SUSTAINABLE ENERGY AUTHORITY OF IRELAND

ENERGY IN THE RESIDENTIAL SECTOR

2018 Report

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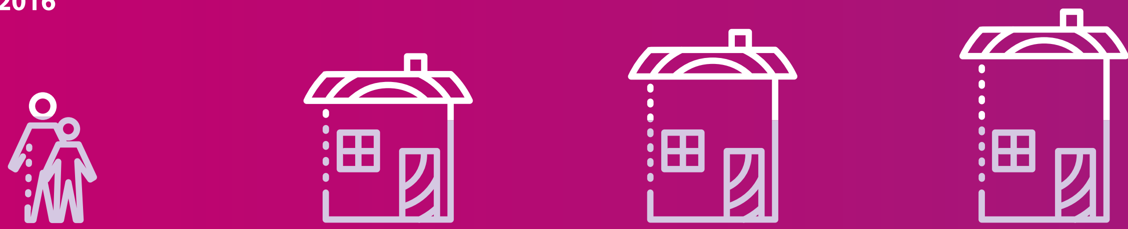
Ireland's Homes in the 21st Century

The residential sector accounts for a quarter of the energy used in Ireland, and is also responsible for a quarter of the energy-related CO_2 emissions. From 2006-2014 there were significant reductions in the amount of emissions from homes, but since 2014 this trend has reversed and carbon dioxide emissions have started to increase. Irish homes emit almost 60% more CO_2 than the average EU home.

Ireland's growing population means the number of dwellings is increasing with

1.7 million households in 2016

2000 – 2016

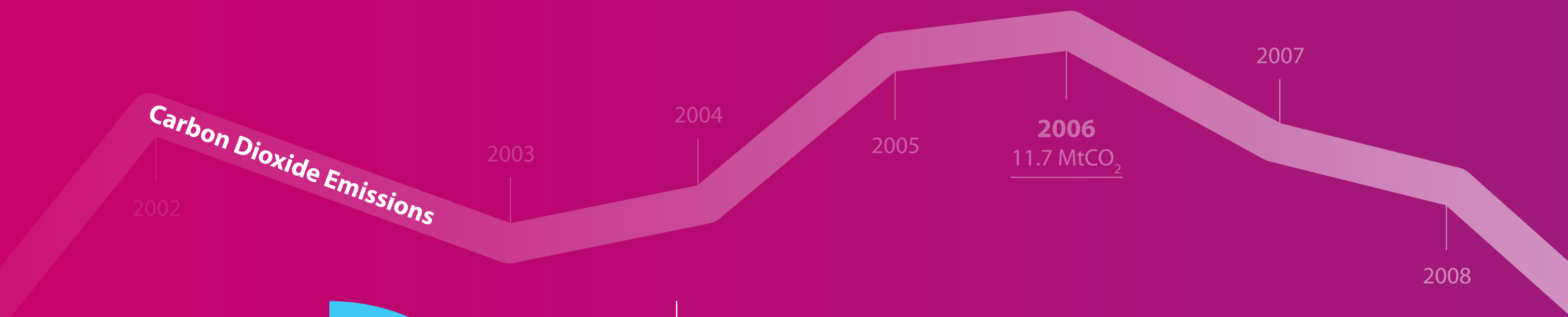


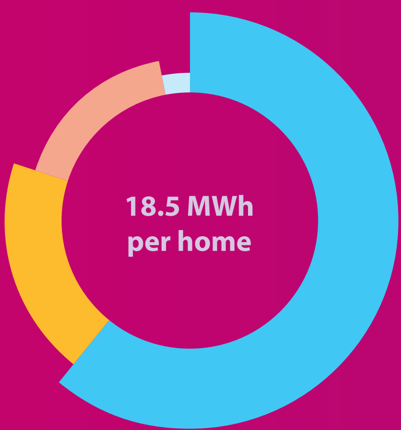
25%
increase in population

15%
increase in average floor area across all homes

39%
increase in number of occupied houses

60%
increase in total floor area





Energy use in an average Irish home 2016

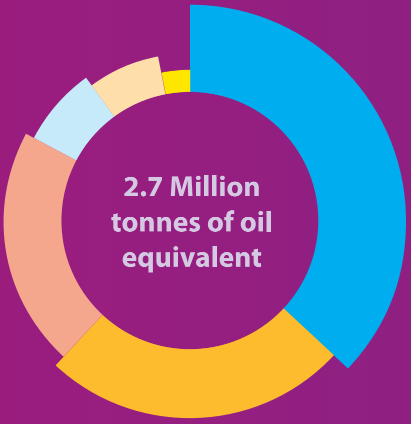
Space heating	61%
Water heating	19%
Lighting and appliances	17%
Cooking	3%

25% ↓

Reduction in CO_2 from 2006 to 2014

Through a combination of:

- Energy efficiency improvements
- High energy prices
- Reduced disposable incomes

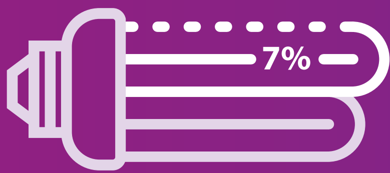


Irish household final energy usage 2016

Oil	37%
Electricity	25%
Gas	21%
Coal	7%
Peat	7%
Renewables	3%

In 2015, the average Irish home used

7% more energy



than the average EU home

It also emitted

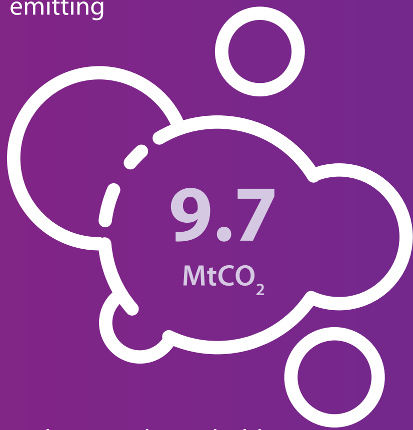
58% more CO_2

due to greater use of high-carbon fuels including oil, coal and peat

In 2016, Irish households consumed

2.7 **Mtoe of energy**

emitting



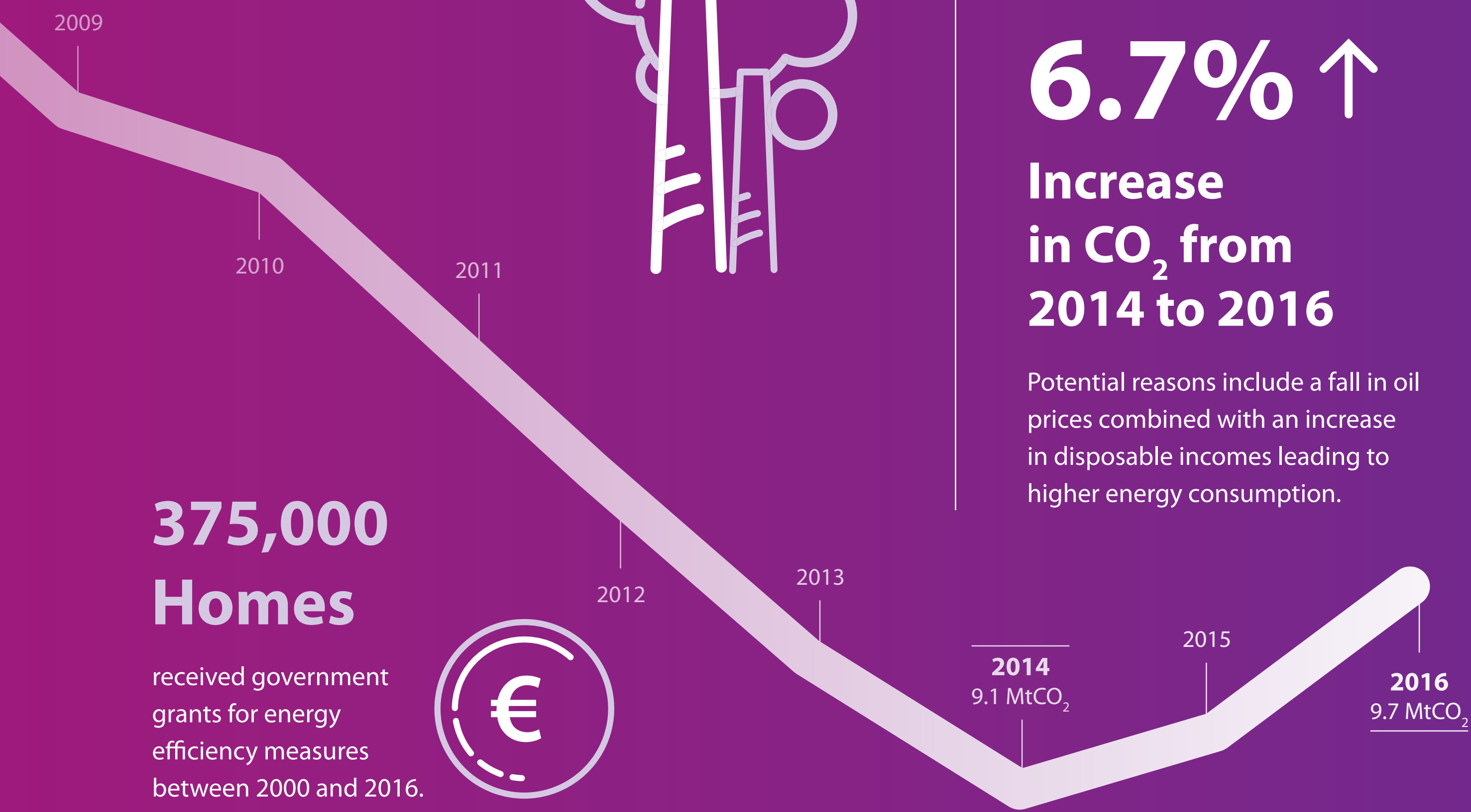
and costing households

€3.4 billion

6.7% ↑

Increase in CO_2 from 2014 to 2016

Potential reasons include a fall in oil prices combined with an increase in disposable incomes leading to higher energy consumption.



375,000 Homes

received government grants for energy efficiency measures between 2000 and 2016.

Sustainable Energy Authority of Ireland

SEAI is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with Government, homeowners, businesses and communities to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies. SEAI is part-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 policymakers and informing investment decisions. Based in Cork, EPSSU is SEAI's specialist statistics team. Its core functions are to:

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

Acknowledgements

SEAI gratefully acknowledges the cooperation of all the organisations, agencies, energy suppliers and distributors that provided data and responded to questionnaires throughout the year.

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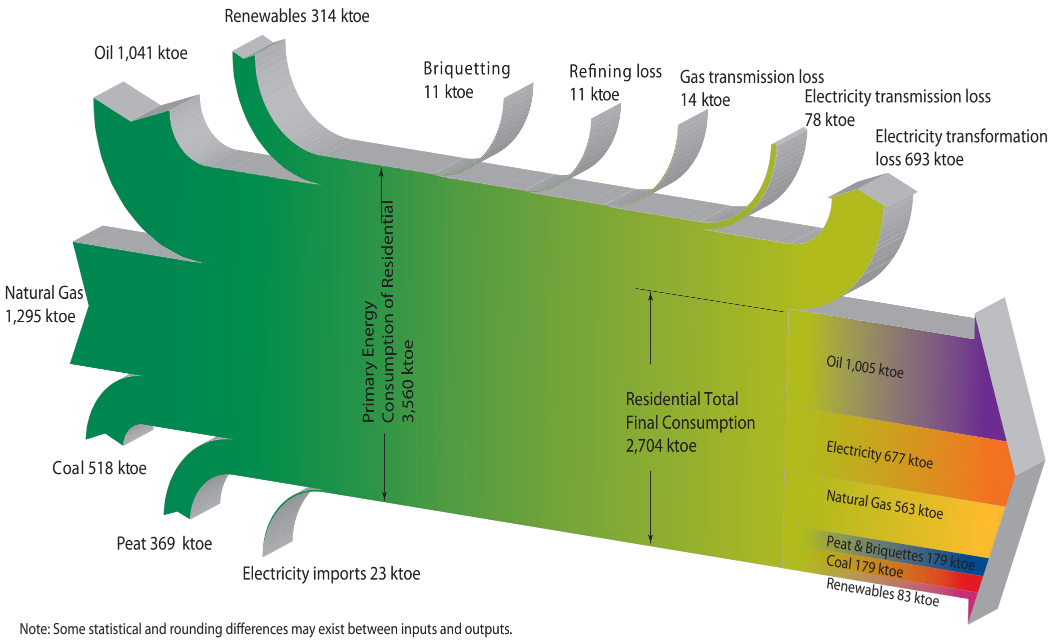
1 Residential Sector Energy Demand and Related Carbon Emissions

This section presents statistics on energy use in the residential sector, showing trends in energy demand and associated carbon emissions. Through monitoring these trends, it is possible to track the contribution of the sector to carbon reduction and renewable energy targets. We also present, for the first time, an estimate of the breakdown of Ireland's residential energy by end-use; such as space heating, water heating and cooking. Splitting energy use data into end-uses provides more detailed insights into how we use energy in our homes.

1.1 Energy

Figure 1 shows Ireland's residential sector energy balance for 2016 as an energy flow diagram. Fuel inputs, which are on the left, totalled 3,560 ktoe (kilotonnes of oil equivalent) and include the fuels[1] used to generate the electricity consumed by the sector. This is referred to as the primary energy use. The energy transformation losses, which were mostly from electricity generation, amounted to 808 ktoe, which was 23% of residential primary energy use. Final energy consumption[2] is illustrated on the right hand side of the graph, and was 2,704 ktoe in 2016. This represents 23% of Ireland's total final energy use.

Figure 1: Residential sector energy balance, 2016



Source: SEAI

Figure 2 shows the trend for residential sector final energy consumption between 1990 and 2016. Variations in weather from year to year, in particular temperature variations, affect energy demand, particularly for space heating. It is possible to correct for the effect of annual weather variations using the method of degree-days, which is explained further in *Section 2.5*. *Figure 2* shows the trend in residential final energy after weather-correction has been applied. Accounting for weather variations, residential energy demand decreased every year between 2007 and 2012, but grew in 2013, 2015 and 2016. Between 2014 and 2016, overall residential sector final energy consumption increased by 6.5% (3.2% per annum) when adjusted for weather effects.

1 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.

2 Final Energy is essentially Primary Energy less the quantities of energy required to transform and distribute primary sources, such as crude oil into forms suitable for use by consumers e.g. refined oils and electricity.

Plausible reasons for the overall decrease in residential energy use between 2007 and 2014 include a combination of:

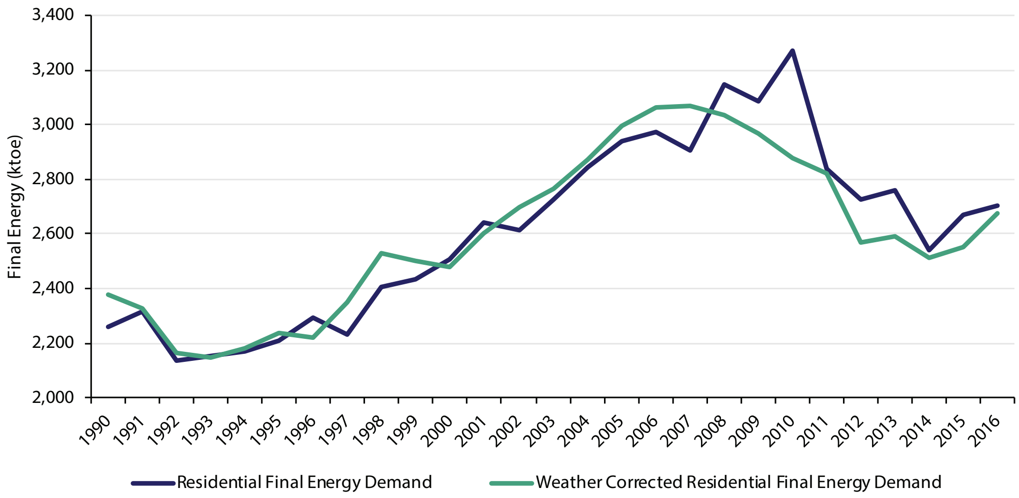
- Improved thermal efficiency of new dwellings and existing dwellings that were upgraded.
- Reduced household incomes and expenditure, due to the economic downturn
- High energy prices
- Fuel switching from traded energy such as oil and gas to un-traded energy, such as wood and sod peat, which are not well accounted for in the national statistics

Plausible reasons for the increase in residential energy use in 2015 and 2016 include:

- Increasing household incomes and expenditure
- Reduced energy price, particularly of oil
- Fuel switching from un-traded wood and peat to oil and gas

Section 2 of this report provides insights into these underlying drivers. More data and research is required to fully understand the reasons for the recent increase in household energy use, and to allow better predictions of future trends.

Figure 2: Residential sector final energy demand, 1990 to 2016



Source: SEAI

Table 1 shows data on final energy consumption for each sector of the economy in 1990, 2005 and 2016. In 1990 the residential sector was the largest energy-using sector but was surpassed by the transport sector in 1992. From 1992 to 2016, the residential sector had the second largest final energy demand after the transport sector, and in 2016 it accounted for 23% of final energy demand. Apart from the agriculture sector, which is small in energy terms, the residential sector experienced the smallest growth between 1990 and 2016.

Between 2014 and 2016, overall residential sector final energy consumption increased by 6.5% when adjusted for weather.

Table 1: Final energy consumption by sector

	Quantity (ktoe)			Shares %			Growth %		Average annual growth rates %		
	1990	2005	2016	1990	2005	2016	'90 – '16	'05 - '16	'90 – '05	'05 – '16	2016
Transport	2,019	5,082	4,947	28%	40%	42%	145%	-3%	6.3%	-0.2%	3.4%
Residential	2,258	2,940	2,704	31%	23%	23%	20%	-8%	1.8%	-0.8%	1.2%
Industry	1,720	2,633	2,445	24%	21%	21%	42%	-7%	2.9%	-0.7%	1.6%
Services	972	1,569	1,357	13%	12%	12%	40%	-14%	3.2%	-1.3%	7.8%
Agriculture	280	383	226	4%	3%	2%	-19%	-41%	2.1%	-4.7%	2.7%
Total	**7,249**	**12,607**	**11,680**				**61%**	**-7%**	**3.8%**	**-0.7%**	**3.0%**

Source: SEAI

The residential sector had the second largest final energy demand in 2016, after the transport sector.

Figure 3 and *Table 2* show residential final energy use split by fuel type and corrected for weather for the period 1990 to 2016. Weather-correction is only applied to the portion of each fuel that is estimated to be used for heating. *Table 3* shows residential final energy use without weather-correction for reference.

Between 1990 and 2000, there was a clear switch away from solid fuels such as coal and peat, which would traditionally have been burned in open fires, towards oil and gas, typically used in central heating systems. In the latter part of the period from 2005 to 2016, the fuel shares became more stable, with a gradual increase in the shares of electricity and gas and a continuing, though gradual, decline in coal and peat use.

Between 1990 and 2005, the use of wood logs declined, along with the decline of coal and peat use for open fires. In the period 2005 to 2016, renewables grew significantly, primarily due to increasing use of wood pellets.

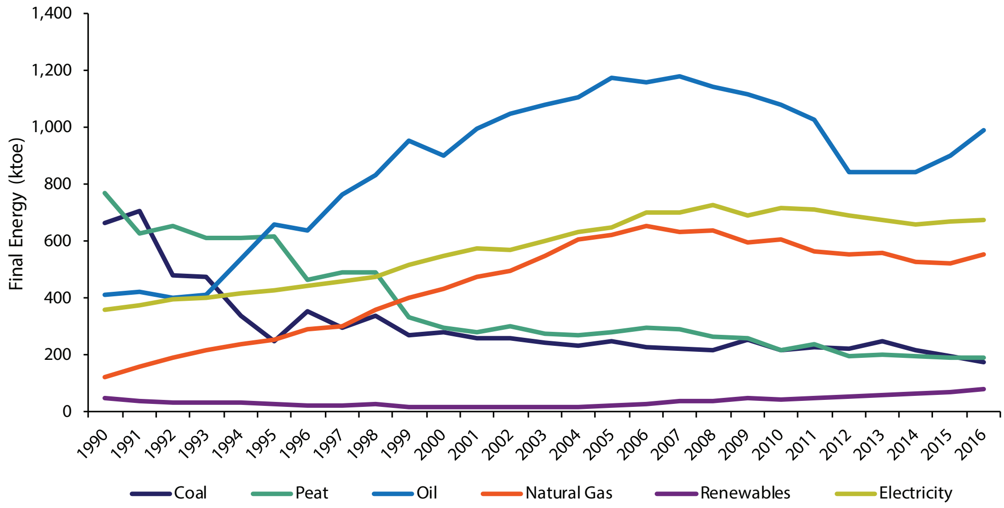
Looking at the period 2007 to 2014, overall weather-corrected residential energy use declined by 18% or 556 ktoe. The majority of the reduction was from oil, which fell by 28% or 334 ktoe, followed by gas, which fell by 17% or 106 ktoe. Between 2014 and 2016, overall weather-corrected residential energy use increased by 6.5% or 162 ktoe. The majority of the increase was from oil use, which increased 146 ktoe, or 17%. In comparison gas increased by 26.7 ktoe or 5.1%. One potential reason for the higher fluctuation in oil use, relative to gas, may be the greater increase in oil price, relative to gas, in the period 2010 to 2015. Another factor may be that the majority of oil-fired dwellings are located in rural areas where there may be greater opportunity for fuel switching to solid fuels. Data from the 2016 census, discussed further in *Section 2.2.8*, suggests that there was some shift from oil to solid fuel heating systems between the 2011 and 2016 census.

There is a high degree of uncertainty on the amounts of untraded fuels, for example wood and sod peat used in the residential sector, as there are currently no reliable sources of data for these fuels. However, it is estimated that untraded wood and sod peat combined accounted for just 1.2% of residential total final energy consumption in 2016. Appendix 4 provides more information on how statistics on residential energy use are produced.

It is also notable that total electricity consumption peaked in 2008 and has reduced slightly to 2016, having more than doubled between 1990 and 2008. There is some evidence of a levelling off in the growth of large household appliances and an increase in appliance efficiency, as discussed in *2.6*. Other contributing factors could be increased electricity prices, a reduction in electricity used for space and water heating due to greater thermal efficiency or fuel switching. Improved data on electricity use in households and on appliance ownership and use, specific to Ireland, would add to our understanding of this trend.

Household electricity consumption more than doubled between 1990 and 2008, but reduced between 2008 and 2016

Figure 3: Residential sector final energy demand (weather-corrected) split by fuel type, 1990 to 2016



Source: SEAI

Table 2: Residential sector final energy consumption, weather-corrected, by fuel type

Residential Final Energy (Weather-Corrected)	Quantity (ktoe)			Shares %			Growth %		Average annual growth rates %		
	1990	2005	2016	1990	2005	2016	'90 – '16	'05 - '16	'90 – '05	'05 – '16	2016
Coal	664	252	176	29%	9%	7%	-73%	-30%	-6.3%	-3.2%	-9.3%
Peat	769	280	194	34%	10%	7%	-75%	-31%	-6.5%	-3.3%	2.6%
Oil	413	1,173	991	18%	40%	37%	140%	-15%	7.2%	-1.5%	9.9%
Natural Gas	124	622	555	6%	21%	21%	346%	-11%	11.3%	-1.0%	6.0%
Direct Fossil Fuels Use (Total)	**1,971**	**2,326**	**1,917**	**87%**	**79%**	**71%**	**-3%**	**-18%**	**1.1%**	**-1.7%**	**6.0%**
Renewables	47	23	82	2%	1%	3%	73%	252%	-4.6%	12.1%	13.8%
Electricity	359	648	676	16%	22%	25%	N/A	4%	4.0%	0.4%	0.6%
Total	**2,378**	**2,998**	**2,675**	**105%**	**102%**	**99%**	**13%**	**-11%**	**1.6%**	**-1.0%**	**4.8%**

Source: SEAI

Table 3: Residential sector final energy consumption, by fuel type

Residential Final Energy	Quantity (ktoe)			Shares %			Growth %		Average annual growth rates %		
	1990	2005	2016	1990	2005	2016	'90 – '16	'05 - '16	'90 – '05	'05 – '16	2016
Coal	626	246	179	28%	8%	7%	-71%	-27%	-6.0%	-2.9%	-13.3%
Peat	725	273	197	32%	9%	7%	-73%	-28%	-6.3%	-2.9%	-1.9%
Oil	389	1,145	1,005	17%	39%	37%	158%	-12%	7.5%	-1.2%	5.1%
Natural Gas	117	607	563	5%	21%	21%	380%	-7%	11.6%	-0.7%	1.4%
Direct Fossil Fuels Use	**1,857**	**2,271**	**1,944**	**82%**	**77%**	**72%**	**5%**	**-14%**	**1.3%**	**-1.4%**	**1.4%**
Renewables	45	23	83	2%	1%	3%	86%	266%	-4.4%	12.5%	8.8%
Electricity	356	646	677	16%	22%	25%	90%	5%	4.0%	0.4%	-0.1%
Total	**2,258**	**2,940**	**2,704**				**20%**	**-8%**	**1.8%**	**-0.8%**	**1.2%**

Source: SEAI

1.2 Carbon Dioxide Emissions

Table 4 shows data on energy-related CO_2 emissions for each sector of the Irish economy in 1990, 2005 and 2016. From 1990 to 1999, the residential sector was the largest source of energy-related CO_2 emissions in Ireland. From 2001 to 2016, the residential sector was the second largest source of energy-related CO_2 emissions after the transport sector. In 2016, transport accounted for 37% of national energy-related CO_2 emissions, with residential accounting for 25%.

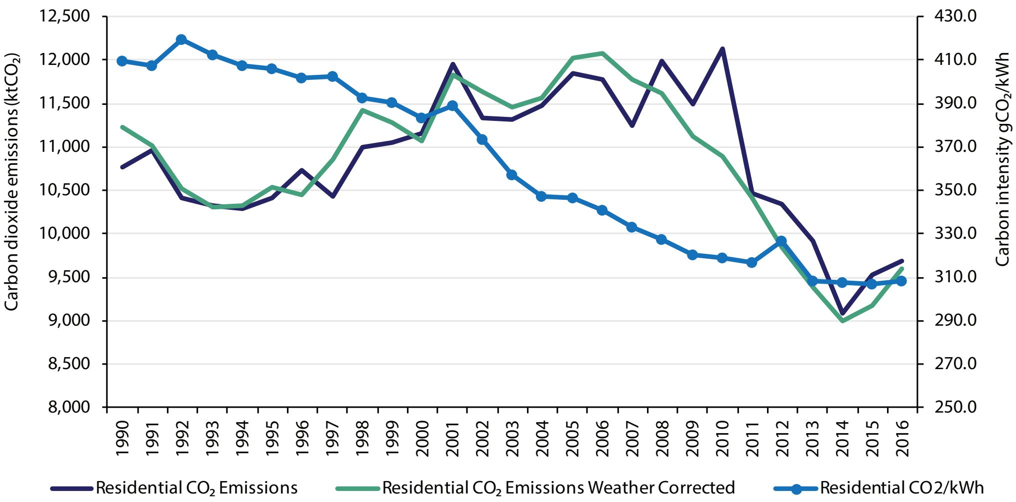
Table 4: Energy-related CO_2 emissions by sector

	Quantity (ktoe)			Shares %			Growth %		Average annual growth rates %		
	1990	2005	2016	1990	2005	2016	'90 – '16	'05 - '16	'90 – '05	'05 – '16	2016
Transport	6,043	15,293	14,620	20%	33%	37%	142%	-4%	6.4%	-0.4%	3.9%
Residential	10,764	11,843	9,690	35%	25%	25%	-10%	-18%	0.6%	-1.8%	1.6%
Industry	7,899	10,519	8,765	26%	22%	22%	11%	-17%	1.9%	-1.6%	4.2%
Services	4,730	7,764	5,189	15%	17%	13%	10%	-33%	3.4%	-3.6%	7.4%
Agriculture	1,133	1,414	817	4%	3%	2%	-28%	-42%	1.5%	-4.9%	3.5%
Total	**30,569**	**46,834**	**39,081**				**28%**	**-17%**	**2.9%**	**-1.6%**	**3.8%**

Source: SEAI

The CO_2 emissions resulting from energy use in the residential sector are shown in *Figure 4* and *Table 5*. Data is shown for total CO_2 emissions ($ktCO_2$), weather-corrected total CO_2 emissions ($ktCO_2$), and the carbon intensity of all residential fuel use (gCO_2/kWh). Weather-corrected CO_2 emissions decreased between 2006 and 2014, and returned to growth in 2015 and 2016, in line with the trend in energy consumption in this period. The carbon intensity of residential energy, (i.e. the CO_2 emissions per unit of energy used), has decreased steadily since 1990. In the early part of the period, this was due mostly to switching from coal and peat to oil and gas, and in the latter part was due mostly to the improved carbon intensity of electricity. Between 2005 and 2016, electricity use in households increased by 5% but the associated CO_2 emissions decreased by 20%.

Figure 4: Residential energy-related CO_2 emissions and CO_2 intensity, 1990 to 2016



Source: SEAI

Between 2005 and 2016, electricity use in households increased by 5%, but the associated CO_2 emissions decreased by 20%

Table 5: Energy-related CO_2 emissions in the residential sector

Residential CO_2 Emissions	Quantity ($ktCO_2$)			Share			Growth		Average Annual Growth rates		
	1990	2005	2016	1990	2005	2016	1990-16	2005-16	1990-05	2005-16	2016
Coal	2,483	989	721	23%	8%	7%	-71%	-27%	-6.0%	-2.8%	-13.2%
Peat	3,123	1,170	842	29%	10%	9%	-73%	-28%	-6.3%	-2.9%	-1.8%
Oil	1,175	3,467	3,008	11%	29%	31%	156%	-13%	7.5%	-1.3%	5.1%
Natural Gas	270	1,443	1,317	3%	12%	14%	388%	-9%	11.8%	-0.8%	-0.5%
Direct Fossil Fuels	**7,052**	**7,069**	**5,889**	**66%**	**60%**	**61%**	**-16%**	**-17%**	**0.0%**	**-1.6%**	**0.3%**
Electricity	3,713	4,773	3,801	34%	40%	39%	2%	-20%	1.7%	-2.0%	3.7%
Total	**10,764**	**11,843**	**9,690**				**-10%**	**-18%**	**0.6%**	**-1.8%**	**1.6%**
Total Weather Corrected	**11,227**	**12,033**	**9,602**				**-14%**	**-20%**	**0.5%**	**-2.0%**	**4.7%**

Source: SEAI

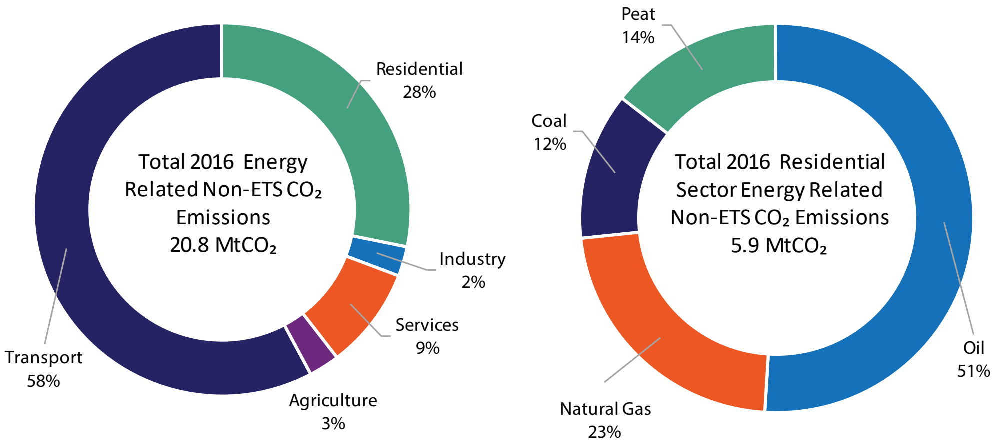
1.2.1 Non Emissions Trading Scheme Carbon Emissions

The EU 2020 Climate and Energy Package[3] set a target for the EU as a whole to achieve 20% greenhouse gas (GHG) emissions reduction by 2020. The GHG emissions reductions targets are split across two categories. The first category covers large scale carbon emitters in industry, electricity generation and aviation. These bodies are dealt with at EU level under the EU Emission Trading System (ETS). The second category covers all GHG emissions not covered by the ETS, known as the non-ETS sector. This includes the majority of GHG emissions in the residential, transport and agricultural sectors. Achieving GHG emissions reductions in the non-ETS sector is the responsibility of national governments. The Effort Sharing Decision (2009/406/EC)[4] set a mandatory target for Ireland to reduce non-ETS emissions by 20% below 2005 levels by 2020.

Figure 5 shows Ireland's energy-related Non-ETS sector CO_2 emissions split by sector, and also presents residential energy-related non-ETS CO_2 emissions split by fuel type. In the residential sector, CO_2 emissions resulting from use of electricity generated by large public power stations are covered by the ETS sector[5]and so are not included in this chart. Oil-based central heating systems are responsible for over half of all residential energy-related non-ETS CO_2 emissions. Coal and peat use combined accounted for 27%, more than natural gas at 23%.

Residential energy-related non-ETS CO_2 emissions reduced by 17% between 2005 and 2016. The reduction in oil use over the period was the largest factor behind this reduction, followed by the reduction in peat and coal use.

Figure 5: Energy-related non-ETS CO_2 emissions split by sector, and for the residential sector split by fuel type, 2016



Source: SEAI

3 See https://ec.europa.eu/clima/policies/strategies/2020_en
4 See https://ec.europa.eu/clima/policies/effort_en#tab-0-0
5 Similarly, if waste heat from large power plants or industrial facilities was to be used in district heating schemes, then this would also be counted under the ETS scheme.

1.3 Residential Sector Energy by End-Use

This section presents new estimates of household energy use split by end-use, i.e. the share of energy used for space heating, water heating, cooking, lighting and electric appliances. This data breakdown gives greater insight into how energy is used in the home. This can help inform policy and behaviour change to maximise energy efficiency, and minimise fossil fuel use and CO_2 emissions.

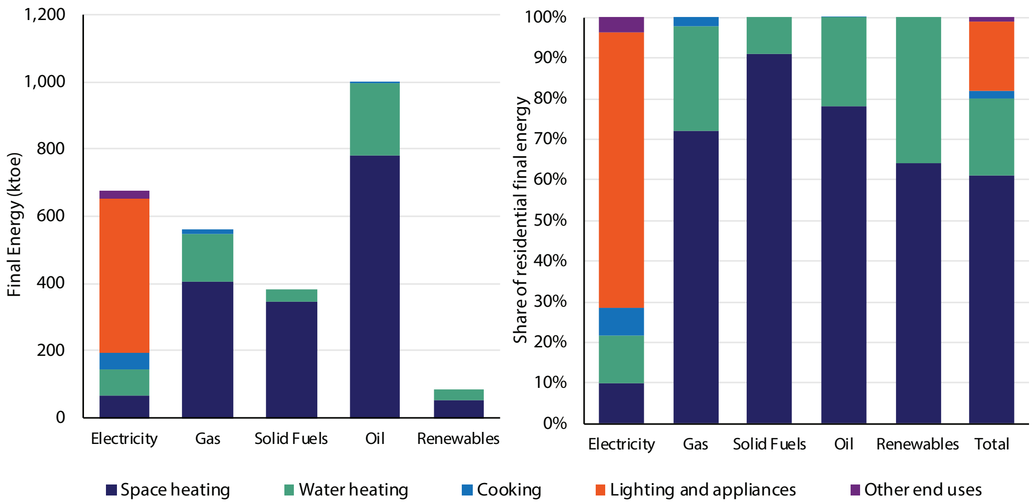
It is not simple to estimate household energy split by end-use using standard energy use data; for example, it is not simple to estimate from an electricity meter reading what share of electricity is used for appliances versus water heating. To overcome this difficulty there are a number of possible approaches, for example household surveys, modelling or in-situ measurement.

It was decided that modelling was the most appropriate option for Ireland, in the first phase, based on data and resource requirements. This led to the development of the Irish Residential Energy End-Use Model (IREEUM), which is described in more detail in Appendix 3. In practice a combination of methods is required to effectively produce an accurate assessment. Incorporating robust data gathered through household surveys or in-situ measurement would improve accuracy. It is envisaged that the initial model can be built upon and improved over time through including the results of some or all of the other methods of data collection.

Figure 6 and *Table 6* show residential sector final energy consumption for 2016, split by fuel type and end-use. The relative share of each end-use for each fuel type is shown on the right hand side of *Figure 6*. This is the key output from the modelling exercise. These shares are then applied to data from the National Energy Balance for residential fuel use to give residential final energy by fuel type and end-use, as shown on the left hand side. It is estimated that in 2016:

- space heating accounted for 61% of residential final energy, or approximately 1,652 ktoe;
- space and water heating together accounted for 80% household energy use;
- space heating accounted for the majority of all fuel types, except electricity;
- lighting and appliances accounted for 68% of electricity use, with space and water heating accounting for 22%.

Figure 6: Residential energy by fuel type, split by end-use, 2016



Source: SEAI

Table 6: Residential final energy by fuel type and end-use, 2016

	Total	Space heating		Water heating		Cooking		Lighting and appliances		Other end-uses	
	ktoe	%	ktoe	%	ktoe	%	ktoe	%	ktoe	%	ktoe
Electricity	677	10%	67	12%	79	7%	47	68%	459	4%	25
Gas	563	72%	405	26%	145	2%	13	0%	0	0%	0
Solid Fuels	381	91%	347	9%	34	0%	0	0%	0	0%	0
Oil	1,000	78%	780	22%	219	0%	1	0%	0	0%	0
Renewables	83	64%	53	36%	30	0%	0	0%	0	0%	0
Total	**2,704**	**61%**	**1,652**	**19%**	**507**	**2%**	**61**	**17%**	**459**	**1%**	**25**

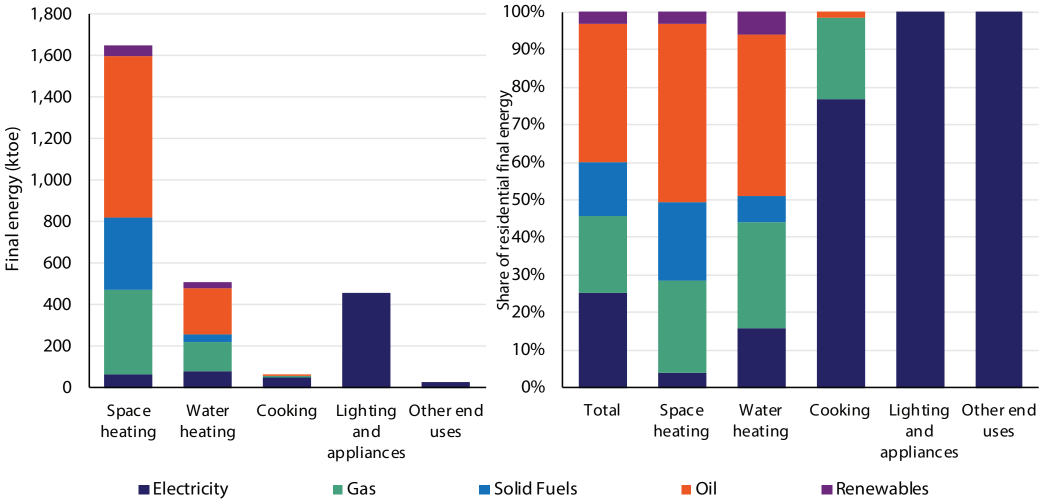
Source: SEAI

Space heating accounts for 61% of residential final energy

Figure 7 shows final energy by end-use, split by fuel type. It is estimated that in 2016:

- Oil accounted for 47% of energy used for space heating, gas 25% and solid fuels 21%.
- Oil accounted for 43% of energy used for water heating, gas 29% and electricity 16%.

Figure 7: Residential energy by end-use, split by fuel type, 2016



Source: SEAI

Oil accounts for 47% of energy used for space heating

2 Underlying Factors Influencing Residential Energy Demand

This section examines the underlying drivers of residential sector energy usage and CO_2 emissions to provide a deeper understanding of the observed trends. Factors such as the housing stock, energy prices and weather are analysed based on data produced by SEAI, the Central Statistics Office, Eurostat, the IEA, and the Department of Housing.

2.1 Demographics

Population is one of the main determinants of the numbers of dwellings. *Table 7* shows the population of the Republic of Ireland in census years between 1991 and 2016. The population increased by 3.8% between 2011 and 2016, by 12% in the 10 years from 2006 to 2016 and by 31% in the 20 years from 1996 to 2016.

Table 7: Rep. of Ireland population and average number of persons per household, census years 1991 to 2016

	1991	1996	2002	2006	2011	2016
Population	3,525,719	3,626,087	3,917,203	4,239,848	4,588,252	4,761,865
Persons per household	3.5	3.3	3.1	2.8	2.7	2.7

Source: CSO

The total number of dwellings also depends on the average number of persons per household. Historically, the number of persons per household in Ireland has been declining, but is still high by international standards. *Table 7* shows the average number of persons per household for census years from 1991 to 2016. The 2016 census results show that occupancy marginally increased between 2011 and 2016, breaking the historical trend. This can be attributed in part to the housing supply crisis that became increasingly pronounced throughout 2015 and 2016, originating with the collapse of the house building industry following the 2008 financial crisis.

Household size in Ireland, at 2.7 persons per household, remains very high by European standards, and is second only in the EU28 to Croatia. This compares to 2.4 persons per household in the UK in 2015. The EU countries with the lowest persons per household were Sweden on 1.9, and Germany and Denmark both on 2.0[6]. The trend for reducing average household size together with increasing population have resulted in a large increase in the number of occupied dwellings. This trend is likely to continue, given projected population growth and a likely further decrease in household size.

Ireland had 2.7 persons per dwelling in 2016, the second highest in the EU

Another factor affecting the demand for energy in the residential sector is the proportion of a typical day that a dwelling is occupied and heated. Dwellings which are empty for extended periods during the day typically require less energy for heating and lighting than those which are occupied, and heated, throughout the day. This is less true for highly efficient dwellings that retain heat throughout the day.

There is no direct data on the portion of the day that dwellings are heated, however a number of variables can be used to guide estimates. The portion of the day where a dwelling is heated tends to be lower where all residents are in employment or full time education outside the home and higher where residents are not in employment.

The rate of female participation in the workforce is one influencing factor. Over the past two decades 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 2011 this had increased to 53% and remained 53% at the end of 2016[7]. The number of households headed by retirees is another factor, as these households are more likely to be occupied and heated through out the day. In 1996 there were 259,003 households headed by people over 65 years of age. By 2016 this has increased to 395,522[8]. As the population ages the number of households headed by persons aged 65 and older will continue to increase.

6 Eurostat Household composition statistics; http://ec.europa.eu/eurostat/statistics-explained/index.php/Household_composition_statistics
7 CSO Quarterly National Household Survey; Available from www.cso.ie
8 CSO Census data; Private Households in Permanent Housing Units by Age Group of Reference Person. Available from www.cso.ie

2.2 The Housing Stock

The physical characteristics of the housing stock strongly influence the sector's energy demand, for example the number and type of dwellings, floor areas, fuels used, thermal efficiency, etc. In this section, we present some of the data available on these factors.

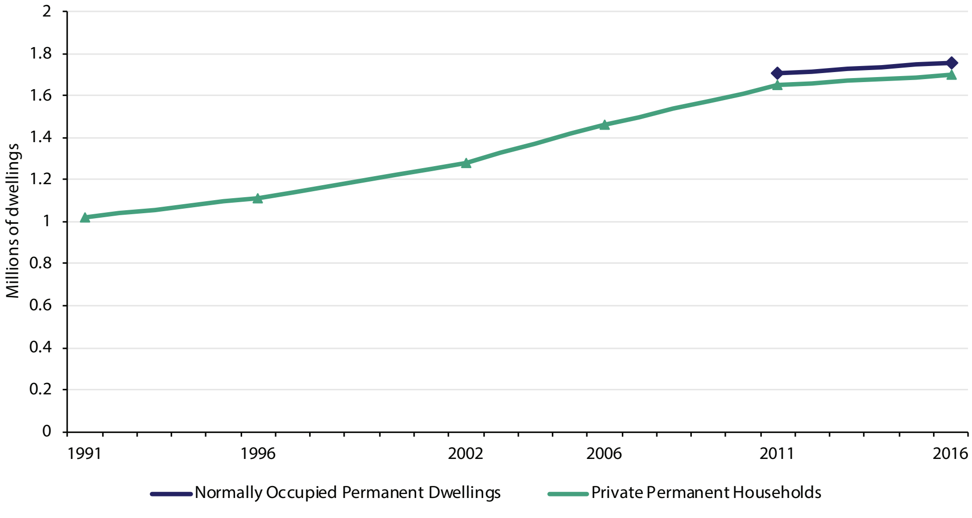
2.2.1 Number of Dwellings

The number of dwellings is tracked by the CSO in the national census. A time series is available back to 1926, recording the number of "permanent private dwellings", also referred to as "permanent private households". This has historically been used as the best indicator of the actual number of occupied dwellings in the country. It does not include temporary dwellings, holiday homes that are only occupied for part of the year and non-private households, defined as groups of persons situated in boarding houses, hotels, prisons or ships, etc[9].

The number of occupied dwellings increased by 33% between 2002 and 2016

The number of dwellings in Ireland remained below 700,000 from the 1920s through to the 1960s, but it grew significantly in the 1970s, and exceeded 1 million for the first time in the 1991 census. *Figure 8* and *Table 8* show the number of private households in permanent housing units in census years between 1991 and 2016. *Table 8* also shows the annual average growth rates between census years. The annual growth rate of 3.4% observed between 2002 and 2006 was the highest ever recorded, while the growth rate of just 0.6% recorded between 2011 and 2016 was the lowest since the 1960's. Overall, the number of occupied dwellings increased by 66% between 1991 and 2016 and by 33% between 2002 and 2016.

Figure 8: Private households in permanent housing units, 1991 to 2016



Source: CSO

Table 8: Private households in permanent housing units, 1991 to 2016

	1991	1996	2002	2006	2011	2016
Private Households in Permanent Housing Units	1,019,723	1,114,974	1,279,617	1,462,296	1,649,408	1,697,665
Annual average growth rate between censuses		1.8%	2.3%	3.4%	2.4%	0.6%

Source: CSO

The 2011 and 2016 census provided a more detailed breakdown of the occupancy status of dwellings, shown in *Table 9*. The indicator "Occupied by usual residents of the household" corresponds to "permanent private households" from previous census years. This breakdown also includes the category of "Unoccupied — residents temporarily absent", i.e. the dwelling is normally occupied but the residents were temporarily absent from the dwelling on the night of the census.

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

A more accurate estimate of the number of dwellings that are normally occupied in the census year may be to sum the dwellings "Occupied by usual resident(s) of the household", "Occupied by visitors only" and "Unoccupied — residents temporarily absent". In this report we label these as "Normally occupied permanent dwellings". For 2016 the number of these was 1,758,185, up by 52,791 since 2011.

For the calculations and indicators presented in this report, we have continued to use the number of dwellings "Occupied by usual residents of the household" on the night of the census, as the total number of occupied dwellings for 2011 and 2016. This is to allow comparison between years before and after 2011, for example to compare energy use per dwelling in 2005 to that in 2016, which would otherwise not be possible.

It is important to note that if an indicator such as energy per dwelling was calculated based on the higher figure of "Normally Occupied Permanent Dwellings", then this would give a lower estimate of energy consumption per dwelling. This would likely be more accurate than the estimate based on dwellings "Occupied by usual resident(s) of the household", but would not be comparable to pre-2011 data. This approach may be revised in future years as a longer time series becomes available for "Normally occupied permanent dwellings".

Table 9: Occupancy status of dwellings, 2011 and 2016

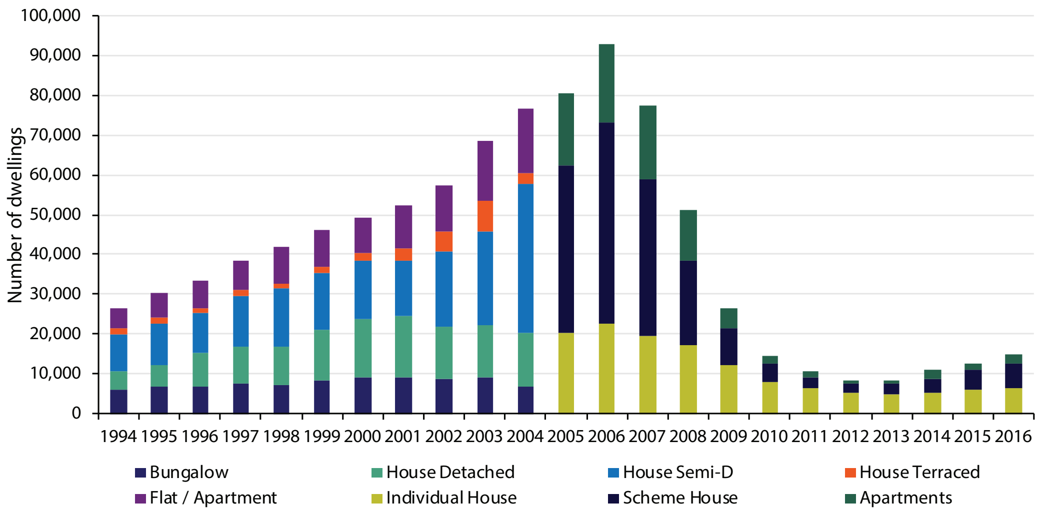
	2011	2016
Total housing stock (B+C+D+E+F+G)	1,994,845	2,003,645
Occupied by usual resident(s) of the household (B)	1,649,408	1,697,665
Occupied by visitors only (C)	10,703	9,788
Unoccupied — residents temporarily absent (D)	45,283	50,732
Unoccupied — vacant house (E)	168,427	140,120
Unoccupied — vacant flat (F)	61,629	43,192
Unoccupied — vacant holiday home (G)	59,395	62,148
Normally occupied permanent dwellings (B+C+D)	***1,705,394***	***1,758,185***

Source: CSO & SEAI

2.2.2 New Dwelling Completions

The Department of Housing, Planning Community and Local Government publishes data on housing completions. This is based on data on residential connections to the electricity network. This data is supplied by the ESB. It is used as a proxy for house completions as it is considered the best available indicator that a house was completed and was ready for habitation. This data set is available dating back to 1970s, providing a valuable time series. *Figure 9* shows ESB connections for the period 1994 to 2016. Note that the methodology for categorising dwellings changed in 2005[10].

Figure 9: New dwellings completed by type, 1994 to 2016



Source: Department of Housing, Planning, Community and Local Government

10 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.

The most obvious feature is the sharp reduction in activity post 2006. It is also significant that the share of individual detached houses went from 25% in 2006 to 62% in 2011, due the relatively greater fall in construction of scheme[11] houses and apartments.

Recently, concerns have been raised over the use of the ESB new connections data-set as a proxy for new dwelling completions. This is because the ESB new connections data-set also includes dwellings that were disconnected from the electricity grid for a period of at least two years, and subsequently re-connected. Such dwellings would be incorrectly counted as "new dwellings". This may have been significant in the period 2011 - 2016 when construction activity was at low levels and there were large numbers of vacant dwellings. The Department of Housing has committed to continue to engage with ESB Networks to explore the scope for further refinement of the data and to collaborate with the CSO to develop further insights into the housing stock and flows of housing units.

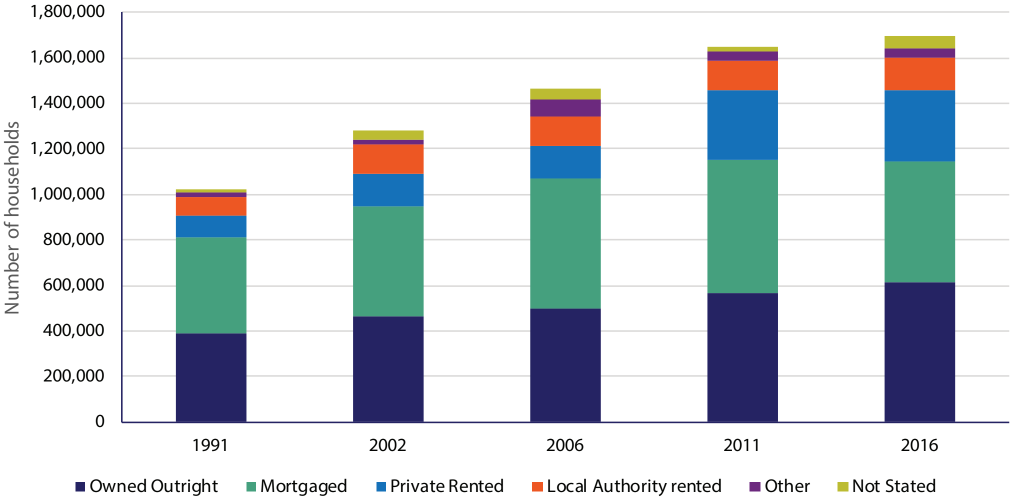
2.2.3 Occupier Status

Research has shown that owner-occupiers have a greater incentive to invest in energy saving measures than either the landlords or tenants of rented accommodation[12]. This is because in rented accommodation, the landlord typically pays for the work, but the benefit, in the form of improved comfort and lower heating bills, is typically received by the tenant. This reduces the motivation for the landlord to invest in energy efficiency measures, and is widely recognised as a significant barrier to increasing the energy efficiency of rented residential housing.

> Over a quarter of all households in Ireland in 2016 were rented either privately or through a local authority (>450,000 dwellings).

Table 10 illustrates the ownership profile of households in census years between 2002 and 2016[13]. Owner-occupied dwellings include those that are owned outright or are mortgaged. The share of households in owner-occupied dwellings decreased over the period, to 68% in 2016, although the absolute number increased. The number of households in private rented accommodation increased most dramatically between 2006 and 2011; more than doubling in absolute numbers. Between 2011 and 2016, the number of households in private rented accommodation increased only marginally, and decreased as a share of all households from 19% in 2011 to 18% in 2016. Nevertheless over a quarter of all occupied dwellings in Ireland in 2016 were rented, either privately or through a local authority, amounting to over 450,000 dwellings.

Figure 10: Private households in permanent housing units by ownership of dwelling, 1991 to 2016



Source: CSO

11 "Scheme Houses" are where houses are part of a multi-house development where connection is provided to two or more houses.
12 IEA, 2007. Mind the Gap – Quantifying Principal-Agent Problems in Energy Efficiency. Available from www.iea.org
13 Other includes those occupying the accommodation rent-free and renting in the voluntary sector.

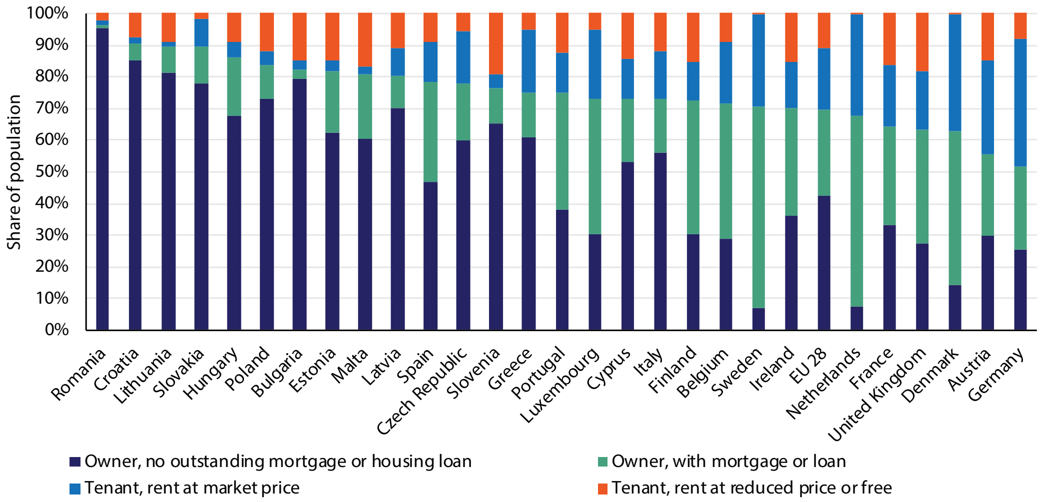
Table 10: Private households in permanent housing units by ownership of dwelling, census years 1991 to 2016

	1991	2002	2006	2011	2016
All households	1,019,723	1,279,617	1,462,296	1,649,408	1,697,665
Owned Outright	387,278	461,166	498,432	566,776	611,877
Mortgaged	421,107	484,774	569,966	583,148	535,675
Private Rented	98,929	141,459	145,317	305,377	309,728
Local Authority rented	81,424	132,989	129,056	129,033	143,178
Other	21,589	21,560	72,181	40,378	44,205
Not Stated	9,396	37,669	47,344	24,696	53,002
% Owner Occupied	79%	74%	73%	70%	68%
% Private Rented	10%	11%	10%	19%	18%
% Local Authority Rented	8%	10%	9%	8%	8%

Source: CSO

Historically, Ireland has had high levels of home ownership compared to other European countries. In 2007, Ireland had the second highest level of owner-occupiers of the EU15 countries, behind only Spain. The decreasing share of households in owner-occupied dwellings in recent years has seen Ireland move towards the EU average. In 2015, Ireland had the 7th lowest rate of home ownership in the EU28 according to Eurostat estimates, as shown in *Figure 11*. Note that there are higher ownership rates in eastern Europe[14].

Figure 11: Distribution of population by tenure status in the EU, 2015



Source: Eurostat

2.2.4 Type of Dwelling

In addition to the number of households, the type of dwellings also affects household energy consumption. All else being equal, apartments typically have the lowest heat loss as a result of their lower proportion of exposed surface area and generally smaller size. Detached houses generally have greatest heat loss because they have a larger proportion of exposed surface area. Data on dwelling type is available from the 2016 census and is presented in *Table 11*. This shows the number of occupied dwellings in 2016, split by dwelling type and by period in which the dwelling was constructed. In 2016, 42% of all dwellings in Ireland were detached houses while 12% were apartments. The share of apartments in the cohort of dwellings built after 2001 is significantly higher than in the period before, but remains low by European standards.

In 2016, 42% of all dwellings in Ireland were detached houses

14 Eurostat, 2017, available from http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics

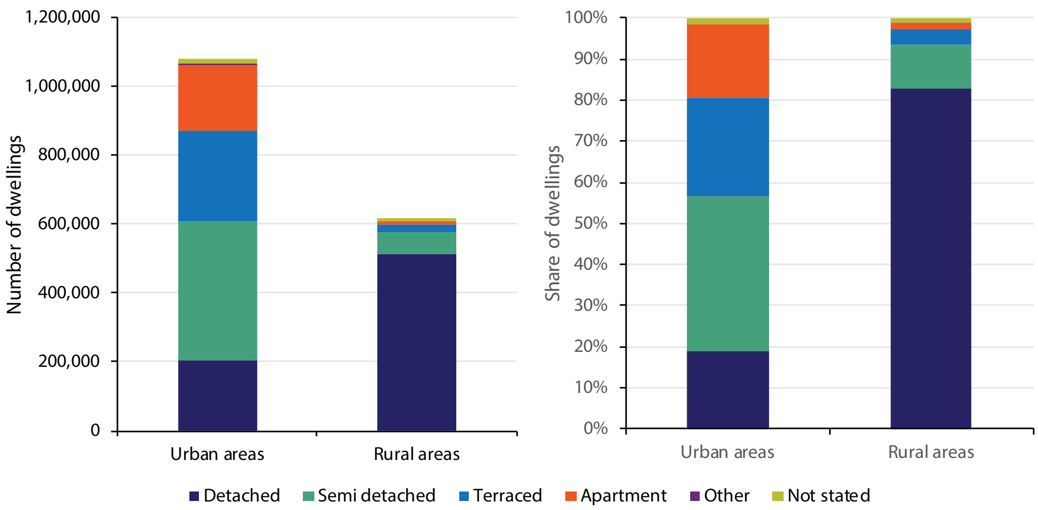
Table 11: Private households in permanent housing units by type of accommodation and period of construction

	Number of Households					Share of households				
	All years	Pre 1981	1981 to 2001	2001 to 2010	2011 to 2016	All years	Pre 1981	1981 to 2001	2001 to 2010	2011 to 2016
All households	1,697,665	706,489	411,855	431,763	33,436					
Detached	715,133	303,318	197,946	175,223	18,050	42%	43%	48%	41%	54%
Semi- detached	471,948	194,168	129,959	115,869	5,900	28%	27%	32%	27%	18%
Terraced	284,569	167,727	42,718	51,682	3,127	17%	24%	10%	12%	9%
Apartment	200,879	35,255	38,987	86,768	6,082	12%	5%	9%	20%	18%
Other	25,136	6,021	2,245	2,221	277	1%	1%	1%	1%	1%

Source: CSO

Figure 12 and *Table 12* show the data from the 2016 census on dwelling types in urban and rural areas. Whether a dwelling is located in an urban or rural area can have an impact on the type of fuel and heating system that is available to a householder or that they are likely to choose. For example with urban dwellings, it may be possible to connect to the gas network or to consider a district heating network, but for rural dwellings, heat pumps or biomass boilers are more likely alternatives. In 2016, 64% of all households were in urban areas. 83% of dwellings in rural areas were detached houses compared to 19% in urban areas.

Figure 12: Private households in permanent housing units by type of accommodation and urban or rural areas



Source: CSO

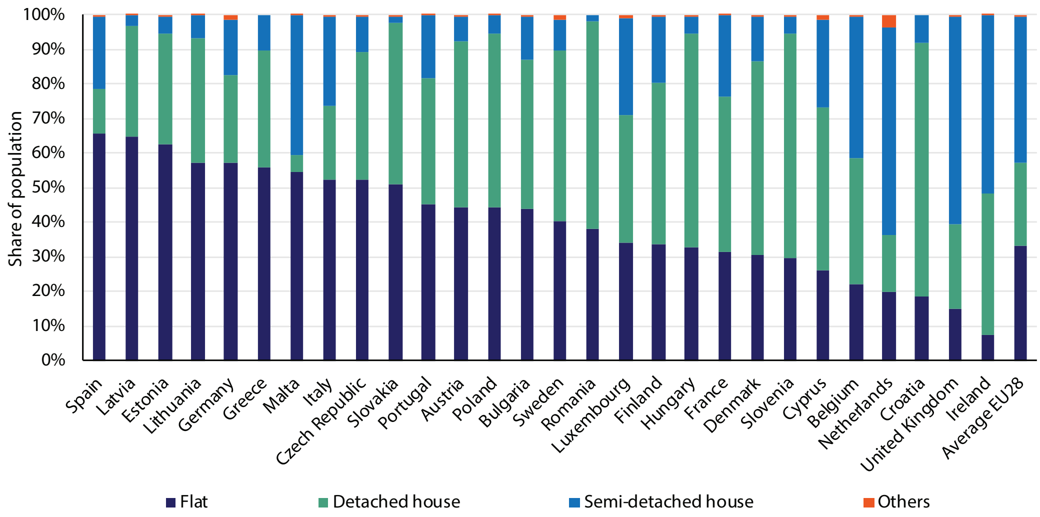
Table 12: Private households in permanent housing units by type of accommodation and rural or urban areas

	Number of Households			Share by Dwelling Type		
	State	Urban	Rural	State	Urban	Rural
All households	1,697,665	1,080,837	616,828			
Detached	715,133	203,346	511,787	42%	19%	83%
Semi- detached	471,948	406,798	65,150	28%	38%	11%
Terraced	284,569	260,319	24,250	17%	24%	4%
Apartment	200,879	192,127	8,752	12%	18%	1%
Other	3,266	3,021	245	0%	0%	0%
Not Stated	21,870	15,226	6,644	1%	1%	1%

Source: CSO

Data is also available from Eurostat showing the proportion of the population in each EU member state living in different dwelling types in 2015[15] and this is presented in *Figure 13*. Ireland had the lowest proportion of people living in apartments of any EU member state at 7%. The next nearest member state was the UK at 15%, while in Spain, 66% of the population lives in apartments. The average across the whole EU28 was 33%.

Figure 13: Distribution of population by dwelling type in EU member states, 2015



Source: Eurostat

In Ireland, in 2015, 7% of people lived in apartments, the lowest share in the EU; the EU average was 33%.

2.2.5 Estimated Floor Area

The CSO publish data on the average floor area of houses and flats that are granted planning permission. This trend is shown in *Figure 14* for the period 2001 to 2016 and data for selected years is shown in *Table 13*. Average floor areas of new houses granted planning permission grew from 130 square metres in 1990 to 149 square metres in 2005; (2005 was the year in which the largest ever number of houses were granted planning permission).

Figure 14 also shows that there is a significant difference between average floor areas of one-off detached houses and multi-development houses. In 2016 the average floor area of a new one-off house granted planning permission was 241 square metres, compared to 135 square metres for a multi-development house, and 90 square metres for an apartment. The average floor area of new one-off houses increased from 186 square metres in 2001, the first year in which data is available, to 253 square metres in 2009, an increase of 36%. Between 2009 and 2016, the average floor area of new one-off dwellings declined by 5% while that of multi-development houses increased by 2%.

The average floor area of all new houses granted permission grew sharply between 2005 and 2012, particularly after 2009, but this was primarily due to the sharper reduction in the number of multi-development houses granted planning permission, compared to one-off houses, following the severe contraction in the house building sector post 2009. This lead to the weighted average of all houses moving more towards that of the average one-off house. As the number of multi-development houses granted planning increased after 2012, this trend was reversed and the average floor area of all houses decreased between 2012 and 2016.

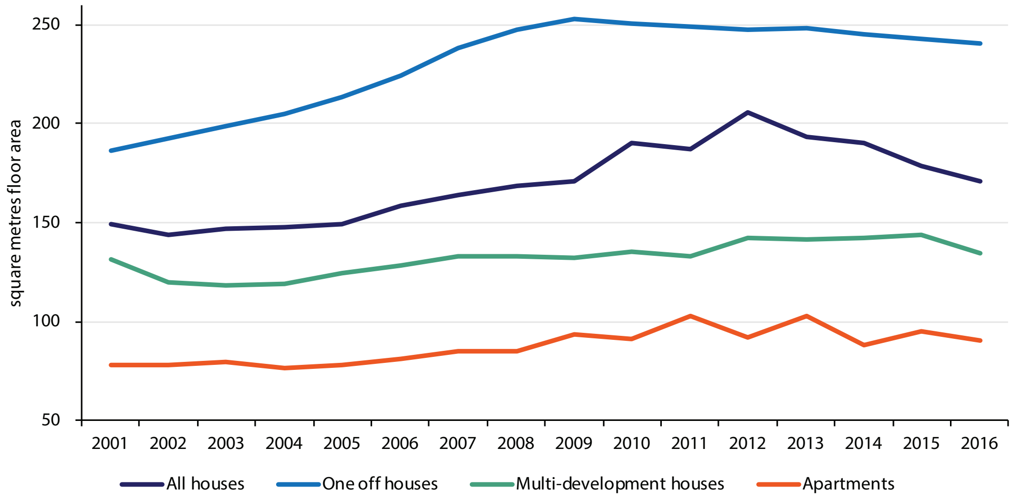
15 Eurostat; From EU Statistics on Income and Living Conditions (EU-SILC); See http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics

Table 13: Number and average floor area of residential units granted planning permission

	Number and average floor area of units granted planning permission						
	1990	2001	2005	2010	2012	2014	2016
All Houses granted planning permission	19,804	60,729	75,650	11,604	5,389	6,626	12,481
Average floor area per house	130	149	149	190	206	190	171
One off houses granted planning permission		19,792	20,868	5,582	3,250	3,096	4,230
Average floor area per one off house		186	214	250	248	245	241
Multi-development houses granted planning permission		40,937	54,782	6,022	2,139	3,530	8,251
Average floor area per multi-development house		131	125	135	142	143	135
Apartments granted planning permission	2,270	17,780	23,702	6,874	861	785	3,894
Average floor area per apartment	64	78	78	92	92	88	90

Source: CSO and SEAI

Figure 14: Average floor areas of new dwellings granted planning permission, 2001 to 2016



Source: CSO and SEAI

The above data on floor area only refers to planning permissions granted for new dwellings. It is useful to have an estimate of the average and total floor area for all occupied dwellings, for example, to calculate energy intensities. SEAI have produced an updated methodology[16] for estimating total stock floor area. This is based on data from the BER database, CSO data on the average floor area of new planning permissions, the number of occupied dwellings, and an estimate of the rate of obsolescence[17].

Table 14 shows both the estimated average dwelling floor area and the estimated total floor area of all occupied dwellings for selected years between 1990 and 2016. Average floor area per dwelling has increased steadily over the period as larger dwellings are added to the stock. In 2016, the average dwelling was 21% larger than in 1990, and 15% larger than in 2000.

Figure 15 shows the trend for average floor area per dwelling, number of dwellings and total floor area of the housing stock as an index relative to 2000. The estimated total floor area of all occupied dwellings increased by 60% between 2000 and 2016, and 103% between 1990 and 2016. This was primarily driven by the increasing number of dwellings; up by 39% between 2000 and 2016, together with the increase in average floor area per dwelling.

Between 2000 and 2016, the total floor area of all homes increased by 60%

16 SEAI previously estimated total stock floor area based on an estimate of the overall floor area in 1980, together with CSO data on the average floor area of new planning permissions, the number of occupied dwellings, and an estimate of the rate of obsolescence. The results of this earlier analysis were shown in earlier editions of this report.

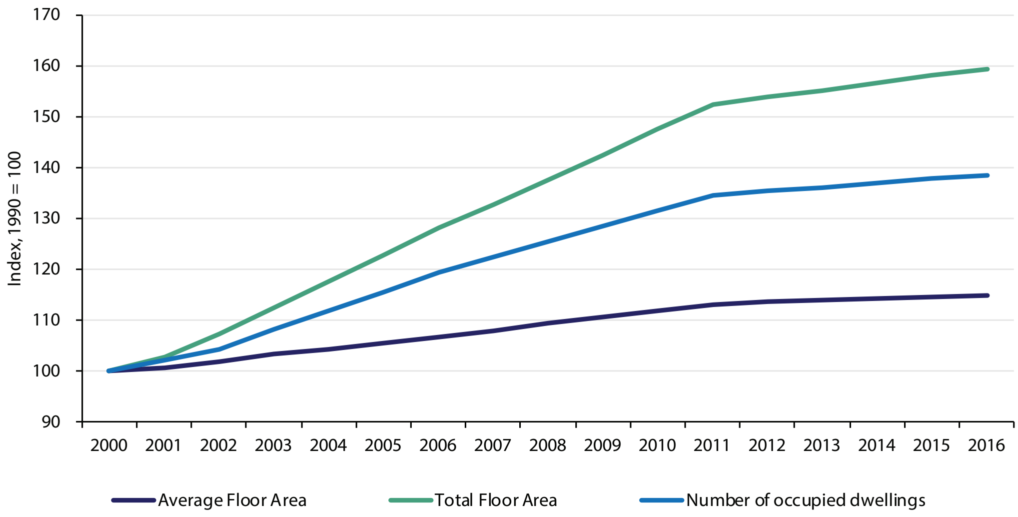
17 The rate of obsolescence is a significant factor but is not well understood for Ireland . The ESRI has previously made estimates of the obsolescence rate, based on CSO data on the number of dwellings in each age cohort and on the number of house completions.

Table 14: Average floor area per dwelling and total floor area of dwelling stock

	1990	2000	2005	2010	2015	2016	% Growth 2000-2016
Estimated average dwelling floor area (square metres)	99	103	109	116	119	119	15%
Estimated total floor area of occupied dwellings (million square metres)	100	127	156	187	200	202	60%

Source: SEAI

Figure 15: Index of average floor area, total floor area and number of occupied dwellings, 2002 to 2016



Source: SEAI

2.2.6 Building Regulations and Period of Construction

The first thermal insulation requirements for residential dwellings in Ireland formally came into effect in 1979, and these regulations have been reviewed and improved many times since. The requirements are set out in the Technical Guidance Documents to Part L of the Building Regulations, governing the conservation of fuel and energy, commonly abbreviated as TGDL. There has been a significant improvement in the energy efficiency requirements, in particular since 2008.

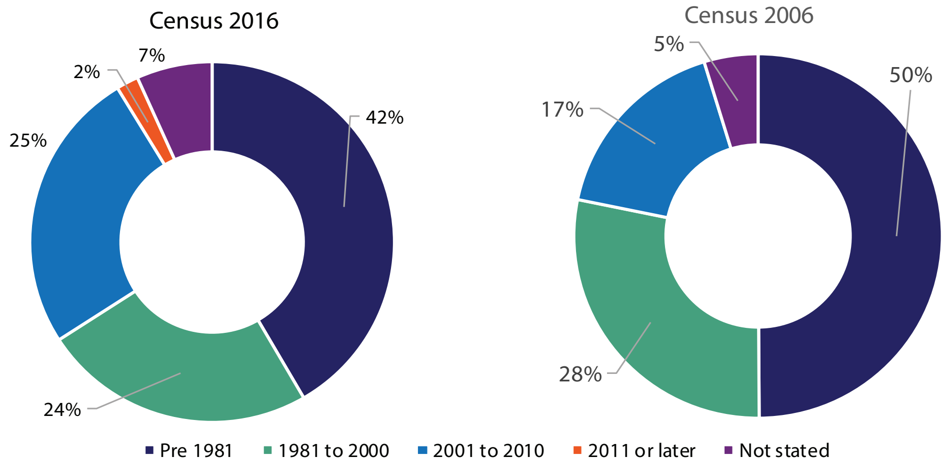
The 2008 regulations introduced the concept of the Energy Performance Coefficient (EPC). The EPC is the ratio between the energy performance of a dwelling, calculated using the Dwelling Energy Assessment Procedure (DEAP), and that of an equivalent reference dwelling complying with the 2005 regulations. The regulations set a Maximum Permitted EPC (MPEPC). In 2008, this was set to 0.6; to meet the regulations, a dwelling would need to achieve 40% efficiency savings compared to the reference dwelling. The 2011 regulations reduced the MPEPC to 0.4; to meet the regulations a dwelling would need to achieve 60% efficiency savings compared to the reference dwelling.

It is estimated that the cumulative improvements to the building regulations since 1979 mean that a dwelling built to the 2011 regulations would require 90% less energy than the equivalent dwelling built in 1978 to deliver the same internal temperature, hot water usage, and lighting, throughout the year. In practice, older inefficient dwellings are likely to be impractical or uneconomical to heat to comfortable temperatures for much of the year.

It is a requirement of the recast Energy Performance in Buildings Directive that all new dwellings will be Nearly Zero Energy Buildings (NZEBs) by 31 December 2020. The 2017 revision to the TGDL states that to be considered an NZEB, a dwelling will have to achieve an MPEPC of 0.3.

Given the significant improvement to the building regulations over time, the age profile of the housing stock is an indicator of efficiency. *Table 15* shows the age profile of the housing stock from the 2016, 2011 and 2006 CSO censuses, while *Figure 16* illustrates the change between 2006 and 2016. The share of the housing stock built before 1981 corresponds approximately to the period before the introduction of insulation requirements for new dwellings. The number of occupied dwellings built before 1981 fell from 729,762 in 2006 to 706,489 in 2016; the number of dwellings in the "Not Stated" category increased by 44,912 in the same period, which may account for some of the difference. In 2016, 25% of the stock was constructed between 2001 and 2010, but only 2% was constructed between 2011 and 2016.

Figure 16: Private households in permanent housing units by period of construction, 2016



Source: CSO

Table 15: Private households in permanent housing units by period of construction

Period in which Built	2016 Census		2011 Census		2006 Census	
	Number	Share	Number	Share	Number	Share
Before 1981	706,489	42%	721,154	44%	729,762	50%
1981 to 2000	411,855	24%	411,137	25%	413,881	28%
2001 to 2010	431,763	25%	437,507	27%	249,443	17%
2011 or later	33,436	2%	0	0%	0	0%
Not stated	114,122	7%	79,610	5%	69,210	5%
Total	**1,697,665**		**1,649,408**		**1,462,296**	

Source: CSO

2.2.7 Energy Efficiency Retrofit Programmes

Since 2000, the Government has supported a range of programmes to upgrade the energy efficiency of the existing housing stock. Government programmes currently in place to support energy efficiency upgrades include:

- Better Energy Homes
- Better Energy Warmer Homes
- Better Energy Communities
- Warmth and Wellbeing Pilot Scheme
- Deep Retrofit Pilot
- Social Housing upgrades
- Rental Sector – Housing Assistance Package Pilot
- Energy Efficiency Obligation Scheme

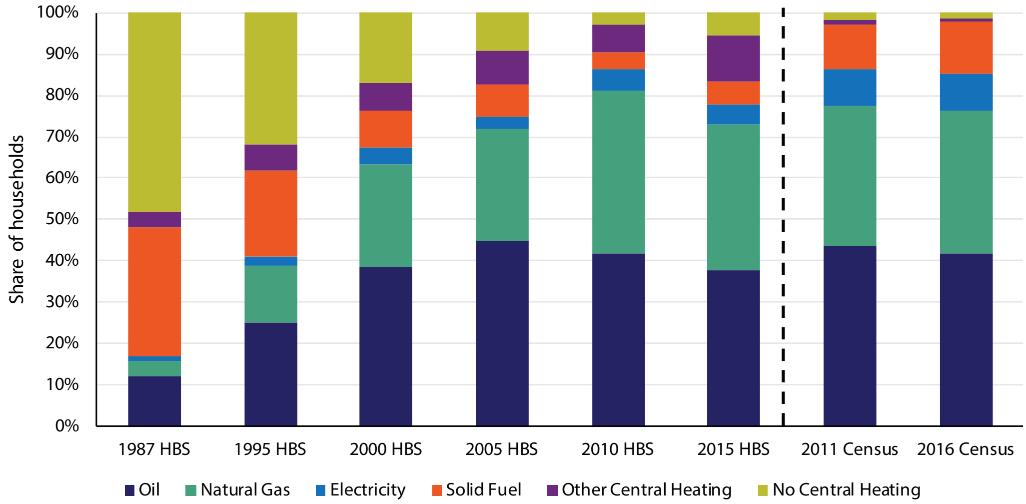
The SEAI administered Better Energy Homes and Better Energy Warmer Homes schemes have delivered energy efficiency improvements to over 375,000 homes since 2000.

2.2.8 Fuels Used for Space Heating

Figure 17 and *Table 16* show fuel used for central heating from 1987 to 2016 using a combination of data from the CSO Household Budget Survey (HBS)[18]and from the 2011 and 2016 censuses[19]. Census 2011 was the first census to include questions on the type of household heating. The HBS is based on a sub-sample of the population, whereas the census surveys the full population. The HBS is scaled up to the national level based on the most recent census, which for the 2010 HBS was the 2006 census.

There were some differences between the HBS and the census results, particularly for solid fuel and electricity; the reasons for this are not clear. Nevertheless, the broad historical trends across the full time period can be inferred, for example, the widespread adoption of oil and gas central heating systems from the 1990s onwards.

Figure 17: Central heating by fuel type



Source: CSO

Table 16: Central heating by fuel type

	Household Budget Survey						Census	
Fuel Type %	**1987**	**1995**	**2000**	**2005**	**2010**	**2015**	**2011**	**2016**
Oil	12%	25%	39%	46%	41%	38%	44%	41%
Natural Gas	4%	14%	25%	28%	39%	35%	34%	34%
Electricity	1%	2%	4%	3%	5%	5%	9%	9%
Solid Fuel	31%	21%	9%	8%	4%	5%	11%	13%
Other Central Heating	4%	6%	7%	8%	6%	11%	1%	1%
No Central Heating	48%	32%	17%	10%	3%	6%	2%	1%

Source: CSO

The results of the 2011 and 2016 censuses for the number of households split by central heating fuel type are given in more detail in *Table 17* below. The significant increase in the number of dwellings in the "Not Stated" category creates some uncertainty when comparing the results. With this caveat in mind, there are a number of notable changes: a slight reduction in the number of oil-fired central heating systems, an increase in the numbers of coal and peat-fired systems, and a significant increase in the number of wood-fired systems.

18 CSO, Various Years. Household Budget Survey. www.cso.ie
19 Note that the census results are shown excluding households where heating type was "Not Stated".

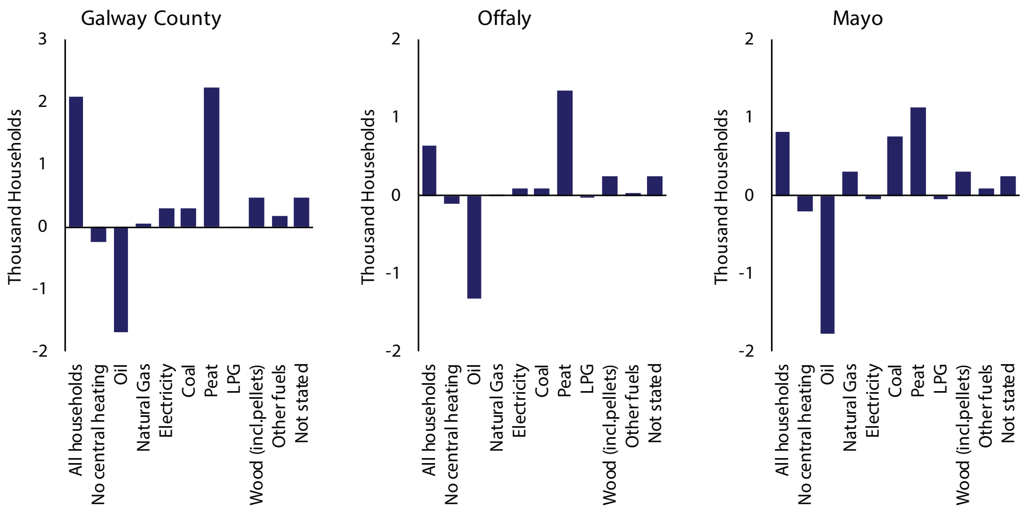
Table 17: Changes in central heating by fuel type between 2011 and 2016 Census

Households by Central Heating Type	Census 2011	Census 2016	Absolute Change	% Change
All households	1,649,408	1,697,665	48,257	3%
No central heating	26,952	23,174	-3,778	-14%
Oil	711,330	686,004	-25,326	-4%
Natural Gas	550,215	569,166	18,951	3%
Electricity	140,419	146,302	5,883	4%
Coal	79,145	86,611	7,466	9%
Peat	78,638	90,029	11,391	14%
LPG	10,452	9,990	-462	-4%
Wood (incl. pellets)	21,395	33,976	12,581	59%
Other fuels	8,524	11,068	2,544	30%
Not stated	22,338	41,345	19,007	85%

Source: CSO

The reported increase in the number of coal and peat-fired central heating systems is a surprising result. The counties with the largest increase in the number of respondents reporting peat use for central heating were Galway County, Offaly and Mayo[20]. The changes in the absolute number of households by central heating fuel type between the 2011 and 2016 census for these three counties are shown in *Figure 18*. In all of these counties there was a significant reduction in the number of respondents reporting oil-fired central heating systems, despite an overall increase in the number of households.

Figure 18: Changes in the numbers of households between the 2011 and 2016 census split by central heating system fuel type, for the counties with the largest reported increase in peat central heating.



Source: CSO

The drop in the numbers of reported oil-fired central heating systems occurred throughout the country, with the number decreasing in 29 out of the 31 local authority areas. The counties with the largest drop in the number of respondents reporting oil-fired central heating systems were Donegal, Dublin City and Tipperary, followed by Mayo and Galway County.

The changes in the absolute number of households by central heating fuel type between the 2011 and 2016 census for Donegal, Dublin City and Tipperary are shown in *Figure 19*. The potential reasons for the reported reduction in the number of dwellings with oil central heating are complex. For example, in Donegal there was a significant increase in the number of households reporting coal-fired central heating systems, which might suggest a degree of fuel switching[21]. Dublin City recorded the second largest reduction in the number of oil boilers, but in this case, the results are affected by the increased number of dwellings in the "not stated" category. The next largest drop was in Tipperary. Here, the largest increase was in wood-fired boilers, which includes wood pellets, while there were also increases in peat and coal systems, again suggesting fuel switching.

20 Personal communication from Maria Galavan, based on analysis carried out for EPA through UCD student placement programme.

21 The census asks about the fuel used by the central heating system. It is possible that respondents are giving the fuel that they primarily use for heating, rather than the fuel used by the central heating system. It may be the case that some households with oil central heating systems are primarily using a secondary heating system burning solid fuels, and are reporting this in the census as a peat or coal-fired central heating system. This could show up in the census results as a reduction in the number of oil-fired central heating systems and an increase in the number of coal and peat-fired systems.

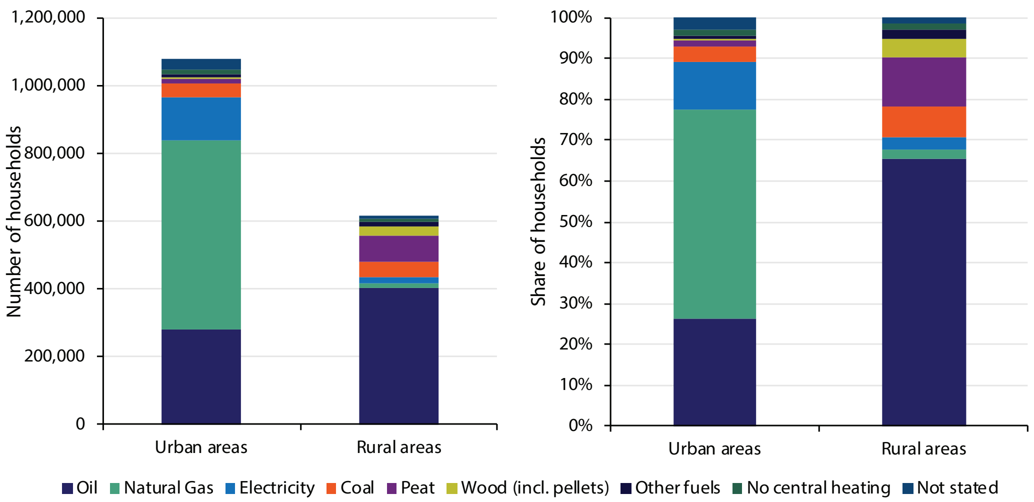
The overall drop in the number of households reporting oil central heating systems, and the increase in the number reporting solid fuel central heating systems, is also reflected in the 2010 and 2015 HBS. Further research is needed to understand the reasons for this observed shift away from oil central heating systems. Research is also needed to understand to what degree households with oil central heating systems rely on secondary heating systems such as stoves burning solid fuels, particularly during periods of high oil prices.

Figure 19: Changes in the numbers of households between the 2011 and 2016 census split by central heating system fuel type, for the counties with the largest reported decrease oil central heating.

Source: CSO

Figure 20 shows the number and share of households split by central heating fuel type split and by rural and urban areas. The clear difference in the share of gas central heating systems reflects the fact that the gas grid serves urban areas. The higher share of electric heating in urban areas is due to the higher share of apartments.

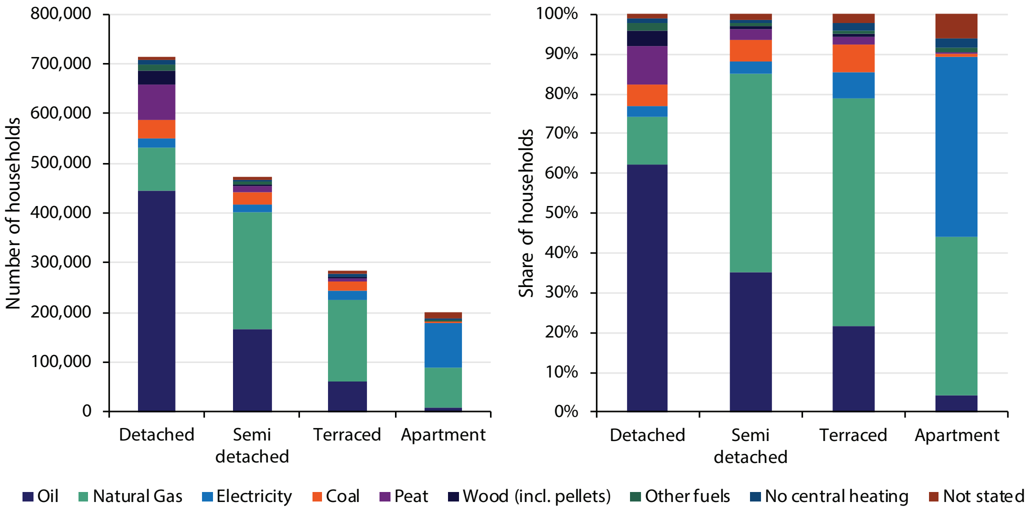
Figure 20: Private households in permanent housing units by central heating fuel type and urban or rural area.



Source: CSO

Figure 21 shows the housing stock split by central heating fuel type split and by dwelling type. Most detached houses are in rural areas, away from the gas grid and so use oil, whereas most semi-detached and terraced houses are in urban areas, have better access to the gas grid and are more likely to use natural gas. As discussed in Section *2.2.5,* the typical rural detached oil-fired dwelling is likely to have a greater floor area than the typical urban, semi-detached, gas-fired dwelling. Electricity remains the single largest heating source for apartments, followed by natural gas.

Figure 21: Private households in permanent housing units by central heating fuel type and by type of dwelling



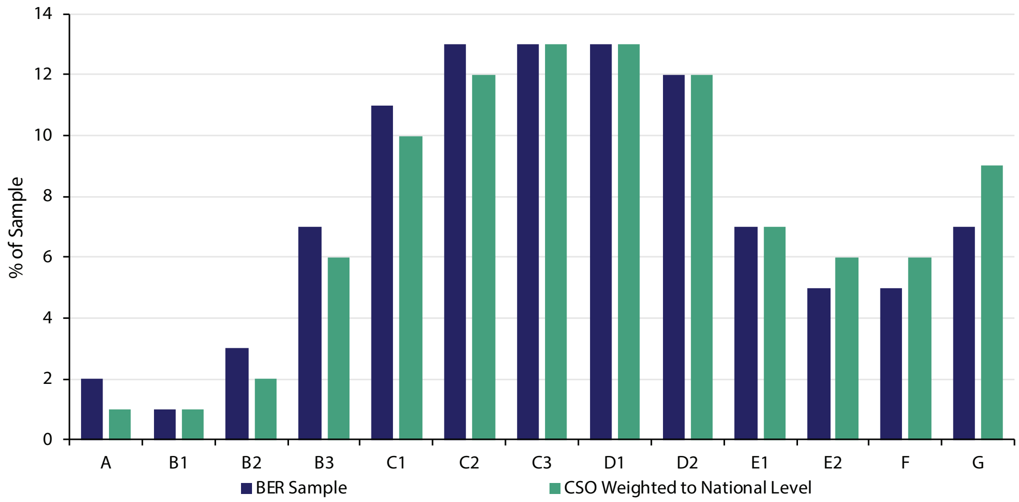
Source: CSO

2.2.9 Building Energy Rating (BER) Assessments

The results of every BER assessment carried out, as well as the large amount of data collected on the physical characteristics of each dwelling to carry out the assessment, are recorded in the BER database[22] (see Appendix 5 for more information on BERs). At the end of 2016, over 700,000 dwellings, or just over 39% of the residential housing stock, had been assessed and were included in the BER database. The CSO analyses the BER database and produces high-level statistics on the numbers of BERs, which are released in quarterly bulletins. The following sections present results taken from a combination of the CSO analysis and SEAI analysis of the BER database.

Figure 22 presents the distribution of BER grades within the BER database at the end of 2016. The BER database is not a representative sample of the stock of occupied dwellings. The CSO applies weightings to the BER sample to scale it to the most recent census data, which for the end of 2016 was the 2011 census.

Figure 22: Distribution of BERs in the BER database and for the national housing stock, 2016



Source: CSO & SEAI

The results of this adjustment are also shown in *Figure 22*. The distribution of BERs in the BER database at the end of 2016 was quite similar to the estimated distribution of the total dwelling stock, due to the large size of the sample (~40%), but was skewed slightly towards the better BER grades.

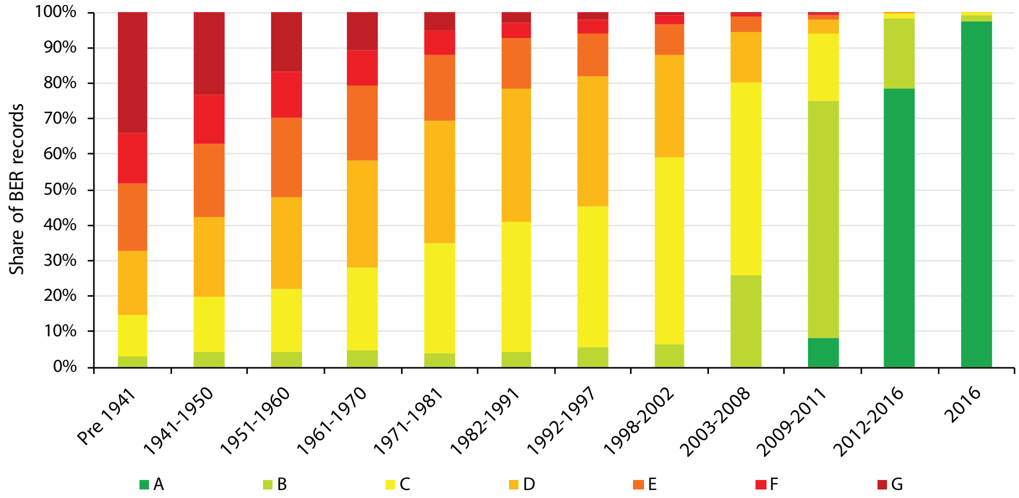
The profile of BERs in the BER database by the period of construction is shown in *Figure 23*. This shows the BER grade

22 The BER scheme and database are audited and administered by SEAI.

when the most recent BER assessment of the dwelling was carried out, not when the dwelling was originally constructed. Many dwellings in the older age bands shown here as C or D may have been F or G when originally constructed, but were subsequently upgraded with improved insulation, and had the BER assessment carried out after these works. This profile is not weighted to the national level. For the older age bands in particular, it is likely to be biased towards the better BER grades as the BER database includes over 375,000 dwellings constructed prior to 2006 that underwent energy efficiency upgrades as part of SEAI grant schemes.

A clear trend can be seen over time. There is a gradual improvement in the profile from 1941 until 2002 and then a more dramatic improvement thereafter, particularly for dwellings constructed after 2008. Over 50% of dwellings in each of the bands from 1961 until 2008 fall within the D or C mid-range of BERs. Following the introduction of the 2008 building regulations, there was a dramatic increase in energy performance. Of all dwellings in the BER database constructed in 2016, 98% achieved an A rating. An A rated dwelling would typically require 60%-75% less energy to heat to a comfortable level year-round compared to an equivalent C rated dwelling.

Figure 23: Distribution of BERs in the BER database by period of construction

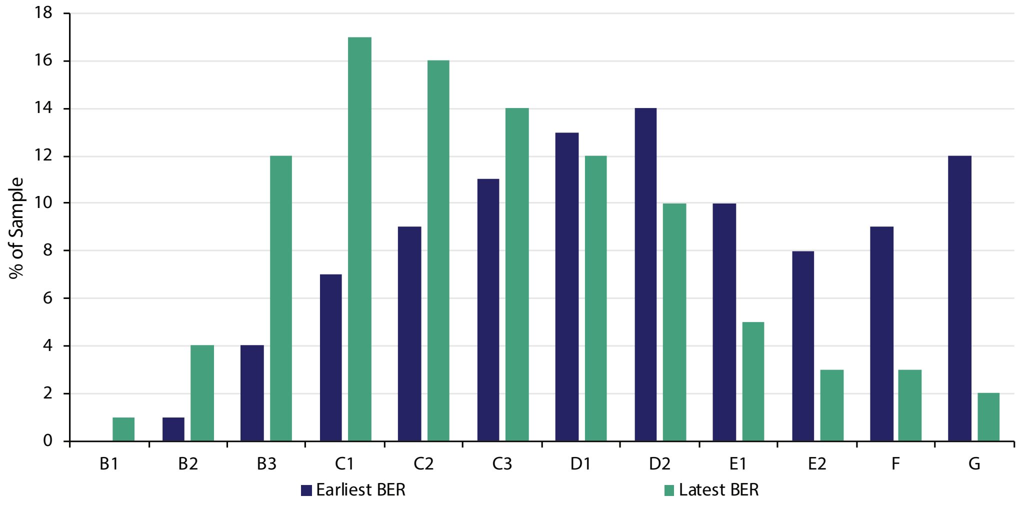


Source: SEAI

98% of dwellings constructed in 2016 in the BER database achieved an A rating

Figure 24 presents the BER profile for dwellings that have had more than one BER assessment carried out. It shows the profile for the earliest and the latest assessment. A dwelling would require a second BER if it was being sold or rented after a material alteration to the dwelling which would affect its energy performance, or if the homeowner received a government energy efficiency grant. The overall improvement in the BER profile between the earliest and most recent BER is clear. This suggests that the kind of energy efficiency upgrade works typically carried out to date have been successful in moving dwellings from the E, F and G grades to D, C and B3 grades. Deeper retrofit measures will be required to move further towards the B1, A3 level.

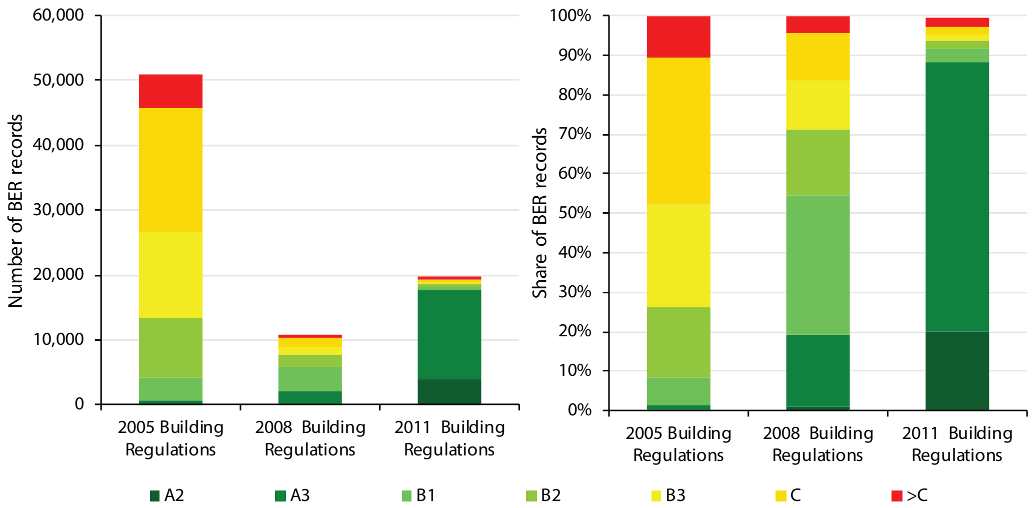
Figure 24: Distribution of BERs for all grant aided dwellings in the BER database



Source: CSO & SEAI

Looking more closely at the effect of the recent changes to the building regulations, *Figure 25* shows the detailed BER grade split for dwellings constructed to each of the last three editions of the building regulations[23]. Under the 2005 regulations, the most common BER grade was B3 followed by C1, while just 1% achieved an A grade. Under the 2008 regulations, the most common BER grade was B1 with the next most common A3 at 18%, with 1% of dwellings achieving A2. Under the 2011 regulations, 68% of dwellings achieved an A3 grade and a further 20% an A2 grade.

Figure 25: Distribution of BERs in the BER database split by building regulations

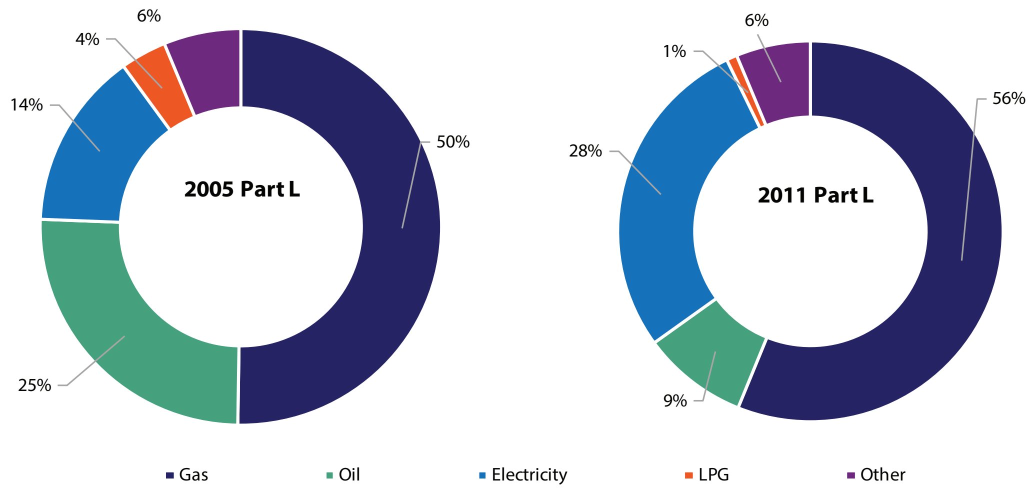


Source: SEAI

Figure 26 shows two charts, the first of dwellings in the BER database built to the 2005 Part L of the Building Regulations and the second those built to the 2011 regulations. The charts show the split by fuel type of the main space heating system. Based on this data dwellings built to meet the 2011 Part L are less likely to use oil, and more likely to use electric heat pumps for main space heating.

23 Note that for new dwellings constructed to the 2005 building regulations or later, each BER record has a specific identifier for which edition of the building regulations the dwelling conforms to.

Figure 26: Dwellings in the BER database split by main space heating fuel and building regulation



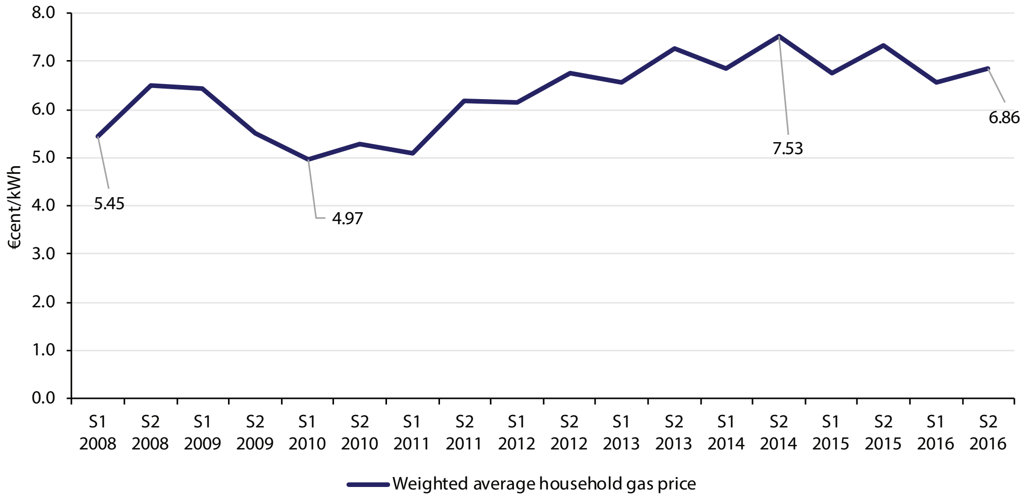
Source: SEAI

2.3 Energy Prices

2.3.1 Household Electricity and Gas Prices

SEAI publishes biannual reports titled *Electricity and Gas Prices in Ireland*[24]. For households, prices include all charges payable including: energy consumed, network charges, capacity charges, commercialisation, meter rental, each netted for any rebates or premiums due. The prices are based on the methodology for the revised EU Gas & Electricity Price Transparency Directive[25] which came into effect on 1st January 2008. The prices represent weighted average prices of the full market, using the market share of the various suppliers as weighting factors. The prices reported for the Directive for both gas and electricity are split into a number of consumption bands. SEAI also calculate a weighed average of all the consumption bands to give the overall trend in prices. *Figure 27* shows the trend for average household gas prices for the period 2008 to 2016. The price at the end of 2016 was 26% above the start of the period. Between the start of 2010 and the end of 2014 gas prices increased by 52%.

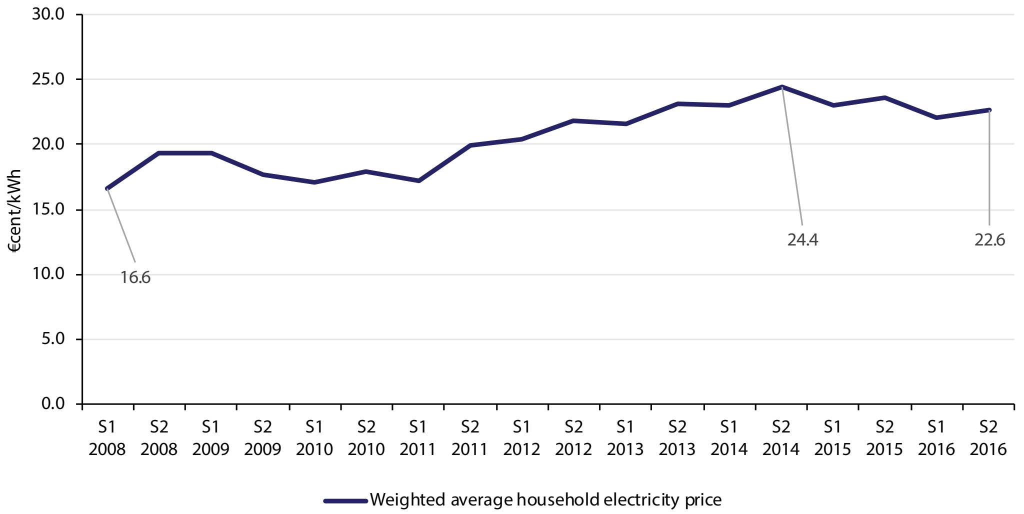
Figure 27: Household gas prices, 2008 to 2016



Source: Eurostat

Figure 28 shows the trend for household electricity prices between 2008 and 2016. The price reached a maximum in the second semester of 2014, 47% above the price at the start of the period.

Figure 28: Household electricity prices, 2008 to 2016



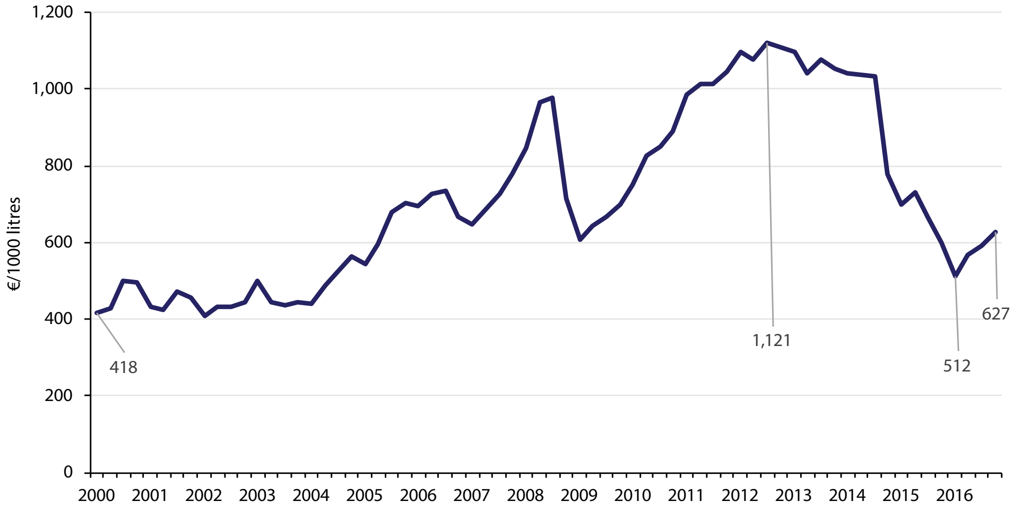
Source: Eurostat

24 Sustainable Energy Authority of Ireland (various dates), *Electricity and Gas Prices in Ireland*, www.seai.ie.
25 Available from http://europa.eu/legislation_summaries/energy/internal_energy_market/l27002_en.htm

2.3.2 Household Oil Prices

Data on the price of household heating oil for Ireland is taken from the International Energy Agency (IEA) Energy Prices and Taxes database. Throughout the 1990s, household oil prices stayed relatively constant and averaged at €311 per 1000 litres (€/kl). *Figure 29* shows the trend from 2000 to 2016 by quarter. Prices peaked in Q3 2012 at 1,121 €/kl, 260% above the 1990-'99 average before falling back to 512 €/kl in Q1 2016.

Figure 29: Household heating oil prices, 2000 to 2016

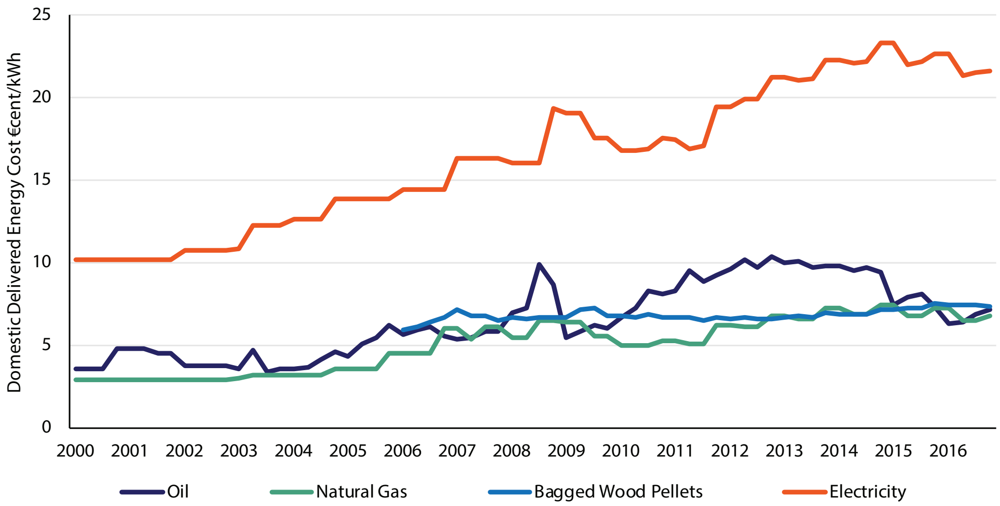


Source: IEA Energy Prices & Taxes

2.3.3 SEAI Domestic Fuel Price Comparison

While data on gas and electricity prices as per the EU directive methodology have been collected since 2008, SEAI has collected data over a longer time period for the quarterly SEAI domestic fuel price comparison sheets. This data is shown in *Figure 30* below. Viewed over a longer time-series, the period 2011 to 2016 saw record high energy prices for electricity, gas and oil. Oil prices peaked in the second quarter of 2012 at 10.4 €cent/kWh, 147% above the 2000-2005 average. Gas peaked in the fourth quarter of 2014 at 7.45 €cent/kWh, 135% above the 2000-2005 average. Electricity price also peaked in the fourth quarter of 2014 at 23.35 €cent/kWh, 101% above the 2000-2005 average.

Figure 30: SEAI domestic fuel price comparison, 2000 to 2016



Source: SEAI

There were record high energy prices for electricity, gas, and oil, between 2012 and 2015.

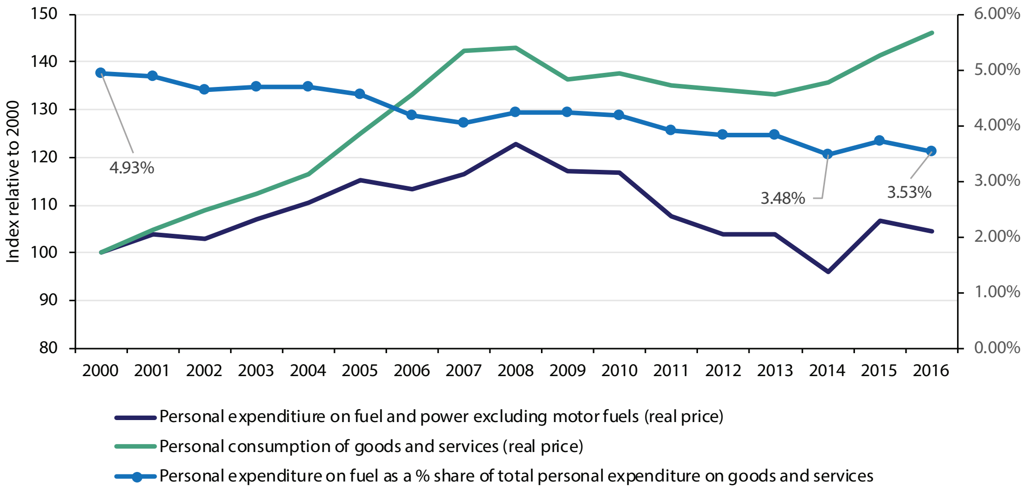
2.4 Residential Expenditure on Energy

The CSO publishes data on personal expenditure on household energy, excluding transport[26]. In 2016, this was approximately €3.4 billion[27]. *Figure 31* shows the trend for both personal expenditure on household energy and total personal expenditure on goods and services[28], expressed as an index relative to the year 2000 for comparability. Notably, the total expenditure on fuel and power decreased by 22% between 2008 and 2014, despite increased fuel prices.

Figure 31 also shows the percentage share of total personal expenditure on goods and services accounted for by household energy. This reduced throughout the period. By 2016, the overall consumption of goods and services had exceeded the previous maximum set in 2008 and was 46% above that in 2000. In 2016 expenditure on household energy was 11% below the peak in 2008, just 5% above that in 2000.

In 2016, Irish households spent €3.4 billion on home energy, excluding motor fuels

Figure 31: Personal expenditure on energy and on goods and services, 2000 to 2016

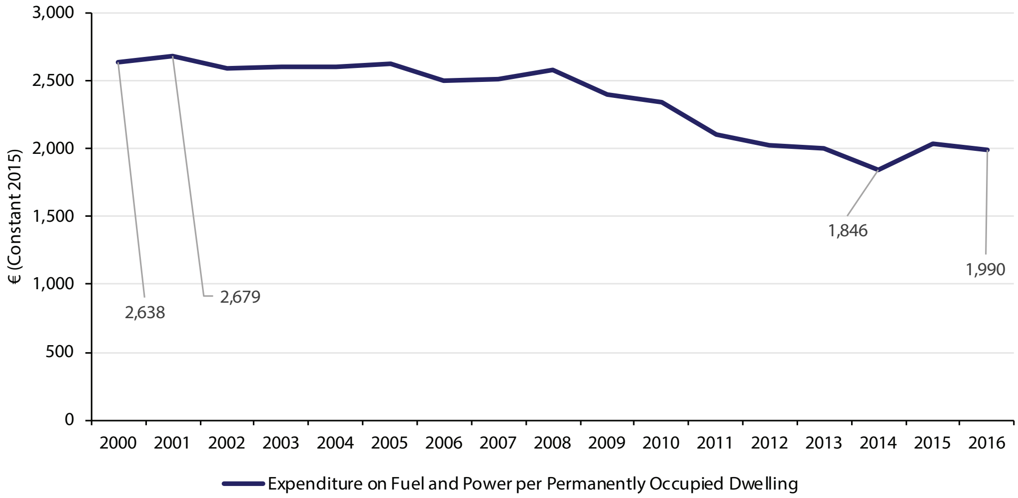


Source: CSO

Figure 32 presents an estimate of the average spend on energy per permanently occupied dwelling (in constant 2015 prices). This is based on CSO data for the total consumption of personal income on fuel and power (excluding motor fuels) and for the total number of private permanent households. Over the period 2008 to 2014, there was a reduction in expenditure on energy per dwelling, despite increases in energy prices for gas, electricity and oil, as detailed in *Figure 30*. Factors contributing to the decrease in energy spend per household since 2008 include reduced disposable income and energy efficiency improvements in the dwelling stock. Further analysis is required to investigate the extent to which the different underlying factors contributed to the overall decrease in expenditure.

26 The Central Statistics Office National Income and Expenditure Annual Results; Consumption of Personal Income for "fuel and power excluding motor fuel".
27 Central Statistics Office, 2017, National Income and Expenditure 2016. Available from www.cso.ie.
28 Total expenditure is defined as personal consumption of goods and services less taxes on personal income and wealth.

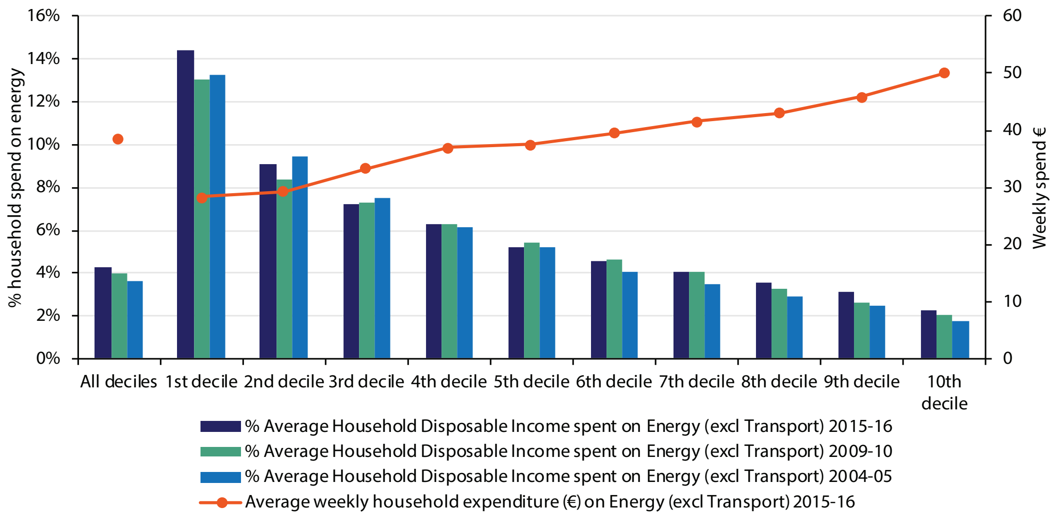
Figure 32: Average spend on energy per permanently occupied dwelling, 2000 to 2016



Source: CSO

Figure 33 shows household expenditure on energy, excluding transport,[29] as a percentage of disposable income, split by income decile. This data is collected by the CSO as part of the HBS[30]. The HBS defines disposable household income as gross income less direct taxation. The income deciles are constructed by ranking all households on their total income, and then splitting them into ten groups, from lowest to highest income. For example, the first income decile contains the 10% of households with the lowest incomes, the tenth decile the 10% of households with the highest incomes. Also shown in *Figure 33* is the absolute amount spent each week on fuel in each decile for 2015–16.

Figure 33: Weekly expenditure on energy as a proportion of disposable income, Household Budget Survey years



Source: CSO

Figure 33 shows that as income decreases, there is a corresponding decrease in the absolute amount spent on energy, but an increase in the proportion of income spent on energy. In 2015–16, those in the first income decile had an average weekly income of €197 and spent on average €28, or 14.4%, on energy. The tenth income decile had an average weekly income of €2,224 and spent €50, or 2.2%, on energy. The average proportion of total household disposable income spent on energy across all households was 4.2% in 2015–16. In 2015–16, those in the tenth income decile spent on average 78% more on energy than those in the first income decile. This highlights that socio-economic factors strongly influence actual energy consumption of households. For this reason, the energy efficiency asset rating of a dwelling, taken in isolation, cannot be assumed to be a good indication of actual energy use of individual households.

Figure 33 also shows the share of household income spent on energy from the previous two HBS in 2009–10 and 2004–05. On average, households spent a slightly higher portion of their income on energy in 2015–16 compared to 2009–10.

29 The variable in the HBS is expenditure on fuel and light (excluding motor fuels) here, referred to as energy.
30 The most recent HBS was published in 2017 for the period 2015-16

In 2015-16, those in the highest income decile spent, on average, 78% more on energy than those in the lowest income decile.

2.4.1 Energy Poverty

Energy affordability has important implications for health, quality of life and energy efficiency. There are many definitions of energy poverty; one of the simplest is the inability to heat or power a home to an adequate degree. 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 that result in spending long periods confined in the home, for example old-age, disability, poor-health, and unemployment.

Fuel-poverty can be gauged through a number of quantitative and qualitative methods. One quantitative method is to consider all households that spend more than 10% of their income on energy as fuel-poor. This was adopted as a preliminary measure of energy poverty by the then Department of Communications Energy and Natural Resources[31] (DCENR) in the 2011 document "Warmer Homes; a Strategy for Affordable Energy in Ireland"[32]. This simple metric has shortcomings, for example, a well-off household may live in an old, energy inefficient house and may spend more than 10% of their income on energy, but may be adequately warm throughout the year, and not suffer any form of poverty or deprivation.

An alternative measure, known as the objective method of calculating energy poverty, seeks to compare a household's income to what it would theoretically have to spend on energy to keep the home heated to World Health Organisation recommended norms. In 2016, DCENR undertook a review of the level of objective energy poverty in Ireland and found that up to 28% of households in Ireland could be in energy poverty[33].

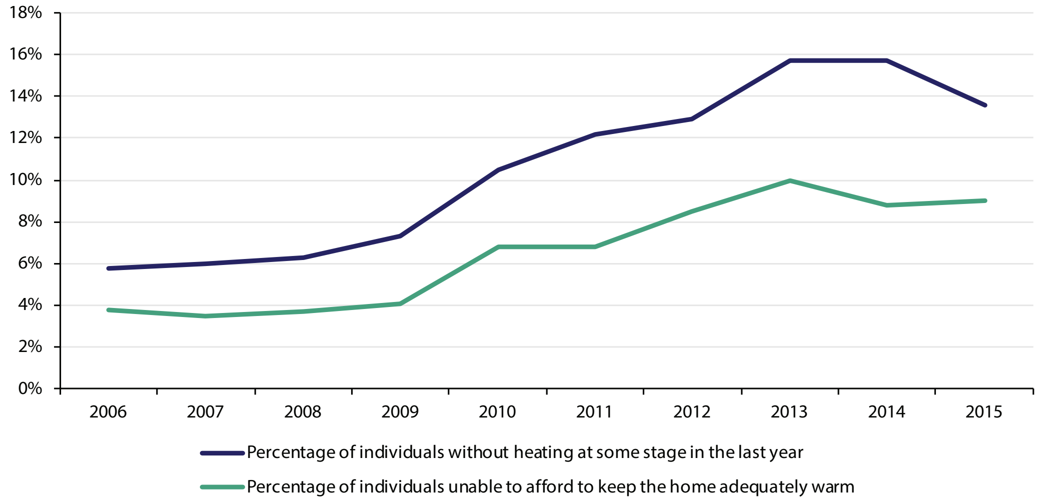
A qualitative method to assess fuel-poverty is to survey respondents, and ask them to subjectively self-report whether they feel they can afford to adequately heat their home throughout the year. One such example is the EU-wide Survey on Income and Living Conditions (SILC), which is carried out by the CSO for Ireland.

The SILC[34] includes two qualitative energy-related questions: whether householders have gone without heating at least once over the previous year, due to lack of money, and whether householders can afford to keep their home adequately warm. A benefit of this survey is that it is collected annually, and for all EU countries. The results for Ireland between 2006 and 2015 are shown in *Figure 34.*

The percentage of individuals who reported that they are unable to afford to keep their home adequately warm increased from 3.5% in 2007 to 10% in 2013

31 The predecessor to the Department of Communications, Climate Action and Environment
32 Available from https://www.dccae.gov.ie/documents/Warmer%20Homes.%20A%20strategy%20for%20Affordable%20Energy%20in%20Ireland.pdf
33 Department of Communications, Energy and Natural Resources, 2016, A Strategy to Combat Energy Poverty 2016-2019. Available from http://www.dccae.gov.ie/en-ie/energy/publications/Pages/Strategy-to-combat-energy-poverty.aspx
34 CSO, annually, Survey on Income and Living Conditions. Available from: http://www.cso.ie/en/silc/releasesandpublications/

Figure 34: Energy-related deprivation indicators in the annual Survey on Income and Living Conditions, 2006 to 2015



Source: CSO

Figure 34 shows that for both of these metrics, the rate of fuel-poverty increased significantly between 2009 and 2013. The percentage of individuals reporting that they went without heating at some stage in the past year, due to inability to afford it, increased from 6% in 2006 to 16% in 2013. The percentage of individuals who reported that they are unable to afford to keep their home adequately warm increased from 4% in 2006 to 10% in 2013. Although the situation improved somewhat in 2014-15, fuel-poverty remains well above the 2006 to 2008 levels.

A 2015 study by the ESRI[35] into the primary causes of fuel-poverty concluded that it was poverty generally, rather than fuel price, or the energy efficiency of the dwelling, that was the primary cause of fuel-poverty. The 2015 SILC found that 34.3% of persons experiencing deprivation were unable to afford to keep their home adequately warm, compared to just 0.2% of persons not experiencing deprivation. In 2016, the DCENR published *'A Strategy to Combat Energy Poverty 2016-2019'*[36]. This report accepts the conclusions of the ESRI analysis and notes that income supports are an essential support measure to combat fuel-poverty. But it expresses the view these such income supports also need to be complemented by programmes that specifically focus on improving the thermal efficiency of homes.

35 Watson, D and Bertrand, M; 2015; Fuel-poverty: a Matter of Household Resources or a Matter of Dwelling Efficiency? Available from: http://www.esri.ie/publications/fuel-poverty-a-matter-of-household-resources-or-a-matter-of-dwelling-efficiency/

36 Department of Communications, Energy and Natural Resources, 2016, A Strategy to Combat Energy Poverty 2016-2019. Available from: http://www.dccae.gov.ie/en-ie/energy/topics/Energy-Efficiency/energy-costs/Pages/Energy-Poverty-Strategy.aspx

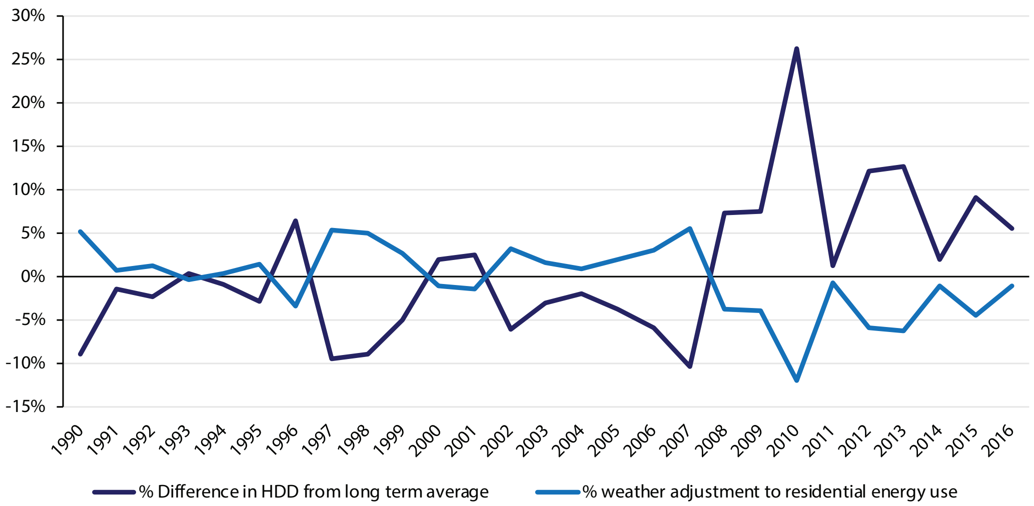
2.5 Weather Effects

Weather variations from year to year, specifically temperature variation, can have a significant effect on energy demand, and in particular on the portion of the energy demand associated with space heating. Using the method of degree-days, it is possible to correct for the effect of these annual weather variations.

Degree-days is a measure used to take account of the external temperature when looking at the amount of heating or cooling that needs to be provided to keep a building at an acceptable operating temperature. In Ireland, the focus has traditionally been on heating degree-days, rather than cooling degree-days, due to the cool climate and lack of air conditioning systems, particularly in the residential sector. The amount of degree-days is calculated relative to a base temperature at which no heating is required for a building to maintain a comfortable indoor air temperature. In Ireland, this is taken to be 15.5 degrees Celsius. If the outdoor air temperature on a given day is on average one degree Celsius lower than the base temperature, then this counts as one degree-day. The number of degree-days is then cumulated over a given time period, e.g. a month, a heating season or a year. The colder the weather, the larger the number of heating degree-days and the more energy required to keep a building at a comfortable indoor temperature, all else being equal. 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.

Figure 35 shows the percentage deviation in the number of heating degree-days (HDD) from the long-term average between 1990 and 2016. 2010 was the coldest year recorded over that period and 2007 was the warmest. The portion of each fuel that is assumed to be used for heating is adjusted by multiplying by the ratio of the long-term average number of degree-days to the number of degree-days in the given year. This adjustment yields a lower normalised energy consumption in cold years, and yields a higher normalised consumption in mild years. Typically, the weather adjustment is within plus or minus 6% of the actual energy consumption. The largest correction over the period was for 2010, an exceptionally cold year, where the weather-corrected energy consumption was 12% less than actual.

Figure 35: Deviation from average heating degree-days and resulting weather adjustment, 1990 to 2016



Source: Met Éireann & SEAI

2.5.1 Degree Days Over Heating Season Versus Over Full Year

The heating degree-day weather adjustment to annual energy consumption considers the degree-days across the entire year, including over the summer months. This assumes that on any day of the year where the average temperature falls below 15.5 degrees Celsius, heating will be supplied to maintain comfortable indoor temperatures.

Another possible assumption is that heating is only supplied during the heating season, which is assumed to run from October to May inclusive. Outside of the heating season, in the summer months of June-September, it could be assumed that even when the temperature goes below 15.5 degrees Celsius, no heating is supplied. The latter assumption is used, for example, by DEAP when calculating a BER. In most years, the difference between the two approaches is minimal, as the number of degree-days over the colder months of the heating season far outweighs the number over the summer months.

Comparing degree-days in 2015 and 2016, the results are unusual because over the full year, 2016 was milder, but over the heating season (January to May and October to December inclusive) 2016 was colder. This is mostly because 2015 had an unusually cold summer, with the highest number of heating degree-days from June to September recorded for the period 1990 to 2016. This difference between the change in degree-days between 2015 and 2016 for the full year versus the heating season was the largest recorded between any two years over the period. This affects the weather-correction result. Actual residential energy use in 2016 was 1.2% higher than in 2015. Correcting for weather using degree-days across the full year, 2016 would have had 4.8% higher energy usage than 2015. If only the degree-days during the heating season are counted, then correcting for weather, 2016 energy usage would have been 0.5% lower than in 2015. Therefore, the fact that 2016 was colder than 2015 over the heating season may be responsible for the overall increase in residential energy use between 2015 and 2016. This highlights that care is needed in interpreting the trend in weather-corrected data between 2015 and 2016 in particular, but also in interpreting the results of weather-corrected energy usage generally.

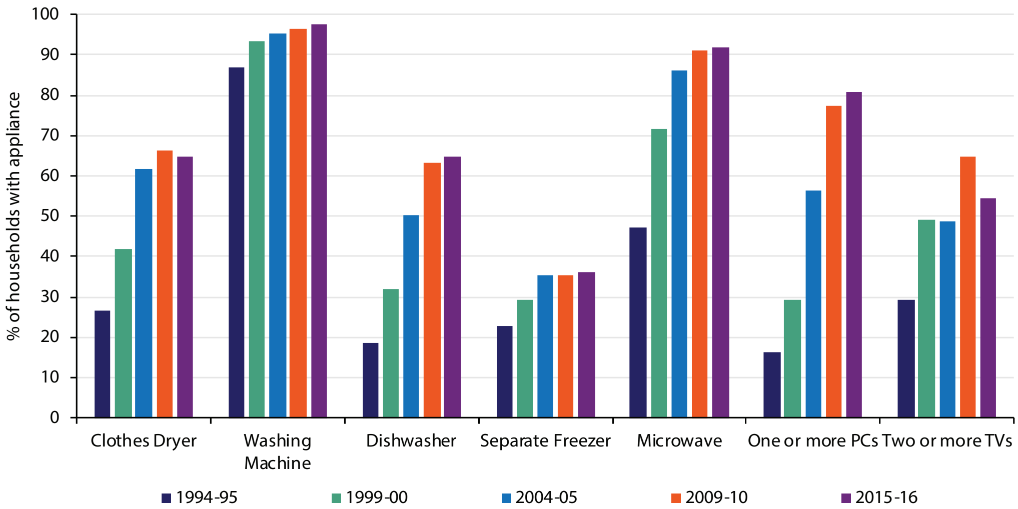
2.6 Electric Appliances

There is limited data on the ownership of household appliances, the usage of household appliances, the energy consumption of household appliances, and the energy use of electricity for other end-uses such as space heating, water heating, lighting and cooking for Ireland.

2.6.1 Appliance Ownership

Ownership of thirteen different appliances has been surveyed as part of the HBS since 1987. Those with the largest growth in ownership are included in *Figure 36 and Table 18*. The HBS does not take account of newer and smaller household appliances, but it does provide a useful trend which can be tracked over time. For many large appliances, the rapid growth in ownership between 1995 and 2010 has levelled of between 2010 and 2016. This is partly because ownership rates are approaching 100% and may be partly due to reduction in disposable incomes over the period. Interestingly, the number of households with two or more TVs decreased between 2010 and 2016.

Figure 36: Percentage ownership of electrical appliances, Household Budget Survey years



Source: CSO Household Budget Survey

Table 18: Percentage ownership of electrical appliances, Household Budget Survey years

Appliance %	1994-95	1999-00	2004-05	2009-10	2015-16
Clothes Dryer	26.6	42	61.7	66.2	64.8
Washing Machine	86.8	93.4	95.3	96.3	97.5
Dishwasher	18.6	32	50.1	63.2	64.7
Separate Deep Freeze	22.8	29.2	35.4	35.3	36.1
Microwave Oven	47.2	71.5	86	91	91.7
Home Computer	16.2	29.3	56.2	77.3	80.8
TV- Two or More	29.2	49.1	48.7	64.8	54.5

Source: CSO Household Budget Survey

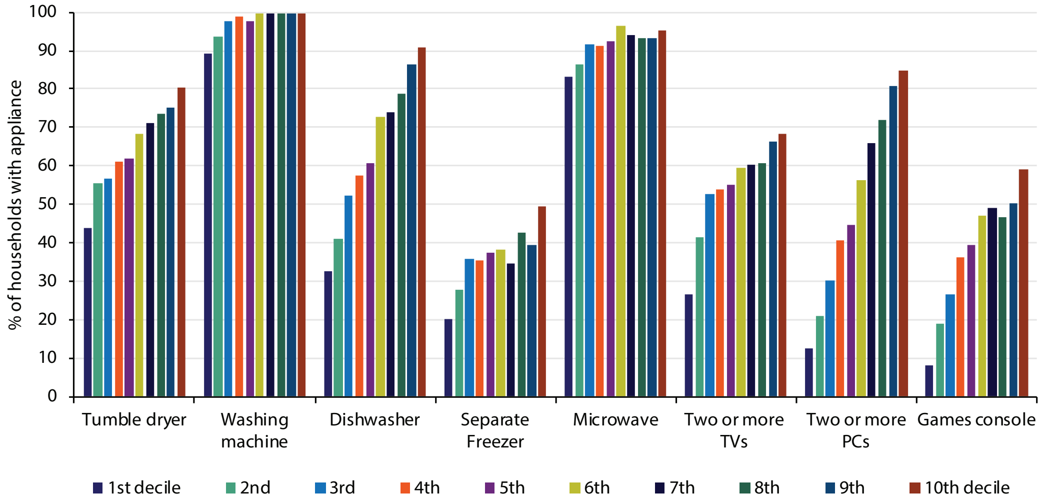
The 2015-16 HBS provides data linking appliance ownership to other household characteristics such as income decile, region, social group, tenure and household composition. From this data it can be seen that, for example, households with children are more likely to have games consoles, and rural houses are more likely to have separate deep freezes.

Figure 37 shows appliance ownership by income decile. Households with higher incomes are more likely to own more appliances, although there are multiple contributory factors. Previous research by the ESRI[37,38] also found that households with higher incomes, and those living in newer and larger homes tend to have more appliances.

37 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.

38 Leahy, E. and Lyons, S., 2010, Energy Policy 38, 4265-4279

Figure 37: Percentage ownership of electrical appliances by income decile, 2015 Household Budget Survey



Source: CSO Household Budget Survey

The HBS does not take account of smaller digital or kitchen appliances. Research by the IEA in 2009 found that digital appliances were already consuming more than traditional appliances in many households in the OECD[39]. It would be reasonable to assume that the number of digital appliances has further increased in the past decade.

2.6.2 Appliance Efficiency

A recent report from ADEME titled "Energy efficiency of White Goods in Europe: monitoring the market with sales data" provides data and analysis on the sales of refrigerators, washing machines and tumble driers in the EU, France, Germany and Italy, 2004 to 2015[40]. The report looks at energy efficiency, energy consumption, size and price.

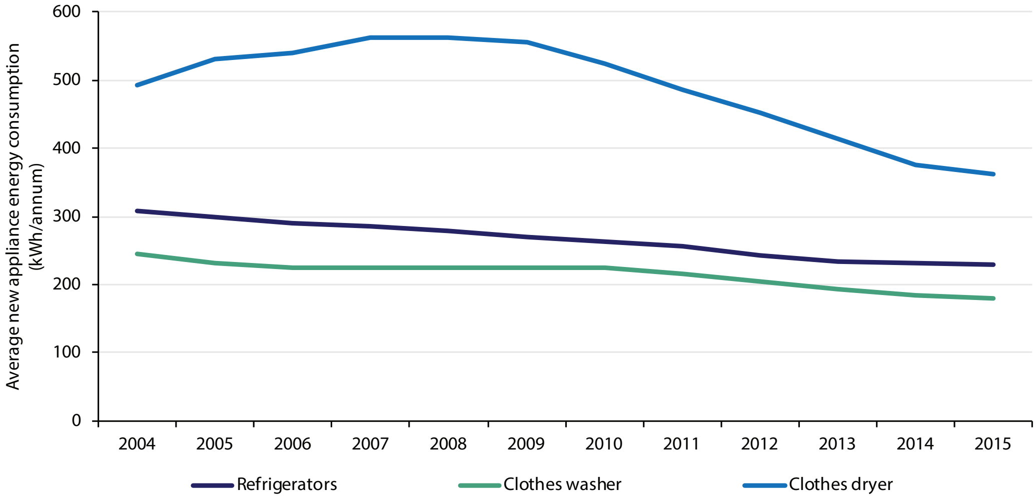
The report estimates that in the EU, the average declared energy consumption of new refrigerators reduced by 26% between 2004 and 2015. Similarly, the energy use of new washing machines sold reduced by 27% and clothes dryers reduced by 27% over the same period. The report emphasises that care must be taken when interpreting these results. The results are based on the stated efficiency of the products based on standardised testing procedures, and do not account for the real-world operation of the machines. Nevertheless, the results point to improved energy efficiency of large electric appliances across the EU.

This improvement can largely be attributed to two EU Directives. The Eco-design Directive (2009/125/EC) requires manufacturers of appliances to decrease the energy consumption of their products by establishing minimum energy efficiency standards at EU level. The regulation covers a wide range of household and other appliances. The Energy Labelling Directive requires manufacturers to supply energy labels with products to allow consumers to make informed decisions on the energy efficiency of appliances when purchasing. In July 2017, the EU Commission published a new Energy Labelling Regulation that will gradually replace the Directive.

39 IEA, 2009, Gadgets and Gigawatts, ISBN 978-92-64-05953-5

40 The professional market analysis company GfK collects data on sales of household appliances across the EU on a commercial basis. In Europe, GfK covers around 90% of the white goods market, and all 28 Member States. Sales data, and data on product characteristics, is obtained by GfK from retailers. Topten, an international consumer information body, purchased sales data on household refrigerators, washing machines and tumble driers from GfK. For this project, GfK provided, for each energy class (A+++ to G), data on sales, sales weighed average energy consumption, size, and for washing machines additionally water consumption. This information is based on the declaration according to the Energy Label regulations.

Figure 38: Average energy consumption of new appliances sold in a selection of EU Countries, 2004 to 2015



Source: Topten International Services[41]

41 Topten International Services, 2015. Energy efficiency of White Goods in Europe: monitoring the market with sales data

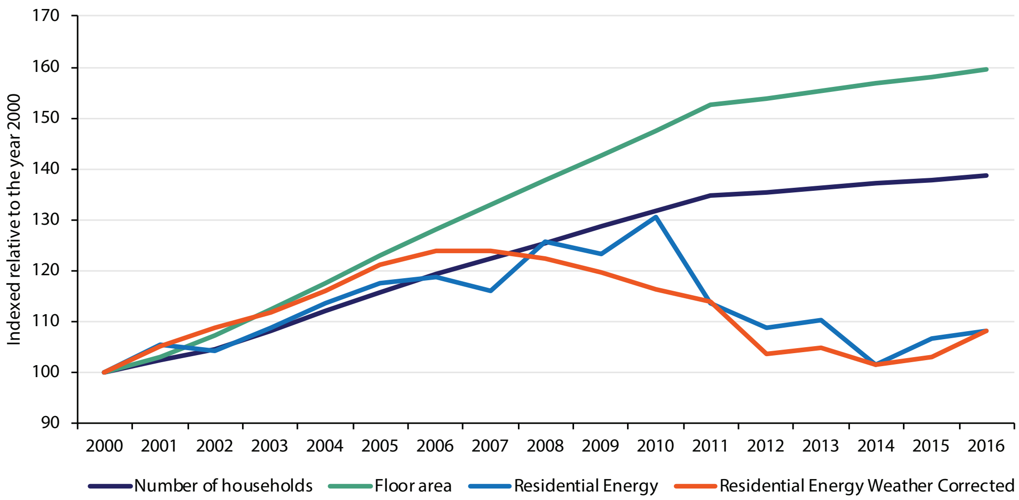
3 Energy Efficiency and Carbon Intensity

This section provides more detail on how efficient Irish homes are, as well as how carbon intensive the fuels that are used in Ireland are. It also looks in more detail at the factors that have driven changes in energy use on Ireland over time.

3.1 Energy Intensity

Figure 39 shows the trend in residential final energy consumption, number of dwellings and total floor area between 2000 and 2016, expressed as an index relative to the year 2000. The growth in residential final energy use between 2000 and 2006 can be explained in part by the proportionate increase in total floor area and number of dwellings in that period. After 2006, there was a decoupling of energy demand from the continued growth in dwelling numbers and floor area. This suggests that there was a significant reduction in the energy intensity of dwellings in the period 2006 to 2014 in particular.

Figure 39: Number of dwellings, total floor area and residential final energy demand, indexed to 2000, 2000 to 2016



Source: SEAI

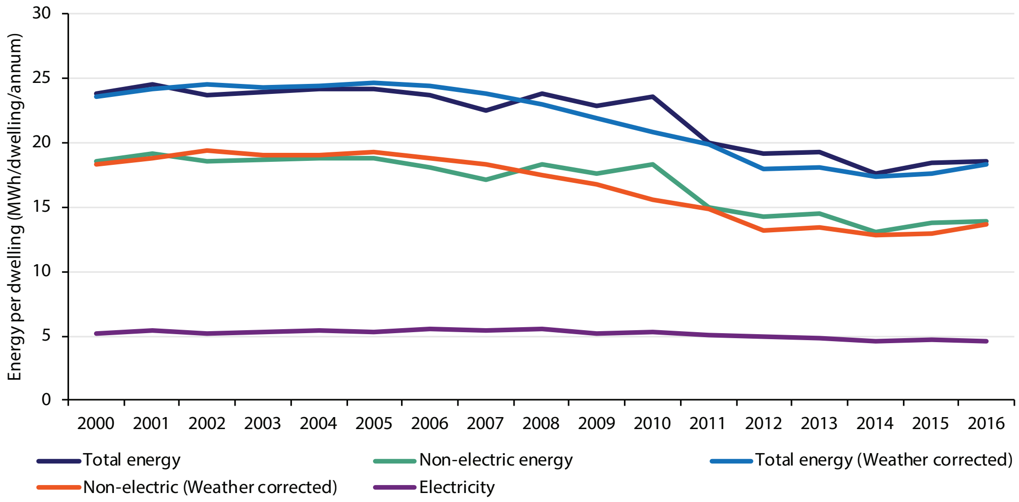
Figure 40, and *Table 19* show final energy consumption per dwelling between 2000 and 2016. The trends for total energy use, electricity use and non-electric energy use are shown. Also shown are total and non-electric energy consumption adjusted to correct for year-to-year weather variation. In 2016, the "average" dwelling consumed 18.5 MWh of final energy, comprising 4.6 MWh of electricity (25%) and 13.9 MWh (75%) of direct energy use.

Final energy use per dwelling remained relatively constant between 2000 and 2005, but reduced significantly between 2005 and 2014, before returning to growth in 2015 and 2016. Weather-corrected total final energy consumption per dwelling fell by 26% over the period 2005 to 2016, but increased by 5.2% in 2016. Factors contributing to the overall reduction in energy intensity would be expected to include changes to the building regulations governing energy efficiency, retrofitting of the existing housing stock, changes in heating behaviour due to reduced purchasing power, and increased energy prices over the period 2007-2014. Conversely, reduced energy prices and increased disposable income in the period 2014-2016 are likely to have contributed to the increase in residential final energy intensity per dwelling in that period.

Between 2007 and 2014, final energy use of electricity per dwelling, weather-corrected, reduced by 16%, having increased by 31% between 1990 and 2007. Potential reasons for the reduction in electricity use per dwelling between 2007 and 2014 reversing the earlier long-term trend of increased electricity usage could include:

- more efficient appliances;
- reduced usage of appliances;
- reduced demand for space and water heating due to greater thermal efficiency of the stock
- fuel switching from electricity to fossil fuels for space and water heating;
- reduced household incomes and expenditure;
- increased electricity prices;

Figure 40: Energy consumption per dwelling, 2000 to 2016



Source: SEAI and CSO

Table 19: Residential energy consumption and CO_2 emissions per dwelling

	Quantity (kWh/dwelling)			Growth %		Average annual growth %		
Energy Consumption per Dwelling	**2000**	**2005**	**2016**	**2005-'16**	**2014-'16**	**2000-'05**	**2005-'16**	**2016**
Total energy per dwelling	23,777	24,134	18,524	-23%	5.3%	0.3%	-2.4%	0.6%
Non electrical energy per dwelling	18,571	18,830	13,885	-26%	6.8%	0.3%	-2.7%	1.1%
Electrical energy per dwelling	5,206	5,303	4,638	-13%	1.0%	0.4%	-1.2%	-0.7%
Energy Consumption per Dwelling (Weather-Corrected)								
Total energy, weather-corrected, per dwelling	23,522	24,612	18,325	-26%	5.2%	0.9%	-2.6%	4.2%
Non-electric energy weather-corrected per dwelling	18,326	19,289	13,697	-29%	6.7%	1.0%	-3.1%	5.7%
Electricity weather-corrected per dwelling	5,195	5,323	4,628	-13%	1.0%	0.5%	-1.3%	0.0%

Source: SEAI

Weather-corrected final energy consumption per dwelling fell by 26% over the period 2005 to 2016, but increased by 5.2% in 2016

The trend in energy per metre squared floor area closely matches that shown for energy per dwelling, but with a greater reduction in intensity due to the greater increase in floor area. As shown in *Table 20,* weather-corrected residential energy per metre squared decreased by 31%, and non-electric fuel use per metre squared decreased by 34% between 2005 and 2016; but these increased by 3.9% and 5.3% respectively in 2016.

Table 20: Residential energy consumption and CO_2 emissions per square metre

	Quantity (kWh/dwelling)			Growth %		Average annual growth %		
Energy Consumption per m²	**2000**	**2005**	**2016**	**2005-'16**	**2014-'16**	**2000-'05**	**2005-'16**	**2016**
Total energy per m²	230	220	156	-29%	5%	-0.9%	-3.1%	0.3%
Non electrical energy per m²	179	171	117	-32%	6%	-0.9%	-3.4%	0.7%
Electrical energy per m²	50	48	39	-19%	0%	-0.8%	-1.9%	-1.0%
Energy Consumption per m² (Weather-Corrected)								
Total energy, weather-corrected, per m²	227	224	154	-31%	5%	-0.3%	-3.4%	3.9%
Non-electric energy weather-corrected per m²	177	176	115	-34%	6%	-0.2%	-3.8%	5.3%
Electricity weather-corrected per m²	50	48	39	-20%	0%	-0.7%	-2.0%	-0.3%

Source: SEAI

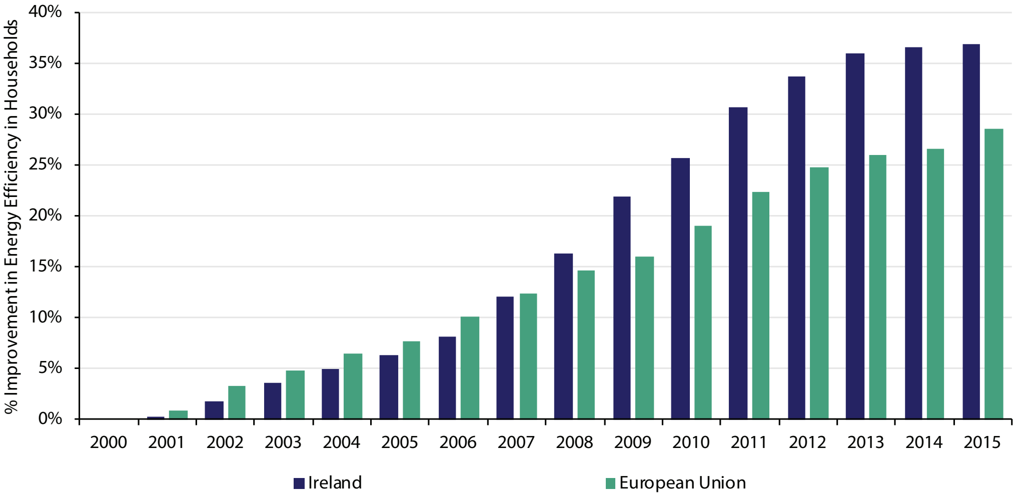
3.2 Energy Efficiency Indicators

Comprehensive monitoring of energy consumption data and analysis of energy efficiency trends for all EU member states are carried out by the Odyssee-Mure[42] project. The project relies on two complementary internet databases that are regularly updated by a network of 37 partners from 31 countries. SEAI provides data and analysis for Ireland. The Odyssee database contains data on energy consumption and related CO_2 emissions, activity indicators, and detailed energy efficiency indicators. The primary objective of the Odyssee project is to evaluate and compare energy efficiency progress by sector in each Member State, and to relate this progress to the observed trends in energy consumption.

The Mure database contains a description of all energy efficiency measures implemented at EU or national level, and also impact evaluations of these policies where available.

Figure 41 presents the results of analysis carried out by the Odyssee project to estimate energy efficiency trends in households across the EU. Results are shown for Ireland and the EU as a whole. The results are based on a methodology specifically developed by the Odyssee project known as the ODEX. Using this methodology, energy efficiency in households in Ireland was estimated to have improved by 37% between 2000 and 2015. This was the second highest increase of any EU country, second to Romania, and compares to an EU average of a 29% improvement. The high level of estimated efficiency improvement for Ireland is as a result of the large reduction in energy per square metre floor area observed between 2006 and 2014, as discussed in the previous section.

Figure 41: Energy efficiency improvement in households, 2000 to 2015



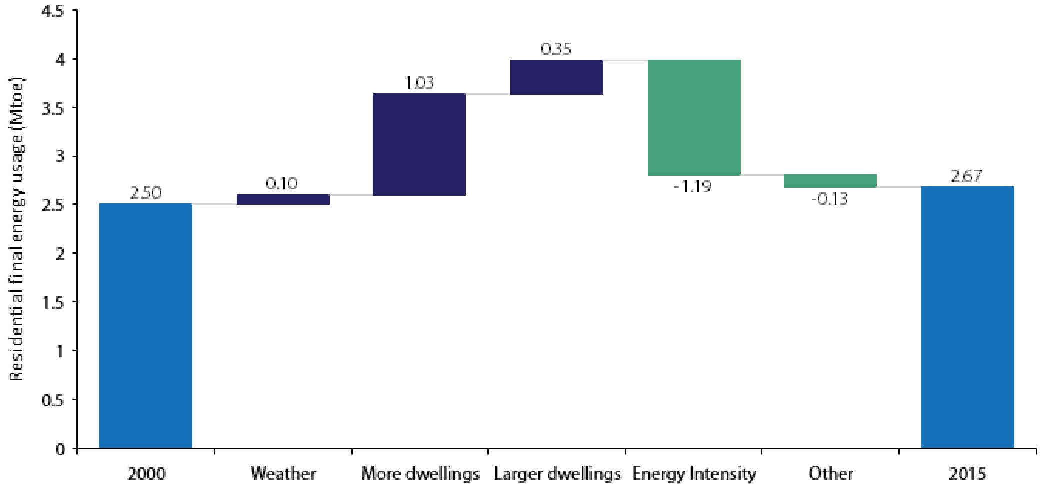
Source: Odyssee-Mure

The Odyssee project also carries out decomposition analysis of energy usage in different sectors. This analysis estimates the effect that different drivers of energy usage have on the overall trend of energy usage over a period of time. *Figure 42* presents the results of this decomposition analysis carried out on the Irish household sector.

The graph shows the change that each of the identified drivers of energy use, taken in isolation, would have had on overall energy use. The drivers considered include weather, number of dwellings, size of dwellings, and dwelling energy intensity, . For example, all else being equal, it is estimated that the increase in the number of dwellings would have lead to an increase of 1.03 Mtoe in residential energy use between 2000 and 2015. Similarly, all else being equal, the reduction in energy intensity per household would have lead to an overall decrease in energy use of 1.19 Mtoe.

42 For more information, see http://www.odyssee-mure.eu/

Figure 42: Decomposition of household energy use in Ireland, 2000 to 2015



Source: SEAI

Detailed data is required to estimate the effects of each of the drivers. Information on factors such as the increase in floor area and the number of dwellings is available and has been included. Other data, such as on the efficiency of electric appliances, is not available. Therefore, it has not been possible to estimate the scale of the effect of these trends on overall energy use. The reduction in energy intensity shown in *Figure 42* is estimated based on the same ODEX methodology that was used to estimate the energy efficiency increase shown in *Figure 41*. This is based on the observed reduction in energy per square metre between 2006 and 2014. This observed decrease in energy intensity is likely due to a number of factors including:

- revised building regulations governing energy efficiency in new dwellings;
- Energy efficiency retrofit upgrading of existing dwellings;
- increased energy prices (including carbon taxes);
- reduced incomes;
- improved awareness and information among consumers.

Further data collection and research would be required to estimate the scale of the impact of each of these factors.

3.3 Carbon Intensity

3.3.1 Carbon Dioxide Emissions per Unit of Energy

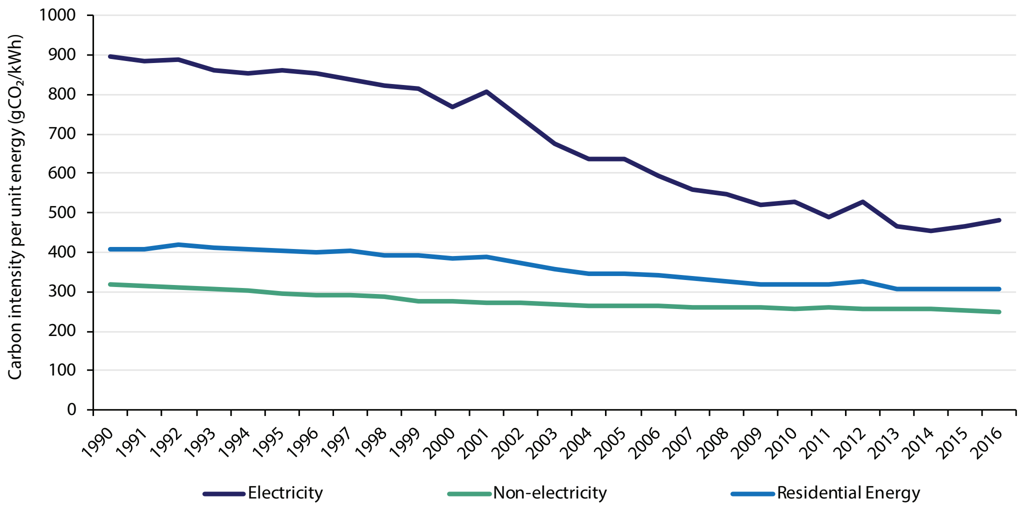
As discussed in section *1.2* , and shown here in *Figure 43,* the CO_2 intensity of the energy used in households has decreased since the 1990s. In the early 1990s, there was a shift away from burning coal and peat in open fires towards burning oil and gas in central heating systems. This resulted in a reduction in the average carbon intensity of the residential fuel mix. Excluding electricity, the carbon intensity of residential direct fuel use reduced by 14% between 1990 and 2000 (1.5% per annum). Between 2000 and 2016, this trend levelled out as central heating systems became standard. The carbon intensity of direct fuel use in households (i.e. all non-electric energy) improved by 9% between 2000 and 2016, (0.6% per annum).

Between 2000 and 2016, the CO_2 emissions per unit of electricity decreased by 37%

The carbon intensity of electricity also decreased during the 1990s, reducing by 14% between 1990 and 2000 (1.5% per annum). The rate of improvement increased from 2000; between 2000 and 2016, the CO_2 emissions per unit of electricity used decreased by 37%, (2.9% per annum).

As a result of these improvements the carbon intensity of the overall residential fuel mix reduced by 20% between 2000 and 2016 (1.4% per annum).

Figure 43: Carbon dioxide emissions per unit of energy used in the residential sector, 2000 to 2016



Source: SEAI

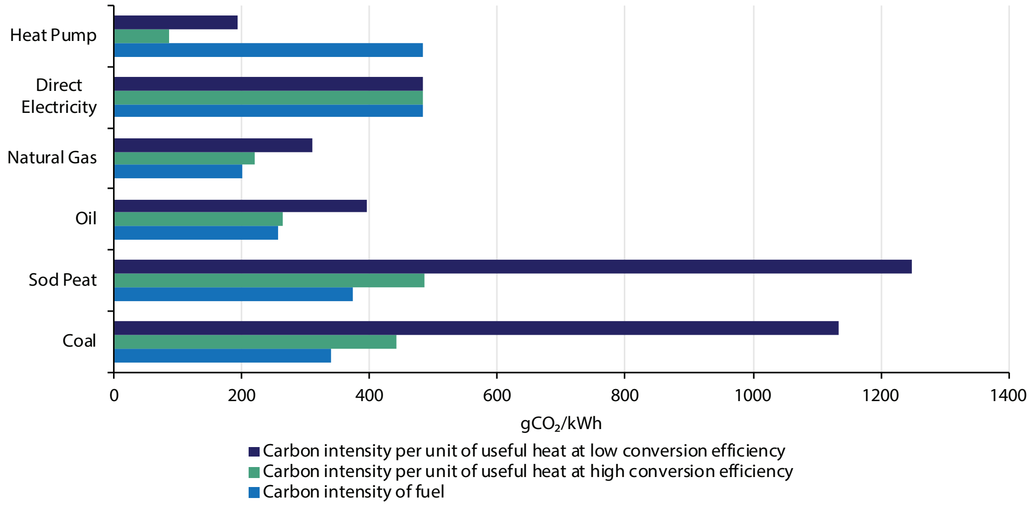
From *Figure 43,* it can be seen that electricity has a higher carbon emissions intensity than the average of the non-electric fuel mix, mainly oil and gas. This is investigated in more detail in *Figure 44* below. *Figure 44* and *Table 21* show the CO_2 emissions per kWh of energy for a number of fossil fuels and electricity. Generally, the carbon emissions intensity of a fossil fuel is expressed in terms of the gCO_2 per unit of energy produced when the fuel is fully combusted. This does not consider the efficiency of the energy conversion process, i.e. what fraction of the heat energy obtained from combusting the fossil fuel is available as useful heat energy, and what fraction is lost as waste heat. The carbon emissions intensity of electricity is taken as the CO_2 produced by the electricity generation sector per unit of electricity delivered. This does take into account the losses in generation and distribution of electricity. When electricity is compared to fossil fuels on this basis, it performs poorly, with a higher carbon emissions intensity than peat. A fairer comparison can be made by taking into account the efficiency of the fossil fuel energy conversion process.

Table 21 shows typical high and low efficiency factors for fossil fuels combustion and for electricity when used for direct heating and in a heat-pump[43]. Coal and peat are often combusted in an open fire, which can have efficiency as low as 30%; i.e. only 30% of the total energy from combusting the fuel is delivered to the dwelling as useful heat. Modern solid multi-fuel stoves capable of burning coal and peat can achieve efficiencies of up to 80%. Oil and gas are typically converted in

43 https://www.seai.ie/energy-in-business/ber-assessor-support/harp-database/

boilers, with efficiencies as low as 65% for older models, and up to 97% for oil and 92% for gas for newer high efficiency models. Electricity, when used for direct electric heating, can be considered to be 100% efficient. When electricity is used to power heat pumps, the heat output can be up to 5.6 times greater than the amount of electric energy input. Using these conversion efficiencies coal and peat burning in open fires is far more carbon intensive per unit of useful heat delivered to the dwelling than direct electric heating. In 2016, direct electric heating remained more carbon intensive per unit of useful heat delivered than oil or gas, even in low efficiency boilers, and potentially higher than coal and peat in high efficiency stoves. This is because a significant amount of electricity was still generated from coal and peat burning power-stations. If electricity is used in a heat-pump then the carbon emissions per unit of useful heat delivered are better than the most efficient gas or oil boilers.

Figure 44: CO_2 emissions per unit of useful heat energy delivered at high and low conversion efficiencies



Source: SEAI

Table 21: CO_2 emissions per unit of useful heat energy delivered at high and low conversion efficiencies

	Coal	Peat	Oil	Natural Gas	Direct Electricity	Electric Heat Pump
Carbon intensity of fuel per kWh of energy obtained when fuel is fully combusted for fossil fuels; carbon intensity of grid electricity in 2016. (gCO_2/kWh)	341	374	257	201	483	483
High efficiency energy conversion rate (%)	77%	77%	97%	91%	100%	560%
Low efficiency energy conversion rate (%)	30%	30%	65%	65%	100%	250%
Carbon intensity per unit of useful heat at high efficiency (gCO_2/kWh)	442	486	265	221	483	86
Carbon intensity per unit of useful heat at low efficiency (gCO_2/kWh)	1135	1248	395	309	483	193

Source: SEAI and CSO

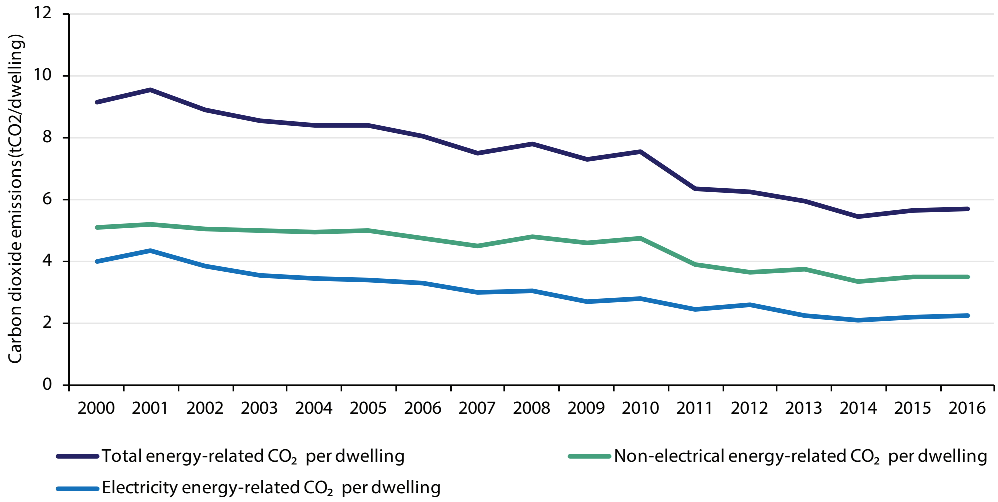
3.3.2 Carbon Dioxide Emissions per Dwelling

Table 22 presents data on the CO_2 emissions per household for selected years. In 2016, the average dwelling was responsible for emitting approximately 5.7 tonnes of CO_2 as a result of energy use. A total of 3.5 tonnes CO_2 (60%) came from direct fuel use and 2.2 tonnes CO_2 indirectly from electricity use.

Energy-related CO_2 emissions per dwelling in 2016 were 32% lower than in 2005

As a result of the falling CO_2 intensity of the residential sector fuel mix, together with the reduction in energy use per dwelling observed since 2007, there has been a steady trend of decreasing CO_2 emissions per dwelling since 2000, as shown in *Figure 45*. Energy-related CO_2 emissions per dwelling in 2016 were 32% lower than in 2005 (33% lower when corrected for weather), and 47% lower than in 1990. Due to the increase in energy use per dwelling in 2016 the CO_2 emissions per dwelling, weather-corrected, increased by 4.1%.

Figure 45: Energy-related carbon emissions per dwelling, weather-corrected, 2000 to 2016



Source: SEAI and CSO

Table 22: Residential energy consumption and CO_2 emissions per dwelling

	Quantity (tCO_2/dwelling)			Growth %		Average annual growth %		
Carbon intensity	**2000**	**2005**	**2016**	**2005-'16**	**2014-'16**	**2000-'05**	**2005-'16**	**2016**
Total energy-related CO_2 per dwelling	9.1	8.4	5.7	-32%	5%	-1.7%	-3.4%	1.0%
Non-electrical energy-related CO_2 per dwelling	5.1	5.0	3.5	-30%	4%	-0.4%	-3.3%	-0.3%
Electricity energy-related CO_2 per dwelling	4.0	3.4	2.2	-34%	7%	-3.4%	-3.6%	3.1%
Carbon intensity (Weather-Corrected)								
Total energy-related CO_2 per dwelling (weather-corrected)	9.0	8.5	5.7	-33%	5%	-1.2%	-3.6%	4.1%
Non-electrical energy-related CO_2 per dwelling (weather-corrected)	5.0	5.1	3.4	-33%	4%	0.3%	-3.6%	4.2%
Electricity energy-related CO_2 per dwelling (weather-corrected)	4.0	3.4	2.2	-34%	7%	-3.3%	-3.7%	3.9%

Source: SEAI and CSO

4 International Comparison

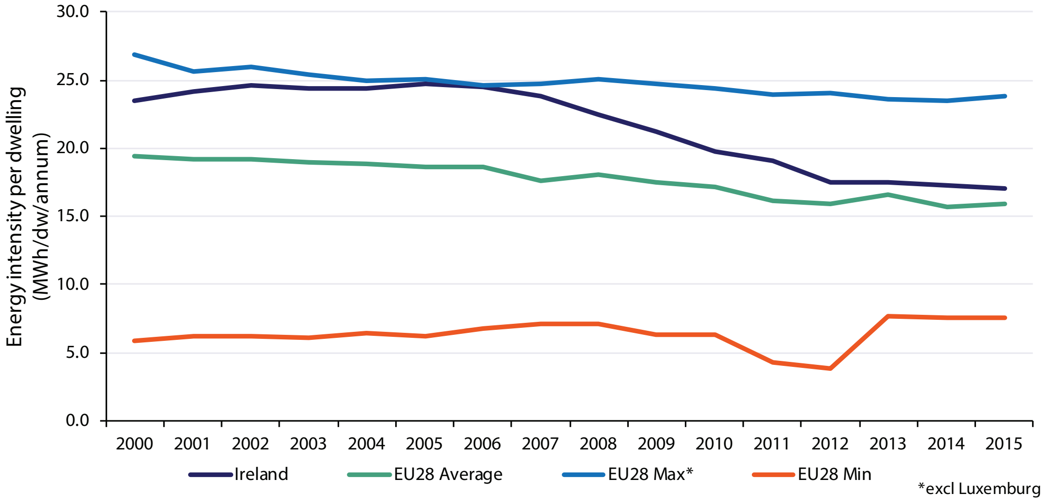
This section provides a comparison between the energy and carbon intensity of Irish households and those in other EU countries.

The Odyssee[44] project gathers large amounts of data on energy use in all EU member states and allows indicators of energy use to be compared between different countries. The data presented in this section is not directly comparable with that presented for Ireland in other sections of this report due to differing methodologies and emission factors used in Odyssee. It is useful, however, for cross country comparisons.

Figure 46 shows energy usage per dwelling for Ireland and the average for all EU states. Shown also are the highest and lowest values in the EU in each year, to show the level of variation. The values are weather-corrected, but are not adjusted for climate variation between different countries. For example, the data for Ireland is adjusted each year based on the difference between the number of degree-days experienced in Ireland that year, and the long-term average annual number of degree-days for Ireland. But it is not adjusted based on the difference between the long-term average annual number of degree-days in Ireland compared to the European average.

In 2006, Ireland had amongst the highest[45] energy usage per dwelling of all EU member states. Despite significant improvements between 2006 and 2012, (see *Figure 40*), Ireland's per dwelling energy usage in 2015 remained 7% above the EU average.

Figure 46: Energy usage per dwelling weather-corrected, 2000 to 2016



Source: ODYSSEE

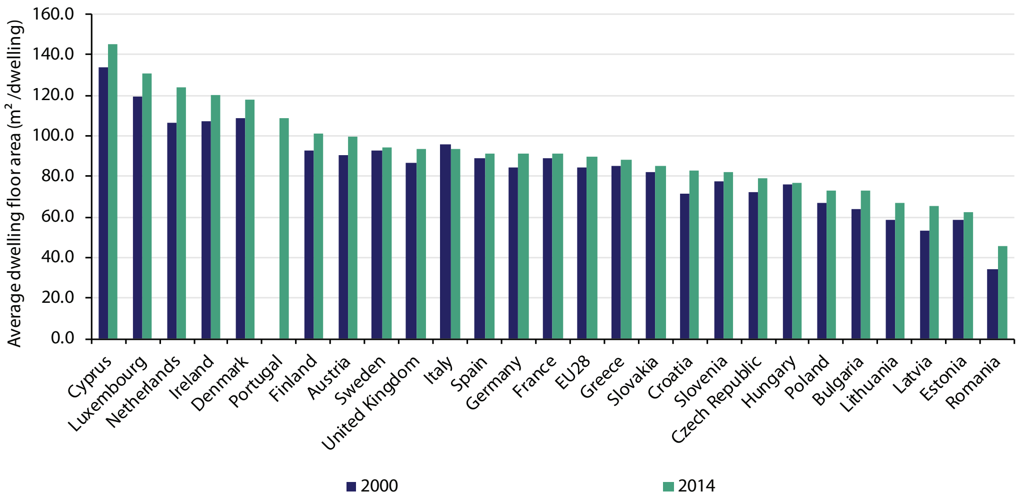
One factor leading to above average household energy consumption in Ireland, compared to other EU countries, is the larger average floor area of Irish dwellings. *Figure 47* shows the average floor area of dwellings for each EU country for 2014, sorted in order from highest to lowest. Shown also is the floor area in 2000 for comparison. In both years the floor area of the average Irish dwelling was amongst the largest in the EU.

In 2015, the energy use of the average Irish dwelling was 7% above the EU average

44 For more information see http://www.odyssee-mure.eu/

45 Note that Luxembourg has been omitted following consultation with the Odyssee database administrators, as it was an outlier with extremely high per dwelling energy usage and carbon emissions..

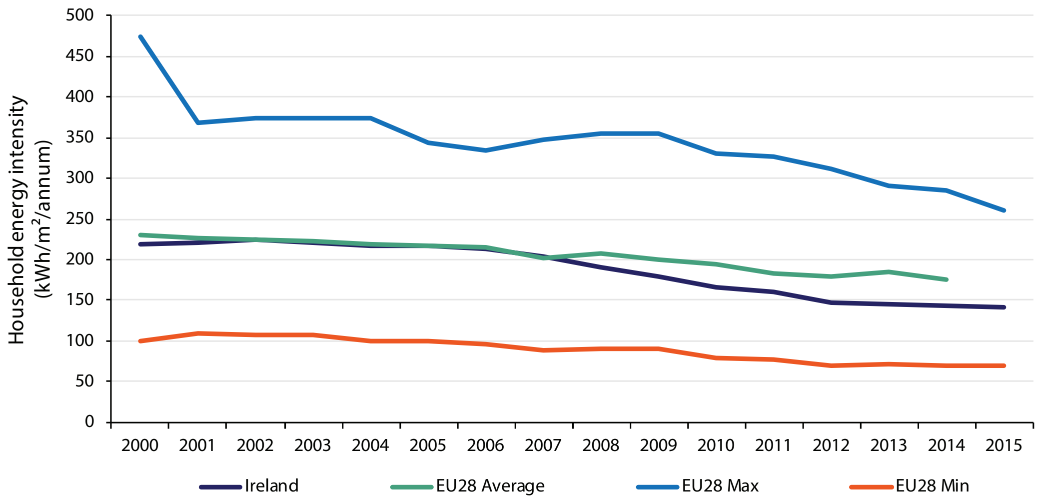
Figure 47: Average floor area per dwelling for EU member states, 2000 and 2014



Source: ODYSSEE

Figure 48 shows household energy consumption per square metre floor area, which eliminates the effect of larger dwelling sizes. As for *Figure 46* the data is weather corrected and trends are shown for Ireland, the EU average, and the range from highest to lowest each year. On this basis, the energy intensity of the Irish dwelling stock has been below the EU average since 2007.

Figure 48: Residential energy use per square metre, weather-corrected, for Ireland and the EU28, 2000 to 2015

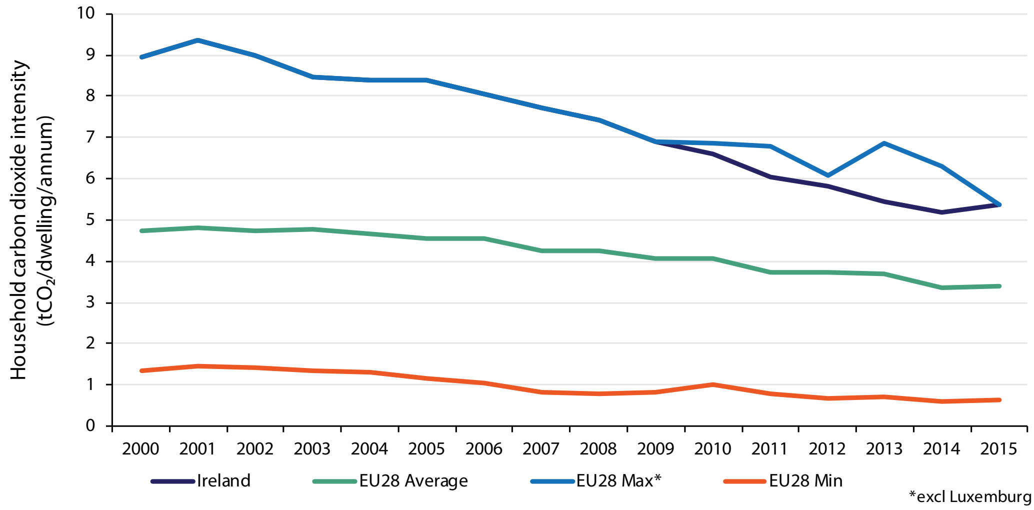


Source: ODYSSEE

Figure 49 illustrates CO_2 emissions per dwelling for Ireland, the EU average, and the highest[46] and lowest values in the EU in each year. Ireland had the highest carbon emissions per dwelling between 2000 and 2010, and again in 2015. In 2015, the average Irish dwelling emitted 58% more energy-related CO_2 than the average EU dwelling. This is due to a combination of the fuel mix used in Irish households, which has a high carbon intensity per unit of fuel used, and due to Ireland having above average energy consumption per dwelling.

46 Note that Luxembourg has been omitted following consultation with the Odyssee database administrators, as it was an outlier with extremely high per dwelling energy usage and carbon emissions.

Figure 49: Residential CO_2 emissions per dwelling, weather-corrected, Ireland and the EU28, 2000 to 2015

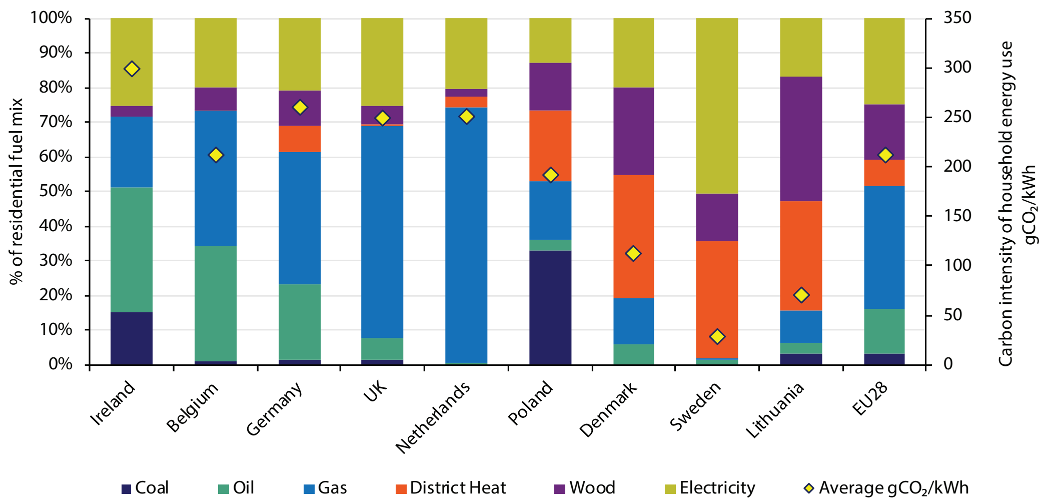


Source: ODYSSEE

In 2015, the average Irish dwelling emitted 58% more energy-related CO_2 than the average EU dwelling

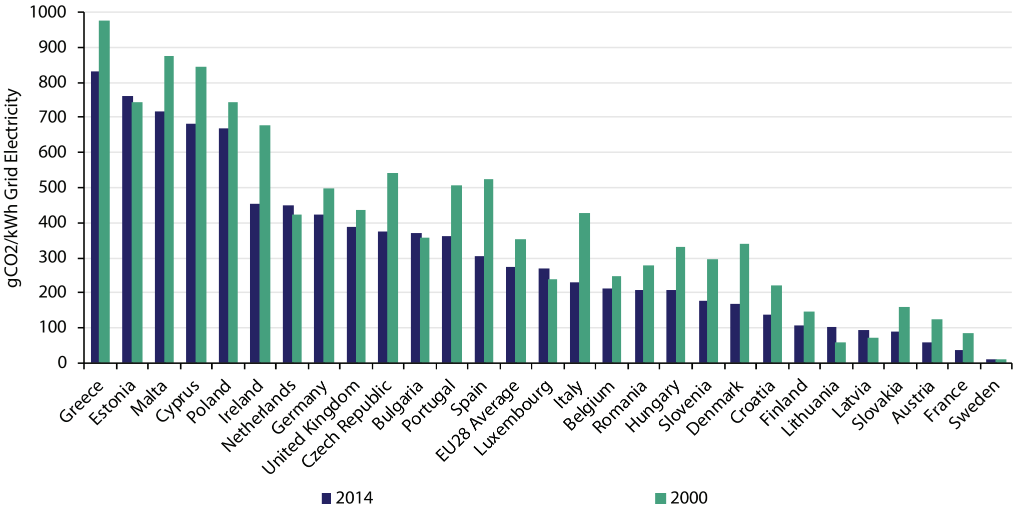
Figure 50 presents the fuel mix (final energy usage) for a select number of EU countries. 15% of energy used in Irish households is from direct use of coal and peat, which is counted here under the heading "coal". These are the two most carbon intensive fuels, and Ireland uses more of them per dwelling than any other EU member state, apart from Poland. In only four other EU states does coal use account for more than 2% of household energy use, and these are all former eastern block countries. 36% of energy used in Irish households is from oil, the highest proportion of any EU member state except for Cyprus. Oil is less carbon intensive than coal but more carbon intensive than gas. Another important factor is that Ireland's electricity remains amongst the most carbon intensive in the EU, despite significant ongoing improvements, as shown in *Figure 51*.

Figure 50: Residential final energy fuel mix, 2015



Source: ODYSSEE

Figure 51: CO_2 emissions per kWh of grid electricity for EU member states, 2000 and 2014



Source: European Environment Agency

Countries with the lowest carbon emissions intensity have high penetrations of district heating and electrification of heating, together with decarbonisation of both the district heating network and the electricity grid. For example, Sweden has achieved very low levels of carbon emissions intensity in households, through the use of district heating systems run on biomass and waste heat from power plants, and a largely decarbonised electricity system, powered by hydro and nuclear. Many eastern European states, for example Lithuania, have low carbon emissions intensity in households, due to widespread use of wood, which is considered carbon neutral, and district heating systems.

5 Areas for improvement in data collection

One of the purposes of this report is to inform and underpin policy decisions in Ireland. It is a further step in an ongoing process of developing and improving energy statistics in the residential sector. This section points to the current gaps in data and suggests areas for further development.

Data Gaps

Appendix 4 provides a short description of how SEAI produces statistics for each of the main fuels used in the residential sector, and where improvements are needed. There are strong policy drivers for gathering improved data, including those related to energy poverty and affordability, energy efficiency, emissions savings, fuel switching and deployment of renewable energy. The CSO is due to publish data from the Business Energy Use Survey for the first time in 2018. This improved data on energy use in the services sector should allow a better estimate of the split between services and residential sector for some fuel types. The area with the greatest need for improved data is in estimating the split of household energy by end-use.

A selection of some of the important data gaps remaining are:

- usage of supplementary space heating;
- the diffusion of more efficient supplementary heating equipment, such as stoves;
- internal temperatures, number of heating hours, number of rooms heated;
- the amount of non-traded wood and peat usage;
- total hot water usage;
- electricity use for hot water, including electrical immersions and electric showers;
- electricity by end-use;
- the market share and sales of appliances by energy rating label category;
- usage of electric appliances;
- linking existing data sets, in particular BERs, energy usage and socio-economic factors.

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Glossary of Abbreviations

Abbreviation	Explanation
BER	Building Energy Rating
CSO	Central Statistics Office
DCCAE	Department of Communications, Climate Action, and Environment
DCENR	Department of Communications, Energy and Natural Resources (Predecessor to the DCCAE)
DD	Degree-Days
DEAP	Dwelling Energy Assessment Procedure
EPC	Energy Performance Coefficient used in DEAP
EPSSU	SEAI Energy Policy Statistical Support Unit
ESR	Energy Statistics Regulation, Regulation (EC) No 1099/2008 of the European Parliament and of the Council
ETS	EU Emissions Trading Scheme
GHG	Greenhouse Gas
HBS	CSO Household Budget Survey
HDD	Heating Degree-Days
IEA	International Energy Agency
IREEUM	Irish Residential Energy End-Use Model
$ktCO_2$	Thousand tonnes of CO_2
ktoe	Thousand tonnes of oil equivalent
MPEPC	Maximum Permitted Energy Performance Coefficient used in DEAP
NZEB	Near Zero Energy performance Buildings
SILC	Survey of Income and Living Conditions
TGDL	Technical Guidance Document to Part L of the Building Regulations
toe	Tonne of oil equivalent

Energy Units

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

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

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

Energy Conversion Factors

To: / From:	toe	MWh	GJ
toe	1	**11.63**	**41.868**
MWh	0.086	**1**	**3.6**
GJ	0.02388	**0.2778**	**1**

Decimal Prefixes

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

Appendix 1: Residential Sector Final Energy Use

Residential Final Energy use (ktoe)	1990	2000	2005	2010	2015	2016
Coal	**626**	**286**	**246**	**254**	**206**	**179**
Bituminous Coal	608	210	163	177	126	101
Anthracite + Manufactured Ovoids	0	59	59	67	68	69
Coke	0	0	0	0	0	0
Lignite	18	17	24	10	13	9
Peat	**725**	**299**	**273**	**254**	**201**	**197**
Milled Peat	0	0	0	0	0	0
Sod Peat	570	179	183	165	128	128
Briquettes	155	120	90	88	73	69
Oil	**389**	**915**	**1,145**	**1,263**	**956**	**1,005**
Crude	0	0	0	0	0	0
Refinery Gas	0	0	0	0	0	0
Gasoline	0	0	0	0	0	0
Kerosene	105	570	795	1,010	775	815
Jet Kerosene	0	0	0	0	0	0
Fuel Oil	0	0	0	0	0	0
LPG	69	57	53	37	37	39
Gasoil / Diesel/ DERV	197	244	256	202	138	145
Petroleum Coke	19	44	41	13	7	6
Naphtha	0	0	0	0	0	0
Bitumen	0	0	0	0	0	0
White Spirit	0	0	0	0	0	0
Lubricants	0	0	0	0	0	0
Natural Gas	**117**	**439**	**607**	**710**	**555**	**563**
Renewables	**45**	**17**	**23**	**54**	**76**	**83**
Hydro	0	0	0	0	0	0
Wind	0	0	0	0	0	0
Biomass	45	17	16	27	32	33
Landfill Gas	0	0	0	0	0	0
Biogas	0	0	0	0	0	0
Wastes	0	0	0	0	0	0
Solar	0	0	0	7	13	14
Geothermal	0	0	6	20	31	37
Non-Renewable (Wastes)	**0**	**0**	**0**	**0**	**0**	**0**
Electricity	**356**	**548**	**646**	**735**	**678**	**677**
Total	**2,258**	**2,504**	**2,940**	**3,270**	**2,672**	**2,704**

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

Appendix 2: Policy Context

Irish energy policy is framed in the context of European legal obligations specified in various Directives and Regulations. This section outlines the key EU and national policies relevant to residential energy use in Ireland.

EU Policy Framework

The **EU 2020 Climate and Energy Package**[47] set out targets of a 20% efficiency improvement, 20% renewable energy share and 20% GHG emissions reduction by 2020.

The GHG emissions reductions targets are split across two categories. The first category covers large-scale carbon emitters in industry, power generation and international aviation. These bodies are dealt with at EU level under the EU Emission Trading System (ETS). The second category covers all GHG emissions not covered by the ETS, known as the non-ETS sector. This includes the majority of GHG emissions in the residential, transport and agricultural sectors, for example. Achieving GHG emissions reductions in the non-ETS sector is the responsibility of national governments. The **Effort Sharing Decision** (2009/406/EC)[48] specifies separate non-ETS GHG emissions reductions targets for each EU member state. The targets for each member state cumulate to meet the overall EU-wide target. Under this decision, Ireland is required to reduce non-ETS emissions by 20% below 2005 levels by 2020.

The European **Renewable Energy Directive** (2009/28/EC)[49] sets targets for Ireland of a 16% share of renewable energy in gross final consumption and a 10% share of renewable energy in transport by 2020.

The 2012 **Energy Efficiency Directive** (EED) (2012/27/EU)[50] establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. The EED requires EU countries to draw-up National Energy Efficiency Action Plans (NEEAPs)[51] and report on progress every three years. It also requires EU member states to develop long-term national building renovation strategies to be included in the NEEAPs.

The recast **Energy Performance of Buildings Directive** (EPBD) (2010/31/EU)[52], together with the EED, is the EU's main legislation covering the reduction of the energy consumption of buildings. The EPBD requires:

- energy performance certificates to be included in all advertisements for the sale or rental of buildings;
- EU countries to establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect;
- all new buildings to be nearly zero energy buildings (NZEB)[53] by 31 December 2020 (public buildings by 31 December 2018);
- EU countries to set minimum energy performance requirements for new buildings, for the major renovation of buildings, and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls etc.);
- EU countries to draw up lists of national financial measures to improve the energy efficiency of buildings.

The **Ecodesign Directive** (2009/125/EC)[54] requires manufacturers of appliances to decrease the energy consumption of their products by establishing minimum energy efficiency standards at EU level. The regulation covers a wide range of household and other appliances[55]. The **Energy Labelling Directive** requires manufacturers to supply energy labels with products to allow consumers to make informed decisions on the energy efficiency of appliances when purchasing. In July 2017, the Commission published a new Energy Labelling Regulation that will gradually replace the Directive.

In 2014, EU leaders adopted the **2030 Climate and Energy Framework**. This builds directly on the 2020 climate and energy package and sets three key targets for the year 2030: at least 40% cut in greenhouse gas emissions (from 1990 levels); at least 27% share for renewable energy; at least 27% improvement in energy efficiency. As was the case for the 2020 targets, GHG emissions reductions will be met through separate targets for the ETS and non-ETS sectors, with non-ETS GHG emissions reductions targets set for each member state. In 2016, the European Commission proposed an"Effort Sharing Regulation" which would set new national binding GHG emission targets for the period 2021–2030.

47 See https://ec.europa.eu/clima/policies/strategies/2020_en
48 See https://ec.europa.eu/clima/policies/effort_en#tab-0-0
49 See http://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive
50 See http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive
51 See http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans
52 See http://ec.europa.eu/energy/en/topics/energy-efficiency/buildings
53 See http://ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings
54 See https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products
55 For a list of the implementing regulation on each category of appliance see https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

In December 2017, the European Council agreed on a general approach to a regulation setting out the system for the governance of the Energy Union which integrates climate and energy planning into a single framework. The regulation is part of the clean energy package and it establishes a cooperation and control mechanism to oversee the implementation of the 2030 EU climate and energy policy objectives and targets, in particular, those regarding renewables, energy efficiency, interconnections and greenhouse gas emissions. Under the regulation, member states would submit integrated **National Energy and Climate Plans**, presenting their objectives, policies and measures in all five areas of the Energy Union, including GHG reduction targets. These plans would cover the period 2021-2030 and would be renewed every 10 years.

Irish Government Policies

Irish national energy policy has been developed in the context of the significant role played by the EU in determining energy policy in the member states. It takes account of European and International climate change objectives and agreements, as well as Irish social, economic and employment priorities.

The **National Policy Position on Climate Action and Low Carbon Development**[56] established the "**National Transition Objective**" of a low carbon, climate resilient and environmentally sustainable economy by 2050.

The **Climate Action and Low Carbon Development Act 2015**[57] provides the statutory basis for the National Transition Objective. It also commits the Minister for Communications, Climate Action and Environment to develop and submit to government a series of National Mitigation Plans and National Adaptation Frameworks.

The current **Energy White Paper**[58], "Ireland's Transition to a Low Carbon Energy Future 2015-2030" was published in December 2015. This document sets out a framework to guide policy between 2015 and 2030, but does not itself set out detailed policy proposals.

The first **National Mitigation Plan**[59] (NMP) was published July 2017. Under the 2015 Act, each NMP must specify the policy measures that Government consider are required to achieve the National Transition Objective. The first plan describes the range of policies and measures currently in place, or under consideration, across the electricity generation, built environment, transport and agriculture sectors that contribute to meeting the National Transition Objective; although it does not represent a complete road-map to achieving the 2050 objective. Current government policies and measures identified in the NMP that address energy in the residential sector include:

- Better Energy Homes;
- Better Energy Warmer Homes;
- Rental Sector – Housing Assistance Package;
- Better Energy Communities;
- Warmth and Wellbeing pilot scheme;
- Deep Retrofit pilot;
- Social Housing Upgrades;
- Building Regulations;
- Building Energy Rating (BER) certificates;
- Energy Efficiency Obligation Scheme;
- Qualibuild;
- Establishment of SEAI Behavioural Economics Unit.

Measures, relating to the residential sector, that the NMP identified as being under consideration include:

- Smart Metering;
- Minimal Thermal Standards in Rental Properties;
- Voluntary Housing Association Upgrades.

The NMP reiterates that increased energy efficiency is the principal strategy for decarbonising the built environment, together with fuel switching to meet the remaining, much reduced energy demand. Policies and measures to meet Ireland's 2020 energy efficiency targets are set out in the **National Energy Efficiency Action Plan**[60]. The most recent fourth NEEAP sets out progress towards the target and the measures in place to maximise progress to the target.

56 Available from http://www.dccae.gov.ie/en-ie/climate-action/publications/Pages/National-Policy-Position.aspx

57 Available from http://www.dccae.gov.ie/en-ie/climate-action/legislation/Pages/Climate-Action-and-Low-Carbon-Development-Act-2015.aspx

58 Available from http://www.dccae.gov.ie/en-ie/energy/topics/Energy-Initiatives/energy-policy-framework/white-paper/Pages/White-Paper-on-Energy-Policy-in-Ireland-.aspx

59 Available from http://www.dccae.gov.ie/en-ie/climate-action/topics/mitigation-reducing-ireland's-greenhouse-gas-emissions/national-mitigation-plan/Pages/default.aspx

60 Available from http://www.dccae.gov.ie/en-ie/energy/topics/Energy-Efficiency/national-energy-efficiency-action-plan-(neeap)/Pages/National-Energy-Efficiency-Action-Plan-(NEEAP).aspx

Appendix 3: Model of Residential Energy End-Use

Requirement to Split Residential Energy Data by End-Use

The Energy Statistics Regulation[61] (ESR) formally defines energy statistics, creating a common framework for the production, transmission, evaluation and dissemination of comparable energy statistics across the EU.

EU countries generally have reliable energy statistics on energy supply, i.e. the total amounts of energy by fuel type used in the country. The availability and reliability of detailed data on energy end-use in final sectors, for example, the amount of gas used for household water heating, is much more variable or limited. The ESR requires that Eurostat and the Member States jointly examine the possibility of improving the existing knowledge on final energy consumption. Following discussions between Eurostat and the Member States on the existing statistics at sectoral level, it was decided to begin to address the gaps in statistical information by focusing on the household sector, rather than transport or services, given the household sector's complexity and relevance in overall energy consumption, and its energy saving potential. Based on this, Commission Regulation (EU) No 431/2014 amends the ESR to require all Member States to supply data on energy consumption in households split by the following end-uses:

- space heating;
- space cooling;
- water heating;
- cooking;
- lighting and appliances;
- other uses.

Reporting became mandatory in 2016 for 2015 data. In addition to meeting the requirements of the ESR, the development of improved statistics on residential energy end-use is important, for example, to better inform policy on energy poverty and affordability, energy efficiency, emissions savings, fuel switching and deployment of renewable energy.

Methodology for Estimating Residential Energy Split by End-Use for Ireland

This section outlines the methodology developed by SEAI to provide a breakdown of household energy consumption by end-use, in response to the 2014 amendment to the Energy Statistics Regulation[62]. Guidance on practical ways to meet the requirements of the ESR are given in the Eurostat Manual for statistics on energy consumption in households (MESH)[63]. The MESH suggests a number of possible high level approaches, namely:

- business surveys;
- household surveys;
- existing administrative data;
- modelling;
- in-situ measurement.

The MESH noted that in practice a combination of some or all of the above methods would be required. Having assessed the strengths, weaknesses and resource requirements of the different possible approaches, it was decided that, in the first phase, modelling was the most appropriate option for Ireland. This led to the development of the Irish Residential Energy End-Use Model (IREEUM). It is important to note that the modelling approach is not a stand-alone option. In order to be effective it needs robust input data, which would usually be gathered through one or more of the other methods. It is envisaged that the initial model can be built upon and improved over time through incorporating the results of some or all of the other methods.

The MESH identifies the Cambridge Housing Model used for the UK as an example of good practice for modelling residential energy end-use. The Cambridge Housing Model is based on the UK Standard Assessment Procedure (SAP) for

61 Regulation (EC) No 1099/2008 of the European Parliament and of the Council; see http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1099

62 COMMISSION REGULATION (EU) No 431/2014 of 24 April 2014 amending Regulation (EC) No 1099/2008 of the European Parliament and of the Council on energy statistics, as regards the implementation of annual statistics on energy consumption in households. See http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32014R0431

63 Available from http://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-13-003

generating dwelling energy performance certificates. The Cambridge Housing Model is freely available and was used as a reference for the development of IREEUM.

IREEUM is based on a modified version of the Irish Dwelling Energy Assessment Procedure (DEAP)[64]. DEAP was developed by SEAI based on the UK SAP and is used to produce energy performance certificates for residential buildings, known in Ireland as Building Energy Ratings (BER). It is also used to demonstrate compliance of new dwellings with Part L of the Irish Building Regulations. DEAP calculates the annual delivered energy consumption, primary energy consumption and carbon dioxide emissions that would be required to deliver standardised levels of internal temperature, hot water, ventilation and lighting. Appendix 5 provides more information on BERs and DEAP

To perform a DEAP calculation for a particular dwelling it is necessary to first carry out a detailed survey of the physical characteristics of the dwelling, for example, surface area and U-value of building elements, heat system characteristics, etc. This is known as a BER survey, and can be carried out by registered BER assessors. The detailed data collected during BER surveys are stored centrally by SEAI in the BER database. This database contains detailed BER survey data on over 700,000 dwellings, or over a third of the entire stock of permanently occupied dwellings in Ireland. A limited version of this database is publicly available on the SEAI website for research purposes.

The Central Statistics Office (CSO) provided SEAI with a sub-sample of the BER database that was weighted to be representative of the Irish housing stock. IREEUM runs a modified DEAP calculation for each of the dwellings in the sample to calculate the energy demand split by fuel type and end-use for each. IREEUM also estimates the electricity use from household appliances. DEAP does not consider appliance energy use, so the energy usage for appliances and cooking is estimated based on the methodology in the UK Standard Assessment Procedure. The key output from IREEUM is the relative share of each end-use, rather than the absolute values. The estimated shares of each end-use for each fuel type are then applied to the SEAI National Energy Balance figures for residential fuel use to give residential final energy by fuel type and end-use.

Further Work Required

The split for each fuel type by end-use as estimated by IREEUM is dependent on the input assumptions used. DEAP was designed to estimate the theoretical energy demand of a dwelling when operating under standardised conditions for variables such as internal temperature, heating patterns and hot water usage. In reality, householders will operate their dwelling differently to these standard assumptions, and this will have an effect on both the overall energy consumption and the relative shares of the different end-uses. For example, if a dwelling maintains a lower internal temperature than the DEAP standard assumptions then it is likely to have a lower overall energy consumption and a higher share of water heating, compared to the DEAP estimate.

IREEUM allows for modification of any of the input variables or assumptions in DEAP. To produce the 2015 & 2016 statistics the only modification of the DEAP standard assumptions was to use real data for mean monthly external temperatures and level of solar radiation.

Further adjustments to the standard DEAP assumptions can be made to better reflect real world conditions wherever this can be supported by evidence. The modelling approach adopted here is not a stand-alone option. In order to be effective, it needs robust input data, which would typically be gathered through one or more of the other broad methods of collecting statistics, e.g. surveys, in-situ monitoring and measurement, and making use of other relevant administrative data sets by linking them to the BER database.

The accuracy and relevance of the model would be enhanced by the collection and measurement of data on factors such as:

- metered gas and electricity energy data linked to the BER dataset;
- internal temperature;
- daily hot water usage;
- secondary fuel usage;
- weekly heating patterns;
- occupancy;
- energy usage of cooking, other electric appliances.

64 For a more detailed description of DEAP, see https://www.seai.ie/energy-in-business/ber-assessor-support/deap/

Appendix 4: Production of Residential Energy Use Statistics

This section provides a brief overview of how statistics on energy use in the residential sector are produced for the National Energy Balance. It is hoped that providing this information will increase understanding of the strengths and weaknesses of the statistical information provided in this report.

Data for the National Energy Balance is primarily collected by top-down surveys of major fuel suppliers and network operators, for example, Gas Networks Ireland provide data on gas. In many cases, estimates or assumptions are then required to split total fuel consumption into the different sectors, for example residential sector and services sector. For distributed generation used on site, such as geothermal and solar energy, it is necessary to make an engineering estimate of the energy consumed.

The following sections describe briefly how residential sector consumption is estimated for each fuel.

Coal

SEAI carry out a monthly sample survey of large solid fuel distributors and importers. An additional estimate is made to cover the smaller units not surveyed. SEAI worked with the CSO in 2009 to develop this estimation technique, which uses data from the CSO trade statistics. Prior to 2009, data was based on estimates by industry experts.

Peat

Industry experts provided an estimate for consumption of sod peat in the residential sector up to 2011. This estimate was no longer available from 2012. For sod peat consumption in 2012, a 20% decrease was applied to the 2011 estimate. Since then, in the absence of further data, the figure has been assumed to have remained constant. In 2015, SEAI consulted with industry experts, and it was decided that there was no basis to amend the figure further. In 2011, sod peat was estimated to account for 67% of residential peat use, the remainder being from peat briquettes for which Bord na Móna provides an estimate.

Oil

Total oil consumption is calculated from DCCAE data collected monthly for the NORA levy[65]. The following sections describe the basis of the estimates made for the residential share of each oil product

Kerosene

Residential consumption of kerosene (home heating oil) is estimated as 90% of total national kerosene consumption. The forthcoming publication of the CSO Business Energy Use Survey (BEUS) should allow this estimate to be improved.

LPG

Residential LPG consumption is estimated based on shares provided by LPG suppliers in 2011. Results from the CSO BEUS will help to improve this figure.

Gasoil

Residential gasoil consumption is estimated based on the estimated 1990 split. Results from the CSO BEUS will help to improve this figure.

Natural Gas

Residential gas consumption is sourced from Gas Networks Ireland metered data.

Biomass

SEAI carry out a sample survey of known wood fuel suppliers. However, there is a very poor response rate to this survey. The market changes frequently and not all suppliers are covered. An estimate is included for untraded firewood. Since 1995, this has been assumed to have followed the same annual trend as coal and peat consumption. In 1995, all wood use was untraded and was estimated as 30 ktoe. By 2016, it was assumed that untraded wood use had dropped to 9 ktoe

65 The National Oil Reserves Agency (NORA) levy was introduced when NORA was set up in 1996, as a means of funding the maintenance of holding 90 days of strategic oil reserves for use in an emergency.

and accounted for 32% of wood energy. The previous “Energy in the Residential Sector, 2013 Report”[66] contains a more detailed description of the methodology for estimating wood use.

Solar Thermal & Solar PV

Residential solar thermal energy use is estimated based two data sources. The installed capacity of solar thermal in existing dwellings is estimated based on data from SEAI grant schemes, which support solar thermal. The installed capacity in new dwellings is estimated based on data from the BER database. The energy use is estimated based on the installed capacity (m^2) and an assumed average output rating (kWh/m^2).

Residential solar PV energy use is estimated based on data provided by ESB networks for the installed capacity of residential PV up to 2015. From 2015 on an estimate of installed capacity in new dwellings is made based on data from the BER database. The energy use is estimated based on the installed capacity (m^2) and an assumed average output rating (kWh/m^2).

Geothermal

Residential geothermal energy use is estimated based on data collected from the Heat Pump Association of Ireland (HPA) on the number and type of heat pump installations. Installed capacity, seasonal performance factor and annual running hours are assumed based on default values for each heat pump type and these are used to estimate the ambient heat delivered. A residential/commercial split was provided by the HPA in 2011 and these shares have been used since.

Electricity

Data on residential electricity use is sourced from the Commission for Regulation of Utilities retail market reports. SEAI estimate a share for the agricultural sector and subtract this to give residential use.

66 Available at https://www.seai.ie/resources/publications/Energy-in-the-Residential-Sector-2013.pdf

Appendix 5: Building Energy Ratings

Building Energy Rating Certificates

Building Energy Rating (BER) certificates were introduced in Ireland in 2007, as required under the Energy Performance in Buildings Directive[67]. The purpose of a BER is to make the energy performance of a dwelling visible and comparable to other dwellings on a like for like basis, allowing buyers and tenants to consider energy performance when deciding to purchase or rent a building. To do this the BER rates the theoretical energy performance of a dwelling, assigning it a rating from A1-G based on a calculation of the primary energy consumption in kWh per metre squared per year under standard conditions. Therefore a 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. The most efficient rating is an "A1" rating, which represents annual energy consumption of less than 25 kWh/m^2., as illustrated in the table below.

Primary Energy Consumption of bands on the BER scale.

BER Grade	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	E1	E2	F	G
Primary Energy kWh/m^2/annum	<25	>25	>50	>75	>100	>125	>150	>175	>200	>225	>260	>300	>340	>380	>450

Source: SEAI

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.

The results of every BER carried out as well as the large amount of data collected on the physical characteristics of each dwelling required for the DEAP calculation are recorded in the BER database. The BER scheme and database are audited and administered by SEAI. At the end of 2016, over 700,000 dwellings or just over 39% of the residential housing stock had been assessed and were included in the BER database. The BER Research Tool[68] gives researchers access to anonymised 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.

The Dwelling Energy Assessment Procedure

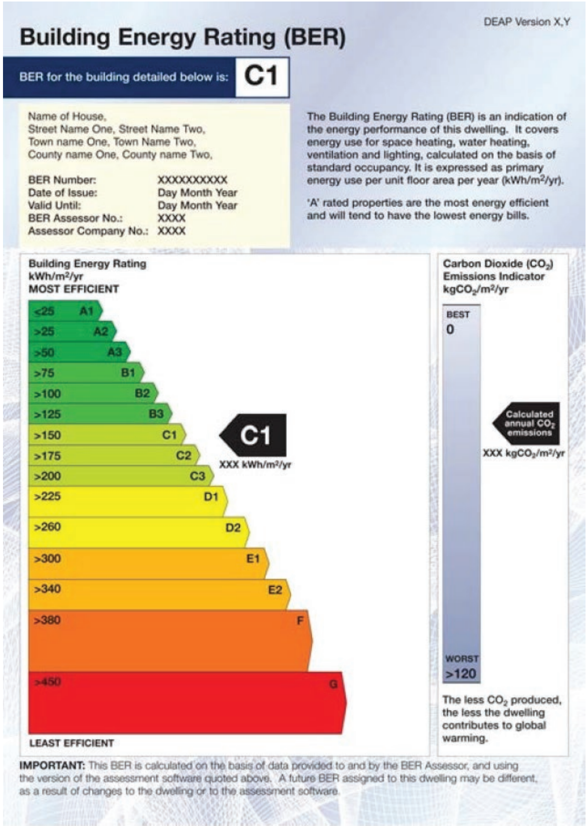
The BER calculation is carried out using the Dwelling Energy Assessment Procedure (DEAP). DEAP and the associated software were developed by SEAI to demonstrate the compliance of new dwellings to part L of the building regulations governing the conservation of fuel and energy and to produce BER certificates and reports.

DEAP calculates the theoretical annual delivered energy consumption, primary energy consumption and carbon dioxide emissions, under a set of standard operating conditions, for example, heating schedule, internal and external temperature, hot water usage per metre squared etc. These standard operating conditions are the same for all dwellings to allow comparability. DEAP takes account of space heating, water heating, ventilation and lighting, as well as reduction in imported energy due to renewable energy generation technologies. DEAP 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, although it does make some assumptions about heat gains from those sources.

It is important to note that the real life operation of a dwelling is likely to differ from the standard assumptions used in DEAP for heating patterns, internal temperature, hot water use, etc. For this reason, DEAP cannot be expected to be an accurate predictor of the real world energy consumption of a dwelling, and this is not its purpose. Instead DEAP gives an "asset rating" to the dwelling that allows different dwellings to be compared to each other on an equal footing. Therefore, a BER is only an indication of the energy performance of a dwelling; the actual energy usage will depend on individual heating patterns and internal temperatures as well as usage of domestic electrical appliances not covered by the assessment.

67 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).
68 The BER Research Tool administered by SEAI is available from: https://www.seai.ie/resources/tools/

The BER is expressed in kWh per metre squared per annum of primary energy. To convert to primary energy DEAP assumes an overhead for extracting, processing and transport of fuels. An overhead of 10% is applied to most fossil fuels delivered to the dwelling, thus the primary energy factor used in 1.1. The primary energy factor for electricity is adjusted periodically to reflect the changing efficiency and carbon intensity of the electricity grid. On January 6th 2016, the primary energy factor for electricity in DEAP was updated from 2.37 to 2.19. In June 2017, this was further updated to 2.08[69]. As a BER is based on primary energy consumption, the result is not directly comparable to the final residential energy consumption in the energy balances.



69 A detailed explanation is available here: http://www.seai.ie/Your_Building/BER/BER_FAQ/FAQ_DEAP/Results/What_are_the_electricity_factors_used_in_the_latest_version_of_DEAP.html

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