SUSTAINABLE ENERGY AUTHORITY OF IRELAND

ENERGY IN IRELAND

2018 Report

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December 2018

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Sustainable Energy Authority of Ireland (SEAI)

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 funded by the Government of Ireland through the Department of Communications, Climate Action and Environment.

SEAI is the official source of energy data for Ireland. We develop and maintain comprehensive national and sectoral statistics for energy production, transformation and end-use. These data are a vital input in meeting international reporting obligations, for advising policymakers and informing investment decisions. SEAI's core statistics 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.

Foreword

Jim Gannon

In October 2018, the Intergovernmental Panel on Climate Change published a Special Report on Global Warming of 1.5°C. The report shows that we are already seeing the consequences of 1°C of global warming through more extreme weather, rising sea levels and diminishing Arctic sea ice. These changes are impacting humanity and ecosystems today. To avoid the risk of long-lasting or irreversible changes to the climate system, it is clear that we must make rapid, far-reaching and unprecedented changes across all aspects of society. The transition to clean energy is an essential part of this.

This year's Energy in Ireland report shows clearly the significant challenge facing Ireland to reduce our reliance on fossil fuels for transport, heating and electricity production. In 2017, as Ireland's economy continued to grow, energy demand in industry, services and transport all increased. Over 90% of all energy used in Ireland was from fossil fuels.

We made progress in 2017 in increasing renewable sources of electricity and establishing Ireland as a world leader in this sector. This, alongside other activities, resulted in a reduction in the CO_2 intensity of our energy in Ireland of 2.6%, and specifically in our electricity sector of 10.2%. However, we still have a considerable way to go to meet our renewable energy targets, in particular for heat and transport which account for 80% of final energy demand.

The recent announcement of seven major climate change projects that will share €77 million government funding through the climate action fund, including major projects on district heating, electrification of transport and renewable sources for heat, is a welcome step in the right direction. This comes as part of the Government of Ireland's National Development Plan which commits to investing €7.6 billion of exchequer funding between now and 2027 to transition Ireland to a low carbon society, with an additional €8.6 billion to deliver sustainable public transport.

The bottom line is that change must come, and we need to continue to use less as we develop our local renewable sources of energy. This development will create significant economic opportunity, and will support the transition to a more sustainable economy – one that is not wedded to fossil fuel use.

Each of us, in our homes and businesses, have opportunities to be more sustainable in our use of energy. No one organisation or policy can address the problem of climate change in isolation. Supports funded by the Government of Ireland are available now to help with this, and all of us as citizens, businesses and motorists need to make choices consistent with a sustainable energy future. Over 400,000 householders have already taken action through Government grant schemes to upgrade their homes and more than 10,000 people are active around the country within our sustainable energy communities network. There remains an open invitation, and a wide range of supports for anyone willing to act.

As part of our statutory mandate, SEAI is committed to the development and provision of high quality data, such as that contained in this report. This insight ensures that policy formation, decision-making and our energy transition are evidence-based. We will continue to work across Government, and with other stakeholders, to ensure that this activity continues to accelerate our transition to a more economically and environmentally sustainable future.

Jim Gannon

Chief Executive

Sustainable Energy Authority of Ireland

Energy in Ireland 2017 highlights

ENERGY USE

+3.0%
ECONOMY (GNI*)

+0.5%
OVERALL ENERGY USE

-2.1%
ENERGY-RELATED CO_2 EMISSIONS

+3.4%	+2.0%	-2.9%	+4.2%	-1.1%
INDUSTRY	TRANSPORT	RESIDENTIAL	SERVICES	ELECTRICITY INPUTS

ELECTRICITY

ALMOST

1/3

OF ELECTRICITY FROM RENEWABLES

ELECTRICITY FUEL MIX

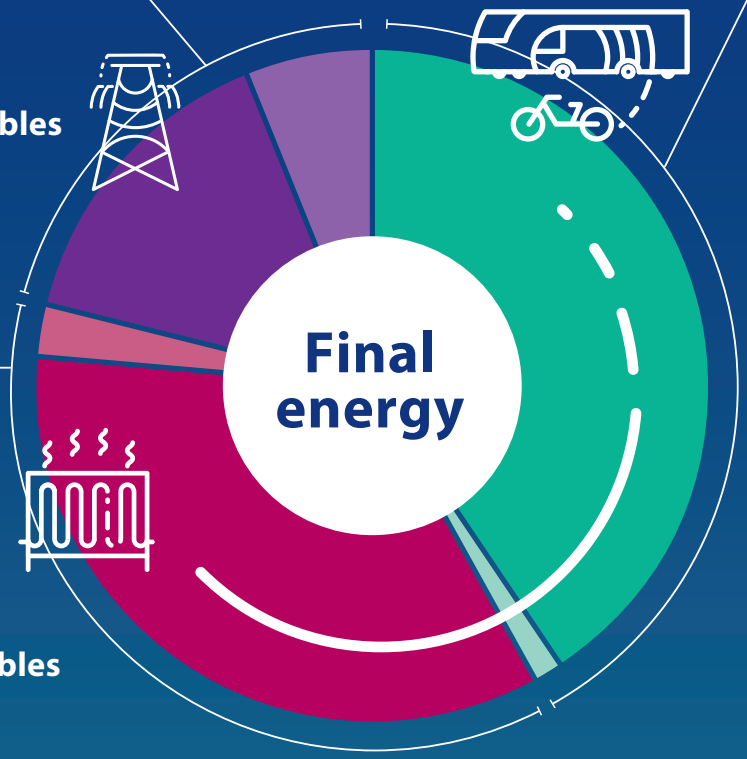
DECREASE IN COAL
-21.2%

DECREASE IN PEAT
-6.4%

INCREASE IN RENEWABLES
+19%

CO_2 INTENSITY OF ELECTRICITY

ALL TIME LOW
437g CO_2/kWh



ELECTRICITY 21%

Demand
+1.6%

CO_2 emissions
-7.3%

Share of renewables
30.1%

TRANSPORT 42%

Demand
+2.0%

CO_2 emissions
+1.2%

Share of renewables
7.4%

HEAT 37%

Demand
+1.0%

CO_2 emissions
-0.3%

Share of renewables
6.8%

90%
energy from fossil fuels

532 MW
WIND INSTALLATIONS

RECORD YEAR

RENEWABLE ELECTRICITY REPLACED
€278 million
OF FOSSIL FUEL IMPORTS

Highlights 2017

Overview

- Overall energy use increased by 0.5%, while the economy grew by 7.2% as measured by gross domestic product (GDP) or 3.0% as measured by modified gross national income (GNI*).
- Energy-related CO_2 emissions fell by 2.1% and were 18% below 2005 levels.
- CO_2 emissions from the combustion of fossil fuels account for approximately 60% of Ireland's total greenhouse gas (GHG) emissions.
- Indigenous energy production in Ireland reached a new record of 4,909 ktoe driven in the main by natural gas production from the Corrib gas field and to a lesser extent by increased renewables.
- This reduced Ireland's energy import dependency from 88% in 2015 to 66% in 2017.

Progress towards targets

- Renewables made up 10.6% of gross final consumption relative to a 2020 target of 16%. This avoided 4.1 million tonnes of CO_2 emissions and €439 million of fossil fuel imports.
- The share of electricity generated from renewable sources increased by 3.3 percentage points in 2017, to 30.1% towards the 40% 2020 target.
- The share of energy used for transport from renewable sources increased in 2017, to 7.4% towards the 10% 2020 target, up from 5.2% in 2016.
- The share of energy used for heat from renewable sources increased by 0.6 percentage points to 6.9% towards the 12% 2020 target.

Electricity

- Final consumption of electricity increased by 1.1% to 26 TWh. At the same time, there was a 1.1% reduction in the fuels used in electricity generation.
- Renewable electricity generation accounted for 30.1% (normalised) of gross electricity consumption. The use of renewables in electricity generation in 2017 reduced CO_2 emissions by 3.3 Mt and avoided €278 million in fossil fuel imports.
- Over 500 MW of wind generation was installed during the year. This saw wind generation account for 25.2% (normalised) of the electricity generated making it the second largest source of electricity generation after natural gas.
- The carbon intensity of electricity fell from 480 gCO_2/kWh in 2016 to 437 gCO_2/kWh. This was as a result of growth in renewable generation and reductions in coal and peat use.

Sectoral highlights

- Final energy use increased in all sectors with the exception of the residential sector.
- Transport continues to dominate as the largest energy-consuming sector, with a 43% share of final consumption.
- Transport energy use increased by 2%.
- The average emissions of new cars purchased in 2017 was 112.7 gCO_2/km, up slightly from 2016. From 2020 onwards, EU Regulation 433/2014 sets a target of 95 gCO_2/km for the average emissions of the new car fleet.
- Industrial energy use increased by 3.4% driven by a 7.6% increase in output as measured by value added.
- Residential energy use fell by 2.9% though when adjusted for weather, it actually increased by 0.2%.
- The average household emitted 5.1 tonnes of CO_2 of which 63% came from direct fuel use in the home and the remainder from electricity use. This is down from 8.4 tonnes in 2005.
- Final energy use in the commercial and public services sector increased by 4.2% – on a weather-corrected basis the increase was 7.4%.
- Energy-related CO_2 emissions in those sectors outside the EU Emissions Trading Scheme (ETS), which covers transport, heating in households, buildings and small industry, fell by 1.7%.

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1 Introduction

This annual publication from the Sustainable Energy Authority of Ireland (SEAI) presents national energy statistics on energy production and consumption in Ireland over the period 2005 – 2017. Specifically, the report presents energy trends and underlying drivers as well as discussion on sectoral energy consumption and how energy trends relate to Government and EU renewable energy targets.

Timely and reliable energy statistics underpin evidence-based decision-making. To this end, this publication presents a comprehensive overview of energy supply and demand in Ireland in order to inform Government policy and the wider energy debate. As the dialogue on climate change continues to gain momentum, it is now more important than ever that rational debate is based on robust statistical evidence from all emitting sectors.

The information in the report is based on annual energy balances for the country that show the flow of energy from production and transformation through to final consumption in different sectors of the economy. The energy balance is the starting point for the construction of various indicators of energy consumption (e.g. energy intensity, per capita, etc.), of energy efficiency and also of other areas of national interest such as energy-related greenhouse gas (GHG) emissions.

The data in the energy balance are based on monthly and annual surveys received from approximately 300 organisations including energy producers, import/export companies and energy supply companies. In addition, SEAI uses these data to fulfil Ireland's energy statistics reporting obligations to Eurostat[1], under the EU Energy Statistics Regulation (EC 1099/2008), and to the International Energy Agency (IEA) through the completion of upwards of a hundred annual, quarterly, monthly and ad hoc questionnaires each year.

The energy balance develops continuously as data revisions and new methodologies become available. This ensures that the best information is available. The main changes related to the period 2005 – 2017 are presented in this report and are described later.

A companion publication, *Energy Statistics – 2018 Report*, is also available, presenting the background data for the analysis contained herein. Additionally, *Energy in Ireland Key Statistics* is available, which summarises Ireland's energy statistics in a concise pocket-sized booklet. It is intended that these publications serve as resources for policymakers, analysts, researchers and anyone with an interest in energy use in Ireland.

An energy data portal containing the background data that this report is based upon, together with energy forecast data, and an electronic version of this and other statistical reports, are available on SEAI's website at http://www.seai.ie/resources/energy-data/.

Feedback and comment on this report are welcome. Contact details are available on the back cover of this report.

1 Eurostat is the statistical office of the European Union and is situated in Luxembourg.

2 Energy Supply and Use Trends

This section provides an overview of energy trends in Ireland, covering the period 2005 – 2017, with a particular focus on 2017. Ireland's total energy supply (gross energy consumption or total primary energy requirement (TPER)) is examined first, both in terms of the mix of fuels used and consumption by individual sectors. Trends in final energy demand, that is, the amount of energy used directly by final consumers, are then assessed. The link between energy use and economic activity, and the impacts of structural and efficiency changes are also discussed. Finally electricity production is examined in its own right because of its importance as an energy service.

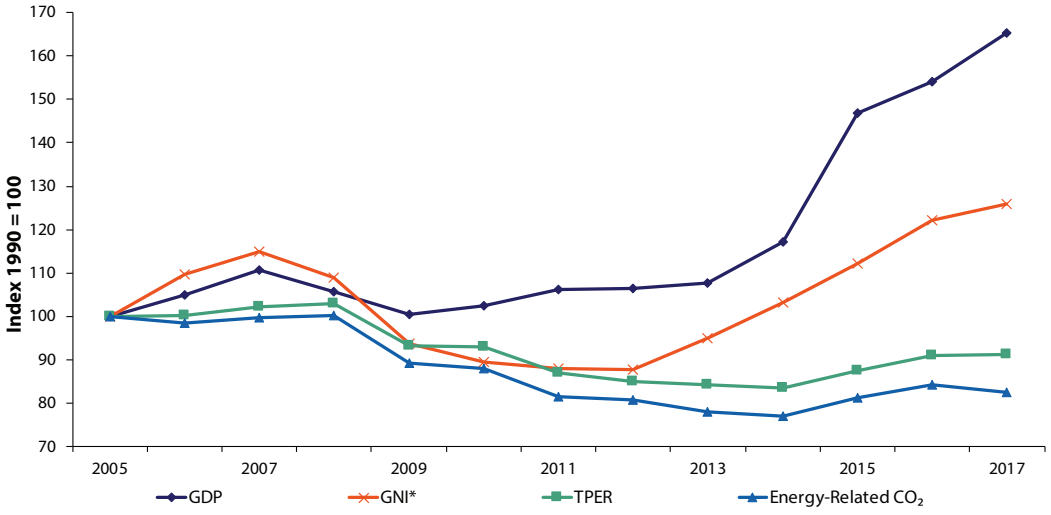
Energy supply depends on the demand for energy services (heating, transportation and electricity uses) and how that demand is satisfied. Energy service demand in turn is driven primarily by economic activity and by the energy end-use technologies employed in undertaking the activity. *Figure 1* shows the historical trends for gross domestic product (GDP), modified gross national income (GNI*)[2], TPER and energy CO_2, each expressed as an index relative to 2005. This captures the changes in economic growth between 2005 and 2017, showing the economic downturn between 2008 and 2012 and the subsequent return to growth after 2013. Both GDP and GNI* are measures of economic growth. GDP is the traditional measure but in Ireland is strongly influenced by the activities of multinational companies particularly in the realms of aircraft leasing and intellectual property rights. GNI* was developed by the Central Statistics Office (CSO) in 2017 to be more reflective of Irish economic activity.

Between 2014 and 2016 there was a return to growth in energy-related CO_2 emissions, but emissions fell in 2017 by 3.5%.

In 2008 the economy experienced a downturn that deepened into 2009. In 2008, industry and transport experienced reductions in energy use while there was continuing energy growth in the residential and services sectors, partly due to weather conditions. In 2009, however, all sectors of the economy experienced reductions in energy use and related emissions, tracking the decline in the economy. The years 2011 to 2013 were mild years compared with 2010 and, notwithstanding the flat growth in GDP and return to growth in GNI* in 2013, there was a drop in energy demand across all sectors of the economy during these years. Between 2007 and 2009, the economy contracted by 8% but by 2017 it had recovered to 49% above the 2007 level. However, overall energy use has fallen since 2008 and in 2017 was still 11% lower than in 2008.

In 2015 GDP grew by 26.3%, much of this was attributed to the transfer into Ireland of assets by multinationals, which had little or no effect on energy use. GNI* grew more modestly at 8.6% in 2015. GDP growth in 2016 was 5.0% and GNI* grew by 9.0%. Growth continued in 2017 with GDP growing by 7.2% and GNI* by 3.0%.

Figure 1: Index of Gross Domestic Product, Total Primary Energy Requirement (TPER) and energy-related CO_2



Source: Based on SEAI and CSO data.

2 Modified gross aational income (or GNI*) was introduced by the CSO in 2017 to assess the level of activity in the Irish economy excluding the effects of globalisation that disproportionately affect the Irish economic results. GNI* is defined as GNI less the effects of the profits of re-domiciled companies and the depreciation of intellectual property products and aircraft leasing companies.

Figure 1 shows the relative decoupling of TPER (also known as gross inland consumption[3]) from economic growth up to 2007 and again from 2011 onwards. This is a result of changes in the structure of the economy and improvements in energy efficiency.

CO_2 emissions[4] grew a little slower than energy use in the period 2005 to 2011 due predominantly to decarbonisation of the electricity sector (see Section *2.6*), however, the trends remain relatively coupled since.

Between 2010 and 2014, the economy grew by 15% as measured by GDP while energy use continued to fall, with a cumulative drop of 10% between 2010 and 2014. Some of the reduction in energy use can be accounted for by weather as 2010 was an exceptionally cold year. Other reasons for the reduction can also be attributed to a large increase (83%) in wind generation, which reduced the primary energy requirements for electricity generation. There also continued to be reductions in the energy intensity of households, due to a combination of improved energy efficiency, record high energy prices and reduced disposable incomes.

Between 2007 and 2009, the economy contracted by 8% but by 2017 it had recovered to 49% above the 2007 level. However, overall energy use has fallen since 2008 and in 2017 was still 11% lower than in 2008.

2015 saw the first significant increase in overall energy use since before the economic downturn in 2008, with TPER growing by 4.8%. This was linked to increased domestic economic activity as evidenced by the fact that final energy consumption in the industry and transport sectors, which are closely aligned with the economy, increased by 3.6% and 5.8% respectively. Overall energy use continued to grow in 2016 but at a more modest rate of 3.8% and continued to grow in 2017 but at a much lower rate of just 0.5%.

Table 1 displays the growth rates for the economy (GDP and modified GNI), primary energy (TPER) and energy-related CO_2 emissions for the period 1990 – 2017 and 2005 – 2017. 2005 is chosen because of its significance with respect to Ireland's 2020 greenhouse gas emissions target. Ireland's GHG emissions in non-Emissions Trading Scheme (non-ETS) sectors (i.e. in transport, agriculture, heating in buildings, waste and small industry) is for a 20% reduction below 2005 levels by 2020. Estimation of non-ETS energy emissions is given in *Section 3.2*.

Between 2005 and 2017, overall energy-related CO_2 emissions fell by 1.6% per annum on average, an aggregate decrease of 18%, while the economy is 65% (4.3% per annum) larger as measured by GDP than it was in 2005 or 26% (1.9% per annum) larger if measured by GNI*. In contrast, over the 27-year period since 1990, on average, energy-related CO_2 emissions grew by 0.7% per annum, while the economy grew by 5.5% per annum. Between 2014 and 2016 there was a return to growth in energy-related CO_2 emissions as shown in *Figure 1* but emissions fell in 2017 by 2.1%.

Table 1: GDP[5], Modified GNI, TPER and CO_2 growth rates[6]

	Growth %	Growth %	Average annual growth rates %				
	1990 – 2017	2005 – 2017	'05 – '17	'05 – '10	'10 – '15	'15 – '17	2017
GDP	319.3	65.2	4.3	0.5	7.5	6.1	7.2
Modified GNI (current prices)	-	25.8	1.9	-2.2	4.6	6.0	3.0
TPER	52.7	-8.7	-0.8	-1.5	-1.2	2.1	0.5
Energy CO_2	25.5	-17.6	-1.6	-2.5	-1.6	0.7	-2.1
Energy CO_2 (excl. int'l aviation)	19.8	-19.8	-1.8	-2.6	-1.8	0.0	-3.5

Energy use is primarily driven by economic activity, but the relationship in Ireland is less straight-forward than for other countries as significant portions of GDP or value added in Ireland is generated with very little consumption of energy. This was very well illustrated in 2015 when GDP grew by 26.3% as a result of the transfer into Ireland of intellectual property. Therefore, care must be taken when comparing macro-economic indicators such as energy intensity across countries.

3 As energy cannot be created or destroyed energy is not strictly speaking consumed. Energy commodities, or fuels, are in effect energy carriers and allow the energy contained in them to be used for mobility, power and heat purposes. When a commodity is used the energy is not lost but transformed into a state that is no longer readily useful, mainly in the form of low grade heat. When this happens the commodity that carried the energy has been consumed and is removed from the energy (commodity) balance. In this way terms such as Gross Inland Consumption and Total Final Consumption (TFC) may be interpreted as the final consumption of energy commodities.

4 Energy-related CO_2 emissions shown here cover all energy-related CO_2 emissions associated with TPER, including emissions associated with international air transport. These are usually excluded from the national GHG emissions inventory in accordance with the reporting procedures of the UN Framework Convention on Climate Change (UNFCCC) guidelines.

5 GDP rates are calculated using constant market prices chain-linked annually and referenced to 2016.

6 Throughout the report where annual growth rates are across multiple years they always refer to *average annual growth rates*.

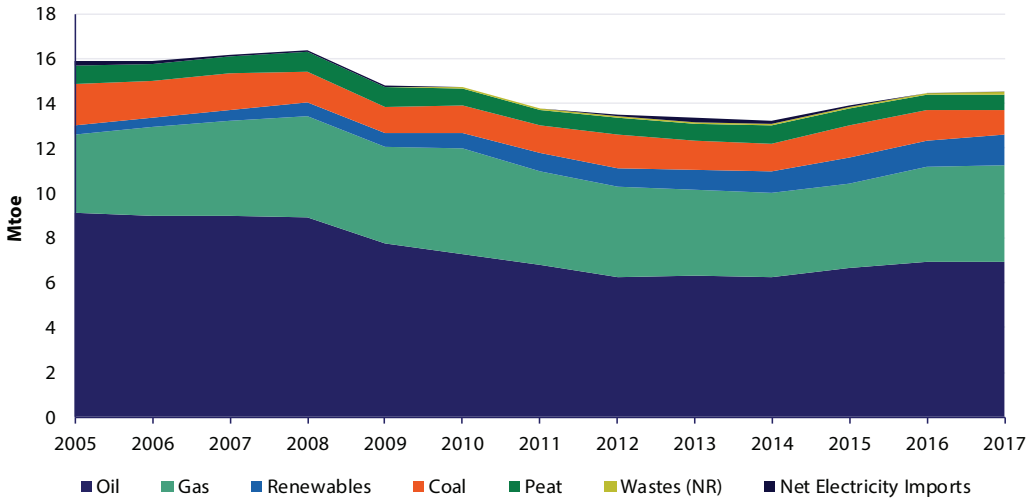
Transport and industry have been more responsive to changes in economic activity, while, in the short term, residential and services energy use is heavily influenced by annual variations in weather and to some extent, energy price.

2.1 Energy Supply

Ireland's energy supply is discussed in terms of changes to the TPER, defined as the total amount of energy used in Ireland in any given year. This includes the energy requirements for the conversion of primary sources of energy into forms that are useful for the final consumer, for example electricity generation and oil refining. These conversion activities are not all directly related to the level of economic activity that drives energy use but are dependent to a large extent, as in the case of electricity, on the efficiency of the transformation process and the technologies involved.

Figure 2 illustrates the trend in energy supply over the period 2005 – 2017, emphasising changes in the fuel mix. Primary energy consumption in Ireland in 2017 was 14,473 ktoe, a 0.5% increase on the previous year. Over the period 2005 – 2017 Ireland's annual TPER fell in absolute terms by 8.7% (0.8% per annum on average).

Figure 2: Total Primary Energy Requirement[7]



The individual fuel growth rates, quantities and shares are shown in *Table 2*. Primary energy requirement peaked in 2008 and has fallen by 11% since then.

Table 2: Growth rates, quantities and shares of TPER fuels

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-14.7	-1.3	-1.8	-2.1	1.7	-1.6	15,306	13,058	96.6	90.2
Coal	-41.6	-4.4	-8.1	3.0	-12.2	-19.8	1,882	1,099	11.9	7.6
Peat	-12.2	-1.1	-0.7	0.0	-4.8	-5.3	791	695	5.0	4.8
Oil	-23.9	-2.2	-4.4	-1.8	2.2	0.5	9,130	6,948	57.6	48.0
Natural Gas	23.2	1.8	6.1	-4.4	7.0	1.5	3,503	4,315	22.1	29.8
Renewables (Total)	263.8	11.4	12.9	10.9	8.9	18.9	370	1,347	2.3	9.3
Hydro	9.6	0.8	-1.0	6.1	-7.4	1.6	54	59	0.3	0.4
Wind	569.5	17.2	20.4	18.5	6.4	21.1	96	640	0.6	4.4
Biomass	109.6	6.4	3.1	6.2	15.2	13.2	180	378	1.1	2.6
Other Renewables	572.8	17.2	34.2	4.5	11.4	27.1	40	270	0.3	1.9
Wastes (Non-Renewable)	-	-	-	51.7	35.5	89.6	-	126	-	0.9
Electricity Imports (net)	-133.2	-	-25.5	7.4	-	-4.7	176	-58	1.1	-0.4
Total	**-8.7**	**-0.8**	**-1.5**	**-1.2**	**2.1**	**0.5**	**15,852**	**14,473**		

The following are the main trends in national fuel share:

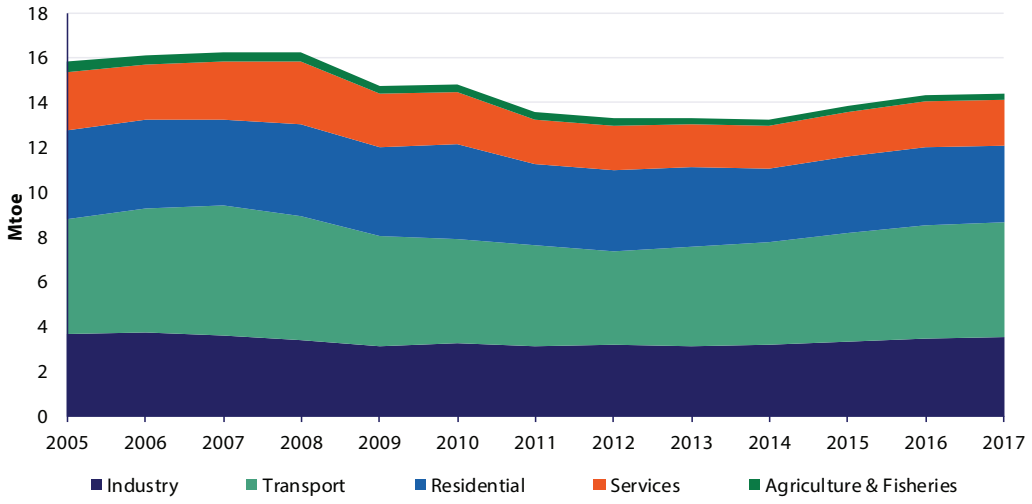
- Overall primary energy use grew by 0.5% in 2017.

7 'Wastes (NR)' in the graph represents energy from non-renewable wastes.

- Fossil fuels accounted for 90% of all energy used in Ireland in 2017. Demand for fossil fuels fell by 1.6% in 2017 to 13,058 ktoe but was 15% lower than in 2005.
- Coal use decreased by 20% in 2017 and its share of TPER fell to 7.6% down from 10.3% in 2015. Since 2005, coal demand has fallen by 42% (4.4% per annum).
- Peat use fell by 5.3% in 2017 and its share of overall energy use was 4.8%.
- Oil continues to be the dominant energy source and maintained a 48% share of TPER in 2017. The share of oil in overall energy use peaked in 1999 at 60%. Consumption of oil, in absolute terms, increased by 0.5% in 2017 to 6,948 ktoe but compared with 2005, oil demand in 2017 was 24% lower.
- Natural gas use increased in 2017 by 1.5% to 4,315 ktoe and its share of TPER increased to 30%. Natural gas use was 23% higher than in 2005.
- Total renewable energy increased by 19% during 2017 to 1,347 ktoe in 2017. Hydro and wind increased by 1.6% and 21% respectively. Biomass use increased by 13.2% in 2017 to 378 ktoe and other renewables increased by 27% to 270 ktoe. The overall share of renewables in primary energy stood at 9.3% in 2017 up from 7.9% in 2016.
- Energy from non-renewable wastes increased by 90% in 2017 to 126 ktoe and accounted for 0.9% of primary energy.
- Ireland continued to be a net exporter of electricity in 2017, exporting 58 ktoe, 4.7% less than in 2016.

Figure 3 allocates Ireland's primary energy supply to each sector of the economy, according to its energy demand. The allocation is straightforward where fuels are used directly by a particular sector. Regarding electricity, the primary energy associated with each sector's electricity consumption is included to yield the total primary energy supply for each sector.

Figure 3: Total Primary Energy Requirement by sector[8]



Primary energy supply gives a more complete measure than final energy demand (accounted for in the gas, oil, electricity and coal bills) of the impact of the individual sectors on national energy use and on energy-related CO_2 emissions.

Table 3 shows the growth rates of the different sectors in terms of TPER and also provides the percentage shares of TPER for 2005 and 2017. With the exception of the residential sector, all other sectors' energy use grew in 2017, which can be directly attributed to the growth in the economy. Energy use in the residential sector is mainly for space heating, and 2017 was a warmer year than 2016.

Demand for fossil fuels fell by 1.6% in 2017 to 13,058 ktoe and was 15% lower than in 2005.

8 International air transport kerosene is included in the transport sector in these graphs. Later graphs showing CO_2 emissions by sector omit international air transport energy emissions following UN Intergovernmental Panel on Climate Change (IPCC) guidelines. In addition, the effects of cross-Border trade (fuel tourism) and the smuggling of diesel and petrol are not included in this analysis. Estimates of fuel tourism are now included in the energy balance and presented in the transport section (Section *4.2*).

Table 3: Growth rates, quantities and shares of TPER by sector

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Industry	-3.1	-0.3	-2.1	0.4	2.9	1.5	3,635	3,523	22.9	24.4
Transport	-0.8	-0.1	-2.1	0.8	2.8	2.0	5,181	5,138	32.7	35.6
Residential	-13.5	-1.2	1.5	-4.1	-0.5	-2.9	3,928	3,398	24.8	23.6
Services	-21.5	-2.0	-3.0	-3.2	3.7	1.8	2,647	2,079	16.7	14.4
Agriculture / Fisheries	-37.8	-3.9	-5.2	-5.1	2.9	2.6	468	292	3.0	2.0

Changes in sectoral primary energy consumption presented in *Table 3* are as follows:

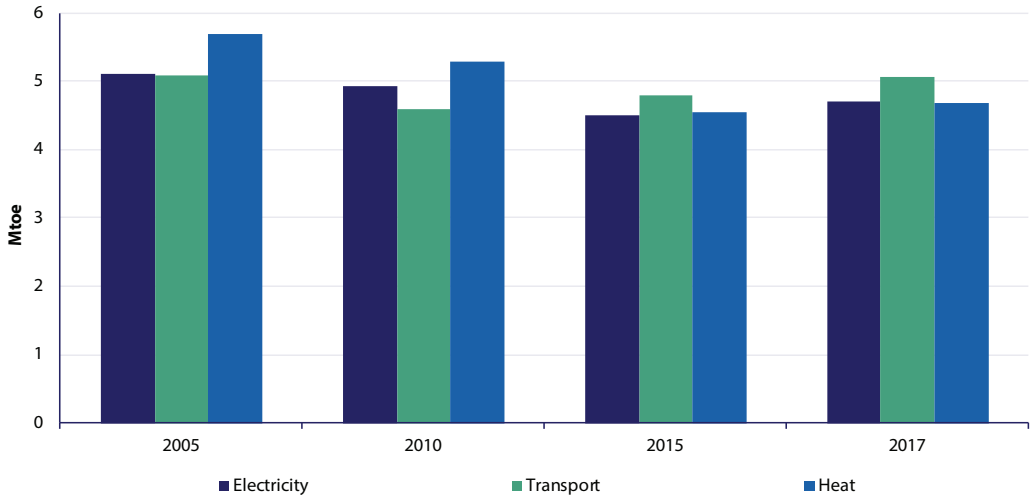
- Transport experienced an increase in primary energy use in 2017 of 2% to 5,138 ktoe. Transport primary energy use fell by 28% between 2007 and 2012 but has increased by 22% since then. Transport remains the largest energy consuming sector with a 36% share of primary energy in 2017.
- In 2017, primary energy use in households fell by 2.9% to 3,398 ktoe. 2017 was warmer than 2016 with 2.9% fewer heating degree days. Residential share of primary energy was 24% in 2017.
- Industry primary energy increased by 1.5% in 2017 to 3,523 ktoe. Industry's share of primary energy was 24% in 2017.
- Use of primary energy in the commercial and public services sector increased by 1.8% in 2017 to 2,079 ktoe. Services' share of primary energy was 14% in 2017.
- Primary energy use in the residential sector and services sector can be considered collectively as energy in buildings as most of the energy use is associated with heating/cooling and lighting the buildings. In 2017, primary energy in buildings accounted for 38% of primary energy supply. Overall, primary energy use in buildings has fallen by 17% since 2005 (1.5% per annum) and in 2017 it fell by 1.1% to 5,477 ktoe.
- Agriculture/fisheries' primary energy use increased by 2.6% in 2017 to 292 ktoe and accounted for 2% of primary energy.

Sectoral energy-related CO_2 emissions are discussed in Section *3.2*.

2.2 Energy Use by Mode of Application

Energy use can be categorised by its mode of application: whether it is used for mobility (transport), power applications (electricity) or for thermal uses (space, water or process heating). These modes also represent three distinct energy markets. Where thermal or transport energy is provided by electricity (e.g. electric heaters and electric vehicles) this energy is considered under electricity, and not under thermal or transport, so that double counting is avoided.

Figure 4: Primary energy by mode of application



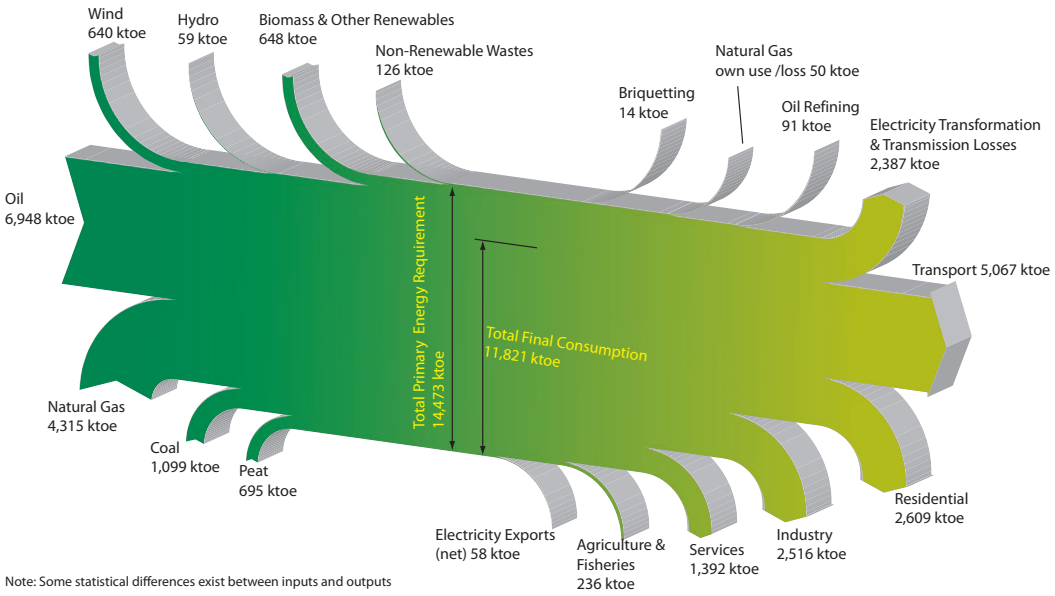
In 2005, thermal uses for energy (5,683 ktoe) accounted for the highest share of primary energy at 36%, while transport and electricity were equal at 32%. In 2017, the transport share had risen to 35% (5,063 ktoe), the thermal share had fallen

to 32% (4,689 ktoe), and the share of energy use for electricity generation was 33% (4,696 ktoe). The changes in mode shares are shown in *Figure 4*.

2.3 Energy Balance for 2017

Figure 5 shows the energy balance for Ireland in 2017 as a flow diagram. This illustrates clearly the significance of each of the energy/fuel inputs, shown on the left, as well as showing how much energy is lost in transformation and the sectoral split of final energy demand.

Figure 5: Energy flow in Ireland 2017[9]



Oil dominates as a fuel, accounting for 6,948 ktoe, representing 48% of the total requirement. Renewables are disaggregated into wind, hydro and other renewables in *Figure 5* and accounted for 9.3% of TPER.

Transport continues to be the largest of the end-use sectors, accounting for 5,067 ktoe, representing 43% of total final consumption (see *Section 2.4*) in 2017.

Losses associated with the generation and transmission of electricity amounted to 16% of TPER or 2,387 ktoe in 2017 (50% of the primary energy used for electricity generation). In 2005, losses associated with electricity generation represented 19% of TPER and 59% of the primary energy used for generation.

Figure 6 shows an alternative view of the 2017 energy balance. In this the total primary energy is shown as 168,294 GWh (14,473 ktoe) in the centre and then the shares by mode in the next circle, and finally the shares of energy sources used in each of the modes in the outer circle. All of the percentages shown are of the total primary energy figure in the centre.

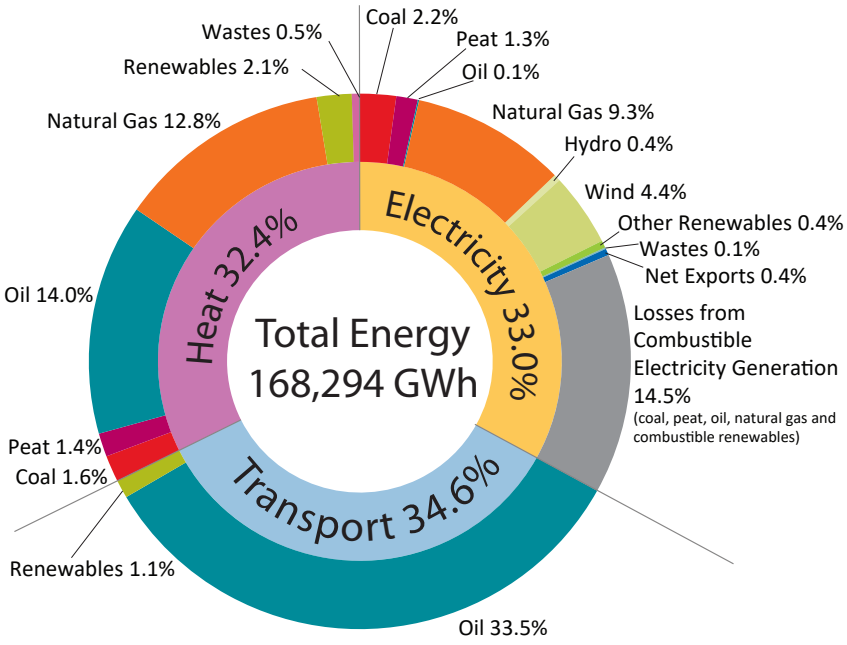
Taking transport as an example in *Figure 6*, it can be seen that transport accounted for 35% of overall primary energy and that oil use in transport, which accounts for the bulk of transport energy use (96%), accounts for 34% of primary energy use and renewable energy use in transport accounts for just 1.1%.

Energy use for heat purposes accounted for 32% of primary energy and oil and gas make up the largest proportions of energy use for heat. Oil use for heat accounted for 14% of overall energy, natural gas 12.8% followed by renewables at 2.1%, coal 1.6%, peat 1.4% and wastes at 0.5%.

Energy used to generate electricity accounted for 33% of all energy use in Ireland in 2017. A significant proportion of it, accounting for 14.5% of all energy use, is lost in the transformation process from combustible fuels to electricity. The figures in the outer circle show the proportions of electricity generated by the different energy sources and their share of overall primary energy. The largest share of electricity generated comes from natural gas and represents 9.3% of primary energy use. This is followed by wind which accounted for one fifth of electricity generated and 4.4% of primary energy. Coal generated electricity represented 2.2% of primary energy in 2017, peat 1.3% and oil just 0.1%.

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

Figure 6: Primary energy by mode and fuel



2.4 Energy Demand

Final energy demand is a measure of the energy that is delivered for use in activities as diverse as manufacturing, movement of people and goods, essential services and other day-to-day energy requirements of living; space and water heating, cooking, communication, entertainment, etc. This is also known as total final consumption (TFC) and is essentially total primary energy less the quantities of energy required to transform primary sources such as crude oil and other fossil fuels into forms suitable for end-use consumers; electricity, patent/manufactured fuels, etc. These transformation, processing or other losses entailed in delivery to final consumers – known as 'energy overheads' – are not included in the TFC figures.

Figure 7: Total Final Consumption by fuel

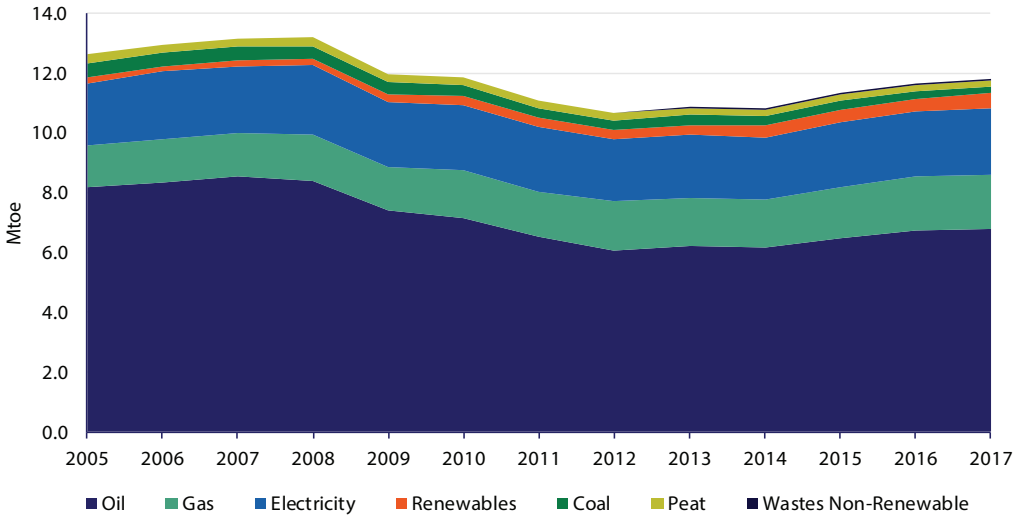


Figure 7 shows the shift in the pattern of final energy demand by fuel over the period 2005 – 2017.

Ireland's TFC in 2017 was 11,821 ktoe, an increase of 1.4% on 2016 and 6.2% lower than the 2005 level of 12,606 ktoe. When corrected for weather[10], final energy consumption increased in 2017 by 3.3%. Final consumption peaked in 2008 at 13,189

10 Weather correction is a method of smoothing out the variations in energy use for heating purposes resulting from annual changes in weather patterns. See Section *2.8 Energy and the Weather*.

ktoe and has fallen by 10.4% since then. The changes in the growth rates, quantities and respective shares of individual fuels in final consumption over the period are shown in *Table 4*. For more detail on absolute values associated with *Table 4* see the companion document Energy Statistics 1990 – 2017.

Table 4: Growth rates, quantities and shares of TFC fuels

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-12.3	-1.1	-1.9	-1.4	1.9	0.5	10,324	9,055	81.9	76.6
Coal	-48.2	-5.3	-5.4	-3.2	-10.3	-12.0	484	251	3.8	2.1
Peat	-31.0	-3.0	-1.5	-4.5	-3.1	-4.4	274	189	2.2	1.6
Oil	-17.1	-1.6	-2.7	-2.0	2.4	0.9	8,196	6,791	65.0	57.5
Natural Gas	33.2	2.4	3.0	1.6	3.0	1.7	1,369	1,824	10.9	15.4
Renewables (Total)	151.0	8.0	10.5	5.2	8.5	17.4	188	472	1.5	4.0
Wastes (Non-Renewable)	-	-	-	38.8	26.1	67.8	0	70	0.0	0.6
Combustible Fuels (Total)	-9.2	-0.8	-1.7	-1.2	2.3	1.4	10,507	9,542	83.3	80.7
Electricity	6.2	0.5	0.9	-0.3	1.5	1.1	2,094	2,223	16.6	18.8
Total	**-6.2**	**-0.5**	**-1.2**	**-1.0**	**2.2**	**1.4**	**12,606**	**11,821**		
Total Weather Corrected	**-5.9**	**-0.5**	**-2.2**	**-0.3**	**3.4**	**3.3**	**12,645**	**11,903**		

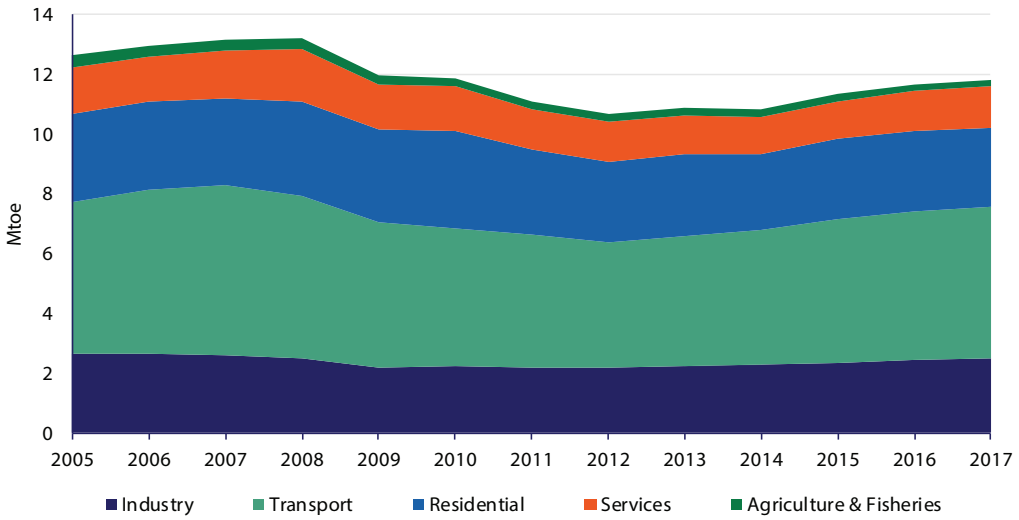
The most significant changes can be summarised as follows:

- Consumption of fossil fuels increased by 0.5%. Coal and peat consumption fell, while oil and natural gas use increased.
- Final consumption of oil increased by 0.9% in 2017 to 6,791 ktoe. This was driven by increased oil use in industry, services and transport, which saw the final use of oil grow by 2.6%, 1.2% and 7.9%, respectively, while consumption fell by 3.8% in the residential sector. The share of oil in final consumption in 2017 was 57%.
- In 2017, natural gas consumption increased by 1.7% to 1,824 ktoe. The share of gas in final consumption in 2017 was 15%.
- Final consumption of coal fell by 12% in 2017 to 251 ktoe. Its share of final use in 2017 was at 2.1%. Coal use in industry fell by 4% to 102 ktoe and by 17% in the residential sector to 149 ktoe.
- Final consumption of electricity in 2017 increased by 1.1% to 2,223 ktoe (or 25,850 GWh). In 2017, electricity accounted for 19% of final energy use.
- Final consumption of peat fell by 4.4% in 20167 to 189 ktoe. Peat accounted for 1.6% of final energy consumption in 2017.

Figure 8 also shows the sectoral trend in TFC over the period.

Consumption of fossil fuels increased by 0.5%. Coal and peat consumption fell, while oil and natural gas use increased.

Figure 8: Total Final Energy Consumption by sector



The effect of the economic downturn is evident from 2008 to 2012. It is also evident from *Figure 8* that transport continues to dominate as the largest energy-consuming sector (on a final energy basis) with a share of 43% in 2017. The shares of the industry and residential sectors have decreased since 1990. In 2017, industry accounted for 21% of final energy use and the residential sector for 22%.

Table 5: Growth rates, quantities and shares of TFC by sector

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Industry	-4.4	-0.4	-3.1	1.0	3.1	3.4	2,633	2,516	20.9	21.3
Transport	-0.3	0.0	-2.0	0.8	2.9	2.0	5,084	5,067	40.3	42.9
Residential	-11.1	-1.0	2.1	-4.0	-0.9	-2.9	2,937	2,609	23.3	22.1
Services	-11.3	-1.0	-1.3	-2.7	4.2	4.2	1,569	1,392	12.4	11.8
Agriculture / Fisheries	-38.4	-4.0	-5.1	-5.6	3.4	4.1	383	236	3.0	2.0
Total	**-6.2**	**-0.5**	**-1.2**	**-1.0**	**2.2**	**1.4**	**12,606**	**11,821**		

The changes in growth rates, quantities and shares are shown in *Table 5* and summarised as follows:

- Overall final energy consumption grew by 1.4% in 2017 – an increase of 169 ktoe to 11,821 ktoe – with all sectors showing growth except the residential sector.
- There was a 4.2% increase (57 ktoe) in final energy use in the services sector in 2017 to 1,392 ktoe. Correcting for weather, the increase was 9.8%.
- In 2017, final energy use in industry grew by 3.4% – 82 ktoe in absolute terms – to 2,516 ktoe. Over the 2005 – 2017 period, the average growth rate in final energy use in industry was -0.4% per annum (or 4.4% decrease in absolute terms) and its share of TFC remained steady at 21%.
- Energy use in transport grew in 2017 by 2% to 5,067 ktoe but in absolute terms it experienced the highest increase in 2017 of 98 ktoe.
- Final energy use in the residential sector fell by 77 ktoe or 2.9% in 2017 to 2,609 ktoe. Correcting for weather[11], residential energy use increased by 2.6%.
- The agricultural and fisheries sectors' relative share fell from 3.0% in 2005 to 2.0% in 2017. Agriculture energy consumption increased in 2017 by 4.1% (9 ktoe) to 236 ktoe.

11 See Glossary for description of Weather Correction.

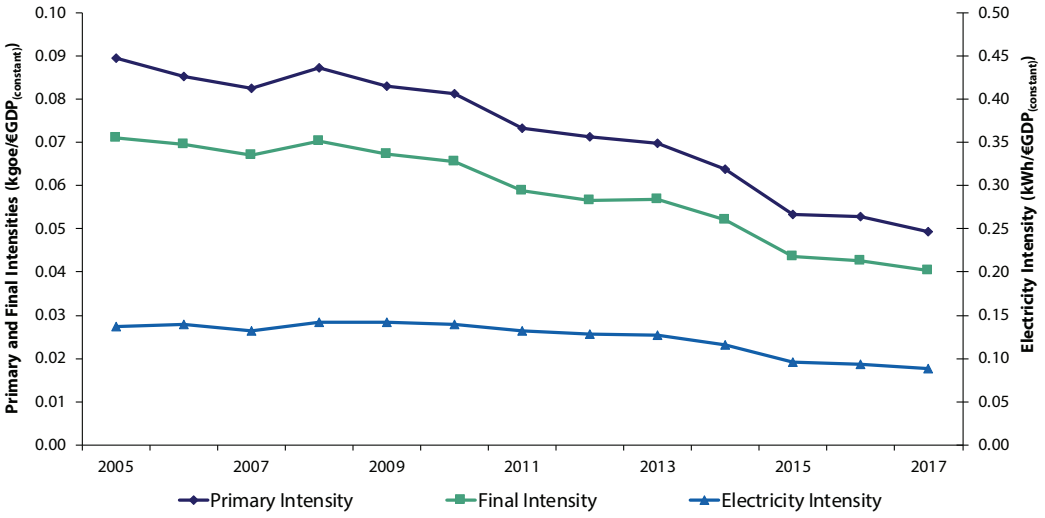
2.5 Energy Intensities

Energy intensity is defined as the amount of energy required to produce some functional output. In the case of the economy, the measure of output is generally taken to be the GDP[12]. GDP measured in constant prices is used to remove the influence of inflation. The inverse of energy intensity represents the energy productivity of the economy.

The intensity of primary and final energy and of electricity requirements has been falling (reflecting improving energy productivity) since 2005, with the exception of 2008, as shown in *Figure 9*. The primary energy intensity of the economy fell by 7.7% (3.9% per annum) between 2005 and 2007. In 2005, it required 89 grammes of oil equivalent (goe) to produce one euro of GDP (in constant 2016 values), whereas in 2007 just 82 goe was required. Between 2007 and 2017 primary energy intensity fell by 40% (4.8% per annum) to 49 goe/$€_{2016}$ and was 64% lower than 1990.

Figure 9 shows the trend in both primary (TPER/GDP) and final (TFC/GDP) energy intensities (at constant 2016 prices). The difference between these two trends reflects the amount of energy required in the transformation from primary energy to final energy – primarily used for electricity generation. Throughout the 1990s there was a slight convergence of these trends, particularly after 1994, mostly reflecting the increasing efficiency of the electricity generation sector. This trend towards convergence intensified from 2001 to 2007 (increased efficiency in electricity generation) when primary intensity fell at a faster rate than final intensity. The decrease in primary intensity between 2001 and 2007 was 20%, whereas for final intensity the decrease was 15%.

Figure 9: Primary, final and electricity intensities



Between 2010 and 2017, the primary and final intensity trends converged slightly, with primary energy intensity falling at a slightly faster rate, 39%, compared with a 38% fall in final intensity.

There are many factors that contribute to how the trend in energy intensity evolves. These factors include: technological efficiency and the fuel mix, particularly in relation to electricity generation; economies of scale in manufacturing; and, not least, the structure of the economy. Economic structure, in Ireland's case, has changed considerably over the past 20 to 30 years. The structure of the economy has shifted in the direction of the high value-added[13] sectors, such as pharmaceuticals , electronics and services. Relative to traditional 'heavier' industries, such as car manufacturing and steel production, these growing sectors are not highly energy intensive. Examples of changes to the industry sector structure include the cessation of steel production in 2001, of fertiliser production in late 2002, and of sugar production in 2007.

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

The sharp fall in intensity in 2015 of 16% must be viewed in the context of the 26% increase in GDP as a result of the transfer of assets into Ireland. This should be viewed as an adjustment rather than a reduction in intensity, as the increase in GDP had little or no effect on energy consumption. This is a good example of why energy intensity is not a good measure of energy efficiency progress.

12 It can be argued that in Ireland's case, gross national product (GNP) should be used to address the impacts due to the practice of transfer pricing by some multinationals. The counter argument is that energy is used to produce the GDP and by using the GNP some of the activity would be omitted. The practice internationally is to use GDP, so for comparison purposes it is sensible to follow this convention. The CSO introduced modified gross national income (GNI*) in 2017 to better reflect the level of activity in the Irish economy.

13 See Glossary.

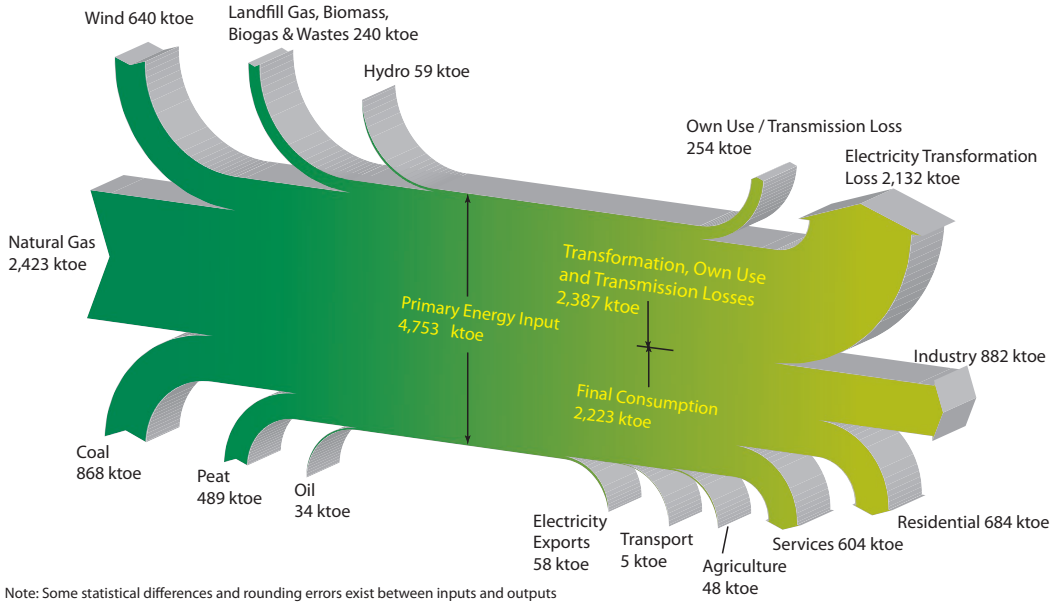
The final electricity intensity of the economy has not been falling as fast as primary or final energy intensities. Over the period 2005 – 2017, the electricity intensity fell by 36%. This is attributed to the shift towards increased electricity consumption in energy end-use. Electricity final intensity increased by 2% between 2007 and 2010, but fell by 37% between 2010 and 2017.

2.6 Electricity Generation

Modern economies and societies are dependent on reliable and secure supplies of electricity. We have seen in *Figure 4* that the generation of electricity accounts for one-third of all energy use each year in Ireland. *Figure 10* shows the flow of energy in electricity generation[14]. Total energy inputs to electricity generation in 2017 amounted to 4,753 ktoe, 33% of TPER. The relative size of the useful final electricity consumption compared with the energy lost in transformation and transmission is striking. These losses represent 50% of the energy inputs. The growing contribution from renewables (hydro, wind, landfill gas and biomass) is also notable, as is the dominance of gas in the generation fuel mix. In 2017, natural gas accounted for 51% (2,423 ktoe) of the fuel inputs to electricity generation – a 3.5% increase compared with the previous year.

In 2017, the share of renewables in the generation fuel mix increased to 18.6%, compared with 15.5% in 2016 due in the main to increased wind generation. Overall, the use of renewables in the electricity generation fuel mix increased by 18.3% in 2017 compared with 2016.

Figure 10: Flow of energy in electricity generation 2017



Note: Some statistical differences and rounding errors exist between inputs and outputs

Figure 11 shows a similar picture to *Figure 10* except that the electricity outputs are shown by fuel used to generate the electricity and as percentages, for the purposes of assessing against the various targets. Renewable generation consists of wind, hydro, landfill gas, biomass (including the renewable portion of wastes and a small amount of biodiesel) and other biogas. In 2017, electricity generated from renewable sources amounted to 8,877 GWh, accounting for 29.6% of gross electricity consumption compared with 25.5% in 2016.

Total energy inputs to electricity generation in 2017 amounted to 4,753 ktoe, 1.1% less than in 2016 and 7% less than in 2005.

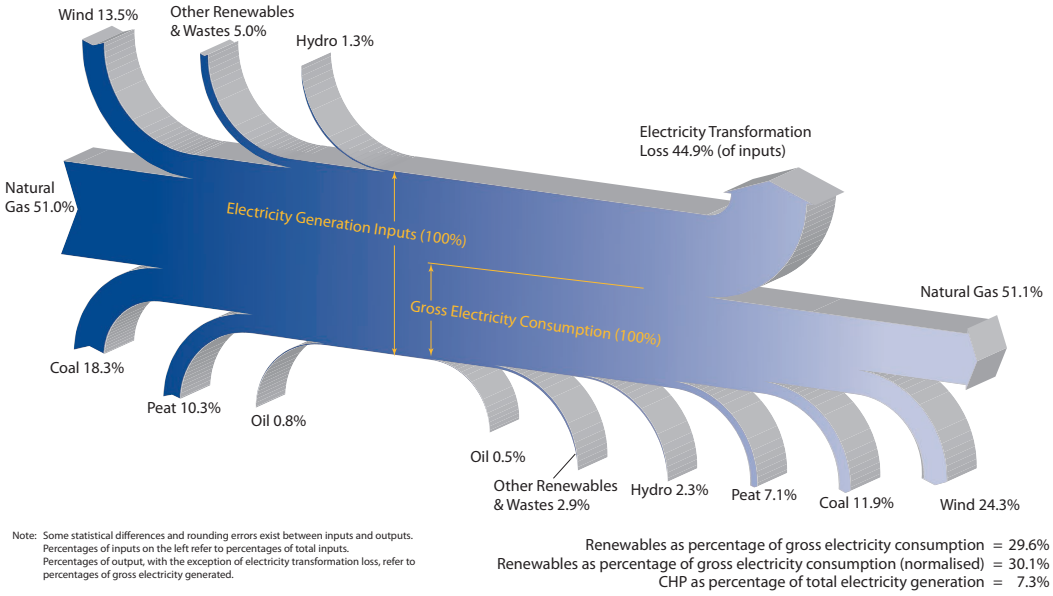
In calculating the contribution of hydropower and wind power for the purposes of EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources, the effects of weather variation and capacity change are

14 Electricity generation is covered by the ETS and as such is not covered by EU Decision 406/2009/EC. Therefore, a CO_2 impact comparison with 2005 is not considered in this section.

smoothed through the use of a normalisation rule[15]. Using normalised figures for wind and hydro, renewables accounted for 30.1% of gross electricity consumption in 2017. The national target is to achieve at least a 40% share by 2020.

In 2017, wind generation accounted for almost one-quarter or 24.8% (25.2% normalised) of electricity generated and was again the second largest source of electricity generation after natural gas.

Figure 11: Flow of energy in electricity generation 2017 – outputs by fuel



The efficiency of electricity supply shown in *Figure 12* is defined as final consumption of electricity divided by the fuel inputs required to generate this electricity and expressed as a percentage. The inputs include wind, hydro and imported electricity which are direct electricity inputs and do not have the transformation losses associated with them that fossil fuels and combustible renewables do. The final consumption excludes the generation plant's 'own use' of electricity and transmission and distribution losses. Hence, this is supply efficiency rather than generating efficiency. In 2017, the supply efficiency was 49%, whereas the overall generating efficiency was 55%.

In 2017, wind generation accounted for almost one-quarter or 24.8% (25.2% normalised) of electricity generated and was again the second largest source of electricity generation after natural gas.

From the mid-1990s onwards, the influence of the use of higher efficiency natural gas plants and the increase in production from renewable sources is evident. The sharp rise between 2001 and 2004 (from 35% to 40%) is accounted for, principally, by the coming on stream of new combined cycle gas turbine (CCGT) installations (392 MW in August 2002 and 343 MW in November 2002), an increase in imports of electricity, and the closure of old peat-fired stations.

There was an increase in electricity supply efficiency, from 41.9% in 2006 to 43.6% in 2007, due largely to the commissioning of two further CCGT plants, Tynagh (384 MW) in 2006 and Huntstown 2 (401 MW) in 2007, and the increase in renewable electricity. During 2010, the efficiency decreased to 44.6% from a high of 45.5% in 2009, due in part to the reduction in wind and hydro resources and also due to the commissioning phases of two new CCGT power plants in Whitegate and Aghada that came online during the year. In 2014, a new 460 MW CCGT generation plant operated by Endesa in Great Island, Co Wexford, commenced its commissioning phase and went into commercial operation in 2015, while a 240 MW heavy fuel oil generation plant, also at Great Island, was retired.

In 2011, with these new CCGT power plants fully operational and with the increased contribution from wind and hydro, efficiency increased to 47.3%. In 2012, the relatively high price of gas coupled with low prices for coal and CO_2 resulted in less gas and more coal being used in electricity generation. Peat generation, which is supported by the Public Service Obligation Levy, also increased in 2012. Combined, these reduced efficiency to 45.6%. 2013 saw somewhat of a reversal

15 Article 5 and Annex II of EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

of the trend evident in 2012 and, with increased imports, saw the efficiency of supply rise to 48.4% and then to 49.1% in 2014 and 2015.

In 2017, increased hydro and wind resources and lower coal and peat generation helped to increase the efficiency of supply to 49.1%.

Figure 12: Efficiency of electricity supply

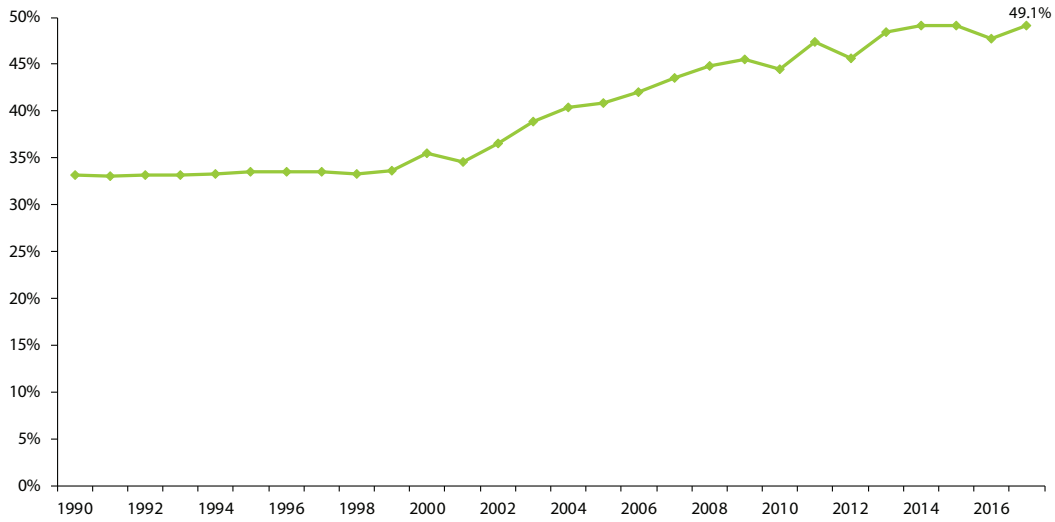


Figure 13: CO_2 emissions per kWh of electricity supplied; with contributions by fuel

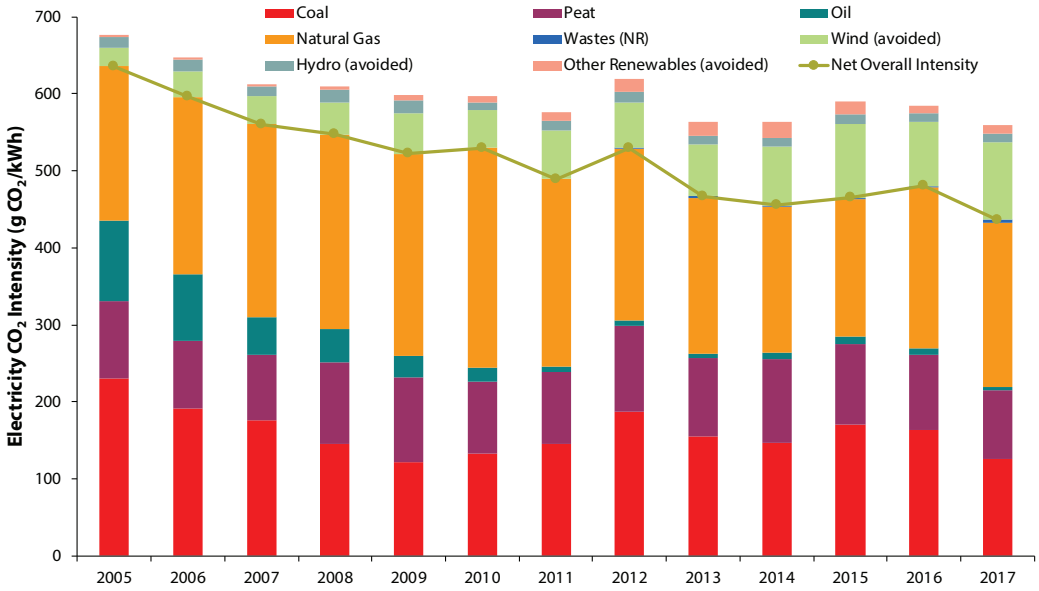


Figure 13 shows as stacked bars the shares of the various fuels contributing to the overall emissions intensity of electricity, as well as the reduction in intensity as a result of emissions avoided by renewable generation from wind, hydro and other renewables. It is important to note that this graph represents the shares of the fuels to the overall intensity and not the intensity of the generation by the individual fuels themselves. The net overall intensity is shown as a line graph in *Figure 13*.

Since 2005, the share of high carbon content fuels, such as coal and oil, has generally been reducing, with a corresponding rise in the relatively lower carbon natural gas and zero carbon renewables. Imported electricity is also considered zero carbon from Ireland's perspective as emissions are counted in the jurisdiction in which they are emitted. This resulted in the carbon intensity of electricity dropping by 49%, from 896 g CO_2/kWh in 1990 to a low of 455 g CO_2/kWh in 2014. The intensity increased to 465 g CO_2/kWh in 2015 due to increased coal generation and a reduction in net imports. It increased further in 2016 to 480 g CO_2/kWh as a result of lower wind and hydro resources. Better wind and hydro resources in 2017, coupled with increased wind capacity, saw the intensity of electricity fall to a new low of 437 g CO_2/kWh.

Better wind and hydro resources in 2017, coupled with increased wind capacity, saw the intensity of electricity fall to a new low of 437 g CO_2/kWh.

The reasons for the reduction in carbon intensity of electricity in 2017 were:

- 21.1% increase in wind generation (13.5% share of inputs);
- 1.6% increase in hydro generation (1.3% share of inputs);
- 21.2% reduction in coal use in generation (18.3% share of inputs);
- 6.4% reduction in peat use in generation (10.3% share of inputs);
- 50% reduction in oil use in generation (0.7% share of inputs);
- 15.4% increase in bioenergy use in generation (3.9% share of inputs);
- 5% reduction in net exports of electricity;

Countering these were a:

- 3.5% increase in gas used in generation, increasing the gas share in fuel inputs to 51%;
- 126% increase in the use of non-renewable wastes (1.2% share of inputs).

2.6.1 Combined Heat and Power

Combined heat and power (CHP) is the simultaneous generation of usable heat and electricity in a single process. In conventional electricity generation much of the input energy is lost to the atmosphere as waste heat. Typically, up to 60% of the input energy is lost with as little as 40% being transformed into electricity. CHP systems channel this extra heat to useful purposes so that usable heat and electricity are generated in a single process. The efficiency of a CHP plant can typically be 20% to 25% higher than the combined efficiency of heat-only boilers and conventional power stations. Also, if embedded in the network close to the point of electrical consumption, CHP can avoid some of the transmission losses incurred by centralised generation. Therefore, in the right circumstances CHP can be an economic means of improving the efficiency of energy use and achieving environmental targets for emissions reduction.

The installed capacity[16] of CHP in Ireland at the end of 2017 was 348 megawatt electrical (MWe) (419 units[17]) – up from 343 MWe (403 units) in 2016 (see *Table 6*). Of the 419 units, only 298 were reported as being operational. The operational installed capacity increased by 6.6 MWe, to 318.7 MWe[18], in 2017 compared with 2016.

Table 6: Number of units and installed capacity by fuel 2017

	No. of Units	Installed Capacity (MWe)	No. of Units %	Installed Capacity %
Natural Gas	370	319.9	89%	92%
Solid Fuels	2	5.2	0%	1%
Biomass	3	5.5	1%	2%
Oil Fuels	23	8.7	6%	3%
Biogas	21	9.1	5%	3%
Total	**419**	**348**	**100%**	**100%**

Source: SEAI

Natural gas was the fuel of choice for 320 MWe (370 units) in 2017. It is worth noting that there is one single 160 MWe gas plant that dominates. Oil products[19] and biogas made up the next most significant shares with 9.0 MWe and 8.8 MWe, respectively, (21 and 23 units, respectively) and the remainder was biomass at 5.5 MWe (3 units) and solid fuels at 5.2 MWe (2 units). CHP in Ireland is examined in more detail in a separate SEAI publication[20].

Figure 14 illustrates the contribution from CHP to Ireland's energy requirements in the period 2000 – 2017. Fuel inputs have increased by 212% (9.2% per annum) while the thermal and electrical outputs increased by 277% (8.1% per annum) and 332% (9.0% per annum), respectively, over the period. In 2017 fuel input increased by 0.1% and thermal output decreased

16 Megawatt electrical or MWe is the unit by which the installed electricity generating capacity or size of a CHP plant is quantified, representing the maximum electrical power output of the plant.
17 Note that units are distinct from CHP plants or schemes and that there may be more than one CHP unit at a site.
18 Revised since the 2017 CHP Update.
19 Oil products are comprised of LPG, heavy fuel oil, refinery gas and biodiesel.
20 Sustainable Energy Authority of Ireland (2018), *Combined Heat and Power in Ireland – 2018 Update*. Available from: www.seai.ie

by 1.6%, while electricity generated fell by 0.5%. The large increase in 2006 is accounted for by the Aughinish Alumina plant which came online in that year.

Figure 14: CHP fuel input and thermal/electricity output 2000 – 2017

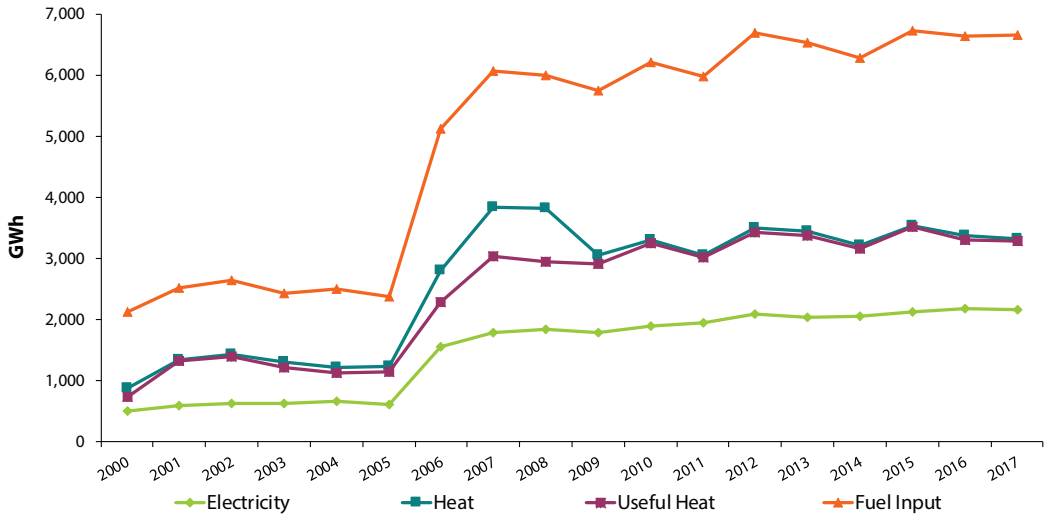
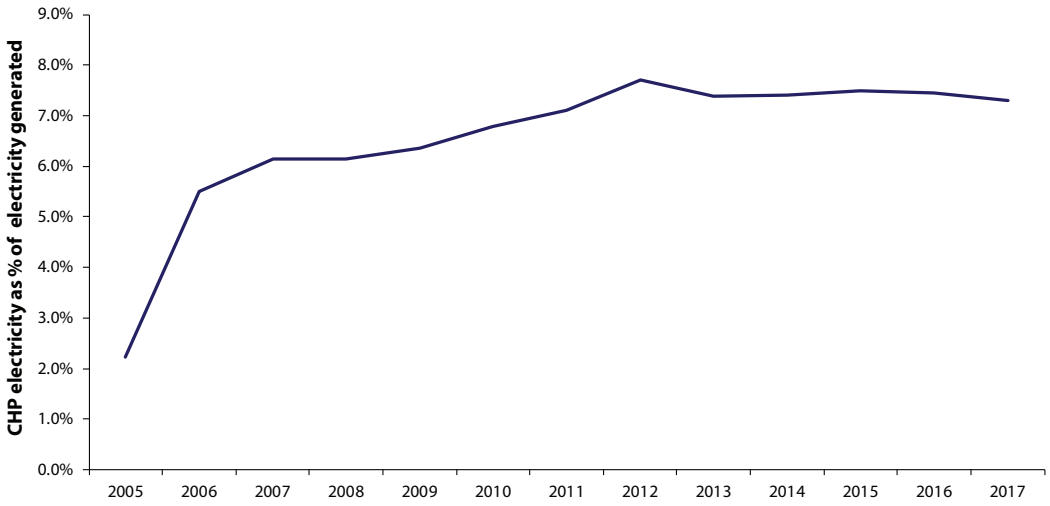


Figure 15 focuses on CHP-generated electricity in Ireland as a proportion of gross electricity consumption (i.e. electricity generation plus net imports) in the period 2005 – 2017. In 2017, 7.3% of total electricity generation was generated in CHP installations compared with 7.1% in 2016. Some CHP units export electricity to the national grid. In 2017, there were 13 units exporting electricity to the grid. These units exported 1,384 GWh of electricity in 2017, an increase of 0.7% on 2016.

Figure 15: CHP electricity as percentage of total electricity generation 2005 – 2017



2.6.2 Primary Fuel Inputs into Electricity Generation

The trends in the mix of primary fuels employed for electricity generation are shown in *Figure 16*. The shift from oil to gas since 2001 is evident, as is the growth of renewable generation since the early 2000s.

The fuel inputs to electricity generation were one-third of the TPER in 2017.

Figure 16: Primary fuel mix for electricity generation

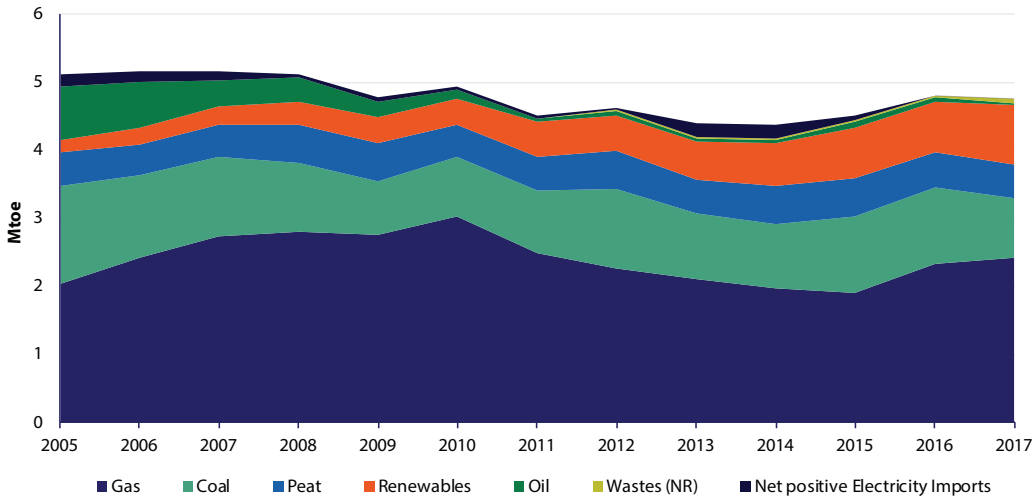


Table 7 shows the growth rates, quantities and shares of the primary fuel mix for electricity generation over the period 2005 – 2017.

The primary fuel requirement for electricity generation grew by 56% from 3,094 ktoe in 1990 to a high of 5,258 ktoe in 2001. Between 2001 and 2014 the requirement reduced by 17%, while the final consumption of electricity increased by 15%. In 2017, 4,754 ktoe of energy was used to generate electricity, 1.1% less than in 2016 and 9.6% less than peak levels in 2001. The fall in inputs to electricity generation in 2017 is against the backdrop of a 1.5% increase in electricity generated and a 1.1% increase in indigenous demand – the difference between generation and demand being accounted for by net exports to the UK.

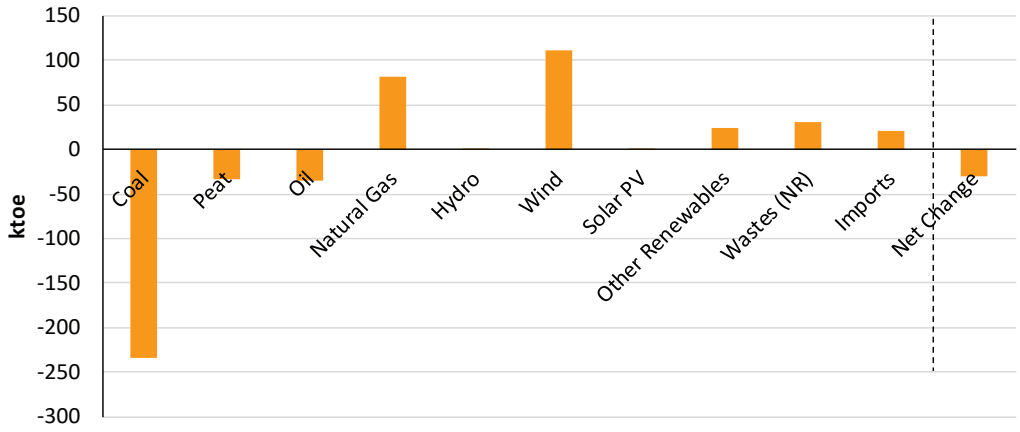
The fuel inputs to electricity generation were one-third (33%) of the TPER in 2017. Electricity consumption as a share of TFC increased from 17% to 19% between 2005 and 2017.

Table 7: Growth rates, quantities and shares of electricity generation fuel mix (primary fuel inputs)

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-19.9	-1.8	-1.0	-4.1	2.0	-5.4	4,759	3,814	93.0	80.2
Coal	-39.0	-4.0	-9.4	5.4	-12.3	-21.2	1,422	868	27.8	18.3
Peat	-2.0	-0.2	-0.3	2.4	-6.1	-6.4	499	489	9.8	10.3
Oil	-95.7	-23.1	-29.6	-8.9	-37.3	-50.4	794	34	15.5	0.7
Natural Gas	18.6	1.4	8.2	-8.9	13.0	3.5	2,044	2,423	40.0	51.0
Renewables (Total)	391.9	14.2	15.4	15.3	8.6	18.3	180	884	3.5	18.6
Hydro	9.6	0.8	-1.0	6.1	-7.4	1.6	54	59	1.1	1.3
Wind	569.5	17.2	20.4	18.5	6.4	21.1	96	640	1.9	13.5
Other Renewables	518.2	16.4	20.1	9.1	26.7	15.4	30	184	0.6	3.9
Wastes (Non-Renewable)	-	-	-	-	50.8	126.1	-	56	-	1.2
Combustible Fuels Total	-15.3	-1.4	-0.8	-3.7	3.2	-3.9	4,788	4,053	93.6	85.3
Electricity Imports (net)	-	-	-25.5	7.4	-	-	176	-	3.4	-
Total	**-7.0**	**-0.6**	**-0.7**	**-1.8**	**2.8**	**-1.1**	**5,114**	**4,754**		

Figure 17 shows the change in 2017, by fuel, compared with 2016 of the inputs into electricity generation along with the net overall change.

Figure 17: Change in fuel inputs to electricity generation in 2017 compared with 2016



The main trends are:

- Overall fuel inputs into electricity generation decreased by 1.1% in 2017 to 4,574 ktoe (55,280 GWh), while electricity generated increased by 1.5% to 2,637 ktoe (30,667 GWh) and final consumption of electricity increased by 1.1%, to 2,223 ktoe (or 25,850 GWh).
- The overall share of fossil fuels used in electricity generation was 80% in 2017 (3,841 ktoe), down from 93% in 2005 and down on the 2016 figure of 84%.
- Natural gas share of energy used in electricity was 51% in 2017 up from 49% the previous year. Natural gas use in electricity generation increased by 3.5% (82 ktoe) in 2017 to 2,423 ktoe and generated 51% of electricity.
- Oil share of energy in electricity generation was 0.7% in 2017 and its use fell by 50% (34 ktoe) to 34 ktoe and generated 0.5% of electricity
- In 2017, consumption of coal for electricity generation fell by 21% (234 ktoe) to 868 ktoe and accounted for 18% of the energy used in electricity generation. Twelve per cent of electricity generated was from coal in 2017.
- Peat consumption in electricity generation fell by 6.4% (33 ktoe), to 489 ktoe, in 2017 and accounted for 10.3% of the fuel mix. Some 7.1% of electricity generated in 2017 was from peat.
- Overall, renewables' contribution to the electricity fuel mix increased by 18.3% (137 ktoe) in 2017 and accounted for 18.6% of the fuel mix and 29% of the electricity generated. Wind and hydro contribution to electricity generation increased by 21% (111 ktoe) and 1.6% (0.9 ktoe), respectively, in 2017, due to better wind and hydro resources compared with the previous year. Other renewables use in electricity generation increased by 15% (25 ktoe) to 184 ktoe, with the increase coming mainly from the co-firing of biomass in the peat stations and the renewable portion of waste in waste-to-energy plants.
- The use of energy from waste as a fuel source for electricity generation decreased by 126% in 2017 to 56 ktoe and accounted for 1.2% of all fuel inputs.
- Net exports of electricity fell by 4.7% (3 ktoe).

The primary energy attributed to hydro and wind is equal to the amount of electrical energy generated, rather than the primary energy avoided through the displacement of fossil fuel-based generation[21] (see Renewable Electricity in Ireland 2015). It is therefore more common to see the share of hydro and wind reported as a percentage of gross electricity generated. Electricity generated from hydro accounted for 2.3% (2.4% normalised) of the total and wind accounted for 24.8% (25.2% normalised) in 2017.

Table 8 shows the growth rates, quantities and shares of the electricity generated by fuel over the period 2005 – 2017.

21 An alternative approach based on *primary energy equivalent* was developed in a separate report: SEAI (2014), *Renewable Energy in Ireland – 2012*. Available from https://www.seai.ie/resources/publications/Renewable-Energy-in-Ireland-2012.pdf

Table 8: Growth rates, quantities and shares of electricity generated by fuel

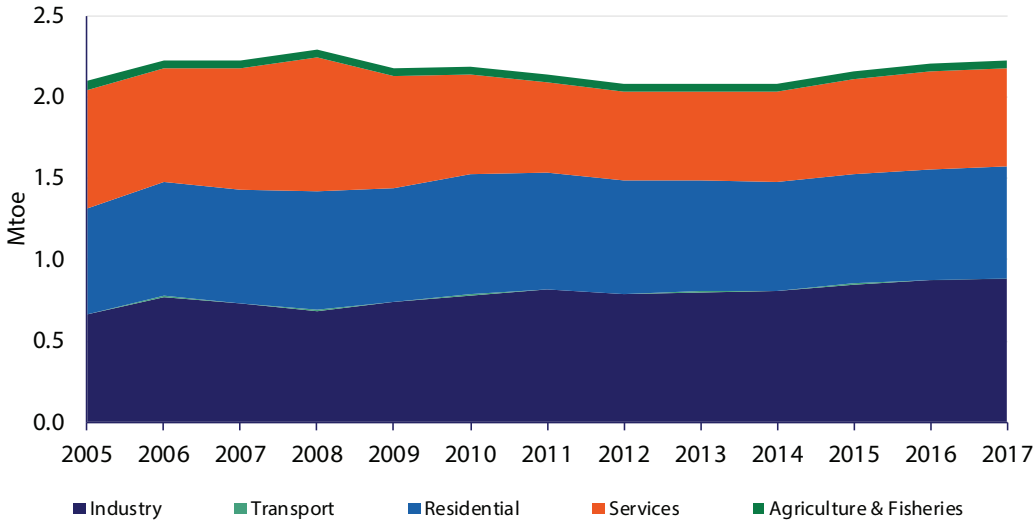
	Overall Growth %	Average Annual Growth %					Quantity (GWh)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Coal	-43.0	-4.6	-11.1	6.5	-13.5	-22.4	6,389	3,645	23.1	11.9
Peat	-11.7	-1.0	-2.3	2.9	-7.3	-6.6	2,450	2,164	8.9	7.1
Oil	-95.8	-23.1	-29.0	-7.6	-40.9	-51.6	3,340	142	12.1	0.5
Natural Gas	35.5	2.6	9.4	-7.3	12.6	2.3	11,574	15,680	41.8	51.1
Renewables (Total)	373.8	13.8	14.8	16.1	6.3	18.2	1,873	8,877	6.8	28.9
Hydro	9.6	0.8	-1.0	6.1	-7.4	1.6	631	692	2.3	2.3
Wind	569.5	17.2	20.4	18.5	6.4	21.1	1,112	7,445	4.0	24.3
Solar	-	-	-	27.7	157.2	162.4	-	11	-	0.03
Other Renewables	460.3	15.4	19.3	8.7	23.8	7.9	130	730	0.5	2.4
Wastes (Non-Renewable)	-	-	-	-	46.7	118.8	-	159	-	0.5
Electricity Imports (net)	-	-	-25.5	7.4	-	-	2,044	-	7.4	-
Total	**10.8**	**0.9**	**0.7**	**0.1**	**3.2**	**1.5**	**27,671**	**30,667**		

Overall, the share of electricity generated by renewables was 29.6% in 2017, up from 25.5% in 2016, while the renewables share of energy inputs to electricity generation was 18.6%. Normalising for wind and hydro as per EU Directive 2009/28/EC the share of electricity generated from renewables in 2017 was 30.1%.

2.7 Electricity Demand

Figure 18 shows the final electricity consumption in each of the main sectors. The difference between fuel input (see *Figure 16*) and delivered electricity output (*Figure 18*) is accounted for by the transformation losses, totalling 2,133 ktoe in 2017, and electricity net exports (58 ktoe) as shown in *Figure 10* and *Figure 11*. The size of the transformation loss is due to electricity in Ireland being predominantly generated thermally (85% in 2017) and therefore primary energy requirement has always been significantly higher than final electricity consumption. This ratio of primary to final[22] energy in electricity consumption fell from 3.0 in 1990 to 1.8 in 2017. Final consumption of electricity grew by 1.1% in 2017 to 25,850 GWh compared with a 1.1% fall in the fuel inputs to electricity generation.

Figure 18: Final consumption of electricity by sector



Final electricity demand peaked in 2008 at 2,294 ktoe and was 3.1% lower than that in 2017 at 2,223 ktoe.

Industry has the largest share of final electricity use at 40%.

22 On a net calorific value basis.

Table 9 shows changes in individual sectors' electricity demand and the impact on final consumption of electricity. The electricity use in transport includes that used by the Dublin Area Rapid Transit (DART) system and the Luas in Dublin, and electric vehicles on the road. In absolute terms electricity consumption in transport is small at 52 GWh (4.5 ktoe), of which electric vehicles are estimated to account for approximately 8 GWh.

Electricity demand grew in all sectors in 2017. Transport experienced the largest growth in electricity at 7.3% but from a very small base to account for just 0.2% of the final share of electricity in 2017.

In terms of shares of final electricity use, industry has the largest share at 40%, with the residential sector being the second largest at 31%.

Table 9: Growth rates, quantities and shares of electricity final consumption

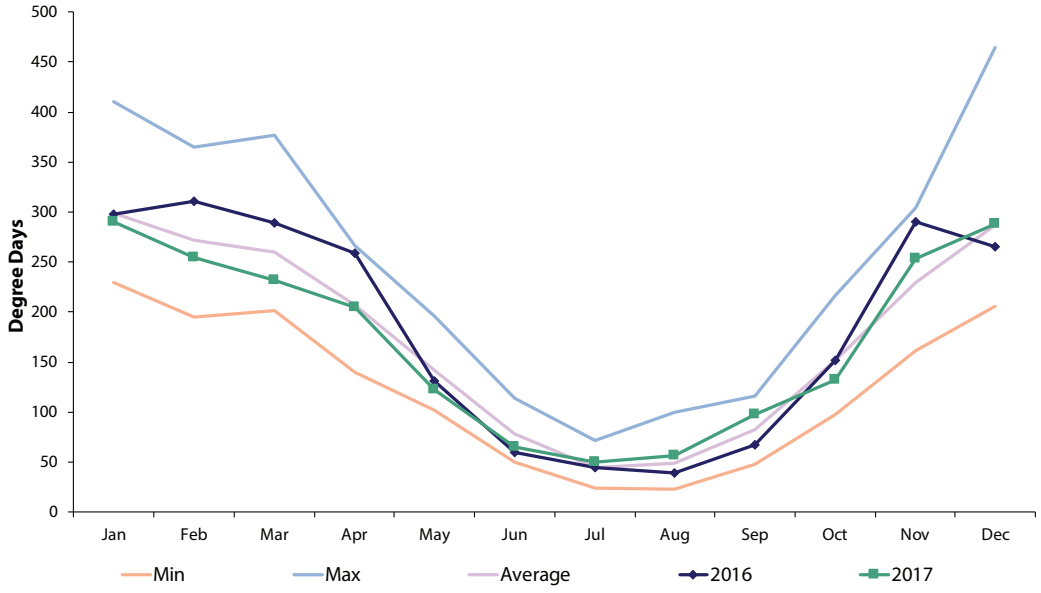
	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Industry	33.6	2.4	3.5	1.6	2.1	1.1	660	882	31.5	39.7
Transport	-10.9	-1.0	-5.0	-0.9	9.8	7.3	5	5	0.2	0.2
Residential	6.0	0.5	2.6	-1.6	0.5	1.1	646	684	30.8	30.8
Services	-17.0	-1.5	-3.3	-1.2	2.1	1.1	728	604	34.8	27.2
Agriculture / Fisheries	-13.3	-1.2	-2.8	0.0	0.0	0.0	55	48	2.6	2.2
Total	**6.2**	**0.5**	**0.9**	**-0.3**	**1.5**	**1.1**	**2,094**	**2,223**		

2.8 Energy and the Weather

Weather variations from year to year can have a significant effect on the energy demand of a country, in particular on the portion of the energy demand associated with space heating. A method to measure the weather or climatic variation is through the use of 'degree days'.

Degree days are the measure or index used to take account of the severity of the weather when looking at energy use in terms of heating (or cooling) load on a building. A degree day is an expression of how cold (or warm) it is outside, relative to a day on which little or no heating (or cooling) would be required. It is thus a measure of the cumulative temperature deficit (or surplus) of the outdoor temperature relative to a neutral target temperature (base temperature) at which no heating or cooling would be required. It should be noted that the larger the number of heating degree days, the colder the weather. Also note that the typical heating season in Ireland is October to May. If, for example, the outdoor temperature for a particular day is 10 degrees lower on average than the base temperature (15.5 degrees), this would contribute 10 degree days to the annual or monthly total.

Figure 19: Heating degree day trend 2017 versus 2016



Source: Met Eireann and SEAI

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

Figure 19 shows the heating degree days per month for 2017 and 2016. The graphs show the minimum, maximum and average degree days for each month for the last 30 years together with the monthly degree days for each year. *Figure 19* also shows that 2017 was a below average year in terms of heating requirement between January and July and again in October. The rest of the year was more or less average. Compared with 2016, there were 6% less heating degree days (i.e. it was warmer) in 2017.

3 Policy Perspectives

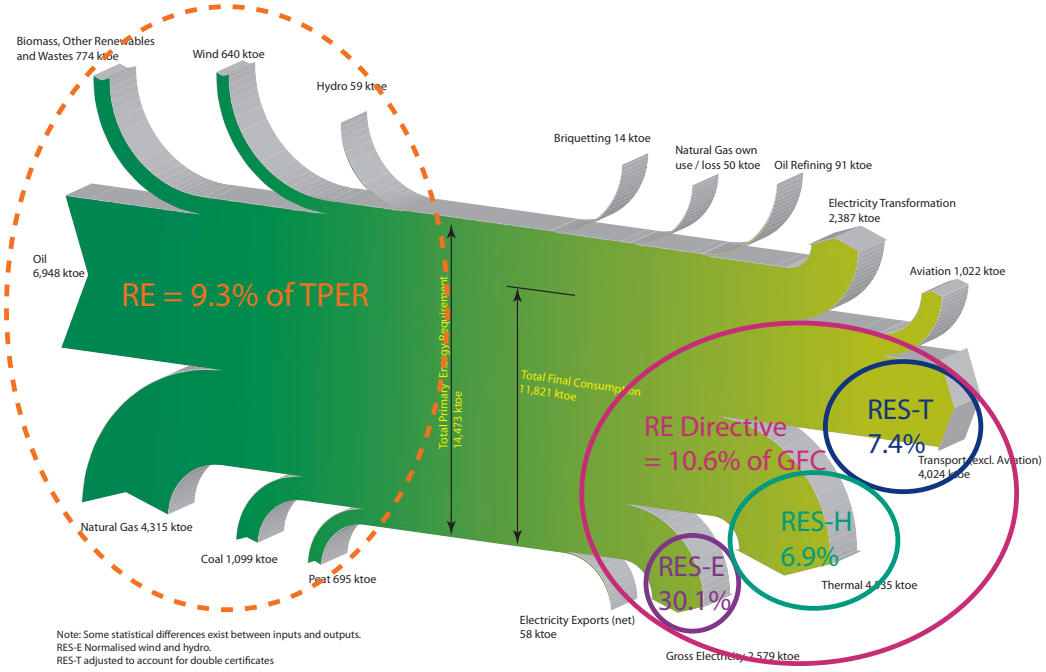
The energy trends discussed in *Section 2* are analysed to assess performance with regard to Government policies and targets. This section focuses on those detailed in the EU Directives related to renewable energy, GHG and transboundary emissions.

3.1 Progress towards Renewable Energy Targets

The target for Ireland in the EU Renewable Energy Directive[23] is a 16% share of renewable energy in gross final consumption (GFC) by 2020. The Directive requires each Member State to adopt a national renewable energy action plan (NREAP) to set out each Member State's national targets for the share of energy from renewable sources consumed in transport, electricity and heating in 2020 that will ensure delivery of the overall renewable energy target. These sectoral targets are referred to as RES-E (electricity), RES-T (transport) and RES-H (heat).

The contribution from renewables in 2005 was 2.8%, rising to 10.6%[24] of GFC[25] in 2017. *Figure 20* illustrates where the various renewable targets fit within overall energy use in Ireland and the progress towards those targets in 2017. Towards the right of the figure, the 2017 percentages of renewables are shown relative to the amount of final energy to which they refer. Also shown is how these relate to the Directive's target (see also *Table 10*).

Figure 20: Progress to targets 2017



Towards the left of *Figure 20* the overall contribution of renewable energy to TPER is shown at 9.3%. While there is no specific target for this measure, it does help to illustrate the position of renewables in the overall energy use in Ireland.

Table 10 shows progress towards the individual national modal targets and to the overall Directive target for the period 2005 – 2017. Here, the percentages in each row (RES-E, RES-T and RES-H) relate to the specific modal targets, while the percentages in the final row relate to the overall target using the definition in EU Directive 2009/28/EC.

23 EU Directive 2009/28/EC: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=en.
24 Calculated as per Directive 2009/28/EC.
25 GFC in the Directive is different from TFC as conventionally defined in the energy balance (see *Glossary of Terms on page 73*). Hydro and wind electricity generation are normalised as per the Directive in order to smooth out variations in weather.

Table 10: Renewable energy progress to targets[26]

	Progress towards Targets									Target
% of Each Target	2005	2010	2011	2012	2013	2014	2015	2016	2017	2020
RES-E (normalised)	7.2	15.6	18.3	19.8	21.3	23.5	25.5	26.8	30.1	40
RES-T	0	2.5	3.8	4.0	4.9	5.3	5.9	5.2	7.4	10
RES-H	3.4	4.3	4.7	4.9	5.2	6.3	6.2	6.3	6.9	12
Overall RES	**2.8**	**5.7**	**6.6**	**7.1**	**7.6**	**8.6**	**9.1**	**9.2**	**10.6**	**16**

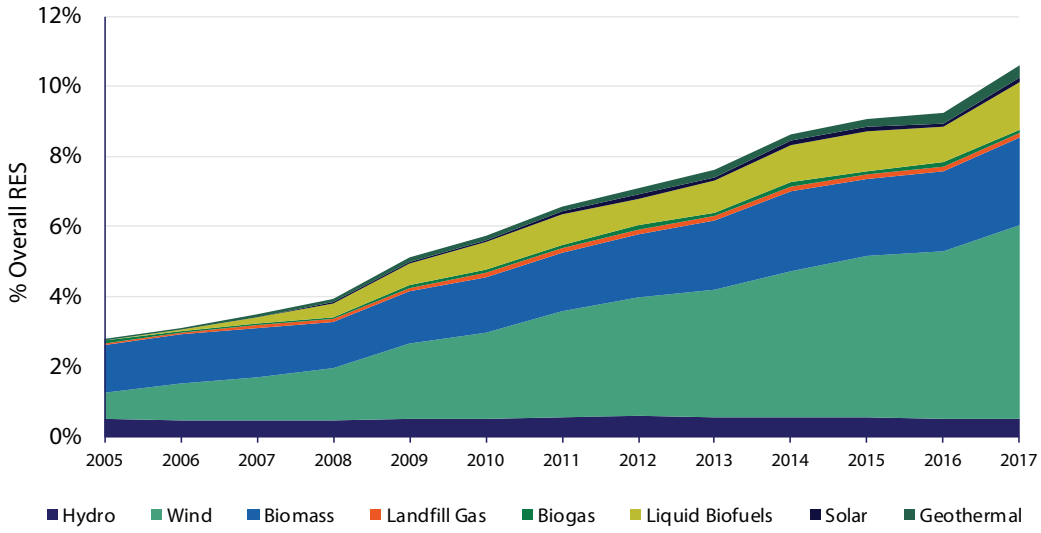
Source: SEAI

RES-E increased by 3.3 percentage points in 2017, to 30.1% towards the 40% 2020 target. RES-T increased in 2017, to 7.4% towards the 10% 2020 target from 5.2% in 2016 (see Section *3.1.3*). RES-H increased by 0.6 percentage points in 2017, to 6.9% towards the 12% 2020 target.

Wind accounted for 52% of the contribution towards the Directive target.

Figure 21 shows the contribution as per the Directive methodology from 2005 to 2017 while *Figure 22* shows the renewable energy percentage contributions to GFC by mode with RES-E normalised.

Figure 21: Renewable energy (%) contribution to Gross Final Consumption (Directive 2009/28/EC)



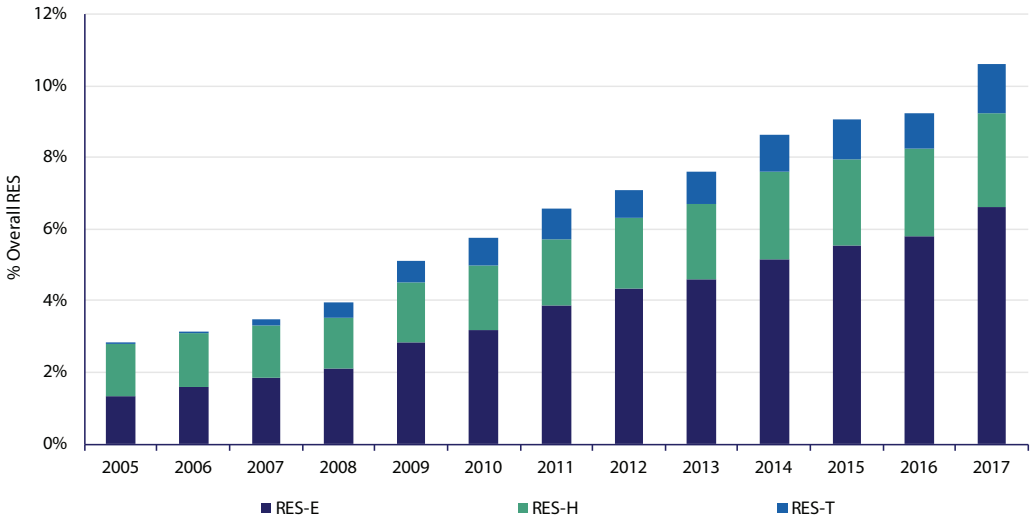
Source: SEAI

Wind accounted for 52% of the contribution towards the Directive target. Bioenergy accounted for 38% of the contribution which consists of biomass at 23 percentage points, liquid biofuels at 13 percentage points and biogas at 2.1 percentage points. The remaining contribution came from hydro and geothermal at 4.9% and 3.3% respectively, and solar at 1.2%.

Bioenergy accounted for 39% of the contribution towards the overall Renewable Energy Directive target.

26 Note that individual target percentages are not additive. RES-T includes double certificates for advanced biofuels. The table contains some revisions compared with the last edition of Energy in Ireland – 2017 Report.

Figure 22: Renewable energy (%) contribution to GFC by Mode[27]



Source: SEAI

A more detailed discussion of renewable energy in Ireland can be found in SEAI's publication *Renewable Energy in Ireland*[28]. This section presents key graphs and updates where available from the renewables report.

3.1.1 Electricity from Renewable Energy Sources (RES-E)

Ireland's NREAP specified a target of 40% electricity consumption from renewable sources by 2020. The total contribution from renewable energy to gross electricity consumption in 2017 was 30.1% normalised (compared with 26.8% in 2016).

The share of electricity from renewable energy has increased fourfold between 2005 and 2017 – from 7.2% to 30.1% – an increase of 23 percentage points over 12 years. In absolute terms, there has been a fivefold increase in the volume of renewable electricity generated from 1,873 GWh in 2005 to 8,877 GWh in 2017.

Table 11 and *Figure 23* shows how electricity production from wind energy has increased to the point where it accounted for 84% of the renewable electricity generated in 2017. Electricity generated from biomass accounted for 8% of renewable electricity in 2017. Biomass consists of contributions from solid biomass, landfill gas, the renewable portion of waste and other biogas.

Wind energy accounted for 84% of the renewable electricity in 2017.

Wind, hydro and bioenergy-generated electricity in 2017, respectively, accounted for 25.2%, 2.4% and 2.4% of Ireland's gross electricity consumption. Solar photovoltaic (PV) accounted for 0.04%.

Table 11: Renewable energy contribution to Gross Electricity Consumption (RES-E normalised)

Renewable Electricity %	2005	2010	2011	2012	2013	2014	2015	2016	2017
Hydro (normalised)	2.7	2.6	2.7	2.8	2.7	2.6	2.5	2.5	2.4
Wind (normalised)	4.0	11.9	14.3	15.5	16.9	19.0	21.3	22.0	25.2
Biomass	0	0.4	0.5	0.9	1.1	1.2	1.0	1.6	1.8
Landfill Gas	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
Biogas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Solar PV	0	0	0	0	0	0	0.01	0.01	0.04
Overall	**7.2**	**15.6**	**18.3**	**19.8**	**21.3**	**23.5**	**25.5**	**26.8**	**30.1**

27 RES-T double certification for advanced biofuels are not included in the overall RES target.
28 Available from http://www.seai.ie/

Figure 23: Renewable energy contribution to Gross Electricity Consumption (RES-E normalised)

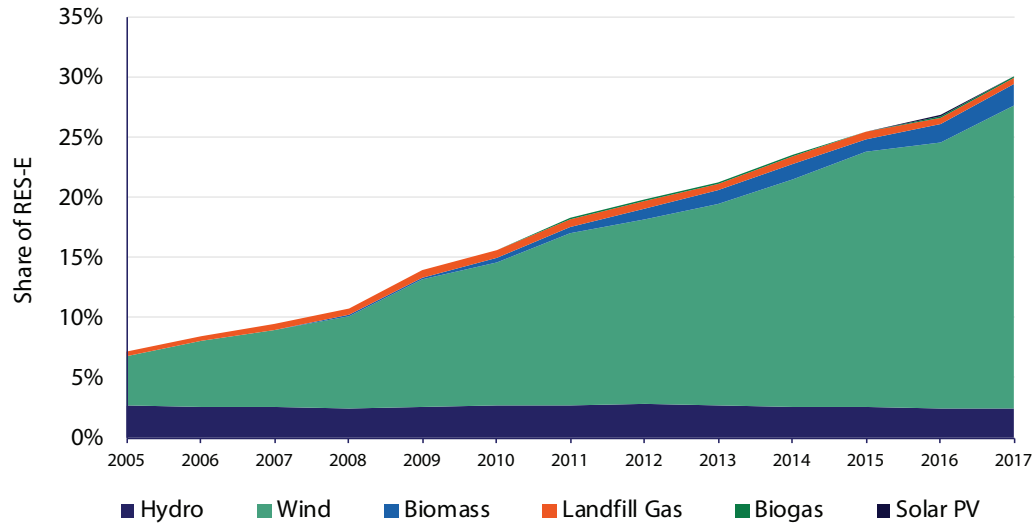
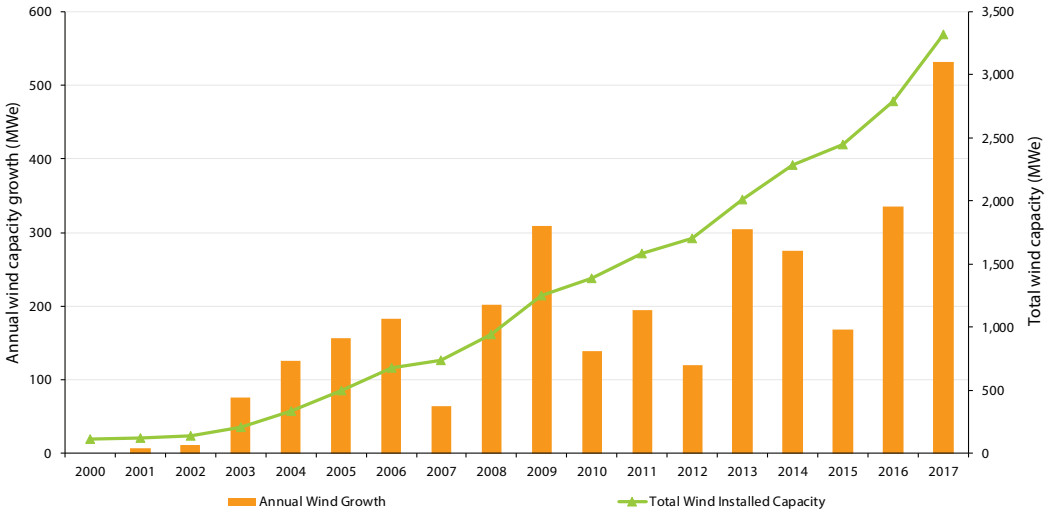


Figure 24 shows the annual growth in installed wind-generation capacity and overall cumulative capacity since 2000. By the end of 2017, the installed capacity of wind generation reached 3,318 MW. The peak recorded wind power output was 2,947 MW, delivered on 16 April 2018[29] at 19:30 hr and represented 72% of demand at that time. During 2017, 532 MW of wind capacity was installed.

According to EirGrid's Generation Capacity Statement 2018, as of 2017 there are 2,640 MW of additional wind generation planned with having either connection contracts or having applied for connection. Historically, there has been a maximum of just over 500 MW installed in any one year since 2005 and on average the installation rate has been 200 MW.

Figure 24: Installed wind generating capacity 2000 – 2017[30]



Source: EirGrid

The output from wind and hydro generation is affected by the amount of the resource (wind and rainfall) in a particular year. It is also affected by the extent of outages of the plant for reasons such as faults, maintenance and curtailment. An indication of how these factors affect the output of wind and hydro can be obtained by examining the capacity factor for these generation types. The capacity factor is the ratio of average electricity produced to the theoretical maximum possible if the installed capacity was generating at a maximum for the full year.

The rate of capacity increase each year can have a significant impact on the capacity factor in periods of large annual capacity increases. If significant capacity is added late in the year, this would artificially reduce the capacity factor for the

29 Wind generation data, EirGrid: http://smartgriddashboard.eirgrid.com/#roi/wind

30 *Installed Wind Report*, EirGrid: http://www.eirgridgroup.com/customer-and-industry/general-customer-information/connected-and-contracted-generators/ and ESB Networks, http://www.esb.ie/esbnetworks/en/generator-connections/Connected-Contracted-Generators.jsp

year. To mitigate this, the wind capacity factors in *Table 12* are calculated using the average of the installed capacity in any given year and the previous year.

Table 12: Annual capacity factor for wind and hydro generation in Ireland 2005, 2010 – 2017

Capacity Factor	2005	2010	2011	2012	2013	2014	2015	2016	2017
Wind	30%	23.7%	33.1%	27.4%	28.0%	27.0%	31.4%	27.6%	28.5%
Hydro	31%	29%	34%	39%	29%	34%	39%	33%	33%

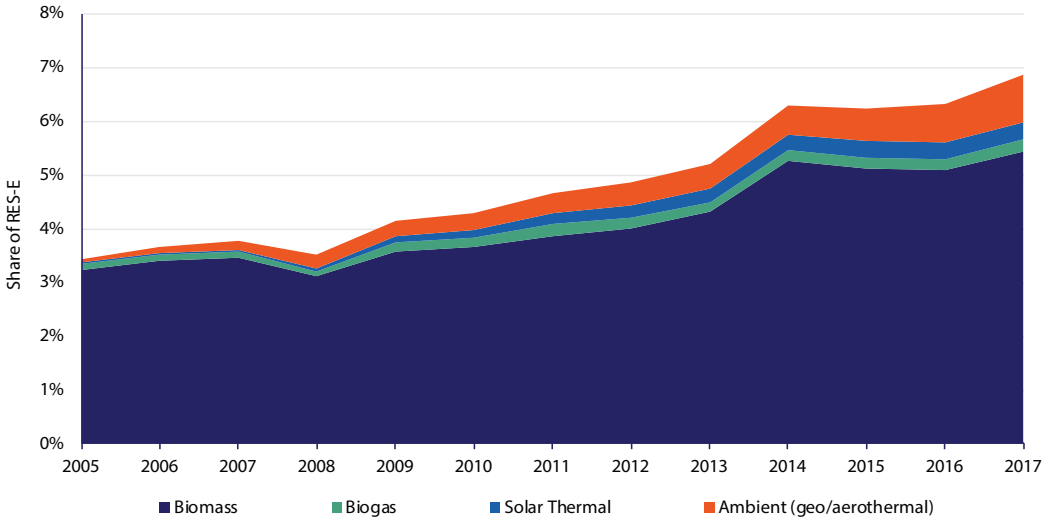
Source: EirGrid and SEAI

The average countrywide wind capacity factor was 30% in 2005 but fell to 24% in 2010 largely due to it being a low wind year compared with historic average levels. The hydro capacity was also at its lowest level since 2003 due to the low level of rainfall in 2010. The wind capacity factor increased to 28% in 2017 and the hydro capacity factor remained steady at 33%.

3.1.2 Heat from Renewable Energy Sources (RES-H)

Ireland's NREAP specified a target of 12% renewable heat by 2020. *Figure 25* shows the contribution from renewable energy to heat or thermal energy uses. The increasing activity in specific sub-sectors of industry, as well as some incentives and regulations for renewable systems in residential dwellings, has led to renewable energy use rising from 187 ktoe in 2005 to 312 ktoe in 2017 (a growth of 67%). In 2017, renewable thermal energy increased by 9.8% in absolute terms relative to 2016. The renewable share of thermal energy increased by 0.6 percentage points to 6.9% in 2017.

Figure 25: Renewable energy contribution to thermal energy (RES-H)



Following a decline in the contribution from renewables to thermal energy in the early 1990s (from 2.6% in 1990 to 2.1% in 1995), RES-H grew between 2000 and 2014, from 2.4 % to 6.3%, and fell in 2015 to 6.2% and increased again in 2016 and 2017 to 6.9%. This growth, dominated by solid biomass[31], is mostly due to the increased use of wood waste as an energy source in the wood products and food sub-sectors of industry. In addition, recent growth in renewable energy use in the residential and services sectors can be attributed to the support of grant schemes and revisions to building regulations requiring a share of the energy demand in new dwellings to come from renewable sources.

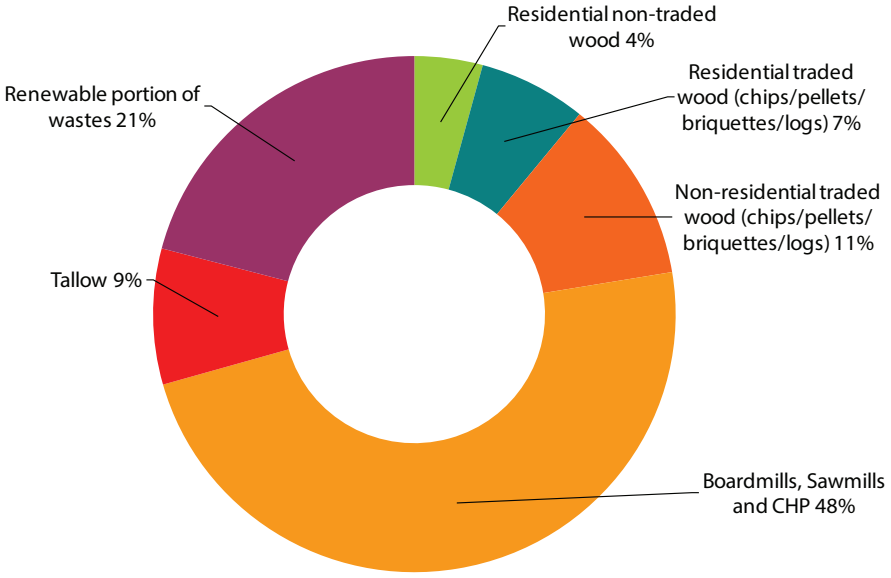
Figure 26 shows the composition of biomass in TFC in 2017. Forty-eight per cent of all solid biomass is consumed in the wood and wood products industry sub-sector, where wood wastes or wood residues of that sector are being combusted for heat. Similarly tallow, a by-product or output of the food sector, is combusted for heat in that sector and is also being refined for use as a biofuel in transport. Tallow accounts for 9% of all solid biomass. A further 21% of solid biomass in 2017 is used for heat in the cement industry in the form of the renewable portion of solid wastes.

Wood chips, pellets and briquettes make up 18% of all the solid biomass consumed in Ireland. The remaining 4% is an estimate of the non-traded wood logs which are being used in open fires or stoves in households. The non-traded wood consumption is estimated in the absence of available data and varies with different methodologies. However, as this non-

31 Solid biomass covers organic, non-fossil material of biological origin which may be used as fuel for heat production. It is primarily wood, wood wastes (firewood, wood chips, barks, sawdust, shavings, chips, black liquor [a recycled by-product formed during the pulping of wood in the paper-making industry] etc.), other solid wastes (straw, oat hulls, nut shells, tallow, meat and bone meal, etc.) and the renewable portion of industrial and municipal wastes.

traded wood is only a small part of the total solid biomass consumption, the variation in estimates is small relative to the overall total solid biomass consumption used for the calculation of RES-H.

Figure 26: Composition of biomass used for heat in TFC in 2017



Source: SEAI

3.1.3 Transport Energy from Renewable Sources (RES-T)

The EU Renewable Energy Directive established a mandatory minimum 10% target for the contribution of renewable energy in the final consumption of energy in transport by 2020. According to the Directive for this target, a weighting of 5 is applied to the electricity from renewable energy sources consumed by electric road vehicles and a weighting of 2.5 is applied to electricity from renewable energy sources consumed by rail transport, where the contribution is calculated as the share of electricity from renewable energy sources as measured two years before the year in question. Also supported through a weighting factor of 2 are second-generation biofuels, and biofuels from waste; that is, biofuels that diversify the range of feedstocks used to become commercially viable, receive an extra weighting compared with first-generation biofuels. These weighting factors are used for the calculation of RES-T only and do not apply when calculating the transport contribution to the overall RES share.

In 2010, a biofuel obligation scheme was established which required fuel suppliers and consumers to include, on average, 4% biofuel by volume (equivalent to approximately 3% in energy terms) in their annual sales. The biofuel obligation scheme is a certificate-based scheme which grants one certificate for each litre of biofuel placed on the market in Ireland; two certificates are granted to biofuel which is produced from wastes and residues. Oil companies are required to apply to the National Oil Reserves Agency (NORA) for certificates and to demonstrate that the quantities of biofuel for which they are claiming certificates are accurate. Since the introduction of the Sustainability Regulations (SI 33 of 2012) in 2012, the companies are also required to demonstrate that the biofuel being placed on the market is sustainable, fulfilling the requirements of Directive 2009/28/EC. Biofuel that is not deemed to be sustainable will not be awarded certificates and cannot be counted towards the biofuel obligation.

The obligation was increased to 6% in 2013 and to 8% in 2017[32] and will increase further to 10% from January 2019[33].

In 2015, new rules[34] came into force which amend the legislation on biofuels – specifically Directive 2009/29/EC and Directive 2009/30/EC – to reduce the risk of indirect land use change and to prepare the transition towards advanced biofuels. The amendment:

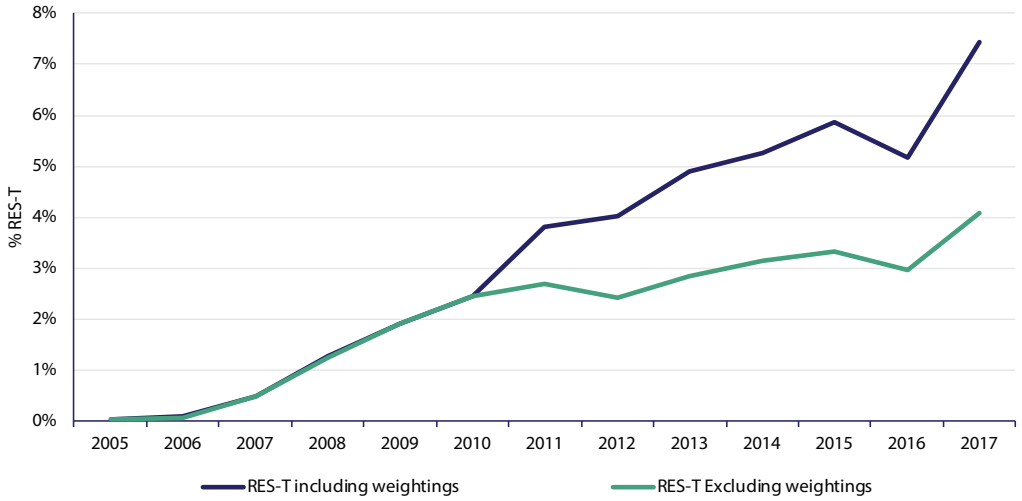
- Limits the share of biofuels from crops grown on agricultural land that can be counted towards the 2020 renewable energy targets to 7%;
- Proposed a specific sub-target of at least 0.5% for advanced biofuels in road and rail energy from 2021 rising to 3.6% in 2030[35];

32 S.I. No. 225/2016 - National Oil Reserves Agency Act 2007 (Biofuel Obligation Rate) Order 2016 http://www.irishstatutebook.ie/eli/2016/si/225/made/en/print#
33 http://www.nora.ie/_fileupload/SI198%20of%202018%20Rate%20Increase%2010%20percent.pdf
34 http://ec.europa.eu/energy/en/topics/renewable-energy/biofuels/land-use-change
35 COM(2016) 767 final/2 http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016PC0767R(01)&from=EN

- Harmonises the list of feedstocks for biofuels across the EU, whose contribution would count as double towards the 2020 target of 10% for renewable energy in transport;
- Requires that biofuels produced in new installations emit at least 60% fewer GHGs than fossil fuels;
- Introduces stronger incentives for the use of renewable electricity in transport. The renewable portion of electricity consumed by rail transport carries a 2.5 multiplier. For the calculation of the electricity from renewable energy sources consumed by electric road vehicles, that consumption is considered to be five times the energy content of the input of electricity from renewable energy sources;
- Includes a number of additional reporting obligations for the fuel providers, EU countries, and the European Commission.

The figure for renewables in transport energy (RES-T) in 2017 was 4.1%, or 7.4% when the weightings for biofuels and renewable electricity are applied in accordance with the Directive (see *Figure 27*). These are an increase on the respective 2016 figures of 3.0% and 5.2%, resulting from the increase in the obligation to 8%. Fifteen per cent of the required certificates for 2017 were carried forward from 2015 and 2016, as allowed under the Biofuel Obligation Scheme[36].

Figure 27: Renewable energy as a proportion of (road and rail) transport (RES-T)



In absolute terms, biofuels in transport increased from 1 ktoe in 2005 (0.03%) to 98 ktoe in 2011 (2.6% of transport energy) (see *Table 13*). The quantity fell in 2012 to 85 ktoe mainly as a result of the majority of biodiesel qualifying for double certificates, thereby allowing the obligation to be met with certificates but causing the actual volume of biofuel to fall. Actual volumes increased again after 2013 to reach 128 ktoe (3.3% of transport energy) in 2015 but fell to 119 ktoe in 2016 (3.0% of transport energy) before increasing again in 2017 by 36% to 161 ktoe. In 2017, all of the biodiesel and 1% of bioethanol used for road transport were eligible for double certificates[37].

Table 13: Biofuels growth in ktoe and as a proportion of road and rail transport energy 2005, 2010 – 2017

Fuel	2005	2010	2011	2012	2013	2014	2015	2016	2017
Petrol (ktoe)	1,822	1,478	1,399	1,272	1,197	1,134	1,075	1,003	904
Diesel (ktoe)	2,378	2,236	2,221	2,224	2,368	2,519	2,727	2,951	2,955
Biofuels (ktoe)	1.1	92.6	97.8	84.9	102.2	116.2	128.1	118.5	160.6
Renewable Electricity		0.4	0.5	0.6	0.7	0.7	0.8	1.0	1.2
Petrol plus Diesel	4,200	3,713	3,621	3,497	3,566	3,652	3,802	3,954	3,859
Biofuel Penetration	***0.0%***	***2.4%***	***2.6%***	***2.4%***	***2.8%***	***3.1%***	***3.3%***	***3.0%***	***4.1%***
Weighted Renewables (ktoe)	1	94	139	142	178	195	228	209	296
Weighted Renewables Share	***0.0%***	***2.5%***	***3.8%***	***4.0%***	***4.9%***	***5.3%***	***5.9%***	***5.2%***	***7.4%***

36 http://www.nora.ie/regulationslegislation/biofuels-obligation-scheme.152.html
37 http://www.nora.ie/_fileupload/457-18X0074%20-%20BOS%20Annual%20Report%20for%202017.pdf

Renewable energy share in transport (RES-T) in 2017 was 4.1%, or 7.4% when the weightings for biofuels and renewable electricity are applied.

3.1.4 CO_2 Displacement and Avoided Fuel Imports

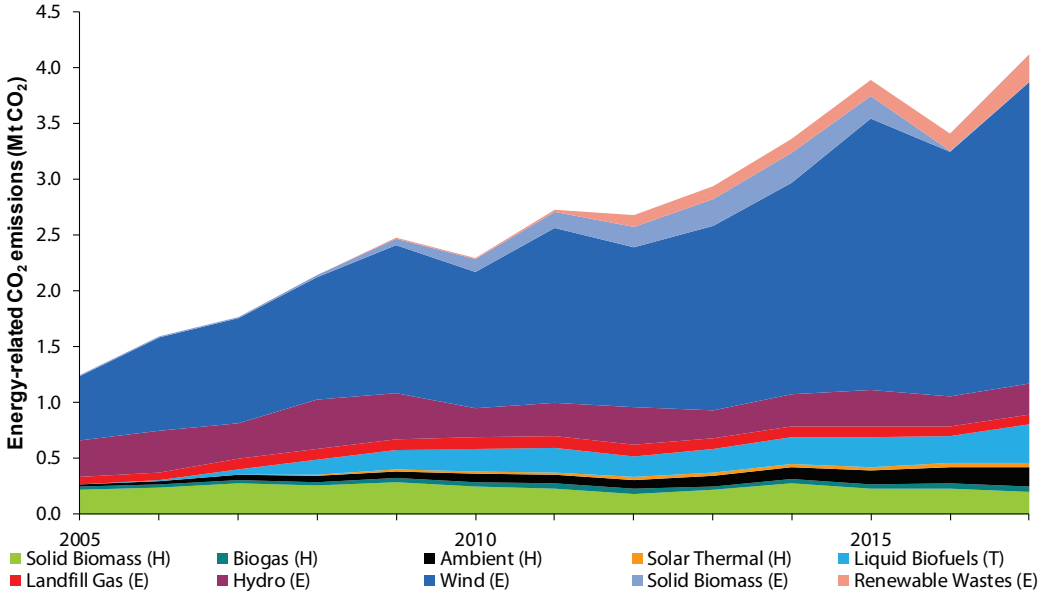
The avoided carbon emissions and displacement of fossil fuel imports by renewable energy generation are estimated using the primary energy equivalent approach. The results obtained using this methodology have been further refined, using the results of a more detailed dispatch model of the operation of the entire all-island electricity system in the year 2012, so that the effects of ramping and cycling of fossil fuel plants are accounted for[38,39].

Figure 28 shows the trend in avoided CO_2 emissions from renewable energy for the period 2005 – 2017. The estimated amount of CO_2 avoided from renewable energy increased by 231% over the period 2005 – 2017, reaching 4,122 kt CO_2 in 2017. The emissions avoided from wind were most significant in 2017, at 2,698 kt CO_2, followed by hydro at 274 kt CO_2, solid biomass at 205 kt CO_2 and liquid biofuels used in transport at 340 kt CO_2.

Since 2016, electricity generation from peat is no longer supported by the PSO. Instead, co-firing of biomass with peat at Edenderry is supported under REFIT 3. Without the REFIT from co-firing with biomass, electricity generation from peat would fall down the merit order and be replaced by gas generation (applying the operating margin approach, as for other renewables). The emissions from electricity generated from gas are lower than from electricity generated by peat co-fired with biomass at the proposed rates of co-firing. Therefore, co-firing biomass with peat no longer avoided carbon emissions after 2015.

In relation to the displacement of fossil fuels by renewable energy, it is estimated that in 2017 approximately €439 million in fossil fuel imports were avoided, of which €226 million was avoided by wind generation. The displacement of fuel imports is calculated by estimating how much extra fossil fuel would have had to be imported had there been no renewable generation in 2017. The estimates are based on the use of marginal generation fuel that would otherwise have been required to produce what had been generated by renewable energy.

Figure 28: Avoided CO_2 from renewable energy 2005 – 2017



In 2017, approximately €439 million in fossil fuel imports were avoided by the use of renewables, of which €226 million was avoided by wind generation.

38 See SEAI reports Quantifying Ireland's Fuel and CO_2 Emissions Savings from Renewable Electricity in 2012 and Renewable Energy in Ireland 2012 for further details on the methodologies used to calculate the avoided emissions.

39 Holttinen, Hannele, et al (2014), '*Estimating the Reduction of Generating System CO_2 Emissions Resulting from Significant Wind Energy Penetration.*' 3thInternational Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants, Berlin.Vol. 10. No. 2.1.

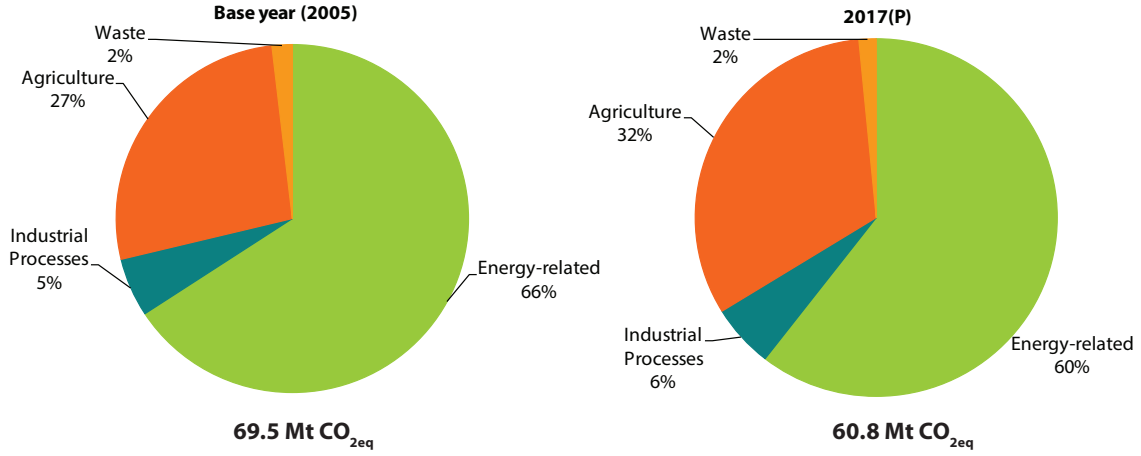
3.2 Greenhouse Gas Emissions Targets

In 2008, the EU agreed a Climate and Energy Package that included a target to reduce GHG emissions across the EU by 20% below 1990 levels by the year 2020. This resulted in two specific pieces of GHG emissions legislation affecting Ireland:

- Directive 2009/29/EC requiring Emissions Trading Scheme (ETS) companies to reduce their emissions by 21% below 2005 levels by 2020;
- Decision 406/2009/EC requiring Ireland to reduce non-ETS emissions by 20% below 2005 levels by 2020.

Figure 29 shows GHG emissions by source for 2005 and provisional figures for 2017, as reported by the Environmental Protection Agency (EPA).

Figure 29: Greenhouse Gas Emissions by Source



Source: Based on EPA data

Figure 29 shows that the share of energy-related emissions in total GHG emissions have fallen since 2005. The share of GHG emissions arising from energy-related activities was 60% (36.8 Mt) in 2017 compared with 66% (45.7 Mt) in 2005. The share from agriculture increased from 27% to 32% in the same period from 18.7 Mt to 19.6 Mt.. It is interesting to note that for the EU as a whole, energy production and use represented 79% of GHG emissions in 1990. The significant role of agriculture in the Irish economy underlies Ireland's variance from the EU average.

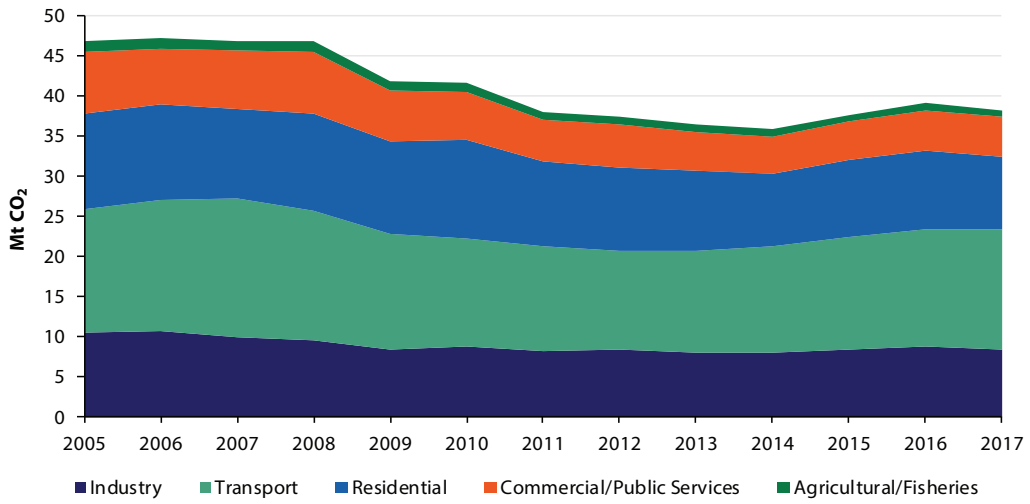
The sectoral energy-related CO_2 emissions presented in *Figure 30* and *Table 14* are based on the economic sectoral disaggregation contained in the energy balance, with the upstream emissions from electricity generation and other energy transformations allocated to the economic sectors where that electricity is used. This differs from the way in which national GHG emissions inventories are reported by the EPA, where the 'energy sectors' (for example, electricity generation and oil refining) are reported separately according to United Nations Framework Convention on Climate Change (UNFCCC) and UN Intergovernmental Panel on Climate Change (IPCC) reporting guidelines.

The share of GHG emissions arising from energy-related activities was 60% (36.8 Mt) in 2017 compared with 66% (45.7 Mt) in 2005.

Energy-related GHG emissions fell by 3% in 2017.

The sectoral breakdown of energy-related CO_2 emissions shown represents 96% of energy-related GHG emissions, with the remaining 4% accounted for by energy-related nitrous oxide (N_2O) and methane (CH_4). Energy-related CO_2 emissions in 2017 were 19% higher than 1990 levels but 20% lower than in 2005.

Figure 30: Energy-related CO_2 emissions by sector[40,41]



As shown in *Table 14,* transport accounted for the largest share of energy-related CO_2 emissions, with a share of 39% in 2017, up from 33% in 2005. The residential sector accounted for the second largest share in 2017, at 24%, followed by industry at 22% and services at 13%. Energy-related CO_2 emissions in agriculture and fisheries accounted for just 2.2%.

Table 14: Growth rates, quantities and shares of primary energy-related CO_2 by sector

	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Industry	-20.1	-1.8	-3.7	-0.9	0.5	-3.4	10,523	8,412	22.5	22.1
Transport	-3.0	-0.3	-2.4	0.7	2.7	1.2	15,299	14,843	32.7	38.9
Residential	-23.4	-2.2	0.5	-4.7	-2.4	-6.1	11,846	9,076	25.3	23.8
Services	-35.8	-3.6	-4.9	-4.2	1.0	-2.8	7,769	4,987	16.6	13.1
Agriculture / Fisheries	-42.0	-4.4	-5.7	-5.6	1.9	0.5	1,414	820	3.0	2.2

A more detailed discussion can be found in SEAI's publication, called Energy-Related CO_2 Emissions in Ireland .

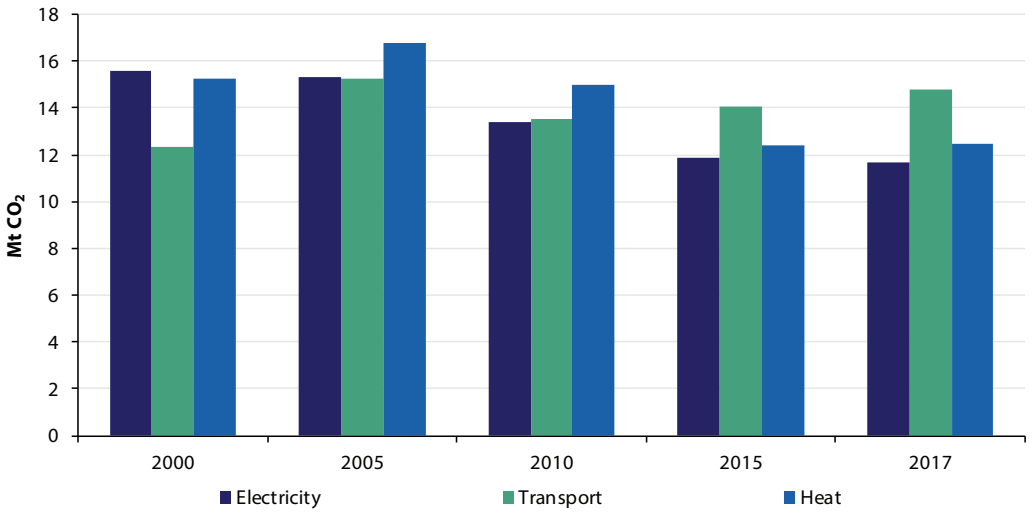
Figure 31 and *Table 15* illustrate the variations in emissions by mode of energy use. Here the emissions are allocated according to whether the energy used is for transport, electricity, or thermal energy. These modes also represent distinct energy markets. The graph presents the emissions in the years 2000, 2005, 2010, 2015 and 2017. In 2017, the shares of energy-related CO_2 emissions from transport, electricity and thermal applications were 38.5%, 30.3% and 31.2% respectively.

Transport accounted for the largest share of energy-related CO_2 emissions, with a share of 39% in 2017, up from 33% in 2005.

40 *Figure 30* and *Table 14* are based on SEAI estimates and use a different methodology to that used by EPA for compiling the national inventory. International air transport emissions are excluded from the national GHG emissions inventory in accordance with the reporting procedures of the UNFCCC guidelines.

41 Emissions for agriculture shown in the chart and the table are for energy-related emissions only.

Figure 31: Energy-related CO_2 emissions by mode of energy application



Energy-related CO_2 emissions fell in all modes after 2005, by 18% overall, to 38.5 Mt. The fastest rates of decline were observed in heat (25% decrease) followed by electricity (24% decrease) and transport (2.9% decrease). In 2017, emissions fell by 7.3% in electricity and 0.3% in heat but increased by 1.2% in transport.

Table 15: Growth rates, quantities and shares of energy-related CO_2 emissions by mode of application

	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Transport	-2.9	-0.2	-2.4	0.7	2.7	1.2	15,261	14,820	32.7	38.5
Electricity	-23.9	-2.3	-2.6	-2.4	-0.9	-7.3	15,337	11,664	32.8	30.3
Heat	-25.3	-2.4	-2.1	-3.9	0.5	-0.3	16,104	12,032	34.5	31.2
Total	**-17.5**	**-1.6**	**-2.4**	**-1.8**	**0.9**	**-2.0**	**46,702**	**38,516**		

Source: SEAI

Given the binding target at the national level is for the non-ETS[42] sectors, *Table 16 and Figure 32* show the trends in non-ETS energy-related CO_2 emissions for the transport, residential, services and agriculture[43] sectors since 2005, non-ETS industry from 2005 onwards and non-ETS transport since 2012. This excludes emissions associated with electricity usage by these sectors as these emissions are included in ETS.

Table 16: Growth rates, quantities and shares of ETS and non-ETS energy-related CO_2 since 2005

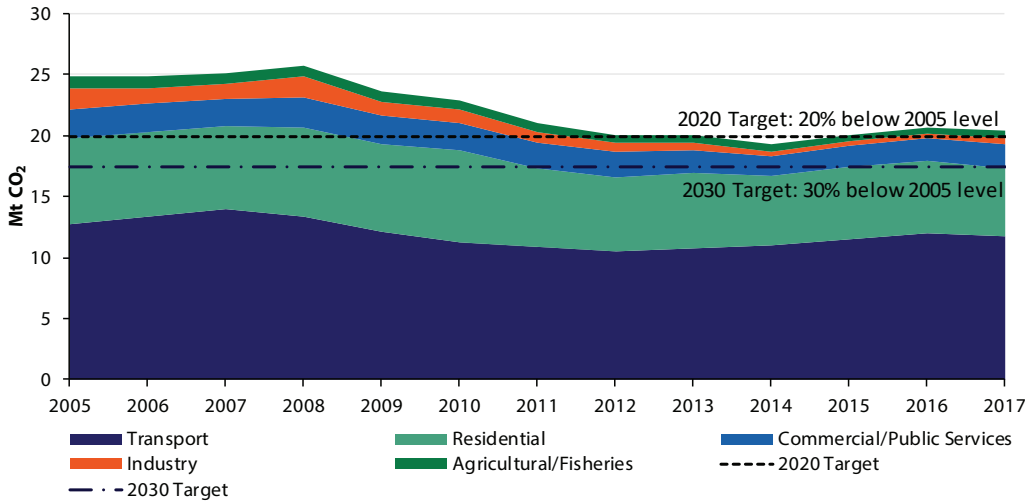
	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
ETS CO_2	-19.5	-1.8	-3.4	-1.1	0.6	-2.7	22,034	17,744	47.0	46.5
Non-ETS CO_2	-17.8	-1.6	-1.6	-2.6	0.8	-1.7	24,817	20,394	53.0	53.5
Total Energy-Related CO_2	**-17.6**	**-1.6**	**-2.5**	**-1.6**	**0.7**	**-2.1**	**47,543**	**39,182**		

Table 16 shows non-ETS sectors' (including non-ETS industry) energy-related CO_2 emissions decreased by 1.6% per annum between 2005 and 2010, and 2.6% per annum between 2010 and 2015, with emissions increasing by 0.4% per annum between 2015 and 2017. Non-ETS energy-related CO_2 emissions were 18% below 2005 levels in 2017. Under EU Decision 406/2009/EC, there is a requirement for Ireland to achieve a 20% reduction in total non-ETS GHG emissions (including, notably, methane emissions from agriculture) on 2005 levels by 2020.

The emissions trading sector has experienced a 19% fall in energy-related emissions since 2005, and emissions fell by 2.7% in 2017 compared with the previous year. The share of emissions covered in the ETS in overall energy-related emissions stands at 47% in 2017.

42 EU Decision 406/2009/EC.
43 Agricultural energy use only.

Figure 32: Non-emissions trading energy-related CO_2[44]



3.2.1 Transboundary Gas Emissions

Emissions of sulphur dioxide (SO_2) and nitrogen oxides[45] (NO_X) from energy use are associated with acid rain, smog and other environmental issues (including acidification and eutrophication) that are commonly described as air quality issues. Under Article 4.1 of Directive 2001/81/EC, Member States must limit their annual national emissions of the pollutants sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and volatile organic compounds (VOC). *Table 17* shows the emission levels for SO_2 and NO_x in 2016 as well as the 2010 ceiling limit set in the Directive.

Table 17: SO_2 and NO_x emissions and National Emissions Ceiling Directive limits for 2010[46]

	1990 (kt)	2016 (kt)	2010 Ceiling (kt)	% above 2010 Ceiling
NO_x	140	107.3	65	65%
SO_2	183	13.8	42	-

Source: EPA

SO_2 levels in Ireland fell by 92% between 1990 and 2016. Emissions from power generation fell by 96% over the period as a result of the installation of abatement equipment and the switch from oil to natural gas. Reductions in the order of 82% in SO_2 emissions in the residential and services sectors and a 92% reduction in industry were achieved over the period through the use of low sulphur coal and a switch to natural gas from oil.

NO_x emissions contribute to the acidification of soils and surface waters, tropospheric ozone formation and nitrogen saturation in terrestrial ecosystems. Power generation plants and motor vehicles are the principal sources of NO_x, through high-temperature combustion. NO_x emissions in Ireland decreased by 39% between 1990 and 2016 and have decreased by 35 kt, or 25% since 2008. The latest estimate is 107.3 kt in 2016, which is an increase of 46% on the previous year. In 2016, NO_x emissions were 65% above the 2010 ceiling.

Ireland has applied an adjustment to NO_x emission inventories, as allowed under Article 5(1) of EU Directive 2016/2284 in accordance with Part 4 of Annex IV, as Ireland is non-compliant with national emission reduction commitments as a result of applying improved emission inventory methods updated in accordance with scientific knowledge. Ireland exceeded the emission ceiling in 2010 and has been compliant with the NOx emission ceiling since 2011.

The transport sector, which mainly consists of road transport, is the principal source of NO_x emissions, contributing approximately 41% of the total in 2016. The industrial and power generation sectors are the other main sources of NO_x emissions, with contributions of 10.5% and 7.5% respectively in 2016. The remainder of NO_x emissions emanate from the residential/commercial and the agricultural sectors, which together produced around 11.2% of the total in 2016.

44 The 2020 target of 20% below 2005 levels refers to total GHG emissions and not just energy-related CO_2 emissions. While there's no specific target for energy-related CO_2, the datum of 20% below 2005 levels is shown here for illustrative purposes.

45 Collective term for nitric oxide (NO) and nitrogen dioxide (NO_2)

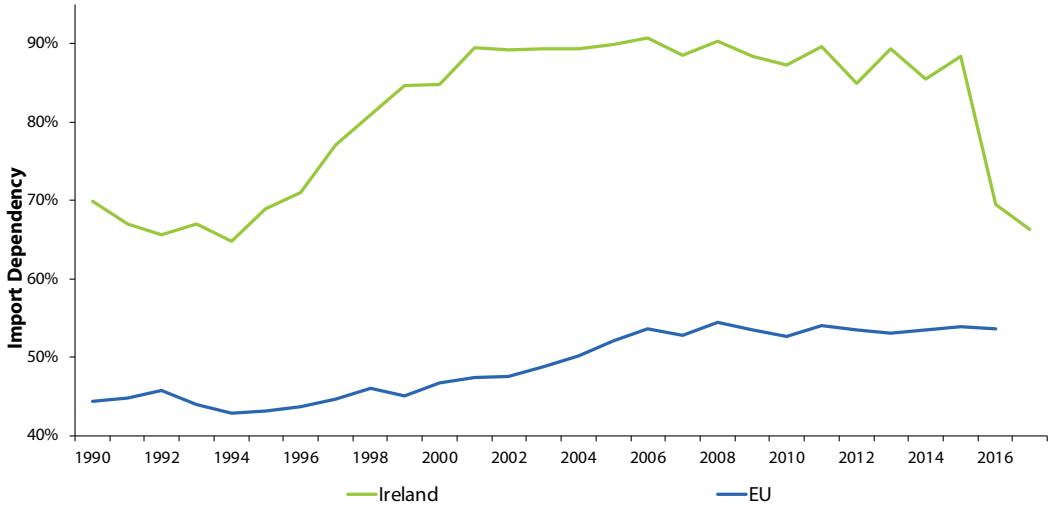
46 See http://www.epa.ie/downloads/pubs/air/airemissions/

3.3 Energy Security

Energy security relates to import dependency, fuel diversity and the capacity and integrity of the supply and distribution infrastructure. Ireland's energy security is closely linked to EU security of supply, but import dependency is examined here for Ireland in its own right. Energy security is treated in more detail in a separate SEAI publication[47]. *Figure 33* illustrates the trend in import dependency since 1990, comparing it with that for the EU as a whole and shows the dramatic change in Ireland's import dependency in 2016 resulting from the start of natural gas production from the Corrib gas field.

Indigenous production accounted for 32% of Ireland's energy requirements in 1990. However, since the mid-1990s, import dependency had grown significantly, due to the increase in energy use together with the decline in indigenous natural gas production at Kinsale since 1995 and decreasing peat production. Ireland's overall import dependency reached 90% in 2006. It varied between 85% and 90% until 2016 when it fell to 69% and further to 66% in 2017. It is estimated that in 2015 the cost of all energy imports to Ireland was approximately €4.6 billion; this fell to €3.4 billion in 2016 due mainly to reduced gas imports but increased again in 2017 to €4 billion.

Figure 33: Import dependency of Ireland and EU



Source: SEAI and Eurostat

This trend reflects the fact that Ireland is not endowed with significant indigenous fossil fuel resources and has only in recent years begun to harness significant quantities of renewable resources and more recently natural gas from the Corrib gas field. *Figure 34* shows the indigenous energy fuel mix for Ireland over the period. The reduction in indigenous supply of natural gas (until 2016) is clearly evident from the graph as is the switch away from peat. Production of indigenous gas decreased by 94% over the period between 1990 and 2015 to 106 ktoe but then increased dramatically in 2016 to 2,473 ktoe. It increased again in 2017 to 2,854 ktoe. This is the highest natural gas production level ever recorded in Ireland. This high level of production from the Corrib gas field is expected to taper off significantly in the next couple of years[48].

Indigenous renewable energy production increased by 220% between 2005 and 2017 to 1,185 ktoe.

Indigenous production of all energy in Ireland reached the highest level ever with a new peak in 2017 of 4,909 ktoe, up from the previous peak in 2016 at 4,242 ktoe.

Peat production was down since 2013 following a bumper production during that summer which provided very good harvesting conditions for peat. In 2017 peat production was up 9.5% to 744 ktoe compared with the previous year.

Ireland's import dependency varied between 85% and 90% until 2016 when it fell to 69% with Corrib gas field starting production and fell further to 66% in 2017.

47 Sustainable Energy Authority of Ireland (2015), *Energy Security in Ireland*, www.seai.ie
48 https://www.gasnetworks.ie/corporate/company/our-network/GNI_NetworkDevPlan_2016.pdf

Figure 34: Indigenous energy by fuel[49]

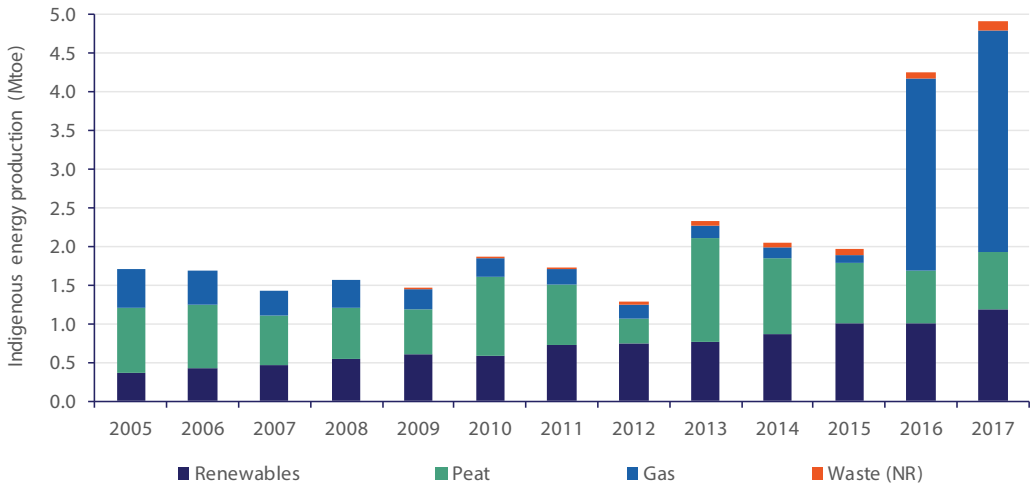


Figure 35 shows the trend for net fuel imports (imports minus exports) over the period 2005 – 2017. The dependence on oil, due largely to energy use in transport, is the most striking feature up until 2008. Between 2008 and 2017, net imports have fallen by 35%, with oil imports falling 23%. In 2017, net imports fell by 4.3% and were 33% below 2005 levels, while oil imports were 26% below 2005. In 2016, gas imports fell by 53% due to new indigenous production from the Corrib gas field. Gas imports fell by a further 17% in 2017.

Coal imports have remained stable over the period, reflecting the base load operation of Moneypoint electricity generating plant. In 2016, oil, gas and coal accounted for 72%, 14% and 12% of net imports, respectively.

Contributions to the decrease in import dependency in 2017 were:

- Natural gas imports were down 17% to 1,409 ktoe;
- Net oil imports were down 3.3% to 7,125 ktoe;

Countering these were;

- Coal imports were up 6.5% to 1,220 ktoe;
- A 14.5% increase in renewable energy imports (biomass and biofuels) to 159 ktoe.

Figure 35: Imported energy by fuel

49 Wastes (NR) is non-renewable energy from wastes.

3.4 Cost Competitiveness

Energy use is an important part of economic activity and therefore the price paid for energy is a determining factor in the competitiveness of the economy. Ireland has a high import dependence on oil and gas and is essentially a price-taker on these commodities. The EU has introduced competition into the electricity and gas markets through the liberalisation process in order to reduce energy costs to final consumers.

Since 2010, energy prices[50] in Ireland have increased by 0.8% in real terms, compared with an average fall of 2.4% in OECD Europe and a 4.9% fall in the United States (US) over the same period based on data from the IEA. In 2017, overall energy prices in Ireland were 3.2% higher than in 2016, compared with an increase of 1.5% in OECD Europe and a 7.7% increase in the US.

Crude oil prices averaged around $54/barrel in 2017 compared with $44/barrel on average in 2016. Up to mid-October 2018, the average price for Brent crude oil was $82/barrel[51].

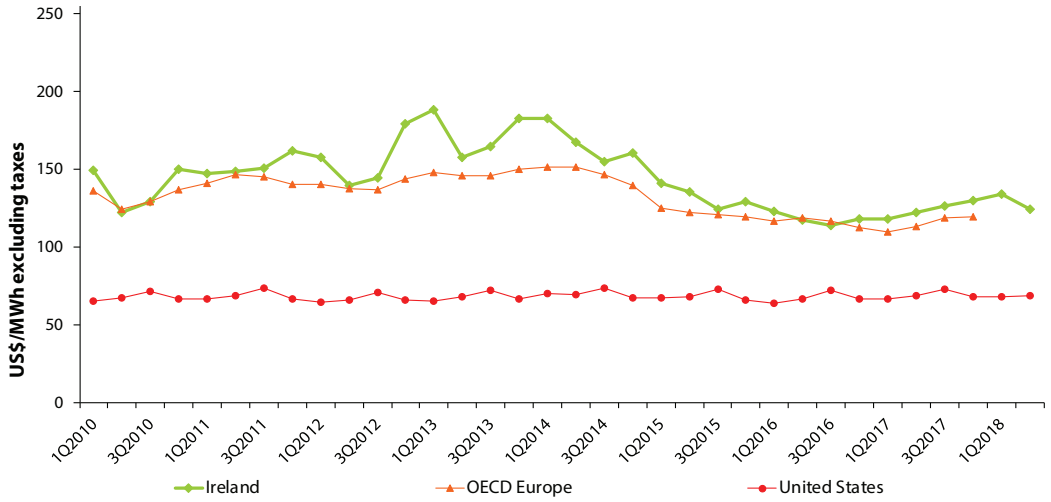
The price of natural gas at the UK National Balancing Point[52] was on average 23% higher in 2017 compared with 2016.

SEAI publishes biannual reports titled *Understanding Electricity and Gas Prices in Ireland*[53] based on the methodology for the revised EU Directive on the transparency of gas and electricity prices[54], which came into effect in January 2008. These reports focus specifically on gas and electricity prices using data published by Eurostat and are a useful reference on cost-competitiveness and cover both business and households.

This section focuses on business energy prices. It presents comparisons of the cost of energy in various forms in Ireland and compares prices in OECD Europe and the US. The source of the data presented here is the IEA's *Energy Prices and Taxes*. This data source was chosen because it is produced quarterly and the latest complete data is available for the second quarter of 2018. Prices shown are US dollars and are in current (nominal) money[55]. Relative price increases since 2010, however, are tabulated for EU-15 countries and the US in index format in both nominal and real terms.

3.4.1 Energy Prices in Industry

Figure 36: Electricity prices to industry



Source: Energy Prices and Taxes © OECD/IEA, 2018

50 International Energy Agency, 2018, Energy Prices and Taxes - 2nd Quarter 2018.
51 US Energy Information Administration http://www.eia.gov
52 National Grid UK https://www.nationalgrid.com/uk/gas/market-operations-and-data/transmission-operational-data
53 Sustainable Energy Authority of Ireland (various dates), Electricity and Gas Prices in Ireland – 2nd Semester (July – December) 2017.
54 http://europa.eu/legislation_summaries/energy/internal_energy_market/l27002_en.htm
55 Nominal and real values: Nominal value refers to the current value expressed in money terms in a given year, whereas real value adjusts nominal value to remove effects of price changes and inflation, to give the constant value over time indexed to a reference year.

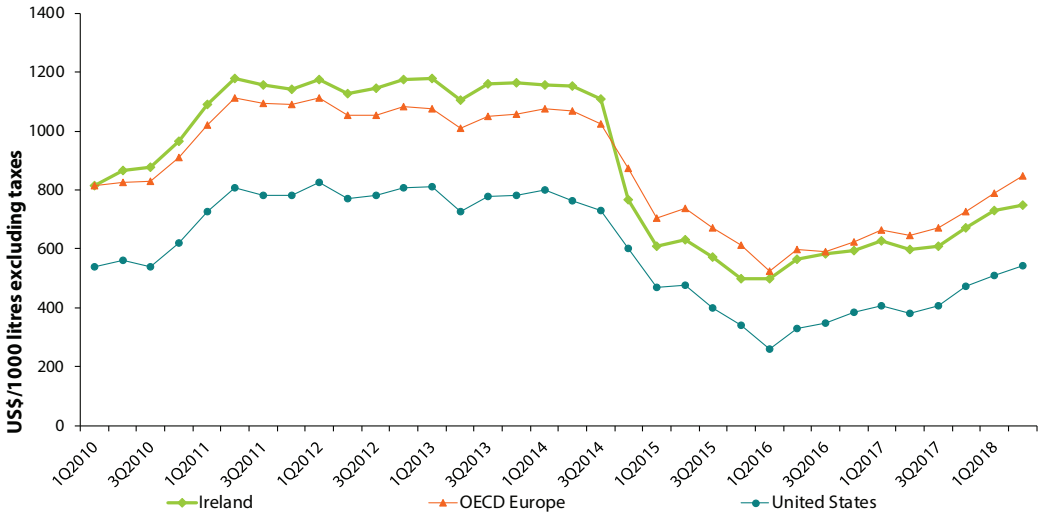
Table 18: Electricity price to industry increase since 2010

Index 2010 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom	United States
2nd qtr 2018 (nominal)	115	75	118	95	97	126	128	116	**101**	105	78	89	124	97	78	138	102
2nd qtr 2018 (real)	99	68	105	86	88	119	118	113	**94**	97	70	82	119	87	71	120	90

Source: Energy Prices and Taxes © OECD/IEA, 2018

Table 18 shows that electricity prices to Irish industry fell by 6% in real terms between 2010 and 2018. The fuel mix for electricity generation is one factor that has a key bearing on the variation in the price of electricity. In the EU, Ireland has a high overall dependency for electricity generation on fossil fuels at 66%, behind Greece at 71%, Netherlands at 80% and Poland at 84%. Ireland also has a high dependency on gas generation at 51%.

Figure 37: Oil prices to industry



Source: Energy Prices and Taxes © OECD/IEA, 2018

Table 19: Oil price to industry increase since 2010

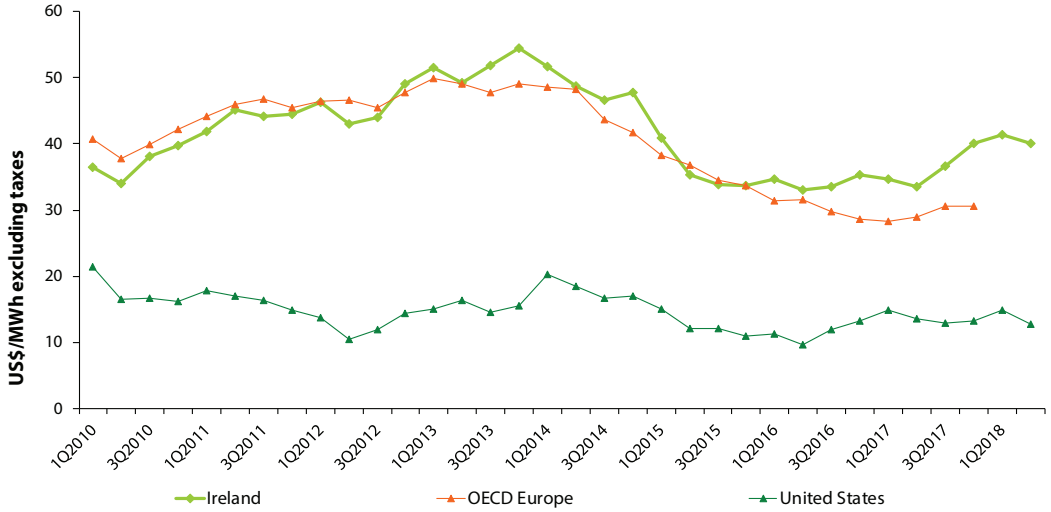
Index 2010 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom	United States
2nd qtr 2018 (nominal)	120	121	124	113	117	125	104	107	**108**	119	108	114	115	108	133	105	106
2nd qtr 2018 (real)	103	110	110	102	106	119	97	104	**100**	111	97	105	112	98	120	92	94

Source: Energy Prices and Taxes © OECD/IEA, 2018

Table 19 shows that oil prices to industry in Ireland were 8% lower in real terms in 2018 than in the year 2010. The average decrease in oil price in Europe was 17% and 12% in the US.

Crude oil prices averaged around $54/barrel in 2017 compared with $44/barrel on average in 2016. Up to mid-October 2018, the average crude oil price returned to $73/barrel.

Figure 38: Natural gas prices to industry



Source: Energy Prices and Taxes © OECD/IEA, 2018

Table 20: Natural gas price to industry Increase since 2010

Index 2010 = 100	OECD Europe	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom	United States
2nd qtr 2018 (nominal)	103	134	84	96	164	105	77	79	**120**	92	81	94	95	96		120	72
2nd qtr 2018 (real)	87	122	75	86	149	99	72	77	**112**	86	73	87	91	87		104	64

Source: Energy Prices and Taxes © OECD/IEA, 2018

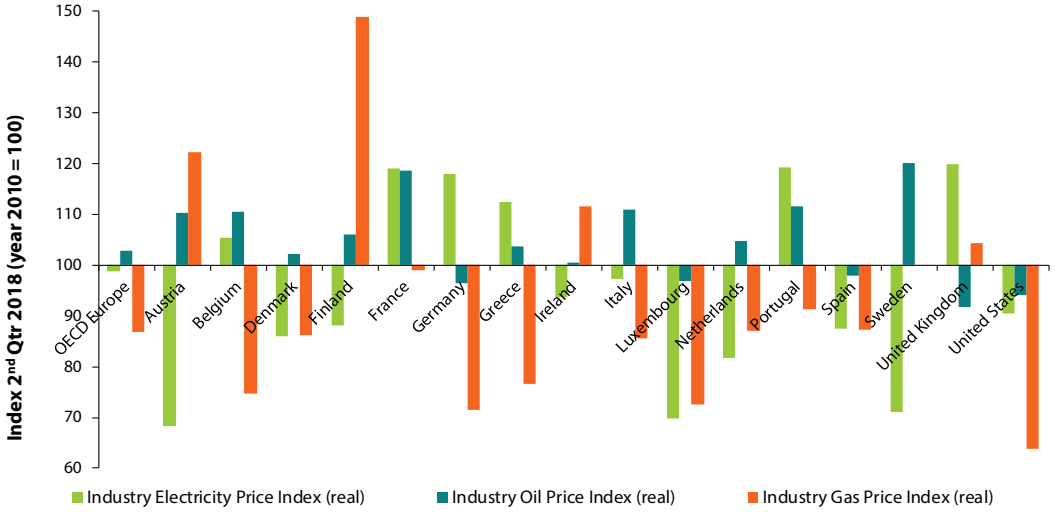
With reference to *Figure 38*, natural gas prices to Irish industry increased from the second quarter 2010 until the end of 2013. Price had been relatively stable from the middle of 2015 until the middle of 2017 when it started to rise again. In the second quarter of 2018 the price of gas to industry in Ireland was 12% above 2010 levels in real terms. *Figure 38* also shows the gap between gas prices in Europe and the US.

The price of natural gas at the UK National Balancing Point was on average 23% higher in 2017 compared with 2016.

Figure 39 summarises the data presented in *Tables 17, 18* and *19*. The IEA publishes an overall energy price index (real) for industry, which shows that the overall energy price to Irish industry between 2010 and 2017 fell by 4%, compared with a fall of 4.6% for OECD Europe and 16% reduction in the US. This should be considered in the context of the weighting of energy in the cost base of Irish industry[56].

56 Sustainable Energy Authority of Ireland (2007), *Energy in Industry 2007 Report*, available from www.seai.ie. This report found that 94% of industrial enterprises in Ireland spent less than 4% of their overall costs on energy. These enterprises also accounted for 93% of industrial gross value added.

Figure 39: Real energy price change to industry since 2010 in EU-15 (index)



Source: Energy Prices and Taxes © OECD/IEA, 2018

In 2017, energy prices for industry in Ireland decreased by 0.5% in real terms compared with 2016. In OECD Europe, the increase was 1.9%, while in the US energy prices increased by 5.9%.

The year 2017 saw global oil price increasing, with the price increasing from around $44/barrel on average in 2016 to $54/barrel on average in 2017. Natural gas price at the UK Balancing Point was on average 23% higher in 2017 compared with 2016.

The overall energy price to Irish industry between 2010 and 2017 fell by 4%, compared with a fall of 4.6% for OECD Europe and 16% reduction in the US.

4 Sectoral Trends and Indicators

This section explores the changes in energy trends that are taking place at a sectoral level. These help in understanding the general patterns of energy use and to assist in assessing the likely impacts of policies and measures on achieving particular targets.

4.1 Industry

Trends in 2017

The economic activity of industry increased in 2017 by 7.6% and energy use grew by 3.4% compared with the previous year to 2.5 Mtoe. The main trends in energy use in industry were:

- In 2017 consumption of oil, gas, renewables, wastes and electricity increased while coal use fell.
- Oil use increased by 2.6% to 497 ktoe and accounted for approximately one-fifth (19.8%) of industry's energy use.
- Natural gas consumption in industry increased by 1.2% in 2017 to 764 ktoe and accounted for 30% of industry's final energy demand.
- Renewable energy use in industry increased by 15.3% in 2017 and accounted for 8% of industry's energy use.
- Electricity consumption in industry increased by 1.1% to 882 ktoe and accounted for 35% of final energy consumption in industry.
- The use of wastes (non-renewable) in industry increased by 68% in 2017 to 70 ktoe and accounted for 2.8% of energy use in industry.
- Coal use fell by 4% to 102 ktoe and accounted for 4.1% of the energy share of industry.

Trends 2005 – 2017

Final energy use in industry was 4.4% lower in 2017 compared with 2005. Between 2006 and 2009, there was an 18% fall in industrial final energy use. Following a small increase in 2010 of 2.8%, consumption in industry fell until 2012. After 2012, energy use in industry increased by 15.4%. In 2017, it increased by 3.4%.

Figure 40 shows that over the period 2005 – 2017 only electricity, natural gas, wastes and renewables have increased their share. Since 2009, non-renewable wastes have been used in industry, and in 2017 accounted for 2.8% of industry's energy use. The share of electricity has risen from 25% to 35%, natural gas from 18% to 30% and renewables from 6.2% to 8% (see *Table 21*). The increase in renewables is mainly due to the use of biomass in the wood-processing industry, the use of tallow in the rendering industry and the use of the renewable portion of wastes in cement manufacturing.

Figure 40: Industry final energy use by fuel

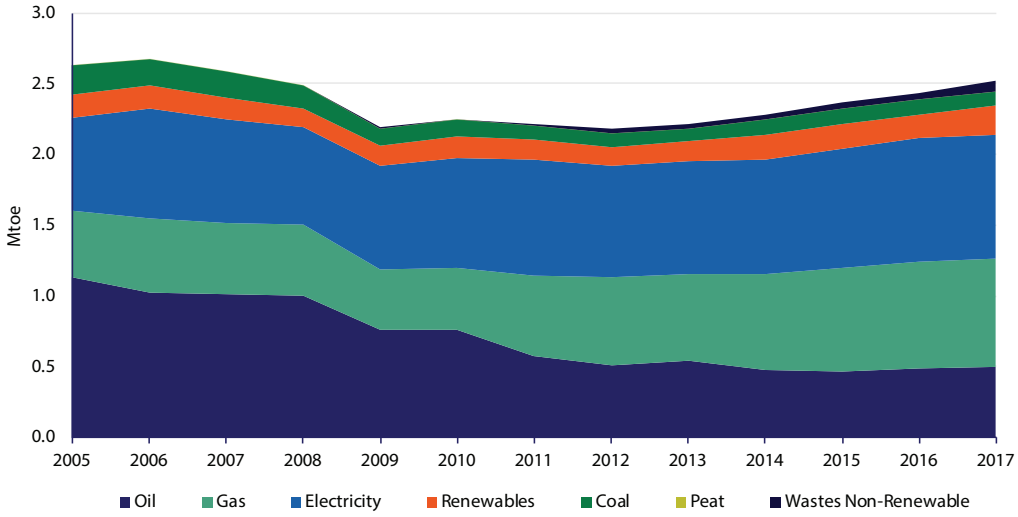


Table 21 shows the growth rates, quantities and relative shares of energy in industry.

Table 21: Growth rates, quantities and shares of final consumption in industry

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-24.7	-2.3	-6.3	-0.1	2.4	1.3	1,810	1,364	68.7	54.2
Coal	-51.7	-5.9	-11.8	-1.2	-1.7	-4.0	212	102	8.0	4.1
Oil	-56.3	-6.7	-7.8	-9.3	3.5	2.6	1,136	497	43.2	19.8
Gas	65.4	4.3	-1.1	10.8	2.3	1.2	462	764	17.5	30.3
Renewables	22.9	1.7	-1.4	3.2	6.0	15.3	163	201	6.2	8.0
Wastes (Non-Renewable)	-	-	-	38.8	26.1	67.8	-	70	0.0	2.8
Combustible Fuels (Total)	-17.2	-1.6	-5.7	0.7	3.6	4.6	1,973	1,634	74.9	65.0
Electricity	33.6	2.4	3.5	1.6	2.1	1.1	660	882	25.1	35.0
Total	**-4.4**	**-0.4**	**-3.1**	**1.0**	**3.1**	**3.4**	**2,633**	**2,516**		

Direct use of all fossil fuels accounted for 54% of energy use in industry in 2017 and grew by 1.3% in 2017. Over the period 2005 – 2017, use of fossil fuels in industry fell by 25%. So, while coal and oil consumption in industry has fallen over the period by 52% and 56%, respectively, overall fossil fuel did not fall at the same rate because of increased natural gas use (+65%). These changes in fuel mix did result in lower emissions from fuel use in industry during this period.

Energy-related CO_2 Emissions – including emissions associated with electricity

In order to determine industry's total energy-related CO_2 emissions, it is necessary to include estimations of upstream emissions for electricity consumed by industry. *Figure 41* shows the primary energy-related CO_2 emissions of industry, showing the on-site CO_2 emissions associated with direct fuel use and the upstream emissions associated with electricity consumption.

Figure 41: Industry energy-related CO_2 emissions by fuel

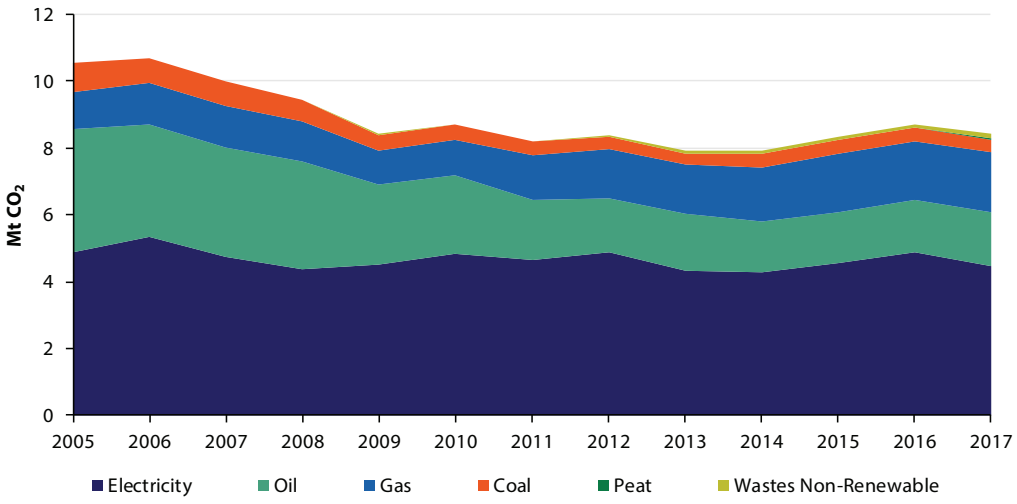


Table 22 shows the growth rates, quantities and relative shares of energy-related CO_2 emissions in industry.

As detailed in *Table 22*, industrial energy-related CO_2 emissions fell by 3.4% in 2017 to 8.4 Mt CO_2. Electricity consumption was responsible for 53% of industry's energy-related emissions in 2017.

The economic activity of industry increased in 2017 by 7.6% and energy use grew by 3.4% compared with the previous year to 2.5 Mtoe.

Table 22: Growth rates, quantities and shares of energy-related CO_2 emissions in industry

	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Coal	-51.7	-5.9	-11.8	-1.2	-1.8	-4.0	838	405	8.0	4.8
Oil Total	-57.0	-6.8	-8.5	-8.9	3.4	2.4	3,706	1,593	35.2	18.9
Kerosene	-31.0	-3.0	-2.0	-5.2	-0.1	-5.2	372	257	3.5	3.1
Fuel Oil	-90.2	-17.6	-8.0	-33.4	6.4	33.8	1,502	147	14.3	1.8
LPG	13.2	1.0	-0.1	0.6	5.0	2.9	275	311	2.6	3.7
Gas Oil	-41.2	-4.3	-4.6	-7.3	4.3	3.6	609	358	5.8	4.3
Petroleum Coke	-44.9	-4.8	-21.3	11.5	2.8	-1.4	944	520	9.0	6.2
Natural Gas	62.7	4.1	-1.0	10.7	1.4	1.2	1,098	1,786	10.4	21.2
Wastes (Non-Renewable)	-	-	-	40.9	26.1	67.8	-	147	0.0	1.8
Total Combustible Fuels	-30.3	-3.0	-7.2	-0.7	2.5	2.6	5,644	3,935	53.6	46.8
Electricity	-8.3	-0.7	-0.2	-1.1	-1.1	-8.1	4,880	4,477	46.4	53.2
Total	**-20.1**	**-1.8**	**-3.7**	**-0.9**	**0.5**	**-3.4**	**10,523**	**8,412**		

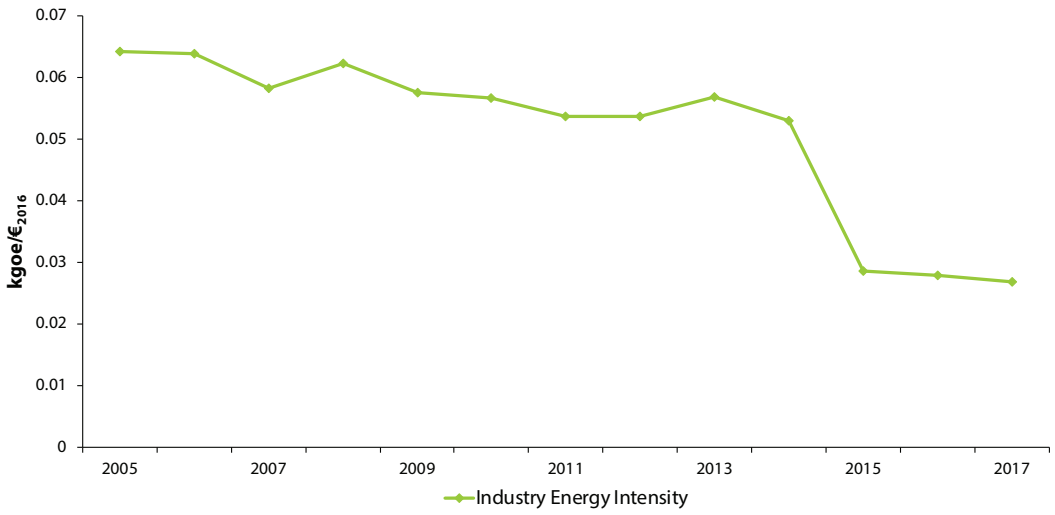
Energy-related CO_2 Emissions – excluding emissions associated with electricity

If upstream electricity-related emissions are omitted, then there was a 2.6% increase in CO_2 emissions from combustible fuels used on-site in industry in 2017. This is as a result of changes in the volume and fuel mix used in industry, with increased oil (+2.6%) and natural gas (+1.2%) countered by reduced coal (-4.0%) and increased renewables (+15%).

4.1.1 Industry Energy Intensity

Industrial energy intensity is the amount of energy required to produce a unit of value added, measured in constant money values. *Figure 42* shows the industrial energy intensity between 2005 and 2017 expressed in kilograms of oil equivalent per euro of industrial value added at 2016 money value (kgoe/$€_{2016}$). Over the period, industrial energy consumption fell by 4.4%, while value added increased by 129%, resulting in a reduction in intensity of 58%. In other words, to generate a euro of value added in 2017, it took less than half of the amount of energy it took in 2005.

Figure 42: Industry energy intensity



Value-added output from industry grew by 92% in 2015 relative to 2014. The large increase in gross value added (GVA) in 2015 is explained by a number of one-off factors, such as the transfer of assets into Ireland, and what are known as reverse takeovers. This increase in GVA incurred no additional energy consumption.

Energy intensity in this form is not a good indicator of energy efficiency, and variation may be the result of many factors such as structural changes, fuel mix, volume, and other changes.

4.2 Transport

Trends in 2017

In 2017, overall energy use in transport increased by 2% compared with the previous year.

- Petrol use fell in 2017, with petrol reducing by 9.8% to 904 ktoe. Petrol consumption is now lower than it was in 1990.
- Diesel consumption grew by 0.1% during 2017, to 2,955 ktoe, and was the most dominant fuel used, accounting for 58% of all energy use in transport.

Trends 2005 – 2017

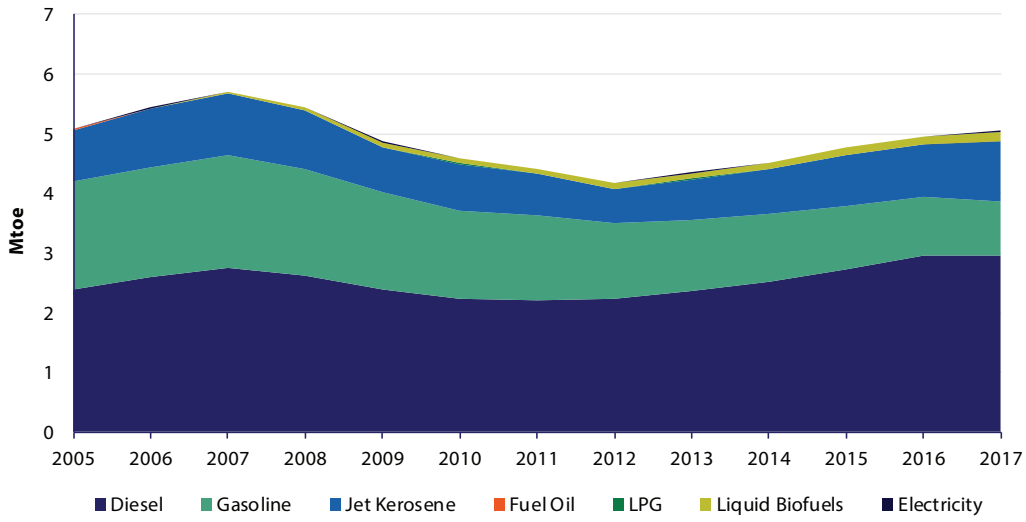
Over the period 2005 – 2017, the biggest shift in the transport market has been from petrol to diesel. While consumption of diesel increased by 242%, petrol use fell by 50%. Diesel's overall market share grew from 47% in 2005 to 58% in 2017.

Transport energy use peaked in 2007 at 5,715 ktoe and fell each year thereafter until 2013. As the economy started to expand again, transport energy use has grown every year since 2013 and in 2017 was 21% higher than in 2012. Energy consumption in transport was 0.3% lower in 2017 than in 2005.

As the economy started to expand again, transport energy use has grown every year since 2013 and in 2017 was 21% higher than in 2012.

As shown in *Figure 43* transport energy in 2017 was 11% below the peak in 2007.

Figure 43: Transport final energy use by Fuel[57]



The growth rates for the different transport fuels over the period are shown in *Table 23*.

Petrol consumption is now lower than it was in 1990.

57 This is based on data of fuel sales in Ireland rather than fuels consumed in Ireland. The effect of cross border trade (fuel tourism) is not taken into account in the figures presented here. SEAI's report, *Energy in Transport 2014 Report,* presents estimates of fuel tourism which are shown in *Figure 58* in the transport report.

Table 23: Growth rates, quantities and shares of final consumption in transport

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-3.5	-0.3	-2.4	0.7	2.6	1.1	5,078	4,902	99.9	96.7
Total Oil	-3.8	-0.3	-2.4	0.7	2.5	1.2	5,076	4,882	99.8	96.3
Petrol	-50.4	-5.7	-4.1	-6.2	-8.3	-9.8	1,822	904	35.8	17.8
Diesel	24.2	1.8	-1.2	4.1	4.1	0.1	2,378	2,955	46.8	58.3
Jet Kerosene	19.1	1.5	-1.7	1.5	9.8	17.6	857	1,021	16.9	20.2
LPG	33.6	2.4	-12.8	37.5	-26.7	-46.6	1	1	0.0	0.0
Natural Gas	818.1	20.3	-0.9	13.3	127.0	-5.0	2	20.23	0.0	0.40
Renewables	14528.0	51.5	142.8	6.7	12.0	35.6	1	161	0.0	3.2
Combustible Fuels (Total)	-0.3	0.0	-2.0	0.8	2.9	2.0	5,079	5,063	99.9	99.9
Electricity	-10.9	-1.0	-5.0	-0.9	9.8	7.3	5	5	0.1	0.1
Total	**-0.3**	**0.0**	**-2.0**	**0.8**	**2.9**	**2.0**	**5,084**	**5,067**		

Energy-related CO_2 Emissions

The growth rates and shares of the energy-related CO_2 emissions from the different transport fuels, which are shown in *Table 24*, closely match the changes in transport fuel consumption. Between the 2007 peak and 2012, the primary energy-related CO_2 emissions fell by 28%. Transport emissions began to rise again in 2013 for the first time since 2007, increasing by 3.9%. Emissions increased in 2017, by 1.2%, to 14.8 $MtCO_2$ but were 3% below the 2005 level.

Table 24: Growth rates, quantities and shares of energy-related CO_2 emissions in transport

	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Total Oil Products	-3.2	-0.3	-2.4	0.7	2.5	1.2	15,256	14,773	99.7	99.5
Petrol	-50.4	-5.7	-4.1	-6.2	-8.3	-9.8	5,337	2,649	34.9	17.8
Diesel	24.2	1.8	-1.2	4.1	4.1	0.1	7,299	9,068	47.7	61.1
Jet Kerosene	19.1	1.5	-1.7	1.5	9.8	17.6	2,562	3,052	16.7	20.6
LPG	33.6	2.4	-12.8	37.5	-26.7	-46.6	3	4	0.0	0.0
Natural Gas	802.8	20.1	-0.8	13.2	124.9	-5.0	5	47	0.0	0.3
Electricity	-38.8	-4.0	-8.4	-3.5	6.4	-2.5	37	23	0.2	0.2
Total	**-3.0**	**-0.3**	**-2.4**	**0.7**	**2.7**	**1.2**	**15,299**	**14,843**		

4.2.1 Transport Energy Demand by Mode

Fuel consumption in transport is closely aligned to the mode of transport used: jet kerosene is used for air transport, fuel oil for shipping and electricity is currently consumed mostly by the DART system and, since 2004, by Luas, but increasing now in electric vehicles on the road. LPG is almost exclusively used for road transport, as is petrol. The bulk of petrol consumption for road transport is assumed to be for private car use, although there are a significant number of petrol-driven taxis in operation and practically all motorcycles use petrol. Diesel consumption is used for road transport, navigation and rail.

SEAI's 2014 report *Energy in Transport*[58] presents an estimation of the energy use in transport by different modes. The contribution from each mode of transport to energy demand is shown in *Figure 44* and detailed in *Table 25*. In 2014, a new category of light goods vehicle (LGV) was added. This has been made possible on the basis of the analysis of the fuel efficiency of LGVs and an assessment of annual mileage estimated from the Commercial Vehicle Roadworthiness Test data from the Road Safety Authority (RSA). Energy use identified under the LGV category was previously included in the Unspecified category.

Trend in 2017

Overall energy use in transport increased by 2% in 2017. Energy consumption by heavy goods vehicles (HGVs) increased by 1.6% in 2017, while consumption by LGVs grew by 4.8%. Overall energy use by goods vehicles in total increased by 2.6% in 2017.

58 Sustainable Energy Authority of Ireland (2014), *Energy in Transport – 2014 Report*, https://www.seai.ie/resources/publications/Energy-in-Transport-2014-report.pdf

Private car energy consumption fell by 1.7% in 2017 to 2,087 ktoe and accounted for 41% of transport energy use. Petrol consumption by private cars fell by 11.2% in 2017 to 744 ktoe while diesel consumption increased by 3.4% to 1,259 ktoe and biofuels use increased by 28% to 82 ktoe.

Table 25: Growth rates, quantities and shares of transport final energy demand by mode

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Road Freight	-32.9	-3.3	-9.2	-1.9	9.2	1.6	1,112	746	21.9	14.8
Light Goods Vehicle (LGV)	-	-	-	-1.1	1.4	4.8	-	337	-	6.7
Private Car	10.3	0.8	1.3	1.4	-1.6	-1.7	1,893	2,087	37.2	41.4
Public Passenger (Road)	-13.2	-1.2	0.8	-4.1	1.4	2.5	157	137	3.1	2.7
Rail	-7.5	-0.6	-0.6	-2.1	2.7	3.0	45	42	0.9	0.8
Aviation	19.0	1.5	-1.7	1.5	9.8	17.5	859	1,022	16.9	20.2
Fuel Tourism	-58.1	-7.0	-10.0	15.7	-41.4	-57.7	387	162	7.6	3.2
Navigation	52.6	3.6	5.4	2.1	3.0	-11.7	50	76	1.0	1.5
Unspecified	-24.5	-2.3	-14.9	-16.1	101.4	71.3	580	438	11	8.7
Total	**-0.7**	**-0.1**	**-2.0**	**0.8**	**2.7**	**2.0**	**5,082**	**5,046**	100	100.0

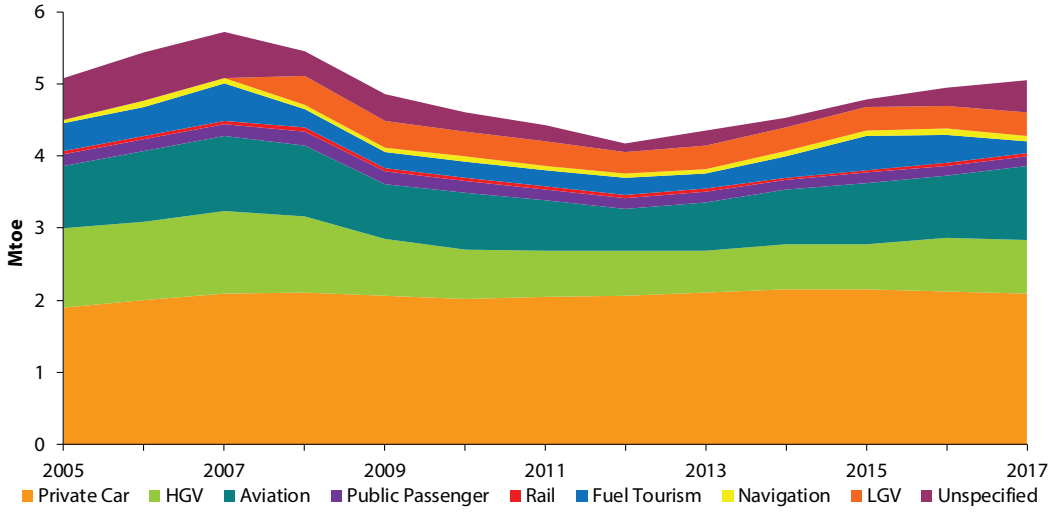
Aviation energy consumption grew by 17.5% in 2017 to 1,022 ktoe.

Road transport accounted for 66% of transport TFC in 2017 (77% if unspecified and fuel tourism are included as road transport). Private car use accounted for almost two-thirds (63%) of road transport, with goods vehicles accounting for almost another one-third (33%), and public passenger services the rest (4%).

Aviation was responsible for 20% of transport TFC in 2017 and rail transport 0.8%. Public passenger (road) consumption increased by 2.5% in 2017.

Combined petrol and diesel fuel tourism is also included in *Figure 44*. Only fuel tourism out of the Republic of Ireland (ROI) is included in this graph (i.e. fuel which is purchased in ROI but consumed elsewhere).

Figure 44: Transport energy demand by mode 2005 – 2017



Trends 2005 – 2017

Figure 44 clearly shows the growth in transport energy consumption prior to the economic downturn after 2007, the fall in consumption during the recession, and the recovery in energy consumption growth from 2013 onwards as the economy starts to grow again.

HGV road freight in particular has been affected by both the economic boom and the recession, experiencing both the greatest increase in the period 1990 – 2007 (231%, from 346 to 1,145 ktoe) and the greatest contraction in the period 2007

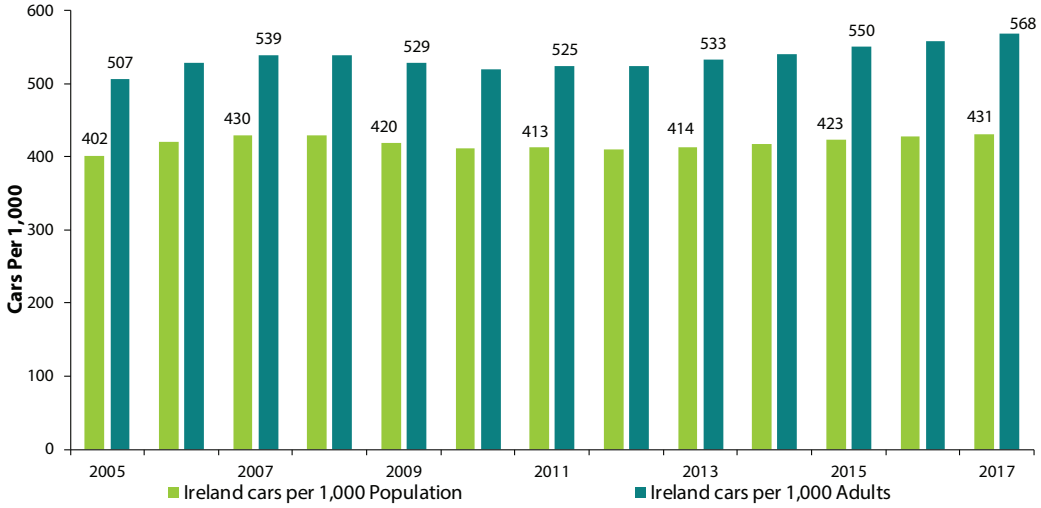
– 2013 (49%, from 1,145 to 621 ktoe). The energy consumption of HGVs increased by 29% between 2013 and 2017 and in 2017 HGV energy consumption increased by 1.6% to 746 ktoe but was still 33% below the 2005 level.

Over the period, private car energy consumption increased by 10% to 2,087 ktoe and accounted for 41% of transport energy in 2017. Aviation energy use increased by 19% over the period to 1,022 ktoe and accounts for 20% of transport energy.

4.2.2 Private Car Transport

In 2017, the number of vehicles on Irish roads was 2.7 million (2,675,879), of which 77% were private cars. The number of private cars peaked in 2008 at 1,923,471 and numbers fell in three of the following five years. In 2017, the number of licensed private cars on the road increased by 1.9% to a new peak of 2,066,112, exceeding the 2008 numbers by 7.4%.

Figure 45: Private cars per 1,000 of population



Source: Based on Vehicle Registration Unit and CSO data

The car density in 2017 (as shown in *Figure 45*) was 431 cars per 1,000 of population, up on the 2016 figure of 428. This is compared with an EU-27 average of 505 in 2016 and a UK average of 469 also in 2016[59].

4.2.3 CO_2 Emissions of New Private Cars

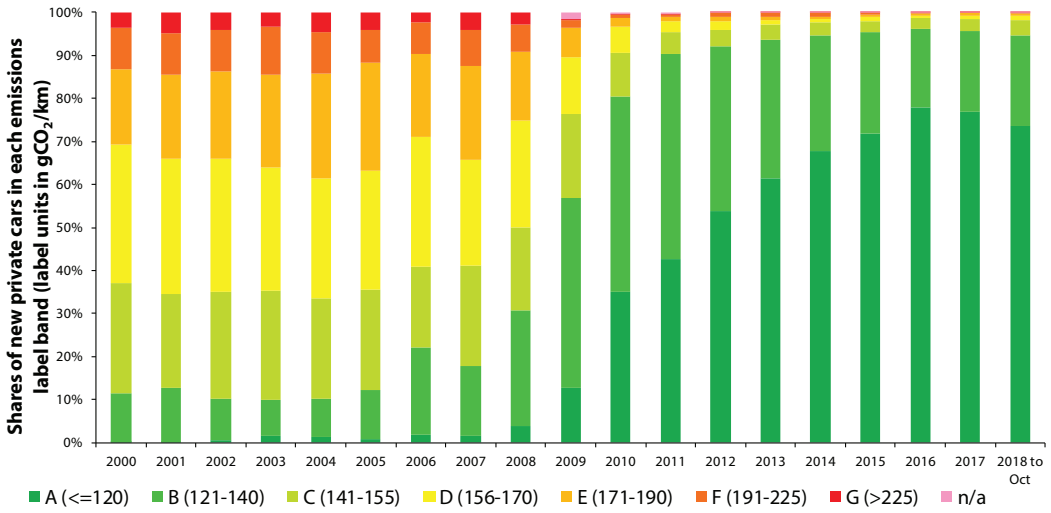
All new cars have associated fuel consumption and CO_2 emissions figures measured under test conditions and are licensed according to CO_2 emissions bands. *Figure 46* and *Table 26* show the shares of new car sales[60] between 2000 and October 2018 classified by emissions label band. The combined effect of the EU legislation obligating manufacturers to reduce average fleet emissions and the changes to the Irish taxation system for private cars has been to continue to steadily drive down the average new car fleet emissions year on year since 2008. Between 2000 and 2005, the share of cars in the A label band (i.e. <120 g CO_2/km) was on average less than 1%. In 2017, 77% of new cars purchased in Ireland were in the A category, down from 78% in 2016. Up until the end of September 2018, 74% of new cars were in the A category.

In 2017, the share of A and B label band cars was 95.7% and for the first 10 months of 2018 it was down slightly to 94.6%. While the share of B label cars continued to increase in 2017, the share of A label cars fell slightly (see *Table 26*).

The share of private cars in the A label emissions band rose from just 1.5% in 2007 to 78% of the new private cars sold in 2016, but fell slightly to 76.7% in 2017.

59 https://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU
60 Licensed as private cars.

Figure 46: Shares of new private cars in each emissions band 2000 – 2017 (+2018 to October)



Source: Based on Vehicle Registration Unit data

The share of high-emitting cars in label bands E, F and G only amounted to 0.8% of new cars sold during 2017 and the same during first 10 months of 2018, in the latter case just 913 cars out of a total of 118,732.

Table 26: Shares of new private cars in each emissions band, 2005, 2010 – 2017 (+2018 to October)

CO_2 Band	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018 to October
A	0.9%	35.1%	42.5%	53.8%	61.3%	67.8%	71.8%	78.0%	76.7%	73.6%
B	11.4%	45.2%	47.8%	38.2%	32.2%	26.8%	23.5%	18.2%	18.9%	21.0%
C	23.2%	10.1%	5.0%	4.0%	3.7%	3.0%	2.6%	2.5%	2.7%	3.6%
D	27.6%	6.2%	2.6%	1.9%	0.9%	0.8%	1.0%	0.6%	0.7%	0.9%
E	25.1%	2.0%	1.0%	1.0%	0.8%	0.4%	0.6%	0.5%	0.7%	0.6%
F	7.5%	0.6%	0.6%	1.0%	1.0%	0.9%	0.4%	0.3%	0.1%	0.2%
G	4.2%	0.3%	0.2%	0.1%	0.1%	0.1%	0.05%	0.03%	0.02%	0.04%

Source: Based on Vehicle Registration Unit data

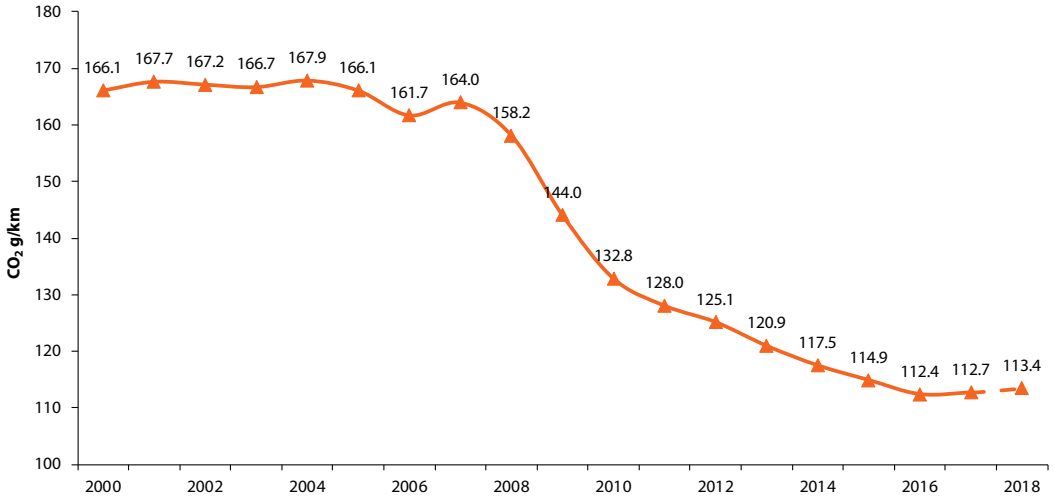
Figure 47 shows the change in the weighted average specific CO_2 emissions of new cars between 2000 and 2017, with an estimate for 2018. Through the combined effects of the taxation change introduced in July 2008 and the obligation on manufacturers to reduce overall fleet emissions, the average emissions of the new car fleet has fallen, reaching 112.4 g CO_2/km in 2016, which is within band A4. This was 32% below the level in 2007. Average emissions increased for the first time in 2017 since 2007 to 112.7 g CO_2/km and it is estimated that the average emissions of new cars purchased in 2018 has increased again to 113.4 g CO_2/km.

Data presented in this report on the carbon emissions ratings of new cars are based on the results of a standardised laboratory test procedure based on the New European Driving Cycle (NEDC). The difference between the test emissions and the emissions actually produced in real-world driving conditions is referred to as the on-road factor. A number of reports by the International Council on Clean Transportation (ICCT) have highlighted data from a number of sources which suggest that the on-road factor has increased dramatically in recent years and that the real-world fuel consumption and carbon emissions of new vehicles is now significantly greater than the reported test values[61].

From September 2018, a new test methodology called the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) came into force for all new cars. This new test is expected to better reflect real-world driving profiles.

61 For more information see www.theicct.org.

Figure 47: Specific CO_2 emissions of new cars, 2000 – 2017 (2018 estimated)

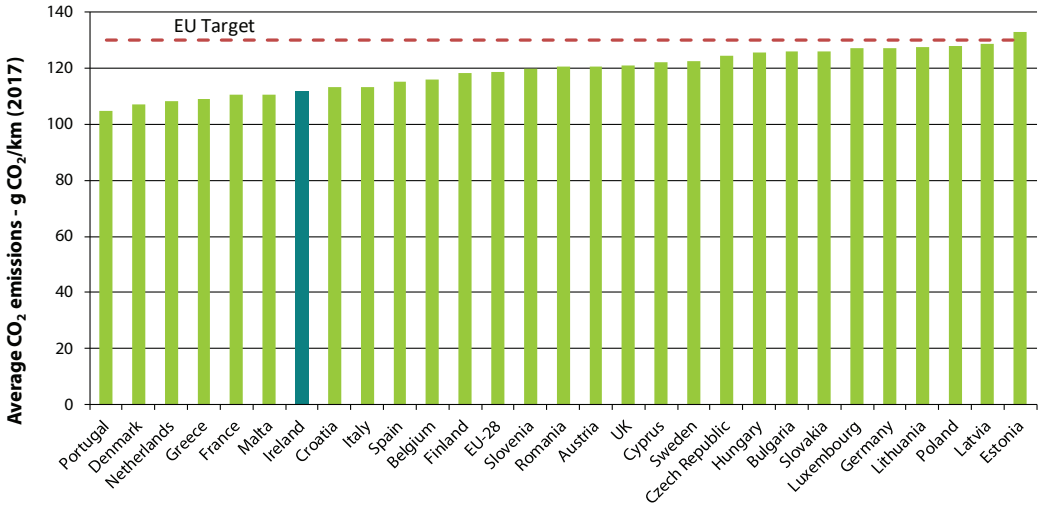


Source: Based on Vehicle Registration Unit and VCA data

Figure 48 shows the position of Ireland in relation to other EU Member States in terms of new car emissions. In 2017, the average CO_2 emissions from new cars in Ireland were 5.8% below the EU average and ranked seventh lowest out of the 28 countries. EU Regulation 443/2009/EC set a target for all passenger cars to have average emissions below 130 g CO_2/km by 2015. All EU Member States were below this in 2016 with the exception of Estonia at 132.8 g CO_2/km.

From 2020, EU Regulation 333/2014 sets a target of 95 g CO_2/km for the average emissions of the new car fleet.

Figure 48: Specific CO_2 emissions of new cars: international comparison – 2017[62]



Source: European Environment Agency

At the end of 2017, 66% of the stock of private cars in Ireland had been purchased in 2008 or later.

4.2.4 Energy Efficiency of New Private Cars

All new cars have associated fuel consumption figures[63] (measured under test conditions), quoted for urban, extra-urban and combined driving. SEAI calculates a weighted average specific fuel consumption figure for new cars entering the national fleet by weighting the test values by the sales figures for each individual model.

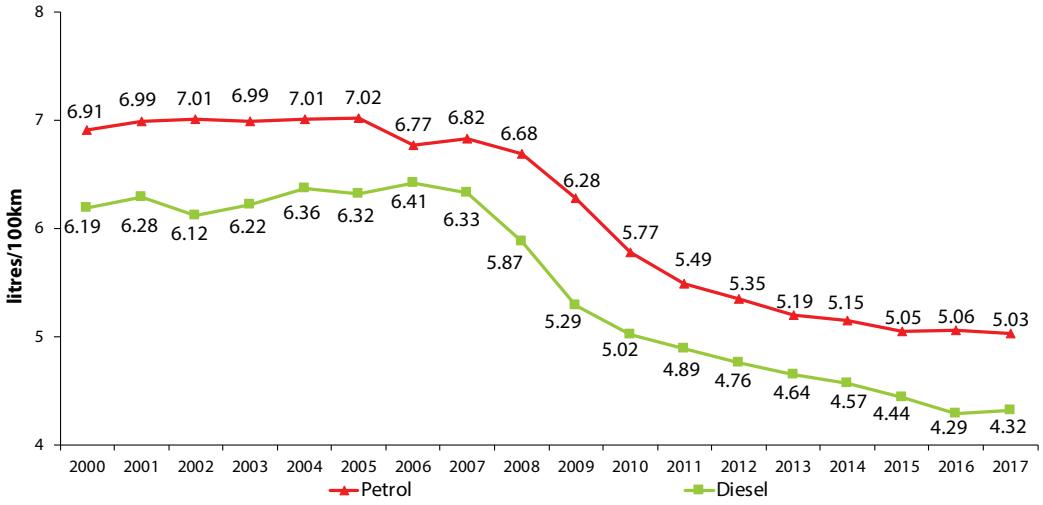
The weighted average of the fuel consumption of new cars first registered in the years 2000 – 2017 was calculated using an extract from the Vehicle Registration Unit's national database and data on the fuel consumption of individual models.

The results of this analysis are shown in *Figure 49*.

62 European Environment Agency (2017), *Monitoring CO_2 emissions from passenger cars and vans in 2016*, http://www.eea.europa.eu//publications/monitoring-co2-emissions-from-passenger

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

Figure 49: Weighted average test specific fuel consumption of new cars 2000 – 2017



Source: Based on Vehicle Registration Unit and VCA data

Before 2008, for new petrol cars, the lowest average fuel efficiency was recorded in 2006 (6.77 litres/100 km)[64]. Since 2006, there has been a 26% improvement in the fuel efficiency of new petrol cars, to 5.03 litres/100 km. For new diesel cars, the average fuel efficiency in 2006 was 6.41 litres/100 km. Since 2006, there has been a 33% improvement in the average fuel efficiency of new diesel cars, to 4.29 litres/100 km until 2016. In 2017, the average specific fuel consumption of new diesel cars increased slightly to 4.32 litres/100 km.

Generally, until 2005, the decrease in fuel efficiency suggests that the purchasing trend towards large cars over the period outweighed any of the efficiency benefits of engine improvements. This changed during 2008 following the introduction of policy measures aimed at improving the CO_2 emissions of new cars. Since CO_2 emissions are very closely linked to fuel efficiency, such policy measures have had a direct and corresponding effect on fuel efficiency.

Since 2006, there has been a 33% improvement in the average fuel efficiency of new diesel cars, to 4.29 litres/100 km, but in 2017 the average specific fuel consumption of new diesel cars increased slightly to 4.32 litres/100 km.

4.2.5 Private Car Average Annual Mileage

SEAI's report *Energy in Transport – 2007 Report*[65] first profiled private car average annual mileage. A refining and updating of the results has since taken place and the revised figures are presented here. These are based on the analysis of the National Car Test (NCT) results.

Average mileage for all private cars decreased by 7.1% (0.4% per annum on average) over the period 2000 – 2017. Petrol car annual mileage fell by 22% (1.5% per annum) while diesel car average mileage fell by 15.4% (1% per annum). Many households now own two cars. This will typically increase the transport energy usage per household but will also reduce the per car average mileage. Also, the fall in the average diesel mileage reflects the growing share of diesel cars many of which are replacing lower annual mileage petrol cars.

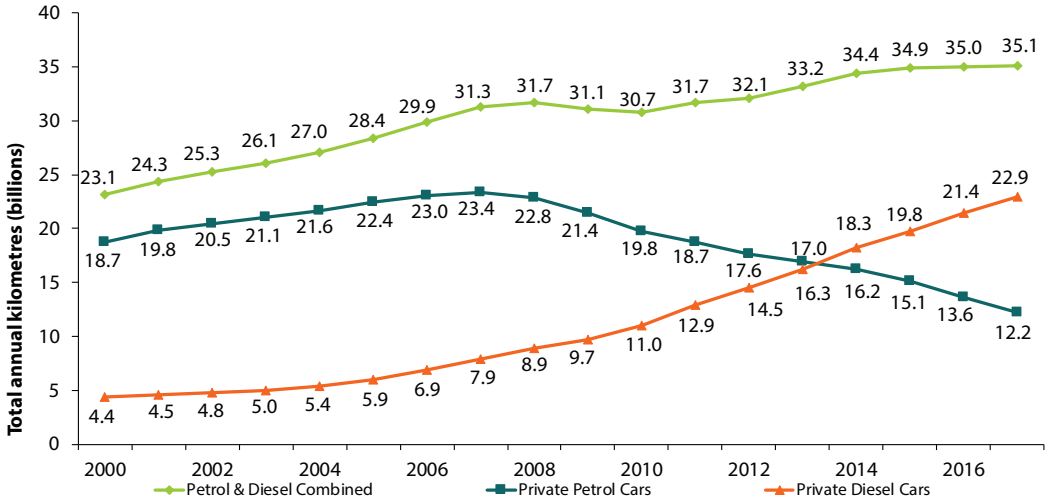
Figure 50 shows the total kilometres driven by private cars in Ireland each year from 2000 to 2017, based on an analysis of NCT data. Overall, the total number of kilometres travelled has increased, which in turn has led to increased private car fuel consumption, as detailed in *Section 4.2.1*. Total mileage by all private cars increased by 52% over the period 2000 – 2017. Total mileage of private cars increased slightly (0.4%) in 2017 compared with 2016.

Overall travel in petrol cars has been falling since 2007, reducing by 48% between 2007 and 2017, while travel by diesel cars increased by 190% over the same period. Indeed, the rate of increase of overall travel by diesel cars increased after 2007 to 11% per annum, compared with 9% per annum between 2000 and 2007. In 2000, 81% of total private car mileage

64 The figures of litres/100km for petrol and diesel are not directly comparable as petrol and diesel have different energy content (calorific values).
65 Sustainable Energy Ireland (2014), Energy in Transport – 2014 Report, for latest transport report

was fuelled by petrol and 19% by diesel. In 2017, petrol accounted for 35% and diesel for 65%. Between 2000 and 2017, the total mileage by petrol cars fell by 35%, while total mileage for diesel cars increased by 423%. This reduction in travel by petrol vehicles and increase in travel by diesel vehicles is due to the changing ownership patterns since the changes in the vehicle registration tax (VRT) and annual road tax were introduced in 2008.[66]

Figure 50: Total private car annual mileage 2000 – 2017

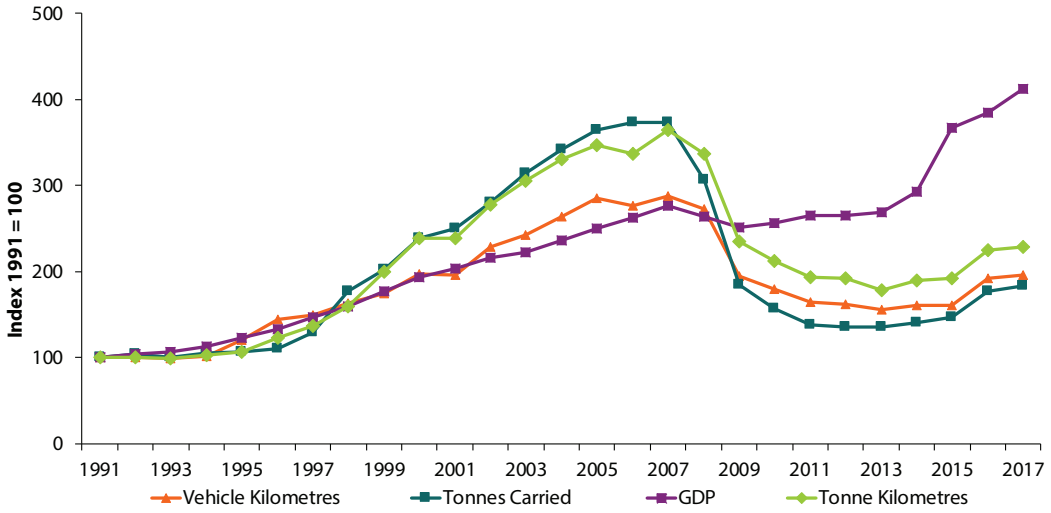


Source: Based on NCT Data

4.2.6 Heavy Goods Vehicle Activity

As discussed in *Section 4.2.1*, HGV freight transport was responsible for the largest share of the decrease in transport sector energy demand in the period 2007 – 2013. This was primarily the result of reduced activity in the sector. Three metrics which measure activity in the road freight sector are tonne-kilometres, vehicle kilometres and tonnes carried. *Figure 51* and *Table 27* present data on these three metrics, along with GDP as an index with respect to 1991. The data are taken from the CSO's *Road Freight Transport Survey* for 1991 to 2017, which considers vehicles taxed as goods vehicles, weighing over 2 tonnes unladen and those which are actually used as goods vehicles, rather than for service-type work, for example.

Figure 51: Road freight activity 1991 – 2017



Source: CSO

Between 2007 and 2009, GDP fell, but has since returned to growth. In 2017, the overall tonnes carried grew by 3.9% to 147 Mt and were 51% below 2007 levels. Tonne-kilometres were 37% lower in 2017 than in 2007 and vehicle kilometres travelled were 32% below. Again, it should be noted that all three transport metrics contracted more sharply than GDP after the economic crisis of 2008.

66 A note of caution: As the mileages are based on NCT tests and new cars are only first tested when they are four years old there is an inherent lag in the recording of the changing average mileage patterns in this data.

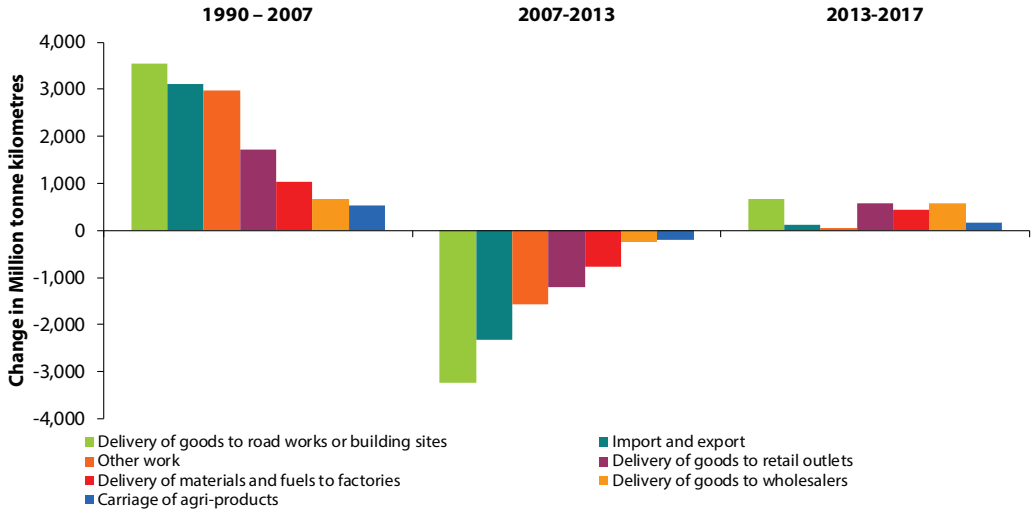
Table 27: Road freight activity 1991 – 2017

	Growth %	Average Annual Growth %					Quantity		
	'91 – '17	'00 – '05	'05 – '10	'10 – '15	'15 – '17	2017	1991	2007	2017
Mega-Tonne Kilometres	128.9	7.8	-9.3	-2.1	9.3	1.7	5,138	18,707	11,759
Kilo-Tonnes Carried	83.7	8.8	-15.5	-1.3	11.7	3.9	80,137	299,307	147,229
Mega-Vehicle Kilometres	96.3	7.7	-8.8	-2.2	10.6	2.2	811	2,332	1,592
GDP (million € @2014 prices)	312.5	5.3	0.5	7.5	6.1	7.2	71,015	196,203	292,971

Source: CSO

It is important to understand why freight has been so responsive to economic drivers in the past in order to estimate how it will respond to potential future economic trends. To do this, it is useful to analyse in more detail which sectors of the economy contributed to the changes in tonne-kilometres transported in the period 1990 – 2017. The CSO provides data on HGV activity classed by main type of work done. To highlight which categories contributed most in absolute terms to the increase in activity between 1990 and 2007, the contraction from 2007 to 2013, and the recent return to growth from 2013 to 2017, these data are shown in *Figure 52*.

Figure 52: Absolute change in road freight activity by main type of work done 1990 – 2017



Source: CSO

The category 'Delivery of goods to road works or building sites' experienced the largest absolute increase (3,545 Mtkm) and the second largest percentage increase (521%) between 1990 and 2007 and subsequently experienced both the largest absolute decrease (3,248 Mtkm) and the largest percentage decrease (77%) between 2007 and 2013. Of the total increase in freight transport activity from 1990 to 2007 (13,578 Mtkm), 'Delivery of goods to road works and building sites' was responsible for 26%, the highest share, while of the total reduction in activity from 2007 to 2017 (6,947 Mtkm) it was responsible for 37%, again the largest share.

The next biggest contributor to both the rise and fall of transport activity was 'Import and export', which between 1990 and 2007 accounted for 3,104 Mtkm (23%) of the total increase, and between 2007 and 2013 accounted for 2,315 Mtkm (24%) of the total reduction.

In the recent period, 2013 to 2017, delivery of goods to road-works or building sites increased by 69%, but still remains 61% below 2007 levels. Growth in road freight for 'delivery of materials and fuels to factories' has grown to be 53% above 2013 levels. There has been a 5% increase in the 'Import and export' and 'Other work' categories, despite sharp reductions in the previous period. 'Import and export' is the category with the largest share of activity throughout the period 2007 to 2017 but it remains 47% below 2007 levels. As activity in the economy in general and in the construction sector increases there is the potential for significant further growth in the freight activity of these categories.

4.3 Residential

Trends in 2017

Residential energy use fell by 2.9% in 2017 relative to 2016. 2017 was milder than 2016 in terms of degree days (6% fewer degree days[67]). When corrections for weather effects[68] are taken into account energy use in the residential sector increased by 0.2% in 2017 relative to 2016 (see *Table 28*).

The salient trends in energy use in the residential sector are as follows:

- Overall direct fossil fuel use in households decreased by 4.3% to 1,860 ktoe in 2017 and accounted for 71% of household energy use.
- Oil consumption in households fell by 3.8% in 2017 to 967 ktoe. Oil's share of household energy stood at 37% in 2017.
- Electricity consumption increased by 1.1% in 2017 to 684 ktoe (7,959 GWh) and its share of residential final consumption was 26%.
- Natural gas usage decreased by 1.3% in 2017 to 555 ktoe and accounted for 21% of residential energy use.
- Direct renewables usage in households fell in 2017 by 1.1% to 65 ktoe, and its share stood at 2.5%.
- Coal use in households fell in 2017 by 16.8% to 149 ktoe and a 5.7% share of the residential sector energy use.
- Peat usage decreased by 4.3% in 2017 and peat briquette usage fell by 12.4%. Total peat consumption was 188 ktoe in 2017. The peat and briquette share in household energy was 7.2% in 2017.

Weather-corrected energy use in the residential sector increased by 0.2% in 2017 relative to 2016.

Trends 2005 – 2017

Figure 53 shows the trend for residential sector final energy consumption between 2005 and 2017, with and without weather correction. Weather correction yields a lower normalised energy consumption in cold years, (e.g. 2010), and yields a higher normalised consumption in mild years, (e.g. 2007). Accounting for weather variations, residential energy demand decreased every year between 2007 and 2012 but has grown in 2015, 2016 and 2017. Residential final energy use in 2017 was 2,609 ktoe 11% below that in 2005. Correcting for weather variations, 2017 residential final energy use was also 11% below 2005.

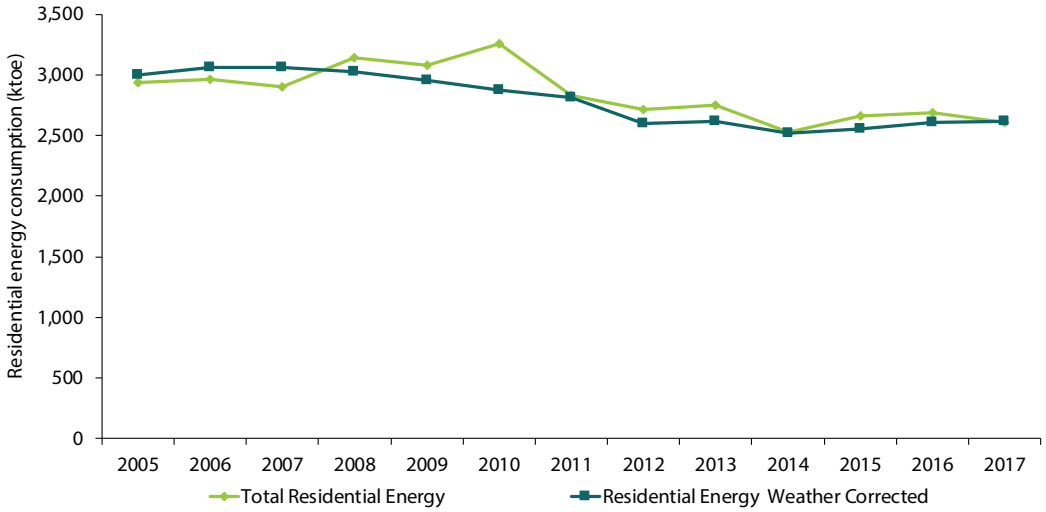
Figure 54 shows the mix of fuels consumed in the residential sector over the period. Between 2005 and 2017, the fuel shares have been more stable, with a gradual increase in the share of electricity and of gas and a continuing though gradual decline in coal, peat and oil use.

Oil remains the dominant fuel in the residential sector, though its share reduced slightly from 39% in 2005 to 37% in 2017. Electricity was the second most dominant energy form in the sector in 2017 at 21%, with natural gas having the next largest share at 21%. The renewables share of final energy used directly in households in 2017 was 2.5%. The growth rates, quantities and shares are shown in *Table 28*.

67 See Glossary for definition of 'degree days'.

68 Annual variations in weather affect the space heating requirements of occupied buildings. Weather correction involves adjusting the energy used for space heating by benchmarking the weather in a particular year with that of a long-term average measured in terms of number of degree days. It is assumed that 65% of fuels and 10% of electricity use in households is used for space heating.

Figure 53: Residential final energy

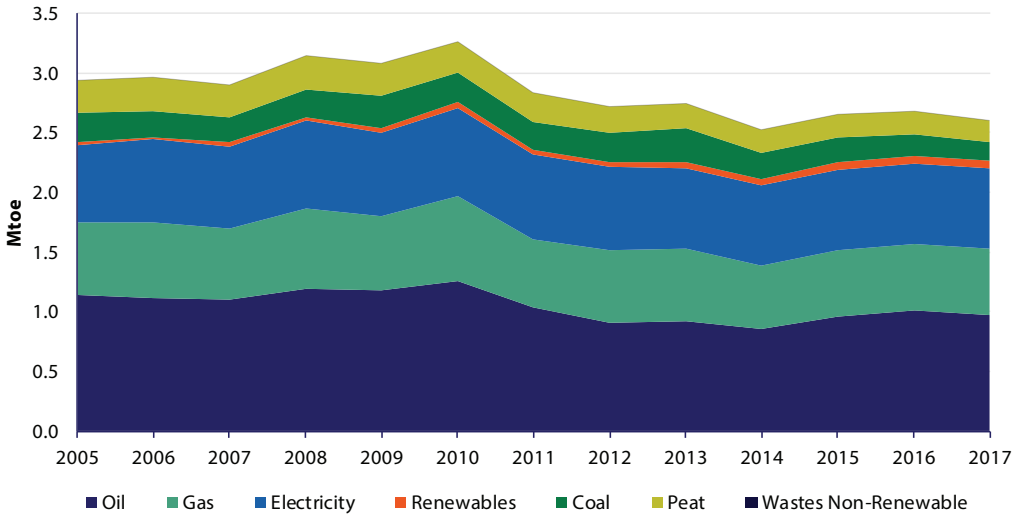


Source: SEAI

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. Some reasons for this may be: the higher oil price and the greater increase in oil price, relative to gas, in the period 2010 to 2015; potentially there are greater opportunities for fuel switching to peat and non-traded wood in rural areas, where the majority of oil-fired dwellings are located.

It is also notable that total electricity consumption peaked in 2010 and has fallen by 7% since.

Figure 54: Residential final energy use by fuel



Source: SEAI

Table 28: Growth rates, quantities and shares of final consumption in residential sector

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-18.1	-1.7	1.8	-5.0	-1.5	-4.3	2,271	1,860	77.3	71.3
Coal	-39.5	-4.1	0.7	-4.1	-15.1	-16.8	246	149	8.4	5.7
Peat	-31.0	-3.0	-1.5	-4.6	-3.1	-4.3	273	188	9.3	7.2
Briquettes	-32.9	-3.3	-0.5	-3.7	-8.8	-12.4	90	61	3.1	2.3
Oil	-15.5	-1.4	2.0	-5.4	0.6	-3.8	1,145	967	39.0	37.1
Gas	-8.5	-0.7	3.2	-4.8	0.0	-1.3	607	555	20.7	21.3
Renewables	228.7	10.4	17.6	6.9	2.3	-1.1	20	65	0.7	2.5
Combustible Fuels (Total)	-17.5	-1.6	1.9	-4.9	-1.6	-4.5	2,287	1,887	77.9	72.3
Electricity	6.0	0.5	2.6	-1.6	0.5	1.1	646	684	22.0	26.2
Total	**-11.1**	**-1.0**	**2.1**	**-4.0**	**-0.9**	**-2.9**	**2,937**	**2,609**		
Total Weather Corrected	**-12.6**	**-1.1**	**-0.8**	**-2.3**	**1.3**	**0.2**	**2,995**	**2,618**		

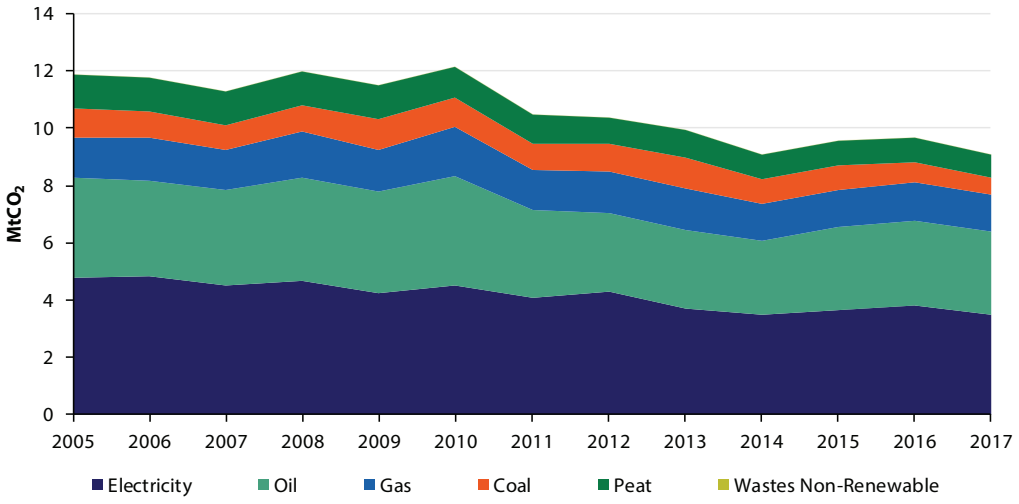
Source: SEAI

Energy-related CO_2 Emissions – including emissions associated with electricity

The residential sector is examined in more detail with respect to energy-related CO_2 emissions in *Figure 55*. In order to determine total energy-related CO_2 emissions from the residential sector, it is necessary to view electricity on a primary energy basis, that is, the fuels required to generate the electricity consumed by households.

There was a reduction in energy-related CO_2 emissions between 2010 and 2014, but there was a return to growth in CO_2 emissions in 2015 and 2016, which fell again in 2017 by 3.4%. Over the period 2005 – 2016, energy-related CO_2 emissions[69] from the residential sector fell by 23%. In 2017 residential sector energy-related CO_2 emissions (including upstream electricity emissions) were 8,412 kt CO_2, representing 24% of the total energy-related CO_2 emissions. The residential sector total was the second largest source of CO_2 emissions after transport, which accounts for 38%.

Figure 55: Residential energy-related CO_2 by fuel



Source: SEAI

69 Energy-related emissions detailed are not corrected for weather.

Table 29: Growth rates, quantities and shares of energy-related CO_2 emissions in residential sector

	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Coal	-39.2	-4.1	0.6	-4.0	-14.9	-16.6	989	602	8.4	6.6
Peat	-31.0	-3.0	-1.5	-4.6	-3.0	-4.2	1,170	807	9.9	8.9
Briquettes	-32.9	-3.3	-0.5	-3.7	-8.8	-12.4	374	251	3.2	2.8
Oil	-16.5	-1.5	1.8	-5.5	0.5	-3.8	3,467	2,894	29.3	31.9
Gas	-10.0	-0.9	3.3	-4.9	-0.9	-1.3	1,443	1,299	12.2	14.3
Renewables	-	-	-	-	-	-	-	-	0.0	0.0
Combustible Fuels (Total)	-20.8	-1.9	1.4	-5.0	-2.3	-4.9	7,069	5,602	59.7	61.7
Electricity	-27.3	-2.6	-1.1	-4.2	-2.6	-8.1	4,777	3,475	40.3	38.3
Total	**-23.4**	**-2.2**	**0.5**	**-4.7**	**-2.4**	**-6.1**	**11,846**	**9,076**		

Energy-related CO_2 Emissions – excluding emissions associated with electricity

If upstream emissions associated with electricity use are excluded, the CO_2 emissions from direct fossil fuel use in the residential sector in 2017 were 21% lower than in 2005. This was achieved through a combination of less carbon-intensive fuel mix and a reduction in overall energy usage post-2010. Excluding upstream electricity emissions, direct CO_2 emissions from the household sector were 5,602 kt and were 4.9% lower in 2017 compared with 2016 (see *Table 29*).

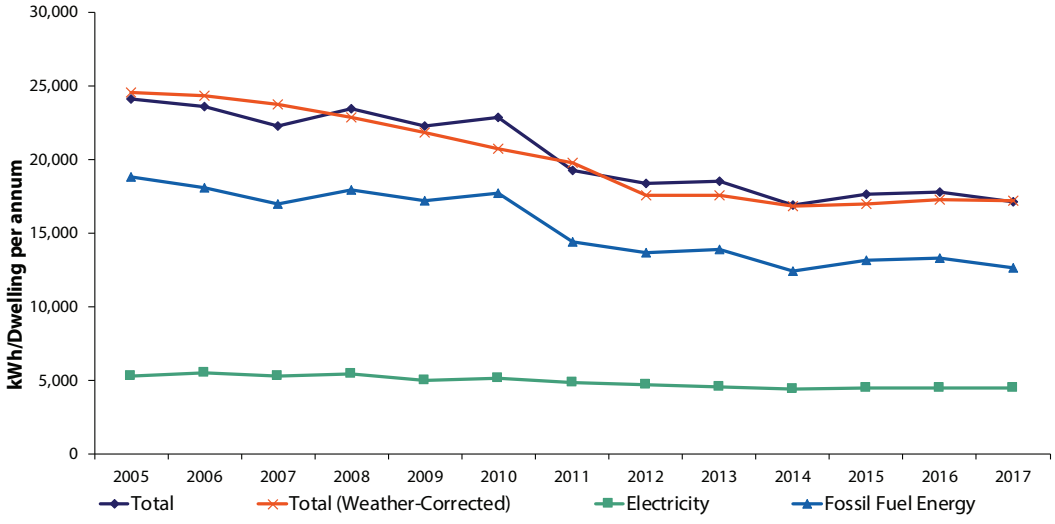
4.3.1 Unit Consumption of the Residential Sector

The unit consumption of the residential sector is typically defined in terms of the energy consumed per dwelling. In 2017, the average dwelling consumed a total of 17,211 kWh of energy based on weather-corrected data, 0.3% below the 2016 level. This comprised 12,708 kWh (74%) of direct fuels and 4,503 kWh (26%) of electricity.

In 2017, the average dwelling consumed a total of 17,211 kWh of energy; 74% of this was direct fuels and the remainder electricity.

Figure 56 shows the trend in final energy consumption per dwelling with and without weather-correction. Looking at this in conjunction with *Table 30*, it can be seen that final energy use per dwelling reduced significantly between 2005 and 2014 before returning to growth in 2015 and 2016 and falling in 2017. Weather-corrected total final energy consumption per dwelling had been flat for these last three years but is still 30% below 2005 levels in 2017. Between 2007 and 2017, final energy use of electricity per dwelling, weather corrected, reduced by 15%.

Figure 56: Unit consumption of energy per dwelling (permanently occupied)



Source: Based on SEAI, CSO and Met Éireann data

Table 30: Growth rates and quantities of residential unit energy consumption and unit CO_2 emissions

	Overall Growth %	Average Annual Growth %					Quantity (kWh/dwelling)	
Unit Energy Consumption	**2005 – 2017**	**'05 – '17**	**'05 – '10**	**'10 – '15**	**'15 – '17**	**2017**	**2005**	**2017**
Total Energy	-28.8	-2.8	-1.0	-5.0	-1.5	-3.5	24,105	17,154
Fuel Energy	-32.7	-3.2	-1.2	-5.8	-2.0	-4.8	18,802	12,654
Electrical Energy	-15.1	-1.4	-0.6	-2.7	-0.1	0.5	5,302	4,500
Unit Energy Consumption Weather Corrected							**Quantity (kWh/dwelling)**	
Total Energy Weather Corrected	-30.0	-2.9	-3.4	-3.9	0.7	-0.3	24,583	17,211
Fuel Energy Weather Corrected	-34.0	-3.4	-4.2	-4.2	0.8	-0.9	19,261	12,708
Electrical Energy Weather Corrected	-15.4	-1.4	-0.6	-2.8	0.3	1.1	5,322	4,503
Unit Energy-Related CO_2 Emissions							**Quantity (tCO_2/dwelling)**	
Total Energy CO_2	-38.6	-4.0	-2.6	-5.7	-3.0	-6.7	8.4	5.1
Fuel CO_2	-36.5	-3.7	-1.7	-6.0	-2.9	-5.4	5.0	3.2
Electricity CO_2	-41.7	-4.4	-4.1	-5.2	-3.2	-8.7	3.4	2.0

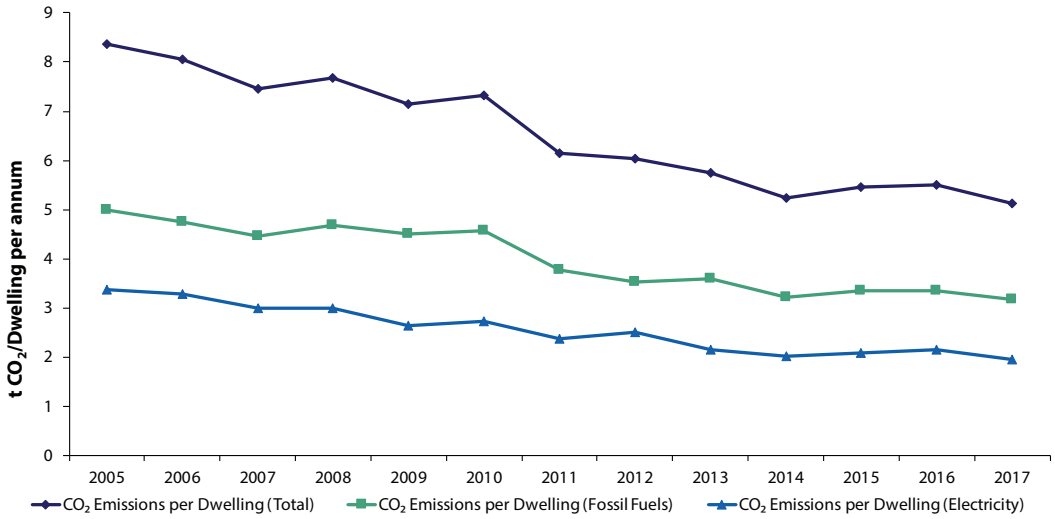
Energy-related CO_2 Emissions per Dwelling

The emissions of energy-related CO_2 per dwelling fell by 39% over the period 2005 – 2017, while the reduction for unit energy use was 29% – see *Table 30* and *Figure 57*. In 2017, the average dwelling was responsible for emitting 5.1 tonnes of energy-related CO_2. A total of 3.2 tonnes CO_2 (62%) came from direct fuel use in the home and the remainder indirectly from electricity use.

Energy-related CO_2 emissions per dwelling for direct non-electric fuel use fell by 37% between 2005 and 2017, primarily as a result of reduced energy consumption per dwelling. CO_2 emissions from electricity use reduced by 32% in the same time period due to a combination of reduced electricity use and reduced carbon intensity of the electricity grid. The carbon intensity of grid electricity has improved since 2002, when high-efficiency CCGT plants were brought online and because of the growing contribution of renewables in electricity generation.

Emissions from energy use in households decreased by 6.7% in 2017, mainly as a result of decreased CO_2 intensity of electricity supplied and reduced fossil fuel consumption.

Figure 57: Unit energy-related CO_2 emissions per dwelling



Source: SEAI

In 2017, the average dwelling emitted 5.1 tonnes of energy-related CO_2.

4.4 Commercial and Public Services

Trends in 2017

The commercial and public services energy use increased by 4.2% in 2017 relative to 2016. As 2017 was milder than 2016 (6% fewer degree days), when corrections for weather effects are taken into account, energy use in services increased by 7.4% in 2017 (see *Table 31*). This is against the backdrop of the economic activity of services, as measured by value added, increasing by 5.8%.

The key trends in 2017 are as follows:

- Final energy use in services grew by 4.2% in 2016 to 1,392 ktoe; however when corrected for weather effects the increase was 7.4%.
- Oil, gas and electricity make up 97% of the energy consumed in the services sector. The contributions from coal and peat are negligible.
- Electricity consumption in services increased by 1.1% to 604 ktoe and accounted for 43% of final energy consumption in services in 2017.
- Oil consumption increased by 7.9% to 257 ktoe. The share of oil in the sector's final consumption was 18%.
- Natural gas consumption increased by 6.4% to 484 ktoe and its share of the sector's final consumption was 35%.
- Overall fossil fuel use in services increased by 6.9% to 742 ktoe.
- Renewable energy use in services increased by 4.6% to 46 ktoe from increased use of biomass, heat pumps and biogas. The share of renewables in services' final energy consumption was 3.3%.

Trends 2005 – 2017

Final energy use in the commercial and public services sector fell by 11% (1.0% per annum) over the period 2005 – 2017, to a figure of 1,392 ktoe. The decrease was also 12.5% if weather-corrected energy use is considered. During this period, the value added generated by the sector grew by 60%, while the numbers employed increased by 19%.

Figure 58: Commercial and public services final energy use by fuel

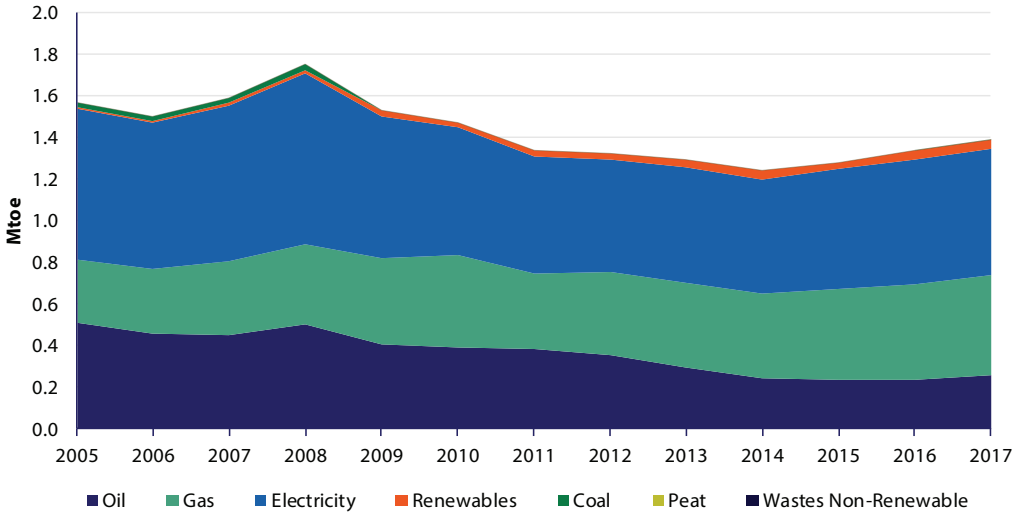


Figure 58 shows the changes in the fuel mix in the services sector over the period. The range of fuels used in this sector is small – essentially oil, gas and electricity. Oil and gas are used predominantly for space heating, but also for water heating, cooking and, in some sub-sectors, laundry. Gas consumption increased by 62% since 2005, to 484 ktoe. Electricity is used in buildings for heating, air conditioning, water heating, lighting, and information and communications technology (ICT). Electricity in services is also used for public lighting and water and sanitation services.

Electricity consumption in services fell by 17% (1.5% per annum) between 2005 and 2016, to 604 ktoe (7,027 GWh), and has a higher share at 43% than any other individual fuel in services, down from 46% in 2005. Electricity use in services is driven by the changing structure of this sector and the general increase in the use of ICT, electric heating and air conditioning.

Growth rates, quantities and shares are shown in *Table 31*.

Table 31: Growth rates, quantities and shares of final consumption in the commercial and public services sector

	Overall Growth %	Average Annual Growth %					Quantity (ktoe)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Fossil Fuels (Total)	-11.4	-1.0	-0.1	-4.2	5.3	6.9	837	742	53.4	53.3
Coal	-	-	-	-	-	-	27	-	1.7	-
Oil	-49.7	-5.6	-5.2	-9.6	4.3	7.9	511	257	32.6	18.5
Natural Gas	62.2	4.1	8.1	-0.4	5.8	6.4	299	484	19.0	34.8
Renewables	1045.1	22.5	39.6	8.7	19.2	4.6	4	46	0.3	3.3
Combustible Fuels (Total)	-8.3	-0.7	0.2	-4.0	5.6	6.2	840	770	53.6	55.3
Electricity	-17.0	-1.5	-3.3	-1.2	2.1	1.1	728	604	46.4	43.4
Total	**-11.3**	**-1.0**	**-1.3**	**-2.7**	**4.2**	**4.2**	**1,569**	**1,392**		
Total Weather Corrected	**-12.5**	**-1.1**	**-4.0**	**-1.1**	**6.4**	**7.4**	**1,597**	**1,397**		

Energy-related CO_2 Emissions – including emissions associated with electricity

Figure 59 shows the primary energy-related CO_2 emissions of the services sector, distinguishing between the on-site CO_2 emissions associated with direct fuel use and the upstream emissions associated with electricity consumption. Emissions from non-electrical energy fell by 20% over the period and the emissions associated with electricity consumption fell by 43%. In 2017, the non-electricity emissions increased by 7% and the electricity associated emissions in services fell by 8.1%. Overall energy-related CO_2 emissions in this sector fell by 2.8% in 2017 to just under 5 Mt CO_2.

In the services sector, the share of emissions associated with electricity demand in 2017 was 62%. In 2005, the split between electricity and thermal fuels (oil and gas) emissions was 69% electricity and 31% fuels (see *Table 32*).

Figure 59: Commercial and public services sector CO_2 emissions by fuel

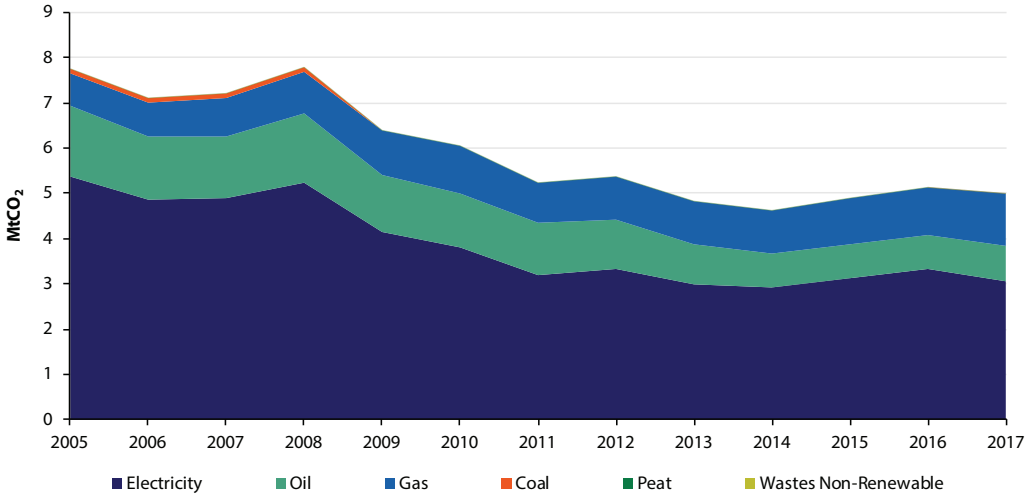


Table 32: Growth rates, quantities and shares of CO_2 emissions in commercial and public services

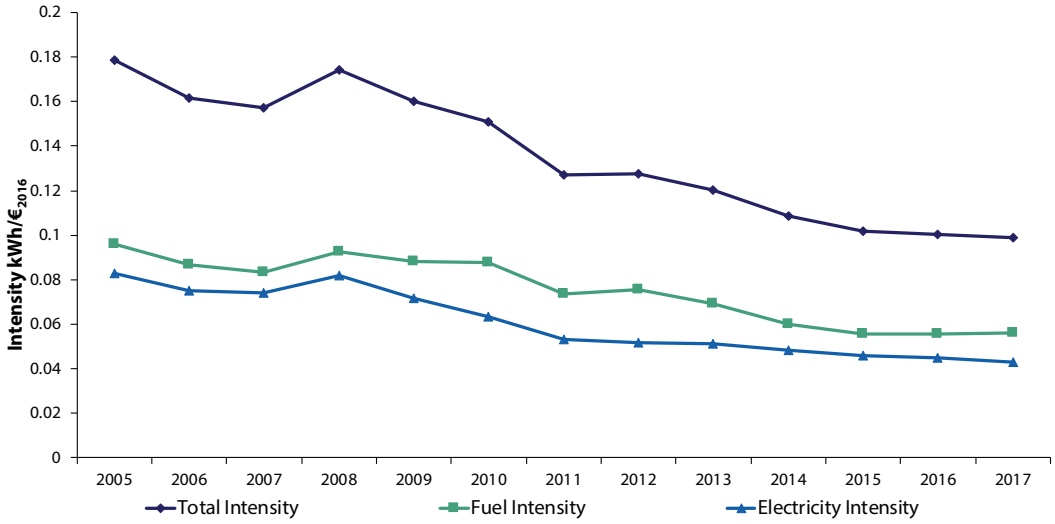
	Overall Growth %	Average Annual Growth %					Quantity (kt CO_2)		Shares %	
	2005 – 2017	'05 – '17	'05 – '10	'10 - '15	'15 - '17	2017	2005	2017	2005	2017
Combustible Fuels	-19.5	-1.8	-1.2	-4.9	4.6	7.0	2,385	1,919	30.7	38.5
Electricity	-43.0	-4.6	-6.7	-3.8	-1.1	-8.1	5,383	3,068	69.3	61.5
Total	**-35.8**	**-3.6**	**-4.9**	**-4.2**	**1.0**	**-2.8**	**7,769**	**4,987**		

4.4.1 Energy Intensity of the Commercial and Public Services Sector

The energy intensity of the services sector is generally measured with respect to the value added generated by services activities. As shown in *Figure 60*, this intensity is flatter than that of industry. The overall energy intensity of the services sector was 45% lower in 2017 than it was in 2005, principally because of the rapid growth in the value added in the sector. There was a general downward trend in services' energy intensity since 2005. Energy intensity in services fell by 1.5% in 2017.

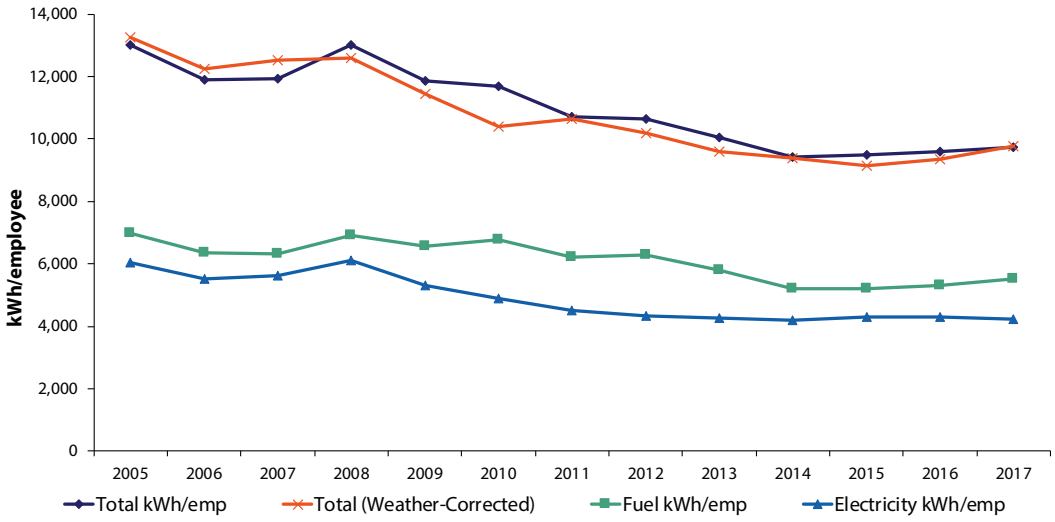
Electricity intensity has been falling since 2005, with the exception of 2008. In 2017, electricity intensity decreased by 4.4% compared with 2016 but remained 48% below 2005.

Figure 60: Energy intensity of commercial and public services sector



Two other indicators in this sector are energy use per unit of floor area and per employee. The consumption of oil and gas is mainly for space-heating purposes and is related to the floor area heated, not directly related to the number of people occupying a building at a given time. Due to an absence of data on floor area in the services sector, it is not currently possible to calculate the consumption per unit of floor area.

Figure 61: Unit consumption of energy and electricity per employee in the commercial and public services sector



Unit consumption of electricity per employee is used as an indicator of energy use in the services sector because, in the main, there is a correlation between electricity use and the number of employees. In *Figure 61*, it can be seen that unit consumption of electricity fell between 2008 and 2011 but has been relatively stable since. Electricity use per employee fell by 1.6% in 2017.

Fuel consumption per employee increased by 3.9% in 2017, and stood at 21% below 2005 levels. If corrections are made for the effects of weather, then the fuel consumption per employee increased by 8.5% in 2017 when compared with 2016 (see *Table 33*).

Table 33: Growth rates and quantities of unit consumption per employee in commercial and public services

	Overall Growth %	Average Annual Growth %					Quantity (kWh)	
	2005 – 2017	'05 – '16	'05 – '10	'10 – '15	'15 – '17	2017	2005	2017
Total kWh/employee	-25.3	-2.4	-2.1	-4.1	1.2	1.4	13,020	9,727
Fuel kWh/employee	-21.1	-2.0	-0.6	-5.2	2.9	3.9	6,980	5,505
Electricity kWh/employee	-30.1	-2.9	-4.1	-2.6	-0.9	-1.6	6,040	4,223
Weather Corrected (wc)								
Total kWh/employee (wc)	-26.3	-2.5	-4.7	-2.5	3.3	4.4	13,248	9,759
Fuel kWh/employee (wc)	-22.8	-2.1	-4.4	-3.0	6.1	8.5	7,163	5,530
Electricity kWh/employee (wc)	-30.5	-3.0	-5.2	-1.9	0.0	-0.4	6,085	4,228

As a result of the heterogeneous nature of the services sector, it is difficult to assess the amount of energy that is consumed. Energy statistics relating to fuel consumption for the services sector in Ireland are calculated as a residual. This approach is unsatisfactory, not least because the energy use in the sector is affected by uncertainties in all other sectors. As a result, there is only limited statistical information available to policy-makers with which to formulate and target energy efficiency policies and measures for the sector.

Work is ongoing, however, to address this situation and new data will become available in the near future from a joint CSO/SEAI Business Energy Use Survey (BEUS) and the Public Sector Energy Programme, which will enable a deeper analysis of service sector energy use. Other studies have also been conducted in the areas of commercial building stock characterisation and consumer attitudes to investment energy efficiency in the sector[70].

4.4.2 Public Sector Developments

The public sector consists of approximately 4,400 separate public bodies, of which about 4,000 are individual schools. The other 400 comprise, inter alia, Government Departments, non-commercial State bodies, State-owned companies and local authorities. Each 'public body' is a stand-alone organisation and can range in size from very small (e.g. a small rural school or a five-person agency) to very large (e.g the Health Service Executive, An Garda Síochána). The vast majority of energy is consumed by the 100 largest organisations.

Public services[71] energy consumption comprises two main classes of energy consumer:

- Public sector buildings (offices, hospitals, clinics, nursing homes, schools, prisons, barracks, Garda stations, etc.), which primarily consume electricity, natural gas and oil-based fuels in addition to smaller amounts of renewable and solid fuels;
- Public sector utilities, which primarily consume electricity, for example, waste water treatment plants, water treatment facilities, pumping stations, and street lighting (~400,000 units).

The Fourth National Energy Efficiency Action Plan (NEEAP) and the European Union (Energy Efficiency) Regulations 2014 (SI 426 of 2014) set out several obligations on public bodies with respect to their 'exemplary role' for energy efficiency. The NEEAP sets a 33% efficiency target for the sector by 2020, equivalent to 279 ktoe.

Since 1 January 2011, public sector bodies have been required to report to Government annually on their energy usage and the actions they have taken to reduce consumption. SEAI and the Department of Communications, Climate Action and Environment (DCCAE) have developed an energy monitoring and reporting system[72] to satisfy the reporting requirements of both SI 426 of 2014 and the NEEAP. Since 2013, all public sector organisations have been obliged to use this system to report their annual energy consumption to SEAI. The system includes a national public sector energy database, which includes all public sector electricity and natural gas meter numbers. Over time, the monitoring and reporting system will build a comprehensive bottom-up picture of energy consumption in the sector through the population of the national public sector energy database.

In 2017 SEAI published the *Annual Report 2017 on Public Sector Energy Efficiency Performance*[73]. It noted that 336 public sector bodies and 2,171 schools completed reports on energy and these represented 97% of total public sector energy consumption. The total energy consumption in 2016 of these bodies was 9,375 GWh (primary energy), which consisted of 4,909 GWh of electricity, 2,349 GWh of thermal energy and 2,117 GWh of transport energy. This cost the state €536 million

70 SEAI (2015), *Extensive survey of the commercial buildings stock in the Republic of Ireland – Insights Paper*, https://www.seai.ie/resources/publications/Extensive-Survey-of-Commercial-Buildings-Stock-in-the-Republic-of-Ireland.pdf
SEAI (2015), Survey of consumer behaviour in the commercial sector in the Republic of Ireland – Insights Paper, https://www.seai.ie/resources/publications/Survey-of-Consumer-Behaviour-in-the-Commercial-Sector-in-the-Republic-of-Ireland.77933.shortcut.pdf

71 In addition, the energy consumed by public bodies also includes some consumption counted in the transport sector in the National Energy Balance, e.g. public transport fleets (rail, bus, etc.) as well as other transport fleets operated by public bodies; for example, ambulances, local authority vehicles, Garda fleet, Defence Forces' vehicles, etc.

72 Additional information on this system is available from https://www.seai.ie/energy-in-business/public-sector/

73 Available from https://www.seai.ie/resources/publications/2017_Annual_Report_on_Public_Sector_Energy_Efficiency_Performance.pdf

in 2016. The report also noted that these bodies have achieved annual primary energy savings of 2,336 GWh or a 20% improvement on business as usual, yielding a cost saving of €133 million. The public sector has a target of 33% energy efficiency improvement by 2020.

Public sector bodies have achieved annual primary energy savings of 2,336 GWh or a 20% improvement on business as usual, yielding a cost saving of €133 million. The public sector has a target of 33% energy efficiency improvement by 2020.

5 Energy Statistics Revisions and Corrections

Some changes, revisions and corrections to the historic energy balance data were implemented during 2018. The most significant of these were:

Gasoline

2017

- On-road factor used for estimating gasoline (petrol) consumption of private cars was updated for 2017.

Gasoil / Diesel / DERV

2017

- On-road factor used for estimating diesel consumption of private cars was updated for 2017.

Natural Gas

2005 – 2017

- Improved methodology for assessing and reporting own use of gas in gas production. This has the effect of showing increased gas production, increased own use of gas, and decreased industry final consumption for the years 2001 to 2016.

Fuel Oil

2008 – 2017

- Revised fuel oil usage in services sector based on data from the public sector energy programme.

Solar Thermal

2011 – 2017

- Methodology to assess the extent of the contribution of solar thermal was updated based on revisions to the estimates of new dwelling completions.

Ambient Heat / Heat Pumps

2002 – 2017

- The estimated amount of ambient energy has grown significantly in recent years due to the increased uptake of heat pumps. Methodology to assess the extent of the contribution of ambient heat was changed to be based on an analysis of the BER dataset. This also had the effect of revising the estimation of the share of heat from renewable sources.

Electricity

2016 – 2017

- Revised assessment of solar PV in households based on analysis of BER data.

2005 – 2017

- Revision to the annual installed capacity for wind based on updated EirGrid and ESBNetworks data. This affected the estimation of the normalisation of share of electricity from renewable sources.

Energy balance data analysed in this report were frozen on 5 October 2018. Balance data are updated whenever more accurate information is known. To obtain the most up-to-date balance figures, visit the statistics publications section of SEAI's website (https://www.seai.ie/resources/seai-statistics/energy-data/). A new Data Portal on this website links to interactive energy statistics, forecasts, and other data developed by SEAI.

An energy data service is also available at CSO Databank. This service is hosted by the CSO with data provided by SEAI.

Glossary of Terms

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

Carbon intensity (kg CO_2/kWh): This is the amount of carbon dioxide that will be released per kWh of energy of a given fuel. For most fossil fuels the value of this is almost constant, but in the case of electricity it will depend on the fuel mix used to generate the electricity and also on the efficiency of the technology employed.

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

Combined heat and power plants: Combined heat and power (CHP) refers to plants which are designed to produce both heat and electricity, for own use only or third-party owned selling electricity and heat on site as well as exporting electricity to the grid.

Energy intensity: The amount of energy used per unit of activity. Examples of activity used in this report are gross domestic product (GDP), value added, number of households, employees, etc. Where possible, the monetary values used are in constant prices.

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

Gross domestic product (GDP): The gross domestic product (GDP) represents the total output of the economy over a period.

Gross electrical consumption: Gross electricity production is measured at the terminals of all alternator sets in a station; it therefore includes the energy taken by station auxiliaries and losses in transformers that are considered integral parts of the station. The difference between gross and net production is the amount of own use of electricity in the generation plants.

Gross final consumption (GFC): Directive 2008/28/EC defines Gross Final Consumption (GFC) of energy as the energy commodities delivered for energy purposes to industry, transport, households, services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production, and including losses of electricity and heat in distribution.

Gross inland energy consumption: Sometimes abbreviated as gross inland consumption, is the total energy demand of a country or region. It represents the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration.

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

Modified gross national income (GNI*): Modified Gross National Income (or GNI*) was introduced by the CSO in 2017 to assess the level of activity in the Irish economy excluding the effects of globalization that disproportionately affect the Irish economic results. GNI* is defined as GNI less the effects of the profits of re-domiciled companies and the depreciation of intellectual property products and aircraft leasing companies.

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

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

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

Value added: Value added is an economic measure of output. The value added of industry, for instance, is the additional value created by the production process through the application of labour and capital. It is defined as the value of industry's output of goods and services less the value of the intermediate consumptions of goods (raw materials, fuel, etc.) and services.

Wastes - non-renewable [Wastes (NR)]: The non-renewable portion of wastes used as an energy source.

Energy Conversion Factors

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

Energy Units

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

kilowatt hour (kWh): The conventional unit of energy that electricity is measured 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 41,686 kJ/kg. A related unit is the kilogram of oil equivalent (kgoe), where 1 kgoe = 10^{-3} toe.

Decimal Prefixes

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

Calorific Values

Fuel	Net Calorific Value toe/t	Net Calorific Value MJ/t
Crude Oil	1.0226	42,814
Gasoline (Petrol)	1.0650	44,589
Kerosene	1.0556	44,196
Jet Kerosene	1.0533	44,100
Gasoil / Diesel	1.0344	43,308
Residual Fuel Oil (Heavy Oil)	0.9849	41,236
Milled Peat	0.1860	7,787
Sod Peat	0.3130	13,105
Peat Briquettes	0.4430	18,548
Coal	0.6650	27,842
Liquefied Petroleum Gas (LPG)	1.1263	47,156
Petroleum Coke	0.7663	32,084
	Conversion Factor	**Conversion Factor**
Electricity	86 toe/GWh	3.6 TJ/GWh

Emission Factors

Liquid Fuels	t CO_2/TJ (NCV)	g CO_2/kWh (NCV)
Motor Spirit (Gasoline)	70.0	251.9
Jet Kerosene	71.4	257.0
Other Kerosene	71.4	257.0
Gas/Diesel Oil	73.3	263.9
Residual Oil	76.0	273.6
LPG	63.7	229.3
Naphta	73.3	264.0
Petroleum Coke	92.9	334.5
Solid Fuels and Derivatives		
Coal	94.6	340. 6
Milled Peat	116.7	420.0
Sod Peat	104.0	374.4
Peat Briquettes	98.9	355.9
Gas		
Natural Gas	56.9	204.7
Electricity		
(2017)	121.3	436.6

Sources

Applus+ (National Car Test)

Central Statistics Office

Department of Communications, Climate Action and Environment

Department of Housing, Planning, and Local Government

Department of Transport

EirGrid

Environmental Protection Agency

ESB Networks

European Commission DG TREN

EU-funded ODYSSEE Project

Eurostat

Gas Networks Ireland

International Energy Agency

Met Éireann

Revenue Commissioners

Road Safety Authority (Vehicle Registration Unit)

References

Central Statistics Office (2017), *Census 2016 profile 1 – Housing in Ireland*, http://www.cso.ie/en/csolatestnews/presspages/2017/census2016profile1-housinginireland/

Central Statistics Office (2017), *Road Ffreight Transport Ssurvey for 1991–2017*, https://www.cso.ie/en/releasesandpublications/ep/p-rfts/roadfreighttransportsurvey2017/

Central Statistics Office (2018), *Planning Permissions Quarter 2 2018*, https://pdf.cso.ie/www/pdf/20180914083950_Planning_Permissions_Quarter_2_2018_full.pdf

Central Statistics Office (2018), *National Income and Expenditure 2017*, https://www.cso.ie/en/releasesandpublications/ep/p-nie/nie2017/

Commission of the European Communities (1997), *A community strategy to promote combined heat and power and to dismantle barriers to its development*, http://europa.eu.int/comm/energy/demand/legislation/heat_power_en.htm

Commission of the European Communities (1997), *COM(97)599 Energy for the Future: Renewable Sources of Energy – White Paper for a Community Strategy and Action Plan*, http://europa.eu/documents/comm/white_papers/pdf/com97_599_en.pdf

Commission of the European Communities (1998), *COM(98)353 Climate Change – Towards an EU Post-Kyoto Strategy*, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:51998DC0353&from=EN

Department of Communications, Energy and Natural Resources (DCENR) and Sustainable Energy Authority of Ireland (SEAI) (2006), *Bioenergy in Ireland*, http://www.seai.ie/

Department of Communications, Energy and Natural Resources (2015), *Ireland's Transition to a Low Carbon Energy Future 2015 - 2030*, https://www.dccae.gov.ie/documents/Energy%20White%20Paper%20-%20Dec%202015.pdf

National Oil Reserves Agency, (2018), *Biofuel Obligation Scheme*, http://www.nora.ie/biofuels-obligation-scheme.141.html

di Cosmo V. and Malaguzzi Valeri L. (2014), *The Effect of Wind on Electricity CO_2 Emissions: the case of Ireland – ESRI Working Paper No. 493*, https://www.esri.ie/publications/the-effect-of-wind-on-electricity-co2-emissions-the-case-of-ireland/.

EirGrid (2018), *All Island Generation Capacity Statement 2018 – 2027*, http://www.eirgridgroup.com/site-files/library/EirGrid/Generation_Capacity_Statement_2018.pdf

European Environment Agency (2017), *Monitoring CO_2 emissions from passenger cars and vans in 2016*, https://www.eea.europa.eu/publications/co2-emissions-new-cars-and-vans-2016

European Union (2003), Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:123:0042:0046:EN:PDF

European Union (2003), Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0087&from=EN

European Union (2004), Directive 2004/8/EC of the European Parliament and of the Council on the promotion of cogeneration based on useful heat demand in the internal energy market and amending Directive 92/42/EEC, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0008&from=EN

European Union (2006), Directive 2006/32/EC of the European Parliament and of the Council on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:EN:PDF

European Union (2007), Council Decision 2007/394/EC amending Council Directive 90/377/EEC with regard to the methodology to be applied for the collection of gas and electricity prices charged to industrial end-users, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0394&from=EN

European Union (2009), Decision No 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009D0406&from=EN

European Union (2009), Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and subsequently repealing Directives 2001/77/EC and 2003/30/EC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Eurostat (2015), *Energy, transport and environment indicators – 2014 edition*, http://ec.europa.eu/eurostat/web/products-pocketbooks/-/KS-DK-14-001

Gas Networks Ireland (2016), *Network development plan 2016: assessing future demand and supply position*, https://www.gasnetworks.ie/corporate/gas-regulation/system-operator/publications/GNI-Network-Development-Plan-2017.pdf

Holttinen, H., Kiviluoma, J., McCann, J., et al. (2014), *Estimating the reduction of generating system CO_2 emissions resulting from significant wind energy penetration. Proceedings of the 13th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants*. Berlin: Energynautics. Vol. 10. No. 2.1.

International Energy Agency (2015), *Energy Balances of OECD Countries 2015*, Paris: IEA.

ICF Consulting and Byrne Ó Cléirigh (2004), *Determining the share of national greenhouse gas emissions for emissions trading in Ireland*, Dublin: Department of the Environment, Heritage and Local Government http://www.epa.ie/pubs/reports/air/etu/EPA_%20icf_and_boc_final_report_2004.pdf

National Oil Reserves Agency (2011), *Energy (Biofuel Obligation and Miscellaneous Provisions) Act 2010*, http://www.nora.ie/regulationslegislation/biofuels-obligation-scheme.152.html

National Oil Reserves Agency (2018), *Biofuel Obligation Scheme,* http://www.nora.ie/biofuels-obligation-scheme.141.html

OECD / IEA / Eurostat (2005), *Energy Statistics Manual*, Paris: OECD/International Energy Agency.

O'Rourke, K. (2005), *Model of the Housing Stock*. Personal communication with Energy Policy Statistical Support Unit.

SEAI (2005), *Profiling Energy and CO_2 Emissions in the Services Sector*, https://www.seai.ie/resources/publications/

SEAI (2007), *Energy in Industry – 2007 Report*, https://www.seai.ie/resources/publications/Energy-in-Industry-2007-report.pdf.

SEAI (2013), *Energy in the Residential Sector*, https://www.seai.ie/resources/publications/Energy-in-the-Residential-Sector-2013.pdf

SEAI (2014), *Energy in Transport – 2014 Report*, https://www.seai.ie/resources/publications/Energy-in-Transport-2014-report.pdf

SEAI (2015), *Extensive survey of the commercial buildings stock in the Republic of Ireland – Insights Paper*, https://www.seai.ie/resources/publications/Extensive-Survey-of-Commercial-Buildings-Stock-in-the-Republic-of-Ireland.pdf

SEAI (2015), *Survey of consumer behaviour in the commercial sector in the Republic of Ireland – Insights Paper*, https://www.seai.ie/resources/publications/Survey-of-Consumer-Behaviour-in-the-Commercial-Sector-in-the-Republic-of-Ireland.77933.shortcut.pdf

SEAI (2016), *Combined Heat and Power in Ireland – 2017 Update,* https://www.seai.ie/resources/publications/CHP-Update-2017.pdf.

SEAI (2016), *Energy Efficiency in Ireland – 2016 Report*, https://www.seai.ie/resources/publications/Energy-Efficiency-in-Ireland-2016-Report.pdf

SEAI (2016), *Energy Security in Ireland – A Statistical Overview*, https://www.seai.ie/resources/publications/Energy-Security-in-Ireland-2015.pdf

SEAI (2016), *Renewable Electricity in Ireland 2015*, https://www.seai.ie/resources/publications/Renewable-Electricity-in-Ireland-2015.pdf

SEAI (2017), *Annual Report 2016 on Public Sector Energy Efficiency Performance*, https://www.seai.ie/resources/publications/Annual-Report-2016-on-Public-Sector-Energy-Efficiency-Performance.pdf

SEAI (2017), *Electricity & Gas Prices in Ireland – 2nd Semester (July – December) 2017*, https://www.seai.ie/resources/publications/Electricity-and-Gas-Prices-in-Ireland-Price-July-Dec-2017-.pdf.

SEAI (2017), *Ireland's Energy Projections – 2017*, https://www.seai.ie/resources/publications/Irelands_Energy_Projections.pdf

UNFCCC (2003), *caring for climate – a guide to the climate change convention and the Kyoto Protocol*, http://unfccc.int/resource/docs/publications/caring_en.pdf

Vehicle Registration Unit (various years), *Irish Bulletin of Vehicle and Driver Statistics*. Dublin: Department of Transport, Tourism and Sport.

Energy Balance 2017

kilo tonnes of oil equivalent (ktoe)	Coal	Peat	Oil	Natural Gas	Renewables	Non-Renew/Waste	Electricity	Total
Indigenous Production	0	744	0	2,854	1,185	126		4,909
Imports	1,230	0	9,314	1,409	159		96	12,207
Exports	10	6	2,188	0	0		154	2,358
Mar. Bunkers	0	0	156		0			156
Stock Change	-121	-43	219	53	3			110
Primary Energy Supply (incl. non-energy)	**1,099**	**695**	**7,189**	**4,315**	**1,347**	**126**	**-58**	**14,713**
Primary Energy Requirement (excl. non-energy)	**1,099**	**695**	**6,948**	**4,315**	1,347	126	**-58**	**14,473**
Transformation Input	**868**	**568**	**3,289**	**2,478**	**183**	**56**	**44**	**7,486**
Public Thermal Power Plants	868	481	33	2,142	174	56		3,754
Combined Heat and Power Plants	0	8	1	281	10			300
Pumped Storage Consumption							34	34
Briquetting Plants	0	79	0		0			79
Oil Refineries and other energy sector	0	0	3,255	54	0		10	3,319
Transformation Output	**0**	**75**	**3,281**	**0**	**63**	**14**	**1,954**	**5,387**
Public Thermal Power Plants	0	0	0		58	14	1,748	1,748
Combined Heat and Power Plants – Electricity	0	0	0		5		188	188
Combined Heat and Power Plants – Heat					0			0
Pumped Storage Generation							17	17
Briquetting Plants		75	0		0			75
Oil Refineries		0	3,281		0			3,281
Exchanges and Transfers	**15**	**0**	**-15**	**0**	**-701**	**0**	**701**	**-0**
Electricity					-701		701	0
Heat								0
Other	15		-15		0			-0
Own Use and Distribution Losses	**0**	**14**	**91**	**50**	**0**		**254**	**408**
Available Final Energy Consumption	**247**	**189**	**7,074**	**1,788**	**463**	**70**	**2,298**	**12,129**
Non-Energy Consumption	**0**	**0**	**240**	**0**	**0**	**0**	**0**	**240**
Final non-Energy Consumption	0	0	240	0	0			240
Total Final Energy Consumption	**251**	**189**	**6,791**	**1,824**	**472**	**70**	**2,223**	**11,821**
Industry	**102**	**1**	**497**	**764**	**201**	**70**	**882**	**2,516**
Non-energy Mining	0	0	32	12	0		63	107
Food, Beverages and Tobacco	21	1	137	104	23		188	475
Textiles and Textile Products	0	0	3	1	0		11	15
Wood and Wood Products	0	0	3	2	126		38	169
Pulp, Paper, Publishing and Printing	0	0	3	3	0		21	27
Chemicals and Man-made Fibres	0	0	29	64	0		161	254
Rubber and Plastic Products	0	0	9	4	0		39	53
Other Non-metallic Mineral Products	81	0	182	17	52	70	56	457
Basic Metals and Fabricated Metal Products	0	0	8	419	0		68	496
Machinery and Equipment n.e.c.	0	0	5	5	0		23	33
Electrical and Optical Equipment	0	0	42	122	0		109	274
Transport Equipment Manufacture	0	0	5	2	0		19	25
Other Manufacturing	0	0	39	6	0		86	131
Transport	**0**	**0**	**4,882**	**20**	**161**	**0**	**5**	**5,067**
Road Freight	0	0	713		33			746
Light Goods Vehicles (LGV)			322	0	15			337
Road Private Car	0	0	2,005		82		1	2,088
Public Passenger Services	0	0	131		6			137
Rail	0	0	38		0		4	42
Domestic Aviation	0	0	4		0			4
International Aviation	0	0	1,018		0			1,018
Fuel Tourism	0	0	155		7			162
Navigation	0	0	76		0			76
Unspecified	0	0	420	20	17			458
Residential	**149**	**188**	**967**	**555**	**65**		**684**	**2,609**
Commercial/Public Services	**0**	**0**	**257**	**484**	**46**	**0**	**604**	**1,392**
Commercial Services	0	0	170	212	39		433	854
Public Services	0	0	87	272	8		171	538
Agricultural	**0**	**0**	**165**	**0**	**0**		**48**	**213**
Fisheries	**0**	**0**	**23**		**0**			**23**
Statistical Difference	-4	-0	43	-35	-9	0	75	68

Note: This is the short version of the energy balance. A more detailed expanded balance showing detailed sub-fuel data is available on the SEAI website at https://www.seai.ie/resources/publications/Energy-Balance-2017.pdf

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