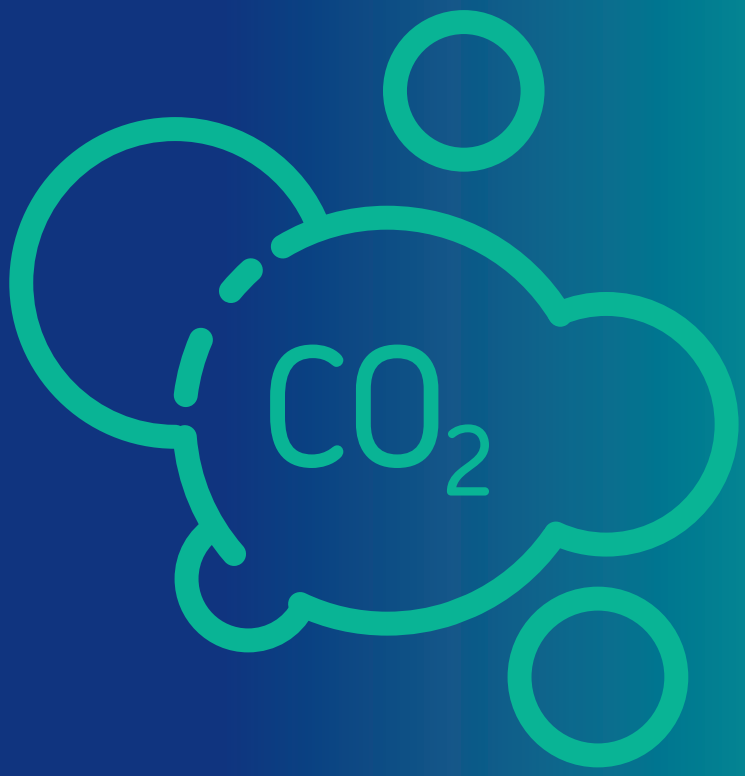
SUSTAINABLE ENERGY AUTHORITY OF IRELAND

ENERGY-RELATED CO_2 EMISSIONS IN IRELAND 2005 – 2018

2020 Report



Sustainable Energy Authority of Ireland

SEAI is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with Government, homeowners, businesses and communities to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies. SEAI is 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

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ENERGY-RELATED CO_2 EMISSIONS IN IRELAND 2005 – 2018

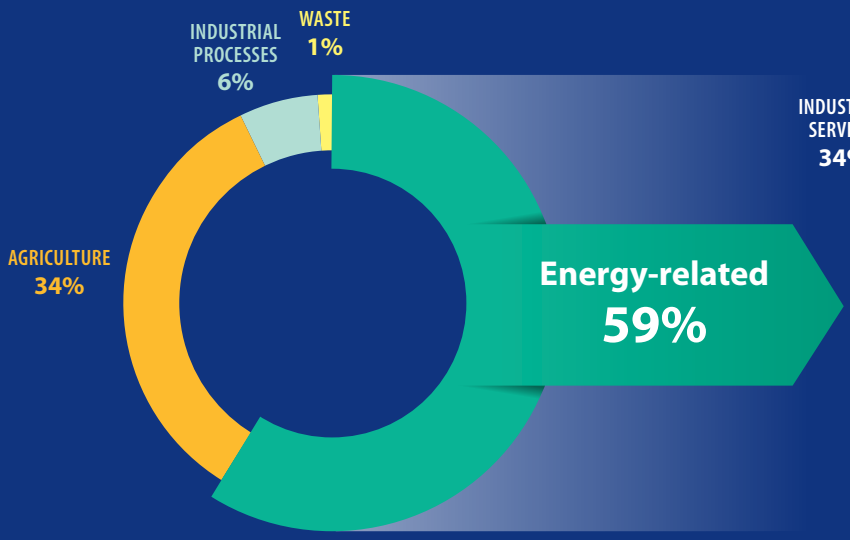
CO_2 emissions from fossil fuel combustion

Feburary 2020

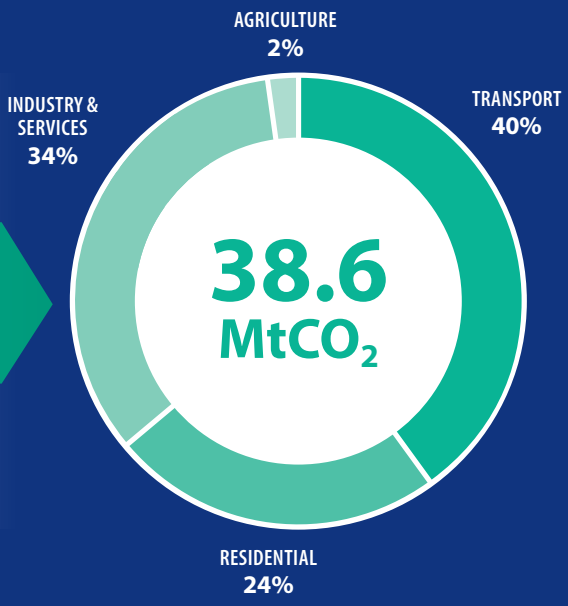
SUSTAINABLE ENERGY AUTHORITY OF IRELAND

CO_2 Emissions from Energy Use in Ireland in 2018

Greenhouse gas emissions by source



Energy-related CO_2 emissions by sector



Most CO_2 emissions came from

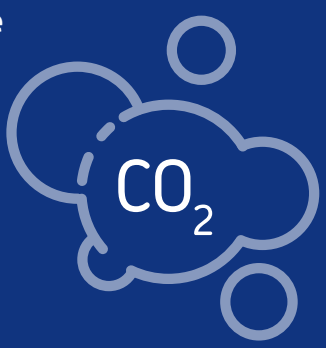
OIL 56%

GAS 27%

COAL, PEAT 16%

Avoided CO_2 emissions from renewable energy was

4.9 $MtCO_2$

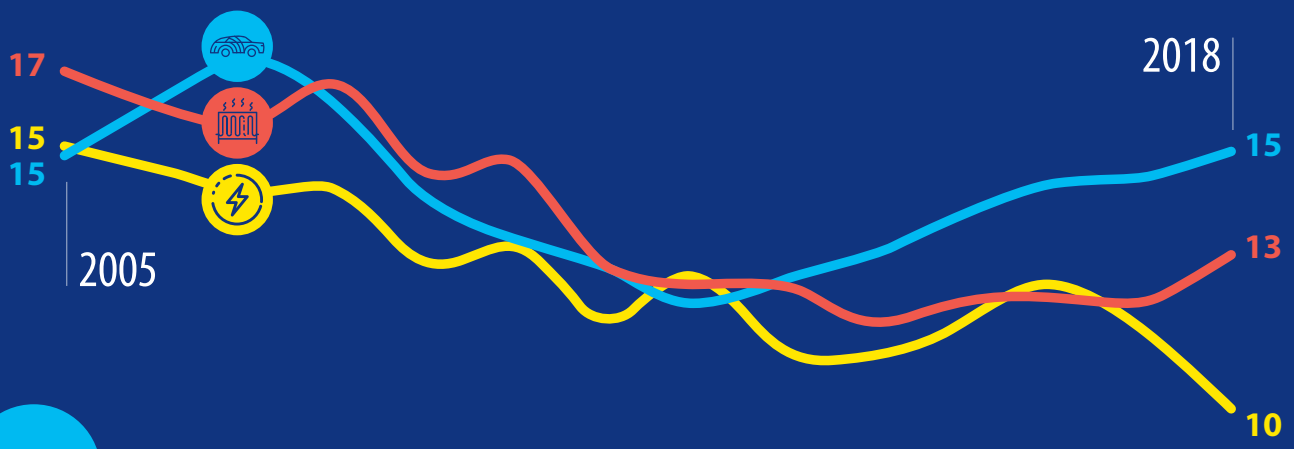


This equates to the CO_2 emissions of

50%

of homes in Ireland

Energy related CO_2 emissions ($MtCO_2$)



TRANSPORT

Emissions

+24% since 2012

Transport remains **almost entirely dependent on oil**

97%

Biggest contributors to transport emissions in 2018

- CARS 40%
- AVIATION 21%
- FREIGHT 14%

HEAT

Emissions from heat have been **INCREASING** since 2014

Biggest contributors to heat emissions in 2018

- HOMES 47% +8%
- INDUSTRY 21% +5%
- SERVICES 16% +8%

ELECTRICITY

Emissions

-33% between 2005 and 2018

Fuels for electricity generation (2005–2018)

RENEWABLES	COAL	OIL
+466%	-66%	-96%

Biggest electricity users in 2018

- INDUSTRY 39%
- HOMES 30%
- SERVICES 27%

Highlights

Economy, energy use and CO_2

- Fossil fuels used for energy accounted for 59% of all Ireland's greenhouse gas emissions in 2018.
- Transport was the largest source of energy-related CO_2 emissions (40%), followed by heat (33%) and electricity generation (27%).
- Energy use in Ireland remains strongly linked to economic growth. As the economy returned to growth after 2014, so too did energy use in heat, transport and electricity.
- Overall energy-related CO_2 emissions declined slightly in 2018, as the reductions in electricity generation outweighed the increase in heat and transport.
- This reduction was not enough to keep Ireland on track to meet long term decarbonisation goals.
- The CO_2 emissions intensity of Ireland's energy supply is 20% higher than the European average. This is due to greater use of high-carbon fossil fuels including coal, peat and oil.
- Changes in the mix of fuels used means that CO_2 emissions per unit of energy used are improving

CO_2 emissions from transport

- Transport was responsible for the largest share of energy-related CO_2 emissions in 2018 at 40%, up from 33% in 2005.
- CO_2 emissions from transport increased by 24% between 2012 and 2018.
- Transport remains almost entirely dependent on fossil fuels. In the absence of decarbonisation of the fuel mix, CO_2 emissions from transport are increasing in line with increasing energy use.
- Private cars are responsible for the largest share of transport emissions at 40%, aviation is next at 22%, followed by heavy goods vehicles at 14%.
- CO_2 emissions from aviation increased by 8% in 2018 to reach an all time high, surpassing the previous Celtic Tiger peak.

CO_2 emissions from heating

- CO_2 emissions are also increasing from heat, due to increasing energy use.
- CO_2 from fossil fuels burned in homes increased by 8% in 2018.
- There has been a slight reduction in the CO_2 intensity of the mix of fuels used for heat. Much of this is due to a switch away from oil use.
- The amount of oil used for heating reduced by 35% between 2005 and 2018. Most of this reduction happened in industry, where oil use fell by 55%. Oil use in services also fell sharply by 48%.
- There was also an increase in the amount of renewable energy used for heat, but from a low base. Ireland has the second lowest share of renewable energy used for heat in the EU.

CO_2 emissions from electricity

- CO_2 emissions from electricity generation declined in 2018, despite the growth in energy demand.
- There has been a strong reduction in the CO_2 intensity of electricity generation since 2005, especially after 2016.
- CO_2 emissions from coal used to generate electricity reduced by 44% in 2018. This was due to a technical fault at Ireland's only coal fired electricity generation plant, Moneypoint.
- Zero-carbon renewable energy generated 33% of all electricity in 2018, up from just 7% in 2005.

Renewable energy avoiding CO_2 emissions

- Using renewable energy for heat, electricity and transport reduced emissions by 4.9 million tonnes of CO_2. This is equivalent to the CO_2 emissions of almost half of all Irish homes.
- Wind generated electricity alone avoided 3.1 million tonnes of CO_2.

Table of Contents

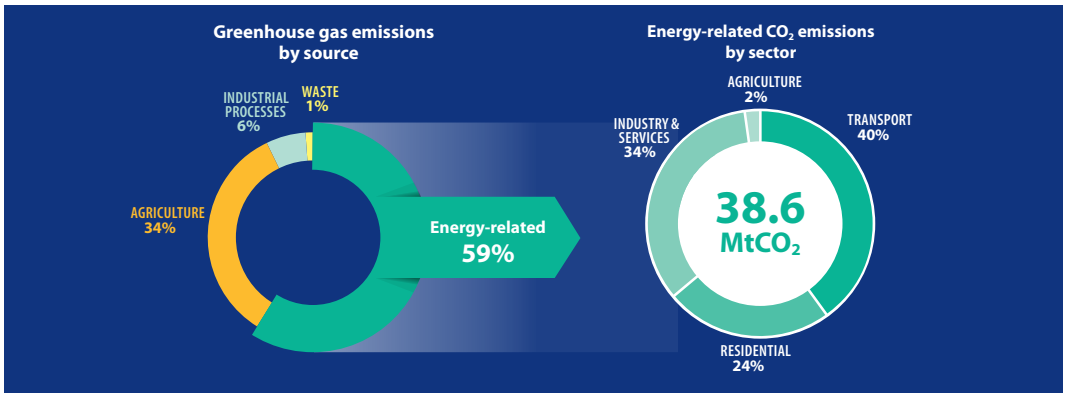
Table of Figures

Table of Tables

1 Summary

Energy consumption accounted for 59% of all Ireland's greenhouse gas emissions in 2018. Transport was the largest source of energy-related emissions (40%), followed by heat (33%) and electricity generation (27%), as seen in *Figure 1*.

Figure 1: Greenhouse Gas Emission by Source, 2018



Source: EPA and SEAI.

Energy use in Ireland remains strongly linked to economic growth. As the economy returned to growth after 2014, so too did energy use in heat, transport and electricity. Energy-related carbon dioxide (CO_2) emissions also increased after 2014, but changes in the mix of fuels used means that CO_2 emissions per unit of energy used reduced slightly in heat and electricity.

Transport remains almost entirely dependent on fossil fuels. There has not been a significant decarbonisation of transport energy use, and so CO_2 emissions from transport are increasing in line with energy use and economic growth. There has been a slight reduction in the CO_2 intensity of the mix of fuels for heat. This is due to a reduction in oil use, particularly in industry and services, and an increase in the amount of renewable energy. This has not been enough to outweigh the growth in energy use and overall CO_2 emissions from heat are increasing.

There has been a more significant reduction in the CO_2 intensity of electricity generation, due to a combination of more wind generation and a reduction in coal use. This meant that CO_2 emissions from electricity generation declined in 2018, despite the growth in energy demand.

Overall energy-related CO_2 emissions declined slightly in 2018, as the reductions in electricity generation outweighed the increase in heat and transport. The overall reduction was not enough to keep Ireland on track to meet long term decarbonisation goals.

The CO_2 emissions intensity of Ireland's energy supply is 20% higher than the European average.

Using renewable energy for heat, electricity and transport reduced emissions by 4.9 million tonnes of CO_2 (Mt CO_2) in 2018. This is equivalent to the CO_2 emissions of half of all Irish homes. Despite this, the latest data shows that the CO_2 emissions intensity of Ireland's energy supply is 20% higher than the European average. This is due to greater use of high-carbon fossil fuels in Ireland, including coal, peat and oil.

Reducing CO_2 emissions from energy use requires increased efficiency and increasing the use of renewable energy in our energy mix. This includes changing how we use energy in our homes, how we travel, and how we generate electricity. Understanding the current trends and the underlying factors that drive changes in energy-related CO_2 emissions is critical for making informed decisions on how we as a society can take action to reduce our carbon footprint. This report provides that evidence by supplying insights into the historical trends of energy-related CO_2 emissions[1].

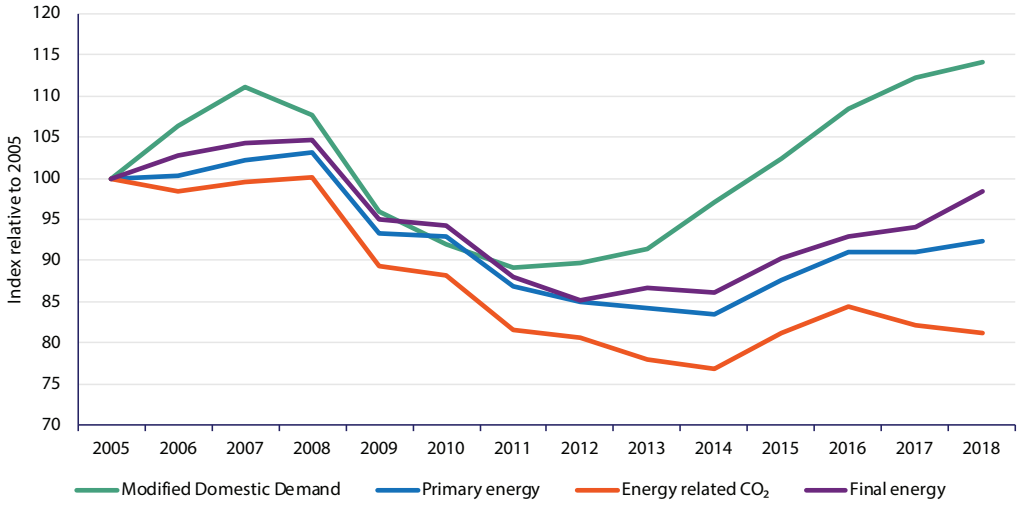
2 Economic Activity and Energy-Related CO_2 Emissions

The historical trends for the economy (measured by modified domestic demand[2]), final energy[3], primary energy[4], and energy-related CO_2, are shown in *Figure 2*. Each is expressed as an index relative to 2005. *Table 1* provides the growth rates for each of these for the period 2005 – 2018. In 2008 the economy experienced a downturn that deepened into 2009. Modified domestic demand dropped by 20% between 2007 and 2011. It returned to modest growth in 2012 and 2013, and stronger growth from 2014 to 2018. In 2018 modified domestic demand was 3% higher than the previous 2007 peak.

When comparing economic growth to energy use, it is best to look at final energy use, as this is the energy directly used in the economy. The trend for final energy between 2005 and 2018 broadly mirrored the trend in economic growth. In 2008, industry and transport experienced reductions in energy use while it continued to grow in the residential and services sectors, partly due to weather conditions. In 2009, however, all sectors of the economy experienced reductions in energy use tracking the decline in the economy. 2010 was an exceptionally cold year, which meant that energy use did not fall as sharply as it would otherwise have, but it subsequently declined in 2011 and again in 2012.

Energy use in Ireland remains strongly linked to economic growth.

Figure 2: Index of Modified Domestic Demand, Primary Energy, Final Energy, and Energy-Related CO_2



Source: Based on SEAI and CSO data.

While the economy grew in 2014, energy use declined. Some reasons for this are that energy prices, particularly oil prices, remained at record high levels, and also that it was a milder year. In 2015 there was a sharp reduction in the price of oil, the economy continued to grow and there was an increase in final energy use. Between 2014 and 2018 final energy use grew by 14% while modified domestic demand grew by 18%.

Primary energy closely matched the trend for final energy, though there was some divergence in 2017 and 2018. This was mostly due to changes in the fuel mix for electricity generation leading to increased efficiency.

Energy-related CO_2 emissions are linked to primary energy use. Energy related CO_2 emissions reduced by more than primary energy over the time period, particularly after 2016. This divergence was due to changes in the mix of fuels used, particularly for electricity generation.

Table 1: Modified Domestic Demand[5], Final Energy, Primary Energy, Energy-related CO_2 Growth Rates[6]

	Growth %	Average annual growth rates %				
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018
Modified Domestic Demand	14.2	1.0	-1.7	2.2	3.7	1.7
Final energy	-2.2	-0.2	-1.2	-1.0	2.9	4.5
Primary energy	-7.6	-0.6	-1.5	-1.2	1.8	1.6
Energy CO_2	-18.8	-1.6	-2.5	-1.6	0.0	-1.2
Energy CO_2 (excl. international aviation)	-21.6	-1.9	-2.6	-1.8	-0.7	-1.9

Source: Based on SEAI and CSO data.

Changes in the mix of fuels used means that CO_2 emissions per unit of energy used are reducing.

2.1 Energy-Related CO_2 Emissions by Mode

Energy use can be split into heat, transport and electricity. These three modes represent distinct energy services or markets. Where thermal or transport energy is provided by electricity (e.g. electric heaters or electric vehicles), this energy is counted under electricity, and not under thermal or transport. This means that there is no overlap and the modes can be added together to give total energy use or CO_2 emissions.

Figure 3 shows emissions split by into these three modes and *Table 2* shows the growth rates for the period 2005 – 2018. In 2018, the shares of energy-related CO_2 emissions from heat, transport and electricity were 33.3%, 39.8% and 26.9% respectively. CO_2 emissions in all modes fell during the economic downturn after 2007.

Transport CO_2 emissions decreased by 19% between 2005 and 2012, but have increased each year after that. In 2018 they grew by 2.9% and had returned to 2005 levels. Within transport the largest increase was in aviation. CO_2 emissions from aviation grew by 8% to an all time high in 2018, surpassing the previous peak set in 2007.

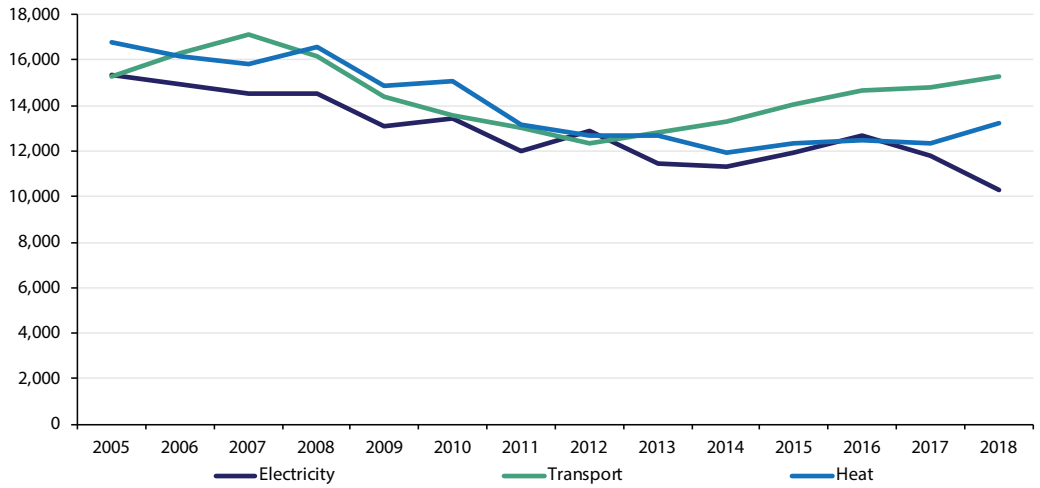
Transport remains almost entirely dependent on fossil fuels.

CO_2 emissions from fossil fuels used for heating reduced overall between 2007 to 2014, when there was a recession and record high energy prices. This was followed by an overall increase from 2014 to 2018, a period of time characterized by economic recovery, increased disposable incomes and a reduction in fossil fuel prices, in particular for oil. In 2018 CO_2 emissions from fossil fuels used for heating increased by 6.9%. CO_2 emissions from heat can also be influenced by weather conditions, due to increased fossil fuel use for heat in colder years. This can be seen in the spikes in CO_2 emissions for heat in especially cold years, such as 2008 and 2010.

Electricity CO_2 emissions vary depending on the amount of electricity consumed and the mix of fuels used for generation. The overall trend from 2005 to 2018 has been decreasing. From 2007 to 2014 this was due to a reduction in electricity usage and a reduction in the CO_2 intensity of electricity generation. After 2014 the demand for electricity began to increase again, in line with economic recovery, and electricity CO_2 emissions increased from 2014 to 2016. There was a sharp decline in electricity CO_2 emissions between 2016 and 2018, in spite of continued growth in electricity demand. This was due to a significant improvement in the CO_2 intensity of electricity generation, which can be seen more clearly in *Figure 4*.

5 Modified domestic demand rates are calculated using constant market prices chain-linked annually and referenced to 2015.
6 Throughout the report where annual growth rates cover multiple years they always refer to average annual growth rates.

Figure 3: Energy-Related CO_2 Emissions by Mode



Source: SEAI

Table 2: Energy-Related CO_2 Emissions by Mode of Application

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Transport	0.0	0.0	-2.4	0.7	2.7	2.9	15,261	15,254	32.7	39.8
Electricity	-32.8	-3.0	-2.6	-2.3	-4.8	-12.6	15,325	10,303	32.8	26.9
Heat	-20.7	-1.8	-2.1	-3.9	2.4	6.9	16,104	12,763	34.5	33.3
Total	**-17.9**	**-1.5**	**-2.4**	**-1.8**	**0.4**	**-0.6**	**46,690**	**38,320**		

Source: SEAI

Figure 4 shows the change in CO_2 emissions intensity per unit of primary energy for heat, transport and electricity. Intensity represents the amount of CO_2 emitted per unit of energy used.

The greatest change in the CO_2 intensity of fuel use was in electricity, particularly after 2016. From 2005 to 2016 there was an overall reduction in CO_2 intensity, due to increasing amounts of renewable wind, and a reduction in the use of oil and coal generation. There were some exceptions to this trend, for example in 2012 when there was an increase in coal use due to market conditions, and in 2016 due to an increase in the use of gas. The sharp reduction in electricity CO_2 emissions intensity between 2016 and 2018 was due to a combination of a 56% reduction in coal used for electricity generation and a 46% growth in renewable wind-generated electricity. The reduction in coal use was due to technical issues at Moneypoint, Ireland's only coal-fired electricity generation station.

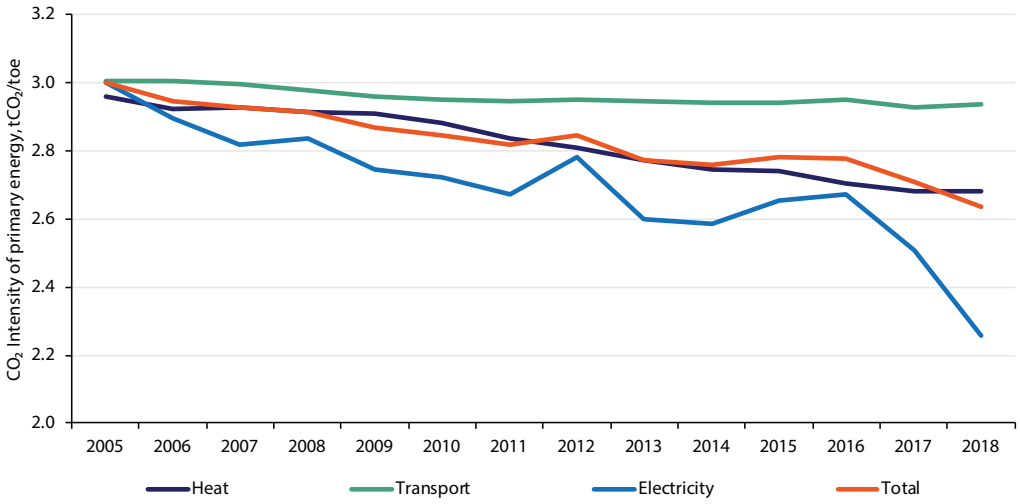
The CO_2 intensity of electricity generation has improved, due to a combination of more wind generation and a reduction in coal use.

There was also a reduction in the CO_2 intensity of the energy used for heat. This was due to a switch from oil to gas for heat in industry, and a reduction in oil use in households resulting from a combination of improved energy efficiency and a period of high oil prices.

There has not been a significant reduction in the CO_2 intensity of the energy used for transport. Transport remains almost entirely dependent on fossil oil, which accounted for 97% of all transport energy in 2018.

Reductions in the CO_2 intensity of the energy we use are positive in that they mean we are causing less CO_2 emissions per unit of energy used. However the rate of these reductions is current being overtaken by the growth in demand for energy for heat and transport, and so overall CO_2 emissions for these modes are increasing. This is at a time when we urgently need to be on a downward trajectory.

Figure 4: CO_2 Intensity of Primary Energy by Mode



Source: SEAI.

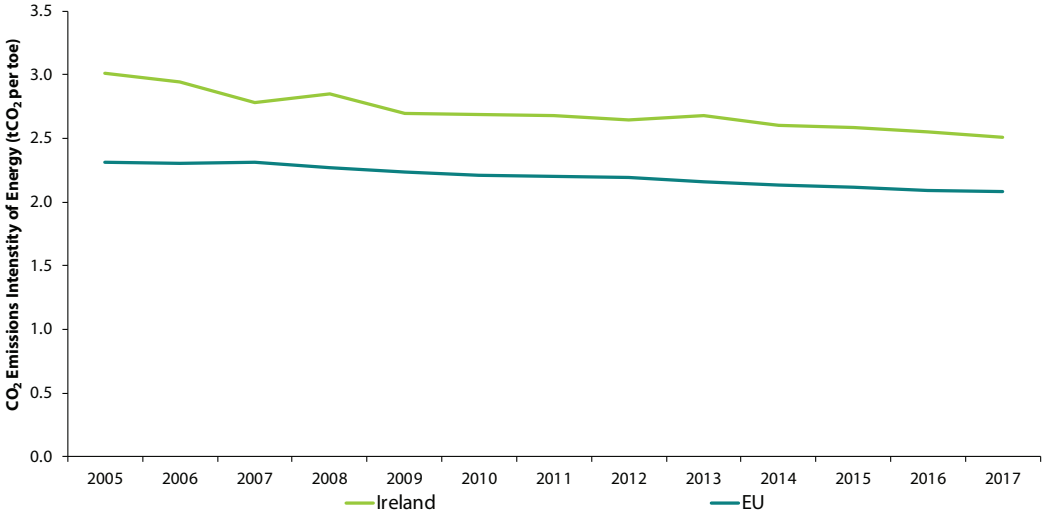
There was a slight reduction in the CO_2 intensity of the mix of fuels used for heat, due to a reduction in oil use, particularly in industry.

3 Energy-Related CO_2 Emissions Indicators

3.1 CO_2 Emissions Intensity of Overall Energy Use

The CO_2 emissions intensity of overall energy use in Ireland in terms of tonnes of CO_2 (t CO_2) per tonne of oil equivalent (toe) of total primary energy supply is shown in *Figure 5*. It also provides a comparison with the EU average. Over the period 2005 – 2017 the emissions intensity in Ireland in terms of overall energy use fell by 17%, to 2.5 t CO_2/toe, from 3.0 t CO_2/toe in 2005. Over the same period the intensity in the EU fell by 10% to 2.1 t CO_2/toe.

Figure 5: CO_2 Emissions Intensity of Primary Energy Use — Ireland and OECD Europe



Source: Based on Eurostat data

The CO_2 emissions intensity of primary energy use (i.e. energy supply) for Ireland was higher than OECD Europe over the whole period, ranging from 30% above in 2005 to 20% above in 2017. Ireland uses a higher share of fossil fuels for electricity and heat, particularly oil, coal and peat, the most CO_2-intensive fossil fuels. In contrast many countries in Europe have a considerably higher share of renewable energy in their fuel mix. This is particularly true for heat, where Ireland has the second lowest share of renewable heat of any EU member state. Many European countries also have higher shares of renewable electricity than Ireland, for example some countries, such as Norway and Austria, have strong hydro energy resources. The prevalence of nuclear energy in many European countries (e.g. France) is another reason for the lower emissions intensity relative to Ireland.

Ireland has the second lowest share of renewable heat in the EU, and continues to use large amounts of highly CO_2-intensive fossil fuels such as oil, coal and peat.

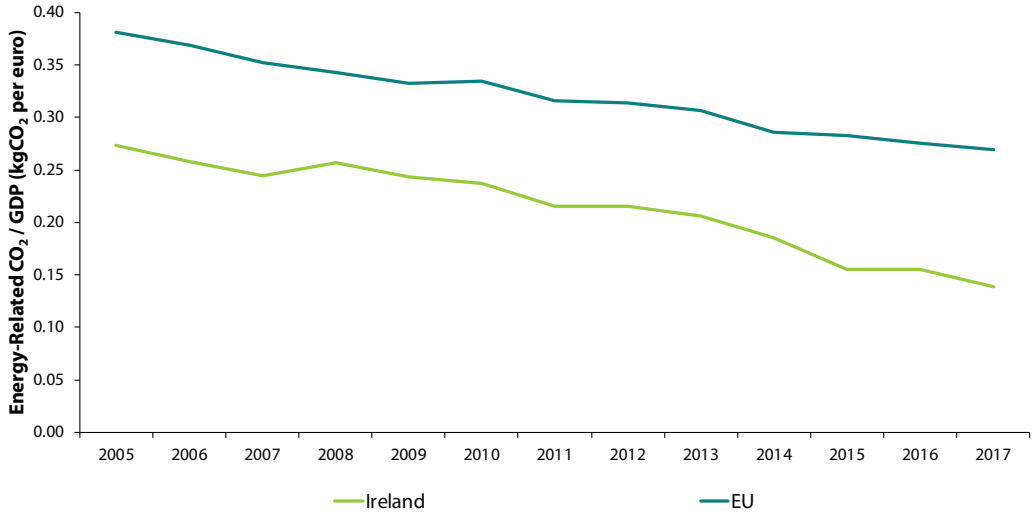
3.2 CO_2 Emissions Intensity of Economic Growth

The energy-related CO_2 intensity of the economy in Ireland between 2005 and 2017 is compared with the average in the EU in *Figure 6*. In 2005 0.27 t CO_2 were emitted in Ireland to generate one euro of GDP (in 2010 value), which was 28% below the level emitted in Europe. The emissions intensity in Ireland fell at a faster rate (5.5% per annum) than in Europe (2.9% per annum) over the period. This metric enables a cross country comparison of the evolution of emissions intensity. However, it must be noted that changes in GDP can be influenced by activities that have no bearing on energy use or related emissions.

Between 2005 and 2017 the energy-related CO_2 emissions intensity of the economy in Ireland fell by 49% (5.5% per annum) to 0.14 t/€GDP and was 48% lower than the average intensity in the EU in 2017. This can be explained in part by

the dramatic increases in GDP due to the activities of multinationals. As these increases are unrelated to energy use in the economy they result in a significant drop in CO_2/GDP. Increasing efficiency in electricity generation, improvements in the energy performance of the built environment and private cars, as well as other structural changes in the economy (such as the closure of energy-intensive industries such as steel, fertilizer and sugar production) would also have contributed.

Figure 6: Energy-Related CO_2 Emissions Intensity of the Economy — Ireland and OECD Europe

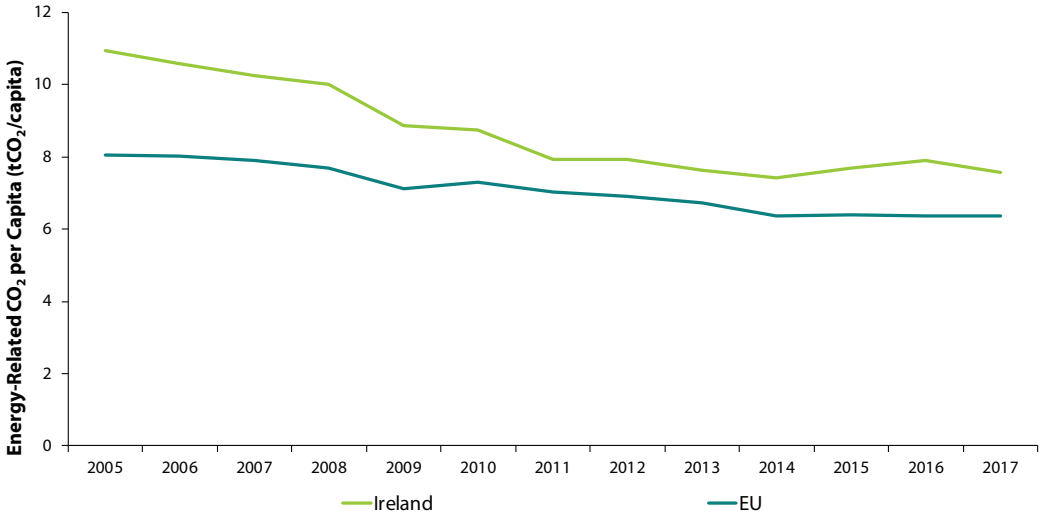


Source: Based on Eurostat data

3.3 Energy-Related CO_2 Emissions Intensity per Capita

Figure 7 shows the level of energy-related CO_2 emissions per capita in Ireland in comparison with the average in the EU. Energy-related CO_2 emissions per capita were above the European average in 2005 by 36%. After that the intensity fell, and in 2017 it was 19% above the EU average. Irish energy-related CO_2 emissions per capita were 31% lower in 2017 than in 2005. They fell from 10.7 tonnes per capita in 2005 to 7.4 tonnes in 2014, but increased to 7.6 tonnes in 2017. Over the same period emissions per capita in Europe fell by 21%, from 8.1 tonnes to 6.4 tonnes.

Figure 7: Energy-Related CO_2 Emissions per Capita — Ireland and OECD Europe



Source: Based on Eurostat data

4 CO_2 Emissions from Fossil Fuel Use

This section presents CO_2 emissions arising from the combustion of different fossil fuels across all sectors of the economy i.e. electricity generation, transport, residential, services, and industry. The CO_2 emissions from the combustion of fossil fuels for energy use represent 96% of energy-related greenhouse gas emissions, with the remaining 4% accounted for by energy-related nitrous oxide and methane.

CO_2 emissions from fossil fuel combustion accounted for approximately 59% of all greenhouse gas emissions in Ireland in 2018. They were 19% lower in 2018 than in 2005. *Table 3* and *Figure 8* show the level of energy-related CO_2 emissions from each individual fossil fuel source after 2005. CO_2 emissions from all fossil fuels fell between 2005 and 2018 with the exception of natural gas, which saw CO_2 emissions increase by 26%. The CO_2 emissions associated with coal fell by 61%. Most of this decrease happened between 2016 and 2018 due to a reduction in coal use for electricity generation, caused by a fault at Ireland's only coal-fired electricity generating station. CO_2 emissions from oil and peat fell by 22% and 15% respectively.

Oil accounted for the largest share of emissions in 2018, at 56%, followed by natural gas at 27%, peat at 8.3% and coal at 7.5%. In 2018, 44% of energy-related CO_2 emissions were in the Emissions Trading Scheme (ETS).

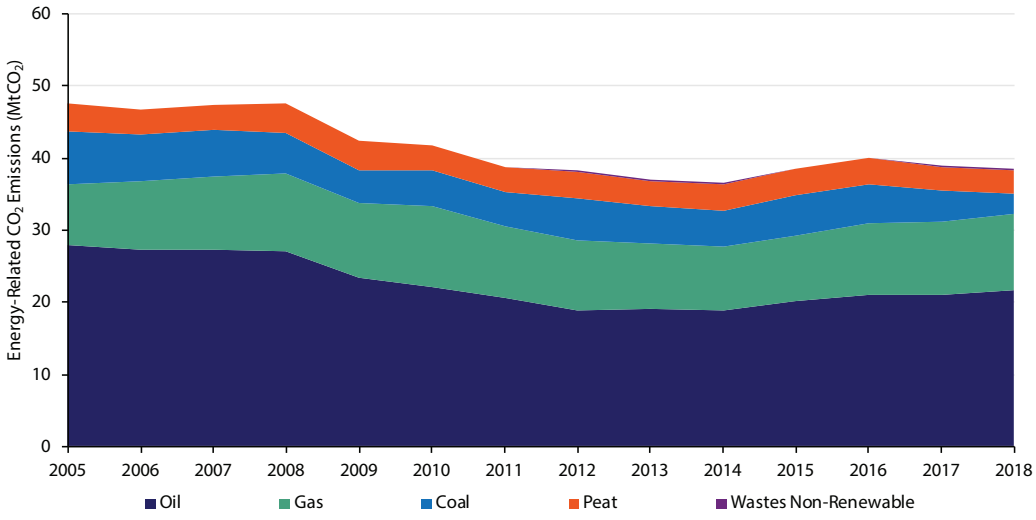
CO_2 emissions from fossil fuel combustion accounted for 59% of all greenhouse gas emissions in Ireland in 2018.

Table 3: Energy-Related CO_2 Emissions by Fossil Fuel[7]

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Coal	-61.5	-7.1	-8.1	3.0	-20.2	-34.0	7,463	2,877	15.7	7.5
Peat	-15.3	-1.3	-0.8	0.1	-4.2	-4.6	3,766	3,191	7.9	8.3
Oil	-22.2	-1.9	-4.6	-1.8	2.5	3.4	27,982	21,760	58.9	56.4
Natural Gas	25.6	1.8	6.2	-4.4	5.2	3.9	8,332	10,466	17.5	27.1
Non-Renewable Waste	-	-	-	54.1	28.3	28.4	0	307	0.0	0.8
Total	**-18.8**	**-1.6**	**-2.5**	**-1.6**	0.0	**-1.2**	**47,543**	**38,599**		

Source: SEAI

Figure 8: CO_2 Emissions from Fossil Fuel Energy Use



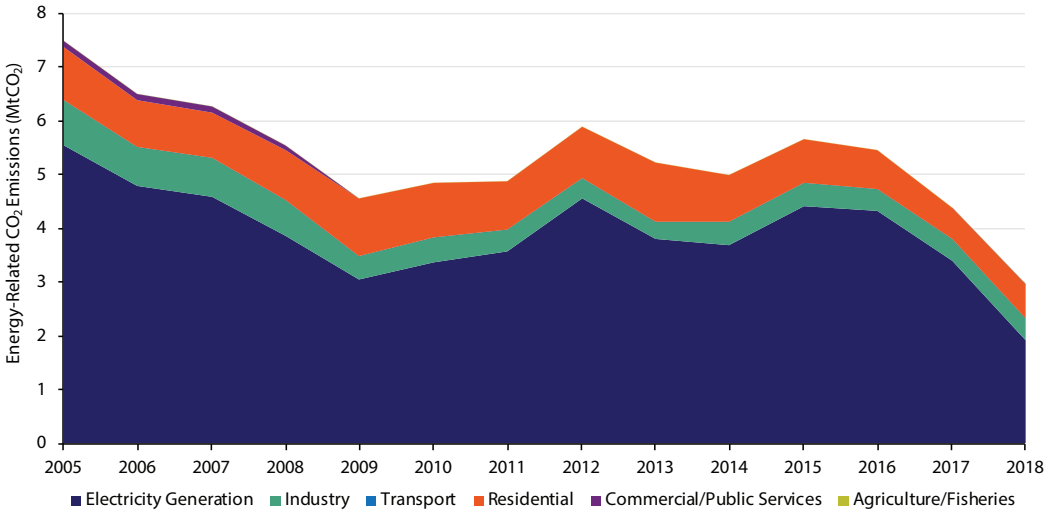
Source: SEAI

7 Note that there are some differences in the estimations of emissions when calculated by top-down overall fuel use and bottom-up sectoral use. This is due to statistical differences in the energy balance between the top-down and bottom-up allocation of energy supply and consumption. The differences were in the order of less than 1% for coal, approximately 1.5% for peat and oil, and 3.7% for natural gas in 2015.

4.1 CO_2 Emissions from Coal Use

Coal use for energy in Ireland is concentrated in electricity generation, which accounted for 65% of the coal CO_2 emissions in 2018, down from 77% in 2017 and 74% in 2005. The residential sector was the next largest source of CO_2 emissions from coal, accounting for 21%, followed by industry, which was responsible for 14%. In 2018, approximately 79% of CO_2 emissions from coal were in the ETS. *Figure 9* and *Table 4* show the trend in CO_2 emissions from coal use between 2005 and 2018.

Figure 9: CO_2 Emissions from Coal Use



Source: SEAI

Between 2005 and 2018 CO_2 emissions from coal fell by 61% (6.9% per annum), from 7.5 Mt to 3.0 Mt. Emissions fell by 46% between 2016 and 2018 (26% per annum). This was primarily from reduced coal use in electricity generation. In 2018, the coal generating station at Moneypoint was offline for the final three months of the year, resulting in a 44% reduction in emissions from coal use in electricity generation. Emissions from coal use in electricity in 2018 were approximately one third of what they were in 2005.

Coal CO_2 emissions reduced by 61% between 2005 and 2018, mostly in electricity generation.

Table 4: CO_2 Emissions from Coal Use

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Industry	-50.2	-5.2	-11.8	-1.2	-0.1	3.1	838	418	11.2	14.1
Transport	-	-	-	-	-	-	0	0	0.0	0.0
Residential	-36.6	-3.4	0.6	-4.0	-8.9	4.3	989	628	13.2	21.3
Services	-100.0	-100.0	-100.0	-	-	-	106	0	1.4	0.0
Agriculture/Fisheries	-	-	-	-	-	-	0	0	0.0	0.0
Electricity Generation	-65.6	-7.9	-9.4	5.5	-24.4	-43.8	5,547	1,907	74.1	64.6

Source: SEAI

CO_2 emissions from coal use in the residential sector fell by 37% over the period 2005 – 2018, and accounted for 21% of the coal CO_2 emissions in 2018. The reduction in coal use in households was partly driven by extensions to the Smoky Coal Ban[8] in 2011, 2013 and 2015.

CO_2 emissions from coal use in industry accounted for 14.1% of coal CO_2 emissions in 2018, and fell by 50% during the period 2005 – 2018. Coal use in industry is limited to a small number of sectors, mainly cement manufacturing and, to a lesser extent, food processing. Some of the reduction in coal combustion in industry, and particularly in cement manufacturing, was driven by the increased use of renewable alternatives, such as meat and bone meal, the renewable

portions of tyre-derived fuels, and municipal waste. Some non-renewable sources also contributed to the reduction in coal use, such as non-renewable waste and petroleum coke.

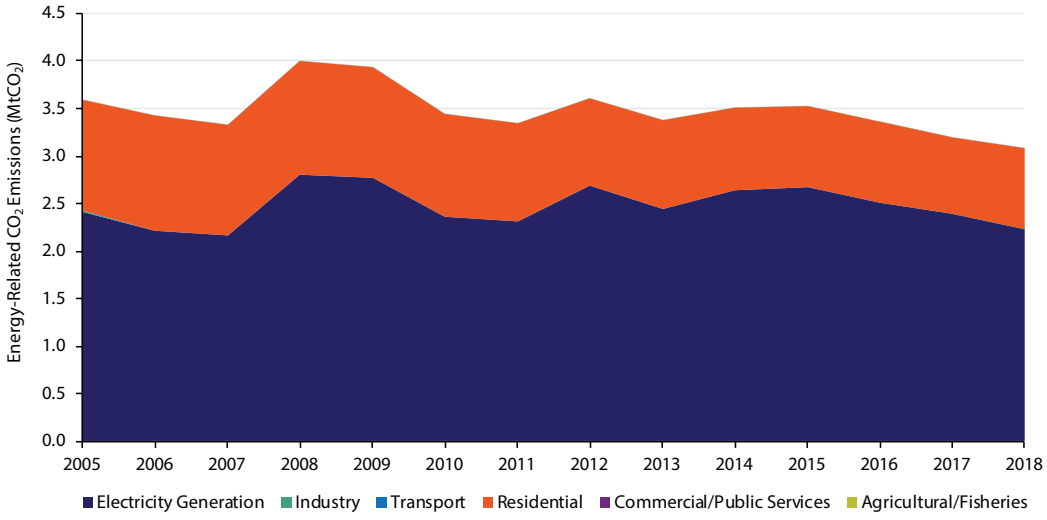
CO_2 emissions from coal use in services fell from 106 kt in 2005 to zero in 2009.

4.2 CO_2 Emissions from Peat Use

Peat is mostly used for electricity generation. In 2018, 73% of peat CO_2 emissions were from electricity generation, up from 67% in 2005. After electricity generation, almost all remaining peat is used for heat in homes, which accounted for 27% of of CO_2 emissions from peat in 2018. Industry accounted for just 0.1%. *Figure 10* and *Table 5* show the trend in CO_2 emissions from peat use between 2005 and 2018.

In 2018, approximately 73% of CO_2 emissions from peat were in the ETS.

Figure 10: CO_2 Emissions from Peat Use



Source: SEAI

Table 5: CO_2 Emissions from Peat Use

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Industry	116.2	6.1	3.3	12.7	0.4	10.3	2	4	0.1	0.1
Transport	-	-	-	-	-	-	0	0	0.0	0.0
Residential	-28.1	-2.5	-1.5	-4.6	-0.7	4.2	1,170	841	32.6	27.3
Services	-100.0	-100.0	-100.0	-	-	-	2	-	0.1	-
Agriculture/Fisheries	-	-	-	-	-	-	-	-	-	-
Electricity Generation	-7.8	-0.6	-0.5	2.5	-5.8	-6.7	2,419	2,230	67.3	72.5

Source: SEAI

Overall CO_2 emissions from peat use fell by 14.4% (1.0% per annum) between 2005 and 2018, to 3.1 Mt. This was partly due to a 28% reduction in peat use in the residential sector, driving emissions down to 0.8 Mt. CO_2 emissions from peat use in electricity generation also fell by 7.8%, to 2.2 Mt, between 2005 and 2018.

Household peat burning caused 840,000 tonnes of CO_2 emissions in 2018, equivalent to over 290,000 cars

4.3 CO_2 Emissions from Oil Use

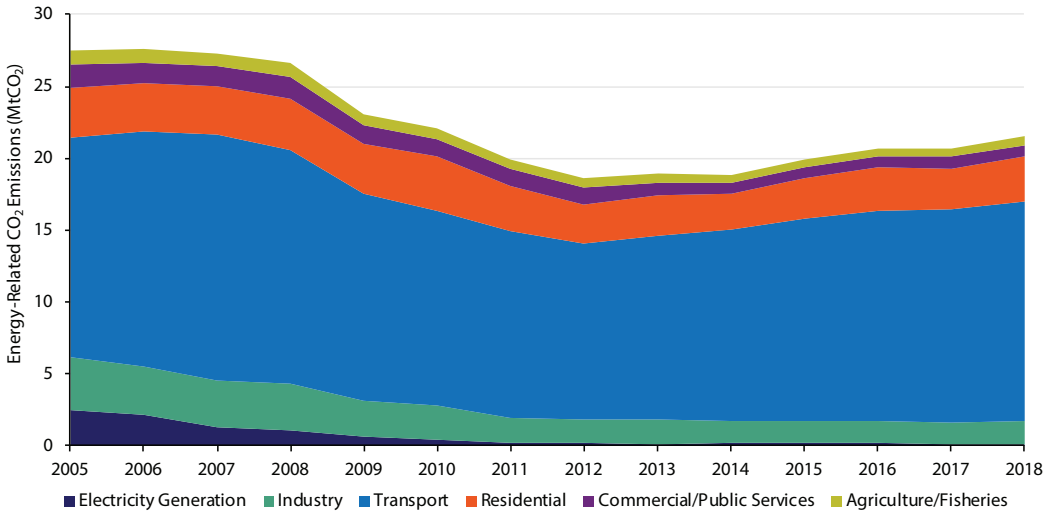
Most oil is used for transport, which was responsible for 71% of oil CO_2 emissions 2018. The residential sector was the next largest source of oil CO_2 emissions, at 15%, followed by industry at 8%. The share of oil CO_2 emissions from electricity generation fell to just 0.5% in 2018, from a peak of 18% in 1999.

CO_2 emissions from oil use fell to a low of 18.6 Mt in 2012, but increased by 16% between then and 2018 to 21.5 Mt. This was driven primarily by increased oil use in transport. The residential sector also contributed to the growth in oil use between 2012 and 2018, though to a lesser extent.

In 2018, approximately 21% of CO_2 emissions from oil use were in the ETS. Almost all of this was from international aviation.

Over 70% of CO_2 emissions from oil use are for transport.

Figure 11: CO_2 Emissions from Oil Use



Source: SEAI

Table 6: CO_2 Emissions from Oil Use

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Industry	-55.4	-6.0	-8.5	-8.9	3.5	7.3	3,706	1,651	13.5	7.7
Transport	-0.4	0.0	-2.4	0.7	2.7	2.9	15,256	15,202	55.4	70.5
Residential	-8.6	-0.7	1.8	-5.5	3.4	9.5	3,467	3,168	12.6	14.7
Services	-47.8	-4.9	-5.2	-9.6	4.2	4.0	1,567	817	5.7	3.8
Agriculture/Fisheries	-38.1	-3.6	-5.5	-6.9	5.5	7.9	1,005	622	3.7	2.9
Electricity Generation	-95.7	-21.4	-29.7	-9.1	-25.8	2.4	2,513	109	9.1	0.5

Source: SEAI

In 2018, 97% of energy use in the transport sector was from oil products. There was a reduction in CO_2 emissions from oil use in transport between 2007 and 2012 due to reduced activity during the economic recession, but also due to improved fuel efficiency, and the use of biofuels blended with petrol and diesel for road transport. CO_2 emissions from oil use in transport began to grow again after 2012 and in 2018 they grew by 2.9%, 24% above the low point in 2012 and just 0.4% below 2005 levels.

CO_2 emissions from oil in the residential sector also fell overall. They peaked during 2010, which was an exceptionally cold year, but had fallen by 32% by 2014, due to a combination of high oil prices, reduced disposable incomes and increased energy efficiency. Between 2014 and 2018 CO_2 emissions from oil in the residential sector increased by 23%, in response to lower oil prices and improved disposable incomes. They increased by 9.5% in 2018, but still remained 16% below the 2010 peak. The residential sector's share of CO_2 emissions from oil use grew from 13% to 15% between 2005 and 2018.

CO_2 emissions from oil use in all other sectors fell over the period, with oil use in electricity generation decreasing the

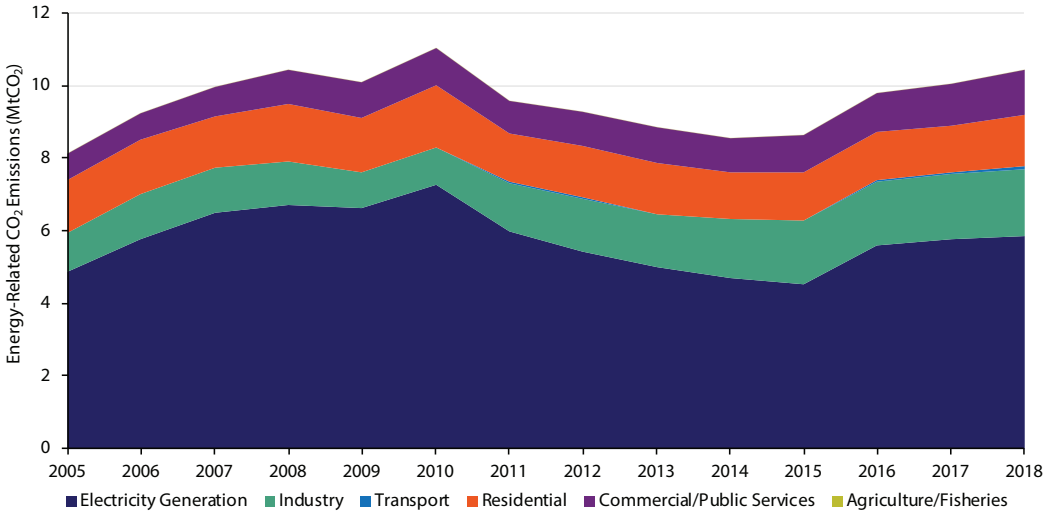
most. The decommissioning of oil generation at Poolbeg and Great Island resulted in a 96% drop, from 2.5 Mt in 2005 to 0.1 Mt in 2018. Oil-related CO_2 emissions fell by 55% in industry, where there was some fuel switching away from oil to natural gas. Oil-related CO_2 emissions in services and agriculture also fell by 48% and 38% respectively. CO_2 emissions in each of the sectors are discussed in more detail in *Section 5*.

4.4 CO_2 Emissions from Natural Gas Use

Natural gas is used mainly for electricity generation and for heat in industry, services and households. In 2018, 56% of CO_2 emissions from the use of natural gas were due to electricity generation, down from 60% in 2005. Less than one fifth (18%) was accounted for by industry, 14% by households and 12% by services. A small amount of natural gas is used for transport, mostly for transporting gas though the gas network itself. There is also compressed natural gas (CNG) used in road transport, but this is insignificant relative to total natural gas or transport energy use.

In 2018, approximately 74% of CO_2 emissions from natural gas were in the ETS.

Figure 12: CO_2 Emissions from Natural Gas Use



Source: SEAI

Overall, CO_2 emissions from natural gas use grew by 29% between 2005 and 2018, to 10.4 Mt. This was driven by an increase in natural gas use in the electricity generation, industry and services sectors, where associated CO_2 emissions increased by 21%, 68% and 75% respectively over the period. Some of the increase in gas use was due to a switch from coal (in electricity generation) and oil (in industry and services)to gas. Coal and oil are more CO_2 intensive than natural gas, so the fuel switching from these to gas leads to a reduction in the overall CO_2 intensity.

Emissions from natural gas use grew by 3.8% in 2018 when compared with 2017, mostly due to increased gas use in the residential and service sectors and for electricity generation.

Table 7: CO_2 Emissions from Gas Use

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Industry	68.1	4.1	-1.0	10.5	2.3	3.5	1,098	1,845	13.5	17.7
Transport	905.7	19.4	-0.8	13.2	78.0	11.6	5	53	0.1	0.5
Residential	-2.2	-0.2	3.3	-4.9	2.2	8.9	1,443	1,411	17.8	13.5
Services	75.1	4.4	8.2	-0.4	6.5	10.0	710	1,243	8.8	11.9
Agriculture/Fisheries	-	-	-	-	-	-	-	-	-	-
Electricity Generation	21.1	1.5	8.4	-8.9	8.9	1.6	4,846	5,867	59.8	56.3

Source: SEAI

Emissions of CO_2 from gas use in electricity generation fell by 6.4% between 2005 and 2015, to 4.5 Mt, and increased by 29% between then and 2018 to 5.9 Mt. The decrease up to 2015 was driven by improvements in the efficiency of gas generation as a result of a number of combined cycle gas turbine plants being commissioned. It was also driven by the displacement of gas generation by wind, and also sometimes by coal, at times of low coal and carbon prices. Gas generation is generally the marginal generation plant on the electricity system, therefore when wind generation increases, gas-fired electricity generation declines. However, in 2016, lower wind availability and a switch from net imports of electricity to net exports

to the UK, due to carbon tax increases there, resulted in an increase in the use of gas for electricity generation in Ireland, and a 20.7% increase in emissions. The rise in CO_2 emissions in 2017 and 2018 was due to increased gas generation to compensate for reduced coal and peat generation.

Emissions from natural gas use in the residential sector fell by 2.2% between 2005 and 2018, to 1.4 Mt, due to improvements in the thermal efficiency of the housing stock, and high gas prices and reduced disposable incomes during some of the period.

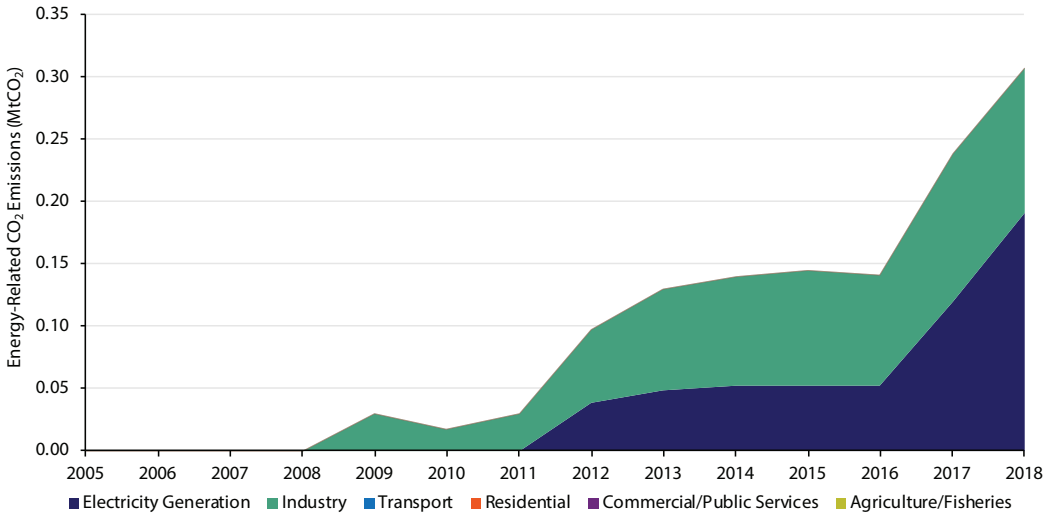
4.5 CO_2 Emissions from Non-Renewable Waste Use

Energy from non-renewable waste is only used in electricity generation and industry. Until mid 2017 there was only one municipal waste-to-energy plant in Ireland. The facility, operated by Indaver, is based in Duleek, Co. Meath and became operational in 2011. It manages 200,000 tonnes of residual waste per annum and has a capacity of 22 MW. In 2017, the Covanta operated waste-energy plant in Ringsend went into operation. It has a capacity of 60 MW.

In 2018, 302 GWh of electricity was produced from waste incineration, which was 1.0% of the total electricity generated. This emitted an estimated 191 kt CO_2.

In industry the use of non-renewable waste is concentrated in the cement industry and consists of meat and bone meal, and the non-renewable portions of municipal waste and tyre-derived fuels. Emissions from this source amounted to 115 kt CO_2 in 2018.

Figure 13: Energy-Related CO_2 Emissions from Non-Renewable Waste Use



Source: SEAI

Table 8: Energy-related CO_2 Emissions from Non-Renewable Waste Use

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Industry	-	-	-	40.9	7.6	-3.7	-	115	-	37.6
Transport	-	-	-	-	-	-	-	-	-	-
Residential	-	-	-	-	-	-	-	-	-	-
Services	-	-	-	-	-	-	-	-	-	-
Agriculture/Fisheries	-	-	-	-	-	-	-	-	-	-
Electricity Generation	-	-	-	-	54.1	60.9	-	191	-	62.4

Source: SEAI

5 Energy-Related CO_2 Emissions by Sector

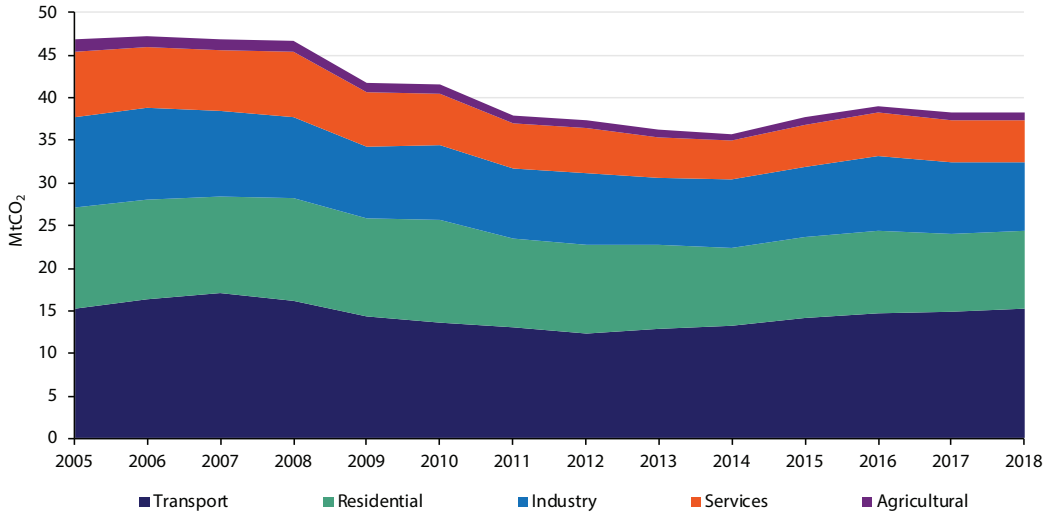
The sectoral energy-related CO_2 emissions presented in this section are based on the sectoral disaggregation contained in the energy balance, with the upstream emissions from electricity generation and other energy transformations allocated to the economic sectors where that electricity is used. This differs from the way in which national greenhouse gas emissions inventories are reported by the Environmental Protection Agency (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 data presented in *Section 5.1* below reflects the CO_2 emissions resulting from the final demand for all forms of energy, including electricity and heat, within each sector and gives a view of the total emissions associated with energy demand. *Section 5.2* and *Section 5.3* present the data on the emissions from electricity generation and heat specifically.

Figure 14 and *Table 9* show the sectoral breakdown of energy-related CO_2 emissions (which represent 96% of energy-related greenhouse gas emissions, with the remaining 4% accounted for by energy-related nitrous oxide and methane.

5.1 Energy-Related CO_2 Emissions by Sector

Figure 14: Energy-Related CO_2 Emissions by Sector



Source: SEAI

Energy-related CO_2 emissions in 2018 were 19% lower than 2005 levels. Transport accounted for the largest share of energy-related CO_2 emissions, with a share of 40% in 2018, up from 33% in 2005. The residential sector accounted for the second largest share in 2018, at 24%, followed by industry at 21% and services at 13%. Energy-related CO_2 emissions in agriculture and fisheries accounted for just 2.2%.

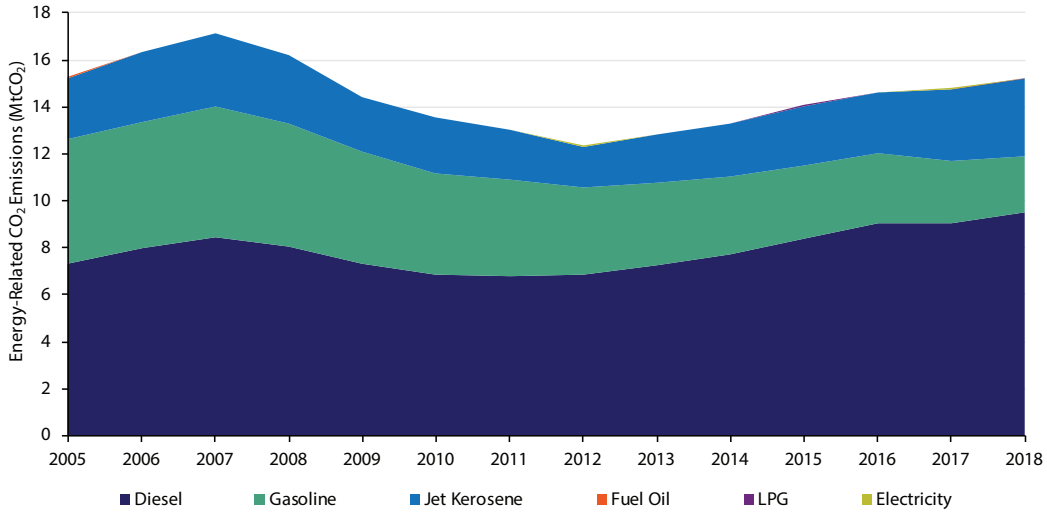
Table 9: Energy-Related CO_2 Emissions by Sector

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Industry	-22.8	-2.0	-3.7	-0.9	-0.9	-3.5	10,519	8,118	22.5	21.3
Transport	-0.1	0.0	-2.4	0.7	2.8	2.9	15,299	15,277	32.7	40.0
Residential	-23.0	-2.0	0.5	-4.6	-1.6	0.0	11,843	9,114	25.3	23.9
Services	-37.4	-3.5	-4.9	-4.1	-0.3	-3.6	7,764	4,860	16.6	12.7
Agriculture/Fisheries	-41.2	-4.0	-5.7	-5.6	1.7	1.2	1,414	831	3.0	2.2

Source: SEAI

5.1.1 Energy-Related CO_2 Emissions from Transport

Figure 15: Energy-Related CO_2 Emissions from Transport



Source: SEAI

Energy-related CO_2 emissions from transport were almost entirely produced by the use of petroleum products (99.5% in 2018) and were concentrated in the use of petrol, diesel and kerosene. Jet kerosene is exclusively used for air transport and petrol is mainly used in cars. Diesel, which accounted for approximately 62% of transport emissions in 2018, is used across multiple modes of transport, such as cars, buses, goods transport, and rail.

Table 10: Energy-Related CO_2 Emissions from Transport

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Total Oil Products	-0.4	0.0	-2.4	0.7	2.7	2.9	15,256	15,202	99.7	99.5
Petrol	-54.9	-5.9	-4.1	-6.2	-8.6	-9.2	5,337	2,406	34.9	15.8
Diesel	30.1	2.0	-1.2	4.1	4.3	4.7	7,299	9,496	47.7	62.2
Jet Kerosene	28.6	2.0	-1.7	1.5	9.2	7.9	2,562	3,294	16.7	21.6
LPG	81.8	4.7	-12.8	37.5	-9.9	-17.8	3	5	0.0	0.0
Electricity	-39.4	-3.8	-8.4	-3.3	3.6	-1.2	37	23	0.2	0.1
Total	**-0.1**	**0.0**	**-2.4**	**0.7**	**2.8**	**2.9**	**15,299**	**15,277**		

Source: SEAI

In 2018, the transport emissions were 15,277 kt, which represented 40% of the total energy-related CO_2 emissions. Emissions peaked in 2007 at 17.1 Mt and fell rapidly during the economic downturn, to 12.3 Mt in 2012, a fall of 28%. Between 2012 and 2018 emissions increased by 24%. In 2018, energy-related CO_2 emissions in transport were 0.1% higher than in 2005.

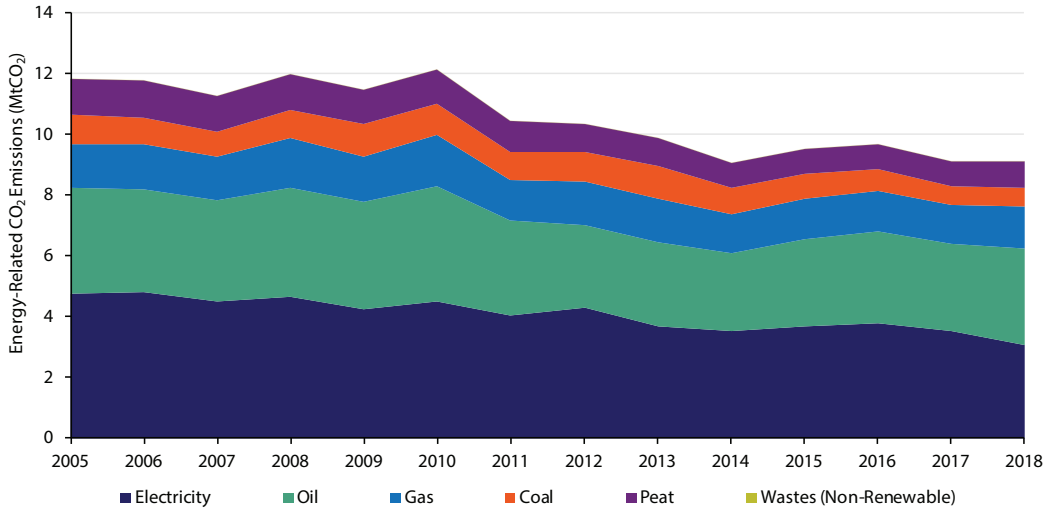
Over the period there was a change in the fuel mix, particularly in relation to petrol and diesel. This was the result of changes to the taxation regime; motor tax for private cars was no longer calculated on engine size, but on CO_2 emissions. In 2005, petrol accounted for 35% of transport CO_2 emissions and this fell to 16% in 2019. In absolute terms, petrol CO_2 emissions fell by 55% over the period, to 2.4 Mt. In contrast, diesel accounted for 48% of the emissions in 2005, a figure which rose to 62% in 2018. In absolute terms, diesel CO_2 emissions increased by 30%, to 9.5 Mt.

CO_2 emissions from aviation increased by 8% in 2018 to reach an all time high, surpassing the previous Celtic Tiger peak for the first time.

5.1.2 Energy-Related CO_2 Emissions from the Residential Sector

In 2018, residential sector energy-related CO_2 emissions (including upstream electricity emissions) were 9,114 kt CO_2, representing 24% of the total energy-related CO_2 emissions. The residential sector total was the second largest in terms of CO_2 emissions after transport (40%). Excluding upstream electricity emissions, direct CO_2 emissions from households were 6,047 kt CO_2, and were 8% higher in 2018 compared with 2017.

Figure 16: Energy-Related CO_2 Emissions from the Residential Sector



Source: SEAI

Over the period 2005 – 2018, energy-related CO_2 emissions[9] from the residential sector fell by 23% (2.0% on average per annum). If upstream emissions associated with electricity use are excluded, the CO_2 emissions from direct fossil fuel use in the residential sector fell by 14% between 2005 and 2018, while the number of households increased by 26%.

Energy-related CO_2 emissions in the residential sector peaked in 2010 at 12.1 Mt. This was the coldest year in recent times with prolonged cold periods at both the beginning and end of the year.

CO_2 from fossil fuels burned in homes increased by 8% in 2018, but this was cancelled out by the CO_2 from the electricity used decreasing by 13%.

Table 11: Energy-Related CO_2 Emissions in the Residential Sector

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Coal	-36.6	-3.4	0.6	-4.0	-8.9	4.3	989	628	8.4	6.9
Peat	-28.1	-2.5	-1.5	-4.6	-0.7	4.2	1,170	841	9.9	9.2
Briquettes	-23.8	-2.1	-0.5	-3.7	-1.9	13.5	374	285	3.2	3.1
Oil	-8.6	-0.7	1.8	-5.5	3.4	9.5	3,467	3,168	29.3	34.8
Gas	-2.2	-0.2	3.3	-4.9	2.2	8.9	1,443	1,411	12.2	15.5
Combustible Fossil Fuels (Total)	-14.5	-1.2	1.4	-5.0	1.0	8.0	7,069	6,047	59.7	66.4
Electricity	-35.8	-3.3	-1.1	-4.0	-5.9	-12.7	4,773	3,067	40.3	33.6
Total	**-23.0**	**-2.0**	**0.5**	**-4.6**	**-1.6**	**0.0**	**11,843**	**9,114**		

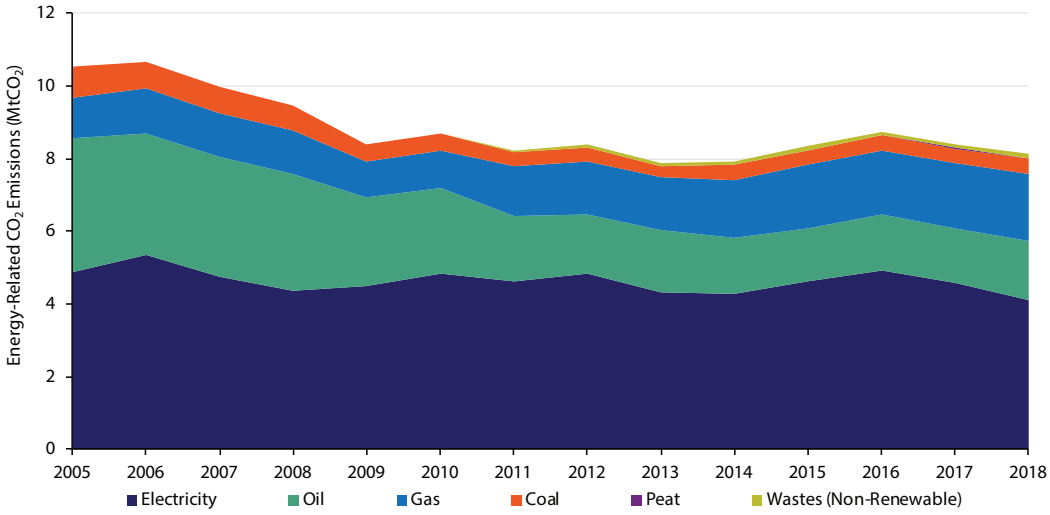
Source: SEAI

The CO_2 emissions per household fell by 39% over the period to 5.2 t CO_2/household. This was driven by a number of factors, such as improved thermal efficiency, a significant decrease in the carbon intensity of electricity, and also a period of high energy prices and reduced disposable income. Per-household emissions from electricity fell by 49% over the period, to 1.7 t CO_2/household. Direct use of fossil fuels in households fell by 32% over the period, to 3.4 t CO_2/household.

5.1.3 Energy-Related CO_2 Emissions from Industry

The primary energy-related CO_2 emissions in industry, including the upstream emissions associated with electricity consumption, are shown in *Figure 17*. Over the period 2005 – 2018, overall energy-related CO_2 emissions in industry fell by 23% (2.0% per annum), to 8.1 Mt. Industry CO_2 emissions peaked in 2001 at 11.6 Mt.

Figure 17: Energy-Related CO_2 Emissions from Industry



Source: SEAI

Industrial activity, as measured by gross value added (GVA) of industry, increased by 146% between 2005 and 2018. There was a large increase in GVA in 2015 caused 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.

Table 12: Energy-Related CO_2 Emissions from Industry

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Coal	-50.2	-5.2	-11.8	-1.2	-0.2	3.1	838	418	8.0	5.1
Oil Total	-55.4	-6.0	-8.5	-8.9	3.5	7.3	3,706	1,651	35.2	20.3
Kerosene	-24.0	-2.1	-2.0	-5.2	3.2	10.2	372	283	3.5	3.5
Fuel Oil	-93.8	-19.2	-8.0	-33.4	-10.5	-2.3	1,502	93	14.3	1.1
LPG	22.7	1.6	-0.1	0.6	6.1	9.0	275	337	2.6	4.2
Gas Oil	-37.5	-3.6	-4.6	-7.3	5.0	6.3	609	381	5.8	4.7
Petroleum Coke	-41.0	-4.0	-21.3	11.5	4.2	7.2	944	557	9.0	6.9
Natural Gas	68.1	4.1	-1.0	10.5	2.3	3.5	1,098	1,845	10.4	22.7
Waste (Non-Renewable)	-	-	-	40.9	7.6	-3.7	-	115	0.0	1.4
Total Combustible Fossil Fuels	-28.5	-2.6	-7.2	-0.8	2.6	4.8	5,644	4,033	53.6	49.7
Electricity	-16.2	-1.4	-0.2	-0.9	-3.9	-10.4	4,876	4,085	46.4	50.3
Overall Total	**-22.8**	**-2.0**	**-3.7**	**-0.9**	**-0.9**	**-3.5**	**10,519**	**8,118**		

Source: SEAI

As detailed in *Table 12*, upstream emissions from electricity consumption accounted for 50% of industrial energy-related CO_2 emissions — as much as all the other fossil fuels used by industry combined.

Over 50% of CO_2 emissions from industry are indirect emissions from electricity use.

If upstream electricity-related emissions are omitted then there was a 29% decrease in CO_2 emissions from combustible fossil fuels used on-site in industry between 2005 and 2018. Some of the reduction is the result of lower combustible fossil fuel use in industry, which fell by 16%. Changes in the fuel mix also contributed to lowering emissions. In 2005, oil

accounted for 35% of the emissions and this dropped to 20% in 2018. Of the oil products, heavy fuel oil has the highest emission factor.

In 2005, heavy fuel oil accounted for 14% of industry's CO_2 emissions (41% of industry's oil emissions) but this fell to just 1.1% in 2018. This was the result of fuel switching in alumina production, from the direct use of heavy fuel to a more efficient use of natural gas in combined heat and power production.

Natural gas, a fossil fuel with lower CO_2 intensity, increased its share in industry energy-related CO_2 emissions from 10% to 23% over the period. The renewable energy share of final energy consumption also grew slightly, accounting for 7.6% of industry demand in 2018, compared with 6.2% in 2005.

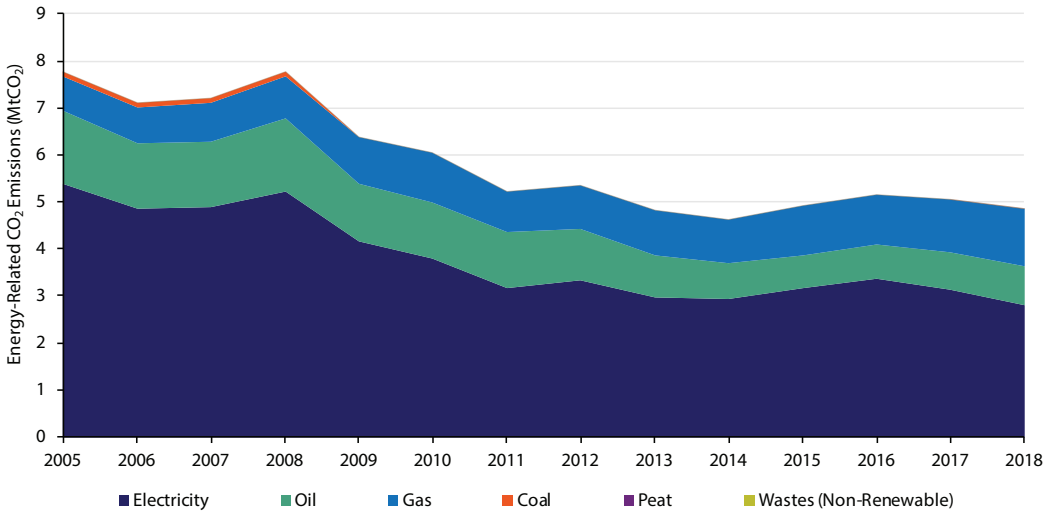
There has been a shift away from oil use in industry; CO_2 emissions from oil use in industry decreased by 55% between 2005 and 2018.

5.1.4 Energy-Related CO_2 Emissions from Services

The primary energy-related CO_2 emissions from the services sector, including the upstream emissions associated with electricity consumption, are shown in *Figure 18*. CO_2 emissions from direct fossil fuel combustion in the services sector decreased by 14% between 2005 and 2018, and the emissions associated with electricity consumption fell by 48%. This was driven by both a 12% reduction in electricity demand in services and a reduction in the emissions intensity of electricity generation. During this period, employment in services increased by 23% and the value added generated in services increased by 55%[10].

In 2018 non-electricity emissions increased by 7.5% and the electricity-associated emissions in services fell by 10.4%. Overall, energy-related CO_2 emissions in this sector fell by 3.6% in 2018 to 4.9 Mt CO_2. Energy-related CO_2 emissions in services peaked in 2003 at 7.9 Mt, and have fallen by 38% since then.

Figure 18: Energy-Related CO_2 Emissions from Services



Source: SEAI

There is a smaller range of energy sources used in the service sector, than in industry or households. The sector now relies on oil, natural gas and electricity, and hasn't used coal since 2008. Over the period 2005 – 2018, there was a significant move from oil to gas in the fuel mix used in the sector, with the share of emissions from oil falling from 20% to 17%, and that of gas increasing from 9.1% to 26%. This factor, together with a 1.8% reduction in combustible fossil fuel use in services contributed to a 14% reduction in CO_2 emissions from fossil fuel use.

Table 13: Energy-Related CO_2 Emissions from Services

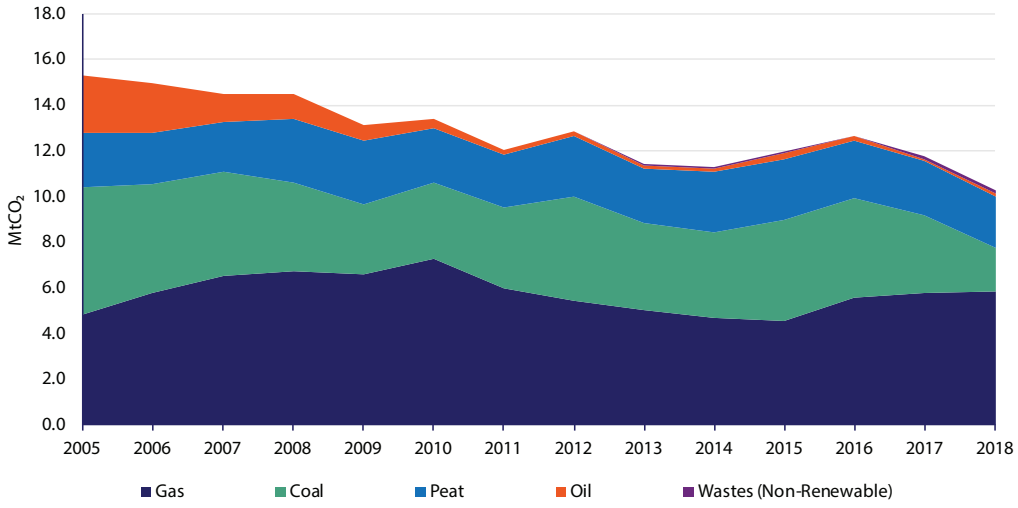
	Growth %	Average annual growth rates %					Quantity (kt)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Coal	-100.0	-100.0	-100.0	-	-	-	106	-	1.4	0.0
Oil	-47.8	-4.9	-5.2	-9.6	4.2	4.0	1,567	817	20.2	16.8
Gas	75.1	4.4	8.2	-0.4	6.5	10.0	710	1,243	9.1	25.6
Electricity	-48.0	-4.9	-6.7	-3.6	-3.9	-10.4	5,379	2,800	69.3	57.6
Total	**-37.4**	**-3.5**	**-4.9**	**-4.1**	**-0.3**	**-3.6**	**7,764**	**4,860**		

Source: SEAI

5.2 CO_2 Emissions from Electricity Generation

The trend in CO_2 emissions from fossil fuel combustion in electricity generation over the period 2005 – 2018 are shown in *Figure 19*. CO_2 emissions from fossil fuels used in electricity generation fell by 33% over the period, to 10.3 Mt in 2018. *Table 14* shows the growth rates, quantities and shares of emissions from fossil fuel combustion in electricity generation. Emissions from gas-generated electricity grew by 21%, while emissions from all other fossil fuel sources fell. Gas accounted for 32% of the sector's emissions in 2005, and had risen to 57% by 2018.

Figure 19: CO_2 Emissions from Electricity Generation by Fossil Fuel



Source: SEAI

CO_2 emissions from natural gas use in electricity generation fell by 6.4% over the period 2005 – 2015, but increased by 8.9% between 2015 and 2018 and were 21% higher in 2018 than in 2005.

The share of emissions from coal-generated electricity fell from 36% to 19%, and in absolute terms coal emissions fell by 66%, to 1.9 Mt.

Emissions from coal and peat fell in 2018 compared with 2017, by 44% and 7.8% respectively, while natural gas emissions increased by 1.6%.

Table 14: CO_2 Emissions from Electricity Generation

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Fossil Fuels (Total)	-34.0	-3.1	-2.6	-2.4	-5.3	-13.3	15,325	10,112	100.0	98.1
Coal	-65.6	-7.9	-9.4	5.5	-24.4	-43.8	5,547	1,907	36.2	18.5
Peat	-7.8	-0.6	-0.5	2.5	-5.8	-6.7	2,419	2,230	15.8	21.6
Oil (Total)	-95.7	-21.5	-29.8	-9.1	-26.0	2.5	2,513	108	16.4	1.0
Fuel Oil	-96.4	-22.6	-32.1	-10.9	-23.6	1.0	2,283	82	14.9	0.8
Gas Oil and Refinery Gas	-87.9	-15.0	-17.4	-6.2	-24.4	12.0	208	25	1.4	0.2
Gas	21.1	1.5	8.4	-8.9	8.9	1.6	4,846	5,867	31.6	56.9
Wastes (Non-Renewable)	-	-	-	-	54.1	60.9	-	191	-	1.9
Total	**-32.8**	**-3.0**	**-2.6**	**-2.3**	**-4.8**	**-12.6**	**15,325**	**10,303**		

Source: SEAI

Coal and peat generated 14% of electricity in 2018, as shown in *Figure 20* but they accounted for 40% of CO_2 emissions from electricity emissions, as shown in *Table 14*. Natural gas generated 52% of the electricity used and accounted for 57% of CO_2 emissions from electricity generation.

Coal and peat generated 14% of electricity in 2018, but they were responsible for 40% of CO_2 emissions from electricity generation.

Figure 20: Flow of Energy in Electricity Generation 2018

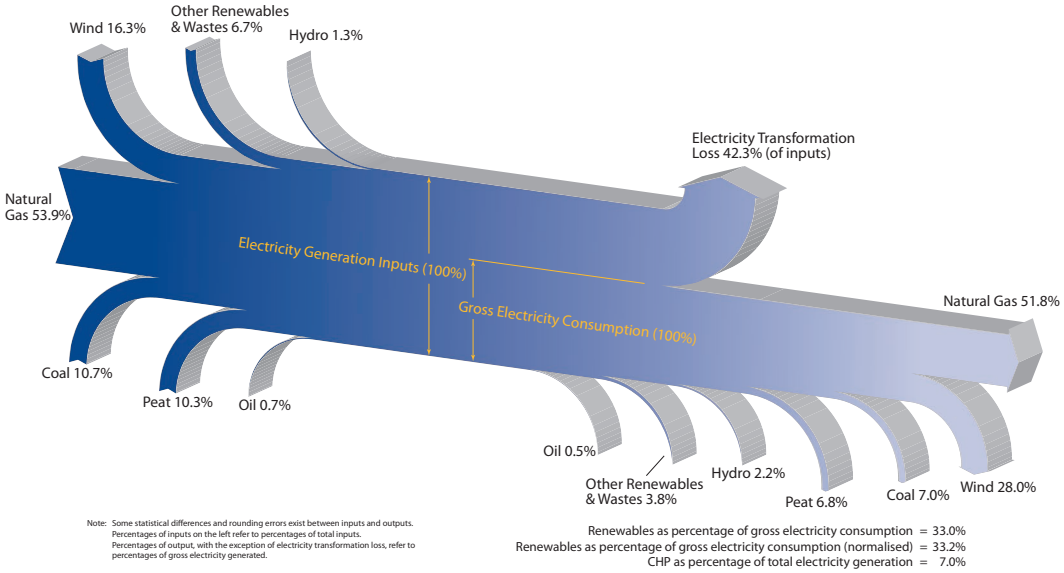
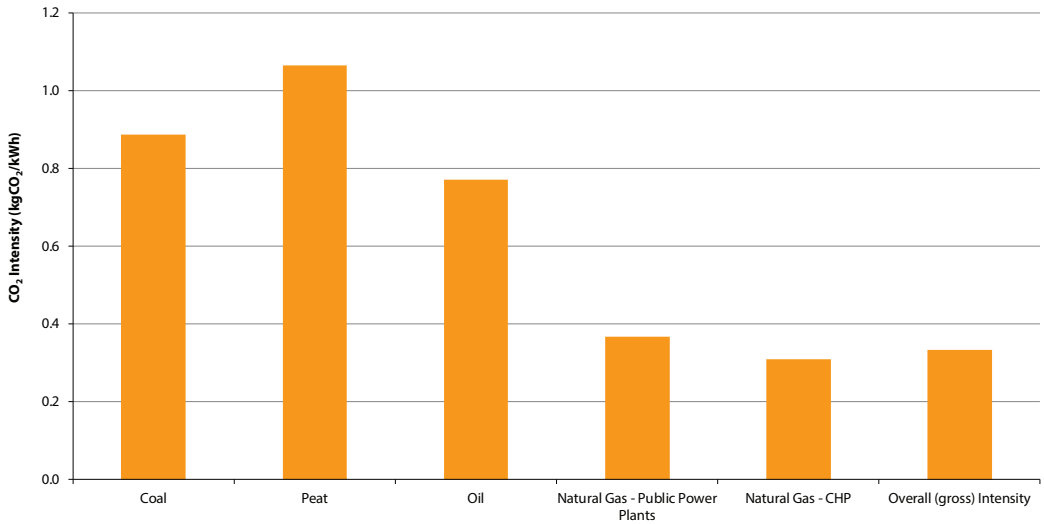


Figure 21 shows the relative emissions intensity of electricity generation from different fossil fuels in 2018. Emissions from peat were the highest, at 1,065 gCO_2/kWh, followed by coal at 886 gCO_2/kWh. Electricity generated from oil was 771 gCO_2/kWh but oil generation only made up 0.5% of the electricity generated in 2018. The emissions intensity of natural gas generation was 366 gCO_2/kWh in 2018 and the overall figure (on a gross basis) was 334 gCO_2/kWh, down from 393 gCO_2/kWh in 2017 and 430 gCO_2/kWh in 2016.

Figure 21: Gross Emissions Intensity of Electricity Generation by Fossil Fuel, 2018



Source: SEAI

Table 15: Gross Emissions Intensity of Electricity Generation by Fossil Fuel, 2005, 2010 and 2012 – 2018

CO_2 intensity of electricity generation $kgCO_2/kWh$	2005	2010	2012	2013	2014	2015	2016	2017	2018
Coal	0.868	0.950	0.906	0.889	0.934	0.907	0.920	0.931	0.886
Peat	0.987	1.082	1.100	1.069	1.060	1.059	1.084	1.104	1.065
Oil	0.752	0.712	0.725	0.705	0.723	0.653	0.724	0.740	0.771
Natural Gas	0.419	0.400	0.384	0.381	0.373	0.367	0.364	0.368	0.366
Natural Gas - Public Plants	0.419	0.407	0.392	0.390	0.382	0.375	0.366	0.370	0.368
Natural Gas - CHP	0.407	0.337	0.326	0.323	0.312	0.327	0.306	0.313	0.308
Overall	**0.554**	**0.468**	**0.467**	**0.411**	**0.404**	**0.415**	**0.430**	**0.393**	**0.334**

5.3 Energy-Related CO_2 Emissions from Heat

The heat sector consists of all energy used for heating purposes, such as space and water heating in households, commercial buildings and industry, and process heating in industry and cooking[11].

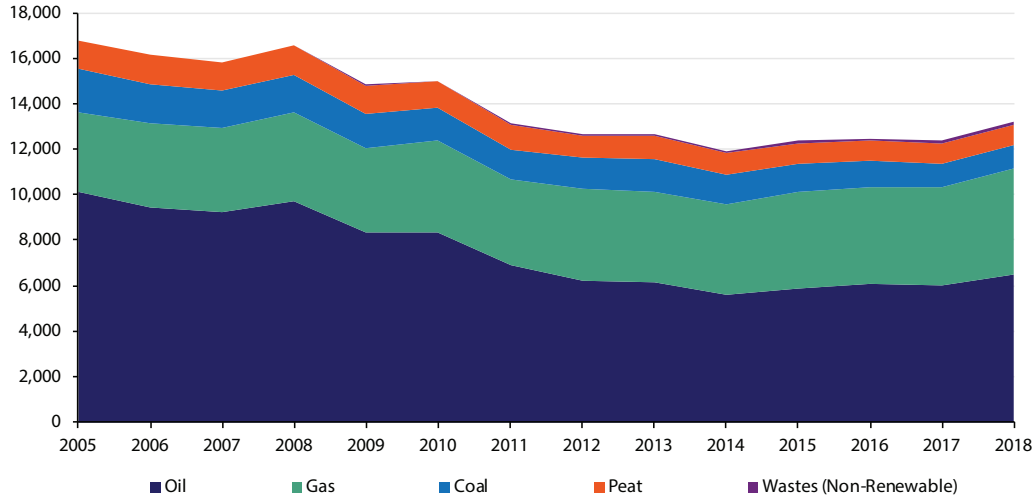
Figure 22 shows the trend in energy-related CO_2 emissions from heat demand between 2005 and 2018. CO_2 emissions from the use of fossil fuels for heat fell by 23% between 2005 and 2018, from 17 Mt to 13 Mt.

Heat energy demand declined overall between 2008 and 2014, but grew between 2014 and 2018. The CO_2 intensity of the fuel mix used for heat reduced, due mostly to a switch from oil to gas, particularly in industry and services. Although gas is a fossil fuel, it is less CO_2 intensive than oil, so a switch from oil to gas lowers average emissions, but does not eliminate them, as in the case of renewable energy.

CO_2 from oil used for heat reduced by 37% between 2005 and 2018, while CO_2 from gas increased by 31%. Oil was still responsible for the largest share of energy-related CO_2 emissions from heat in 2018, at 49%, and the second largest was from natural gas at 35%.

Overall, energy-related CO_2 emissions from heat increased by 4.8% in 2018. Emissions from peat, oil and gas increased by 0.7%, 4.7% and 7.1% respectively in 2018 while emissions from waste fell by 3.6%.

Figure 22: CO_2 Emissions by Heat Generated by Fossil Fuel



Source: SEAI

CO_2 emissions from fossil fuels used for heat reduced by 23% between 2005 and 2018, due to an overall reduction in heat use and a shift away from oil.

Table 16: Energy-Related CO_2 Emissions from Heat Generation

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Coal	-49.4	-5.1	-4.7	-3.9	-7.8	0.0	1,916	969	11.3	7.4
Peat	-28.7	-2.6	-1.4	-5.2	0.0	0.7	1,347	960	7.9	7.4
Oil	-36.8	-3.5	-4.4	-6.3	3.1	4.7	10,213	6,451	60.2	49.5
Natural Gas	30.6	2.1	2.9	2.0	0.8	7.1	3,481	4,546	20.5	34.9
Wastes	-	-	-	40.9	7.6	-3.7	0	115	0.0	0.9
Total	**-23.1**	**-2.0**	**-2.5**	**-3.3**	**1.1**	**4.8**	**16,957**	**13,042**		

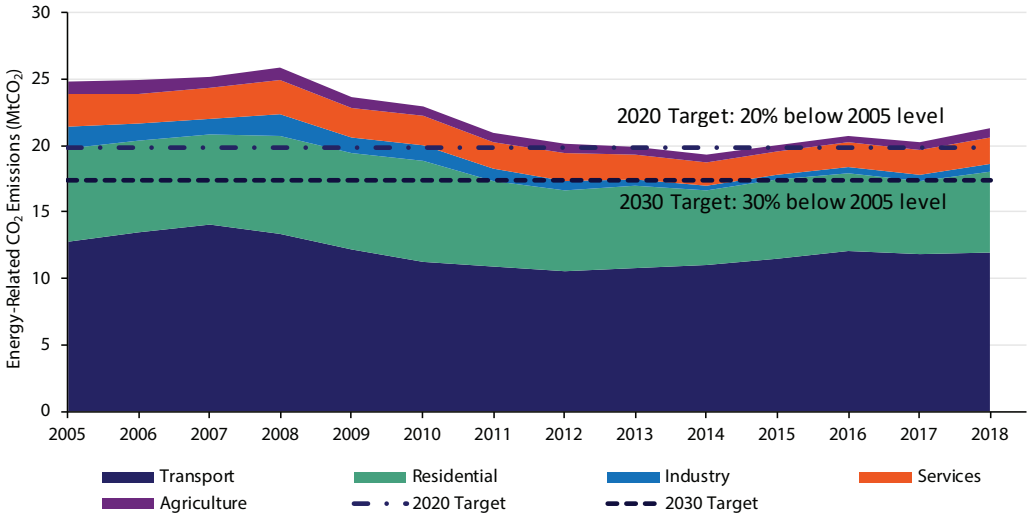
Source: SEAI

6 ETS and non-ETS Energy-Related CO_2 Emissions

The EU 2020 Climate and Energy Package[12] set a target for the EU as a whole to achieve a 20% greenhouse gas emissions reduction by 2020. The greenhouse gas emissions reductions targets are split across two categories. The first category covers large scale carbon emitters in industry, electricity generation and aviation. These bodies are dealt with at EU level under the EU Emissions Trading System (ETS). The second category covers all greenhouse gas emissions not covered by the ETS, known as the non-ETS sector. This includes the majority of greenhouse gas emissions in the residential, transport and agricultural sectors. Achieving greenhouse gas emissions reductions in the non-ETS sector is the responsibility of national governments. The Effort Sharing Decision (2009/406/EC) set a mandatory target for Ireland to reduce non-ETS emissions to 20% below 2005 levels by 2020.

Figure 23 shows the trend in non-ETS energy-related CO_2 emissions for the transport, residential, services, industry and agricultural sectors from 2005 onwards. This excludes emissions associated with electricity use by these sectors as these emissions are included in the EU ETS. It also excludes international aviation, and industry that is in the ETS.

Figure 23: Non-ETS Energy-Related CO_2 Emissions



Source: SEAI

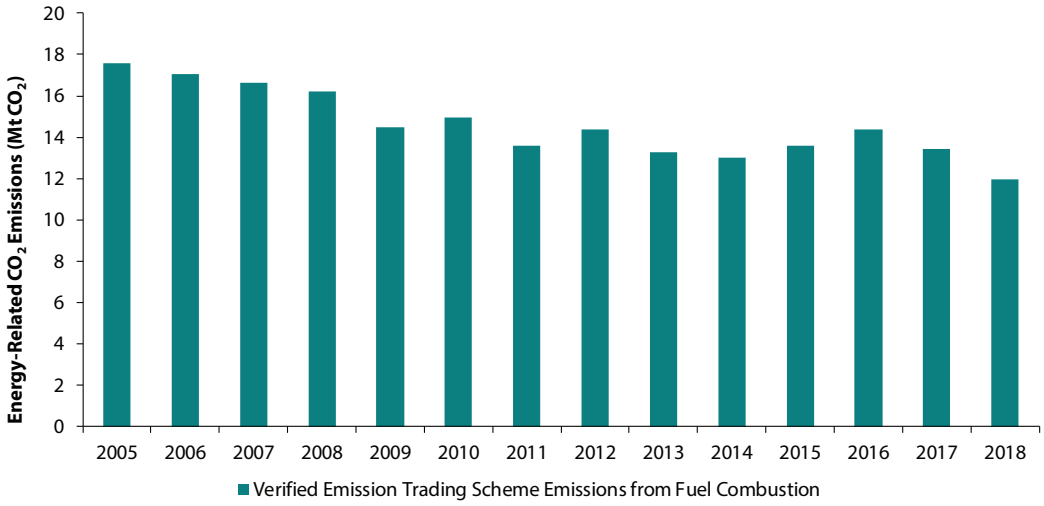
Non-ETS energy-related CO_2 emissions were 14% lower in 2018 than in 2005, however there has been an overall increase since the low point in 2014. In 2018, non-ETS energy-related CO_2 emissions increased by 4.7% compared with the previous year, due to increases in all sectors, particularly in households.

The non-ETS sector as a whole (including non-energy-related emissions from agriculture) must reduce greenhouse gas emissions to 20% below 2005 levels by 2020, and 30% by 2030. In 2018 energy-related CO_2 emissions made up 51% of all non-ETS greenhouse gas emissions. Non-energy-related agriculture emissions (mostly biogenic methane) made up 44%. There is no specific sub target for energy-related CO_2 emissions, but it is still useful to compare the trend against the overall 2020 and 2030 targets. This is illustrated in *Figure 23*. Energy-related CO_2 emissions dipped below the 2020 target in 2014, but increased to 5.7% points above it in 2018.

Non-ETS energy-related CO_2 emissions increased by 4.7% in 2018, due to increases in all sectors, particularly in households.

Figure 24 shows the trend in emissions from fossil fuel combustion from those installations included in the EU ETS in Ireland after 2005. CO_2 emissions in the ETS fell by 23% (2.0% per annum) between 2005 and 2018, from 22 Mt to 17 Mt. In 2018, emissions fell by 5.5% compared with the previous year. The share of emissions covered in the ETS in overall energy-related emissions stood at 44% in 2018.

Figure 24: Emissions Trading Scheme Emissions from Fossil Fuel Combustion — Ireland



Source: European Environment Agency based on EPA data

Table 17: Energy-Related CO_2 Emissions, ETS and non-ETS

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
ETS CO_2	-23.1	-2.0	-3.4	-1.1	**-1.2**	-5.5	22,033	16,953	47.0	44.4
Non-ETS CO_2	-14.3	-1.2	-1.6	-2.6	**1.9**	4.7	24,805	21,248	53.0	55.6
Total CO_2	**-18.8**	**-1.6**	**-2.5**	**-1.6**	**0.0**	**-1.2**	**47,543**	**38,599**		

Source: SEAI

Emissions trading is a 'cap and trade' scheme where an EU-wide limit or cap is set for participating installations. The cap is reduced over time so that total emissions fall. Within that limit 'allowances' for emissions are auctioned or allocated for free (outside the power generation sector). Individual installations must report their CO_2 emissions each year and surrender sufficient allowances to cover their emissions. If their available allowances are exceeded, an installation must purchase more. If an installation has succeeded in reducing its emissions, it can sell its leftover allowances. The system is designed to bring about reductions in emissions at the lowest possible overall cost. This system is expected to play an increasingly important role in assisting European industry in implementing the type of reductions envisaged in the European Commission's target (at least an overall 20% reduction of greenhouse gas emissions in the EU by 2020).

The EPA is responsible for the implementation of the EU ETS in Ireland, and administers the accounts on Ireland's domain in the Union Registry. Currently there are 100 stationary installations with open accounts and two more are due to open accounts this year. Fifteen aviation operators are also currently included in the scheme, including six large Irish-registered commercial airlines. In view of the much-anticipated International Civil Aviation Organisation (ICAO) agreement last year on a global market-based mechanism to address emissions from international aviation, aircraft operators were only required to report and surrender in relation to emissions from flights within the European Economic Area for 2016. A European Commission proposal to continue this reduced coverage until there is sufficient clarity about the nature and content of the legal instruments adopted by the ICAO for the implementation of the global market-based mechanism is currently being debated in the European Parliament and the EU Council.

ICAO Assembly Resolution A39-3 decided to implement a global market-based mechanism in the form of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to address any annual increase in total CO_2 emissions from international civil aviation (i.e. civil aviation flights that depart in one country and arrive in another) above 2020 levels, taking into account special circumstances and respective capabilities.

7 CO_2 Emissions Avoided through the use of Renewable Energy

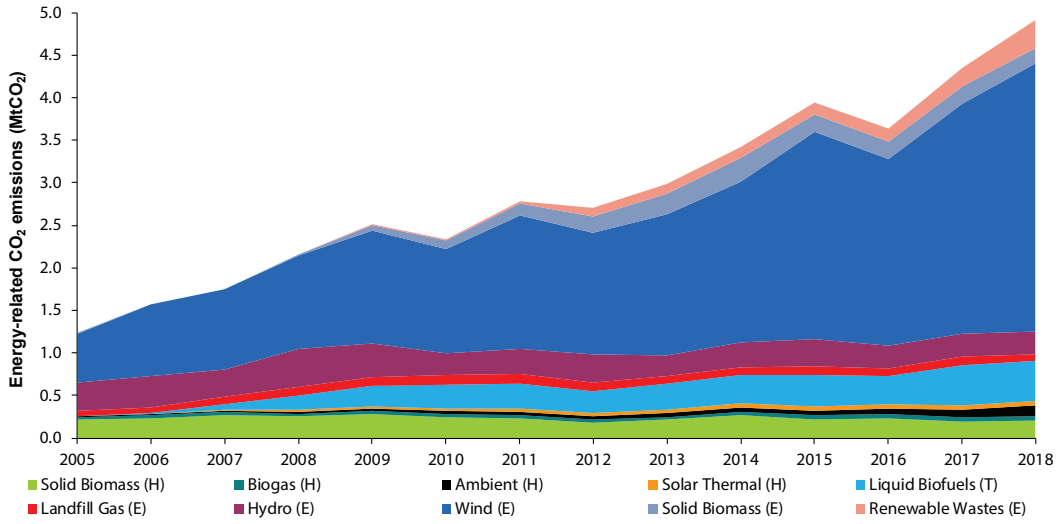
The replacement of fossil fuels with renewable zero-carbon energy sources is essential for reducing greenhouse gas emissions. It also improves energy security by reducing our reliance on imported fossil fuels. This section presents the current estimates of overall avoided emissions through the use of renewable energy in electricity generation, transport and heat markets. The methodology used to calculate the fossil fuels displaced by renewable energy is described in Appendix 2.

It is estimated that in 2018 Ireland's use of renewables displaced approximately €623 million in fossil fuel imports. Wind generated electricity was responsible for the large majority of this, avoiding €432 million of fossil fuel imports.

Figure 25 shows the trend in avoided CO_2 emissions from renewable energy for the period 2005 – 2018. The estimated amount of CO_2 avoided from renewable energy increased by 298% over the period 2005 – 2018, reaching 4,920 kt CO_2 in 2018.

Replacing fossil fuels with renewable alternatives avoided 4.9 million tonnes of CO_2 emissions in 2018, equivalent to the CO_2 from half of all houses.

Figure 25: CO_2 Emissions Avoided through the use of Renewable Energy



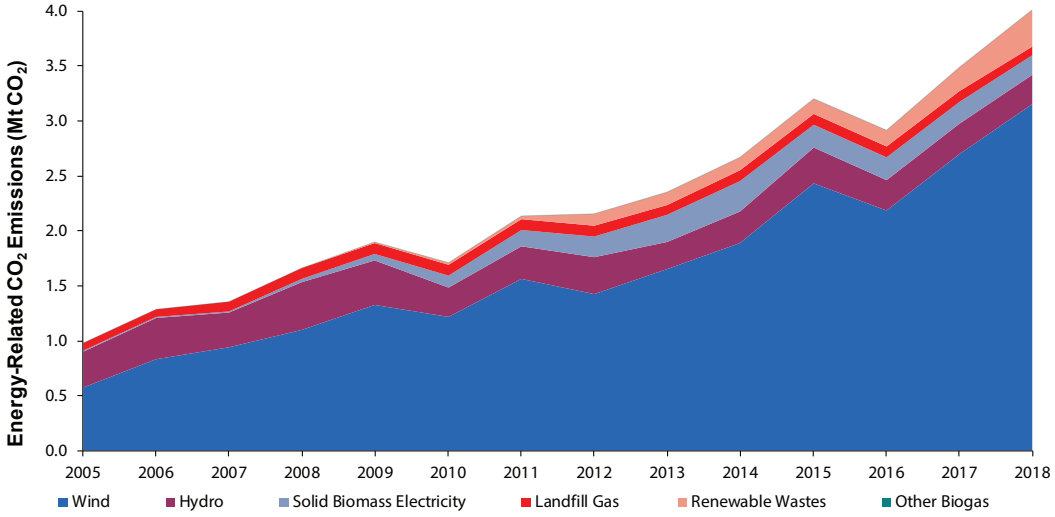
Source: SEAI

7.1 CO_2 Emissions Avoided through the use of Renewable Energy for Electricity Generation

Figure 26 shows the trend in avoided CO_2 emissions from renewable energy for the period 2005 – 2018. The estimated amount of CO_2 avoided from renewable energy use in electricity generation increased by 311%, reaching 4,016 kt CO_2 in 2018, as illustrated in *Figure 26* and *Table 18*.

In 2018, electricity generated from wind increased by 16% and, coupled with increased generation from other renewables, avoided emissions in electricity generation increased by 15%. Again, wind provided the bulk of avoided emissions at 3,149 kt CO_2 or 78% of the avoidance. Hydro, renewable waste and other renewables avoided 273 kt CO_2, 335 kt CO_2 and 259 kt CO_2 respectively in 2018.

Figure 26: CO_2 Emissions Avoided through the use of Renewable Energy for Electricity Generation



Source: SEAI

Table 18: CO_2 Emissions Avoided through the use of Renewable Energy for Electricity Generation

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Wind	445.7	13.9	16.2	14.8	8.9	16.7	577	3,149	59.1	78.4
Hydro	-16.6	-1.4	-4.5	4.4	-5.4	-0.1	328	273	33.6	6.8
Landfill Gas	23.4	1.6	10.4	-1.1	-7.3	-14.0	65	80	6.7	2.0
Solid Biomass Electricity	2700.0	29.2	76.5	13.2	-4.2	-12.3	6	178	0.7	4.4
Other Biogas	-	-	-	-	-	-	-	-	-	-
Renewable Waste	-	-	-	55.0	34.5	49.0	-	335	-	8.3
Total	**311.5**	**11.5**	**11.9**	**13.3**	**7.9**	**15.0**	**976**	**4,016**		

Source: SEAI

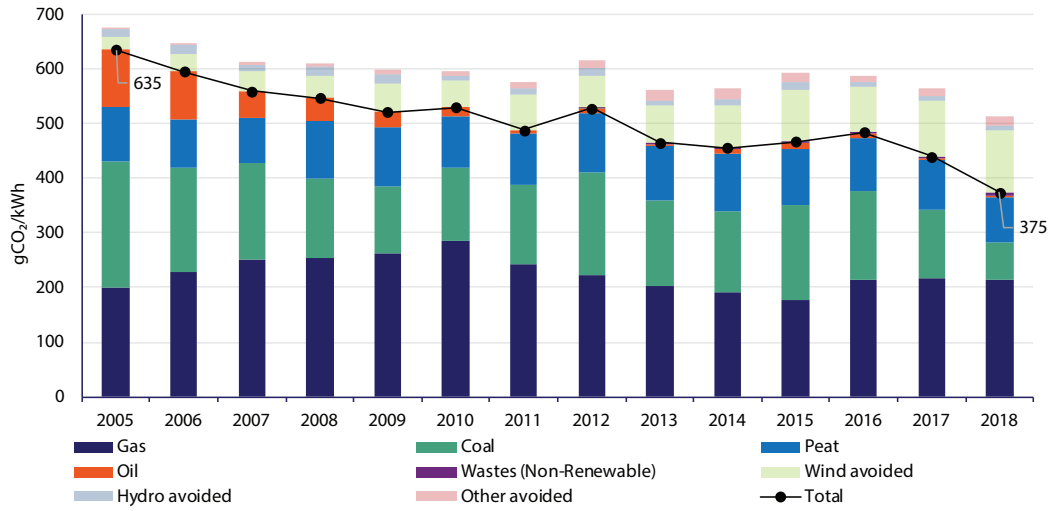
82% of CO_2 emissions avoided from the use of renewable energy were from electricity, 64% were from the use of wind.

The CO_2 emissions intensity of electricity supplied between 2005 and 2018 is shown in *Figure 27*. The intensity in 2005 was 635.4 gCO_2/kWh and by 2018 this had reduced by 41% to 375.2 gCO_2/kWh.

The stacked bars in *Figure 27* show the shares of the various fossil fuels contributing to the overall emissions intensity, as well as the reduction in intensity as a result of emissions avoided by renewable generation. It is important to note that this graph represents the shares of the fossil fuels in relation to the overall intensity, rather than the generation by the individual fuels themselves. The net overall intensity is shown as a line graph in *Figure 27*.

Electricity CO_2 emissions intensity fell to a new low of 375 gCO_2/kWh in 2018, down from 635 gCO_2/kWh in 2005.

Figure 27: CO_2 Intensity of Electricity



Source: SEAI

Table 19: CO_2 Emission Sources Contributing to Electricity CO_2 Intensity

CO_2 Intensity (gCO_2/kWh)	2005	2010	2012	2013	2014	2015	2016	2017	2018
Coal	230.0	133.4	187.1	155.0	149.3	173.0	164.9	126.9	69.4
Peat	100.3	93.2	110.3	99.4	106.9	104.3	95.9	89.4	81.2
Oil	104.2	17.0	7.0	5.4	7.5	10.4	8.1	3.9	3.9
Gas	200.9	286.2	223.0	203.8	190.3	177.6	213.1	216.2	213.6
Waste (Non-Renewable)	-	-	1.6	2.0	2.1	2.0	2.0	4.4	7.0
Net Overall Intensity	**635.4**	**529.8**	**489.0**	**530.0**	**467.2**	**454.9**	**464.9**	**480.4**	**436.6**
Wind (avoided)	23.9	48.2	58.7	67.5	76.4	95.3	83.5	101.0	112.0
Hydro (avoided)	13.6	10.3	13.7	10.1	11.7	12.6	10.3	10.2	10.0
Other Renewables (avoided)	3.0	9.1	16.3	18.2	20.0	17.3	9.8	12.2	15.3

Source: SEAI

Since 1990 the share of high carbon content fossil fuels, such as coal and oil, has 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 under the United Nations Framework Convention on Climate Change (UNFCCC) and UN Intergovernmental Panel on Climate Change (IPCC) reporting guidelines as emissions are counted in the jurisdiction in which they are emitted. This resulted in the carbon intensity of electricity dropping by 58%, from 896 gCO_2/kWh in 1990, to a low of 375 gCO_2/kWh in 2018.

The reasons for the decrease in carbon intensity of electricity in 2018 were a:

- 44% reduction in coal use in generation (11% share of inputs);
- 16% increase in wind generation (16% share of inputs);
- 16% increase in bioenergy use in generation (4.7% share of inputs);
- 3.3% reduction in peat use in generation (10.3% share of inputs);
- 0.4% increase in hydro generation (1.3% share of inputs);
- 95% reduction in net exports of electricity.

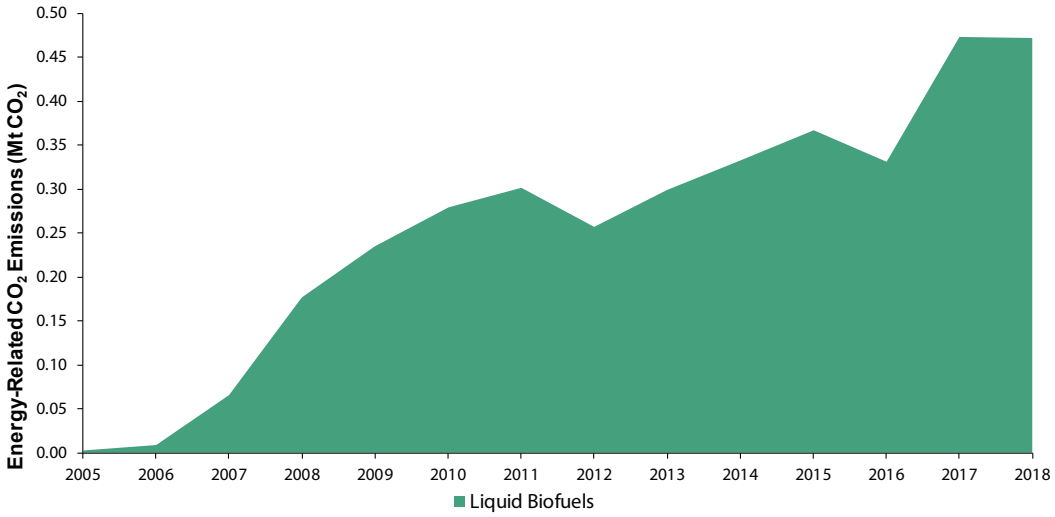
Countering these were a:

- 1.5% increase in gas used in generation, increasing the gas share in fuel inputs to 54%;
- 61% increase in the use of non-renewable waste (2% share of inputs);
- 2.3% increase in oil use in generation (0.8% share of inputs).

7.2 CO_2 Emissions Avoided through the use of Renewable Energy for Transport

The avoided CO_2 emissions associated with biofuels are accounted for in this analysis according to the UNFCCC reporting guidelines. Thus the CO_2 avoided from bioethanol in transport is equated with CO_2 emissions that would have arisen from petrol consumption, and CO_2 avoided from biodiesel and pure plant oil is determined from the diesel consumption displaced[13].

Figure 28: CO_2 Emissions Avoided through the use of Renewable Energy for Transport



Source: SEAI

The use of biofuels in transport only began in 2005. Directive 2009/28/EC established a mandatory minimum 10% target for the contribution of renewable energy in the final consumption of energy in road and rail transport by 2020. In order to provide incentives to achieve the 2020 target, a Mineral Oil Tax Relief Scheme was introduced in 2005. In 2010 a Biofuel Obligation Scheme was established that 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 certificate based. It grants one certificate for each litre of biofuel placed on the market in Ireland. Two certificates are granted to biofuel that is produced from wastes and residues. Oil companies and consumers are required to apply to the National Oil Reserves Agency (NORA) and 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), the companies are also required to show that the biofuel placed on the market is sustainable. 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% by volume in 2013, 8% from 1 January 2017 and 10% from 2019.

Table 20: CO_2 Emissions Avoided through the use of Renewable Energy for Transport

	Growth %	Average annual growth rates %					Quantity (kt CO_2)	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018
Liquid Biofuels	14,011	46.3	142.4	5.6	8.7	-0.3	3.3	471

Source: SEAI

Emissions avoided by the use of liquid biofuels in transport grew from 3.3 kt in 2005 to 471 kt in 2018. Avoided emissions in transport fell by 0.3% in 2018.

The use of biofuels in transport was down in 2018 compared with 2017 as a result of certificates being carried forward from previous years to meet 2018 obligations. Of the required certificates for 2018, 16% were carried forward from 2016 and 2017 (as allowed for under the Biofuel Obligation Scheme).

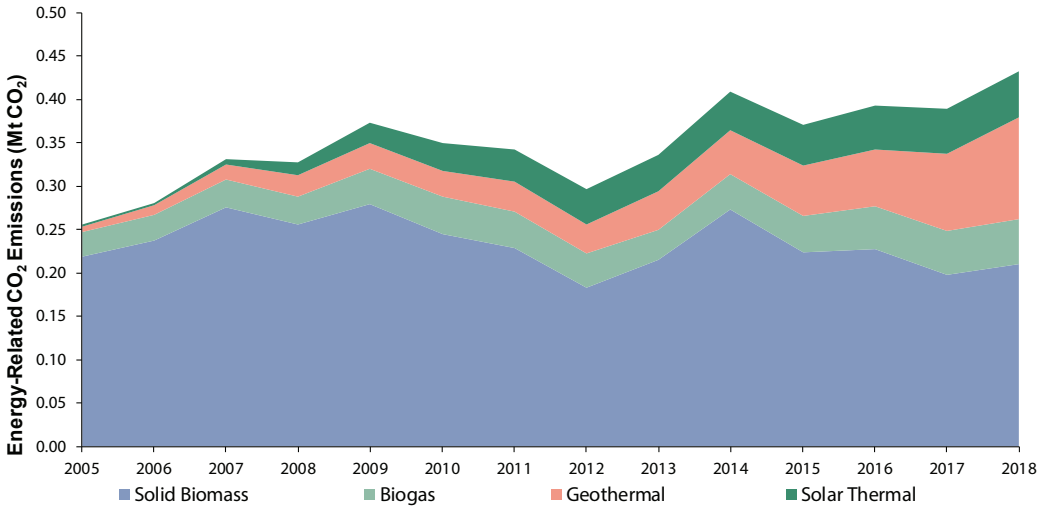
7.3 Avoided CO_2 Emissions in Heat

It is assumed that the thermal energy from renewable energy (solid biomass, biogas, geothermal, solar and renewable waste) displaces thermal energy from oil-fired boilers. The CO_2 avoided from thermal renewable energy is equated with the CO_2 emissions that would have arisen from this oil consumption.

The exception is the use of solid biomass in the wood processing industry. In this case we assume that the biomass used does not displace fossil fuel, as biomass has traditionally been used for heat in this sector. This is significant because solid biomass used in the wood processing industry accounted for 42% of all renewable heat energy in 2018.

Figure 29 shows the estimated avoided emissions in the heat sector through the use of renewable energy sources. The use of renewables for thermal applications increased by 65% between 2005 and 2018, while the associated CO_2 emissions from heat fell by 21%.

Figure 29: CO_2 Emissions Avoided through the use of Renewable Energy for Heat



Source: SEAI

Table 21: CO_2 Emissions Avoided through the use of Renewable Energy for Heat[14]

	Growth %	Average annual growth rates %					Quantity (kt CO_2)		Shares %	
	2005 – 2018	'05 – '18	'05 – '10	'10 – '15	'15 – '18	2018	2005	2018	2005	2018
Solid Biomass	-3.6	-0.3	2.3	-1.8	-2.0	6.3	219	211	85.6	48.8
Biogas	80.2	4.6	8.8	-0.9	7.3	2.1	29	52	11.2	11.9
Ambient Heat / Geothermal	1843.7	25.6	36.8	14.8	26.6	32.3	6	116	2.3	27.0
Solar Thermal	2,386.1	28.0	72.5	7.9	3.6	2.1	2	53	0.8	12.3
Total	**69.2**	**4.1**	**6.5**	**1.2**	**5.2**	**11.1**	**255**	**432**		

Source: SEAI

Overall emissions avoided through the use of renewable energy for heat grew by 69% between 2005 and 2018, from 255 kt to 432 kt. The largest share of avoided emissions from the use of solid biomass was 211 kt in 2018. The use of geothermal and ambient energy (heat pumps) accounted for 27% of the avoided emissions in 2018, at 116 kt, while solar thermal avoided 53 kt (12.3% share).

14 Figures presented have been revised downwards since the last edition of this report as a result of changes to the methodology for estimating ambient heat from heat pumps and solar thermal.

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 (gCO_2/kWh): This is the amount of CO_2 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.

Combined heat and power (CHP) plants: Combined heat and power (CHP) refers to plants that generate electricity and usable heat in a single process. In conventional electricity generation much of the input energy is lost to the atmosphere as waste heat. CHP systems channel this lost heat to useful purposes, increasing the overall efficiency.

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

Modified domestic demand: Modified domestic demand is an indicator of economic activity. It was introduced by the Central Statistics Office (CSO) as an alternative to GDP, in order to more accurately reflect the level of activity in the domestic economy, and to remove the distorting effects of globalisation.

Total final consumption: 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: 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): The non-renewable portion of wastes used as an energy source.

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.

Energy Conversion Factors

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

Decimal Prefixes

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

Emission Factors

	t CO_2/TJ (NCV)	g CO_2/kWh (NCV)
Liquid Fuels		
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
Naphtha	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		
(2018)	104.2	375.2

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Energy Balance 2018

kilo tonnes of oil equivalent (ktoe)	Coal	Peat	Oil	Natural Gas	Renewables	Non-Renew/Waste	Electricity	Total
Indigenous Production	0	816	0	2,752	1,326	145		5,040
Imports	845	0	9,099	1,728	150		139	11,962
Exports	15	7	1,717		9		142	1,891
Mar. Bunkers	0	0	162					162
Stock Change	-106	-123	160	0	4			-64
Primary Energy Supply (incl. non-energy)	**725**	**686**	**7,380**	**4,480**	**1,471**	**145**	**-2**	**14,885**
Primary Energy Requirement (excl. non-energy)	**725**	**686**	**7,148**	**4,480**	1,471	145	**-2**	**14,653**
Transformation Input	**489**	**540**	**3,127**	**2,501**	**213**	**91**	**54**	**7,015**
Public Thermal Power Plants	489	467	34	2,188	204	91		3,472
Combined Heat and Power Plants	0	5	1	273	9			287
Pumped Storage Consumption							43	43
Briquetting Plants	0	68	0		0			68
Oil Refineries and other energy sector	0	0	3,092	41	0		11	3,144
Transformation Output	**0**	**65**	**3,167**	**0**	**73**	**26**	**1,873**	**5,203**
Public Thermal Power Plants	0	0	0		68	26	1,668	1,668
Combined Heat and Power Plants – Electricity	0	0	0		5		185	185
Combined Heat and Power Plants – Heat					0			0
Pumped Storage Generation							20	20
Briquetting Plants		65	0		0			65
Oil Refineries		0	3,167		0			3,167
Exchanges and Transfers	**22**	**0**	**-24**	**0**	**-804**	**0**	**804**	**-2**
Electricity					-804		804	0
Heat								0
Other	22		-24		0			-2
Own Use and Distribution Losses	**0**	**11**	**93**	**58**	**0**		**259**	**421**
Available Final Energy Consumption	**258**	**199**	**7,303**	**1,921**	**454**	**55**	**2,362**	**12,551**
Non-Energy Consumption	**0**	**0**	**232**	**0**	**0**	**0**	**0**	**232**
Final non-Energy Consumption	0	0	232	0	0			232
Total Final Energy Consumption	**261**	**197**	**7,065**	**1,948**	**464**	**55**	**2,334**	**12,324**
Industry	**105**	**1**	**516**	**790**	**198**	**55**	**936**	**2,601**
Non-energy mining			34	13	0		67	114
Food, beverages and tobacco	19	1	136	111	26		201	494
Textiles and textile products			3	1	0		12	16
Wood and wood products			3	2	129		40	175
Pulp, paper, publishing and printing			3	4	0		22	29
Chemicals and man-made fibres			28	69	0		171	268
Rubber and plastic products			10	5	0		41	56
Other non-metallic mineral products	87		193	18	43	55	60	456
Basic metals and fabricated metal products			10	422	0		71	503
Machinery and equipment n.e.c.			6	6	0		24	35
Electrical and optical equipment			46	131	0		116	292
Transport equipment manufacture			5	2	0		20	27
Other manufacturing			40	7	0		91	138
Transport	**0**	**0**	**5,020**	**23**	**154**	**0**	**5**	**5,202**
Road Freight			697		30			727
Light Goods Vehicles (LGV)			318	0	14			332
Road Private Car			1,979		78		1	2,058
Public Passenger Services			134		6			139
Rail			38		0		4	42
Domestic Aviation			6		0			6
International Aviation			1,097		0			1,097
Fuel Tourism			177		8			184
Navigation			84		0			84
Unspecified			490	23	20			533
Residential	**155**	**197**	**1,059**	**604**	**68**		**703**	**2,786**
Commercial/Public Services	**0**	**0**	**268**	**532**	**43**	**0**	**642**	**1,484**
Commercial Services	0	0	177	233	35		460	905
Public Services	0	0	91	299	8		182	579
Agricultural	**0**	**0**	**175**	**0**	**0**		**48**	**223**
Fisheries	**0**	**0**	**27**		**0**			**27**
Statistical Difference	-3	2	6	-27	-10	0	27	-5

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 http://www.seai.ie/

Appendix 1: Indicators of Economic Growth

The relationship between economic activity and energy demand is less straightforward in Ireland than it is for most other countries. Gross Domestic Product (GDP) is the most widely accepted measure of economic activity, but in Ireland it is strongly influenced by the activities of multinational companies. Some of the activities of these companies result in large amounts of value added, but very little consumption of energy. This was very well illustrated in 2015 when GDP grew by 25% as a result of the transfer into Ireland of intellectual property. Therefore, care must be taken when comparing macro-economic indicators, such as energy per unit GDP, across countries.

The Central Statistics Office (CSO) have developed new indicators of economic activity as alternatives to GDP, to more accurately reflect the level of activity in the domestic economy, and to remove the distorting effects of globalisation. One such alternative indicator is modified domestic demand, first published in the Quarterly National Accounts results for Quarter 1 2017. In contrast to GDP, modified domestic demand grew by 5.3% in 2015.

When comparing economic growth to energy use, we have chosen to use modified domestic demand, as it better reflects the changes in activity that relate to energy use. Previous editions of this report presented another economic indicator, modified gross national income (GNI*), as an alternative to GDP. For more information on the differences between GDP, GNI* and modified domestic demand refer to the CSO.

Appendix 2: Displacement of Fossil Fuels by Renewable Energy

SEAI estimates the amount of fossil fuel use that is avoided through the use of renewable energy, and the resulting reduction in CO_2 emissions. To do this, we are required to make a number of assumptions about which fossil fuels are displaced by each renewable energy source.

Renewable Heat and Transport

Renewable transport is the most straightforward. We assume that biodiesel and biogasoline replace conventional diesel and petrol respectively.

Renewable thermal energy is assumed to displace thermal energy from oil-fired boilers. The exception is the use of solid biomass in the wood processing industry. In this case we assume that the biomass used does not displace fossil fuel, as biomass has traditionally been used for heat in this sector. This is significant because solid biomass used in the wood processing industry accounted for 58% of all renewable thermal energy in 2017. Biomass used for heat generation in CHP is assumed to displace heat from oil-fired boilers.

Renewable Electricity

Variable Renewable Generators

For renewable electricity, there are a number of considerations. The first is what type of fossil fuel electricity generation is being displaced by renewables. Previously, we assumed that each kWh of electricity generated from non-combustible renewable generation displaced a kWh of electricity from across the entire fossil fuel plant mix. The methodology used now draws on approaches that have been developed for use in baselining studies in credit-based emissions-trading systems[15,16]. Variable renewable energy generators primarily displace electricity from the last fossil fuel plant dispatched to meet electricity demand, also known as the marginal generator. In Ireland these are mostly gas generators.

A further consideration is the interaction between variable renewable electricity generation and both fossil fuel generation and cross-border trade. The simple approach of assuming that a unit of electricity from renewables displaces a unit of electricity from fossil fuel generators cannot account for these complex interactions. To accurately account for these interactions a full dispatch model of the Irish electricity system is required.

SEAI conducted such an analysis for a single year (2012) using a detailed dispatch model. This work is presented in the SEAI report *Quantifying Ireland's Fuel and CO_2 Emissions Savings from Renewable Electricity in 2012,* which was published in May 2014[17,18]. The advantage of such a model is that it is capable of comprehensively accounting for the extensive range of dynamic factors that influence the interaction of renewable plant and fossil fuel generators and which affect the savings attributed to renewable generation, such as ramping and cycling effects, contingency reserve, network constraints, cross-border electricity trade, etc.

The disadvantage of dispatch models is that because of the level of detail involved, they are labour-intensive to build, update and maintain. For this reason, it is not practical to routinely use a dispatch model to estimate the annual avoided fossil fuel usage and carbon emissions from renewable energy. Instead, the results of the single-year analysis using the dispatch model have been used to inform and refine the results of the simplified approach, particularly by enabling the emissions resulting from ramping and cycling of fossil fuel plants in response to renewable electricity generation to be estimated and accounted for. There are clear limitations in this analysis but it does provide useful indicative results.

On this basis we assume that renewable hydro and wind electricity generation displaces electricity production from natural gas, which is assumed to be the marginal fossil fuel generator. We further assume that wind generation results in a 5% increase in the energy intensity of the remaining fossil fuel electricity generation mix, due to increased cycling and ramping effects.

Renewable CHP

Biomass used for electricity generation in CHP is assumed to displace electricity production from gas, as the marginal generator.

Biomass Co-firing with Peat

Biomass used for co-firing with peat was assumed to displace peat up until 2015. From 2016 onwards biomass co-fired with peat is assumed to displace natural gas.

Bioenergy CO_2 Accounting

For combustible renewables, such as solid biomass and liquid biofuels used for heat, transport or electricity, we use the standard carbon dioxide accounting rules that are used to calculate Ireland's greenhouse gas emissions targets[19]. Therefore as long as a biofuel meets the minimum sustainability requirements set out in the Renewable Energy Directive it is counted as zero carbon at the point of combustion.

19 Decision 406 of 2009, on the effort of Member States to reduce their greenhouse gas emissions to meet the EU's greenhouse gas emission reduction commitments up to 2020, requires Ireland to reduce greenhouse gas emissions from non-ETS sectors (i.e. sectors outside of the EU Emissions Trading Scheme) by 20% below 2005 levels by 2020.

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