SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Combined Heat and Power in Ireland

2016 Update

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Energy Policy Statistical Support Unit

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Energy Policy Statistical Support Unit

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Sustainable Energy Authority of Ireland

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

Energy Policy Statistical Support Unit (EPSSU)

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

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

Acknowledgements

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

Overview

Capacity

- The installed capacity of CHP in Ireland at the end of 2015 was 342 MWe (385 units), of which 312 MWe (281 units) was operational, an increase of 1.5 MWe (0.5%) in operating capacity from 2014.

CHP by Fuel

- Natural gas was the fuel of choice for 242 operational CHP units in 2015. Oil products made up the next most significant share with 21 units while biogas accounted for 14 units. The remainder was biomass and solid fuel with 2 units each.
- Natural gas fuelled 288 MWe (92%) of the operational capacity in 2015. Oil products fuelled 7.9 MWe (2.5%), biogas 6.3 MWe (2.0%), biomass 5.4 MWe (1.7%) and solid fuel was used by the remaining 5.2 MWe (1.7%).
- Biomass and bioenergy CHP, as renewable energy sources, can be counted towards Ireland's renewable energy targets.

CHP by Sector and Sub-Sectors

- There are a large number of relatively small units in the services sector. The services sector accounted for 83% of the units and 13% of the operational capacity.
- Within the services sector hotels account for the majority (25%) of units while the leisure sub-sector (which includes swimming pools, leisure centres, gyms, etc.) is the second largest at 16%.
- The industry sector accounted for 17% of the units and 87% of the operational capacity.
- The food sub-sector of industry contains the largest number of units with 47% of units and 26% of industrial operational capacity.

CHP Electricity Generation

- In 2015, 7.5% of Ireland's electricity was from CHP installations, compared with 7.3% in 2014.
- In 2015, there were 20 units exporting electricity to the grid. These units exported 1,417 GWh of electricity in 2015, an increase of 3.3% on 2014.

CHP Heat Output

- In 2015 CHP installations met 6.9% of Ireland's total thermal energy demand.
- The useful heat output was estimated at 98% of the total heat generated by CHP plants in 2015[1].

CHP Fuel Input and Thermal/Electrical Outputs

- In 2015, fuel input increased by 7.5%, estimated useful heat output increased by 11.6% while electricity output increased by 4.1%.
- The overall stock of CHP installations has become more efficient, increasing from 76% in 2001 to an efficiency of 84% in 2015.

Avoided CO_2 Emissions

- The use of CHP in 2015 avoided 382 kt CO_2 emissions when compared with separate electricity and heat production.

EU Emissions Trading Scheme (ETS)

- CHP units that are part of the EU Emissions Trading Scheme made up 11% of the units but 82% of operational capacity in 2015.

Primary Energy Savings

- There was a primary energy saving of 23% or 2,015 GWh from CHP plants in 2015 compared to separate heat and electricity production.

1 The survey responses for useful heat are not always reliable and overall useful heat values are liable to be overestimating the amount of useful heat.

Table of Contents

Table of Figures

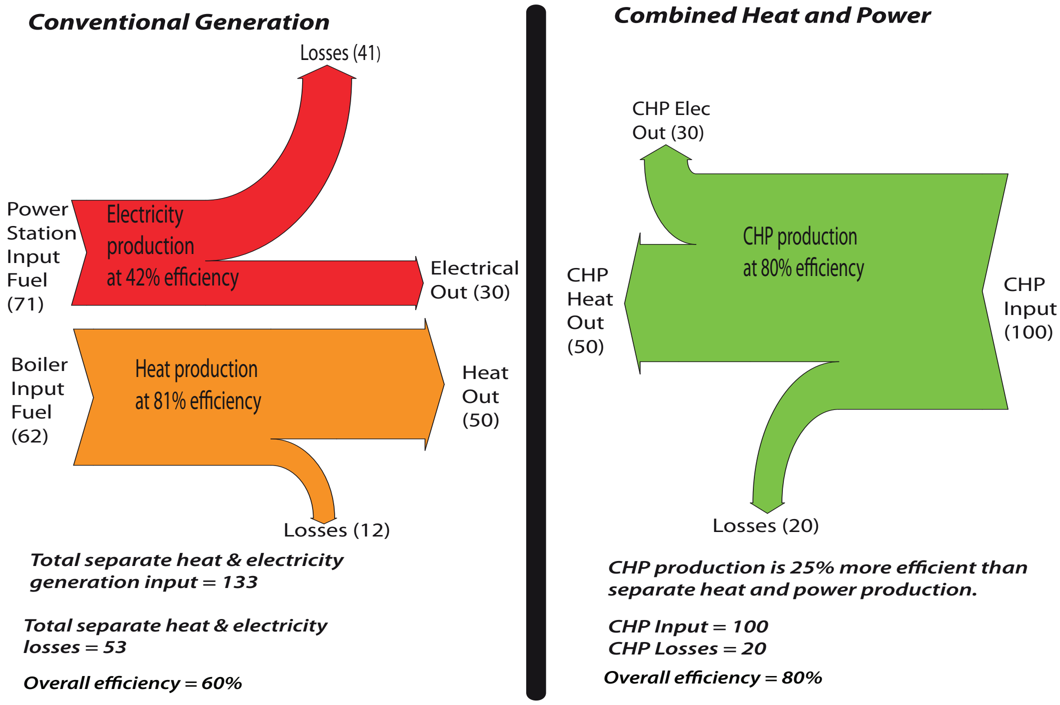
Table of Tables

1 Introduction

In conventional electricity generation much of the input energy is lost to the atmosphere as waste heat. In Ireland over half of the input energy to electricity generation is lost with the other half being transformed into electricity. Combined Heat and Power (CHP) systems channel this lost heat to useful purposes so that usable heat and electricity are generated in a single process. CHP plants are also referred to as cogenerating plants. Where there is cooling energy created in the same process, the plants are referred to as trigeneration plants.

The efficiency of a CHP plant can typically be 20% to 25% higher than the combined efficiency of heat-only boilers and conventional power stations. Figure 1 illustrates how a 25% energy saving can be achieved using CHP compared to the separate production of heat and centralised electricity. The heat efficiency component of the CHP units is calculated from the amount of heat usefully employed as opposed to heat generated. There may also be additional efficiency due to eliminating electricity transmission and distribution losses.

Figure 1 *Comparing Conventional Heat and Electricity Generation to CHP*



Source : SEAI

In the right circumstances, where there is a significant heating or cooling demand in addition to an electricity demand, CHP can be an economic means of improving the efficiency of energy supply and achieving environmental targets for emissions reduction. CHP usually involves the burning of fossil fuels but can also use biomass (including solid biomass, biogas and waste).

This report examines the contribution made by CHP to Ireland's energy requirements for the period 1991 to 2015, with a particular focus on the years 2014 and 2015. This is SEAI's tenth report on the topic. The data are gathered by surveying site operators and CHP unit suppliers. A list of survey questions is included in Appendix A of this report.

2 CHP in Ireland 2015

2.1 Installed Capacity

The installed capacity[1] of CHP in Ireland at the end of 2015 was 342 MWe (385 units[2]), up from 339 MWe (366 units) in 2014, an increase of 0.7%. However, the 2015 installed capacity figures include a number of units that were not operational (29.2 MWe, 104 units). The estimated operating capacity of CHP in Ireland at the end of 2015 was 312 MWe (281 units). This reflects an increase of 1.5 MWe (0.5%) in operating capacity from 2014 to 2015.

The Aughinish Alumina plant which accounts for 160 MWe has been operational since 2006 and is the single largest CHP installation. In 2015 there were 0.8 MWe of additional non-operational units compared to 2014.

There were 19 new operational units (1.5 MWe) reported in 2015, which were mostly in the services sector.

2.2 CHP by Fuel

It is useful to examine the fuel type associated with CHP plants from the perspectives of both security of supply and environmental impact. CHP is promoted due to the improved efficiencies and reduced emissions that may be achieved relative to the alternatives. In this context, the choice of fuel has a direct impact on the level of emissions reduction that may be achieved.

Table 1 illustrates the operational capacity and number of units by fuel in 2015. Oil fuels used are liquefied petroleum gas (LPG), heavy fuel oil, refinery gas and biodiesel. Natural gas was the fuel of choice for 287.7 MWe (242 units) in 2015. It is worth noting that there is a single 160 MWe gas plant which dominates. Oil fuels made up the next most significant share with 7.9 MWe (21 units) followed by biogas with 6.3 MWe (14 units) and biomass accounted for 5.4 MWe (2 units). The remainder was solid fuels at 5.2 MWe (2 units).

Table 1 *Number of Units and Operational Capacity by Fuel in 2015*

	No. of Units	Operational Capacity MWe	No. of Units %	Operational Capacity %
Natural Gas	242	287.7	86.1%	92.1%
Solid Fuels	2	5.2	0.7%	1.7%
Biomass	2	5.4	0.7%	1.7%
Oil Fuels	21	7.9	7.5%	2.5%
Biogas	14	6.3	5.0%	2.0%
Total	281	312.5	100%	100%

Source: SEAI

2.3 CHP by Sector and Sub-Sector

CHP is more suited to some applications and sectors of the economy than others, depending on how the energy is used, the amount of energy consumption and the split between electrical and heat requirements. Traditionally, CHP was more suited to large industrial concerns but the availability of small scale, reliable gas units since the 1990s (and more recently micro-turbines) meant that the services sector could avail of the technology.

Table 2 presents the number of units and operational capacity for CHP in Ireland in 2015. The majority of units are in the services sector while the bulk of operational capacity is in industry, indicating that there are a large number of relatively small units in the services sector. The services sector accounted for 234 (83%) of the 281 units and 42 MWe of the 312 MWe operational capacity (13%) in 2015.

Table 2 *CHP Number of Units and Operational Capacity by Sector in 2015*

	No. of Units	Operational Capacity MWe	No. of Units %	Operational Capacity %
Services	234	42	83.3	13.4
Industry	47	271	16.7	86.6
Total	281	312	100	100

Source: SEAI

1 Megawatt electrical or MWe is the unit by which the installed electricity generating capacity or size of a CHP plant is quantified, representing the maximum electrical power output of the plant.

2 Note that units are distinct from CHP plants or schemes and that there may be more than one CHP unit at a site.

Examining the breakdown of the services sector further in Table 3 it can be seen that hotels and leisure (which includes swimming pools, leisure centres, gyms, etc.) account for 41% (97 units) of units in the sector while the hospital sub-sector accounts for another 11% (25 units). These sub-sectors, in particular, benefit from having close to relatively consistent demand for heat and electricity. The technology may also be suited to any site that has a sufficient simultaneous demand for both heat and electricity.

It is interesting to note that certain sub-sectors have a small number of CHP units but represent a considerable proportion of the installed capacity, notably airports and the public sector (which includes waste water treatment plants). This is illustrated in Table 3 where the combined Airport/Public Sector sub-sectors have 7.3% of the number of CHP units and 28% of the operational capacity.

Table 3 *Number of Units and Operational Capacity by Services Sub-Sectors in 2015*

	No. of Units	Operational Capacity MWe	No. of Units %	Operational Capacity %	Total CHP No. of Units %	Total CHP Operational Capacity %
Airport	3	6.7	1.3	15.9	1.1	2.1
District Heating	25	0.1	10.7	0.3	8.9	0.0
Education	18	7.9	7.7	18.8	6.4	2.5
Hospital	25	4.3	10.7	10.3	8.9	1.4
Hotel	59	7.8	25.2	18.7	21.0	2.5
Leisure	38	2.9	16.2	7.0	13.5	0.9
Nursing Home	13	0.2	5.6	0.5	4.6	0.1
Office	11	3.6	4.7	8.5	3.9	1.1
Public Sector	14	5.0	6.0	11.9	5.0	1.6
Retail	12	2.0	5.1	4.8	4.3	0.6
Services Other	16	1.4	6.8	3.2	5.7	0.4
Total	234	41.9	100	100	83.3	13.4

Source: SEAI

Table 4 presents the sub-sectoral breakdown of operational capacity and number of units in industry. The 160 MWe installation at Aughinish Alumina dominates capacity with that single site accounting for 59% of the total operational capacity in the industrial sector. It can be seen that the food sector has the largest number of units with 47% (22 units), accounting for 26% (69.1 MWe) of industrial operational capacity in 2015. The sub-sector 'Other' refers to enterprises in the energy and the sawmills sub-sectors.

Table 4 *Number of Units and Operational Capacity by Industry Sub-Sectors in 2015*

	No. of Units	Operational Capacity MWe	No. of Units %	Operational Capacity %	Total CHP No. of Units %	Total CHP Operational Capacity %
Food	22	69.1	46.8	25.5	7.8	22.1
Manufacturing	4	6.3	8.5	2.3	1.4	2.0
Pharmaceutical	13	20.6	27.7	7.6	4.6	6.6
Non Ferrous Metals	1	160.0	2.1	59.1	0.4	51.2
Other	7	14.6	14.9	5.4	2.5	4.7
Total	47	270.6	100	100	16.7	86.6

Source: SEAI

Many of the larger capacity CHP units are part of the EU emissions trading scheme (ETS). ETS companies are subject to an annually declining emissions cap which reduces by 21% in 2020 compared to 2005. The breakdown is illustrated in Table 5 where although the ETS sector has only 11.4% of operational units it has 82% of operational capacity. Of the 32 units in ETS, 26 (248 MW_e) are in the industry sector, with the remaining six (8 MW_e)in the services sector.

Table 5 *Number of Units and Operational Capacity by ETS Sector in 2015*

	No. of Units	Operational Capacity MWe	No. of Units %	Operational Capacity %
ETS	32	255.5	11.4	81.8
non-ETS	249	57.0	88.6	18.2
Total	281	312.5	100	100

Source: SEAI

3 Policy

The European Union CHP Directive[3], approved in February 2004, sought to create a favourable environment for CHP installations. The Directive contained definitions for micro, small and large scale CHP. Table 6 lists Ireland's operational capacity in 2015 according to this classification. It can be seen that units in the over 1 MWe category account for most of the operational capacity (92%) while most units are between 50 kWe and 1 MWe (52%).

Table 6 *Number of Units and Installed Capacity by Capacity Size Range in 2015*

Electrical Capacity Size Range	No. of Units	No. of Units %	Operational Capacity MWe	Operational Capacity %
Micro <50 kWe	84	29.9	0.6	0.2
50 kWe ≤ Small < 1MWe	145	51.6	25.2	8.1
Large ≥ 1 MWe	52	18.5	286.8	91.8
Total	281	100	312.5	100

Source: SEAI

The Energy (Miscellaneous Provisions) Act of 2006[4] is the transposition of the EU CHP Directive into Irish law. The European Commission published Decision 2007/74/EC[5] establishing harmonised efficiency reference values for separate production of electricity and heat in December 2006. The Commission also established detailed guidelines for the implementation and application of Annex II to Directive 2004/8/EC in Decision 2008/952/EC[6].

In 2009 three statutory instruments[7] SI 298, SI 299 and SI 499 relating to CHP were published. SI 298 brought into law section 6 of the 2006 act which relates to CHP. SI 299 gives the Commission for Energy Regulation (CER) the responsibility of calculating Power to Heat Ratios for CHP units in Ireland. Under SI 499 the CER is required to certify high efficiency HE (CHP) and the electricity system operator is required to give such generation priority when dispatching to the system.

The CER's 2009 *Decision Paper: Treatment of Small, Renewable and Low Carbon Generators outside the Group Processing Approach* sets out the approach for securing grid connections for different scales of high efficiency CHP.

On 25 October 2012, the CHP Directive was repealed by Directive 2012/27/EU[8] of the European Parliament and of the Council on energy efficiency[9]. The new Directive places energy efficiency at the core of the EU Energy 2020 strategy, requires Member States to further decouple energy use from economic growth and sets out a common framework of measures for the achievement of the EU's headline 20% energy efficiency target (by 2020).

It recognises that high efficiency CHP, together with district heating and cooling, has significant potential for achieving primary energy savings. It sets out a number of obligations on Member States, including that they establish mechanisms for guaranteeing the origin of electricity from cogeneration and provide priority access or dispatch for electricity generated from high efficiency cogeneration. The Directive also requires that Member States:

- Assess the potential for the application of high efficiency cogeneration and district heating and cooling, implement policies at a local and regional level to encourage the consideration of using efficient heating and cooling systems, and assess the potential for local and regional heat markets;
- Ensure that a cost benefit analysis on the use of high efficiency cogeneration is carried out for new and refurbished electricity generating stations, industrial installations that generate waste heat at a useful temperature, and new and refurbished district heating and cooling systems, where the development has a total thermal input greater than 20 MW;
- Ensure that electricity generated from high efficiency cogeneration is guaranteed access to the grid and is provided with priority dispatch.

Transposition of the Directive in Ireland was completed in 2014 by two statutory instruments, SI 131 and SI 426. SI 426

3 European Union, 2004. *Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market*. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02004L0008-20090420&qid=1409052593848&from=EN

4 Acts of the Oireachtas are available at: http://www.irishstatutebook.ie/home.html

5 European Union, 2007. *Commission Decision of 21 December 2006 establishing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2004/8/EC*. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:032:0183:0188:EN:PDF

6 European Union, 2008. *Commission Decision of 19 November 2008 establishing detailed guidelines for the implementation and application of Annex II to Directive 2004/8/EC for the European Parliament and of the Council*. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008D0952&from=EN

7 Statutory Instruments are available at: http://www.irishstatutebook.ie/home.html

8 Full details are available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF

9 *Directive 2012/27/EU* also repealed *Directive 2004/8/EC (cogeneration)* and amended Directives *2009/125/EC (eco-design of energy-related products)* and *2010/30/EU (labelling of energy-related products)*.

transposes the majority of the Directive into law, including Article 14 which relates to the promotion of efficiency in heating and cooling. It also allows for exemptions for certain installations from the cost benefit analysis mentioned above.

The Energy White Paper (2015)[10] contains an action to develop a policy framework to encourage the development of CHP, taking account of the findings and recommendations of the comprehensive assessment required by the European Union (Energy Efficiency) Regulations 2014.

3.1 High Efficiency CHP Certification

The Commission for Energy Regulation was appointed to certify high efficiency CHP (HE CHP) under SI 299 of 2009. A decision paper (CER/12/125)[11] on the certification process was published in March 2012, with a clarification note (CER/12/184)[12] on the assessment of useful heat published in November 2012. The decision paper put in place a process for applications from generators which would allow them to be assessed for certification as high-efficiency CHP as set out in Directive 2004/8/EC. The certification is based on available data and applicants are required to:

- demonstrate that the heat load is useful heat;
- complete and submit relevant application forms and provide required data;
- maintain operational records and install metering and measurement systems where necessary;
- provide full access to operational data, and
- provide access and facilitate inspection of the plant and records by auditors appointed by the CER.

The calculation methodology is based on that laid out in Directive 2004/8/EC with results provided as follows:

- power to heat ratio;
- primary energy savings (PES);
- determination of HE CHP electricity;
- electrical efficiency;
- heat efficiency;
- overall efficiency.

It is the calculation of the PES, rather than the overall energy efficiency, that ultimately determines whether a CHP plant qualifies as high efficiency. The specific requirements with respect to PES for high efficiency CHP certification are:

- PES ≥10% for plants with capacity greater than or equal to 1 MWe;
- PES >0% for plants below this capacity threshold, i.e. plants less than 1 MWe.

All certified HE CHP plants are required to report annually to the CER detailing whether the high efficiency standards have been met and include key defined parameters which are based on twelve months' operational data. Audits must be carried out and certification may be revoked at any time.

As of October 2015, 208 MWe of existing CHP had been certified as high efficiency by the CER, with a further 787 MWe of planned CHP also certified. Annual reports are required within two months of the anniversary of their certification or commissioning if a planned site.

3.2 Renewable Energy Feed-In Tariff

Further support for biomass CHP and anaerobic digestion CHP is now provided through a Government renewable energy feed-in-tariff (REFIT). REFIT in general is a support mechanism to help meet the national renewable electricity target of 40% by 2020. Specifically REFIT 3[13] (biomass technologies) opened in February 2012 having received state aid clearance from the European Commission in October 2011.

REFIT 3 is designed to incentivise the addition of 310 MW of renewable electricity capacity to the Irish grid. Of this, 150 MW is intended to be high efficiency CHP (HE CHP), using both anaerobic digestion (50 MW) and the thermo-

10 Ireland's Transition to a Low Carbon Energy Future (2015), http://www.dccae.gov.ie/energy/SiteCollectionDocuments/Energy-Initiatives/Energy%20White%20Paper%20-%20Dec%202015.pdf

11 Commission for Energy Regulation (Mar. 2012), *Certification Process for High Efficiency CHP Decision Paper*, http://www.cer.ie/docs/000155/cer12125.pdf

12 Commission for Energy Regulation (Nov. 2012), *Assessment of Useful Heat for High Efficiency CHP Clarification Note*, http://www.cer.ie/docs/000155/cer12184.pdf

13 REFIT 3 Terms and Conditions available from http://www.dcenr.gov.ie/energy/en-ie/Renewable-Energy/Pages/Refit-3-landing-page.aspx

chemical conversion of solid biomass (100 MW), while 160 MW will be reserved for biomass combustion and biomass co-firing. The support levels range from 12 cent per kWh to 14 cent per kWh for biomass and from 13 cent per kWh to 15 cent per kWh for anaerobic digestion depending on the plant size and subject to indexation, with support for any particular project not exceeding 15 years or extending beyond 2030.

Demand for the biomass CHP category exceeded the original allocation of 100 MW and is significantly lower for the other categories. In August 2014 the Government approved the reallocation of 70MW capacity from these categories (35MW anaerobic digestion and 35MW biomass combustion), to biomass CHP. This was done to reflect demand and increase the number of projects without significantly increasing the modelled costs of the scheme.

CHP plants wishing to avail of REFIT 3 must successfully demonstrate that their project will meet the high efficiency CHP standard under the terms of the 2004 Cogeneration Directive (2004/8/EC) and be certified by the Commission for Energy Regulation in this regard. REFIT 3 will close for new applications on December 31st 2015.

3.3 Renewable Heat Incentive

As noted in the Energy White Paper (2015)[14], work has commenced on the design of a Renewable Heat Incentive (RHI). The Minister for Communications, Climate Action and Environment has announced that the scheme will be introduced in 2017 subject to EU state aid clearance. The design of support is focused on non-domestic renewable heat inhalations operating in the non-ETS sector. The initial public consultation on technology review closed on the 18th of September 2015. The submissions informed a detailed specification to design a number of RHI implementation options. The Department of Communications Climate Action and Environment intend to put several options arising from this analysis for further public consultation in Q4 of 2016[15].

3.4 Tax Relief

Provision for a partial relief from carbon tax for mineral oil, natural gas or solid fuel, and a full relief in the case of peat, used for environmentally friendly heat and power cogeneration, was made in Finance Act 2012[16]. These tax reliefs are available to CHP plants, other than micro-CHP, that meet the requirements for high-efficiency cogeneration under Directive 2004/8/EC of the European Parliament and certified as such by the CER. The relief is given by means of repayment to the consumer of the fuel for CHP, therefore the consumer must make the application to their local Revenue District office.

These certified CHP plants may also be eligible for relief from electricity tax for electricity produced from high-efficiency environmentally friendly heat and power generation. This tax relief will normally be claimed by the supplier when making the tax return. There is a further relief from electricity tax for electricity used for combined heat and power generation. Please see the Electricity Tax Guide[17] for more details.

3.5 Targets and Planned Growth

The Government's Energy White Paper[18] published in March 2007 set out the energy policy directions and targets for Ireland to 2020, which include: a total of 400 MWe of installed CHP capacity by 2010 and 800 MWe by 2020. The 2010 target is repeated in the National Climate Change Strategy (NCCS)[19] 2007 to 2012, also published in 2007, which stated that 0.162 Mt CO_2 equivalent will be saved by 2010 as a result of CHP. The 2010 target was missed as the total installed capacity at the end of 2010 was approximately 307 MWe.

The installed capacity at the end of 2015 was 85% of the Government's 2010 target and 43% of the 2020 target. Additional capacity of 488 MWe is required in order to meet the 2020 target of 800 MWe or an average annual growth rate of 21%. This compares to an increase of 0.3% in installed capacity in 2015 and an average annual growth rate of 2.1% between 2006 and 2015.

14 Ireland's Transition to a Low Carbon Energy Future (2015), http://www.dccae.gov.ie/energy/SiteCollectionDocuments/Energy-Initiatives/Energy%20White%20Paper%20-%20Dec%202015.pdf

15 For further information please see http://www.dccae.gov.ie/energy/en-ie/Renewable-Energy/Pages/Heat.aspx

16 *Finance Act 2012* available from http://www.irishstatutebook.ie/2012/en/act/pub/0009/

17 Electricity Tax Guide available from http://www.revenue.ie/en/tax/excise/leaflets/electricity-tax.pdf

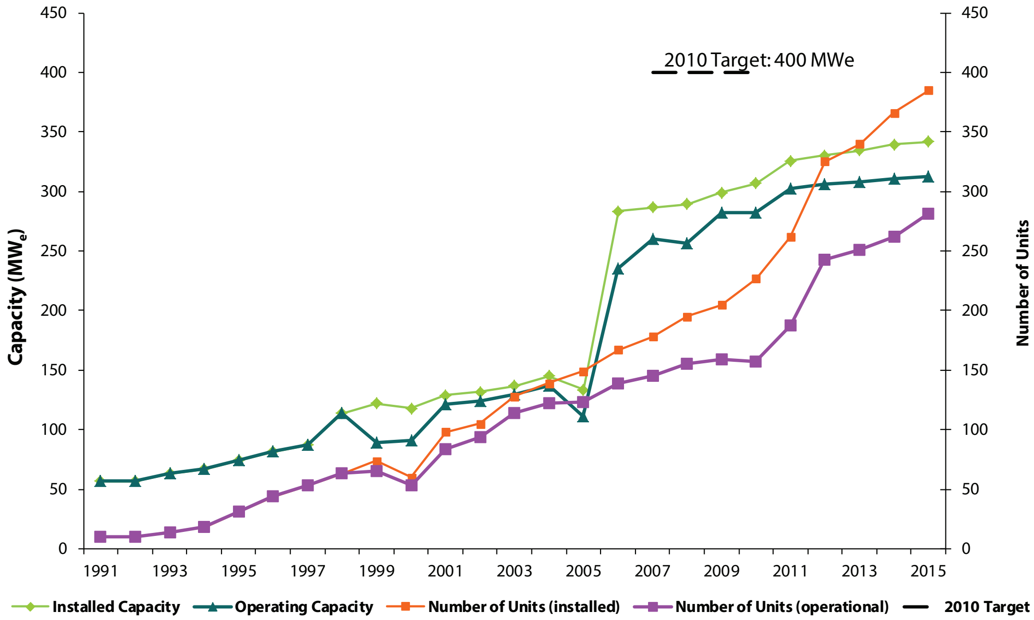
18 Full text available from http://www.dcmnr.gov.ie/Energy/Energy+Planning+Division/Energy+White+Paper.htm.

19 Available from http://www.environ.ie/en/Environment/Atmosphere/ClimateChange/NationalClimateChangeStrategy/PublicationsDocuments/FileDownLoad,1861,en.pdf.

4 CHP Trends 1991 to 2015

Figure 2 presents the number and capacity of CHP units in Ireland over the period 1991 to 2015[20]. The increase in installed capacity over the period was 502% (7.8% per annum) from a low base.

Figure 2 *Number of Units and Installed Capacity 1991 – 2015*



Source: SEAI

The operational capacity increased by 0.5% in 2015. Growth in 2006 was 127%, largely due to the addition of the Aughinish Alumina plant. The average annual growth rate of installed capacity was 6% prior to the addition of the Aughinish Alumina plant (1991 – 2005) and 2.1% after the addition (2006 – 2015) Figure 2 also presents data for the growth in the number of operational units over the period, representing an average incremental growth of 14.9% per annum, again from a low base. In 2015 there was a 7.3% increase in the number of operational units representing an increase of 0.5% in operational capacity.

Table 7 tabulates the operational capacity growth rates from 1991 to 2015.

Table 7 *Growth Rates and Quantities of Operational Capacity*

	Growth %	Average annual growth rates %					Capacity (MWe)	
	1991 – 2015	'91 – '15	'00 – '05	'05 – '10	'10 – '15	2015	1991	2015
Operational Capacity	450.2	7.4	4.2	20.4	2.1	0.5	56.8	312.5

Source: SEAI

The data compiled in the CHP survey quantifies electricity and heat generated by all operational CHP plants in Ireland. Data on useful heat is also requested. Table 8 shows that the useful heat output has increased by 375% since 2000 (10.9% per annum). However, it should be noted that the survey responses for useful heat are not always reliable and the overall useful heat values are likely to be overestimating the amount of useful heat. It is anticipated, once results are available from the CER on the new reporting requirements for high efficiency CHP certification,[21] that data quality on useful heat will improve. However, it will not be possible to update historical values.

It is estimated that the CHP useful heat output met 6.9% of Ireland's total thermal demand[22] in 2015.

20 Data for this report originates from surveys conducted by SEAI in 1996 to 1998, 2000 and 2002 that were part funded by Eurostat. SEAI conducted similar surveys for 1999, 2001 and 2002. The ESB undertook the surveys in 1994 and 1996. A survey was not carried out for 1995. An annual survey has been carried out by SEAI since 2003.

21 High efficiency CHP certification was introduced as a result of SI 499 of 2009 which is discussed in section 4.

22 Thermal energy is defined here as energy used for space, process and water heating, cooking, etc. The total thermal demand is calculated as the residual energy requirement when energy use from transport and electricity generation is subtracted from the total primary energy supply.

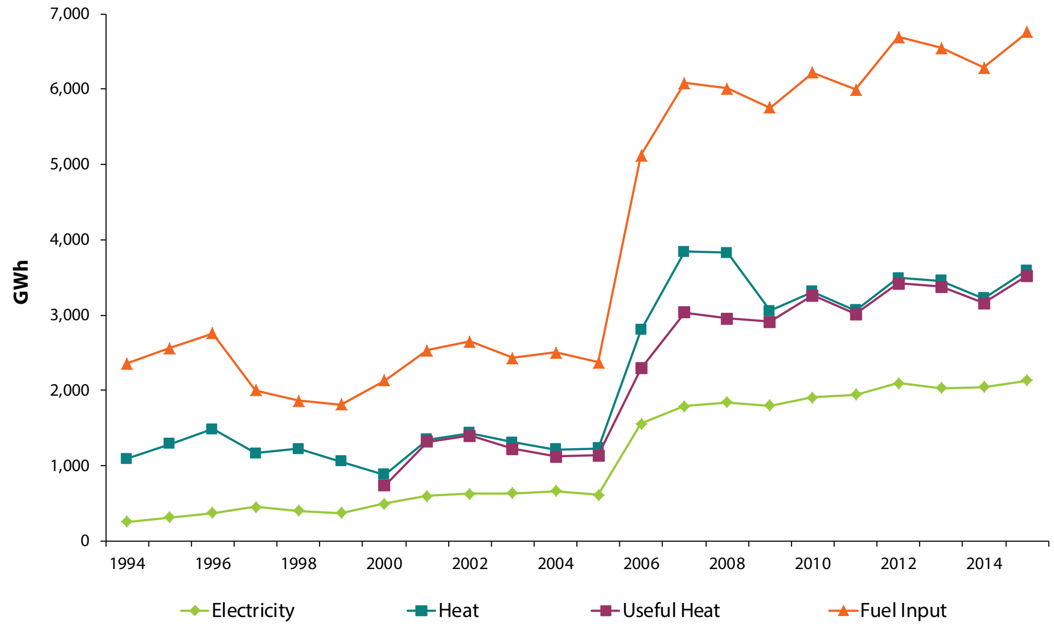
Table 8 *Useful Heat as a Percentage of Heat Generated*

	2000	2005	2010	2011	2012	2013	2014	2015
Heat usefully employed (GWh)	742	1,140	3,262	3,015	3,423	3,379	3,157	3,523
Percentage of total heat generated	84%	92%	98%	98%	98%	98%	98%	**98%**

Source: SEAI

Figure 3 illustrates the trends relating to fuel inputs and electricity and thermal outputs for all operational plants over the period 1994 to 2015. Fuel inputs have increased by 186% (5.1% per annum) while the estimated useful thermal and electrical outputs have increased by 229% (5.8% per annum) and 725% (10.6% per annum) respectively over the period. This suggests that the overall stock of CHP installations has become more efficient over the period. In 2015 fuel input increased by 7.5%, while thermal output increased by 11.4% and electricity increased by 4.1%.

Figure 3 *CHP Fuel Input and Thermal/Electricity Output 1994 – 2015*



Source: SEAI

Table 9 tabulates the growth rates and quantities of fuel inputs and thermal/electricity output from 2000 to 2015.

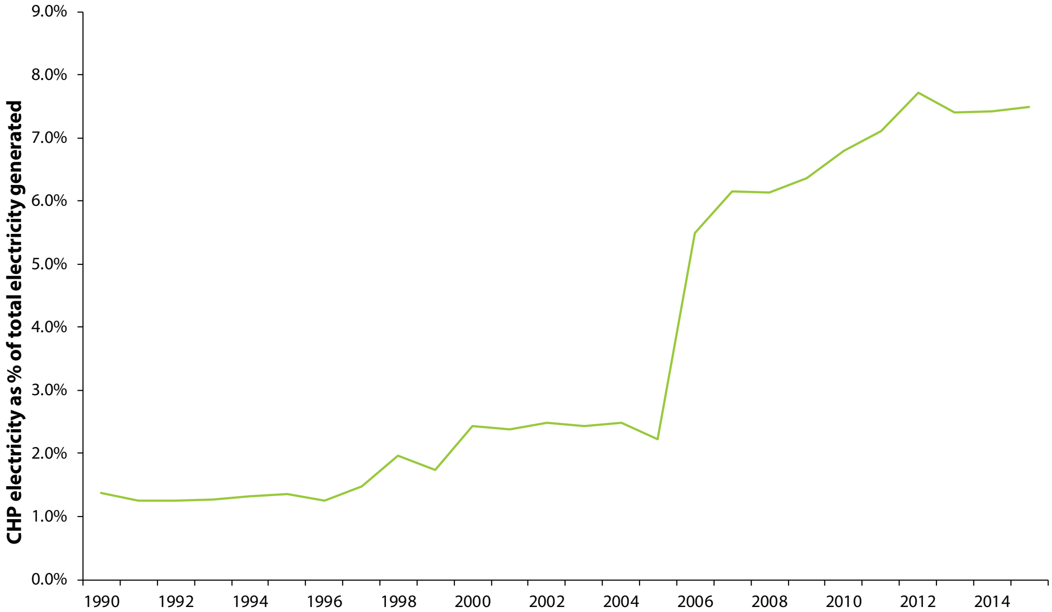
Table 9 *Growth Rates and Quantities of CHP Fuel Input and Thermal/Electricity Output*

	Growth %	Average annual growth rates %					Quantities (GWh)	
	2000 – 2015	'00 – '15	'00 – '05	'05 – '10	'10 – '15	2015	2000	2015
Fuel Input	216.9	8.0	2.2	21.3	1.7	7.5	2,131	6,753
Electricity Output	325.1	10.1	4.1	25.4	2.3	4.1	502	2,134
Heat Output	307.6	9.8	7.0	21.8	1.6	11.4	882	3,595
Useful Heat Output	375.0	10.9	9.0	23.4	1.5	11.6	742	3,523

Source: SEAI

Figure 4 focuses on CHP generated electricity in Ireland as a proportion of gross electricity consumption (i.e. electricity generation plus net imports) in the period 1990 to 2015. In 2015, 7.5% of total electricity generation was from CHP installations compared with 7.4% in 2014.

Figure 4 *CHP Electricity as a Percentage of Gross Electricity Consumption 1990 – 2015*



Source: SEAI

Table 10 tabulates the growth rates and share of CHP electricity of gross electricity consumption from 1991 to 2015.

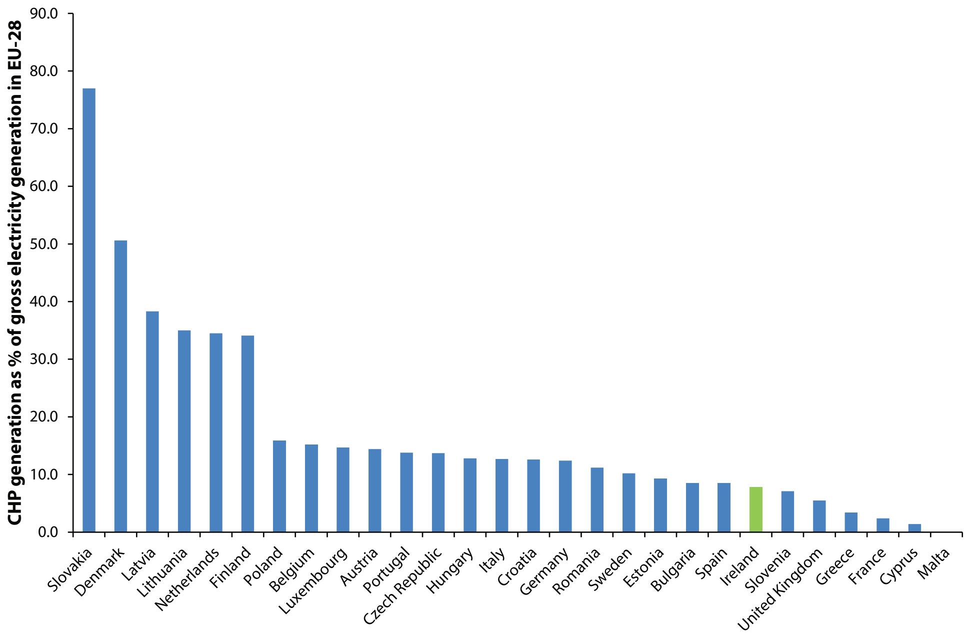
Table 10 *Growth Rates of CHP Electricity as a Percentage of Gross Electricity Consumption*

	Growth %	Average annual growth rates %					Share %	
	1991 – 2015	'91 – '15	'00 – '05	'05 – '10	'10 – '15	2015	1991	2015
CHP Electricity as a Percentage of Gross Electricity Consumption	497.6	7.7	-1.8	25.1	2.0	1.1	1.3	7.5

Source: SEAI

The proportion of total electrical output that was generated from CHP was 11.7% for EU-28 in 2013. Data is not yet available for 2014. Figure 5 shows Ireland's position in relation to the EU-28 in 2013. In Slovakia 77% of total electricity was generated from CHP compared to 0% in Malta.

Figure 5 *CHP Electricity as a Percentage of Gross Electricity Consumption in EU-28 in 2013*



Some CHP units export electricity to the national grid. In 2015, there were 20 units exporting electricity to the grid. These units exported 1,417 GWh of electricity in 2015, a 3.3% increase on what was exported in 2014.

The overall efficiency of the CHP plants since 2001 is shown in Figure 5. The overall efficiency of the CHP plants in 2015 was calculated as 84%. This figure is strongly influenced by the likely overestimation of the useful heat responses to the CHP survey. Many of the responses have the same figure for heat generated and useful heat. Although CHP installations are typically sized to the required heat demand, it is unlikely that all of the heat generated is being used.

Figure 6 *Efficiency of CHP Plants*

Source: SEAI

Table 11 tabulates the growth rates of efficiency of CHP plants from 2001 to 2015.

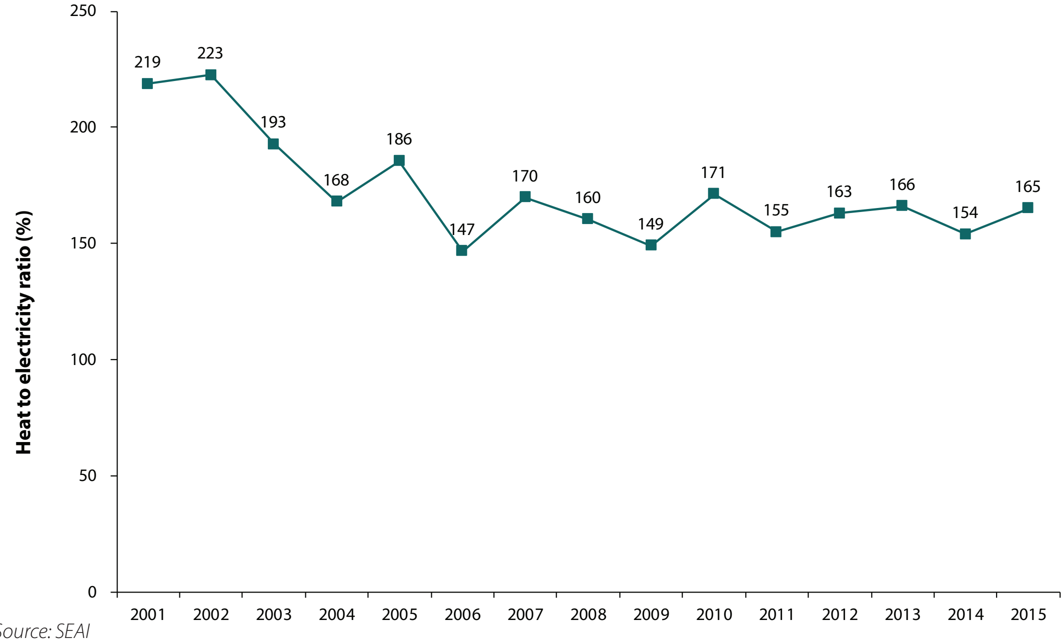
Table 11 *Growth Rates of CHP Plant Efficiency*

	Growth %	Average annual growth rates %					Efficiency (%)	
	2001 – 2015	'01–'15	'01 – '05	'05 – '10	'10 – '15	2015	2001	2015
Efficiency of CHP Plants	10.4	0.7	-0.7	2.4	0.2	1.1	75.9	83.8

Source: SEAI

The heat to power ratio is plotted in Figure 7. The variation in the ratio can be attributed to unreliable responses to the CHP survey for the useful heat values in those years. As mentioned previously, it is anticipated that the data quality on useful heat will improve once the data reported to the CER in accordance with the high efficiency CHP requirements becomes available. In 2015 there was 65% more heat produced from CHP than electricity.

Figure 7 *Heat to Power Ratio of CHP Plants*



Source: SEAI

Table 12 tabulates the growth rates of the heat to power ratio of CHP plants from 2001 to 2015.

Table 12 Heat to Power Ratio of CHP Plants

	Growth %	Average annual growth rates %					Ratio (%)	
	2001 – 2015	'01 – '15	'01 – '05	'05 – '10	'10 – '15	2015	2001	2015
Heat to Power Ratio of CHP Plants	-24.5	-2.0	-4.0	-1.6	-0.7	7.2	218.7	165.1

Source: SEAI

5 Avoided CO_2 from CHP

As mentioned at the beginning of this update, CHP can be used to achieve environmental targets for emissions reduction. Specifically, by utilising the heat that would otherwise be lost in electricity generation, the efficiency of a CHP plant can typically be 20 to 25 percentage points more than the combined efficiency of heat-only boilers and conventional power stations. Also, if embedded in the network close to the point of electrical consumption, CHP can avoid some of the transmission losses incurred by centralised generation. Consequently CHP can bring environmental benefits in the form of CO_2 savings.

The amount of CO_2 avoided by employing a CHP unit is difficult to determine and is widely debated. It requires assumptions relating to the electricity generation in the absence of CHP plants, i.e. relative to a specific baseline. One perspective suggests that CHP displaces the marginal fuel of electricity generation, as less marginal plant generation is required if additional electricity is generated from CHP. This is typically referred to as the *operating margin approach*[23,24]. For example, if additional CHP electricity is produced, less open cycle[25] (mainly natural gas in Ireland) electricity will be generated. The operating margin approach is the approach adopted in this report for calculating the historical emissions avoided by CHP plants.

The assumptions regarding displacement of heat depend on the fuel used and are detailed in Table 13.

Table 13 *Displacement of Heat – Assumptions*

Fuel	Displacement fuel	% efficiency
Natural Gas	Natural gas	80%
Biogas	Fuel oil	80%
Biomass	Fuel oil	80%
Peat	Milled peat	70%
LPG	Gas oil	80%
Coal	Fuel oil	80%
Refinery Gas	Fuel oil	80%
Biodiesel	Gas oil	80%

Source: SEAI

A number of factors influence the quantity of avoided emissions in using the operating margin approach. These include the carbon intensity of the operating margin fuel mix, the overall efficiency of the installed CHP plants and the absolute CHP capacity. The assumption underpinning the operating margin approach is that the CHP plant is displacing the last plant to be dispatched to meet electricity demand – i.e. the marginal gas plants. CHP plants are not generally displacing electricity from either 'must-run' plants (peat) or baseload plants (coal fired station at Moneypoint). The carbon intensity of the marginal generation mix will have a significant impact on the quantity of avoided CO_2. Detailed in Table 14, this varies annually depending on the composition of the marginal generation in any particular year.

Table 14 *Carbon Intensity of the Marginal Generation*

	2001	2005	2010	2011	2012	2013	2014	2015
Intensity CO_2 g/kWh (Operating Margin Mix)	611	520	448	418	414	412	407	400
Annual Change		2.2%	-1.8%	-7.1%	-0.9%	-0.6%	-1.1%	-1.7%

Source: SEAI

The results from the operating margin approach are illustrated in Figure 8 and Table 15[26].

Table 15 *Avoided CO_2 Operating Margin Approach*

	2001	2005	2010	2011	2012	2013	2014	2015
Avoided CO_2 (kt)	215	126	411	371	389	377	384	382

Source: SEAI

The cumulative avoided CO_2 emissions by CHP plants since 2001 is 4,541 kt CO_2.

23 Kartha S., Lazarus M. and Bosi M. Baseline recommendations for greenhouse gas mitigation projects in the electric power sector. *Energy Policy* 2004, 32, 545-566.

24 Ó Gallachóir B. P., O'Leary F., Bazilian M., Howley M. & McKeogh E. J. 2005 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*.

25 Open cycle plants normally operate as the marginal plant as they can respond to varying demand. They typically have efficiencies of approximately 35% and generate increased CO_2 and NO_x emissions compared to combined cycle generators which have efficiencies in the range of 50% - 60%.

26 Historical figures were updated in 2015 resulting in different avoided CO_2 emissions than previously reported in the 2014 CHP update. Where a useful heat figure was not provided the useful heat was assumed to be equal to the actual heat output.

Figure 8 *Avoided CO_2 on the basis of the Operating Margin Approach 2001 – 2015*

Source: SEAI

It can be seen in Figure 8 that the avoided CO_2 from the operating margin approach decreased from 215 kt CO_2 in 2001 to 126 kt CO_2 in 2005[27], a decrease of 41% (12% per annum on average). During this time there was a 17% reduction in the CO_2 intensity (g CO_2/kWh) of the electricity generated from the marginal generation fuel mix, so the decrease in emissions avoided from CHP units was due to overall improvements in the efficiency of the electricity system.

In 2006 there was a sharp increase (163%) in the avoided emissions to 332 kt CO_2, mainly due to the additional capacity added that year. In 2015 avoided CO_2 was 382 kt, an increase of 78% since 2001. This increase in avoided emissions was due to the improvement in the estimated overall efficiency of the CHP plants, which is plotted in Figure 6, as well as the increase in the marginal generation CO_2 emissions.

27 Note that the historical figures for the avoided CO_2 emissions were revised for this update. The heat output used is the amount of heat usefully employed.

6 Primary Energy Savings

Primary energy savings are the savings in primary energy achieved when CHP is used to provide the heat and electricity outputs, instead of separate production. The amount of primary energy savings (PES) provided by CHP is calculated according to the formula specified in EU Directive on the promotion of cogeneration[28]. Using this method the primary energy savings are calculated as a percentage of the overall primary energy use for separate heat and electricity generation.

The results are shown in Table 16. In order for CHP to qualify as high efficiency CHP under the directive, small and micro scale CHP must achieve positive primary energy savings compared to the separate production of heat and electricity. CHP at a scale greater than 1 MWe must achieve a PES of at least 10% in order to qualify as high efficiency CHP. This calculation is based on useful heat only, so the result is determined by the accuracy of the useful heat responses in the annual CHP survey.[29] Based upon the data provided by CHP plant operators, the total population of CHP plants has achieved positive primary energy savings in each year since 2000, with the average PES exceeding 10% since 2001[30].

Table 16 *Primary Energy Savings*

	2000	2005	2010	2011	2012	2013	2014	2015
% PES	9.7%	19.5%	25.8%	24.1%	24.8%	22.6%	22.8%	23.0%
PES (GWh)	229	575	2,163	1,898	2,212	1,906	1,856	2,015

Source: SEAI

28 European Union, 2004. Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market. Available from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0008&from=EN

29 A significant portion of survey respondents do not distinguish between the total CHP heat output and the useful heat which results in overestimation of primary energy savings.

30 Historical figures were updated in 2015 resulting in different primary energy savings than previously reported in the 2014 CHP update. Where a useful heat figure was not provided the useful heat was assumed to be equal to the actual heat output.

Appendix A: Annual CHP Survey

Installation Date[1]	Prime Mover[2]	Fuel Type[3]	Installed Electrical Capacity (kWe)[4]	Installed Thermal Capacity (kWt)[5]	Annual Operating Hours[6]	Fuel Input e.g. Tonnes, Litres[7]	Fuel Input MWh[8]	Total Electricity Generated MWh[9]	Total Heat Generated MWh[10]	Heat Usefully Employed MWhr[11]	Grid Connection to Export[12]	Electricity Exported to the Grid MWh[13]	Heat to Power Ratio[14]

Notes

1. Provide the date when the CHP unit came online.
2. Choose one from the following: Combined cycle, Steam: backpressure turbine, Steam: condensing turbine, Gas turbine with heat recovery, Internal combustion engine or Other. Please specify when choosing other.
3. Choose one from the following: Coal, Peat, Residual Fuel oil, Gasoil, Natural gas, Refinery gas, Biogas, Biomass or Other. Please specify when choosing Other.
4. The rated electrical capacity of the CHP unit.
5. The rated thermal capacity of the CHP unit.
6. The total amount of hours the unit was in operation during the year.
7. This is the total amount of fuel used by the CHP unit in the year, excluding fuel used for supplementary firing (i.e. firing to meet heat demand not met by CHP output).
8. Same as number 7 but converted to MWh
9. Total amount of electricity generated by the CHP unit in the year.
10. Total amount of heat generated by the CHP unit in the year. Do not include heat generated from other sources.
11. Useful heat is the total amount of CHP heat that was used during the year as distinct from the total heat produced.
12. Is the unit connected to the national grid to export electricity (yes or no) ?
13. Total amount of electricity sold on to the national grid in the year.
14. Power to heat ratio is the ratio between electricity from CHP and useful heat when operating in full CHP mode.

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