Combined Heat & Power in Ireland

Trends and Issues – 2004 Data Update

sei SUSTAINABLE ENERGY IRELAND
Energy Policy Statistical Support Unit

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Sustainable Energy Ireland

Sustainable Energy Ireland (SEI) is Ireland's national energy agency. Established on May 1st 2002 under the Sustainable Energy Act 2002, SEI has a mission 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. 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 the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan.

SEI manages programmes aimed at:

- 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;
- publishing statistics and projections on sustainable energy and achievement of targets.

SEI is responsible for advising Government on policies and measures on sustainable energy; implementing programmes agreed by Government and stimulating sustainable energy policies and actions by public bodies, the business sector, local communities and individual consumers.

Energy Policy Statistical Support Unit

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, meeting international reporting obligations and informing investment decisions. Based in Cork, the Energy Policy Statistical Support Unit 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;
- contribute to the development and promulgation of appropriate sustainability indicators.

Introduction

In conventional electricity generation heat is produced as a by-product and usually released into the atmosphere. Combined Heat and Power (CHP) systems channel this extra heat to useful purposes so that usable heat and electricity[1] 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 2004, with a particular focus on the year 2004. This booklet should be read in conjunction with the report published in March 2004 entitled, "*Combined Heat and Power in Ireland- Trends and issues 1991 – 2002*[2] and is the second[3] in a series of data updates.

Installed Capacity and Number of Units 2004

The installed capacity[4] of CHP in Ireland at the end of 2004 was 145 MW_e (139 units[5]). This includes a number of units that are not operational (5.3 MW_e or 8 units) and a number whose status of is currently unknown (1 MW_e 4 units). Installed capacity at the end of 2003 was 136.5 MW_e (128 units) therefore there was an increase of 8.5 MW_e (11 units, an increase of 8.6%) during 2004 which represents a 6.1% increase in installed capacity.

Regarding growth in 2005 there are 10 units with an installed capacity of approximately 1.5 MWe which are due to be operational by the end of the year. This will be offset by the closure in early 2005 of the Irish Sugar plant in Carlow (14.8 MW_e) and the ADM plant, located in Ringaskiddy Co. Cork, in November (5 MW_e) so total installed capacity by end 2005 is estimated to be 126.4 MW_e (147 units). Data for 2005 is, of course, provisional and will be validated when the 2005 survey is concluded in early 2006.

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.

Figure 1 illustrates the installed capacity and number of units by fuel in 2004. Solid fuels are peat and coal, oil products are comprised of LPG and heavy fuel oil, gas includes

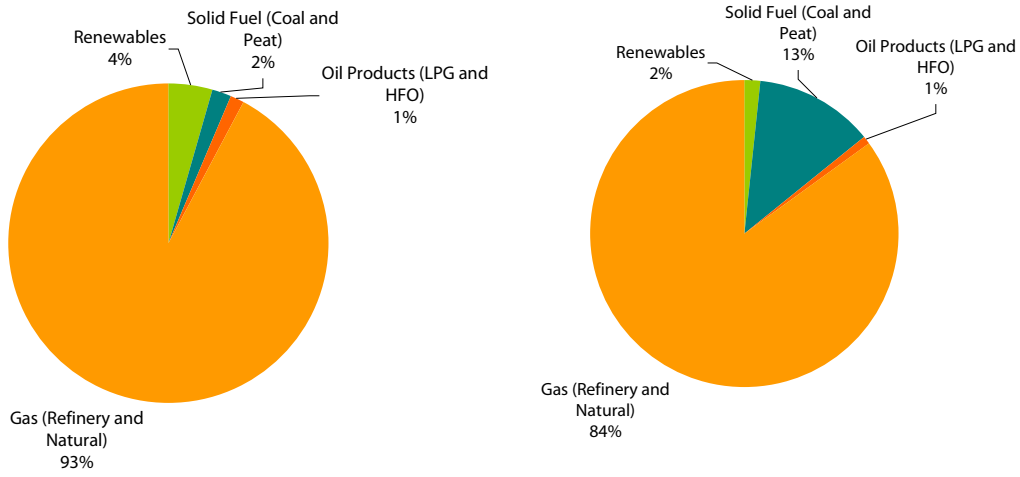
[1] In a small number of cases internationally mechanical rather than electrical power is produced, in addition to heat.
[2] Available from http://www.sei.ie/uploads/documents/upload/publications/SEI_CHP_Report_Final.pdf
[3] The first update was published in March 2005 and is available at http://www.sei.ie/uploads/documents/upload/publications/CHP_2005_Update_Final.pdf
[4] 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.
[5] Note that units are distinct from CHP plants or schemes and that there may be more than one CHP unit at a site.

refinery gas and natural gas and renewables has wood biomass and biogas as its constituent parts.

Gas fuels were the fuel of choice for 123.3 MW_e (128 units) in 2004. 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, 2.4 MW_e (6 units).

Regarding renewable CHP, in 2004, Ireland's first solid biomass fuelled CHP plant came online. The CHP plant uses wood processing products such as sawdust, bark and woodchips together with forest thinings to generate heat for Grainger Sawmills' timber drying operations. The bulk of the electricity generated is exported to the national grid. The project is supported under Sustainable Energy Ireland's Research Development and Demonstration Programme.

Figure 1: Number of Units and Installed Capacity by Fuel 2004



Total Units: 139 **Total Installed Capacity: 144.9 MW_e**

SOURCE: SEI

It is likely that gas will continue to be the fuel of choice for the majority of CHP Units for the foreseeable future even though the price of natural gas relative to electricity, which is a key factor in the decision making process for installing CHP, has been increasing in recent years. In fact some operators have found it uneconomical to run their units as a result of the high price of natural gas.

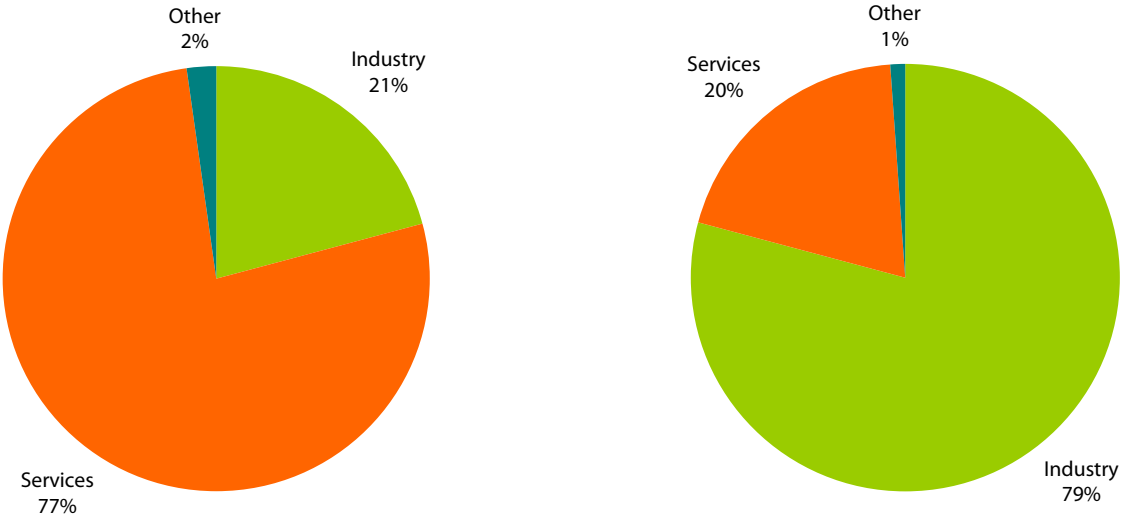
CHP by Sector and Sub-Sector

CHP is more suited to some 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.

Figure 2 presents the number of units and installed capacity for CHP in Ireland in 2004. In 2004 the services sector accounted for 107 (77%) of the 139 units and 29 MW_e of the 145 MW_e installed capacity (20%). 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. Traditionally, CHP was more suited to large

industrial concerns but the availability of ready made, small scale, reliable, gas units in the 1990's 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.

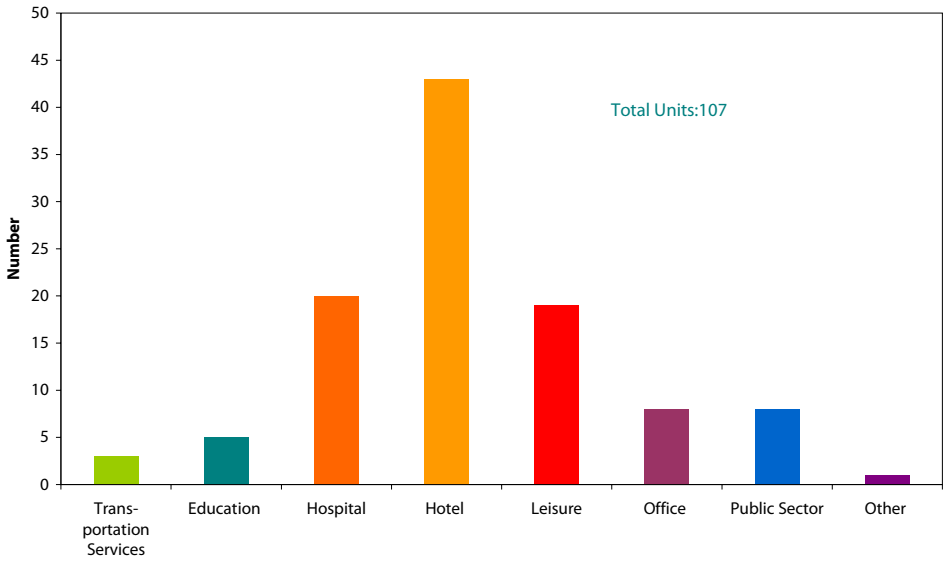
Figure 2: CHP Number of Units and Installed Capacity by Sector 2004



SOURCE: SEI

Examining the breakdown of services further in figures 3 and 4 it can be seen that *hotels* and *hospitals* account for the majority (59%, 63 units) of units in the sector while the *leisure* sub-sector accounts for another 17.7% (19 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.

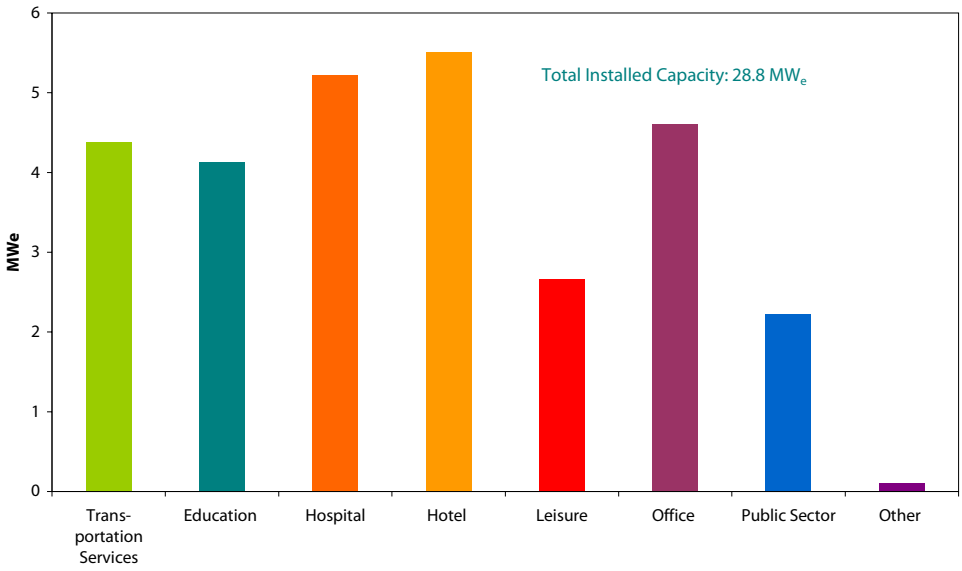
Figure 3: Number of Units by Services Sub-Sectors 2004



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 transportation services and education.

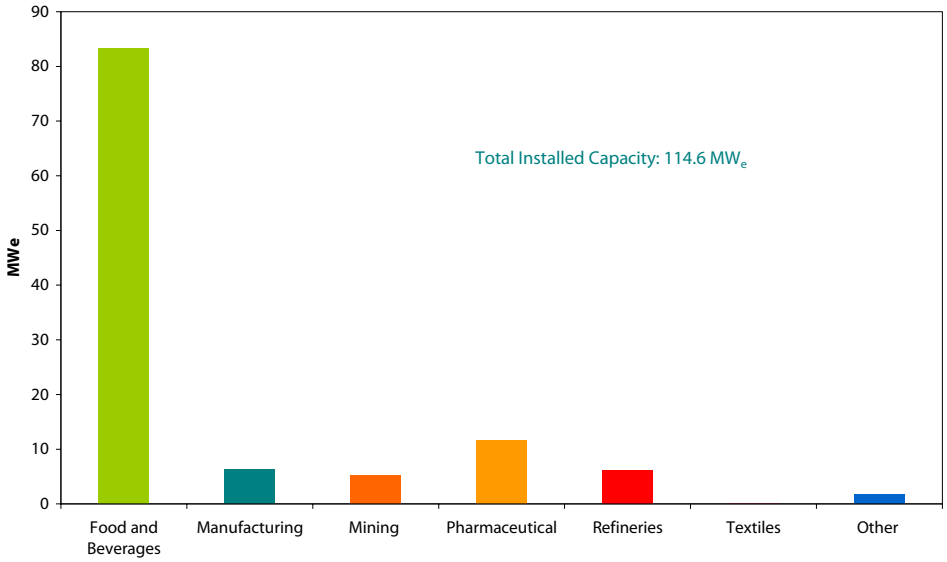
Figure 4: Installed Capacity by Services Sub-Sectors 2004



SOURCE: SEI

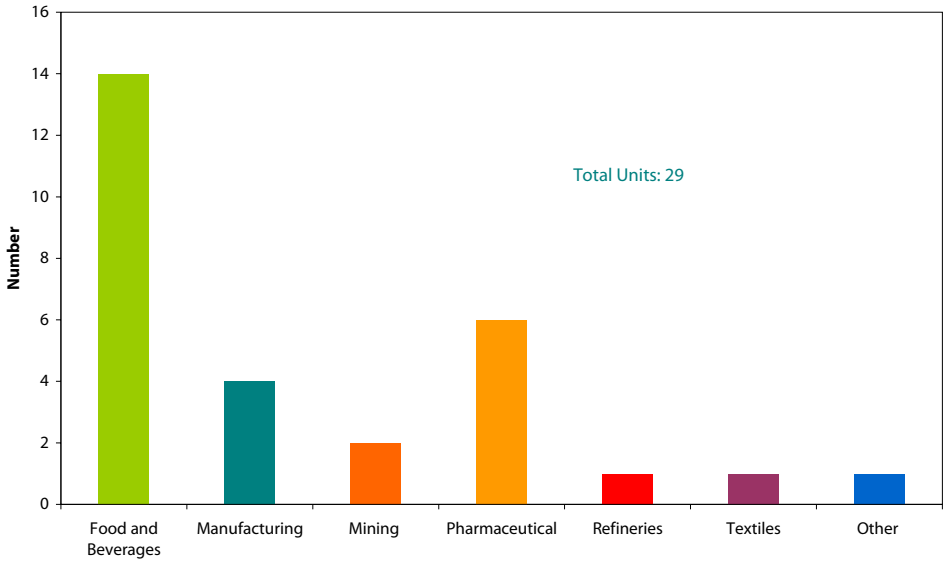
It is also possible to examine the sub-sectoral breakdown of installed capacity and number of units in industry, figures 5 and 6. It can be seen that *the food and beverages* sub-sector dominates with 48% (14 units) of units and 73% (83 MW_e) of industrial installed capacity in 2004.

Figure 5: Installed Capacity by Industry Sub-Sectors 2004



SOURCE: SEI

Figure 6: Number of Units by Industry Sub-Sectors 2004



SOURCE: SEI

Policy

The European Commission published a strategy document on CHP in 1997[6] which aims to double the 1994 CHP penetration by 2010 (from 9% to 18%). This target refers to the EU–15 and in 2002 (the latest year data is available) the proportion of total electrical output that was generated from CHP was 12%, indicating the scale of the challenge for the remaining years.

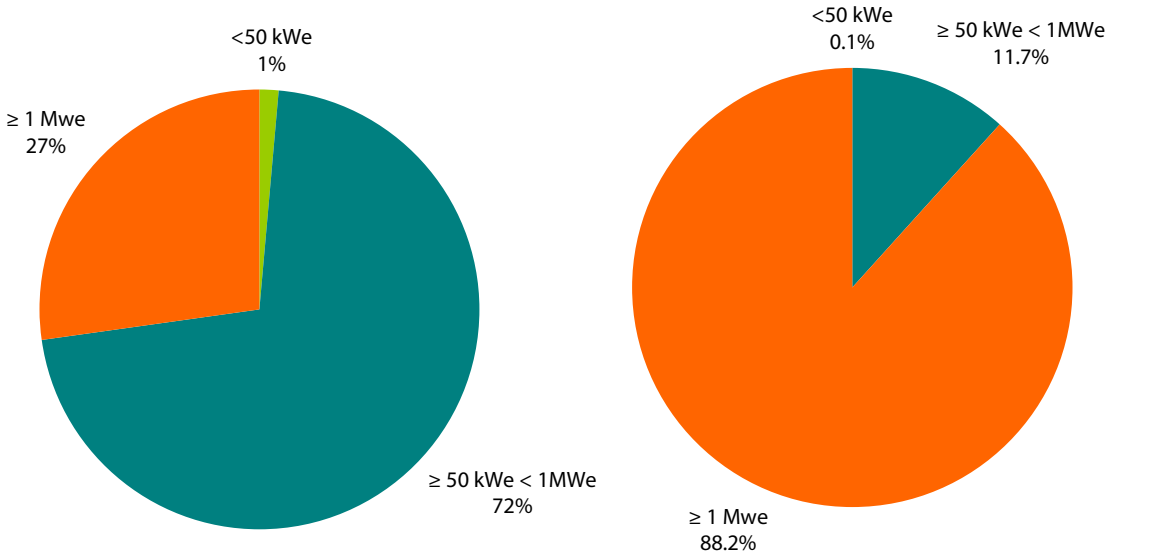
The European Union CHP Directive[7], approved in February 2004, seeks to create a favourable environment for CHP installations. Transposition of the Directive into national law in each Member State is required by 21st February 2006. The Directive requires all Member States to analyse national potentials for CHP identifying the potential for heating and cooling demands. It contained a number of provisions designed to promote the use of CHP in liberalised electricity markets across the EU.

The Directive also contains new definitions for micro, small and large scale CHP. Figure 7 and table 1 illustrate how Ireland's installed capacity fitted into those classifications in 2004. It can be clearly seen that the majority of units are in the over 1 MW_e category in terms of installed capacity (88%) while the bulk in the number of units are between 50 kW_e and 1 MW_e (71%).

[6] Commission of the European Communities (1997) A Community Strategy to Promote Combined Heat and Power and to Dismantle Barriers to its Development.

[7] 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

Figure 7: Number of Units and Installed Capacity by Capacity Size Range 2004



Total Units: 139 Units

Total Installed Capacity: 144.9 MW_e

SOURCE: SEI

Table 1: Number of Units and Installed Capacity by Capacity Size Range 2004

Electrical Capacity Size Range	Number of Units	Share of Total Units (%)	Installed Capacity (kW_e)	Share of Total Installed Capacity (%)
Micro <50 kWe	2	1.4	76	0.1
50 kWe ≤ Small < 1MWe	99	71.2	16996	11.7
Large ≥ 1 MWe	38	27.3	127839	88.2
Total	139	100	144911	100

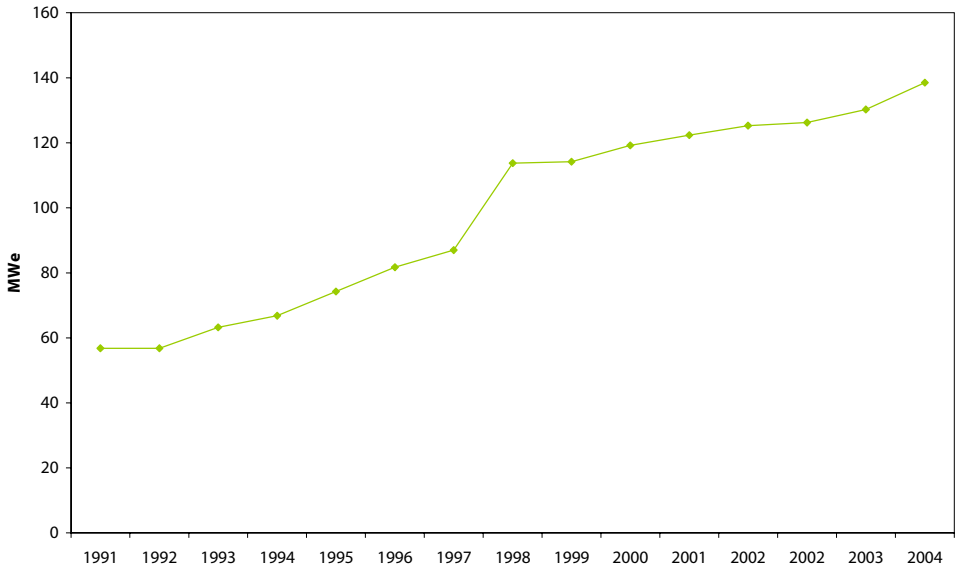
SOURCE: SEI

CHP 1991 to 2004

Figure 8 presents installed capacity[8] of operational units in Ireland over the period 1991 to 2004. Growth over the period was 144% or 7% per annum. Growth in operational installed capacity in 2004 was 6%, representing the largest annual increase in growth rate since 1998.

[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 2004 was 138.5 MW_e and in 1991 it was 56.8 MW_e.

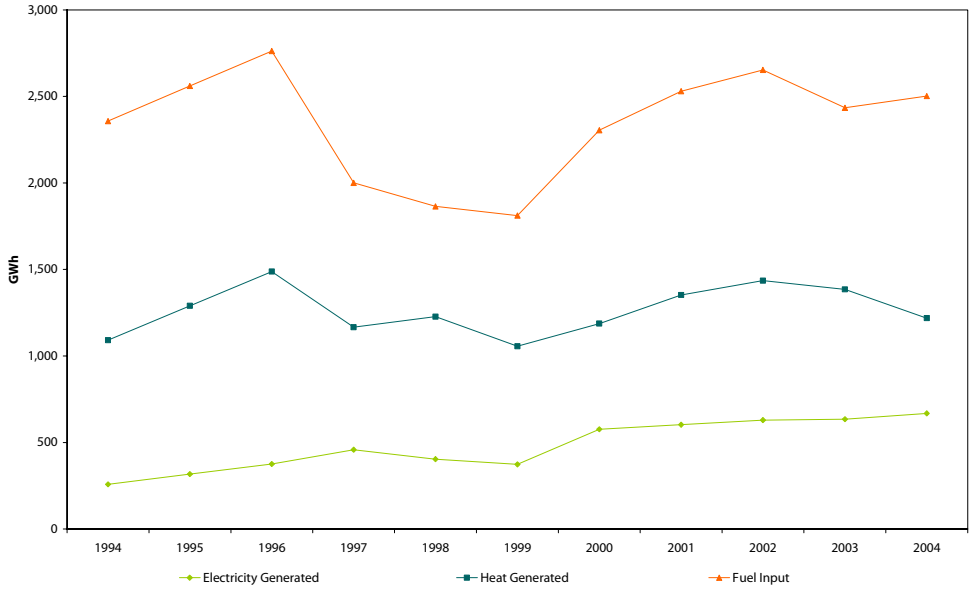
Figure 8: Installed Capacity 1991 – 2004



SOURCE: SEI AND EUROSTAT

Figure 9 illustrates the trends relating to fuel inputs and electricity and thermal outputs over the period 1994 to 2004. Fuel inputs have increased by 6% (0.6% per annum) while the thermal and electrical outputs have increase by 12% (1.1% per annum) and 158% (10% per annum) respectively over the period. This suggests that the overall stock of CHP installations has become more efficient over the period. In 2004 fuel input increased by 2.8%, thermal output decreased by 12% while electricity increased by 5.3%. This equates to a 37% decrease in the heat to electricity ratio.

Figure 9: CHP Fuel Input and Thermal/Electricity Output 1994 to 2004



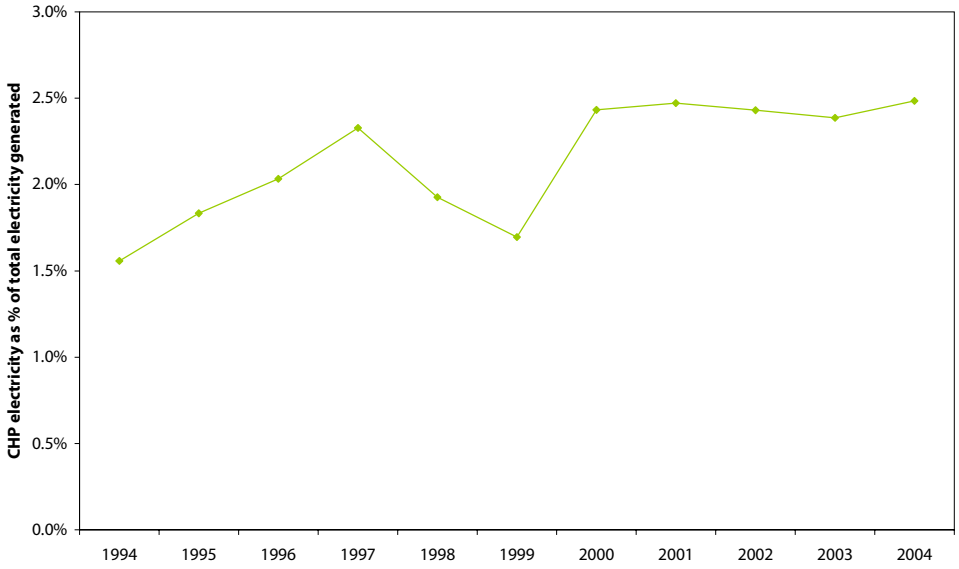
SOURCE: SEI AND EUROSTAT

Figure 10 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 2004. After growth in the mid 1990's and then again in 2000, the share of total generation from CHP has reduced slightly each year. In 2004[9] 2.48% of total electricity generation was generated in CHP installations compared with 2.39% in 2003 and 2.43% in 2002. The reduction in the ratio of CHP electricity to gross electricity consumption in 1998 and 1999 is due to reduced CHP electrical output in those years.

Some CHP sites export electricity to the national grid. In 2004 there were 19 units (14 plants) exporting electricity to the grid. These 19 units exported 107 GWh of electricity in 2004, an increase of 10.3% on 2003. 2.1% decrease on 2002.

Figure 10: CHP Electricity as a % of Gross Electricity Consumption 1994 to 2004



SOURCE: SEI

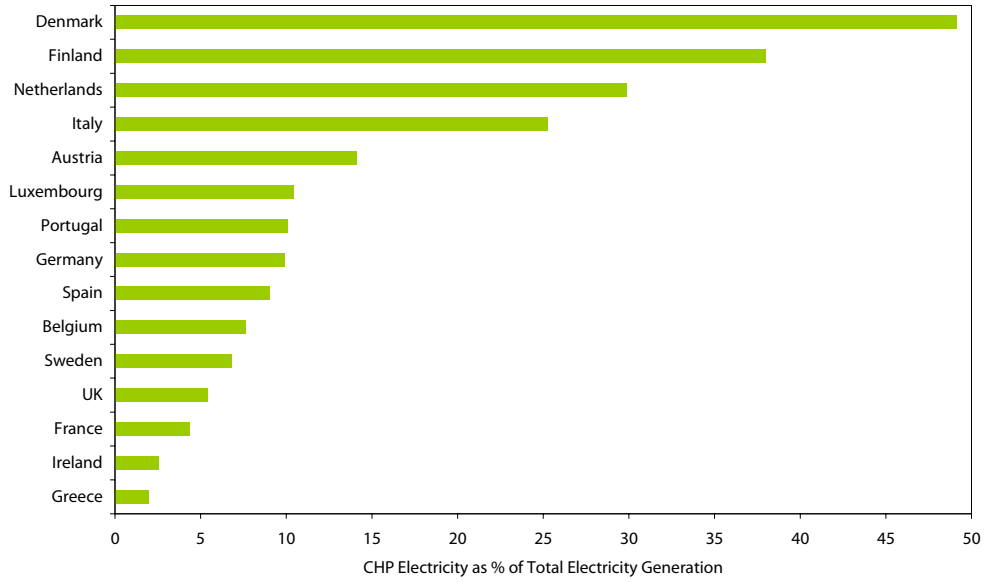
Figure 11 compares the importance of CHP electricity across the EU 15. Data is presented for 2002, the most recent year for which comparable data is available. Two groups of countries can be identified.

The first group is made up of Denmark, Finland, Italy and Netherlands in which CHP electrical production was at least 25% of their total electricity production, district heating is an important factor in explaining this.

The second group comprises Portugal, Austria, Luxembourg, Germany, Spain, Belgium, France, Greece, Ireland, Sweden, and the UK in which electrical production from CHP was relatively low, ranging from 2% to 14%%.

[9] Note that the national total for electricity generation is provisional.

Figure 11: EU (15) CHP Electricity as a Percentage of Total Electricity Generated[10] 2002



Source: IEA and CHP Plant Statistics Project 2002 for EUROSTAT

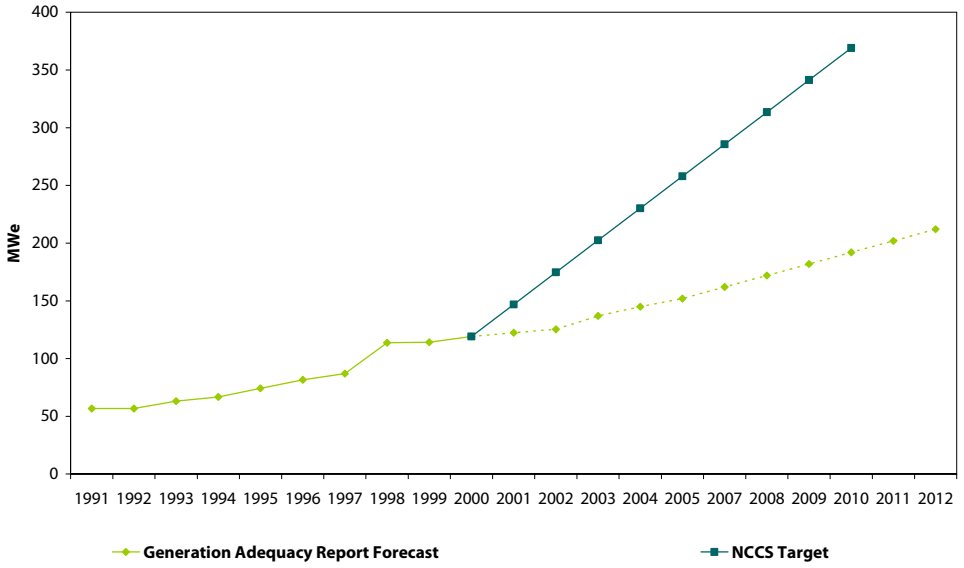
Planned Growth and Targets

ESB National Grid, in its most recent Generation Adequacy Report covering the period 2005 to 2011[11] predicts that 67 MW_e of installed capacity will be added by 2012, from a base of 145 MW_e at the end of 2004. Figure 12 illustrates the Generation Adequacy Report (GAR) forecast, which results in a total instated capacity of 212 MW_e in 2011.

The National Climate Change Strategy sets a target of 0.25 Mt reduction of CO_2 per annum attributable to CHP, relative to business as usual, to be achieved by 2010. It has been estimated[12] that an additional 250 MW_e will need to be installed by the end of the decade, in order to achieve this target. The NCCS target is shown for comparison in figure 13.

[10] Not including imports.
[11] ESB National Grid, 2004, Generation Adequacy Report.
Available from http://www.eirgrid.ie/EirGridPortal/uploads/Announcements/GAR%202005%20-%20FINAL.pdf
[12] Irish Energy Centre, 2001, An Examination of the Future Potential of CHP in Ireland- A Report for Public Consultation.
Available from http://www.sei.ie/uploads/documents/upload/publications/chp_report.pdf

Figure 12: CHP Forecast and NCCS Target 1991 to 2012



SOURCE: ESB NATIONAL GRID / NCCS

Avoided CO_2 from CHP

As mentioned at the beginning of this report 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*[13,14]. 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.*

[13] 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.

[14] 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.

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 preliminary analysis that electricity from CHP plants would displace:

electricity generated by the average generation fuel mix. The emissions avoided in this case provide an estimate for historic and current emissions avoided.
electricity generated by a combined cycle gas turbine (CCGT) plant (representing likely future displacement of cheapest new plant alternative). 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 2.

Table 2: Displacement of Heat –Assumptions

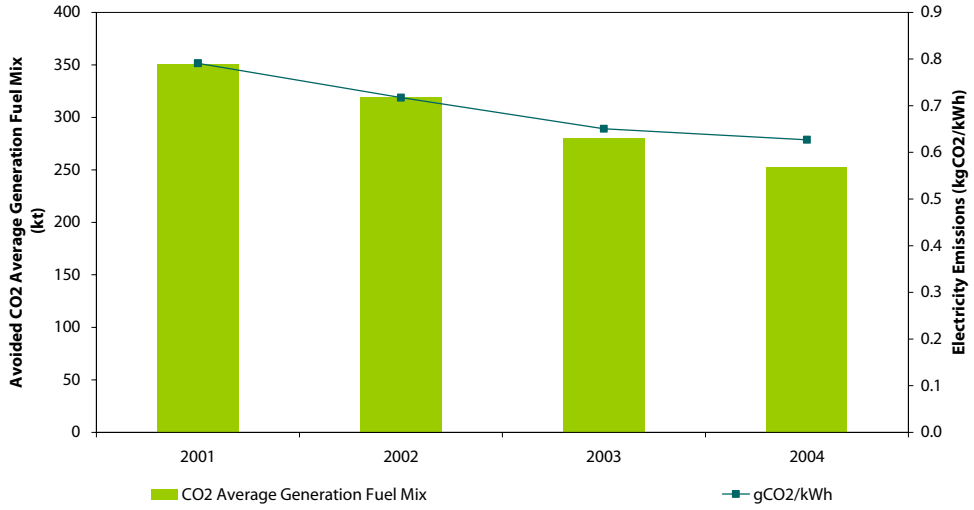
Fuel	Displacement fuel	% efficiency
Natural Gas	Natural gas	80%
Biogas	Fuel oil	80%
Biomass	Fuel oil	80%
Peat	Milled Peat	70%
LPG	Gas oil	80%
Coal	Fuel oil	80%
Refinery Gas	Fuel oil	80%

SOURCE: SEI

Avoided CO_2 Average Generation Fuel Mix

Data is presented for the period 2001 to 2004 in figure 13 for avoided CO_2 from the average generation fuel mix for those years. It can be seen that the trend decreased from 350 kt CO_2 in 2001 to 252 kt CO_2 in 2004, a fall of 28% (10.3% per annum on average). This is as a result of the increased efficiency of public electricity generation as illustrated by the declining trend in emissions from electricity generation also shown in figure 14.

Figure 13: Avoided CO_2 Average Generation Fuel Mix 2001 to 2004

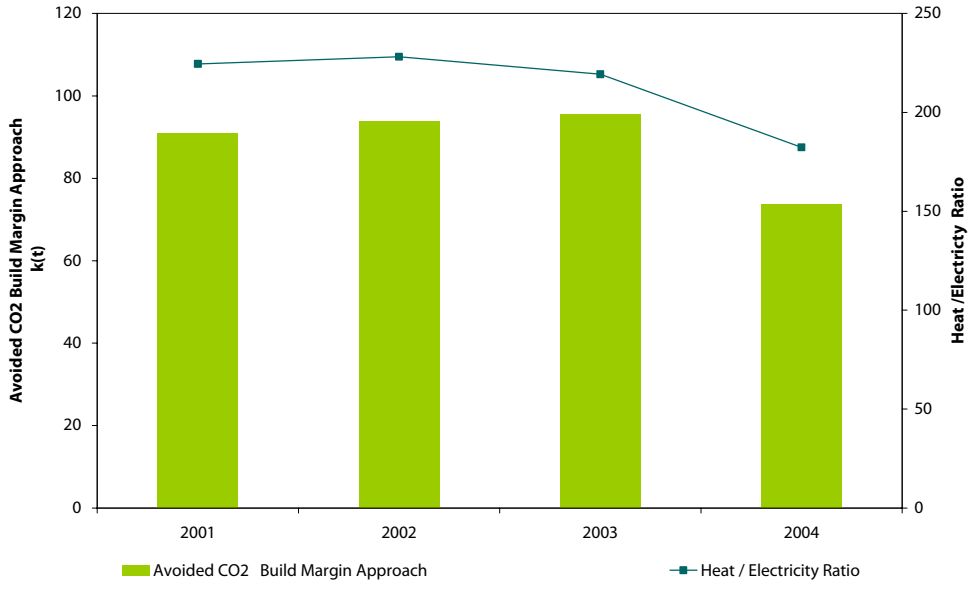


SOURCE: SEI

Avoided CO_2 Build Margin Approach

The trend in the CO_2 avoided using the build margin approach is presented in figure 14. It can be seen that from 2001 to 2003 avoided emissions increased from 90 kt CO_2 to 95 kt CO_2, an increase of 5% or 2.5% per annum on average. The direction of the trend changed in 2004 when avoided emissions were 74 kt CO_2 which is a decrease of 23%. This is a result of a decline in the heat to electricity ratio which is also plotted in figure 14.

Figure 14: Avoided CO_2 Build Margin Approach 2001 to 2004



SOURCE: SEI

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