RENEWABLE ENERGY IN IRELAND

2019 Report

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January 2019

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Sustainable Energy Authority of Ireland

The 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, advising policymakers and informing investment decisions. SEAI's core statistics functions are to:

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

Acknowledgements

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

Highlights

Progress towards targets, 2017

- Overall renewable energy supply was 10.6% of gross final consumption. Ireland has a binding EU target of 16% by 2020.
- The share of renewable transport energy (RES-T), including adjustments, was 7.4%. Ireland has a binding EU target of 10% by 2020.
- The share of renewable electricity (RES-E) was 30.1%. Ireland has a national target of 40% by 2020.
- The share of renewable heat (RES-H) was 6.9%. Ireland has a national target of 12% by 2020.
- Ireland is not on track to meet 2020 renewable energy targets.

Benefits of renewable energy

- Renewable energy displaced 1.8 Mtoe of fossil fuel consumption and avoided 4.2 MtCO_2 of greenhouse gas emissions in 2017. This was equivalent to 11% of total energy-related CO_2 emissions.
- 80% of CO_2 emissions avoided from the use of renewable energy in 2017 were from electricity generation. Reducing the carbon intensity of electricity is critical for meeting Ireland's climate change objectives.

Renewable transport

- More than 99% of RES-T in 2017 was from bioenergy, almost 90% was from biodiesel and 10% was from biogasoline.
- 84% of liquid biofuels used in transport in 2017 were imported.
- Less than 1% of renewable transport energy is from electricity. Most electricity used for transport is used by DART and Luas, but EVs are growing quickly from a low base.

Renewable heat

- The amount of renewable energy used for heat increased by 67% between 2005 and 2017, but the portion of total energy used for heat that was from renewable energy increased by 100%. This is because the total amount of energy used for heat decreased.
- The greatest increase in renewable heat energy has been from the use of renewable wastes in cement manufacture.
- Renewable ambient energy captured by heat-pumps increased over two-and-a-half times between 2010 and 2017. There has been a large increase in the use of air-source heat-pumps in the residential sector.

Renewable electricity

- 62% of renewable energy in 2017 was renewable electricity.
- Wind generated 25% of all electricity in 2017, second only to natural gas.
- A record high of 532 MW of wind-generation capacity was installed in 2017.

EU comparison, 2016

- Ireland was 22nd out of the EU-28 for overall renewable energy share.
- Ireland was 26th out of the EU-28 for progress towards overall 2020 renewable energy target.
- Ireland was 27th out of the EU-28 for RES-H.
- Ireland was 13th out of the EU-28 for RES-E.
- Ireland was 18th out of the EU-28 for RES-T.

Key Figures for Renewable Energy

Data from 2017

Progress towards targets

	2017	2020 TARGETS
Overall Renewable Energy	10.6%	16.0%
Renewable Transport	7.4%	10.0%
Renewable Heat	6.9%	12.0%
Renewable Electricity	30.1%	40.0%

Almost

90%

of our renewable energy comes from:

WIND

SOLID BIOMASS

LIQUID BIOFUELS

4.2 **$MtCO_2$**

in avoided CO_2 emissions from renewable energy which is equivalent to removing

70% **of private cars off the road**

* The latest data from Europe is from 2016.
All other data is 2017.

Renewable Transport

Transport has the
biggest
share of energy use but **smallest** share of renewables

over **99%**
of renewable energy in transport was from bioenergy, including biodiesel and biogasoline

The number of electric cars increased
64%
in 2017 to 2,718

Renewable Heat

Ireland was
27th
out of the 28 EU countries for renewable heat in 2016*

Almost 80%
of renewable energy for heat is solid biomass

28%
increase in renewable heat from heat pumps

Renewable Electricity

Almost 1/3 of electricity comes from renewables

Renewable electricity displaced
€278m
of fossil fuel imports

Ireland had the
third highest
share of wind generated electricity out of the 28 EU countries in 2016*…

…but was **13th**
in overall renewable electricity

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1 Overall renewable energy

This section shows overall renewable energy use from 2000 to 2017. It examines Ireland's progress towards our 2020 renewable energy targets. It presents data on overall renewable energy use split by electricity, heat, and transport, and also by energy source.

1.1 Progress towards renewable energy targets

The Renewable Energy Directive (RED)[1] is the most important legislation influencing the growth of renewables in the European Union (EU) and Ireland.[2] The RED sets out two mandatory targets for renewable energy in Ireland to be met by 2020.

The first relates to overall renewable energy share (RES), and is commonly referred to as the overall RES target. For Ireland, the overall RES target is for at least 16% of Ireland's gross final energy consumption (GFC)[3] to come from renewable sources in 2020.

The second mandatory target set by the RED relates to the renewable energy used for transport. This is commonly referred to as the RES-T target. The RES-T target is for at least 10% of energy consumed in road and rail transport to come from renewable sources.[4]

In addition to these EU mandatory targets, Ireland has two further national renewable energy targets for 2020 . These are for the electricity and heat sectors and are designed to help Ireland meet the overall RES target.

The renewable electricity target is commonly referred to as the RES-E target. The RES-E target is for 40% of gross electricity consumption to come from renewable sources in 2020.[5]

The renewable heat target is commonly referred to as the RES-H target. The RES-H target is for 12% of energy used for heating and cooling to come from renewable sources in 2020.

Table 1 shows progress towards the individual modal targets and towards the overall RES target for select years between 2000 and 2017.[6] The last column shows the targets for 2020.

Ireland is not on track to meet its 2020 renewable energy targets.

Table 1: Progress towards renewable energy targets[7], 2000 to 2017

Target	2000	2005	2010	2015	2016	2017	2020 target
RES-T (with weighting factors)	0.0%	0.0%	2.5%	5.9%	5.2%	7.4%	10.0%
RES-H	2.4%	3.4%	4.3%	6.2%	6.3%	6.9%	12.0%
RES-E (normalised)	4.8%	7.2%	15.6%	25.5%	26.8%	30.1%	40.0%
Overall RES	**1.9%**	**2.8%**	**5.7%**	**9.1%**	**9.2%**	**10.6%**	**16.0%**

Source: SEAI

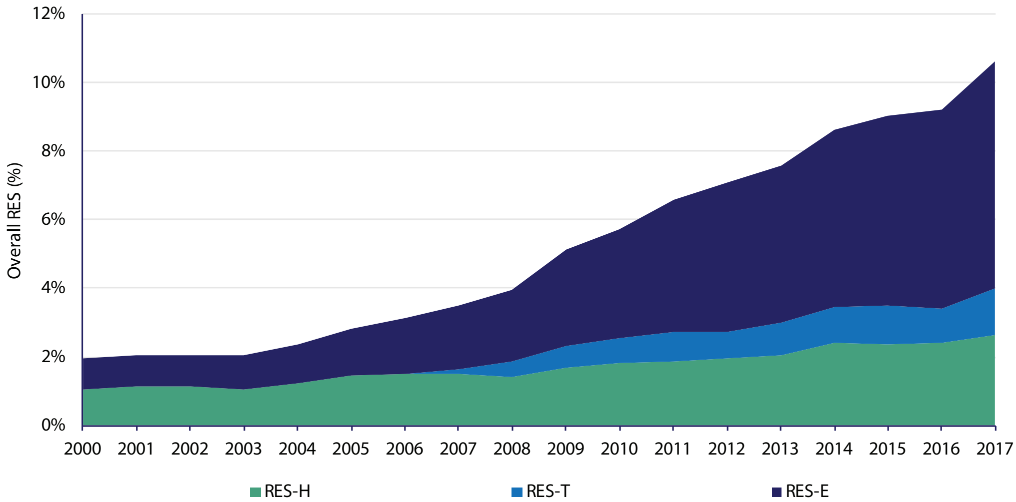
With three years remaining to reach the target, Ireland is not on track to meet any of its 2020 renewable energy targets. Projections of Ireland's renewable energy use in 2020 are covered by a separate SEAI report titled "National Energy Projections to 2030".[8] The projections report discusses in more detail possible future trajectories for renewable energy, while this report focuses on the current levels of renewable energy use, presenting the most recent data for 2017 and the trend since 2000.

1 Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Available from: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0028
2 Statutory Instrument (SI) 147 gives effect to the RED in Irish law.
3 Total primary energy requirement (TPER) is a measure of all energy inputs, including energy that is lost during transformation before it is used by the final customer. Total final consumption (TFC) is a measure of the energy used by final customers only, i.e. excluding the losses from transformation. Gross final consumption (GFC) of energy is an alternative to TFC and is the denominator used by the EU to track progress towards the targets in the EU renewable energy directive (RED).
4 Weighting factors specified in the RED for electricity and advanced biofuels are used in the calculation of the RES-T target. However, these weightings do not apply to the transport contribution to the overall RES target.
5 For the calculation of RES-E, the energy produced from hydro and wind is normalised to even out the effects of high or low wind or rainfall.
6 Note that the individual targets cannot be added to get the overall renewables contribution.
7 Note that individual target percentages are not additive.
8 Available from: https://www.seai.ie/resources/publications/National-Energy-Projections-to-2030.pdf

Figure 1 shows the annual percentage of renewable energy as calculated for the overall RES target.[9] This is split into the three modes: electricity, transport and heat energy. *Table 2* provides further data on the quantities and growth rates of each of these modes. Renewable electricity has been responsible for most of the overall growth in renewable energy since 2000. It was the largest source of renewable energy in 2017, accounting for 62% of total renewable energy. Renewable transport continued to make the smallest contribution, at 13% of renewable energy.

62% of renewable energy in 2017 was renewable electricity.

Figure 1: Renewable energy (normalised) by mode, 2000 to 2017



Source: SEAI

Table 2: Renewable energy (normalised) by mode, 2000 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2000	2010	2017	2000	2010	2017	'00-'17	'10-'17	'00-'10	'10-'17	2017
RES-H	118	218	310	54%	31%	25%	164%	42%	6.4%	5.2%	10.0%
RES-T	0	93	161	0%	13%	13%	-	73%	-	8.2%	35.6%
RES-E	99	385	776	46%	55%	62%	686%	101%	14.6%	10.5%	14.0%
Overall RES	**216**	**696**	**1,247**	**-**	**-**	**-**	**476%**	**79%**	**12.4%**	**8.7%**	**15.3%**

Source: SEAI

9 Wind and hydro energy are normalised; weighting factors for renewable transport energy are not applied.

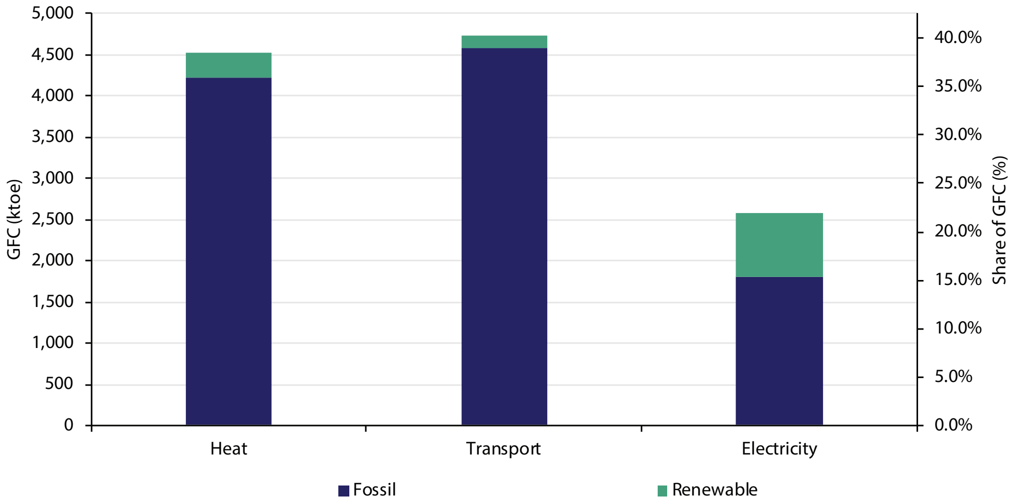
Figure 2 illustrates the total GFC in each mode according to the RED calculation, and the portion of each mode that comes from renewable sources. Significant progress has been made in increasing the share of renewable electricity, but electricity only accounted for 21% of GFC in 2017.

Transport was the mode with the largest share of GFC[10], accounting for 40% of total GFC in 2017. Just 3.4% of this transport GFC was from renewable sources.[11]

Heat accounted for 39% of GFC and 6.9% of this was from renewable sources.

In 2017, 3.4% of transport GFC was from renewable energy. Including the multipliers and other adjustments allowed in the RES-T calculation, RES-T was 7.4%.

Figure 2: Renewable and fossil GFC by mode, 2017



Source: SEAI

10 This graph shows the quantity of GFC for each mode according to the calculation of the denominator for the overall RES target. According to this methodology: aviation is limited to 6.18% of TFC; marine bunkers are excluded; and calorific values for gasoline and diesel as specified in the Directive are applied (these are different to those used in the national energy balance).

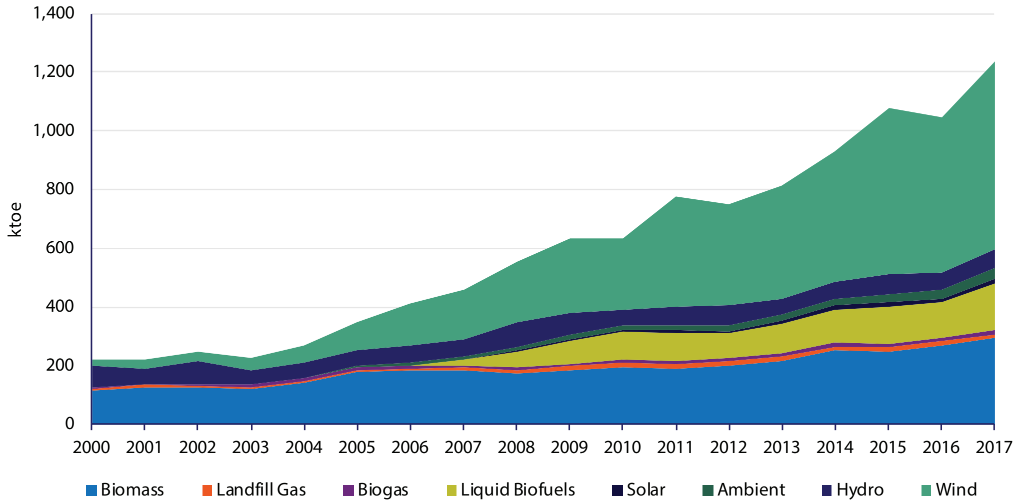
11 The RES-T share was 7.4% in 2017. There are two main differences between the calculation of the RES-T target and the overall RES target. Firstly, the RES-T calculation includes the use of multipliers or weighting factors specified in the RED for electricity and advanced biofuels in the numerator, but not the overall RES calculation. Secondly, the RES-T calculation does not include any aviation in the denominator, but the overall RES calculation includes aviation, limited to 6.18% of TFC.

Figure 3 and *Table 3* show the actual amount of renewable energy used each year, split by source.[12] Wind and hydro have not been normalised, so the actual variation in production from year to year can be seen.

Most of the growth in renewable energy has come from wind. Wind provided 52% of all renewable energy in 2017. Solid biomass and bioliquids were the next largest sources of growth. Bioenergy, including biomass, landfill gas, biogas and bioliquids, collectively accounted for 39% of renewable energy in 2017.

52% of all renewable energy in 2017 was from wind; 39% was from bioenergy.

Figure 3: Renewable energy use, 2000 to 2017



Source: SEAI

Table 3: Renewable energy use by source, 2000 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2000	**2010**	**2017**	**2000**	**2010**	**2017**	**'00-'17**	**'10-'17**	**'00-'10**	**'10-'17**	**2017**
Biomass	113	196	292	52%	31%	24%	158%	49%	5.6%	5.9%	8.7%
Landfill gas	8	16	13	4%	2%	1%	63%	-15%	6.7%	-2.3%	-3.6%
Biogas	4	10	13	2%	2%	1%	212%	30%	9.1%	3.8%	2.3%
Liquid biofuels	0	93	161	0%	15%	13%	-	73%	-	8.2%	35.6%
Total bioenergy	**126**	**315**	**480**	**57%**	**50%**	**39%**	**282%**	**52%**	**9.6%**	**6.2%**	**15.8%**
Hydro	73	52	59	33%	8%	5%	-18%	15%	-3.4%	2.1%	1.6%
Wind	21	242	640	10%	38%	52%	2951%	164%	27.7%	14.9%	21.1%
Solar	0	8	14	0%	1%	1%	-	80%	51.4%	8.8%	7.5%
Ambient	0	16	41	0%	2%	3%	-	163%	78.5%	14.8%	27.9%
Total	**220**	**631**	**1,236**	**100%**	**100%**	**100%**	**463%**	**96%**	**11.1%**	**10.1%**	**17.9%**

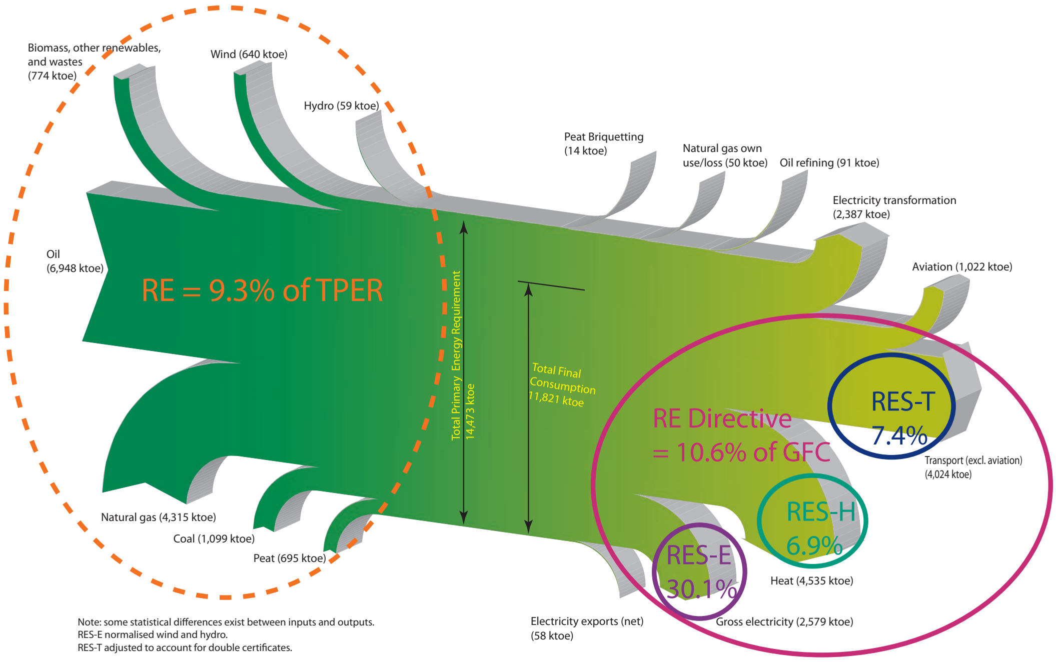
Source: SEAI

12 Ambient energy is the energy that heat pumps use to provide useful heat. It typically comes from freely available but low-grade energy from the outside environment: from air, water, or ground. It can also come from waste energy streams such as exhaust gases or waste water.

1.2 Renewables in the context of overall energy use

The Sankey diagram in *Figure 4* illustrates where the various renewable targets fit within overall energy use in Ireland and the progress towards those targets in 2017. Towards the left of *Figure 4* the overall contribution of renewable energy to TPER is shown at 9.3%. While there is no specific target for this measure it does help to illustrate the position of renewables in Ireland's overall energy. Towards the right of *Figure 4* the current percentages for renewables in transport, heat and electricity with respect to GFC are shown, as well as the percentage of overall renewables. The formulae set out in the RED to calculate these percentages are explained in Appendix 1. Each of the three modes is discussed in more detail in the sections *3*, *4* and *5*.

Figure 4: Renewable energy status in Ireland, 2017



Source: SEAI

2 Displacement of fossil fuels and CO_2 emissions

This section shows how the use of renewable energy displaces the use of fossil fuels. This avoids CO_2 emissions, reduces Ireland's fossil fuel imports and improves energy security.

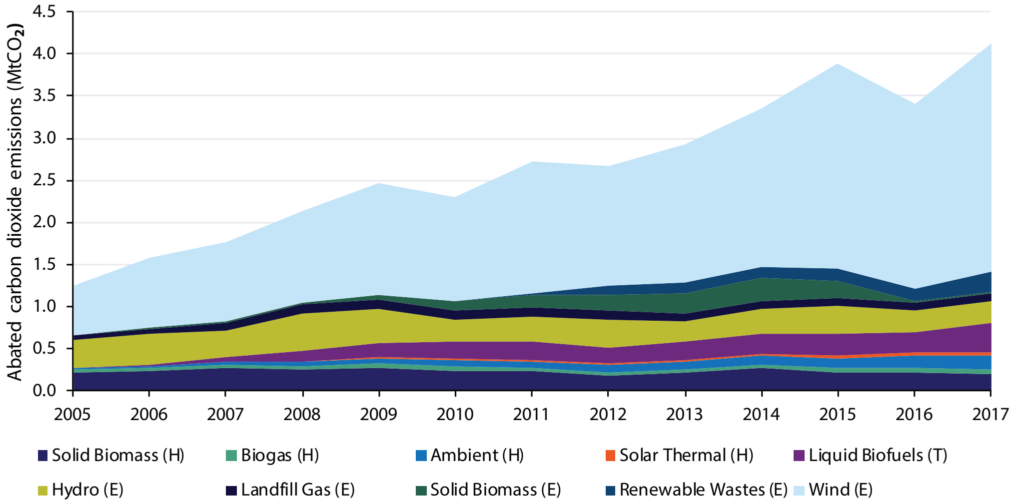
2.1 Avoided CO_2 emissions

Figure 5 shows the annual CO_2 emissions that were avoided from the use of renewable energy[13], across all sectors, from 2005 to 2017.

We estimate that renewable energy displaced 1.8 Mtoe of fossil fuel consumption and avoided 4.2 million tonnes of CO_2 ($MtCO_2$) in 2017. This was equivalent to 11% of total energy-related CO_2 emissions in 2017. We estimate that in 2017 wind energy displaced 1.1 Mtoe of fossil fuel and avoided 2.7 $MtCO_2$, or 65% of the total CO_2 avoided by renewables. 80% of the CO_2 emissions avoided by renewable energy were from renewable electricity.

Electricity generation is covered by the EU emissions trading system (ETS), therefore CO_2 emissions savings achieved in electricity generation do not count directly towards Ireland's EU targets to reduce greenhouse gas (GHG) emissions outside of the ETS (non-ETS). However, decarbonising the electricity system combined with increased electrification of heat and transport through the use of electric vehicles (EV) and heat pumps is an important part of the strategy for decarbonising the energy system as a whole. The use of renewable electricity at current levels helps ensure that switching to EVs and heat pumps does not result in greater CO_2 emissions than the fossil fuel alternative. Electrification of heat and transport also reduces direct fossil fuel use in the non-ETS sector, thereby contributing to meeting the non-ETS GHG emissions reduction target.

Figure 5: Avoided CO_2 from renewable energy, 2005 to 2017



Source: SEAI

Renewable energy avoided 4.2 million tonnes of CO_2 emissions in 2017. 80% of this was in electricity generation. Reducing the carbon intensity of electricity is critical for meeting Ireland's climate change objectives.

13 This only considers CO_2 emissions that result directly from combustion of fossil fuels, and does not consider for non-CO_2 GHG emissions such as NO_x or CH_4.

The methodology used to calculate the fossil fuels displaced by renewable energy is described in Appendix 2. The main assumptions are as follows:

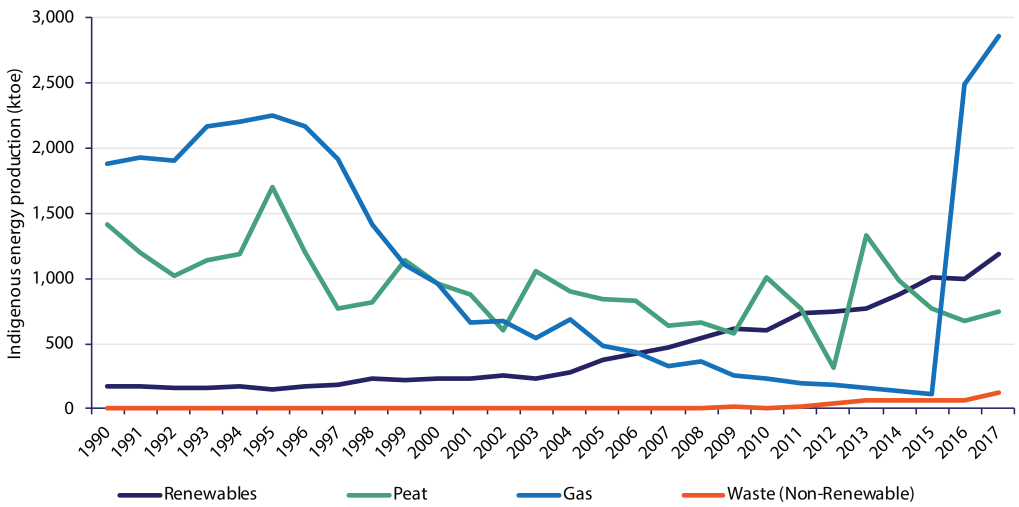
- Renewable hydro and wind electricity generation displace electricity production from natural gas, which is assumed to be the marginal fossil fuel generator. We further assume that wind-generation results in a 5% increase in the energy intensity of the remaining fossil fuel electricity generation mix, due to cycling and ramping effects.[14]
- Biomass used for electricity generation in combined heat and power plants (CHP) is assumed to displace electricity production from gas, as the marginal generator.
- Biomass used for heat generation in CHP is assumed to displace heat from oil-fired boilers.
- Biomass used for co-firing with peat was assumed to displace peat up until 2015. From 2016 onwards biomass co-fired with peat is not assumed to achieve CO_2 savings, due to the ending of the Public Service Obligation (PSO) support for peat.[15]
- Renewable heat energy is assumed to displace heat 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 heat energy in 2017.
- Renewable liquid biofuels used for transport (biodiesel and biogasoline) displace diesel and petrol.
- For combustible renewables, such as solid biomass and liquid biofuels, we use the standard carbon dioxide accounting rules that are used to calculate Ireland's GHG emissions targets. Therefore, as long as a biofuel meets the minimum sustainability requirements set out in the RED, it is counted as zero carbon at the point of combustion.

2.2 Contribution to indigenous energy

Most of the renewable energy used in Ireland is produced or harnessed directly in Ireland. This indigenous energy does not need to be imported from other countries. The main exceptions are liquid biofuels, most of which are imported, along with some solid biomass. Increasing the deployment of indigenous renewable energy reduces the need for energy imports and improves energy security.

Figure 6 shows Ireland's indigenous energy production by source from 1990 to 2017. Historically, peat was the main indigenous energy source in Ireland. Peat production fluctuates significantly from year to year, partly due to the fact that the harvesting of peat can be adversely affected by poor weather and so peat tends to be stockpiled in years with good weather.

Figure 6: Indigenous energy production by source, 1990 to 2017



Source: SEAI

Production of natural gas from the Kinsale gas field began in the late 1970s, peaked in 1995, and declined sharply from then on. In 2016, gas from the Corrib gas field was first brought on stream, and gas regained its position as the largest source of indigenous energy. Production from the Corrib gas field is expected to peak before 2020 and to decline thereafter.

14 See Appendix 2 for further information on the rationale for this.
15 Ibid.

Indigenous renewable energy has grown steadily since the 1990s. By 2015 it had surpassed peat and accounted for over half of all indigenous energy that year, but was overtaken by gas from the Corrib gas field in 2016.

In 2015 renewable energy was Ireland's largest source of indigenous energy production, before being surpassed by natural gas from the Corrib gas field in 2016.

3 Renewable energy in transport

This section shows Ireland's progress towards the renewable transport target and gives information on the sources of renewable transport energy.

Transport has by far the highest fossil fuel dependency, lowest degree of electrification and lowest share of renewable energy compared with the other major economic sectors (residential, industry, services), or compared with the other modes (heat, electricity). In 2017, 97% of transport energy was from oil-based products. It is also the sector with the largest energy demand, accounting for 42% of final energy demand in 2017 or 40% of GFC as per the RED.

3.1 Progress towards renewable transport target

The RED established a mandatory minimum target of 10% for the share of all petrol, diesel, biofuels and electricity consumed in road and rail transport to come from renewable energy by 2020. The RED also specifies a number of weightings or multipliers that can be applied to certain fuels. These weightings help to incentivise these fuels, and also make it easier to meet the RES-T target. A weighting factor of 2 is applied to advanced biofuels and biofuels from waste. A weighting of 2.5 is applied to electricity from renewable energy sources consumed by electric rail transport, and a weighting of 5 is applied to electricity from renewable sources consumed by electric cars. The share of electricity that comes from renewable sources in a particular year is taken to be the share that was measured two years before the year in question.[16]

Figure 7 and *Table 4* below show the progress towards the RES-T target, with and without the weightings applied.[17] In 2017 RES-T stood at 7.4%, compared to the 2020 target of 10%. To understand the year-to-year variations in RES-T, we must look in more detail at policies in place for the different fuel types.

RES-T was 7.4% in 2017; the 2020 target is 10%.

Figure 7: Progress towards renewable transport energy target, 2005 to 2017

Source: SEAI

Table 4: Progress towards renewable transport target, 2005 to 2017

Share of renewable transport	2005	2010	2011	2012	2013	2014	2015	2016	2017
RES-T with weightings	0.0%	2.5%	3.8%	4.0%	4.9%	5.2%	5.9%	5.2%	7.4%
RES-T without weightings	0.0%	2.4%	2.7%	2.4%	2.8%	3.1%	3.3%	3.0%	4.1%

Source: SEAI

16 These weightings only apply to the RES-T target, not to the transport contribution to the overall RES target.

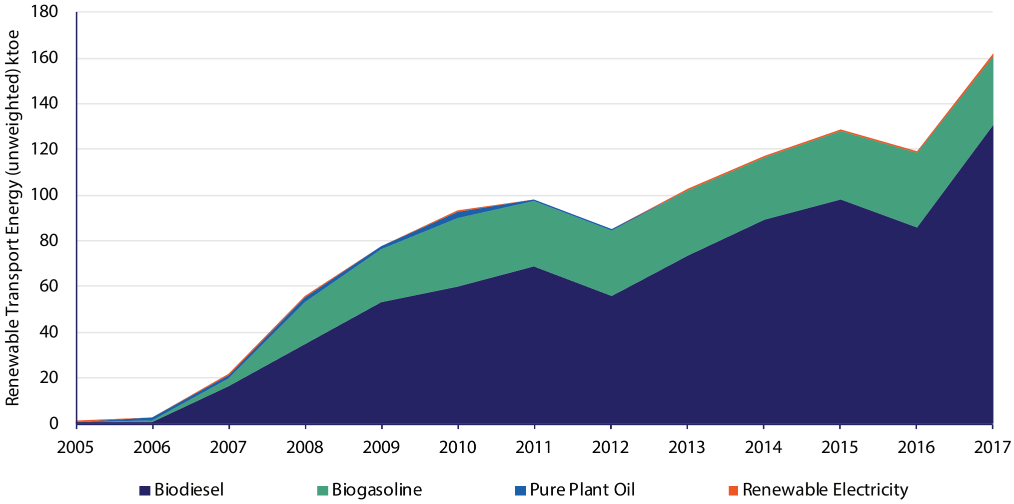
17 Aviation is not included in the denominator for either of these. For the overall RES target, aviation is included in the denominator, limited to 6.18% of TFC.

Figure 8 and *Table 5* show renewable transport energy in absolute energy terms without weightings applied. More than 99% of renewable transport energy was from biofuels in 2017, 81% was from biodiesel and 18% was from biogasoline. The remainder was from renewable electricity. There were noticeable drops in biofuel use in 2012 and 2016; these are explained in Section *3.2*.

> More than 99% of RES-T in 2017 was from bioenergy, and almost 90% was from biodiesel.

Table 6 shows the equivalent amounts of renewable energy with the weightings applied. With weightings, biodiesel made up almost 90% of the contribution towards RES-T in 2017.

Figure 8: Renewable transport energy (without weightings), 2005 to 2017



Source: SEAI

Table 5: Renewable transport energy (without weightings) by source, 2010 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2010	2015	2017	2010	2015	2017	'10-'17	'15-'17	'10-'15	'15-'17	2017
Biodiesel	60	98	131	65%	76%	81%	118%	33%	10.3%	15.5%	53%
Biogasoline	30	30	30	32%	23%	18%	-2%	-1%	-0.2%	-0.4%	-10%
Pure plant oil	2	0	0	2%	0%	0%	-100%	-	-100.0%	-	-
Renewable electricity	0	1	1	0%	1%	1%	170%	43%	13.5%	19.7%	15%
Total renewable transport	**93**	**129**	**162**	**100%**	**100%**	**100%**	**74%**	**25%**	**6.7%**	**12.0%**	**35%**

Source: SEAI

Table 6: Renewable transport energy (with weightings) by source, 2010 to 2017

	Quantity (ktoe)			Shares %			Growth %		Average annual growth rates %		
	2010	2015	2017	2010	2015	2017	'10-'15	'15-'17	'10-'15	'15-'17	2017
Biodiesel	60	196	262	64%	86%	89%	336%	34%	26.6%	15.7%	52%
Biogasoline	30	30	30	32%	13%	10%	-2%	-1%	-0.2%	-0.4%	-10%
Pure Plant Oil	2	0	0	2%	0%	0%	-100%	-	-100.0%	-	-
Renewable Electricity	1	2	3	1%	1%	1%	206%	54%	14.8%	24.0%	20%
Total renewable transport (weighted)	**94**	**228**	**295**	**100%**	**100%**	**100%**	**215%**	**30%**	**19.4%**	**13.8%**	**42%**
RES-T (%)	**2.5%**	**5.9%**	**7.4%**								

Source: SEAI

3.2 Biofuels

Since 2010, suppliers of oil products as road transport fuels in Ireland are required to blend biofuels with the fossil fuel they sell. This scheme is known as the Biofuels Obligation Scheme (BOS) and is administered by the National Oil Reserves Agency (NORA).[18] Fuel suppliers are granted certificates for each litre of biofuel blended that meets the minimum sustainability requirements laid out in the RED and in the indirect land-use change (ILUC) Directive.[19] First-generation biofuels that meet the sustainability requirements are awarded one certificate per litre. Two certificates are supplied for each litre advanced biofuels and biofuels from waste, in line with the weightings specified in the RED. Virtually all biodiesel used in Ireland has qualified for double certificates since 2012, with 100% qualifying in 2016 and 2017, as shown in *Table 7*. In contrast, no bio-gasoline qualifies for double certificates. SEAI uses the NORA data for the amounts of biofuels used in Ireland.

Table 7: Proportion of liquid biofuels used in transport with double certificates, 2011 to 2017

	2011	2012	2013	2014	2015	2016	2017
Bioethanol	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Biodiesel	58.0%	98.7%	99.6%	85.9%	99.1%	100.0%	100.0%

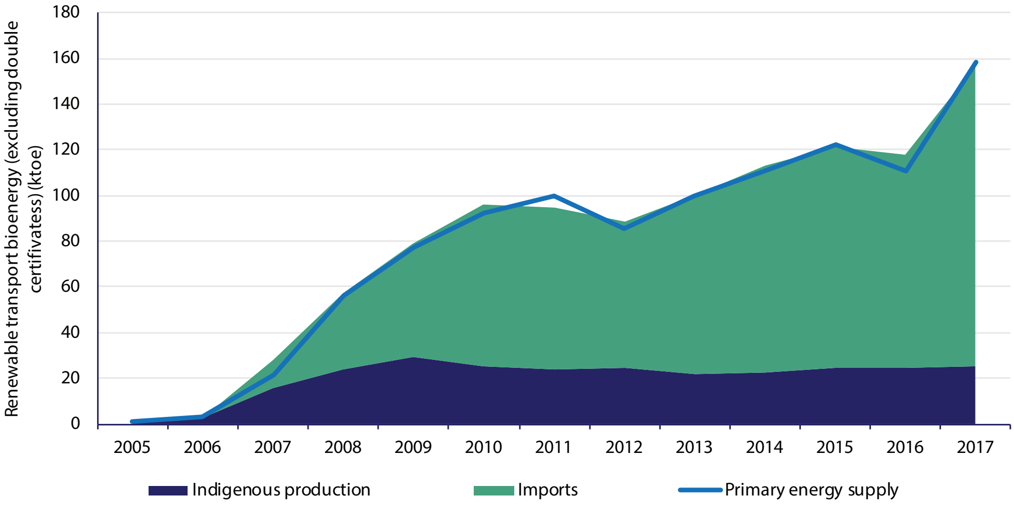
Source: NORA

The obligation was set at 4.167% in volume terms in 2010, 6.383% from 2013 and 8.696% from 2017. This meant that in 2017, each supplier had to submit eight certificates for every 92 litres of fossil fuel sold. The obligation increased further to 11.111% in January 2019 and it is expected that the obligation will increase further to 12.360% in January 2020.[20] There was a noticeable drop in the use of biofuels in 2016. This was as a result of the carry forward of certificates to meet the biofuel obligation in 2016 from previous years. 20% of the required certificates for 2016 were carried forward from 2014 and 2015 as allowed for under the BOS. There was also a drop in the use of biofuels in 2012. The amount of biodiesel which was eligible for double certification increased from 58% in 2011 to 99% in that year. This substantially reduced the actual amount of biodiesel required to be placed on the market in order to satisfy the biofuel obligation.

100% of biodiesel in 2016 and 2017 qualified for double certificates.

Figure 9 shows the amount of liquid biofuels used in transport that are imported and produced indigenously.[21] Indigenous liquid biofuel production has remained relatively constant since 2008, at between 20 and 30 ktoe per annum. This is in spite of increasing demand for liquid biofuels due to the BOS. All indigenous liquid biofuel used in transport has been in the form of biodiesel since 2009. 20% of biodiesel supply in 2017 was from indigenous production. This meant that 16% of all liquid biofuels used in transport in 2017 were produced indigenously, with 84% imported.

Figure 9: Biofuels production, imports and usage, 2005 to 2017



Source: SEAI

18 Prior to 2010, transport bioenergy was incentivised through the Mineral Oil Tax Relief Scheme.
19 Directive (EU) 2015/1513
20 Department of Communications, Climate Action and Environment *Biofuels Obligation Scheme Policy Statement*. Available from: https://www.dccae.gov.ie/en-ie/energy/publications/Pages/Biofuel-Obligation-Scheme-Policy-Statement.aspx [Accessed 10 January 2019].
21 The sum of indigenous production and imports does not always equal the primary energy use in a given year due to stock changes.

3.3 Renewable electricity in transport

The traditional users of electricity for transport in Ireland have been urban rail services, first the DART and from 2004 onwards the Luas, as shown in *Figure 10*.

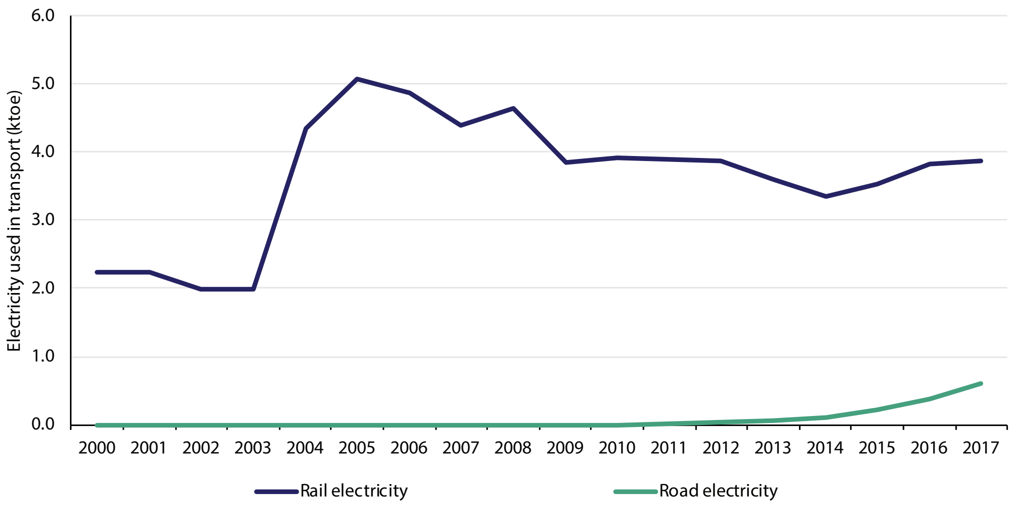
The numbers of electric vehicles (EVs), and their electricity use, remains small, but is growing fast. In 2017 there were 2,718 EVs licensed, up from 1,659 in 2016.

SEAI receives data on the electricity use of the DART and Luas from Irish Rail and Transdev. SEAI estimates the energy consumption of electric vehicles based on the numbers of EVs, an estimate of the annual km driven per EV based on data from the NCT database, and an estimate of the average energy consumption per km of EVs.[22]

Rail transport consumed 44.9 GWh (3.9 ktoe) of electricity in 2017 and SEAI estimate that EVs consumed 7.0 GWh (0.6 ktoe). Only the renewable portion of electricity (as measured two years before the year in question) used in rail and road counts towards the RES-T. In 2017 this was 1.0 ktoe for electric rail and 0.2 ktoe from EVs.[23]

Most electricity used for transport is by DART and LUAS, but EVs are growing quickly from a low base.

Figure 10: Electricity used in transport, 2000 to 2017



Source: SEAI

22 To improve this estimate, more data is needed on annual average kilometres driven for EVs less than four years old before they have their first NCT and on the real-world electricity consumption per kilometre driven.

23 Note that as this renewable electricity is already counted under RES-E, it does not count towards the overall RES target, to avoid double counting.

4 Renewable energy in heat

This section presents the latest data on the share of renewable heat energy, the sectors where it is used and the energy sources used.

In the context of renewable energy, the terms "heat energy" and "thermal energy" are often used interchangeably and they refer to energy used for heating and cooling. Examples include energy used for space and water heating in homes and businesses, cooking, air conditioning, high-temperature process heat in industry, etc.[24]

Thermal/heat energy is the second largest of the three modes of energy. It accounted for 37% of the final energy demand in 2017. The residential sector has the largest demand for heat energy, accounting for 42% of final heat energy in 2017, followed by industry, which accounted for 36%. Heat energy was once dominated by oil, accounting for 60% in 2000, followed by gas at 24%. Since 2005, oil use has fallen and gas has continued to increase so that in 2017, oil accounted for 43% and gas accounted for 40%.

4.1 Progress towards renewable heat target

Although there is no mandatory target for RES-H set in the RED, Ireland has set a target of 12% RES-H to help deliver the overall mandatory target of 16% renewable energy by 2020. *Figure 11* and *Table 8* show the trend for RES-H[25] between 2005 and 2017, divided by source.

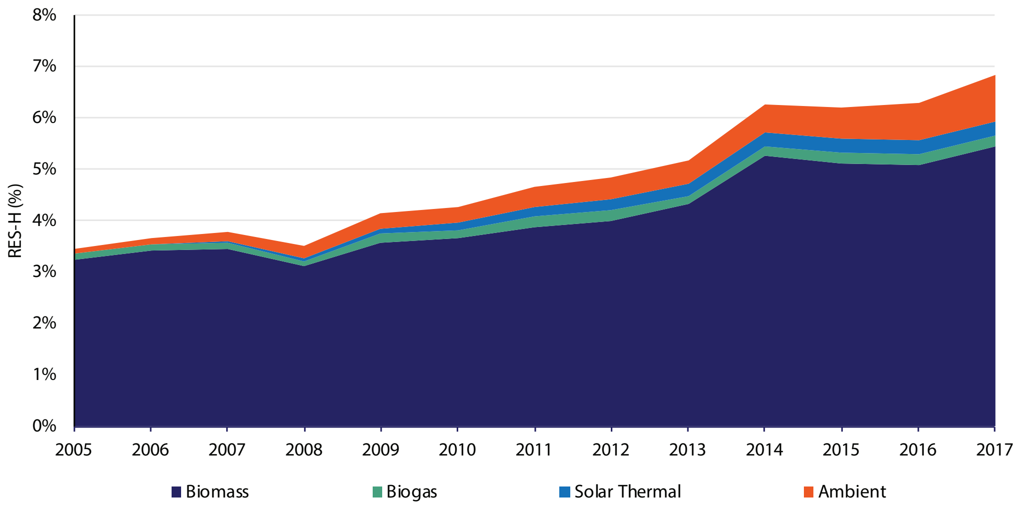
Unlike RES-T, the calculation of RES-H excludes renewable electricity used for heating and cooling.

Renewable heat energy is dominated by solid biomass use, in particular in industry. The use of ambient energy (ground-source and air-source) has grown ten-fold between 2005 and 2017 and is now a significant source of renewable heat energy, accounting for approximately 13% of renewable heat energy in 2017.

RES-H was 6.9% in 2017; the target for 2020 is 12%.

RES-H as a share of heat GFC increased from 3.4% in 2005 to 6.9% in 2017. This was a doubling in the share, or an increase of 100%. The absolute increase in the use of renewable heat energy over the same period was 67%, in terms of energy. The difference was due to the reduction in overall heat energy demand between 2005 and 2017. This highlights that greater energy efficiency in buildings helps Ireland to meet the national renewable heat target, as well as the binding overall RES target.

Figure 11: Percentage RES-H by source, 2005 to 2017



Source: SEAI

24 It is calculated as the residual energy requirement when energy use from transport and electricity generation are subtracted from the total final energy consumption.

25 As per the RED calculation; see Appendix 2

Table 8: Renewable heat energy by source, 2005 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2005	2010	2017	2005	2010	2017	'05-'17	'10-'17	'05-'10	'10-'17	2017
Biomass	176	187	247	94%	86%	79%	40%	32%	1.2%	4.1%	7.9%
Biogas	7	8	10	4%	4%	3%	41%	16%	3.9%	2.2%	4.7%
Solar thermal	0	7	14	0%	3%	5%	-	91%	74.7%	9.7%	4.6%
Ambient	4	16	41	2%	7%	13%	875%	163%	29.9%	14.8%	27.9%
Total renewable heat	**187**	**218**	**312**	**100%**	**100%**	**100%**	**67%**	**43%**	**3.1%**	**5.2%**	**10.0%**
RES-H (%)	**3.4%**	**4.3%**	**6.9%**	-	-	-	-	-	-	-	-

Source: SEAI

Figure 12 and *Table 9* show renewable heat energy by sector and industrial sub-sector. In 2017, most renewable heat energy was still used in industry; between 2005 and 2017, most of the growth was in the residential and commercial sectors, along with cement production (non-metallic minerals sector).

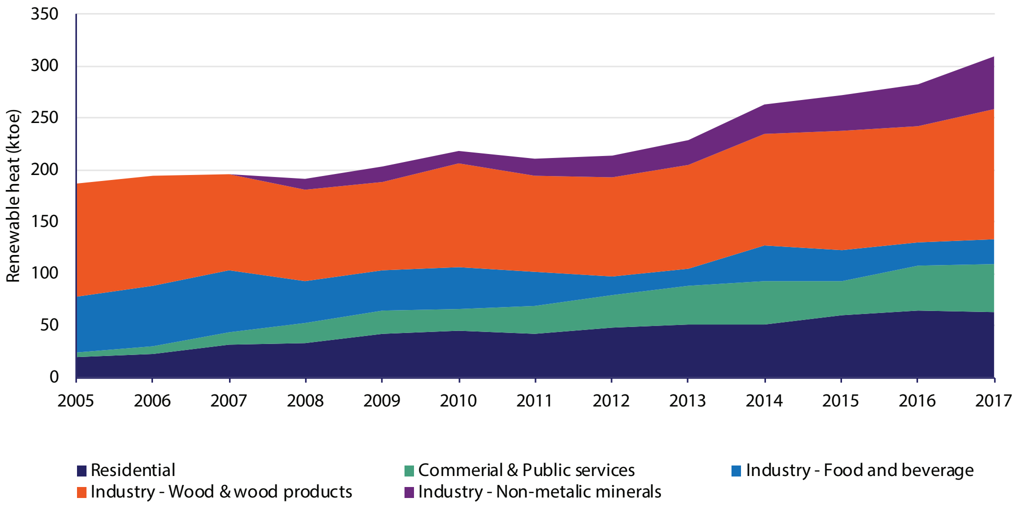
Renewable heat use in the residential sector declined by more than half between 1990 and 2005 due to decreased use of wood in open fires, but increased by 229% between 2005 and 2017.[26] This increase has been due to increased use of wood, including wood chips and wood pellets; solar thermal for water heating; and, increasingly, ambient energy from heat pumps.

Renewable heat increased by a factor of 10 in the services sector between 2005 and 2017. This growth occurred mostly in biomass and ambient energy from heat pumps.[27]

> Increased use of renewable waste in cement manufacture was the largest contributor to renewable thermal energy growth.

In industry, most renewable heat energy is in the form of wood waste used in board and saw mills. The food processing industry mostly uses tallow, but this declined by 57% between 2005 and 2017. A significant new source of renewable heat energy that has emerged since 2005 is the use of renewable waste in cement manufacture.

Figure 12: Renewable heat energy by sector, 2005 to 2017



Source: SEAI

26 Renewable heat in the residential sector is supported by the Building Regulations Part L for dwellings. It was also supported by the Greener Homes Scheme up until 2010.

27 Renewable heat in the commercial sector was previously supported by the Renewable Heat Deployment Programme (ReHeat) up until 2011. From 2019, the Support Scheme for Renewable Heat (SSRH) will support heat pumps, biogas and biomass used for heat in the commercial, public services, industrial and agricultural sectors. For more information about the SSRH see https://www.seai.ie/sustainable-solutions/support-scheme-renewable-/

Table 9: Renewable heat energy by source, 2005 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2005	2010	2017	2005	2010	2017	'05-'17	'10-'17	'05-'10	'10-'17	2017
Industry - food and beverage	54	40	23	29%	19%	7%	-57%	-43%	-5.7%	-7.7%	6.9%
Industry - wood & wood products	109	100	126	58%	46%	40%	15%	26%	-1.8%	3.4%	11.5%
Industry - non-metallic minerals	0	12	52	0%	5%	17%	-	338%	-	23.5%	30.8%
Industry total	**163**	**152**	**201**	**87%**	**70%**	**64%**	**23%**	**32%**	**-1.4%**	**4.0%**	**15.3%**
Residential	20	44	65	11%	20%	21%	229%	46%	17.6%	5.6%	-0.8%
Commercial and public services	4	21	46	2%	10%	15%	1045%	116%	39.6%	11.6%	4.6%
Total	**187**	**218**	**312**	**100%**	**100%**	**100%**	**67%**	**43%**	**3.1%**	**5.3%**	**10.0%**

Source: SEAI

4.2 Solid biomass and renewable wastes

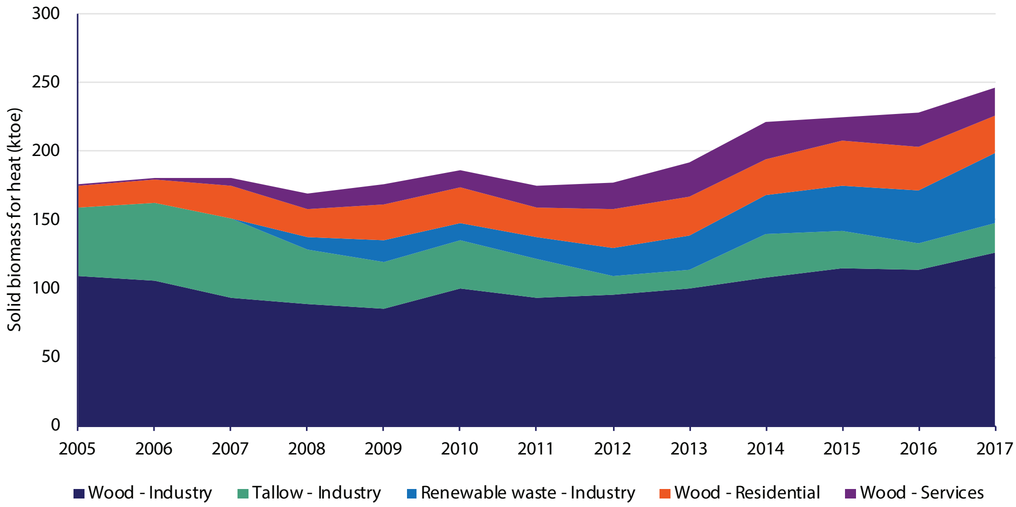
Solid biomass, including renewable wastes, is the largest fuel category in renewable heat. Solid biomass covers organic, non-fossil material of biological origin that may be used as fuel for heat production. It includes wood, wood wastes (firewood, wood chips, barks, sawdust, shavings, chips, black liquor,[28] etc.), other solid wastes (straw, oat hulls, nut shells, tallow, meat and bone meal, etc.) and the renewable portion of industrial and municipal wastes.

Most of the solid biomass used in Ireland is for heat energy purposes, where higher efficiencies, relative to electricity generation, make the best use of this valuable resource.

Data on wood and wood waste is based on surveys of wood suppliers, data on tallow is provided by the Department of Agriculture, Food and the Marine, and data on other industrial energy use, including renewable wastes, is sourced from the Environmental Protection Agency (EPA) ETS database.

The breakdown of solid biomass by type and sector is shown in *Figure 13* and *Table 10*. Most of the growth since 2005 has been from the use of renewable waste in industry.

Figure 13: Solid biomass used for heat by sector, 2005 to 2017



Source: SEAI

28 This is a recycled byproduct formed during the pulping of wood in the paper-making industry.

Table 10: Solid biomass used for heat by sector, 2005 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2005	2010	2017	2005	2010	2017	'05-'17	'10-'17	'05-'10	'10-'17	2017
Wood - Industry	109	100	126	62%	54%	51%	15%	26%	-1.8%	3.4%	11.5%
Tallow - Industry	50	36	21	29%	19%	9%	-58%	-41%	-6.5%	-7.4%	8.9%
Renewable waste - Industry	0	12	52	0%	6%	21%	-	338%	-	23.5%	30.8%
Wood - Residential	16	27	27	9%	14%	11%	68%	0%	10.9%	0.1%	-15.8%
Wood - Services	0	12	21	0%	6%	9%	-	75%	133.7%	8.4%	-14.9%
Total	**176**	**186**	**247**	**100%**	**100%**	**100%**	**40%**	**32%**	**1.2%**	**4.1%**	**7.9%**

Source: SEAI

4.3 Biogas

Biogas is produced from the anaerobic digestion (AD) of sewage, animal slurries and wastes in abattoirs, breweries and other agri-food industries. Biogas can be used directly in boilers to provide heat only, in CHP units to provide both heat and electricity, or can be upgraded to biomethane.

Data on biogas use is obtained from surveys of industry including Irish Water for waste-water treatment plants.

In 2017, 10 ktoe of biogas was used for heat, 2 ktoe was used in industry in the agri-food sector and 8 ktoe was used in the public-service sector in waste-water treatment plants.

4.4 Ambient energy from heat pumps

Ambient energy is the energy that heat pumps use to provide useful heat. In households, heat pumps typically use freely available but low-grade energy from the outside environment: from air, water, or ground. Ambient energy from the ground is often referred to as geothermal energy but for international energy statistics is more correctly known as ground-source ambient energy.[29] The use of ambient energy from the air, or air-source energy, has increased rapidly since 2012. In 2017, the Heat Pump Association of Ireland (HPA) estimates that over 90% of all heat pumps sold in Ireland were air-source heat pumps.

There has been a large increase in the use of air-source heat pumps in the residential sector.

Heat pumps require energy to "pump" the ambient energy from the cooler external environment into the warmer internal environment to provide useful heat. For heat pumps to be effective they need to deliver more energy as useful heat than they themselves consume. The ratio of the energy output from a heat pump to its energy consumption is known as the coefficient of performance (COP). If the COP is 3, then for every 1 unit of energy the heat pump uses, it delivers 3 units of energy as useful heat.

Not all of the energy that is output from a heat pump is considered as renewable ambient energy. To calculate the renewable portion, the final energy demand of the heat pump itself is subtracted from the total output of the heat pump. In the above example of a heat pump with a COP of 3, for every 3 units of heat delivered by the heat pump, 2 units are counted as renewable ambient energy. The COP would typically range from 2.5 to 5.6.

Most heat pumps are run on electricity, though some run on natural gas. For electric heat pumps, it is the final energy of the electricity input to the heat pump that is subtracted from the total heat pump output to get the ambient portion, as per the RED methodology.[30]

The amount of ambient energy used in Ireland is based on an estimate of the total number of heat pumps. This is based on an estimate by HPA of annual sales of heat pumps. For the commercial sector the heat total heat output is based on an assumed typical capacity and COP for each unit installed. For the residential sector, the estimate of heat output per

29 In international energy statistics geothermal refers to harnessing of energy originating from the earths core, for example from high temperature geothermal vents. The low temperature energy in the surface of the earth that is used by heat pumps comes from solar radiation on the earths surface and can be referred to as ground-source ambient energy.

30 A previous version of this report, "Renewable Energy in Ireland 2013", incorrectly stated that the renewable portion of heat pump output was calculated by subtracting the primary energy of the electricity consumption of the heatpump.

unit was revised downwards in 2018 based on data from the BER database. This resulted in a revision of the estimated renewable ambient energy use from 2002 to 2017.

SEAI estimates that 41 ktoe of renewable ambient energy was used in 2017 in Ireland. This was an increase of 163% on the amount in 2010 and made up 13% of all renewable heat energy in 2017.

4.5 Solar thermal

Solar energy can be captured by solar photovoltaic (solar PV) panels to produce electricity or solar thermal panels to produce hot water. Solar PV contributes to the RES-E target and solar thermal contributes to the RES-H target. In this section we look at solar thermal.

The amount of solar thermal energy used in Ireland is estimated based on an estimate of the surface area of panels installed each year, combined with an assumed annual energy production per square metre. The amount of solar thermal panels installed each year is based on data from SEAI-administered grant schemes and from the BER database.

SEAI estimates that 14 ktoe of thermal energy from solar thermal panels was produced in Ireland in 2017, all in the residential sector. This made up 5% of all renewable heat energy.

5 Renewable energy in electricity

Electricity generation has been the most successful of the three modes for the development of energy from renewable sources. Renewable energy sources are now the second largest source of electricity after natural gas. Ireland has no mandatory target for RES-E for 2020 but has set an ambitious national target of 40%. RES-E forms the backbone of Ireland's strategy to achieve the overall 16% renewable energy target for 2020.

Wind energy is the main source of renewable electricity generated in Ireland. Electricity generated from wind is variable and non-synchronous.[31] Incorporating such a large share of wind energy on the Irish electricity network has required the Irish grid operator, EirGrid, to become a world leader in this area through the DS3 programme.

5.1 Progress towards renewable electricity target

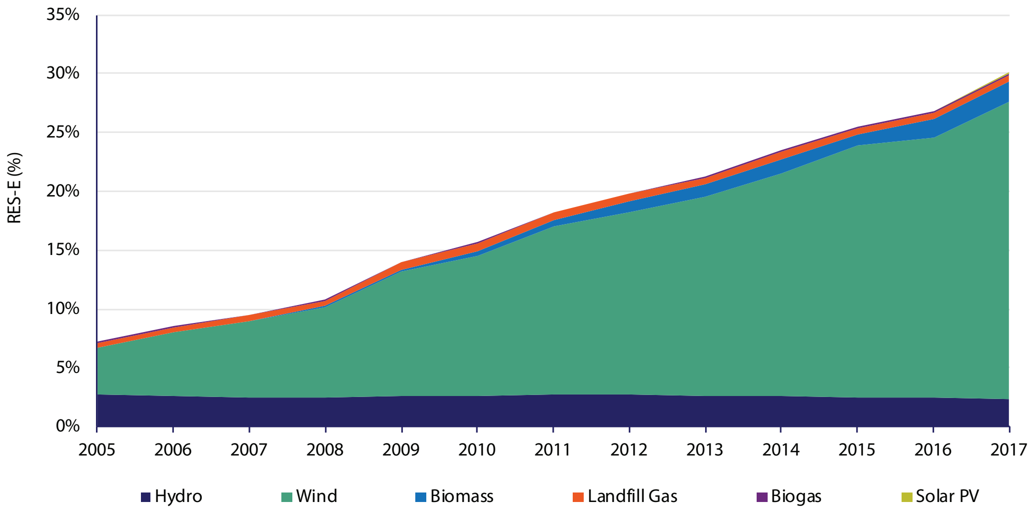
Normalised renewable electricity production by source is shown in *Figure 14* and *Table 11*.

Normalisation is used to smooth out the natural variation in wind speeds and rainfall from year to year. Wind normalisation also adjusts for the effect of large increases in installed capacity midway through a year. Normalisation is discussed more in sections *5.2.3* and *5.3.2*.

RES-E was 30.1% in 2017, up from 26.8% in 2016. The target for 2020 is 40%.

The relatively large share of renewables in electricity generation contrasts with that in heat and transport, reaching 30% in 2017. Renewable electricity is dominated by the growth in wind energy since the early 2000s. Wind accounted for 84% of normalised renewable electricity in 2017. Hydro remained the second largest source of renewable electricity in 2017 at 8%, followed by biomass at 6%. There was large percentage growth in energy from solar PV in 2017 but from a very low base.

Figure 14: Normalised share of RES-E by source, 2005 to 2017



Source: SEAI

31 In a synchronous AC power system, such as that of the Republic of Ireland and Northern Ireland, all of the conventional generating units are synchronised (that is, the waveform of the generated voltages at each generating plant are synchronised), producing electricity at a nominal frequency of 50 Hz. This synchronisation comes from the physical rotation of the large rotors in the electricity generation plant. The physical inertia of these large rotating units also gives the electricity system 'inertia'; that is, a resistance to changes in frequency over very short time periods. This system inertia is an important characteristic in terms of the overall system stability of the electricity grid. Electricity from sources such as wind turbines, and the high voltage direct current (HVDC) electricity from interconnectors, is described as non-synchronous and, crucially, does not provide the same inertia as traditional synchronous plants. A power system with a high penetration of variable non-synchronous wind-generation poses significant challenges for frequency control over multiple time frames.

Table 11: Normalised renewable electricity by source, 2005 to 2017

	Quantity (ktoe)			Shares (%)			Growth (%)		Average annual growth rates (%)		
	2005	2010	2017	2005	2010	2017	'05-'17	'10-'17	'05-'10	'10-'17	2017
Hydro	65	65	62	38%	17%	8%	-6%	-5%	-0.2%	-0.7%	-1.9%
Wind	95	293	651	55%	76%	84%	587%	122%	25.4%	12.0%	16.3%
Biomass & Renewable Waste	1	9	46	0%	2%	6%	6643%	385%	69.3%	25.3%	12.9%
Landfill Gas	9	16	13	5%	4%	2%	46%	-15%	11.4%	-2.3%	-3.6%
Biogas	1	2	4	1%	1%	0%	166%	90%	7.0%	9.6%	-3.5%
Solar PV	0	0	1	0%	0%	0%	-	2165%	-	56.2%	75.3%
Total renewable electricity	**171**	**385**	**776**	**100%**	**100%**	**100%**	**353%**	**101%**	**17.6%**	**10.5%**	**14.0%**
RES-E (%)	**7%**	**16%**	**30%**								

Source: SEAI

5.2 Wind energy

Total electrical output from wind in 2017, not normalised, was 7,445[32] GWh. This was an increase of 21% on 2016. Wind generated 25% of gross electrical consumption in 2017, second only to natural gas.

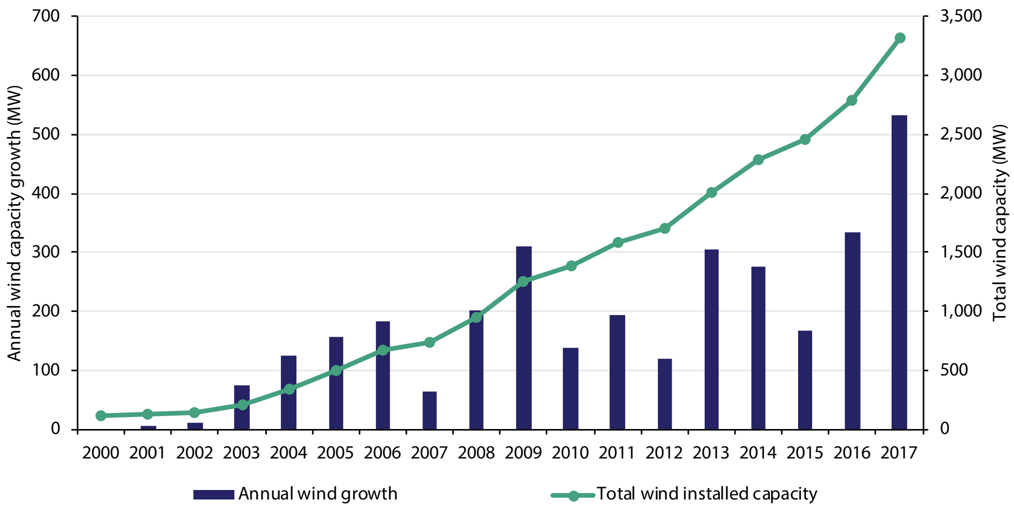
Wind generated 25% of all electricity in 2017, second only to natural gas.

5.2.1 Installed wind capacity

Figure 15 and *Table 12* show the annual growth in installed wind-generation capacity and overall cumulative capacity since 2000. During 2017, 532 MW of wind capacity was installed. This was a record high level, ahead of the previous peak installed capacity of 335 MW achieved in 2016. The average annual installed capacity between 2008 and 2016 was 227 MW.

By the end of 2017, the installed capacity of wind-generation reached 3,318 MW. The peak recorded wind-power output in 2017 was 2,444 MW, delivered on 17 February. It represented 66% of the instantaneous system demand at that point. At the time of writing, the historic peak recorded wind-power output[33] was 3,080 MW, delivered on 12 December 2018, at which time wind accounted for 63% of electricity generated and 69% of the instantaneous system demand.

Figure 15: Installed wind-generation capacity, 2000 to 2017



Source: EirGrid

32 Output from both grid-connected wind farms and large auto-producer turbines.

33 System records are updated on the EirGrid website, as well as 15-minute average data on wind-power; see http://www.eirgridgroup.com/how-the-grid-works/system-information/

Table 12: Installed wind-generation capacity, 2005 to 2017

MW installed wind capacity	2005	2010	2011	2012	2013	2014	2015	2016	2017
Annual increase in installed wind capacity	157	139	194	120	304	275	168	335	532
Total installed wind capacity	493	1,390	1,585	1,704	2,008	2,283	2,451	2,786	3,318
Two-year average installed wind capacity	415	1,321	1,488	1,644	1,856	2,146	2,367	2,619	3,052

Source: EirGrid

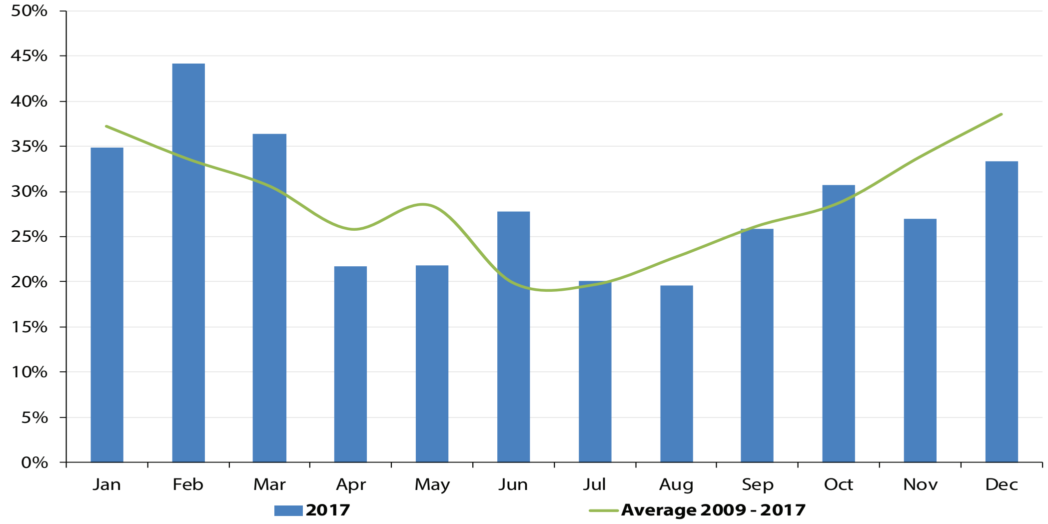
A record high of 532 MW of wind-generation capacity was installed in 2017.

Successfully integrating these levels of non-synchronous generation is unprecedented and presents significant challenges for the real-time operation of the network. In response to these challenges EirGrid began a multi-year programme, 'Delivering a Secure, Sustainable Electricity System', (DS3). The aim of the DS3 programme is to enable the operation of the electricity system in a secure manner while achieving the 2020 renewable electricity targets.[34]

5.2.2 Capacity factors

The capacity factor of wind-power is the ratio of average delivered power over a particular time period to the theoretical maximum power. It can be computed for a single turbine, a wind farm or at the national level. It can be calculated across a range of time frames, from days to months to years. *Figure 16* shows the capacity factors for each month in 2017 compared to the long-term average profile. Average wind-generation capacity factors are higher in the winter months and lower in the summer months. February was the windiest month in 2017.

Figure 16: Monthly wind-generation capacity factors, 2017



Source: EirGrid & SEAI

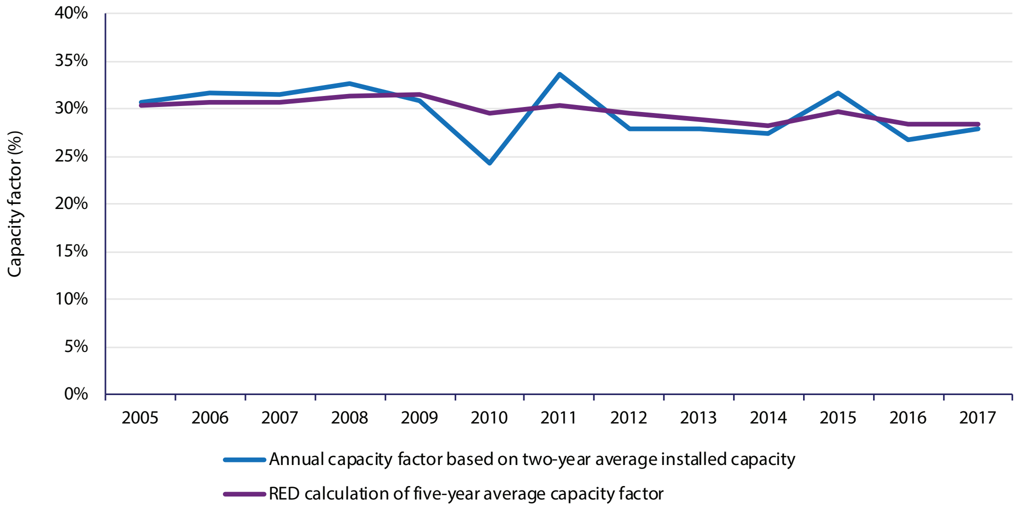
At the national level, the profile of newly installed capacity over the course of the year can significantly impact on the annual average capacity factor. If a significant amount of capacity is installed in the last months of the year then the capacity factor for the year will appear low, as this additional capacity will only have generated electricity or a small fraction of the year. For this reason, the RED specifies that the two-year average installed capacity is used, as shown in *Table 12*.

The capacity factor also varies from year to year depending on how windy each year was. For example 2010 was an exceptionally calm year with low wind speeds resulting in a low capacity factor. The annual average capacity factor for wind-power in Ireland from 2005 to 2017 based on two year average installed capacity is shown in *Figure 17* and *Table 13*.

The 5 year average wind-generation capacity factor for 2017 was 28.3%.

34 For more information on EirGrid's DS3 programme, see http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/

Figure 17: Annual wind capacity factors, 2005 to 2017



Source: EirGrid & SEAI

Table 13: Wind-generation capacity factors, 2005 to 2017

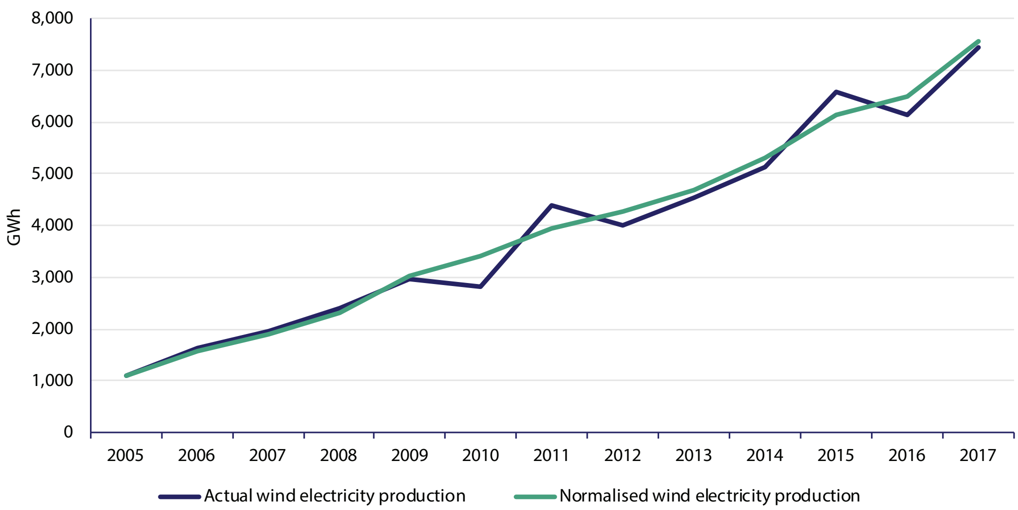
	2005	2010	2011	2012	2013	2014	2015	2016	2017
Annual wind capacity factor based on 2 year average installed capacity	30.6%	24.3%	33.6%	27.8%	27.9%	27.3%	31.7%	26.8%	27.8%
5 year average wind capacity factor based on Renewable Energy Directive	30.3%	29.5%	30.4%	29.6%	28.8%	28.2%	29.6%	28.4%	28.3%

Source: EirGrid

5.2.3 Normalisation of wind energy

The RED allows for the effects of high- or low-wind years to be smoothed out by using an average capacity over five years. This is called normalisation. The average installed capacity over the previous two years and the average capacity factor over the previous five years are used in the calculation. Appendix 1 provides a detailed description of the methodology. *Figure 17* and *Table 13* also show the five-year average capacity factor as per the RED methodology. *Figure 18* shows the actual and normalised annual wind-powered electricity generation from 2005 to 2017.

Figure 18: Normalised wind-powered electricity generation, 2005 to 2017



Source: SEAI and EirGrid

5.3 Hydro energy

5.3.1 Installed hydro capacity

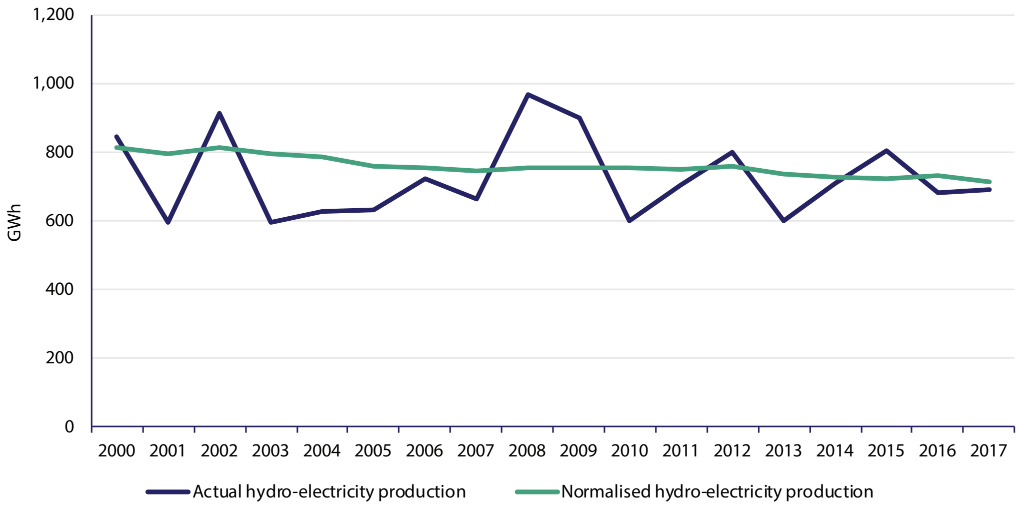
There are 15 hydroelectric[35] generators connected to the electricity transmission system, 14 of which have a maximum export capacity (MEC) of more than 4 MW. The total hydro connected to the transmission system is 212 MW. There are a further 59[36] hydroelectric generators connected to the electricity distribution system, with a total installed capacity of 26 MW.

5.3.2 Normalisation of hydro energy

The normalisation rule for hydro uses the average capacity factor of the previous 15 years and the installed capacity of the reporting year to calculate the normalised hydro contribution towards the renewable energy targets. *Figure 19* shows the actual and normalised data from 2000 to 2017.

In 2017 hydropower generated 692 GWh of electricity (2.3% of gross electricity). Normalised hydro electricity generation was 717 GWh (2.4% of gross electricity).

Figure 19: Normalised hydro-powered electricity generation, 2000 to 2017



Source: SEAI and EirGrid

5.3.3 Pumped hydro storage

Electricity produced by pumped storage from water that has previously been pumped uphill is not classified as being from a renewable energy source and is not included in either the numerator or the denominator of the RES-E or overall RES calculations. There is one pumped hydro station in Ireland, at Turlough Hill, with a total capacity of 292 MW. As all of the electricity produced from this station is from water that has previously been pumped uphill, it is not classed as renewable. Although it is not a renewable electricity source, pumped hydro storage has attributes which are beneficial for integrating variable non-synchronous electricity generation onto the electricity system.

35 EirGrid, *Connected TSO (Non Wind) Generators* [Internet]. Available from: http://www.eirgridgroup.com/customer-and-industry/general-customer-information/connected-and-contracted-generators/ [Accessed December 2018].

36 ESB Networks, *Distribution Energised Connected Non-Wind* [Internet]. Available from: https://www.esbnetworks.ie/new-connections/generator-connections/generator-connection-statistics [Accessed December 2018].

5.4 Solid biomass

Solid biomass covers organic, non-fossil material of biological origin which may be used as fuel. It is primarily wood, wood wastes (firewood, wood chips, barks, sawdust, shavings, chips, black liquor, etc.)[37] and other solid wastes (straw, oat hulls, nut shells, tallow, meat and bone meal).

In electricity generation, biomass is primarily used in co-firing with peat in existing power plants, with a small amount also used in combined heat and power (CHP) plants.

Edenderry Power Station is currently the only peat-fired power station that co-fires with biomass. In 2017, 369 GWh of electricity was produced from the biomass, or 42% of the electricity generated from Edenderry Power Station over the year. Two further peat-powered electricity-generating stations, West Offaly and Lough Ree power stations, have plans to begin co-firing with biomass with peat from 2019, subject to planning permission.

In 2017, 16 GWh of electricity was produced from biomass CHP.

5.5 Renewable wastes

There are currently two municipal waste-to-energy plants in Ireland, in Meath and Dublin, with capacities of 17 MW and 60 MW, respectively.

Part of the municipal solid waste (MSW) used by these plants is biodegradable and is considered to be renewable biomass.[38] When this is combusted, the heat and electricity produced is considered renewable. For each facility, if the renewable portion of the MSW is not known, then a default value of 50% is used. In 2017, 151 GWh of electricity was produced from the combustion of renewable wastes. This was a 99% increase on the previous year, due to the opening of the Dublin Waste to Energy facility in late 2017.

5.6 Landfill gas

Landfill gas is regarded as a renewable or sustainable energy source for the purposes of meeting targets set down under EU renewable energy targets. Landfill gas in Ireland is only used for electricity generation or is flared directly to the atmosphere. There are 24 landfill gas generators connected to the distribution grid with a total maximum export capacity (MEC) of 49 MW.

In 2017, 155 GWh of electricity was produced from landfill gas, representing 0.5% of the gross electricity generated. Electricity generated from landfill gas peaked in 2010 at 182 GWh. It is expected that this resource will gradually decline over time as the organic material in the existing landfills fully decomposes.

5.7 Biogas

Biogas is produced by the anaerobic digestion of biological materials such as animal slurries, agri-food wastes, and sewage sludges. Once biogas is produced, it can be burned in a boiler to produce heat, used in CHP plants to produce heat and electricity, or upgraded further to biomethane. In 2017, a total of 43 GWh of electricity was generated from biogas CHP in industry and waste-water treatment plants.

Sewage sludge produced in the waste-water treatment plants can be anaerobically digested to produce biogas. This biogas is used on-site in the waste-water treatment plants in CHP units to provide heat and electricity for the plants' own use. In 2017, approximately 28 GWh of electricity was produced from sewage sludge gas.

Biogas is also produced from the anaerobic digestion of animal slurries, wastes in abattoirs, breweries, and other agri-food industries. In 2017, approximately 14 GWh of electricity was generated from biogas CHP in industry.

5.8 Solar photovoltaic

Solar photovoltaic (PV) panels can be installed in residential, commercial or industrial settings, or as a stand-alone electricity-generating plant feeding electricity directly to the national grid. We estimate that there were 15.7 MW of installed solar PV capacity in Ireland in 2017: 11.9 MW in the residential sector and 3.8 MW in the commercial/industrial sector.

In the residential sector, solar PV is mostly installed on new homes to meet the requirements of the building regulations for use of energy from renewable sources. SEAI estimates the installed capacity of solar PV on new dwellings based on the

37 This is a recycled by-product formed during the pulping of wood in the paper-making industry.
38 Article 2 (e) of Directive 2009/28/EC.

BER database. A single electricity supplier, Electric Ireland, voluntarily offered a domestic microgeneration rate[39] of €0.09 per kWh for micro-generation exported to the grid, including domestic solar PV. This rate continued to be paid to existing participants until the end of 2018, but the scheme has been closed to new entrants since the end of 2014. There was 1.0 MW of installed residential solar PV connected to the grid at the end of 2017, though there were no additions in 2016 or 2017.

SEAI estimates the installed capacity of solar PV in the commercial/industrial sector using data from SEAI grant programmes such as Better Energy Communities and from regional energy agencies such as the Tipperary energy agency, and on a continuous ad hoc basis based on public announcements by businesses and suppliers.

In 2017, we estimate that 11 GWh of electricity was generated from solar PV, representing 0.1% of renewable electricity or 0.04% of electricity GFC.

In spite of its small contribution in 2017, solar PV is already growing rapidly. As of mid-2018 there were 245 MW of installed capacity contracted for connection to the transmission grid.[40] There is also likely to be continuing growth in the residential sector due to the renewables requirement in the building regulations for new dwellings and also due to the introduction of a capital grant for domestic solar PV in existing dwellings.[41]

39 Details available from: https://www.electricireland.ie/residential/help/micro-generation/electric-ireland-micro-generation-pilot-scheme

40 EirGrid (2018) *Contracted TSO (Non Wind) Generators* [Internet]. Available from: http://www.eirgridgroup.com/site-files/library/EirGrid/Contracted-TSO-(Non-Wind)-Generators.pdf [Accessed December 2018]

41 For more information, see: https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/

6 EU comparison

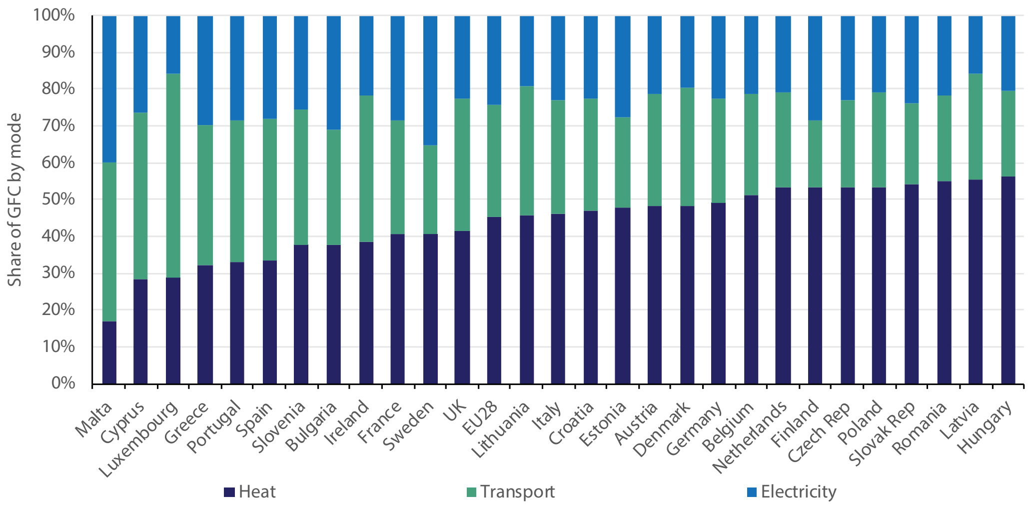
This section provides a comparison of the progress Ireland has made towards its 2020 renewable energy targets with that of other EU member states (MS).

Eurostat has developed a harmonised approach to calculating and reporting renewable energy shares across the EU. This is done using the SHARES[42] tool. Eurostat publishes the results for each member state annually. Here, we examine the latest available data for 2016.

6.1 Gross final consumption in EU by heat, transport and electricity

Figure 20 shows the share of GFC in each of the 28 EU member states (EU-28) split by heat transport and electricity. In 21 out of the EU-28 heat is the largest end use. Ireland is unusual in that transport is the largest end use. In 23 of the EU-28 electricity is the smallest of the three end uses. This context is important when looking at the contribution of renewable energy in each of the modes to overall renewable energy supply for each EU MS.

Figure 20: Gross final consumption in EU by heat, transport and electricity, 2016



Source: Eurostat

6.2 Overall RES

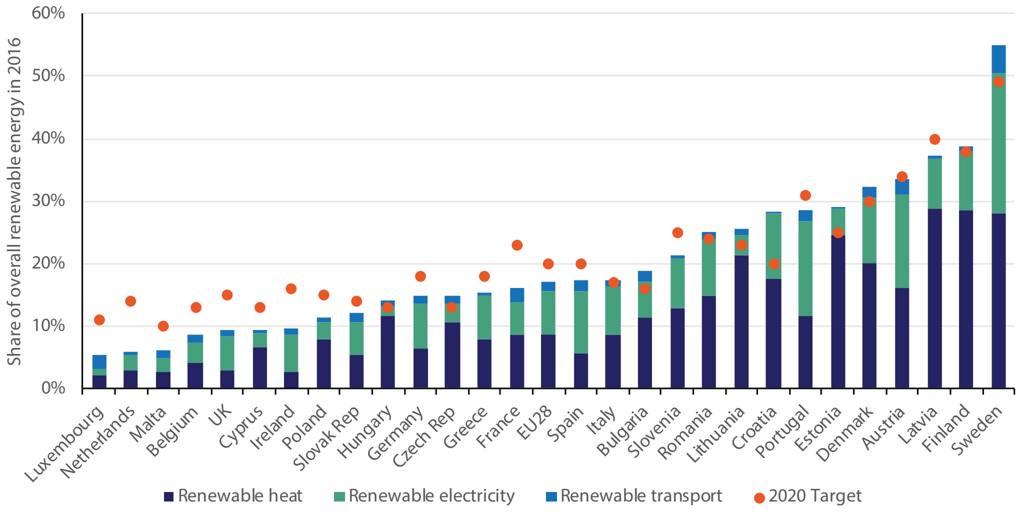
Figure 21 shows the share of overall renewable energy for each MS split by the contribution from each mode. Ireland was 22nd out of the EU-28 for overall RES in 2016 on 9.5%, compared to the EU-28 average of 17.0%. There is a broadly similar pattern across most MS. Although transport is a major final end use (typically the second largest after heat), renewable transport is small and contributes little to overall renewable energy share. The heat and electricity sectors have achieved higher shares of renewable energy. For every MS except Malta, heat is a larger end use than electricity; for most MS, the share of heat is twice as big as the share of electricity. RES-H contributed the largest share of overall RES in 21 of the EU-28 in 2016. For almost all MS, the share of RES-H is the most important factor influencing the share of overall renewable energy.

Ireland was 22nd out of the EU-28 for overall renewable energy share in 2016.

Each MS has its own target for overall renewable energy share in 2020, shown in *Figure 21* by the orange markers. The overall EU-28 target is for 20% overall RES in 2020. MS which had higher shares of renewable energy prior to 2007, when the 2020 targets were determined, were given higher targets for 2020 than the EU-28 average. MS that were starting from a low base in 2007 have targets lower than the EU-28 average. Ireland's 2020 target is for 16% overall RES.

42 See https://ec.europa.eu/eurostat/web/energy/data/shares

Figure 21: Overall renewable energy share in 2016 for EU member states



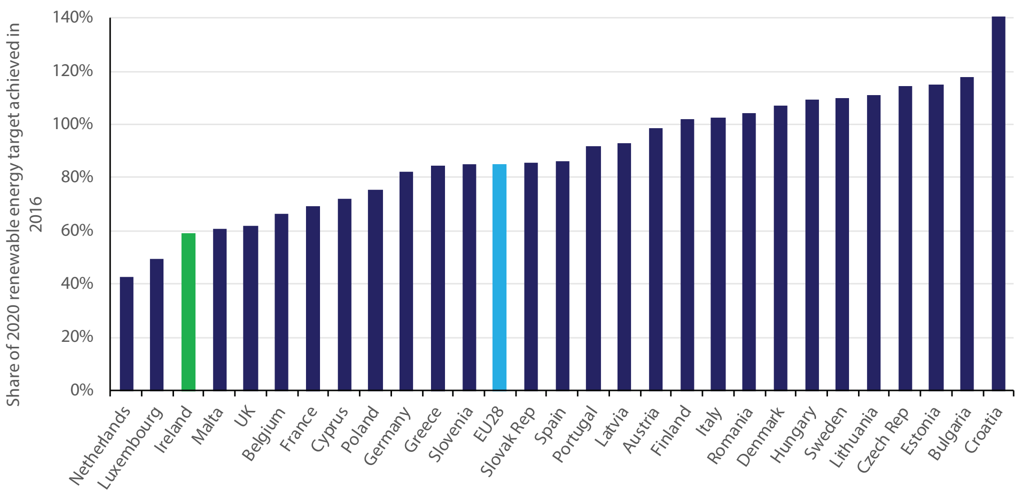
Source: Eurostat

For most of the EU-28, RES-H contributes the largest share to overall renewable energy supply.

Figure 22 examines the progress each MS had made towards meeting its 2020 target in 2016. The progress in 2016 is expressed as a percentage of the 2020 target; if the 2020 target was already fully achieved in 2016, the progress towards target would be 100%; if the MS was only half-way towards the 2020 target, the progress would be 50%. Ireland was 26th out of the EU28 in 2016, having reached 59% of the 2020 target, compared to the average for the EU28 of 85%. Eleven MS had already surpassed their 2020 targets by 2016.

Ireland was 26th out of the EU-28 for progress towards the overall renewable energy 2020 targets in 2016.

Figure 22: Percentage of 2020 renewable energy target achieved in 2016 for EU member states



Source: Eurostat

6.3 Renewable heat

Figure 23 shows data on renewable heat use split into direct energy use, district heating and ambient energy from heat pumps. In 2016, Ireland was 27th out of the EU-28 for renewable heat, at 6.8%. The EU average was 19.1% and Sweden had the highest share at 68.6% RES-H.

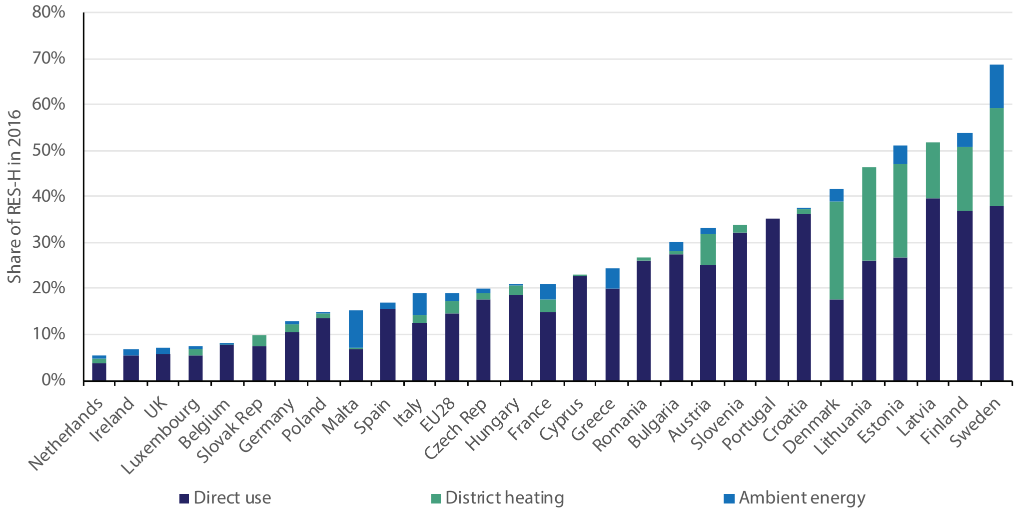
Ireland was 27th out of the EU-28 for renewable heat in 2016

The MS with the highest levels of RES-H are the Baltic countries, which use significant amounts of renewable heat through district heating networks. The MS with the lowest levels of RES-H are the northwestern countries, which have high annual heat demands but did not develop significant district heating networks and are reliant on direct fossil fuel use for heat. Despite the lack of past experience of district heating in Ireland, there are significant opportunities for the development of new district heating networks in specific areas that have high heat demand, in particular utilising waste heat.[43]

Some MS with warmer climates, such as Portugal, have achieved high percentage shares of renewable heating and cooling, but this must be viewed in the context of their overall lower heat demand and the prevalence of traditional wood burning for residential heat.

Ireland's low share of RES-H is the biggest reason for our poor progress towards our overall renewable energy target.

Figure 23: Renewable heat share in 2016 for EU member states



Source: Eurostat

43 See for example the Dublin District Heating Scheme, available at http://www.dublincity.ie/ddhs. For more information, see also *A Guide to District Heating in Ireland*, available from https://www.seai.ie/resources/publications/2016_RDD_79._Guide_District_Heating_Irl_-_CODEMA.pdf

6.4 Renewable electricity

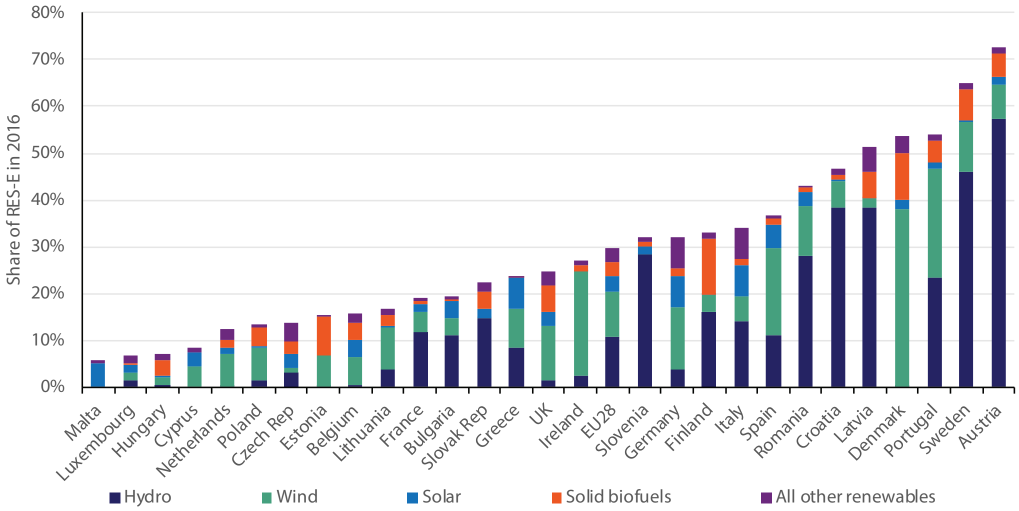
Figure 24 shows the share of electricity from renewable sources for each MS. In 2016, Ireland was 13th out of the EU-28 at 27.2%, just below the EU-28 average of 29.6%.[44]

The MS with the highest share of RES-E tend to have a high share of hydro energy. Electricity that is generated from pumped-hydro plants from water that has previously been pumped uphill does not count as renewable hydroelectricity. However, having pumped-hydro capacity on the electricity grid makes it easier to accommodate significant amounts of variable renewables such as wind. This is the case in Portugal, for example, which had a high share of hydro (23.4%) and the second highest share of wind (23.2%). It is also easier to incorporate large amounts of variable renewables if a MS has extensive interconnection with neighbouring countries. This is the case for Denmark, which had the highest share of wind energy in 2016 at 37.9%.

Ireland was 13th out of the EU-28 for renewable electricity in 2016. The top performing countries tend to have large hydropower resources.

Ireland had the third highest share of wind-generated electricity in 2016 at 22.3%. In Ireland's case, this was achieved without the benefits of significant amounts of pumped-hydro storage or interconnection and required the Irish electricity grid operator EirGrid to become a world leader in incorporating large amounts of variable non-synchronous generation onto an isolated electricity grid.

Figure 24: Renewable electricity share in 2016 for EU member states



Source: Eurostat

44 Ranking MS by the share of RES-E does not give a good indication of the GHG intensity of electricity in each MS, as it ignores the source of the non-renewable electricity, in particular nuclear power. For instance France has a relatively low share of RES-E, mostly from hydropower, but the GHG intensity of French electricity is very low as it is mostly generated from nuclear power. In contrast, Ireland has one of the most GHG-intensive electricity systems in the EU due to the share of coal and peat generation.

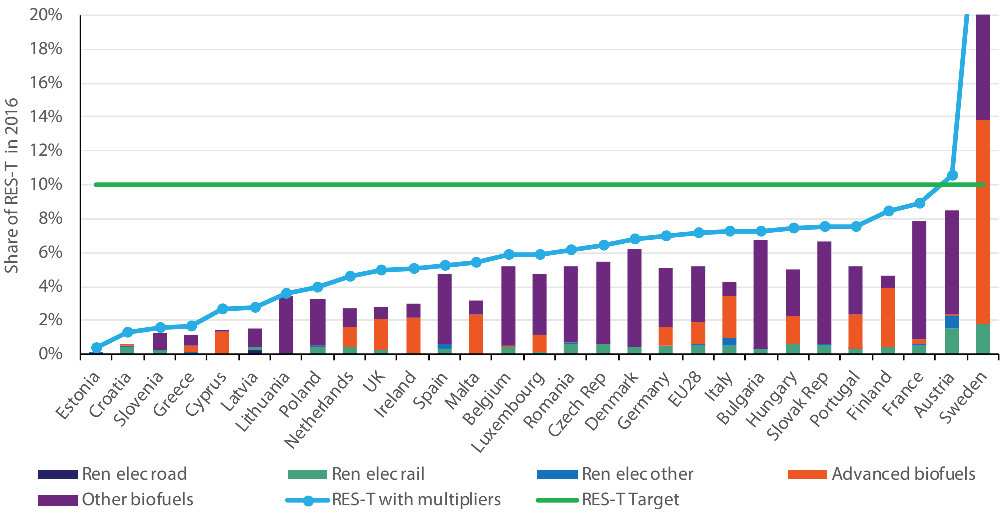
6.5 Renewable transport

In the heat and transport sectors, some MS have natural advantages over others in adopting renewable energy technologies, for example pre-existing district heating networks or large hydroelectricity resources. In comparison, the transport sector is largely a level playing-field for all MS. This is reflected in the broadly similar progress made by the majority of MS, with 14 of the EU-28 achieving between 5.0% and 7.5% RES-T in 2016. In 2016, Ireland was 18th out of the EU-28 for RES-T.

Figure 25 shows the progress of each MS in 2016 towards the RES-T target. The columns for each MS show the amount of each source of renewable energy used without any multipliers applied. The blue line shows the percentage of RES-T achieved when multipliers are taken into account. The green line shows the 2020 target of 10% RES-T for all MS. For most MS, the majority of renewable transport energy use comes from first-generation biofuels, which do not qualify for multiple weightings, such as bioethanol from energy crops.

Ireland was 18th out of the EU-28 for renewable transport in 2016.

Figure 25: Renewable transport share in 2016 for EU member states



Source: Eurostat

The obvious outlier is Sweden, which has managed to achieve 20% of renewable energy in road and rail transport not including multipliers, or more than 30% RES-T including multipliers. In 2016, advanced biofuels accounted for 10.5% of total Swedish road and rail energy demand, in energy terms, not including multipliers.

According to the Swedish Bioenergy Association (Svebio),[45] this is largely due to the use of the so-called "drop-in" biofuel, Hydrotreated vegetable oil (HVO). Conventional biofuels are not chemically identical to the fossil fuel equivalents, and can only be blended up to certain ratios without causing technical difficulties when used in engines designed for fossil fuels. In contrast drop-in biofuels are chemically identical to fossil diesel and so can be blended at any rate or used directly in pure form. Pure HVO, referred to as HVO100, was introduced to the Swedish market in 2015 and is now used widely for commercial vehicles, helped by attractive tax exemptions.[46] The share of biomethane in the natural gas used by compressed natural gas (CNG) vehicles in Sweden also reached a record high of 83% in 2016. Sweden also has the second highest market share of EVs in the EU, coupled with the second highest share of renewable electricity, but does not currently count the renewable electricity used by EVs towards the RES-T target as it has not yet developed a methodology to estimate EV energy use.

45 See https://www.svebio.se/en/about-bioenergy/biodrivmedel/

46 See https://www.svebio.se/press/pressmeddelanden/allt-fler-tankar-hvo100/

Glossary of abbreviations

Abbreviation	Explanation
AD	Anaerobic Digestion
BOS	Biofuels Obligation Scheme
CHP	Combined Heat and Power
CO2	Carbon Dioxide
COP	Coefficient of Performance - usually of heat pump
EPA	Environmental Protection Agency
ETS	EU Emissions Trading Scheme
EU-28	28 Member States of the European Union
EV	Electric Vehicle
GFC	Gross Final Energy Consumption
GHG	Green-House Gas
HVO	Hydrotreated vegetable oil
ILUC	Indirect Land-Use Change
ktoe	kilo-tonne of oil equivalent
MEC	Maximum Export Capacity
MS	EU Member State
MSW	Municipal Solid Waste
NORA	National Oil Reserves Agency
PSO	Public Service Obligation
PV	Solar Photo-Voltaic
RED	Renewable Energy Directive
RES	Renewable Energy Share
RES-E	Renewable Energy Share in Electricity
RES-H	Renewable Energy Share in Heat
RES-T	Renewable Energy Share in Transport
SEAI	Sustainable Energy Authority of Ireland
SSRH	Support Scheme for Renewable Heat
TFC	Total Final Consumption
toe	tonne of oil equivalent
TPER	Total Primary Energy Requirement

Glossary of terms

Air-source energy: Heat energy contained in the air, even at low temperatures. Heat pumps can use this low grade energy as a renewable source useful heat.

Ambient energy: The energy that heat pumps use to provide useful heat. It typically comes from use freely available but low-grade energy from the outside environment: from air, water, or ground. It can also come from waste energy streams such as exhaust gases or waste water.

Biodiesel: Biofuel that can be blended with fossil diesel. Includes biodiesel, biodimethylether (DME), Fischer-Tropsch diesel, cold-pressed bio-oil and all other liquid biofuels which are added to or blended with or used straight as transport diesel.

Biofuels: Generally refers to liquid fuels derived from biomass crops or by-products that are suitable for use in vehicle engines or heating systems. They can be considered as potential replacements or extenders for mineral fuels such as diesel or petrol. Liquid biofuels are typically categorised by the fossil fuels that they can be blended with or can replace. The two most common categories of liquid biofuel are biodiesel and biogasoline.

Bioenergy: An umbrella term for energy produced from any biological material including solid biomass, biogas, liquid biofuels and landfill gas.

Biogas: A gas composed principally of methane and carbon dioxide produced by the anaerobic digestion of organic materials. Common feedstocks for the production of biogas through anaerobic digestion include sewage sludge, animal slurries, agri-food wastes and crops.

Biogasoline: Biofuel that can be blended with fossil gasoline (petrol). Includes bioethanol, biomethanol, bio-ethyl-ter-butyl ether (bioETBE), bio-methyl-tertio-butyl-ether (bioMTBE), and all other liquid biofuels which are added to or blended with or used straight as transport gasoline.

Biomass: Generally refers to solid organic material that can be used for energy. See Solid Biomass

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 MtCO_2 (mega-tonnes of CO_2 {10^6 tonnes}).

Combined Heat and Power (CHP): Combined heat and power (CHP) refers to plants which are designed to produce both heat and electricity. CHP plants may generate for their own use only (auto-producer), may export electricity to the grid, or may also export heat via a district heating network.

Drop-in biofuel: Biofuels that are chemically identical to their fossil fuel equivalent and so can be blended at any rate or used directly in pure form in engines designed to run fossil fuel without modification. In contrast most biofuel are not chemically identical to the fossil fuel equivalents, and can only be blended up to certain ratios without causing technical difficulties with engines designed to run on fossil fuels.

Geothermal energy: Energy originating from the earth's core, for example from high-temperature geothermal vents. The term "geothermal energy" can sometimes be used to refer low-temperature heat energy in the ground that is used by heatpumps, but this is more correctly referred to as to ground-source energy.

Ground-source energy: Low temperature heat energy contained in the ground. Heatpumps can use this low grade energy as a renewable source useful heat.

Gross final consumption (GFC): The Renewable Energy Directive (2009/28/EC) defines gross final consumption of energy as the energy commodities delivered for energy purposes to manufacturing industry, transport, households, services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution.

Heat pump: A heat pump is a device that moves heat from one location (the source) to another (the sink). Heat pumps are used for space heating and cooling, as well as water heating. Geothermal heat pumps operate on the fact that the earth beneath the surface remains at a constant temperature throughout the year, and that the ground acts as a heat source in winter and a heat sink in summer. They can be used in both residential and commercial or institutional buildings. Other heat pump types are available, such as air- and water-source. These operate on the same principle indoors but the method of collecting heat is different for each type.

HVO: Hydrotreated vegetable oil (HVO) is a drop-in biofuel that can be used as a direct substitute for fossil diesel.

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

Hydropower: Potential and kinetic energy of water converted into electricity in hydroelectric plants. Pumped storage is treated separately in the national energy balance. The Renewable Energy Directive 2009/28/EC states that electricity produced in pumped storage units from water that has previously been pumped uphill should not be considered to be electricity produced from renewable energy sources.

Kilowatt hour (kWh): The conventional unit of energy whereby electricity is measured and charged for commercially. Related units are megawatt hour (MWh) and gigawatt hour (GWh) which are one thousand and one million kWhs respectively.

Landfill Gas: A gas composed principally of methane and carbon dioxide produced by anaerobic digestion landfill wastes.

Photovoltaic energy (PV): Energy from solar electric panels. Solar radiation is exploited for electricity generation by photovoltaic cells which convert the solar radiation into DC current.

Refuse derived fuels (RDF): Fuels produced from waste through a number of different processes such as mechanical separation, blending and compressing to increase the fuel value of the waste. Such waste derived fuels can be comprised of paper, plastic and other combustible wastes and can be combusted in a waste-to-energy plant, cement kiln or industrial furnace.

RES-E: Renewable energy share of electricity.

RES-H : Renewable energy share of heat/thermal energy.

RES-T: Renewable energy share of road and rail transport energy.

Solar PV: See Photovoltaic Energy

Solid biomass: Covers organic, non-fossil material of biological origin which may be used as fuel for heat production or electricity generation. It comprises: (a) charcoal, covering the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material and (b) wood, wood wastes and other solid wastes, covering purpose-grown energy crops (poplar, willow etc.), a multitude of woody materials generated by an industrial process (wood/paper industry in particular) or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, black liquor etc.) as well as (c) wastes such as tallow, straw, rice husks, nut shells, poultry litter, crushed grape dregs etc. Combustion is the preferred technology for these solid wastes. The quantity of fuel used is reported on a net calorific value basis.

Solid recovered fuels (SRF): Fuels refined from crude refuse derived fuels (RDF). To be defined as SRF a fuel must meet minimum standards for moisture content, particle size, metals, chloride and chlorine content and calorific value.

Tallow: The fatty tissue or suet of animals.

Tonne of oil equivalent (toe): This is a conventional standardised unit of energy and is defined on the basis of a tonne of oil having a net calorific value of 41686 kJ/kg.

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

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

Wind energy: Kinetic energy of wind exploited for electricity generation in wind turbines.

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Appendix 1: Methodology for calculating renewable energy shares

Renewable Energy Directive 2009/28/EC

Ireland's binding target under the RED is for renewable sources to account for 16% of gross final energy consumption (GFC) in 2020. There are differing methodologies for the calculation of the overall share of energy from renewables and the individual share of renewables by each mode of energy application, namely heat, transport and electricity (termed RES-E, RES-T and RES-H respectively). These individual targets have separate denominators and in some cases weighting factors; therefore, the individual target percentages cannot be simply added together to get the overall share of renewables.

The main difference arises in transport energy consumption. In the overall RES target all transport energy is included, including aviation and marine, whereas the RES-T target relates only to road and rail energy use (i.e. land transport). There are also weighting factors used in the RES-T calculation for some individual renewable sources (namely biofuels from waste, second generation biofuels and renewable generated electricity powering electric vehicles and rail) but in the calculation of the overall renewable energy target weighting factors are not applied.

Gross Final Consumption

The RED defines gross final consumption of energy (GFC) as the energy commodities delivered for energy purposes to manufacturing industry, transport, households, services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution. The renewable energy contribution includes electricity generation, transport energy and thermal energy from renewable sources. This builds on the definition for GFC of electricity used in Directive 2001/77/EC (to track progress in renewable generated electricity) and adds gross final consumption of heat and transport.

- GFC = TFC (Transport) + GFC (Electricity) + GFC (Heat)

In the case of electricity for example, the difference between TFC and GFC is that TFC equates to all electricity demand used by customers, whereas GFC includes the transmission and distribution losses and the in-house use of electricity by electricity generators.

Overall renewables target

In order to facilitate international comparisons of renewable energy, it is necessary to set transparent and unambiguous rules for calculating the share of energy from renewable sources and for defining those sources across all countries. In the RED, the renewable energy share is calculated from the gross final consumption of energy. No weighting factors are applied to renewable energy sources for the calculation of the overall renewable energy share. There is a legally binding European target for Ireland to achieve a 16% share of energy from renewable energy sources in gross final consumption of energy by 2020, specified in Annex 1 of the RED.

Numerator: The numerator here is the sum of the individual renewable sources.

- Electricity – This is the total renewable electricity generation, with the contribution from wind and hydro normalized to account for climatic variation and in the case of wind to smooth the effect of large annual increases in the installed capacity.
- Heat – This is the total renewable energy used for heat purposes, excluding renewable generated electricity that is used for heating to avoid double counting.
- Transport – This is the total renewable energy used for transport, excluding renewable generated electricity that is used for transport to avoid double counting.

Denominator: The denominator is the gross final consumption adjusted so that aviation is limited to 6.18% of gross final consumption (as prescribed in Article 5.6 of the RED).

Renewable electricity (RES-E)

Ireland's 2020 national target for renewable electricity is 40% of gross electricity consumption, but there is no specified mandatory EU RES-E target for 2020.

Numerator: The total renewable electricity for RES-E calculation is the same as the amount calculated for the overall target, i.e. the sum of the individual renewable electricity sources. No multiplication factors are applied in the calculation of the renewable electricity target, but the wind and hydro portions of renewable electricity are normalised for weather variations when reporting progress towards international renewable energy targets.

Denominator: The denominator here is the gross electricity consumption, which is defined as gross electricity generated plus net imports. No account is taken of the renewable content of imports.

It is important to note that the gross electricity generated is different to (greater than) both the final electricity consumption and the total electricity requirement, the latter of which is often quoted by EirGrid, the transmission system operator (TSO). Gross electricity includes electricity used within power stations and also transmission system and distribution system losses, whereas the total electricity requirement is the gross electricity requirement minus the in-house load of power plants.

Normalisation

In calculating the contribution of hydro and wind energy for the purpose of the overall 16% target for renewable energy in Ireland by 2020 in the RED, the effects of climatic variation are smoothed through use of normalisation rules. The normalisation rules are specified in Annex II of the RED and different rules apply for hydro and for wind.

The normalised renewable hydro contribution is calculated as the installed capacity of the latest year for hydro multiplied by the sum of electricity generated, divided by the installed capacity for the last 15 years for hydro energy, as shown in *Equation 1*, where:

- N is the reference year;
- $Q_{N(Norm)}$ is the normalised electricity generated by all hydropower plants in year N for reporting towards the RED;
- Q_i is the actual quantity of electricity generated in year i by all hydropower plants measured in GWh, excluding production from pumped storage units, using water that has previously been pumped uphill and
- C_i is the total installed capacity of all hydropower plants, net of pumped storage, at the end of year i measured in MW.

Equation 1 *Hydro Normalisation Equation*

$$Q_{N(norm)} = \frac{C_N \times \left[\sum_{i=N-14}^{N} \frac{Q_i}{C_i}\right]}{15}$$

Source: European Commission

The normalised wind electricity contribution is calculated as the average installed capacity of the latest two years, multiplied by the sum of electricity generated, divided by the average year-end installed capacity over the last five years, as shown in *Equation 2*, where:

- N is the reference year;
- $Q_{N(Norm)}$ is the normalised electricity generated by all wind-power plants in year N for reporting towards the RED;
- Q_i is the actual quantity of electricity generated in year i by all wind-power plants measured in GWh;
- C_i is the total installed capacity of wind-power plants at the end of year i measured in MW and
- n is 4 or the number of years preceding year N for which capacity and production data are available, whichever is the lower.

Equation 2 *Wind Normalisation Equation*

$$Q_{N(norm)} = \frac{C_N + C_{N-1}}{2} \times \frac{\sum_{i=N-n}^{N} Q_i}{\sum_{j=N-n}^{N} \left(\frac{C_j + C_{j-1}}{2}\right)}$$

Source: European Commission

Renewable heat (RES-H)

In order to meet the 2020 national RES target, renewable thermal energy (RES-H) is required to be around 12% in 2020, but there is not a specified mandatory RES-H target for 2020 in the RED.

Numerator: Total renewable heat for the RES-H target is the same as that for the overall target, i.e. the total renewables used for heat purposes. With regard to geothermal energy, the renewable energy contribution is taken to be the total heat produced by the heat pump less the final energy of the electricity input, i.e. the renewable portion of the heat produced. It is assumed that the coefficient of performance of all heat pumps is 3.5. In the case of direct electric heating, the share of renewable electricity used for heating is not included as it would lead to double counting.

Denominator: In the absence of district heating, thermal GFC is equal to thermal TFC. Hence, thermal GFC is calculated as TFC minus TFC (electricity) minus TFC (transport less electricity used in transport) i.e. the heat demand is calculated as a remainder when electricity and transport demands are subtracted from the overall final consumption.

Renewable transport (RES-T)

There is a mandatory obligation for all Member States to meet the 10% RES-T target by 2020 as well as achieving the overall RES target specified for each Member State.

Numerator: Total renewables for RES-T is the sum of

- first-generation biofuels used for road or rail
- plus second-generation biofuels or biofuels from waste used for road and rail transport multiplied by a weighting factor of 2[47]
- plus the renewable portion of electricity used for road vehicles multiplied by a weighting factor of 5,
- plus the renewable portion of electricity used for rail multiplied by a weighting factor of 2.5,

These weighting factors are used for the calculation of RES-T only and do not apply when calculating the transport contribution to the overall RES share.

The RED attaches an important condition to biofuels: that they must come from sustainable sources. Sustainable sources as defined by Article 17 of the RED are:

- The greenhouse gas emission savings from the use of biofuels and bioliquids shall be at least 35%, in accordance with the methodology prescribed in the RED. This percentage increases to 50% from 2017 and (for new biofuel plants that start production from 1 January 2017) 60% from 2018.
- Biofuels and bioliquids shall not be made from raw material obtained from land with high biodiversity value.
- Biofuels and bioliquids shall not be made from raw material obtained from land with high carbon stock.

Agricultural raw materials cultivated in the EU and used for the production of biofuels and bioliquids shall be obtained in accordance with the requirements and standards set out in the provisions referred to under the heading 'Environment' in part A and in point 9 of Annex II to Council Regulation (EC) No 73/2009.

Denominator: The denominator here is the sum of petrol, diesel, biofuels and electricity used for road and rail transport. The multiplication factor for renewable electricity in rail is included in the denominator, but the multiplication factors for advanced biofuels and renewable electricity used for road transport are not included. Consumption of aviation (kerosene and/or biofuels) and marine transport are not included in the denominator.

Co-operating mechanisms and short-term statistical transfers

If a country is unable to meet the target with indigenous renewable energy sources, there are mechanisms outlined in the RED that could assist in meeting the EU target[48]. There are three main cooperation mechanisms:

- Statistical transfers, where Member States agree to attribute renewable energy produced in one Member to another in their statistical accounting for target compliance. There is no specific plant or physical energy involved.
- Joint projects, where the renewable energy from a particular project is shared between the parties, with or without a physical flow of the energy produced. Under Article 9 of the RED joint projects with physical flows can also be arranged with third countries.
- Joint support schemes, where Member States co-finance their new renewable energy production independent of its location (within their territories).

47 Directive 2009/28/EC; Article 21 (2).

48 European Comission (2013) *Guidance on the use of renewable energy cooperation mechanisms* [Internet]. Available from: http://ec.europa.eu/energy/gas_electricity/doc/com_2013_government_intervention_en.pdf [Accessed December 2018].

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[49], 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[50,51]. 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[52,53]. 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, in particular 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.

49 Sustainable Energy Authority of Ireland (2004) *Renewable Energy in Ireland—Trends and Issues 1990 – 2002.* Available from http://www.seai.ie/Publications/

50 Kartha S., Lazarus M. and Bosi M., 2004, *Baseline Recommendations for Greenhouse Gas Mitigation Projects in the Electric Power Sector,* Energy Policy 32, 545 - 566

51 For further information on Ireland see Ó Gallachóir B. P., O'Leary F., Bazilian M., Howley M. and McKeogh E. J., *Comparing Primary Energy Attributed to Renewable Energy with Primary Energy Equivalent to Determine Carbon Abatement in a National Context.* Journal of Environmental Science and Health Part A: Toxic /Hazardous Substances and Environmental Engineering, Vol. 41, No. 5

52 See http://www.seai.ie/Publications/Statistics_Publications/Energy_Modelling_Group_Publications/Quantifying-Ireland%E2%80%99s-Fuel-and-CO2-Emissions-Savings-from-Renewable-Electricity-in-2012.pdf

53 See also Di Cosmo V. and Malaguzzi Valeri L., October 2014, *ESRI Working Paper No. 493 – The Effect of Wind on Electricity CO_2 Emissions: The Case of Ireland*, ESRI.

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 not assumed to achieve CO_2 savings.

Up until 2015 burning peat for electricity generation was supported directly by the PSO. In this case, where biomass was co-fired with peat, it was assumed to be directly displacing peat, as if the biomass had not been co-fired, peat would have been burned instead. Since 2016, electricity generation from peat is no longer supported by the PSO. Instead, co-firing of biomass with peat at Edenderry is supported under REFIT 3. Without the REFIT from co-firing with biomass, electricity generation from peat would fall down the merit order and be replaced by gas generation (applying the operating margin approach, as for other renewables). The emissions from electricity generated from gas are lower than from electricity generated by peat co-fired with biomass at the current rates of co-firing. Therefore, co-firing biomass with peat resulted in greater carbon dioxide emissions in electricity generation in 2016 and 2017.

In 2017 the co-firing rate of biomass was approximately 40%, i.e. 40% of the energy inputs were from biomass and 60% from peat. The co-firing rate would have to increase to over 65% biomass to break even with the emissions of natural gas generation.

Bioenergy carbon dioxide 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 green-house gas (GHG) emissions targets[54]. Therefore as long as a biofuel meets the minimum sustainability requirements set out in the RED it is counted as zero carbon at the point of combustion.

54 Decision 406 of 2009, on the effort of Member States to reduce their greenhouse gas emissions to meet the EU's GHG emission reduction commitments up to 2020, requires Ireland to reduce GHG 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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