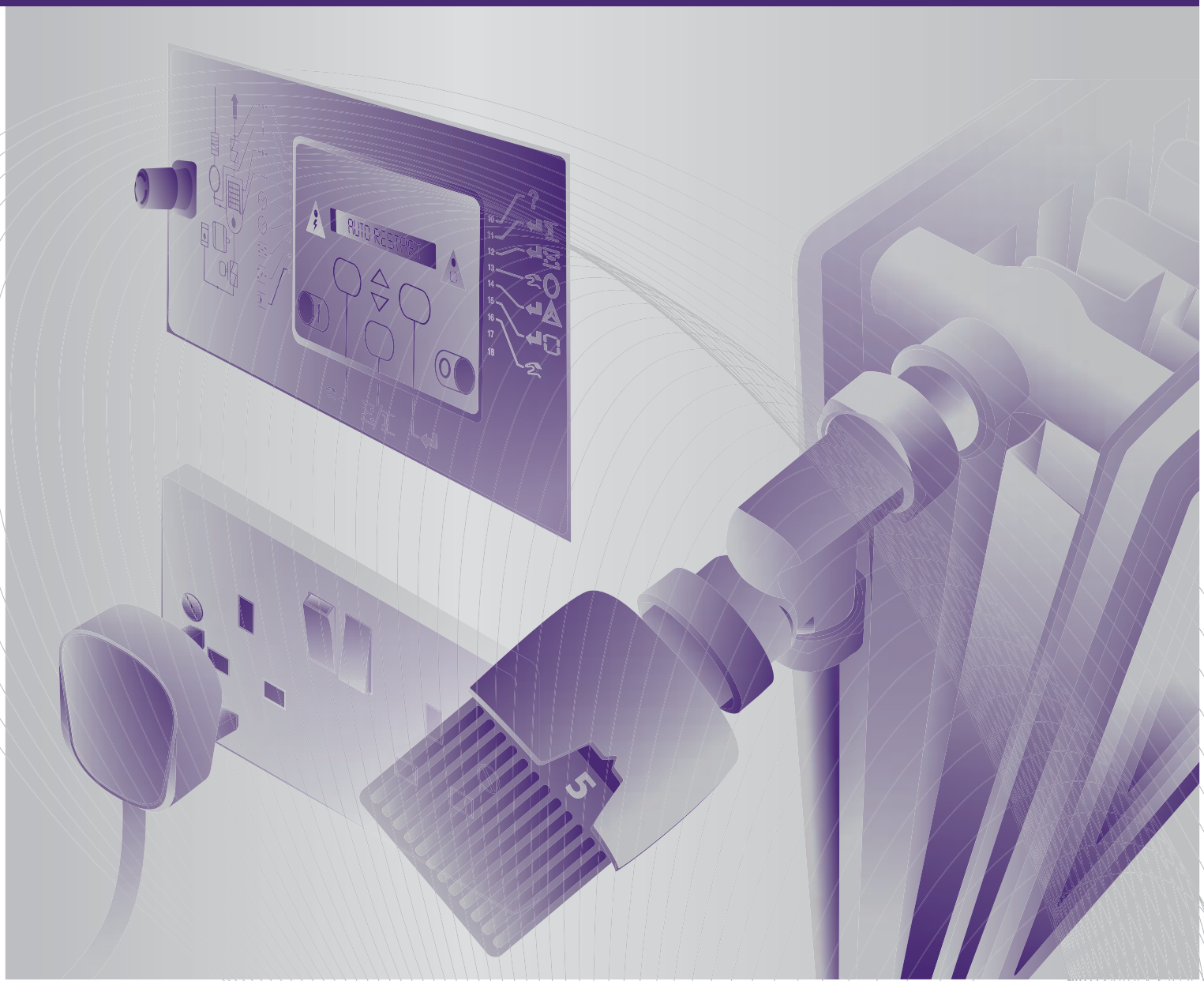
SUSTAINABLE ENERGY IRELAND

Energy Policy Statistical Support Unit

Combined Heat and Power in Ireland

2007 UPDATE



Combined Heat and Power in Ireland

2007 Update

Report prepared by
Fergal O' Leary, Martin Howley and Brian Ó Gallachóir

December 2007

SUSTAINABLE ENERGY IRELAND

Energy Policy Statistical Support Unit

Sustainable Energy Ireland (SEI)

Sustainable Energy Ireland was established as Ireland's national energy agency under the Sustainable Energy Act 2002. SEI's mission is to promote and assist the development of sustainable energy. This encompasses environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy including public bodies, the business sector, local communities and individual consumers. Its remit relates mainly to improving energy efficiency, advancing the development and competitive deployment of renewable sources of energy and combined heat and power, and reducing the environmental impact of energy production and use, particularly in respect of greenhouse gas emissions.

SEI is charged with implementing significant aspects of government policy on sustainable energy and the climate change abatement, including:

- Assisting deployment of superior energy technologies in each sector as required,
- Raising awareness and providing information, advice and publicity on best practice,
- Stimulating research, development and demonstration,
- Stimulating preparation of necessary standards and codes and
- Publishing statistics and projections on sustainable energy and achievement of targets.

It is funded by the Government through the National Development Plan with programmes part financed by the European Union.

Energy Policy Statistical Support Unit (EPSSU)

SEI 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 to meeting international reporting obligations, for advising policy makers and informing investment decisions. Based in Cork, EPSSU is SEI'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 and
- Contribute to the development and promulgation of appropriate sustainability indicators.

Introduction

In conventional electricity generation much of the input energy is lost to the atmosphere as waste heat. Typically 60% of the input energy is lost with just 40% being transformed into electricity. Combined Heat and Power (CHP) systems channel this extra heat to useful purposes so that usable heat and electricity are generated in a single process. In the right circumstances CHP can be an economic means of improving the efficiency of energy use and achieving environmental targets for emissions reduction. CHP usually involves the burning of fossil fuels, but heat and electricity are also produced from biomass (including biogas and waste).

This report examines the contribution made by CHP to Ireland's energy requirements for the period 1991 to 2006, with a particular focus on the years 2005 and 2006. This is SEI /EPSSU's fourth report on the topic.

Installed Capacity and Number of Units 2005 and 2006

The installed capacity[1] of CHP in Ireland at the end of 2006 was 310 MW_e (167 units[2]) up from 147 MW_e (149 units) in 2005, an increase of 111%. The increase in 2006 is due in large part to the Aughinish Alumina plant which accounts for 160 MW_e of the increase. Aside from this single large addition, there was a 2% growth in installed capacity in 2006.

The figures above include a number of units that were not operational (36.2 MW_e, 11 units) and a number whose status of is currently unknown (4.9 MW_e 11 units). A number of large units, including the Irish Sugar plants in Carlow and Mallow, closed in 2005 and 2006. These two plants account for 26 MW_e alone.

Regarding growth in 2007 there are 16 units with an installed capacity of approximately 4.8 MWe which are due to be operational by the end of the year.

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 levels of emissions reductions that may be achieved.

Table 1 illustrates the installed capacity and number of units by fuel in 2006. Oil products are comprised of LPG and heavy fuel oil, gas includes refinery gas and natural gas and renewables has wood biomass and biogas as its constituent parts.

Gas fuels were the fuel of choice for 288 MW_e (161 units) in 2006. The vast majority of this was accounted for by natural gas. Solid fuels made up a significant share with 18.2 MW_e (3 units) while oil products accounted for 0.9 MW_e (2 units) the remainder being biomass, 1.8 MW_e (1 unit).

Table 1: Number of Units and Installed Capacity by Fuel 2006

	Number	Installed Capacity kW_e	Number %	Installed Capacity %
Gas Fuels	161	288,497	96.4	93.2
Solid Fuels	3	18,200	1.8	5.9
Biomass	1	1,830	0.6	0.6
Oil Fuels	2	990	1.2	0.3
Total	167	309,517	100	100

SOURCE: SEI

[1] Megawatt electrical or MW_e 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.

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.

Table 2 presents the number of units and installed capacity for CHP in Ireland in 2006. The services sector accounted for 131 (78%) of the 167 units and 34.6 MW_e of the 310 MW_e installed capacity (11%). The majority of units are in the services sector while the bulk of installed capacity is in industry, indicating that there are a large number of relatively small units in the services sector. Other refers to a mix of agriculture and mixed use enterprises. Traditionally, CHP was more suited to large industrial concerns but the availability of ready made, small scale, reliable, gas units in the 1990's (and more recently micro-turbines) meant that the services sector could avail of the technology whereas previously they would not have had the heat and electricity demands to justify the capital investment.

Table 2: CHP Number of Units and Installed Capacity by Sector 2006

	Number	Installed Capacity kW_e	Number %	Installed Capacity %
Services	131	34,581	78.4	11.2
Industry	31	273,195	18.6	88.3
Other	5	1,741	3.0	0.6
Total	167	309,517	100	100

SOURCE: SEI

Examining the breakdown of services further in Table 3 it can be seen that *hotels* and *hospitals* account for the majority (67%, 87 units) of units in the sector while the *leisure* sub-sector (which includes swimming pools, leisure centres, gyms, etc.) accounts for another 16% (21 units). These sub-sectors, in particular, benefit from having close to constant demand for heat and electricity but the technology may also be suited to any site that has a simultaneous demand for both heat and electricity.

Table 3: Number of Units and Installed Capacity by Services Sub-Sectors 2006

	Number	Installed Capacity kW_e	Number %	Installed Capacity %
Hospital	23	5,765	17.6	16.7
Hotel	64	9,070	48.9	26.2
Public sector	3	2,452	2.3	7.1
Airport	3	4,380	2.3	12.7
Education	6	4,234	4.6	12.2
Office	9	4,716	6.9	13.6
Other	2	1,108	1.5	3.2
Leisure	21	2,856	16.0	8.3
Total	131	34,581	100	100

SOURCE: SEI

It is interesting to note that certain sub-sectors have a small number of CHP units but represent a significant proportion of the installed capacity, notably *airports* and *education*.

Table 4 presents the sub-sectoral breakdown of installed capacity and number of units in industry. It can be seen that *the food and beverages* sub-sector dominates with 45% (14 units) of units and 30% (82 MW_e) of industrial installed capacity in 2006. Other refers to enterprises in the non ferrous metals, refineries, textiles, and sawmills sub-sectors.

Table 4: Number of Units and Installed Capacity by Industry Sub-Sectors 2006

	Number	Installed Capacity kW_e	Number %	Installed Capacity %
Food	14	81,590	45.2	29.9
Manufacturing	5	6,610	16.1	2.4
Mining	2	5,200	6.5	1.9
Pharmaceutical	6	11,560	19.4	4.2
Other	4	168,235	12.9	61.6
Total	31	273,195	100	100

SOURCE: SEI

Policy

The European Union CHP Directive[3], approved in February 2004, seeks to create a favourable environment for CHP installations. The Directive contains definitions for micro, small and large scale CHP. Table 5 illustrates how Ireland's installed capacity fitted into those classifications in 2006. It can be seen that the majority of units are in the over 1 MW_e category in terms of installed capacity (93%) while the bulk in the number of units are between 50 kW_e and 1 MW_e (75%).

Table5: Number of Units and Installed Capacity by Capacity Size Range 2006

Electrical Capacity Size Range	Number	Installed Capacity kW_e	Number %	Installed Capacity %
Micro <50 kW_e	2	76	1.2	0.02
50 kW_e ≤ Small < 1MW_e	125	22,399	74.9	7.24
Large ≥ 1 MW_e	40	287,042	24.0	92.74
Total	167	309,517	100	100

SOURCE: SEI

In the 2006 Budget the Minister of Finance, Brian Cowen TD, announced the allocation of €65 million over the period 2006 to 2010 to "*launch several innovative grant schemes relating to biofuels, combined heat and power, biomass commercial heaters and domestic renewable heat grants*". An indicative allocation of €11M was made for a CHP programme to run in the 2006 to 2010 time frame.

The Budget allocation led to the SEI CHP Deployment Programme which provides grant support to assist the deployment of small-scale (<1MW_e) fossil fired CHP and biomass (anaerobic digestion and wood residue) CHP systems. The National Climate Change Strategy (NCCS)[4] 2007 to 2012, published on the 2nd April 2007 states that 0.162 Mt CO_2 equivalent will be saved by 2010, as a result of the programme.

The CHP Deployment Programme also includes funding for feasibility studies for micro-CHP generation. The objective of the trial is to assess current technology and identify possible barriers, risks and benefits associated with its deployment. This will inform future policy consideration of micro-generation and the opportunities for further efficiency gains through distributed small scale generation[5].

Trial technologies will be installed at 12 sites. The domestic trial sites will be located within the Dundalk Sustainable Energy Zone, where it is planned to install and monitor 6 domestic micro-CHP units and 3 condensing gas boilers as a reference technology.

[3] 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://europa.eu.int/eur-lex/pri/en/oj/dat/2004/l_052/l_05220040221en00500060.pdf
[4] Available from http://www.environ.ie/en/PublicationsDocuments/FileDownLoad,1861,en.pdf.
[5] Details of the trial are available from http://www.sei.ie/index.asp?locID=1091&docID=-1.

An advisory group was initiated in June 2007 with the objective of engaging all key stakeholders to ensure that their objectives are incorporated in the design of the trial and that the trial can reflect and inform the development of regulatory arrangements for micro-generation.

On the 12th March 2007, An Taoiseach Bertie Ahern TD and Noel Dempsey TD, Minister for Communications, Marine and Natural Resources launched the Government's Energy White Paper[6]. The White Paper sets out the energy policy directions and targets for Ireland to 2020. The White Paper states that "*growth in combined heat and power deployment is an important objective to 2020*" and targets of a total of 400 MW_e of installed CHP capacity by 2010, and 800 MW_e by 2020 have been set. As seen above, total operational capacity at the end of 2006 was approximately 268 MW_e.

In addition the Government, will, within two years consider a second CHP target for 2020 in light of further feasibility studies by SEI into CHP applications, a review by CER of potential administrative and regulatory barriers and decisions on appropriate price support mechanisms for electricity generated from new high efficiency large scale CHP. It is also intended that the public sector will act as an exemplar in relation to CHP.

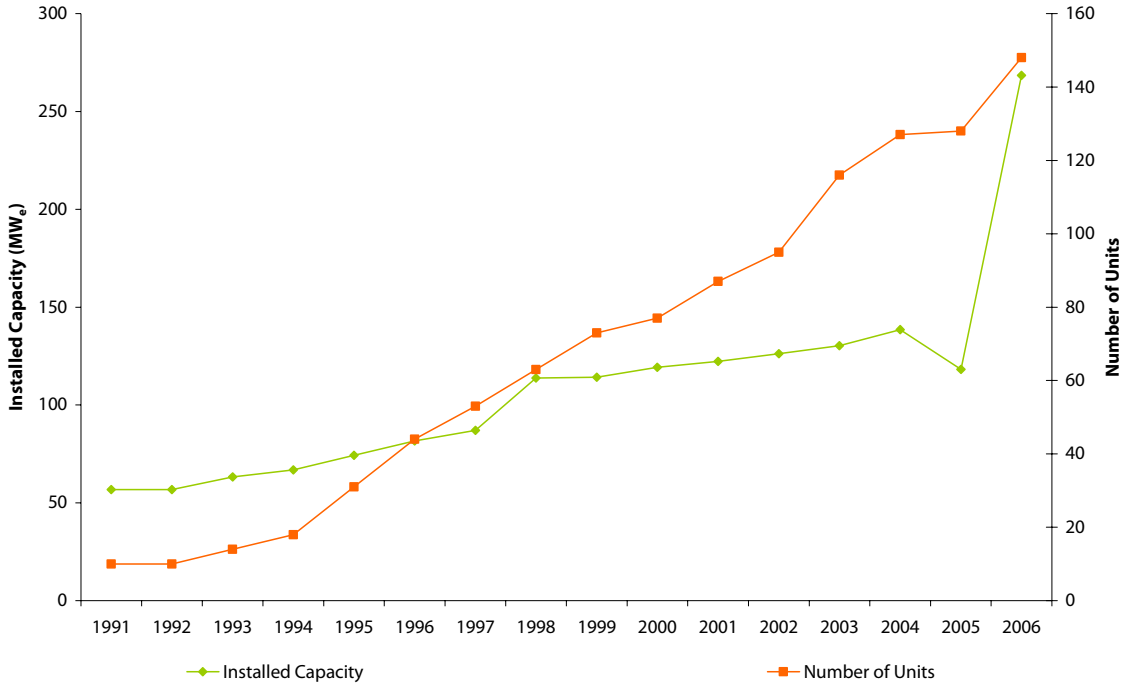
The National Energy Efficiency Action Plan[7] was published for public consultation in October 2007. The Action Plan states that delivery of targets for installed CHP capacity as outlined in the White Paper will achieve savings of 375 GWh by 2010 (from 400 MW installed) and 1,185 GWh by 2020 (from 800 MW installed). These savings are calculated using a primary energy equivalent methodology.

The Programme for Government was published in June 2007 and includes a commitment to remove any regulatory barriers to CHP and district heating systems.

CHP 1991 to 2006

Figure 1 presents number[8] of operational units in Ireland over the period 1991 to 2006.

Figure 1: Number of Units and Installed Capacity 1991 to 2006



SOURCE: SEI

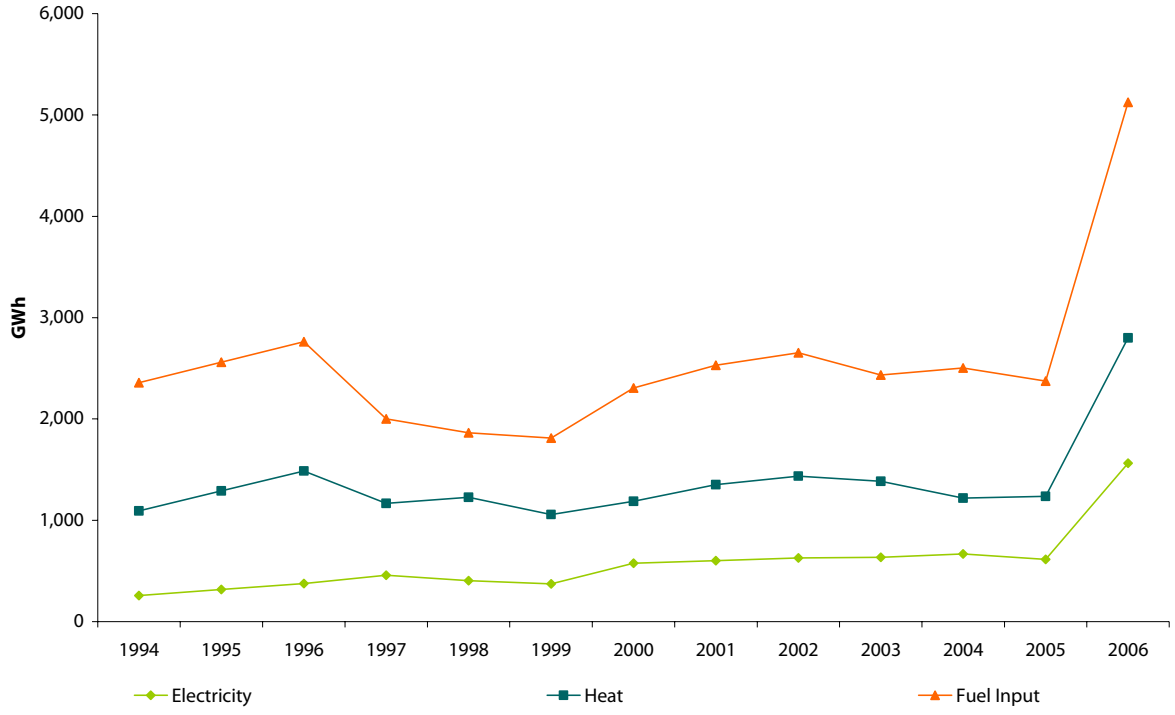
[6] The full text of the White Paper is available at http://www.dcmnr.gov.ie/Energy/Energy+Planning+Division/Energy+White+Paper.htm.
[7] Available from http://www.dcmnr.gov.ie/NR/rdonlyres/6AF7E508-151A-4117-8B30-03698CDA66C4/0/NationalEnergyEfficiencyActionPlan.pdf
[8] This data originates from surveys conducted by SEI in 1996 to1998, 2000 and 2002 that were part funded by EUROSTAT. SEI conducted similar surveys for 1999, 2001 and 2002. The ESB undertook the surveys in 1994 and 1996. There was no CHP survey carried out for 1995.Only operational units are included in the Eurostat funded surveys and thus only operational units are considered in the comparisons made in this section. Using this methodology installed capacity in 2006 was approximately 268 MW_e and in 1991 it was 57 MW_e.

The increase in Installed capacity over the period was 373% (11% per annum) from a low base. Growth in 2006 was 127%, which is largely accounted for by the Aughinish Alumina plant.

Figure 1 also presents data for the growth in the number of units. Growth in the case was 1380% representing an average incremental growth of 20% per annum, again from a low base. Growth in 2006 was 16%.

Figure 2 illustrates the trends relating to fuel inputs and electricity and thermal outputs over the period 1994 to 2006. Fuel inputs have increased by 117% (7% per annum) while the thermal and electrical outputs have increase by 157% (8% per annum) and 504% (16% per annum) respectively over the period. This suggests that the overall stock of CHP installations has become more efficient over the period. In 2006 fuel input increased by 116%, thermal output increased by 127% while electricity increased by 155%.

Figure 2: CHP Fuel Input and Thermal/Electricity Output 1994 to 2006

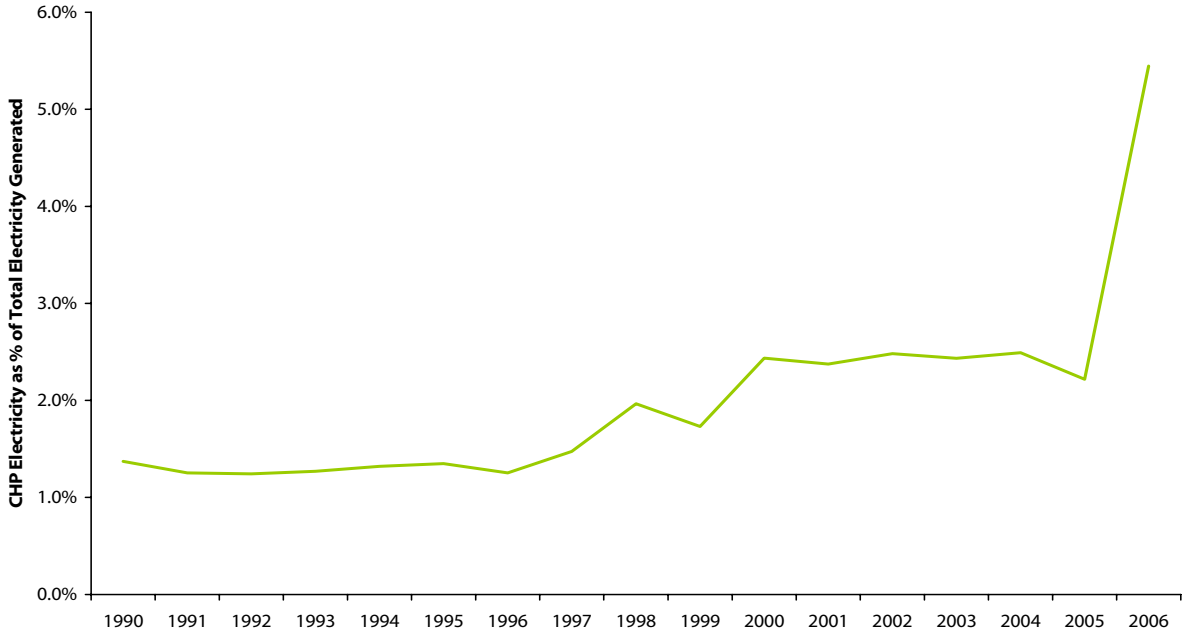


SOURCE: SEI

Figure 3 focuses on CHP generated electricity in Ireland as a proportion of gross electricity consumption (i.e. electricity generation plus net imports) in the period 1994 to 2006. In 2006, 5.4% of total electricity generation was generated in CHP installations compared with 2.2% in 2005 and 2.5% in 2004.

Some CHP units export electricity to the national grid. In 2006 there were 13 units exporting electricity to the grid. These units exported 716 GWh of electricity in 2006, an increase of 662% on 2005.

Figure 3: CHP Electricity as a % of Gross Electricity Consumption 1990 to 2006



SOURCE: SEI

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 efficient 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 electricity is required if additional electricity is generated from CHP. This is typically referred to as the *operating margin approach*[9,10]. For example, if additional CHP electricity is produced, less single cycle (oil or natural gas) electricity will be generated.

An alternative perspective is that new CHP plant will change investment decisions regarding other new generation options, i.e. the CHP plant will avoid (or more likely delay) the need for new capacity and thus CHP will displace *best new entrant* plant electricity. This approach is termed the *build marginal approach.*

The starting point has a key bearing on the projected amount of CO_2 savings, which will be significantly higher if CHP displaces marginal fuel rather than best new entrant fuel. In the absence of detailed information on actual fuel displacement, it is assumed in this analysis that electricity from CHP plants would displace electricity generated by either of these approaches. The emissions avoided in this case are designed to provide insights associated with future CHP penetration.

The assumptions regarding displacement of heat depend on the fuel used and are detailed in table 6.

[9] 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.
[10] 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, Part A: Toxic /Hazardous Substances and Environmental Engineering, Vol.40, Issue No. 6-7.

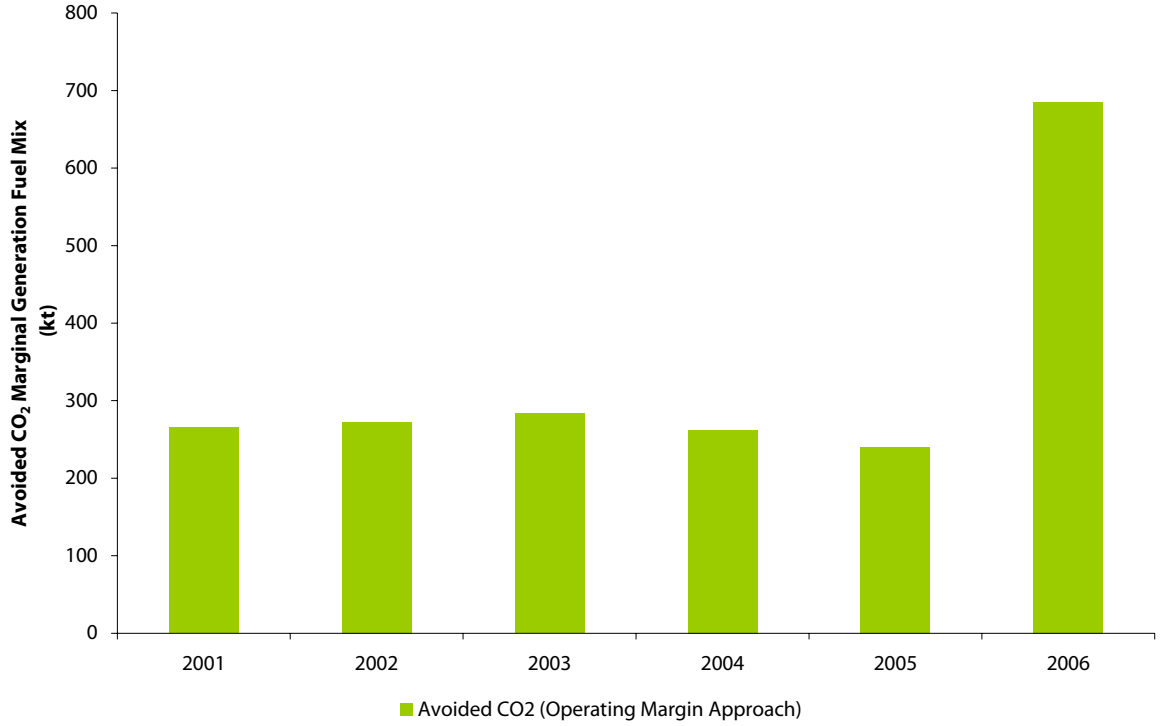
Table 6: Displacement of Heat –Assumptions

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%

SOURCE: SEI

The results from the operating margin approach are illustrated in figure 4 and table 7.

Figure 4: Avoided CO_2 Operating Margin Approach 2001 to 2006



SOURCE: SEI

It can be seen that the trend decreased from 265 kt CO_2 in 2001 to 241 kt CO_2 in 2004, a reduction of 9.3% (2.4% per annum on average). In 2006 there was an increase of 185% to 685 kt CO_2.

The trend in the CO_2 avoided using the build margin approach is presented in figure 5 and table 7. It can be seen that from 2001 to 2003 avoided emissions increased from 73 kt CO_2 to 95 kt CO_2, an increase of 30%. The direction of the trend changed in 2004 when avoided emissions were 61 kt CO_2 which is a decrease of 36%. This is a result of a decline in the heat to electricity ratio which is also plotted in figure 6. There was a reduction of 0.3% in 2005 and an increase of 261% in 2006.

Figure 5: Avoided CO_2 Build Margin Approach 2001 to 2006

SOURCE: SEI

Table 7: Avoided CO_2

	2001	2002	2003	2004	2005	2006
Avoided CO_2 (Operating Margin Approach) kt	265	273	283	263	241	685
Avoided CO_2 (Build Margin Approach) kt	73	77	95	61	61	220

SOURCE: SEI

Sustainable Energy Ireland
Energy Policy Statistical Support Unit
Building 2200
Cork Airport Business Park
Co. Cork
Ireland

T. +353 21 4547050 | epssu@sei.ie
F. +353 21 4547059 | www.sei.ie

Sustainable Energy Ireland
Glasnevin
Dublin 9
Ireland

T. +353 1 8369080 | info@sei.ie
F. +353 1 8372848 | www.sei.ie

Sustainable Energy Ireland is funded by the Irish Government under the National Development Plan 2007-2013 with programmes part financed by the European Union