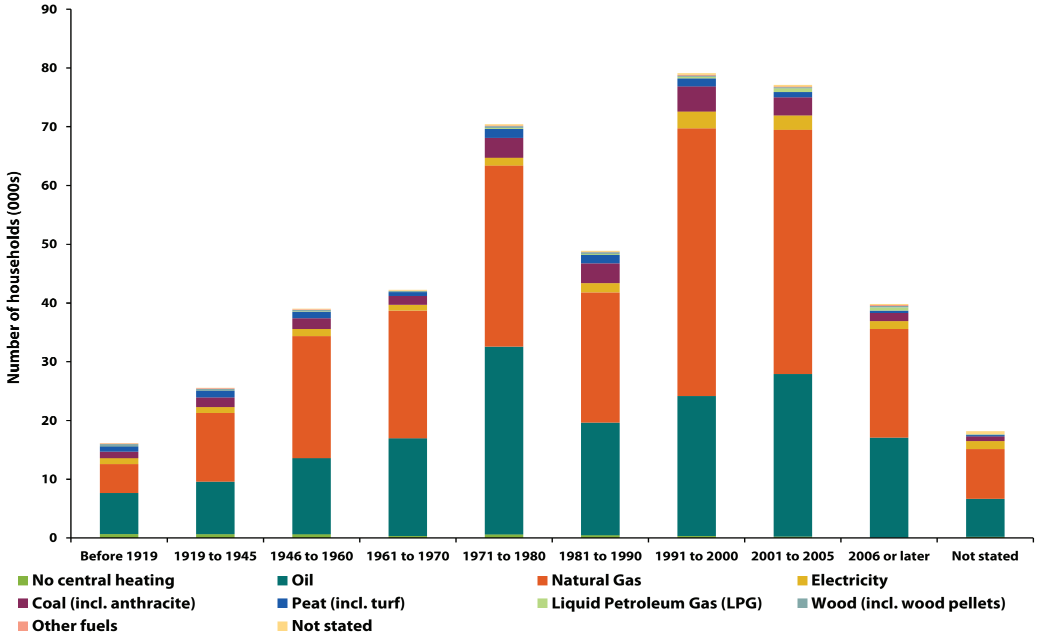


Source: SEAI

Appendix

Semi-detached Houses

Figure 62 *Semi-detached households by heating type by period of construction*



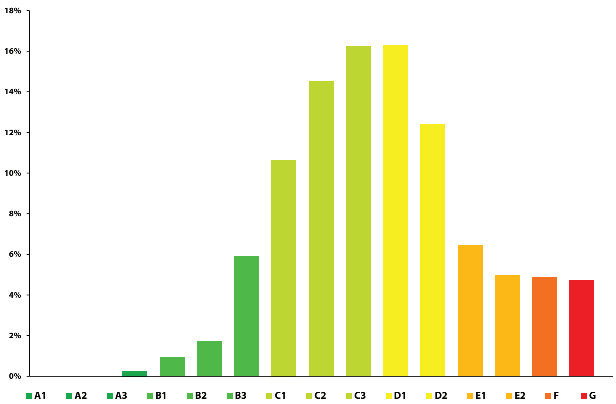
Source: CSO Census 2011

Table 35 *Semi-detached Households by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	1%	4%	3%	2%	1%	1%	1%	0%	0%	0.3%	1%
Oil	38%	43%	35%	33%	39%	45%	39%	30%	36%	42.6%	36%
Natural Gas	50%	30%	46%	53%	52%	44%	45%	58%	54%	46.4%	47%
Electricity	3%	6%	4%	3%	2%	2%	3%	4%	3%	3.3%	7%
Coal (incl. anthracite)	5%	7%	6%	5%	3%	5%	7%	5%	4%	3.5%	4%
Peat (incl. turf)	2%	5%	5%	3%	1%	2%	3%	2%	1%	1.1%	1%
Liquid Petroleum Gas (LPG)	0%	1%	0%	0%	0%	0%	0%	0%	1%	1.4%	0%
Wood (incl. wood pellets)	0%	2%	1%	1%	0%	0%	0%	0%	0%	0.7%	0%
Other fuels	0%	1%	0%	0%	0%	0%	0%	0%	0%	0.4%	0%
Not stated	0%	1%	0%	0%	0%	0%	0%	0%	0%	0.4%	2%
Period of construction (%)		**4%**	**6%**	**9%**	**9%**	**15%**	**11%**	**17%**	**17%**	**9%**	**4%**

Source: CSO Census 2011

Figure 63 *BER distribution of semi-detached houses in the BER database*

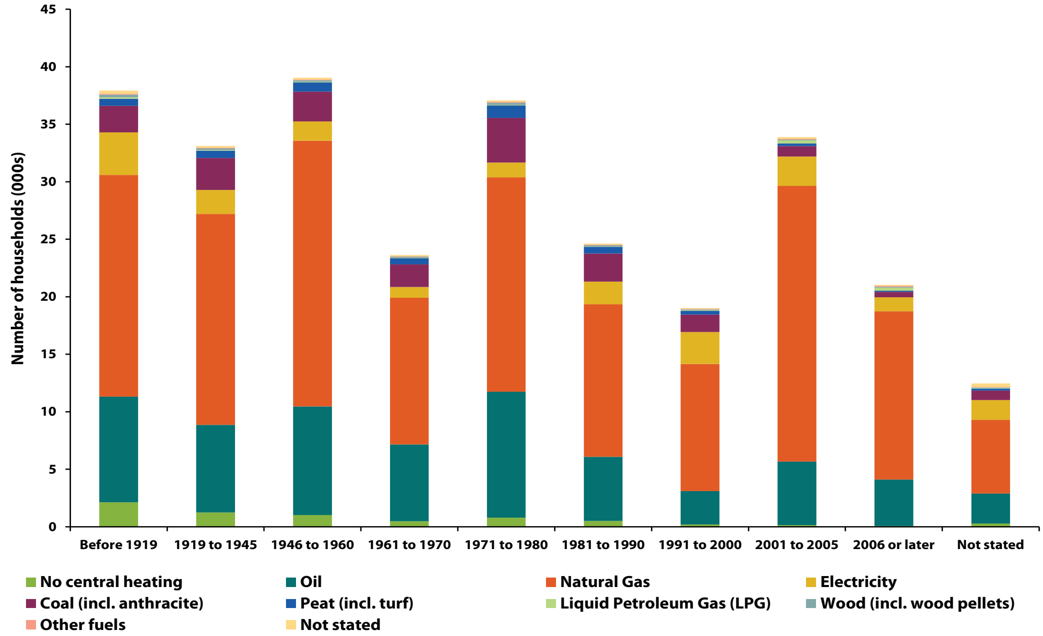


Source: SEAI

Appendix

Terraced Houses

Figure 64 *Terraced Houses by heating type by period of construction*



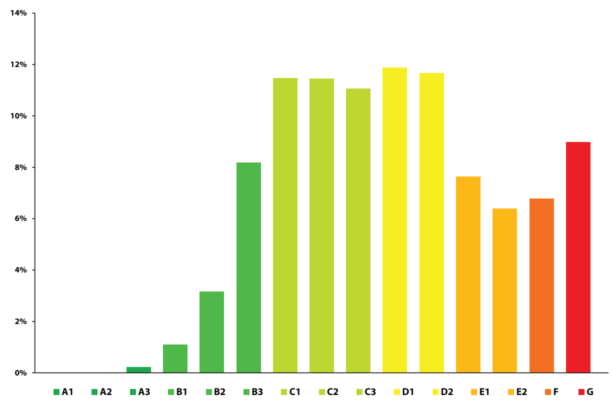
Source: CSO Census 2011

Table 36 *Terraced houses by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	2%	6%	4%	3%	2%	2%	2%	1%	0%	0.3%	2%
Oil	23%	24%	23%	24%	28%	30%	23%	15%	16%	19.2%	21%
Natural Gas	57%	51%	55%	59%	54%	50%	54%	58%	71%	69.6%	51%
Electricity	7%	10%	6%	4%	4%	3%	8%	15%	7%	5.8%	14%
Coal (incl. anthracite)	7%	6%	8%	7%	8%	10%	10%	8%	3%	2.2%	7%
Peat (incl. turf)	2%	2%	2%	2%	2%	3%	2%	2%	1%	0.5%	2%
Liquid Petroleum Gas (LPG)	0%	0%	0%	0%	0%	0%	0%	0%	1%	1.3%	0%
Wood (incl. wood pellets)	0%	1%	0%	0%	0%	1%	0%	0%	0%	0.4%	0%
Other fuels	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.3%	0%
Not stated	1%	1%	0%	0%	0%	0%	0%	0%	0%	0.4%	2%
Period of construction		**13%**	**12%**	**14%**	**8%**	**13%**	**9%**	**7%**	**12%**	**7%**	**4%**

Source: CSO Census 2011

Figure 65 *BER distribution of terraced houses in the BER database*

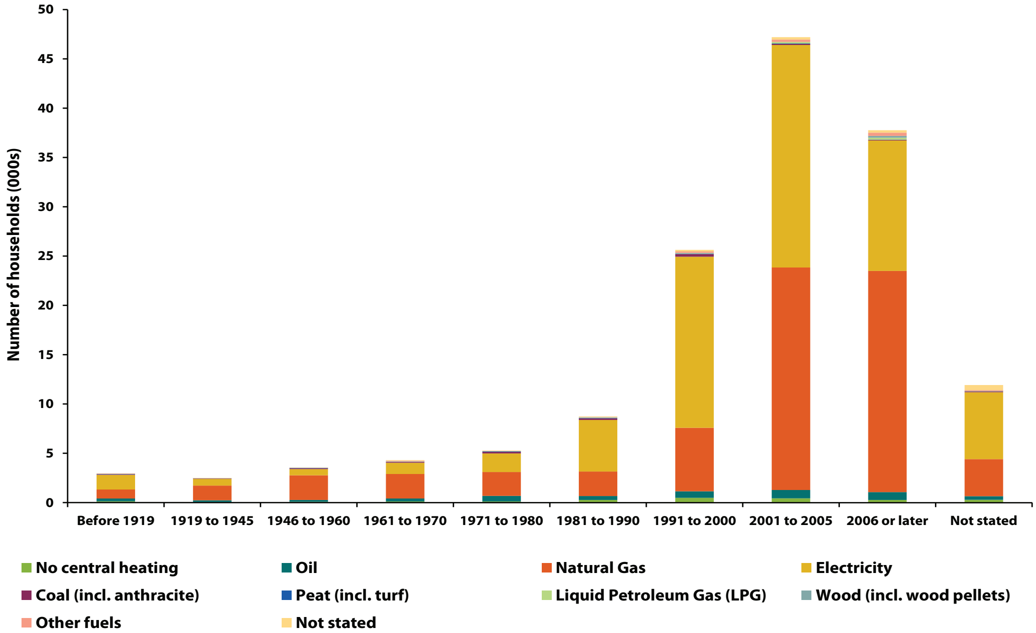


Source: SEAI

Appendix

Purpose-built Flats or Apartments

Figure 66 *Purpose-built flats or apartments by heating type by period of construction*



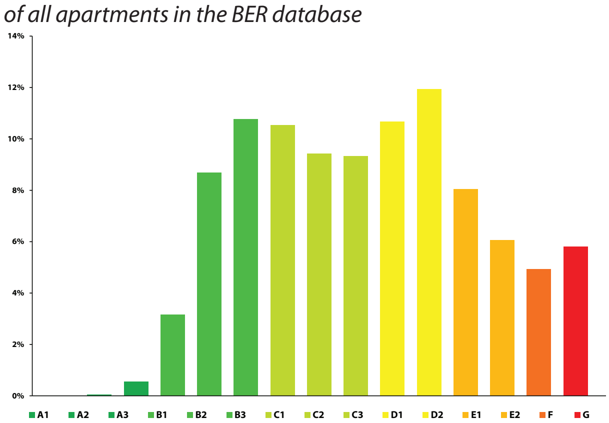
Source: CSO Census 2011

Table 37 *Purpose-built flats or apartments by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	2%	5%	3%	3%	3%	2%	3%	2%	1%	0.7%	2%
Oil	3%	9%	7%	5%	7%	11%	4%	3%	2%	2.1%	3%
Natural Gas	45%	31%	60%	70%	57%	46%	28%	25%	48%	59.4%	31%
Electricity	47%	50%	27%	18%	27%	36%	60%	68%	48%	35.0%	57%
Coal (incl. anthracite)	1%	2%	1%	2%	2%	3%	2%	1%	0%	0.2%	1%
Peat (incl. turf)	0%	1%	1%	1%	0%	1%	1%	0%	0%	0.0%	0%
Liquid Petroleum Gas (LPG)	0%	0%	0%	0%	0%	1%	1%	0%	0%	0.5%	0%
Wood (incl. wood pellets)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.5%	0%
Other fuels	1%	1%	0%	0%	2%	1%	0%	1%	0%	0.9%	1%
Not stated	1%	1%	1%	1%	1%	1%	1%	1%	1%	0.7%	4%
Period of construction (%)		**2%**	**2%**	**2%**	**3%**	**4%**	**6%**	**17%**	**31%**	**25%**	**8%**

Source: CSO Census 2011

Figure 67 *BER distribution of all apartments in the BER database*

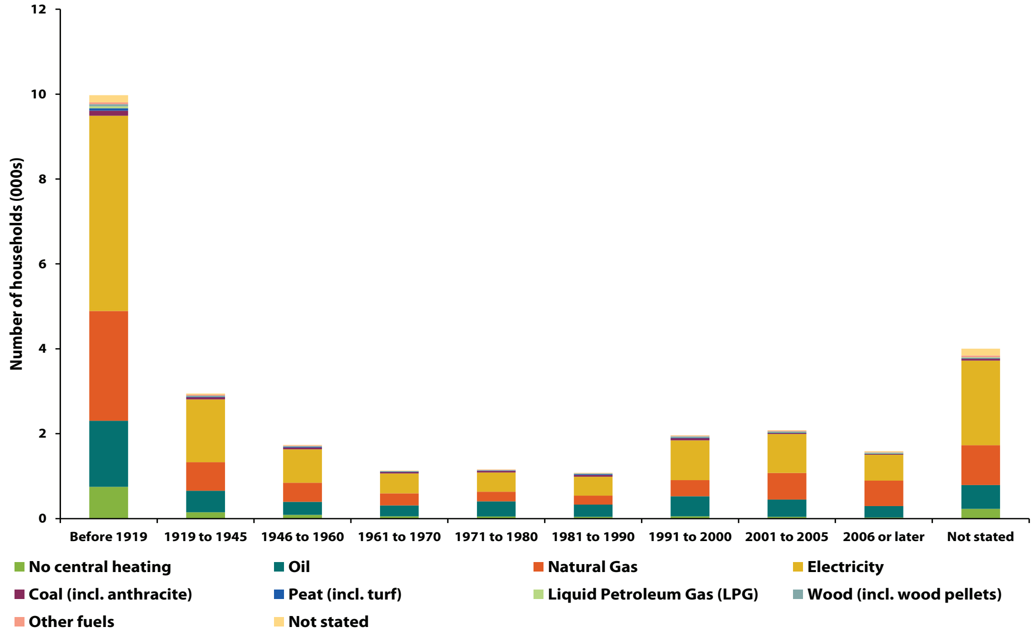


Source: SEAI

Appendix

Flats or Apartments from converted domestic or commercial buildings

Figure 68 *Flats or apartments in converted house or commercial building by heating type by period of construction*



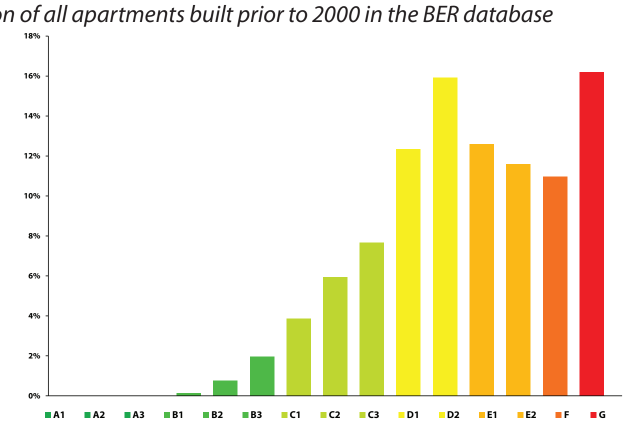
Source: CSO Census 2011

Table 38 *Flats or apartments in converted house or commercial building by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	5%	8%	5%	5%	5%	4%	4%	3%	2%	1.6%	6%
Oil	18%	16%	17%	18%	23%	31%	26%	24%	20%	17.1%	14%
Natural Gas	25%	26%	23%	26%	25%	20%	20%	19%	30%	37.7%	23%
Electricity	46%	46%	50%	45%	42%	39%	41%	48%	44%	38.4%	50%
Coal (incl. anthracite)	2%	1%	2%	2%	2%	3%	4%	3%	1%	0.9%	1%
Peat (incl. turf)	1%	1%	1%	1%	1%	1%	2%	1%	0%	0.8%	0%
Liquid Petroleum Gas (LPG)	0%	0%	0%	0%	0%	0%	1%	1%	1%	0.9%	0%
Wood (incl. wood pellets)	1%	0%	1%	0%	0%	1%	1%	1%	1%	0.7%	0%
Other fuels	1%	0%	1%	1%	1%	0%	0%	1%	1%	0.8%	1%
Not stated	2%	2%	1%	1%	1%	1%	1%	1%	1%	1.0%	4%
Period of construction (%)		**36%**	**11%**	**6%**	**4%**	**4%**	**4%**	**7%**	**8%**	**6%**	**14%**

Source: CSO Census 2011

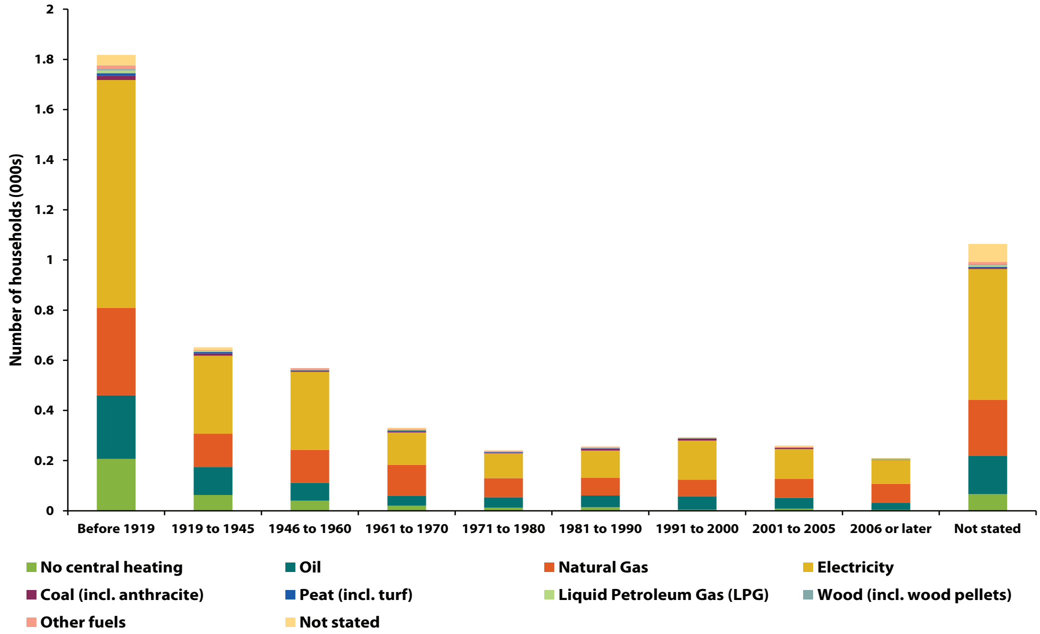
Figure 69 *BER distribution of all apartments built prior to 2000 in the BER database*



Source: SEAI

Bedsits

Figure 70 *Bedsits by heating type by period of construction*



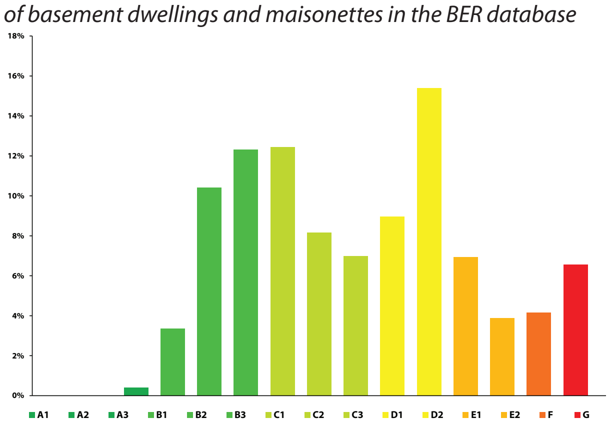
Source: CSO Census 2011

Table 39 *Bedsits by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	8%	11%	10%	7%	6%	5%	5%	2%	3%	1.9%	6%
Oil	15%	14%	17%	13%	12%	17%	18%	18%	17%	12.9%	14%
Natural Gas	23%	19%	21%	23%	37%	32%	28%	23%	29%	36.2%	21%
Electricity	48%	50%	48%	55%	39%	41%	42%	53%	46%	45.2%	49%
Coal (incl. anthracite)	1%	1%	2%	1%	2%	1%	3%	2%	2%	0.5%	0%
Peat (incl. turf)	1%	1%	1%	1%	1%	1%	1%	1%	0%	0.5%	0%
Liquid Petroleum Gas (LPG)	1%	1%	1%	0%	1%	1%	1%	1%	0%	1.0%	1%
Wood (incl. wood pellets)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1.0%	0%
Other fuels	1%	1%	0%	1%	1%	1%	0%	1%	1%	0.5%	1%
Not stated	2%	2%	2%	0%	1%	1%	1%	0%	2%	0.5%	7%
Period of construction (%)		**32%**	**11%**	**10%**	**6%**	**4%**	**5%**	**5%**	**5%**	**4%**	**19%**

Source: CSO Census 2011

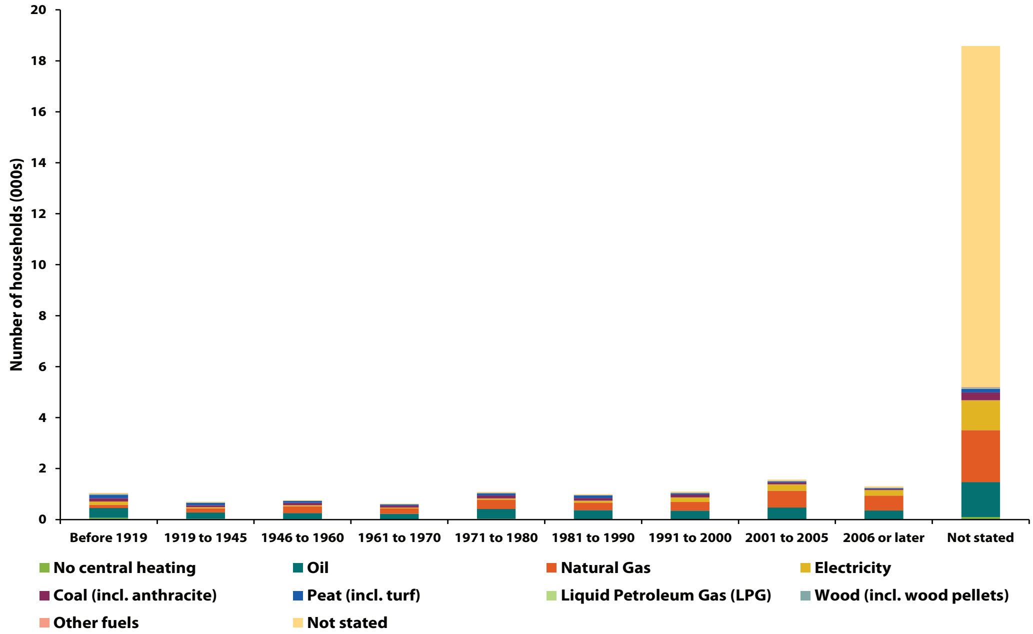
Figure 71 *BER distribution of basement dwellings and maisonettes in the BER database*



Source: SEAI

Not stated

Figure 72 *House type not stated by heating type by period of construction*



Source: CSO Census 2011

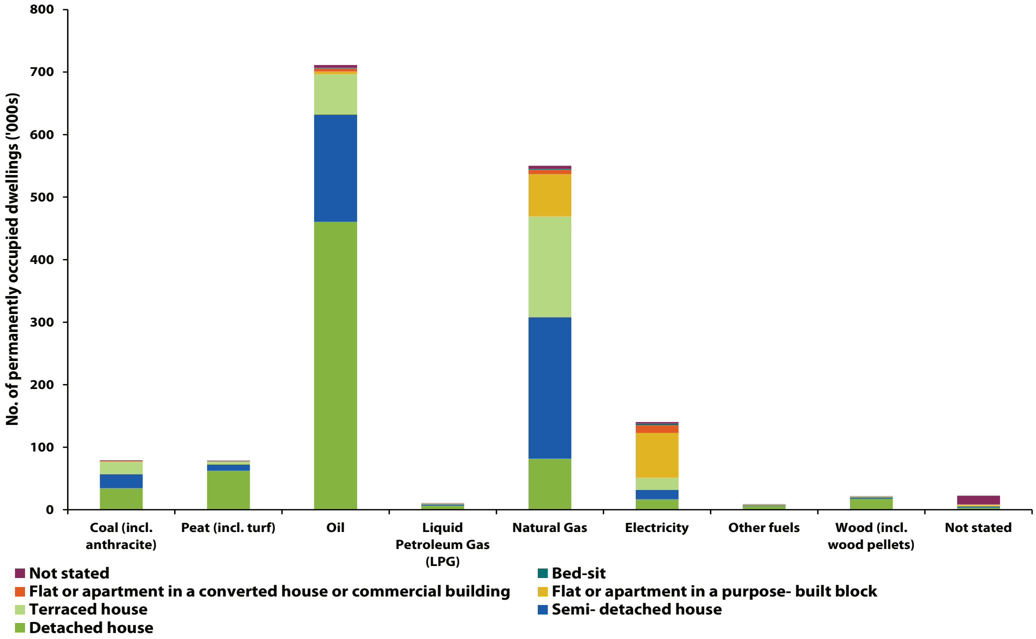
Table 40 *House type not stated by heating type by period of construction*

	All Years	Before 1919	1919 to 1945	1946 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2005	2006 or later	Not stated
No central heating	1%	6%	4%	3%	0%	0%	0%	0%	0%	0.0%	1%
Oil	16%	37%	36%	31%	3%	3%	2%	1%	1%	1.1%	7%
Natural Gas	18%	13%	23%	35%	34%	35%	35%	30%	29%	26.4%	11%
Electricity	8%	12%	6%	5%	33%	34%	30%	31%	42%	44.3%	6%
Coal (incl. anthracite)	4%	12%	11%	13%	6%	5%	8%	16%	16%	16.6%	2%
Peat (incl. turf)	3%	12%	14%	9%	12%	11%	10%	11%	5%	3.2%	1%
Liquid Petroleum Gas (LPG)	0%	1%	0%	0%	8%	8%	11%	5%	3%	2.8%	0%
Wood (incl. wood pellets)	1%	3%	2%	1%	0%	0%	1%	0%	1%	0.2%	0%
Other fuels	0%	0%	1%	0%	1%	1%	1%	1%	0%	0.8%	0%
Not stated	49%	4%	4%	3%	94%	94%	95%	95%	97%	94.9%	72%

Source: CSO Census 2011

Type of fuel by House Type

Figure 73 *Type of fuel use by house type*



Source: CSO Census 2011

Table 41 *Type of fuel use by house type*

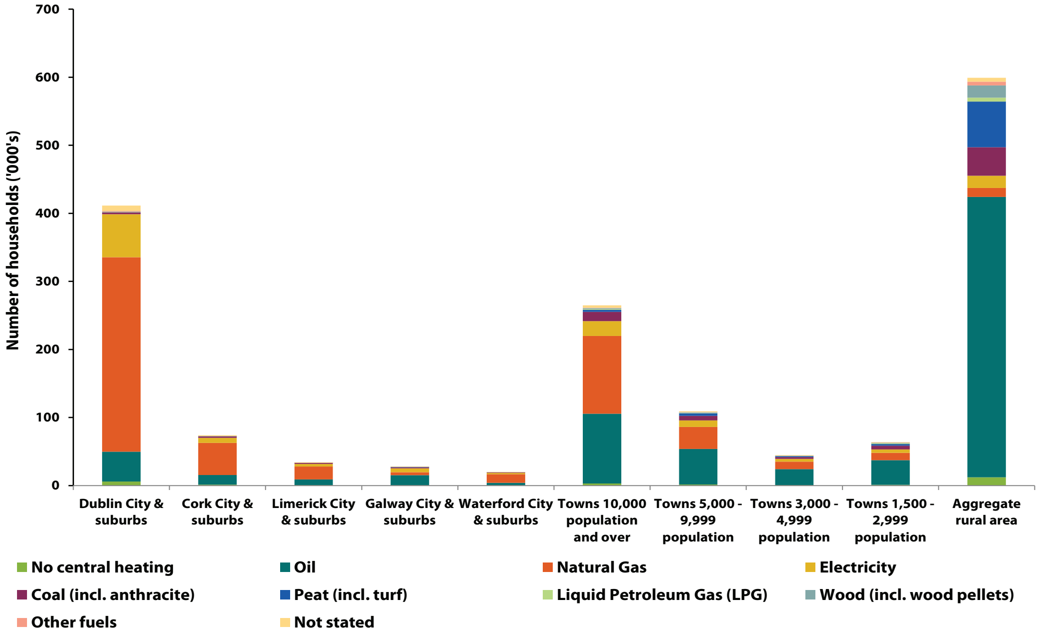
	All Fuels	Coal (incl. anthracite)	Peat (incl. turf)	Oil	Liquid Petroleum Gas (LPG)	Natural Gas	Electricity	Other fuels	Wood (incl. wood pellets)	Not stated
Detached	42.44%	43.45%	79.37%	64.74%	62.00%	14.85%	11.96%	67.75%	81.32%	13.90%
Semi-detached	27.88%	28.28%	12.44%	24.12%	20.69%	41.12%	10.70%	10.85%	10.51%	9.12%
Terraced	16.95%	24.86%	6.46%	9.07%	9.95%	29.34%	14.19%	6.79%	5.44%	6.80%
Flat or apartment in purpose-built block	9.10%	1.34%	0.40%	0.64%	5.28%	12.26%	50.58%	11.13%	1.33%	6.34%
Flat or apartment in converted house or commercial building	1.61%	0.57%	0.24%	0.70%	1.27%	1.27%	9.05%	2.05%	0.68%	1.97%
Bed-sit	0.32%	0.08%	0.05%	0.12%	0.33%	0.24%	1.96%	0.55%	0.07%	0.63%
Not stated	1.69%	1.43%	1.04%	0.61%	0.48%	0.92%	1.56%	0.87%	0.66%	61.24%

Source: CSO Census 2011

Appendix

Type of Fuels by Broad Location

Figure 74 *Type of fuel use by broad location*



Source: CSO Census 2011

Table 42 *Type of fuel use by broad location*

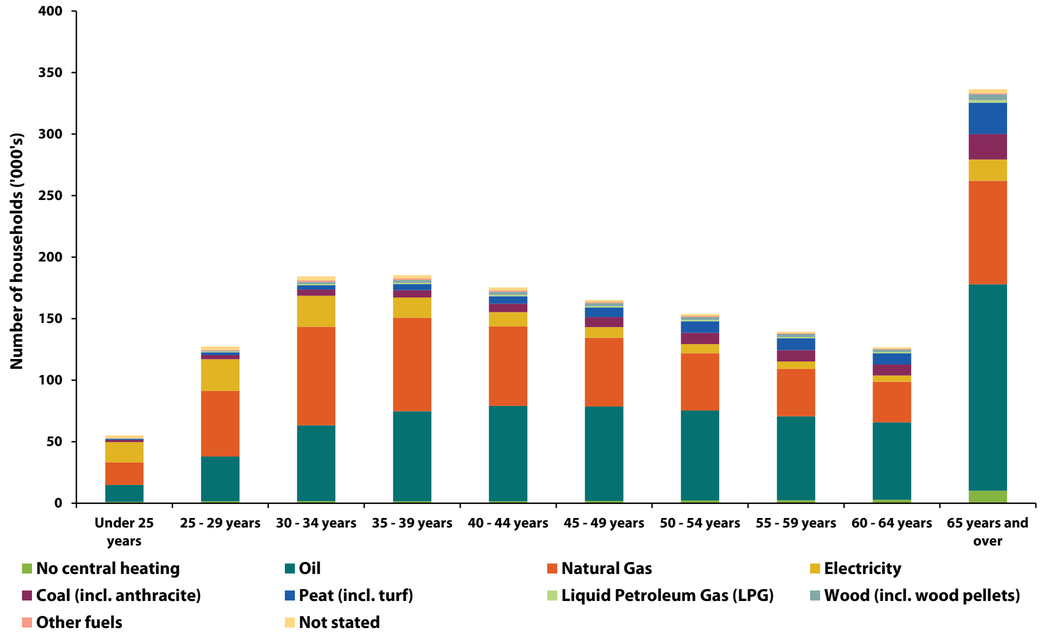
	Dublin City & suburbs	Cork City & suburbs	Limerick City & suburbs	Galway City & suburbs	Waterford City & suburbs	Towns 10,000 pop. & over	Towns 5,000 - 9,999 pop.	Towns 3,000 - 4,999 pop.	Towns 1,500 - 2,999 pop.	Aggregate rural area
No central heating	1.43%	1.85%	1.70%	1.42%	1.60%	1.15%	1.37%	1.37%	1.62%	2.03%
Oil	10.66%	19.10%	24.82%	53.09%	18.67%	38.68%	47.77%	52.46%	56.76%	68.75%
Natural Gas	69.42%	63.70%	55.08%	15.32%	62.97%	43.17%	29.82%	24.95%	16.86%	2.17%
Electricity	15.37%	10.05%	11.34%	20.46%	9.61%	8.19%	8.72%	8.75%	7.83%	3.01%
Coal (incl. anthracite)	0.64%	2.85%	4.61%	5.16%	4.74%	5.17%	6.10%	6.14%	8.55%	6.99%
Peat (incl. turf)	0.07%	0.08%	0.13%	1.13%	0.08%	1.14%	3.48%	3.27%	4.00%	11.19%
Liquid Petroleum Gas (LPG)	0.14%	0.32%	0.15%	0.87%	0.25%	0.52%	0.70%	0.86%	1.66%	0.96%
Wood (incl. wood pellets)	0.11%	0.23%	0.16%	0.40%	0.20%	0.39%	0.60%	0.58%	1.15%	2.99%
Other fuels	0.26%	0.21%	0.21%	0.44%	0.18%	0.23%	0.35%	0.34%	0.45%	0.94%
Not stated	1.90%	1.61%	1.80%	1.72%	1.70%	1.36%	1.10%	1.29%	1.10%	0.97%

Source: CSO Census 2011

Appendix

Type of Central Heating by Age of Reference Occupant

Figure 75 *Type of central heating by age of reference person*



Source: CSO Census 2011

Table 43 *Type of central heating by age of reference person*

	Under 25 years	25 - 29 years	30 - 34 years	35 - 39 years	40 - 44 years	45 - 49 years	50 - 54 years	55 - 59 years	60 - 64 years	65 years and over
No central heating	1.96%	1.23%	0.90%	0.81%	0.93%	1.13%	1.44%	1.77%	2.20%	3.02%
Oil	25.09%	28.50%	33.45%	39.52%	44.17%	46.43%	47.60%	48.85%	49.67%	49.86%
Natural Gas	33.25%	41.93%	43.40%	40.91%	36.85%	33.74%	30.30%	27.65%	26.04%	24.98%
Electricity	29.76%	20.18%	13.71%	8.95%	6.60%	5.34%	4.79%	4.38%	4.07%	5.16%
Coal (incl. anthracite)	3.35%	2.76%	2.69%	3.11%	3.97%	4.96%	6.01%	6.58%	6.95%	6.15%
Peat (incl. turf)	1.36%	1.64%	2.00%	2.71%	3.44%	4.65%	6.01%	6.92%	7.20%	7.54%
Liquid Petroleum Gas (LPG)	0.34%	0.46%	0.51%	0.54%	0.61%	0.67%	0.75%	0.78%	0.81%	0.68%
Wood (incl. wood pellets)	0.40%	0.60%	0.94%	1.26%	1.40%	1.53%	1.55%	1.67%	1.66%	1.34%
Other fuels	0.50%	0.50%	0.65%	0.74%	0.71%	0.58%	0.51%	0.44%	0.38%	0.28%
Not stated	3.99%	2.19%	1.75%	1.45%	1.32%	0.99%	1.03%	0.96%	1.01%	0.98%

Source: CSO Census 2011

Appendix 5: Residential Wood Consumption

A5.1 Energy Conversion Factors for Firewood/ Wood Logs

The gross calorific value (GCV) of dry wood matter is nearly on the same level for all wood species. There is only a minor difference between softwood/coniferous wood (19 MJ/kg) and hardwood/deciduous wood (18 MJ/kg), due to the higher resin and lignin content of coniferous wood. Therefore, the energy content of wood is much more dependent on the water content than on the wood species[1].

The Net Calorific Value (NCV) of wood can be determined by the water content using the following formula:

$$NCV_w = (NCV_0*(100-w)-2.447*w)/100$$

Where:

NCV_w is the net calorific value of wood with a water content w

NCV_0 is the net calorific value of absolute dry wood (i.e. w=0, NCV = GCV)

w is the percentage (%) water content

2.447 is the heat of evaporisation for water at 25°C in MJ/kg

Assuming that most firewood used in Ireland is deciduous[2] (a mixture of 70% deciduous and 30% coniferous) and has a moisture content of 25°C, *Table 44* lists the net calorific values (NCV) assumed for wood logs.

Table 44 *Net calorific values for wood logs / firewood*

GJ/tonne @ 25% moisture (Bulk)	kg/m³@ 25% moisture (Bulk)	kWh/m³ @ 25% moisture (Bulk)	kWh/kg @ 25% moisture (Bulk)
13.11	352	1283	3.64

Source: SEAI

A5.2 Volume Conversion Factors for Firewood/ Wood Logs

Table 45 explains the measures normally used in relation to wood logs/firewood. Bulk refers to the volume in which wood logs/firewood are usually delivered or stored. Solid refers to the wood as felled prior to chopping into logs. Stacked is where the logs are methodically aligned in perpendicular rows. A visual guide to the difference between what is meant by a solid cubic metre, stacked cubic metre or bulk cubic metre is given in *Table 46.*

Table 45 *Average conversions factors for volumes of chopped firewood*

	Bulk (m³)	Stacked (m³)	Solid (m³)
1 m³ bulk	1	0.7	0.5
1 m³ stacked	1.43	1	0.71
1 m³ solid	2	1.4	1

Source: Pirinen[3] 1998

Table 46 *Difference between bulk, stacked and solid cubic meter of firewood*

Bulk (m³)	Stacked (m³)	Solid (m³)
		

Source: EPSSU

1 EU Concerted Action on Renewables, Work Group 2 : Methodologies, 2012, Quality standard for statistics on wood fuel consumption of households.

2 COFORD, 2000, COFORD Strategic Study: Maximising the potential for wood use for energy generation in Ireland. Available from http://www.ca-res.eu/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/dam/ca_res/public_downloads/working_group_summary/WG2_Summary_Report_CA_RES_2012.pdf&t=1360346303&hash=f112497adb73e8c8e271ebcd231bbbf3

3 Pirinen, H., 1998, Lámmityspikkeen laatuohje. Suomen Bioenergiayhdistys, julkaisu 8.17 p. JYváskylá, Finland. Referenced in BENET, Energidalen i Sollefteå AB and Jyväskylä Polytechnic, 2000, Wood Fuels Basic Information Pack. ISBN 952-5165-19-1

A5.3 Energy Content and Usage of Firewood/Wood Logs

Table 47 details the assumptions used to calculate the energy content in wood logs. The energy content of a 'typical' wood log is calculated as 3 kWh.

Table 47 *Estimates of energy content of firewood/wood logs*

	Small	Medium	Large
Length (metres)	0.25	0.33	0.5
Diameter (metres)	0.05	0.15	0.25
Radius (metres)	0.025	0.075	0.125
Circumference (metres)	0.126	0.314	0.628
Volume of cylinder (cubic metres)	0.001	0.008	0.031
Width of logs (metres)	0.06	0.08	0.08
Volume of log (cubic metres)	0.0006	0.0020	0.0039
Share of cylindrical log	50%	25%	12.5%
Energy (kWh)	0.81	2.52	5.04

Source: SEAI

The average household consumption per annum estimates are detailed in *Table 48* assuming that a fire/stove is lit for seven months a year, using the estimate of the energy content of a 'typical' wood log calculated as 3 kWh.

Table 48 *Estimates of firewood/wood logs used in open fire/stove*

	Wood logs per day	Energy input (kWh)	Days per week	kWh per week	kWh per annum
Maximum open fires/stoves usage	10	30	7	210	5,880
Minimum open fires/stoves usage	3	9	2	18	504
Average usage in open fires/stoves	6.5	19.5	4	78	2,184

Source: SEAI

A5.4 Firewood/Wood Log Energy Share of Open Fire/Stove

Calculations for the energy consumption of a typical open fire are detailed in *Table 49*. The assumptions are that 2 wood logs are used to 8 peat briquettes. As wood logs are inclined to spit/spark in open fires typically more coal or peat is used than wood logs in open fires. As both coal and peat are more energy dense a greater energy share would be expected from these fuels.

Table 49 *Energy content of a typical open fire*

	Typical open fire
Bale of peat briquettes (kg)	12.6
per briquette (kg)	0.57
Assume 8 briquettes per fire (kg)	4.58
NCV Peat (kWh/kg)	5.15
Energy in fire (kWh)	23.6
Assume 3 Wood logs (kWh)	9
Share of wood in energy terms	28%

Source: SEAI

An alternative calculation is detailed in *Table 50*. This is a bottom up estimate of the total open fire or stove energy consumption. An overall efficiency of 40% is assumed. Open fires are likely to have an efficiency of 30% whereas most stoves would have efficiencies of over 50%. The final estimate of an average consumption of 2,352 kWh firewood per household per annum gives a similar result to the calculation based on the number of wood logs consumed per household in *Table 48*.

Table 50 *Estimates of energy content of open fire /stove*

	Energy Output Rating (kWh)	Hours per night	Energy input (kWh)	Days per week	Energy per week (kWh)	Energy per annum (kWh)
Maximum open fire/stove usage	8	6	120	7	840	23,520
Minimum open fire/stove usage	5	4	50	2	100	2,800
Average usage in open fires/stoves	6	5	75	4	300	8,400
Assume 28% wood energy						2,352

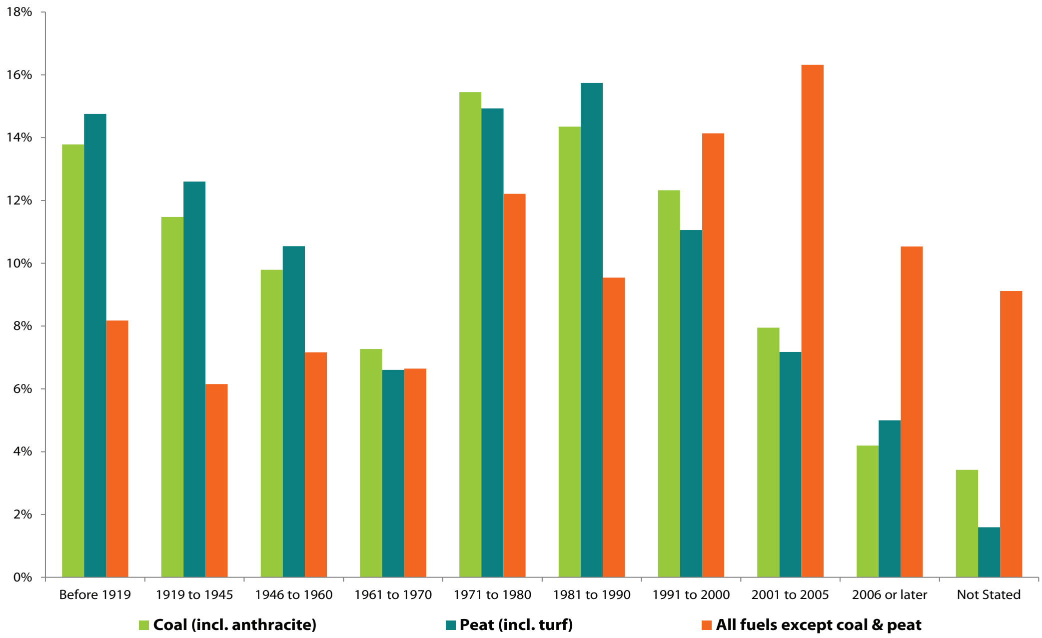
Source: SEAI

A5.5 Assumptions for Calculating Coal & Peat Consumption from Census 2011

The average climate corrected non-electrical consumption per dwelling dropped from approximately 23,300 kWh per dwelling in 1990 to 15,000 kWh in 2011. Households which use solid fuels for space heating tend to heat individual rooms or zones rather than heating the entire house like centrally heated homes. Thus the space heating demand of households relying solely on solid fuels is assumed to be less than that of centrally heated houses.

However, dwellings that rely on solid fuels as the main space heating fuels tend to be older households, as shown in *Figure 76*. The households relying on coal and peat have a greater share of their total stock in the older periods of construction than all other fuels. For example, approximately 14-15% of coal and peat dwellings were build before 1919 but only 8% of dwellings for all other fuels were constructed before 1919. Older dwellings tend to have more energy consumption, as established by analysis of the BER database (see *Figure 50).* Therefore a solid fuel consumption of 15,000 kWh per annum was assumed as the average annual consumption of solid fuel dwellings in 2011. It is assumed that there was an additional 5,000 kWh per annum of firelogs also consumed in the dwellings relying on coal and peat as the main space heating fuel.

Figure 76 *Comparison of share of period of construction of dwellings for coal and peat to that of the rest of the stock*



Source: CSO

Using this bottom up consumption assumption for the number of houses that consume coal and peat (157,783 households) results in an excess of 56% of residential coal and 58% of residential peat compared to the 2011 national energy balance total consumption of coal and peat in the residential sector. This excess coal and peat consumption is used for supplementary heating in open fires, stoves or ranges.

A5.5.1 Sod Peat Consumption

It is assumed that all households that rely on peat as the main space heating fuel use sod peat only (101 ktoe or approximately 242,812 tonnes of sod peat) and all peat briquettes are used for supplementary heat only (79 ktoe). Based on those assumptions the consumption of sod peat as a supplementary fuel accounted for another 61 ktoe in 2011. This equates to somewhere between 150,000 and 200,000 dwellings using sod peat as a supplementary heating fuel.

A5.6 Assumptions for Calculating Firewood/Wood Log Consumption from Census 2011

The following tables detail the assumptions used to estimate wood/firelog use from the census 2011 data. *Table 51* contains the assumption used to estimate wood/firelog consumption in households that solely rely on wood as the main space heating fuel. The overall consumption per household increased in the '80's and '90's as the households are more than likely to have switched from room only heating to heating the whole house by using a back boiler system. The subsequent reduction in homes built in later years is due to stricter building regulations.

Table 51 *Estimates of wood log consumption in homes with wood as the main fuel type from the 2011 Census*

Assumed Energy Consumption per Dwelling (kWh)	Period of Construction	Number of Dwellings & Share by Period of Construction	Total Energy (ktoe)
		21,395	
23,520	Before 1919	22%	
23,520	1919 to 1945	9%	
23,520	1946 to 1960	7%	
23,520	1961 to 1970	5%	
23,520	1971 to 1980	11%	
20,000	1981 to 1990	10%	
18,000	1991 to 2000	9%	
15,000	2001 to 2005	9%	
10,000	2006 or later	17%	
20,000	Not stated	2%	
			36

Sources: CSO and SEAI

It is assumed in *Table 51* that all dwellings that have wood as the main fuel type in Census 2011 are using wood logs, but we know from the SEAI wood fuel suppliers that consumption of wood pellets, chips and briquettes accounted for 13 ktoe in 2011. Therefore consumption of wood that is currently unaccounted for is more likely to be approximately 23 ktoe.

Table 52 examines the wood/firelog consumption of households which mainly rely on the various other solid fuels used in the residential sector for space heating. It is assumed that newer constructed dwellings are less likely to rely on open fires/stoves than older dwellings.

Table 52 *Estimates of wood log consumption in dwellings with coal and peat as the main fuel types from the 2011 Census*

Assumed Wood Energy Consumption per Dwelling (kWh)	Period of Construction	Number of Dwellings by Main Space Heating Fuel & Share of Period of Construction		Total Energy (ktoe)
		Coal	**Peat**	
		79,145	***78,638***	
5880	Before 1919	14%	14%	
5880	1919 to 1945	11%	11%	
5880	1946 to 1960	10%	10%	
5880	1961 to 1970	7%	7%	
5880	1971 to 1980	15%	15%	
5000	1981 to 1990	14%	14%	
4500	1991 to 2000	12%	12%	
3750	2001 to 2005	8%	8%	
2500	2006 or later	4%	4%	
5000	Not stated	3%	3%	
		36	***36***	***72***

Sources: CSO and SEAI

Table 53 examines the wood/firelog consumption of households which rely on oil, natural gas, electricity and where the fuel type was not stated. It is assumed that only 60% of natural gas households have an open fire or stoves after examining the BER research tool database. The rest of the natural gas households use decorative effect gas fired appliances or supplementary electric heating. It is assumed that 95% of oil households, 80% of LPG households and 30% of electricity households have an open fire or stoves after examining the BER research tool database.

Table 53 *Estimates of firewood consumption in dwellings with various main fuel types from the 2011 Census*

Assumed Wood Energy Consumption per Dwelling (kWh)	Period of Construction	Number of Dwellings by Main Space Heating Fuel & Share of Period of Construction					Total Energy (ktoe)
		Gas	**Oil**	**LPG**	**Electricity**	**Not stated**	
		331,050	***675,012***	***8,542***	***41,082***	***30,862***	
2,500	Before 1919	15%	9%	8%	10%	6%	
2,500	1919 to 1945	13%	6%	4%	13%	7%	
2,000	1946 to 1960	11%	7%	3%	11%	7%	
2,000	1961 to 1970	7%	7%	4%	7%	16%	
1,500	1971 to 1980	15%	16%	11%	15%	12%	
1,500	1981 to 1990	16%	12%	16%	16%	15%	
1,500	1991 to 2000	11%	15%	13%	11%	15%	
1,000	2001 to 2005	7%	15%	21%	7%	9%	
1,000	2006 or later	5%	9%	16%	5%	9%	
1,000	Not stated	2%	3%	3%	2%	3%	
		51	***92***	***1***	***6***	***4***	***155***

Sources: CSO and SEAI

Based on the assumptions included in *Table 51*, *Table 52* and *Table 53* the overall residential wood/firelog consumption estimate is 262 ktoe. It is likely that this estimate overstates the fuel use in the residential sector as not all households light a fire/stove as regularly as included in the main assumptions.

A5.7 Assumptions for Calculating Wood Energy Use from Household Budget Survey

In order to estimate the volume of wood logs consumed from the spend reported in the Household Budget Survey an estimate of the price paid for wood logs is required. The price estimate per cubic meter for 2012/2013 was varied the by the inflation of energy products and resulted in the values presented in *Table 54*. It could be argued from the survey responses to the SEAI fuel cost comparison survey that the price of wood has had negligible variation since 2006. It should be noted that the lower the price per cubic meter the higher the physical and energy consumption. Therefore, using the values in *Table 54* gives a worst case scenario.

Table 54 *Historical timeseries of bulk wood log prices to the residential sector*

	2005	2006	2007	2008	2009	2010	2011	2012
Price per cubic metre (€/m3)	99	109	121	135	107	108	119	120
Consumer Price Index (% annual variation)	12.6	8.7	9.9	10.6	-26.5	1.2	9.2	0.7

Source: SEAI

The wood log consumption calculations based on the HBS are detailed in *Table 55*. The spend on wood pellets, briquettes and chips used in the residential sector is subtracted from the overall spend to give the spend on wood logs only. This consumption reflects traded wood only and uses the conversion factors in *Table 45* and *Table 44* for wood at 25% moisture.

Table 55 *Estimates of wood log consumption from the Household Budget Survey*

Year	Spend per dwelling per week €	Number of Dwellings	Total Spend $€_{millions}$	Wood Log Spend $€_{millions}$	Price per m^3	Wood Log consumption (Bulk m^3)	Wood Log consumption (Tonnes)	Wood Log Energy per annum (ktoe)
2006	0.30	1,462,296	22.95	13.12	€109	120,887	42,552	13
2007	0.36	1,499,718	28.34	22.00	€120	182,657	64,295	20
2008	0.40	1,537,141	31.84	25.15	€135	186,674	65,709	21
2009	0.36	1,574,563	29.48	21.60	€106	202,807	71,388	22
2010	0.36	1,611,986	30.57	21.87	€108	202,894	71,419	22
2011	0.37	1,649,408	31.68	25.92	€119	218,346	76,858	24

Sources: CSO and SEAI

Appendix 6: Residential Electricity End Use

Estimates for Residential Electricity End-Use

The assumptions contained in *Table 56* were used to create the breakdown of residential electricity consumption in Ireland in 2011. The source for the number of households was the 2011 Census. The sources for the number of appliances were the 2009/2010 Household Budget Survey and the Smart Metering Trial (SMT). Data on usage was taken from the SMT for wet appliances, with the appliance consumption taken from the Energy Savings Trust (EST). The consumption data for lighting, central heating pumps and fans, and water heating was sourced from the BER database. The cooking and space heating annual consumption was estimated from the Household Budget Survey .

Table 56 *Assumptions for electricity end-use breakdown*

	Unit Consumption (kWh) [households / appliances]	Share of housing stock (%)	Total Electricity Consumption (GWh)	Share of Electricity Consumption (%)	Data Sources
Cooking[1]	**520**	**76**	**648**	**8**	**HBS & SMT**
Refrigerator	162	26	70		EST & HBS
Fridge-freezer	427	79	559		EST & HBS
Freezer (stand alone)	345	35	200		EST & HBS
Consumption of Cold Appliances[2]			**830**	**10**	**EST & HBS**
Washing machine	207	96	329		EST, SMT & HBS
Dishwasher	297	63	309		EST, SMT & HBS
Clothes Dryers	227	66	247		EST, SMT & HBS
Consumption of Wet Appliances[3]			**887**	**11**	**EST, SMT & HBS**
Lighting	**825**	**100**	**1,363**	**16**	**BER database**
Space Heating[4]	**4,250**	**8.5**	**597**	**7**	**HBS & Census**
Central Heating Pump	130	98	211		BER database
Oil Boiler pump	100	43	71		BER database
Gas Boiler flue fan	45	34	25		BER database
Central Heating Pumps & Fans			**307**	**4**	**BER database**
Hot water for non-electrical households	1,470	69	1,683		BER database
Hot water for electrical households	4,000	8.5	421		BER database
Hot Water			**2,104**	**25**	**BER database**
Small Appliances & other[5]			**1,549**	**19**	**Remainder**

Source: SEAI

1. Cooking excludes microwaves, kettles, steamers, slow cookers and other small electrical cooking appliances

2. Cold appliances only includes refrigerators (refrigerators and refrigerator/freezers) and stand-alone freezers

3. Wet appliances include washing machines, dishwashers and clothes dryers

4. Space heating accounts for households with electricity as the main space heating fuel and does not include portable electrical heaters

5. Any errors in the calculations of all the other categories are included in the small appliances and other category as the share of end-use electricity is calculated as a remainder.

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