Biomass CHP Market Potential in the Western Region: An Assessment

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Abbreviations

CHP	Combined Heat and Power
CO_2	Carbon Dioxide
EPA	Environmental Protection Agency
ESCO	Energy Supply Company/Contract
FTE	Full time equivalent jobs
GWh	Gigawatt hour
IBEC	Irish Business and Employers Confederation
IDA	Industrial Development Agency
kW_e	Kilowatts of electrical power
kW_{th}	Kilowatts of thermal heat
LPG	Liquid Petroleum Gas
MW_e	Megawatts of electrical power
MWh	Megawatt hour
MW_{th}	Megawatts of thermal heat
OECD	Organisation for Economic Co-operation and Development
ORC	Organic Rankine Cycle
R&D	Research and Development
SEI	Sustainable Energy Ireland
SO_2	Sulphur dioxide
WDC	Western Development Commission

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Executive Summary

The Western Development Commission (WDC) is currently leading a wood energy development project for the Western Region. This report was commissioned to assess the biomass Combined Heat and Power (CHP) market potential in the region and the potential economic and social benefits that could be derived from development of the sector. This assessment was recommended in the WDC *Wood Energy Strategy and Action Plan*[1]. This research provides public and private stakeholders with practical CHP market information, and will hopefully stimulate further discussion and action at both a regional and national level.

CHP is the combined production of heat and power in a single process. Biomass CHP is a highly efficient means of generating electricity as it allows the use of lower grade thermal energy that cannot be converted into electricity. CHP has historically been a large-scale industrial technology, particularly for biomass. In Ireland, 88% of installed CHP capacity is in industry. Most existing CHP capacity is fossil fuel based, with just two existing biomass CHP installations on the island of Ireland, both approximately 2 MW_e. This would previously have been considered the minimum threshold for economic viability based on standard steam turbine technology.

Technology assessment

With higher oil prices and policy drivers in favour of renewable fuels, many previously marginal technologies are becoming viable, including smaller-scale biomass CHP applications. If biomass CHP is to develop at a number of sites in the Western Region it will predominantly be through technologies such as steam engines, Organic Rankine Cycle (ORC) units, gasification systems and perhaps hot air turbines and Stirling engines. Biomass CHP at a smaller scale than 2 to 3 MW_e is becoming widespread. Many examples can be seen in Germany, Belgium, Austria and Denmark. Between 2004 and 2006 there was an EU-wide growth rate of 11% in terms of electricity produced from biomass CHP.

A significant finding of this report is that with commercially available technologies, biomass CHP is possible for users with a continuous heat load of over 600 kW_{th}[2]. Even so, a major challenge facing the promotion of biomass CHP in the Western Region will be to identify sites with a large enough 'year round' heat load. To a large extent, these are the same obstacles facing both fossil fuelled CHP and district heating systems.

The cost of woodchip and natural gas are comparable at current levels. With the additional capital cost associated with biomass CHP equipment it is exceptional that biomass CHP is chosen where natural gas is available. However, biomass is substantially cheaper than oil or LPG and the additional capital cost may be offset by lower running costs.

The typical case studies presented in this report indicate that under favourable heat load and fuel costs, biomass CHP represents a real commercial opportunity, with simple payback of approximately three years. In order to promote decentralised CHP, projects must be located to exploit their proximity to both the biomass resource and significant heat users.

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1 The full report *Wood Energy Strategy and Action Plan* is available for download at www.wdc.ie

2 Such a heat load would typically be required by a large hotel (>100 rooms) with a swimming pool, or a hospital.

Market assessment

The bottom-up market analysis carried out as part of this study identified 119 potential sites, of which potentially 22 could install biomass CHP under a medium development scenario. Further high and low scenarios were also considered within the study. Of these 22 sites, five could be greater than 5 MW_e, four between 1 MW_e and 5 MW_e and 13 less than 1 MW_e.

The sites above 5 MW_e are likely to be large industrial users, such as the board mills, pharmaceutical, cement and food manufacturers and potentially one substantial district heating scheme. The sites between 1 MW_e and 5 MW_e are likely to include a further selection of manufacturing sites, including food processors, medical devices and other industrial sites, as well as potentially one sizable district heating scheme. The potential sites below 1 MW_e include a number of hospitals, hotels with over 150 bedrooms, a number of feed mills and other manufacturing sites.

The bottom-up market projections suggest a medium scenario target for the region of 42 MW_e by 2020, which exceeds the previous top-down estimate of 19 MW_e carried out in 2007. It is only after the detailed technology assessment that the opportunity for smaller scale units became know.

Benefits of CHP

Substantial social and economic benefits resulting from the growth of biomass CHP were identified by the study. The medium scenario market projections would potentially result in a direct gross investment of €138 million and create approximately 321 jobs by 2020. A requirement for 500,000 tonnes of woodchip was estimated, displacing approximately 370,000 tonnes of CO_2-equivalent from fossil fuel sources.

Issues for development

Experience of biomass CHP in Ireland and awareness of the technology is relatively low. Training in biomass CHP technology should be considered for energy professionals in Ireland. This would be most effective as part of a national CHP support programme and could be delivered at a regional level. Adding experts to speak on relevant biomass CHP topics to the line-up for the existing workshops and seminars on energy and biomass would enhance the knowledge of biomass CHP in Ireland.

The REFIT tariff of €120/MWh for electricity generated by biomass CHP, which was announced in 2007 is competitive, based on both economic analysis and comparison with international schemes. Long-term, stable, feed-in tariff support schemes have had a very positive market impact in other countries.

The 30% capital funding available through SEI's biomass CHP programme is a significant support to the industry, however the duration of this programme may prove a barrier to development. Projects must be completed by 2010 in order to avail of support. Given the lengthy planning process and construction times that can be encountered by biomass projects, this is a significant restriction. Other pre-conditions of the grant programme pose significant cost and therefore risk for a project developer. SEI's programme also offers up to 40% financial support for carrying out biomass CHP feasibility studies. A higher level of funding of feasibility studies would be a comparatively low-cost method of stimulating the industry.

Within the European markets there is a clear link between district heating networks and the application of CHP technology. If biomass CHP is to be seriously considered the barriers to district heating must be reduced. There are currently no direct supports for district heating infrastructure therefore a parallel support for district heating should be considered, which would facilitate a greater number of potential CHP sites.

In the short term all CHP technology will be imported. If the region develops significant research and manufacturing capabilities for CHP technology this would lead to significant indirect job creation. Biomass CHP development is strongly influenced by the regional research capacity on the topic. Many of the innovations first occurred in the areas where the technology was subsequently demonstrated and refined before looking to the export market. Regional research centres need to develop core competences relevant for the combustion of biomass. Greater participation in relevant international research projects should be encouraged.

In order to stimulate regional deployment of biomass CHP, all sites with a continuous heat load above 600 kW_{th} should be encouraged to investigate the applicability of biomass CHP technology. The market segments to be targeted have been identified within the report, particularly the forest products' manufacturers and sawmills.

1.0 Introduction

The Western Development Commission (WDC) is currently leading a wood energy development project for the Western Region[3]. In 2006, the WDC established a Regional Wood Energy Advisory Group[4] to guide the development of the project and act as a mechanism for regional co-ordination.

The WDC commissioned the research report *Wood Energy Development in the Western Region,* (2007) and following this prepared the *Wood Energy Strategy and Action Plan*[5]*,* (2007). The research identified commercial and industrial heat users as a key market opportunity for the region. The potential fuel resource was established as woodchip primarily from private sector forestry and co-products from the wood processing industry.

The strategy estimated a regional biomass CHP target of 75 MW_{th} by 2020 under the medium growth scenario (and a heat market target of 400 MW_{th}). While the heat market has the largest potential in the Western Region, the strategy recognised that the biomass CHP market remains a significant market segment. This report, as recommended under the strategy, provides analysis of the validity of the strategy's estimated growth target and looks at how the regional biomass CHP market could develop in terms of potential market segments and the technology applied.

3 The Western Region includes the seven counties of Donegal, Sligo, Leitrim, Mayo, Roscommon, Galway and Clare.

4 Members include: SEI; Forest Service of Department of Agriculture and Food; Teagasc; Údarás na Gaeltachta; Institute of Technology Sligo; Rural Resource Development Ltd (LEADER programme); Rural Generation Ltd; Association of Irish Energy Agencies (Galway Energy Agency); Department of Communications, Energy and Natural Resources; Irish Farmers Association; Imperative Energy Ltd; Community & Enterprise Division of Donegal County Council.

5 Reports are available to download at www.wdc.ie

Fossil fuel based CHP is a well-established technology in Ireland. There are currently 167 installations in the country with an installed capacity of just over 300 MW_e (SEI, 2008). These range from approximately 50 kW_e up to a 140 MW_e industrial CHP installation at Aughinish Aluminium.

There are currently no biomass CHP projects in the Western Region and only two installed, and commercially operating, on the island of Ireland. With the recent increase in the price of oil and an awareness of the effects of carbon emissions, many previously marginal technologies are becoming viable.

1.1 Report structure

The authors carried out the following tasks for this study:

- a detailed literature review for the technology assessment
- a review of existing regional studies and related national research
- website searches and direct contact with over 30 equipment suppliers (information on 24 biomass CHP suppliers is given in this report)
- consultations with members of the EPA, IBEC, IDA, the Regional Wood Energy Advisory Group, SEI, Teagasc and Údarás na Gaeltachta, and others as listed in the acknowledgements
- analysis of publicly available information to quantify the number of users in various market segments

The biomass CHP technologies considered in this report are biomass-fired and range in size from 100 kW_e to 5 MW_e. These units produce a high proportion of heat, and if the plant is to be economically viable this heat must be used. The *Wood Energy Strategy and Action Plan* highlight the maximum range for biomass CHP in the Western Region of approximately 5 MW_e. The minimum of 100 kWe was chosen as this corresponds with the smallest size currently grant aided by SEI.

A detailed technology review was essential to carry out the required market and economic analysis. Appendix 1 lists approximately 75 examples of biomass CHP less than 5 $MW_{e,}$ identified by the authors during the course of this project. The various technologies employed are introduced and a number of providers are listed in Appendix 2.

Section 3, 'Market assessment', identifies potential users of biomass CHP and separates them into a number of market segments. By quantifying the number of users in each segment and examining their potential, an informed estimate was made of the possible number of installations, given a range of scenarios, by 2020. This 'bottom-up' assessment is compared to other recent studies, and thereby assists in developing a more robust estimate of potential market growth in the region.

Results from the market assessment were used to calculate potential investment and job creation in the region. Two generic case studies show the opportunities and challenges in developing projects using current market conditions and policy supports. Key conclusions and recommendations are summarised at the end of the report.

2.0 Technology assessment

2.1 What is CHP and why is it of interest?

Combined Heat and Power (CHP) is the combined production of heat and power in a single process. Typically, in conventional electricity generation, over 60% of the input energy is lost to the atmosphere as waste heat, while the remaining 40% is transformed into electricity. 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 can also be produced from biomass (including biogas and waste).

CHP has applications in any industry with a constant heat demand and need for electricity. Typical applications include large industry and buildings with year-round energy use such as hospitals and hotels. In Ireland, 88% of installed CHP capacity is in industry with the majority of the remainder (11%) in the service sector (SEI, 2008). The main market in Ireland is for gas-fired CHP for which there are mature CHP technologies and a developed supply chain.

2.2 Factors affecting the viability of CHP

The following critical factors impact upon the viability of CHP projects[6]. The combination of these factors severely restricts the number of potential sites. Many of the topics are considered in greater detail in later sections of the report.

- **Fuel**

  The relationship between fuel and electricity prices is known as the 'spark-spread'. Although this term generally refers to gas, it is equally applicable for biomass fuel. The economics of CHP are most attractive when the spark-spread is high, i.e. when the fuel price is low, relative to the electricity price. Spark-spread has the biggest single impact on both the rate of return and level of risk associated with a CHP project.

- **Electricity price**

  The REFIT (Renewable Energy Feed-in Tariff) price for electricity produced from biomass CHP has been set at €120 per MWh since January 2008. This was an increase from €72 per MWh, giving developers a guaranteed price for electricity and hugely reducing one of the major uncertainties with biomass CHP.

- **Transport costs**

  Given the bulky nature of biomass fuel, transport costs are a significant factor, impacting on the radius from which fuel can be viably sourced.

- **Large scale users**

  As noted above, transport is a significant cost in relation to biomass fuel and when co-firing begins in Irish power stations or other large-scale users emerge, smaller CHP users may be forced to pay a relatively high price compared to the electricity utilities.

- **Complex logistics**

  Unlike gas-fired CHP, biomass projects rely on complex logistics and scheduled deliveries of fuel. This adds significant risk to project developers.

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6 These factors are highlighted in the *CHP Policy Group Report (SEI, 2006)*, with some additional factors included here for biomass CHP

- **Limited number of sites**

  Biomass CHP is only suitable for users with a continuous heat load above 600 kW_{th} as established by the technology research in this report. This equates to very large hotels, hospitals or large industrial sites.

- **Electrical efficiency**

  As biomass CHP has comparably low electrical efficiencies[7], projects require a consistent high heat load and installation should be matched to the heat load rather than the electrical load.

- **Footprint**

  Biomass CHP plants require a large footprint. Not only is the plant bigger than fossil fuelled CHP but typically at least four days of on-site fuel storage are required. This can cover acres of land.

- **Scale and cost**

  The high capital, maintenance and labour requirement of a biomass CHP plant, are all best amortised over as large a plant as possible. However, the high capital cost of biomass projects adds significant project risk and can prove to be an obstacle to financing a project. Innovative solutions such as ESCO agreements are required.

- **Gas and electricity market liberalisation**

  Changes due to the liberalisation of energy markets can have a severe impact on the uncertainty and risk faced by CHP users and developers, and this can result in CHP schemes opting to exit the market. Therefore, biomass CHP requires particular attention in the regulatory environment to ensure that the technology is not set at a disadvantage when compared to conventional forms of generation.

- **Trading rules for importing and exporting electricity and the conditions for dispatch of electricity from the CHP scheme**

  It is important for these rules and conditions to be both transparent and non-discriminatory, and where appropriate they should facilitate CHP.

- **Electricity system tariffs and charges**

  The current system of charging based on maximum import capacity is believed to penalise the CHP generator, (SEI, 2006). An alternative system based on volume of units imported is proposed, which is considered to be a fairer and more cost reflective system as it is based on actual usage rather than capacity.

- **Access and connection conditions for CHP to the electricity network**

  Connecting new CHP generators to the electricity system will require detailed consideration by potential developers even though almost all sites will have existing supply connections. The report *A guide to the process for connecting renewable and CHP plant to the Irish electricity distribution and transmission grids* is a useful source of further information (Econnect, 2008).

- **EU Emissions Trading Scheme (EU-ETS) and Energy Tax Directive**

  The Emissions Trading Directive requires the large power generation sector to purchase carbon certificates, which will in the long term increase their operation costs. This will partially address the inequity between large power generators and CHP users (>20 MW_{th}) participating in the EU-ETS. However, the small-scale CHP user not participating in the EU-ETS receives no such benefit.

- **Legislation and approvals**

  The requirement to understand and seek a large number of consents for a CHP plant, including planning permission and electricity licenses, is considered to be a barrier that inhibits take up. There is probably limited scope for reducing the number of consents required but a clear statement of policy via planning guidelines, examination of the licensing requirement for smaller generators, and provision of a guide to regulatory requirements could assist in the promotion of CHP.

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[7] Biomass CHP units typically have a power to heat ratio of 1:4.

- **Information and awareness**

  If existing markets for CHP are to be expanded and new ones opened up it will be necessary to address the current lack of awareness through the provision of marketing programmes, guidelines and assisted feasibility studies.

2.3 Biomass CHP technologies

This section briefly describes the main biomass CHP technologies and comments on the relevance of such technologies for the potential market of the Western Region. A detailed introduction is available in *The Handbook of Biomass Combustion and Co-firing, (Van Loo and Koppejan, 2008).*

There are currently two commercially operating biomass CHP plants on the island of Ireland: Grainger's sawmill (1.8MW_e) in County Cork and Balcas (2.7MW_e) in County Fermanagh. Both of these are in large sawmills that produce fuel as a waste product of their sawmilling operations. They also require heat to process their finished product and electricity to run their machinery. A further 3 MW_e biomass CHP installation is under construction at Munster Joinery in County Cork. Given the limited application, the level of knowledge of biomass CHP in Ireland is relatively low.

2.3.1 Steam turbines

Power generation using steam turbines is a highly developed technology. High pressure steam (20 – 250 bar) is produced in a boiler and drives a turbine which runs a generator producing electricity. This process is known as a 'Rankine Cycle'.

As a result of the high pressures and temperatures, boilers and other equipment must be designed and manufactured to a high specification. This is expensive and CHP units using steam turbines are usually economical only above 2 MW_e.

2.3.2 Steam engines

Steam engines work under the same principal as steam turbines, extracting energy from steam as the temperature and pressure is reduced. Steam engines operate on a smaller scale than steam turbines but are only appropriate for sites that require process steam. CHP units using steam engines have a poor power to heat ratio.

2.3.3 Organic Rankine Cycle

Instead of using steam, an Organic Rankine Cycle (ORC) uses an alternative substance with more favourable thermal properties. The alternative substance, usually a silicone, drives a turbine using exactly the same principle only at lower temperatures and pressures. As a result, ORC units (from approximately 200 kW_e up to 5 MW_e) are usually more cost-effective than steam turbines. Other advantages include simple start-stop procedures, quiet operation, low maintenance requirements (typically 3 to 5 hours per week) and good performances at partial load.

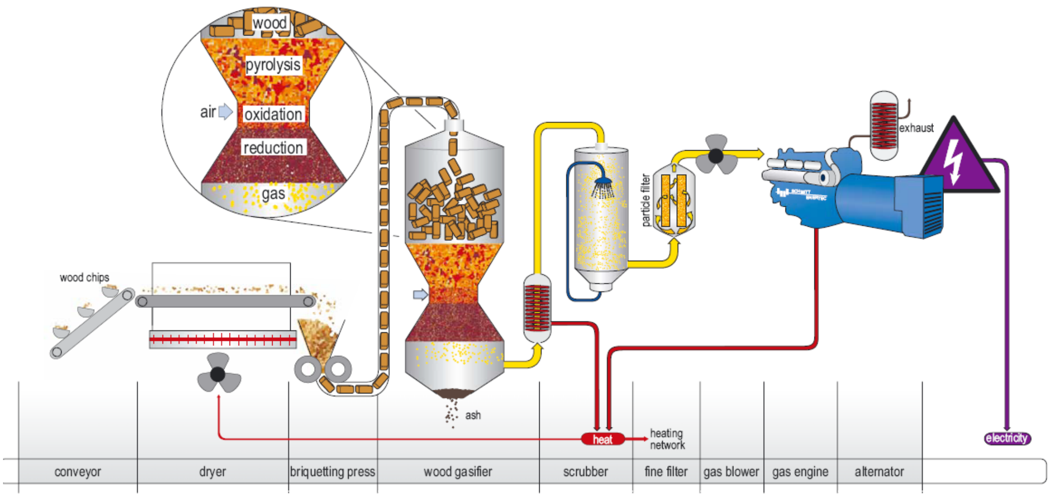
2.3.4 Gasification

Gasification systems turn biomass into a gas. This is burned in a modified gas engine to produce electricity, and heat is recovered as part of the engine cooling.

In the gasifier, woodchip is turned into a fuel known as synthesis gas or syngas. This is generally done by applying high temperature in a partial oxidation process. The syngas components with calorific value are mainly hydrogen (H_2), methane (CH_4) and carbon monoxide (CO). The remaining components are carbon-dioxide (CO_2), usually nitrogen (N_2) and other inert gases.

Afterwards, the gas is cooled and cleaned before it is used to fuel a standard gas engine. Water cools the gas engine and heat is used from this to both dry the fuel and supply the heat demand.

Figure 1: ENERCARB wood gas heat and power plants (Schmitt Enertec)



It is important to have a uniform product entering the gasifier. Some systems use dried woodchips, with a moisture content (approximately 10 to 12%), while others use briquette woodchips to ensure a consistent product.

An advantage of gasification systems is their relatively high power to heat ratio. While steam engine and ORC systems typically convert less than 20% of the input energy to power, biomass gasification systems have electrical efficiencies of up to 33%. Other important advantages are that a boiler is not required and that a conventional gas engine can be used.

Many suppliers are developing gasification systems. A general challenge is to produce gas of a consistent quality to burn in high performance gas engines.

2.3.5 Stirling engine

At a smaller scale, Stirling engine technology is of interest. A biomass burner is used to heat and expand a working gas (typically air, helium or hydrogen) that drives an engine in a closed system.

Initial applications of Stirling engine technology are undergoing testing at a scale of up to 35 kW_e. A significant problem is that ash covers the heat exchangers and reduces efficiencies.

Because of the size and low electrical efficiency (typically ~ 12%) of these units this assessment has not considered Stirling engines any further. Current biomass CHP policy supports are restricted to systems greater than 100 kW_e.

2.3.6 Other research and development

In addition to the ongoing development and commercialisation of the above technologies, other options are being considered and are likely to play a future role in biomass CHP. A review of research and development is beyond the scope of this report, but technologies worth noting are:

- **pyrolysis -** as a means for intermediate processing of biomass into a type of bio-oil suitable for a CHP generator, which may significantly change the economics of distributed generation
- **fuel cells -** in combination with gasification or pyrolysis, fuel cells offer a potentially high efficiency route for small-scale CHP

- **microturbines -** similarly, development of efficient microturbines should offer a route to improve the economics of small-scale CHP

The following resources are recommended for further reading on biomass combustion research:

The Handbook of Biomass Combustion and Co-firing, (Van Loo and Koppejan, 2008)

- www.thermalnet.co.uk - an EU funded network
- www.supergen-bioenergy.net - a UK funded research programme
- www.ieabioenergy.com - International Energy Agency research forum

Technology provider list

Appendix 2 presents a selection of biomass CHP providers (listed in alphabetical order), with a focus on their immediate relevance to the Irish market. Suppliers of turnkey installations as well as the specialised technologies are presented. A listing of further providers is available in Appendix 3. This does not constitute an endorsement of any particular supplier, rather it is an independent review based on the information made available to the authors.

2.4 District heating

District heating is the process of heating a number of separate sites from a central boiler. Typically a heat meter measures the energy used and the customer pays the operator of the boiler for the heat used. The simplest form of district heating is where a small number of houses are run off a single boiler, while on a larger scale entire cities can be heated from a series of large boilers or CHP systems.

The uptake of biomass CHP in Europe is boosted by significant levels of district heating. By supplying a number of end users from the same system it is easier to obtain a heat load large enough to make a project viable. This has given European countries with a history of district heating a significant advantage in developing biomass CHP projects.

There are considerable difficulties facing the deployment of district heating in Ireland and these are addressed in a previously detailed report (WS Atkins, 2002). Some key barriers identified include:

- the mild Irish climate, compared to Northern Europe, and improved insulation standards in modern buildings limit the heat required and hence the potential revenue from heat sales
- unfavorable economic returns due to various factors including the low gas/electricity price differential, high capital costs and uncertain consumer uptake - in a typical district heating scheme the only guaranteed users are those controlled by a local authority as private residents prefer to choose their own method of home heating
- the need to achieve socio-technical change - typically driven by committed enthusiasts acting as technology champions to disseminate knowledge of district heating and its applications

The WS Atkins report states that CHP district heating is more likely to succeed if gas is not available in an area as it cannot compete with decentralised gas fired heating. However, it goes on to state that “there is a good niche opportunity for district heating if the central plant can be fired with a renewable energy source, for example, by using a woodchip fired boiler, or a municipal waste incinerator”.

The level of district heating in Ireland may increase after the publication of a new Part L of the building regulations, which requires a minimum level of renewable energy for each new dwelling and directly encourages small scale CHP (Department of Environment, Heritage and Local Government, 2007). However, it is likely to be several years until district heating becomes established at any significant scale in the Western Region.

2.5 Conclusions of technology assessment

While biomass CHP technologies are continually developing, the products currently available need high heat load factors throughout the year. When sizing a biomass CHP unit it is therefore important to meet the continuous heat demand rather than trying to size according to power demand.

Buildings do not generally use significant space heating in the summer and as this gives a highly seasonal load factor they are generally less suitable for biomass CHP. Sites with industrial or process heat demand are a high potential target market.

The smallest scale commercial biomass CHP units identified were:

- 140 kW_e Spilling Steam Engine, which would require a thermal output of 1100 kW_{th}
- 200 kW_e, Turboden 'T200-CHP' unit with a thermal output of 980 kW_{th} (not yet commercially available)
- 300 kW_e Xylowatt with a 600 kW_{th} thermal output
- 315 kW_e, Adoratec 'AD 315 TF-plus' unit with a thermal output of 1495 kW_{th}

The authors have therefore concluded that biomass CHP using commercially available and proven technologies is only feasible for users with a continuous heat load of over 600 kW_{th}. This is a significant finding of our research.

As the heat load increases, a range of technologies become available. Depending on the technology chosen, a unit in the range of 100 to 300 kW_e will cost between €1 million and €3 million. This is very expensive when compared to similarly sized fossil fuelled CHP units. For comparison, a turnkey installation of a 140 kW_e natural gas fired CHP microturbine currently costs approximately €145,000 (McDonnell, 2008).

Table 1 shows the cost of delivered energy supplied by various fuels at today's prices (SEI, July 2008). It can be seen that the cost of energy from woodchip and natural gas are comparable. With the additional capital cost, it is therefore exceptional under current conditions that a biomass CHP system would be viable when natural gas is available. However, when natural gas is unavailable the alternative to biomass is nearly always oil or LPG and the additional initial capital cost may be paid off by cheaper running costs.

Table 1: Cost of delivered energy (SEI)

Fuel	Delivered energy cost (cent/kWh)
woodchip (35% moisture content)	2.95
natural gas (medium business)	3.27
oil	6.80
LPG	9.50

Wood processing industries that produce residues (woodchip, sawdust etc.) as a by-product, have cheaper raw material and are therefore the highest potential users for biomass CHP in the Western Region.

3.0 Market assessment

The following section presents the potential market segments for CHP application. Research was not conducted into the suitability of any specific sites. However, as outlined in the previous section, only sites with a continuous heat load of over 600 kW_{th} should consider biomass CHP.

Through the research, the authors are aware of the following sites in the Western Region currently (August 2008) investigating biomass CHP:

- Energy Crops Ltd, Letterkenny, Co Donegal
- Leisureland, Galway
- National University of Ireland, Galway
- Sligo Institute of Technology

3.1 Market segments

For this analysis potential sites were divided into the three categories below:

- large energy users consisting of sites with the potential to use a biomass CHP unit of over 5 MW_e
- medium energy users with the potential for a unit of 1 to 5 MW_e
- small energy users that could use a system of less than 1 MW_e

For each category, the authors have looked at a number of high potential market segments and quantified the number of potential sites. The market profile is based on information gathered from publicly available databases, interviews and the authors combined experience in the area. The analysis has considered mainly large single energy users, but for installations > 1 MW_e, the potential for some level of urban district heating penetration has been estimated.

3.1.1 Energy users > 5 MW_e

Large industrial users

A 5 MW_e biomass CHP plant will generate approximately 20 MW_{th} of heat. By coincidence, companies who generate more than 20 MW_{th} of thermal energy are registered for Emissions Trading Permits with the Environmental Protection Agency (EPA). Using this as a cut-off criteria, the following potential sites are located in the Western Region (EPA, March 2008).

Table 2: Emissions trading scheme permits in the Western Region

Company	Industry	Location
Allergen Pharmaceuticals	pharmaceutical	Westport, Co. Mayo*
Baxter Healthcare SA	pharmaceutical	Castlebar, Co. Mayo*
CRH plc	construction material manufacturing	Ennis, Co. Clare*
Finsa Forest Products Ltd	timber processing	Scariff, Co. Clare
University College Hospital	hospital	Galway, Co. Galway*
Masonite Ireland	timber processing	Drumsna, Co. Leitrim
Premier Proteins (2000) Ltd	food	Ballinasloe, Co. Galway*
Shannonside Milk Products Ltd	food	Ballaghadereen, Co. Roscommon
United Fish Industries	food	Killybegs, Co. Donegal

** Westport, Castlebar, Ennis, Galway and Ballinasloe have access to the gas network. Please see Appendix 7 for a map of the national gas pipeline.*

The two wood processing companies, Finsa and Masonite are considered the most favourable sites in the region to adopt biomass CHP as they have a continuous year round requirement for process heat and already have much of the necessary infrastructure and expertise for dealing with large volumes of woodchip.

The two existing biomass CHP sites in Ireland are in sawmills who produce woodchip as a by-product. However, instead of producing woodchip as a waste product both Finsa and Masonite buy in timber to make their final products. Finsa require approximately 350,000 tonnes of timber per year and Masonite approximatley 120,000 tonnes. If they were to install CHP plants they would need to buy additional timber to fuel the boilers (~80,000 tonnes/year for a 5 MW_e plant). Having the logistics in place to procure and handle large volumes of biomass would provide a significant cost advantage.

The existing energy plant at the remaining seven sites requires further investigation. An on-site study and detailed investigation of historical fuel bills would be necessary. Some of these are already likely to have fossil fuel CHP or may not have the space needed to store woodchip and operate a CHP unit.

District heating

There is also the potential to operate a large district heating network from a CHP plant. For comparison, the following plants run district heating networks.

Table 3: District heating networks

Location	Output	Number of customers
Harbooere, Denmark	1.4 MW_e	595 + city's public buildings
Tranas Energy, Sweden	1.6 MW_e	800
Assens, Denmark	4.85 MW_e	2362

The number of homes in a town, average occupancy levels and many other factors will determine if there are sufficient customers to justify a district heating network. However, for this study, the authors are assuming that a district heating network of over 5 MW_e equates to approximately 2,500 customers of a representative size to be successful. Drawing on the European experience, a further assumption is that only towns with a population over 20,000 will have sufficient demand and are therefore candidates for a 5 MW_e CHP unit. Based on 2006 census figures there are only two suitable towns in the region: Galway (population 72,414) and Ennis (population 24,253) (CSO, 2008). Both of these towns are on the mains gas network, which means that it would be difficult for biomass CHP and a district heating network to compete at present energy prices.

3.1.2 Energy users 1 - 5 MW_e

Sawmills

The authors identified two sawmills in the Western Region who could potentially use a unit between 1 and 5 MW_e: Earrai Coillte Chonnacht Teoranta and Murray Timber Products Limited, both in County Galway. We recommend engaging with these businesses to establish if biomass CHP is a viable prospect.

Large Industrial Energy Network (LIEN)

A 1 MW_e biomass CHP plant operating at 50% availability would produce approximately 5,000 MWh of power and 20,000 MWh of heat. If mains electricity and fossil fuelled heat were displaced this would be equivalent to an annual energy bill of approximately €1.5 to €2 million. Sustainable Energy Ireland has a LIEN for companies with an annual energy cost of over €1 million and this includes the majority of large energy users, (Farrelly, 2008). The authors made the assumption that if a facility is not spending over €1 million per annum it would most likely not be a candidate for a biomass CHP plant of over 1 MW_e.

There are currently 11 sites in the Western Region that are members of LIEN and are not members of the Emissions Trading Scheme, (SEI, August 2008). These are listed in Table 4. A detailed analysis is required for each specific site. It is recommended to engage with site operators to assess their interest in biomass and to analyse their suitability for biomass CHP.

Table 4: Members of SEI's Large Energy Network (excluding companies in the ETS)

Company	Industry	Location
Abbott Ireland	chemicals	Co. Sligo
Boston Scientific	medical	Co. Galway
Connacht Gold	food	Co. Sligo
Dawn Country Meats	food	Co. Roscommon
Western Proteins	food	Co. Mayo
Donegal Meat Processors	food	Co. Donegal
Elan Corporation	medical	Co. Roscommon
Element Six	mineral fibres & glass	Co. Clare
Fruit of the Loom	textiles	Co. Donegal
Roche Ireland	chemicals	Co. Clare
Thermo King	refrigeration	Co. Galway

District heating

In a similar analysis to that for large energy users, it is estimated that towns with a population over 10,000 could support a biomass CHP unit of between 1 and 5 MW_e running a district heating network. This would give the following possibilities in the Western Region:

Table 5: Towns in Western Region with a population over 10,000

Town	Population	Connection to gas network
Sligo	19 402	No
Letterkenny	17 586	No
Castlebar	11 891	Yes
Ballina	10 409	under construction

With their size, proximity to forestry and the fact they are not connected to the natural gas network both Sligo and Letterkenny are considered potential towns in the region for a large scale district heating network. Significant barriers to district heating were highlighted in Section 2.4 and a detailed study would be required for each of these towns.

3.1.3 Energy Users < 1 MW_e

The fact that a biomass CHP system should be linked to the thermal load of a site was highlighted in Section 2 and it was concluded that only sites with a heat load of over 600 kW_{th} should consider biomass CHP.

The authors identified four potential market segments in this size range:

- public hospitals
- leisure centres and large hotels
- feed mills
- industrial sites

Unless otherwise stated, all sites identified are likely to have a high heat demand and could be suitable for biomass CHP, particularly those not on the gas network. Several are likely to use gas fired CHP and some may already have invested in biomass heating solutions. Further research is required to identify the heat load of each individual site and their suitability for biomass CHP.

Public hospitals

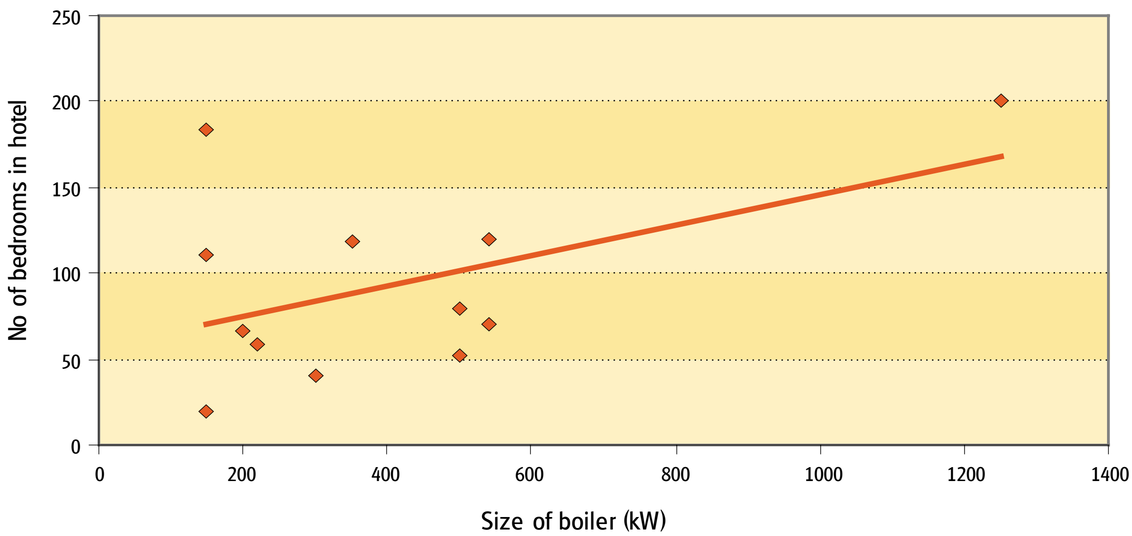
Except for Galway University Hospital, already listed as a large energy user, there are six public hospitals as listed below in Table 6.

Leisure centres and hotels

Two known leisure centres are Leisureland in Galway and Letterkenny Leisure Centre, both of which have a regular thermal load of 500 kW_{th} or less. Leisure centres are therefore unlikely to be suitable candidates for biomass CHP unless they are linked as part of a larger district heating network.

In order to estimate potential demand in the hotel sector it is useful to analyse the uptake to date of SEI's ReHeat programme. Figure 2 below shows a comparison of the size of boilers installed under SEI's ReHeat and Pilot Bioheat Programmes (SEI, June 2008), to the size of the hotel quantified by the number of bedrooms they have.

Figure 2: Installed biomass boilers compared to hotel size



From this graph the authors are making the simplified assumption that a thermal heat load of 600 kW_{th} equates to a hotel with over 100 bedrooms. There are 24 hotels in the Western Region with over 100 rooms each, four of these have over 150 rooms each (Irish Hotels Federation, 2008) and are listed in Table 6.

Over a 100 biomass CHP sites were identified across Europe during the course of this assessment (listed in Appendix 1). None of these are operating solely in hotels, which supports the assumption that hotels are not a high potential category for biomass CHP.

Feed mills

In discussion with two feed mills, the authors have profiled the heat requirement of a representative feed mill at 1 MW_{th}. There are seven feed mills in the region as listed in Table 6.

Industrial

Companies with Integrated Pollution Prevention Control (IPPC) licences are listed on the EPA's website. An IPPC licence is a single integrated licence that covers all emissions from the facility and its environmental management, and is required for a wide range of industrial and agriculture activities.

The authors analysed the list of IPPC licenses (EPA, August 2008) to identify 53 sites in the Western Region that have an IPPC licence that are not already in the Emissions Trading Scheme (EPA, March 2008) or the Large Industry Energy Network (SEI, August 2008). The 53 sites are listed in Appendix 4. Some are likely to have a significant heat load greater than 600 $kW_{th,}$ which should be further investigated.

Table 6: Potential users of biomass CHP systems under 1 MW_e

Regional hospitals
Letterkenny General Hospital
Mayo General Hospital
Mid Western Regional Hospital, Ennis
Portiuncula General Hospital, Ballinasloe
Roscommon County Hospital
Sligo General Hospital
Hotels with over 150 bedrooms
Days Hotel, Galway. 363 rooms
Galway Bay Hotel. 153 rooms
Radisson SAS, Galway. 261 rooms
Clarion Hotel, Sligo. 312 rooms
Feed mills
Connacht Gold, Tubbercurry, Co. Sligo
Connacht Gold Co-Op, Ballaghaderreen, Co. Roscommon
Joseph Stewart Ltd, Boyle, Co. Roscommon
Lough Conn Milling, Ballina, Co. Mayo
McDonagh Milling, Ballybane, Co. Galway
Smyths Daleside Feeds, Lifford, Co. Donegal
Trouw Aquaculture Ltd, Westport, Co. Mayo

3.1.4 Summary of market segments

Table 7 below summaries the number of current sites in each market segment. It also gives an indication of each segment's potential for the uptake of biomass CHP.

Table 7: Summary of potential biomass CHP sites by sector

Size range (MW_e)	Market segment	Current number of sites	Potential
> 5	wood processing industry	2	high
	ETS sites	7	medium
	towns > 20,000	2	medium
	Total	**11**	
1 - 5	medium sized sawmills	2	medium
	SEI's LIEN	11	medium
	towns > 10,000	4	medium
	Total	**17**	
< 1	public hospital	6	medium
	hotels > 100 bedrooms	24	low
	feed mills	7	medium
	other IPPC sites	53	low
	Total	**91**	

Total Number of Potential Sites	**119**

3.2 Market projection

The *Wood Energy Strategy and Action Plan* and *Economic Impact of a Regional Wood Energy Strategy (ADAS, 2007)*[8] identified a counterfactual ('do nothing') position and three growth scenarios, representing the varying degrees of market penetration associated with levels of public support and market conditions.

These four scenarios (defined in Appendix 5) are based around biomass heating and are generally relevant for biomass CHP in so far as a strong wood energy market supports the development of biomass CHP. This report developed similar scenarios that take greater account of CHP policy supports, and these are described below.

Pessimistic 'low' scenario

This scenario assumes static market environment and no additional public intervention, as well as the following:

- recent REFIT[9] price of 12 cent/kWh has no great effect on the market
- biomass CHP programme finishes in 2010 (SEI, 2008)
- price of oil remains static or increases in line with the Consumer Price Index (CPI)
- little or no uptake of district heating as a result of new building regulations (DEHLG, 2007)[10]
- WDC action plan is not implemented

Realistic 'medium' scenario

This scenario assumes all conditions in the pessimistic scenario, as well as the following:

- REFIT programme sees strong uptake
- biomass CHP programme continues to 2020
- price of oil increases faster than CPI
- parts of the WDC action plan are implemented
- the national Bioenergy Action Plan is implemented (DCMNR, 2007(2))
- a significant part of the national CHP target is met through biomass

Optimistic 'high' scenario

This scenario assumes all conditions in the realistic scenario, as well as the following:

- REFIT price increases, or alternative supportive mechanism introduced
- fossil fuel prices increase dramatically
- the full WDC action plan is implemented
- large district heating networks are introduced
- carbon taxes and other policy supports are enacted

8 Reports are available for download at www.wdc.ie

9 REFIT (Renewable Energy Feed-in Tariff) is described in more detail in Section 4.5: Existing national policy supports.

10 More details in Section 2.4: District heating.

It is difficult to predict trends and impact, particularly as there is little or no history of biomass CHP either in the region or nationally. However, the authors have used the above hypothetical scenarios to estimate the potential number of installations for each of the market segments described in Section 3.1 by 2020. This is shown in detail in Table 8.

Table 8: Potential number of units installed by 2020

Size	Market segment	Current number of sites	Potential	Low scenario	Medium scenario	High scenario
> 5 MW_e	wood processing industry	2	high	1	2	3
	ETS sites	7	medium	1	2	4
	towns > 20,000	2	medium	0	1	1
	Total	**11**		**2**	**5**	**8**
1 – 5 MW_e	medium sized sawmills	2	medium	1	1	2
	SEI's LIEN	11	medium	1	2	3
	towns > 10,000	4	medium	0	1	2
	Total	**17**		**2**	**4**	**7**
< 1 MW_e	public hospital	6	medium	1	2	4
	hotels > 100 bedrooms	24	low	2	5	8
	feed mills	7	medium	2	3	4
	other IPPC sites	53	low	2	3	6
	Total	**91**		**7**	**13**	**22**

The figures in Table 8 are summarised in Table 9.

Table 9: Summary of potential number of sites

Size range (MW_e)	Low scenario	Medium scenario	High scenario
> 5	2	5	8
1 – 5	2	4	7
< 1	7	13	22
Total sites	**11**	**22**	**37**

In Table 10 the total potential electrical output (MW_e) is calculated by assuming the following average unit sizing and totalling to the nearest whole number:

- each installation ≥ 5 MW_e = 5 MW_e
- installations between 1 to 5 MW_e = 2.5 MW_e
- those under 1 MW_e = 500 kW_e

Table 10: Summary of potential electrical output (MW_e)

Size range (MW_e)	Low scenario	Medium scenario	High scenario
> 5	10	25	40
1 – 5	5	10	18
< 1	4	7	11
Total MW_e	19	42	69

3.2.1 Fuel requirements

There are many factors that influence the fuel requirements for a biomass CHP plant. These are listed with typical values in Table 11.

Table 11: Typical operating parameters for small scale biomass CHP

Running time	**6 570 hour / year (75% of maximum)**
Load factor	**80%**
Power to heat ratio	**1 : 4**
Overall efficiency	**80%**
Calorific value of fuel	**2.7 MWh/tonne (at 50% moisture content)**

Using the values above, Table 12 gives an estimate of the annual fuel requirement, by 2020, in tonnes and rounded to the nearest 5,000 tonnes.

Table 12: Summary of potential fuel requirement (tonnes of woodchip at 50% moisture content)

	Low scenario	Medium scenario	High scenario
Total MW_e	19	42	69
Total fuel required	**225,000**	**500,000**	**830,000**

The scenarios presented have significant fuel requirements. The *Wood Energy Strategy and Action Plan* estimated wood fuel supply from the region's private forestry sector of approximately 516,000 tonnes by 2020. Therefore it is critical that all potential wood fuel streams (e.g. energy crops, public sector forestry, etc.) are identified and assessed if the fuel demands of the biomass CHP market and the wood heat market are to be met into the future.

3.3 Comparison with previous analysis and policy targets

The following section compares the projections as presented in Table 10 to the national CHP target and the regional CHP target as estimated by the *Wood Energy Strategy and Action Plan.*

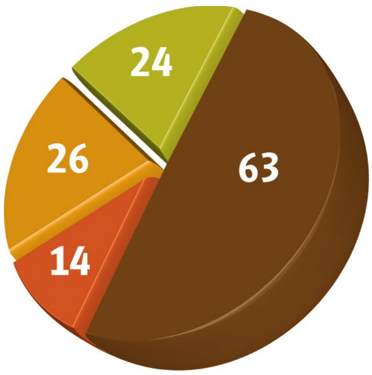
White Paper

The White Paper *Delivering a Sustainable Energy Future for Ireland* (DCENR, 2007(1)) establishes ambitious targets including 800 MW_e of CHP by 2020 with an "emphasis on biomass fuelled CHP".

Bioenergy in Ireland

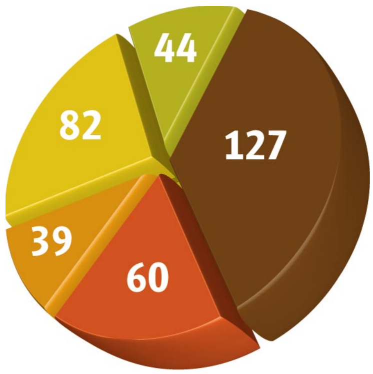
Bioenergy in Ireland (DCENR, 2004) estimates the potential for biomass CHP nationally by 2010 and 2020, projecting that on a national basis, the range of CHP from wood residues will be between 25 and 182 MW_e. Under their medium scenario, by 2020, there will be 127 MW_e of biomass CHP from wood residues. Figure 3 shows the breakdown of this into the following fuel types: pulpwood, sawmill, forest, and construction and demolition (C&D) residues.

Figure 3: Wood CHP estimates (Bioenergy in Ireland, Annex L, 2004)



Agricultural residues, waste and dedicated energy crops are projected to deliver the majority of biomass CHP. The total biomass CHP projected nationally ranges from 131 to 506 MW_e by 2020. The medium scenario is shown in Figure 4.

Figure 4: Bioenergy CHP estimates (Bioenergy in Ireland, Annex L, 2004)



A surprising result of the analysis is that only between 19% and 36% of the biomass CHP target is anticipated to come from wood residues.

It is likely that this analysis understates the utilisation of forest residues in the Western Region, considering the following:

- in the Western Region, due to higher forestation levels and fewer competing energy resources, a higher proportion of wood residues would be used for CHP purposes
- these projections were made on the basis of no significant diversion of biomass from existing markets (board mills, animal bedding, horticulture etc...) - an assumption that would not remain valid if a significant user of pulpwood and forest residues were to disappear from the market
- the projections were made using 2003 data when crude oil costs were under $30 per barrel

Various methods can be used to extrapolate this national data. Pro-rata calculation based on regional population would imply 18% of national CHP targets be met in the Western Region. However, the Western Region contains approximately 40% of Ireland's forestry resource (WDC, 2007), and a higher estimate of biomass CHP potential can be assumed.

Taking the 127 MW_e medium scenario for CHP from wood residues, nationally if 40% of this was met in the Western Region, 50 MW_e of CHP from wood residues is a medium growth projection for the region by 2020.

Wood Energy Strategy and Action Plan

This strategy predicted a range from 30 to 90 MW_{th} of heat energy produced from biomass CHP by 2020. Assuming a power to heat ratio of 1:4, this equates to a range of 8 – 23 MW_e[11].

Comparison of targets

The table below shows a summary of the estimates made in this report, the regional strategy and the author's interpretation of the medium scenario outlined in *Bioenergy in Ireland*. All figures shown are in MW_e and rounded to the nearest whole number.

Table 13: Comparison of projections for CHP in the Western Region

Study	Range	Medium scenario
this report	19 – 69 MW_e	42 MW_e
Wood Energy Strategy/ADAS report	8 – 23 MW_e	19 MW_e
Bioenergy in Ireland		50 MW_e

The regional strategy predicted that only a handful of large (~ 5 MW_e) biomass CHP projects were viable. It was only after the detailed technology report, conducted as part of this assessment, that the opportunity for smaller scale units became known. This explains the difference in predictions above.

3.4 Market impact of co-firing or other large users

The development of the biomass CHP market in the Western Region will be impacted on by the growth of related market segments such as co-firing. Whilst a thorough understanding of the supply and demand metrics is not possible we can provide the following observations on the competitiveness of biomass CHP versus large scale co-firing applications.

A significant recent development entails a five year procurement framework initiated by Bord na Mona for biomass co-firing at its power plant in Edenderry. "Bord na Mona currently supplies approximately 1 million tonnes of peat fuel per annum to Edenderry power station. Bord na Mona wishes to introduce Biomass fuel as an alternative energy source for this power station on a graduated basis over the coming years, to replace a proportion of the current peat fuel," (Bord na Mona, 2008). For comparison, Finsa and Masonite procure a combined 500,000 tonnes of biomass per year in the Western Region.

Mayo Power has received conditional planning permission to construct a 100 MW_e mixed fuel power plant at the former Asahi site near Ballina in County Mayo. The plant will use 500,000 tonnes of biomass annually and a minimum of 65% biomass in its total fuel requirements. The biomass will include a combination of short rotation coppice, mischantus, sawmill residues, woodchip and woodpellets.

In view of the demand for large industrial applications such as those outlined above there is some uncertainty about the availability of biomass for both small-scale CHP and commercial heating applications. Demand may also emerge for the production of woodpellets or briquettes. The potential supply problems are similar for both large scale and smaller decentralised applications. The *Wood Energy Strategy and Action Plan* addresses some aspects of the potential fuel resource availability and the development of supply chains, however further detailed resource research is required.

[11] When rounded to the nearest whole number.

The following table lists some of the positive market drivers of both CHP and co-firing. In order to promote decentralised CHP, projects must be located to exploit their proximity to the biomass resource and to heat end-users.

Table 14: Positive market drivers of CHP vs co-firing

Large scale/co-firing	decentralised CHP
economy of scale	ability to value heat
public procurement	strong policy supports
short lead-time/flexibility	proximity to resource
long-term contracts	smaller amounts of biomass more reliably available

3.5 International comparison

Given that the CHP market is more advanced in other European counties, a basic review of some European markets will inform on the potential development of the Irish market and highlight key issues impacting on biomass CHP growth.

The EUROBSERVER statistics are a useful starting point for a market comparison. These have, only since 2004, begun to classify as a separate category solid biomass used for CHP. There are undoubtedly some inaccuracies with both the methodology and the figures reported, which should improve as further data is gathered. However, some headline trends do emerge.

Between 2004 and 2006 there is an overall growth in biomass CHP of 11% across Europe. Germany, Austria, France, Belgium and the Czech Republic all report very high growth rates over the period. More detailed figures for a range of countries are included in Appendix 6.

Other countries such as Finland, Sweden and Denmark have a long history of biomass CHP and are mature markets for the technology. The factors behind the growth of biomass CHP in a selection of these countries is of interest. This section looks at six countries in further detail.

A report commissioned by the EU Commission on optimal renewable energy policies is a useful source of further information, (Ragwitz et al 2008).

3.5.1 Germany

Germany had 160 installations in 2006, for a capacity in the region of 1 100 MW_e (it added 130 MW_e in 2006). The average size of biomass CHP power plants is thus estimated at 6.8 MW_e.

The following feed-in tariffs were established for biomass and biogas in 2006:

- basic tariff level (up to 20 MW) of €80.3 – €109.9/MWh, with an annual reduction of 1.5%. The duration of the payment is 20 years
- reduced tariffs for waste wood (€37.2/MWh) and for landfill gas or sewage gas (€63.5 – €73.3/MWh)
- bonus payments available for:
  - the use of untreated biomass: €40 – €60/MWh
  - CHP applications: €20/MWh
  - innovative technologies: €20/MWh
  - use of wood combustion: €25/MWh – however, this is not available in combination with the untreated biomass bonus

Continuity and stability of the policy framework as well as high feed-in tariffs for biomass applications combined with reasonable investment incentives and loans have generated a considerable market, (Coenraad et al 2008). The average annual growth of biomass electricity over the period 1997 to 2005 was 32%.

3.5.2 Austria

In 2003, 9.7% (137 PetaJoules) of Austria's primary energy requirement came from biomass. In this same year, a new Green Electricity Act was put in place, which comprised the following measures supportive of biomass CHP, (Nemestothy, K. 2006):

- feed-in tariffs guaranteed for 13 years
- inclusion of electricity from biomass (solid, liquid and gaseous) as well as wastes "containing high biomass fractions" - specifically excluding meat and bone meal, black liquor and sewage sludge
- a target of at least 4% of final demand from biomass by 2008
- an average support level that was put in place in 2003 of €110/MWh with a maximum support of €150/MWh - the average support level almost double the average generation costs (approximately €60/MWh) from competing fuel solutions

Revealing statistics on research and development in Austria are also reported. In 2004, 21% of energy related research and development investment was directed towards bioenergy. This compares with an OECD average of 2.8%.

However, indications are that more recent policy is less supportive of biomass CHP and one report suggests that the Austrian market is likely to stagnate, (Coenraads et al 2008). It is also reported that CHP plants receive investment support of up to 10% of the direct investment costs, although this is capped at €400/kW.

3.5.3 France

A significant proportion of France's biomass CHP growth appears to come from use of waste biomass, such as municipal solid waste and wood waste. The production of electricity from solid biomass was contracted over the period 1997 to 2005. A new feed-in tariff mechanism was introduced in 2005 that provided index-linked support ranging from €61 to €91.5/MWh for 15 years for CHP projects. A national tender system is now in place for some renewable energy installations. Tenders follow an open bidding process, where the successful applicant receives a guaranteed price contract. The tariff of the contract depends on the bid. In 2005, 14 biomass projects with a total installed capacity of 216 MW were contracted. Another biomass call was issued during 2007.

3.5.4 Belgium

Due to the federal political structure in Belgium, policy supports are set separately for the Belgian regions. The most activity in biomass CHP and the most supportive scheme occurs in the Walloon region.

The main promotion scheme for renewable electricity in Belgium is a green certificate system with obligations on electricity suppliers and guaranteed minimum prices ('fall-back prices') for the sale of renewable electricity. Companies that do not reach their target by the end of the certificate accounting period must pay a penalty.

Details of the scheme differ in the four regions: Flanders, Walloon, Brussels and, as a fallback option, Federal. In Walloon and Brussels, certificates are issued when a certain amount of CO_2-emission reduction is maintained through renewable electricity production or co-generation, corresponding with the CO_2-emission of 1 MWh produced from a reference fossil fuel electricity producer.

Feed-in tariffs at a fixed price are a fallback option from the green certificate system to give security to renewable electricity investors. Income from trading green certificates is additional to the price of electricity, so this is in effect a premium. In the Walloon region, the Commission Wallonne pour l'Energie registered trades in the first three months of 2007 for an average price of €90.80/MWh. The minimum fixed price in Wallonia is €65/MWh for 10 years. An interesting feature of the Walloon certificates scheme is that biomass-fired plants are particularly rewarded, receiving up to double the number of certificates for the electricity produced, (Riddoch, 2008).

3.5.5 Denmark

Approximately 60% of the Danish demand for heat is supplied by district heating and more than 50% of the electricity and heat distributed comes from co-generation plants. This demonstrates the strong link between a developed district heating culture and CHP applications.

For new biomass installations, a feed-in tariff of €80/MWh is guaranteed for a period of 10 years, followed by €54/MWh for the next 10 years. There have been CO_2 and SO_2 taxes in place in Denmark since the early 1990s. Biomass as a CO_2 neutral and sulphur-free fuel is exempt from these taxes.

Denmark saw a 24% average annual growth of electricity production from biomass over the period 1997 to 2005.

3.5.6 Czech Republic

A feed-in system for electricity from renewable sources and co-generation has been in place since the beginning of 2002. In March 2005, a new renewable energy sources act was adopted, which allowed producers to choose between having a feed-in tariff or a feed-in premium ('green bonus'). Producers can now choose each year which scheme they would like to use. The feed-in tariff is a guaranteed price paid for each unit of electricity for 15 years whilst the green bonus is paid on top of the market price for electricity.

The Czech Republic has seen strong growth in biomass CHP. In the period 1997 to 2005 the average annual growth of electricity from biomass was 6%.

3.5.7 Comments on international comparisons

Different terms and classifications are used for CHP statistical reporting throughout the EU and it is difficult to make direct comparisons to the Western Region. Many of the systems installed abroad are significantly greater than 5 MW_e, and some as high as 200 MW_e. The average capacity of installed units in Germany is 6.8 MW_e. Schemes of > 5MW_e are unlikely to be viable for many single entities in the region, so without some level of district heating they are not feasible in the Western Region.

The larger plants often burn a variety of fuels; either co-firing with fossil fuels or burning a proportion of municipal solid waste. In Ireland, the public perception of the latter is that they are waste incinerators. Some support schemes include waste, while others choose to have none or limited supports for waste biomass.

Abroad, biomass CHP is considered a developed technology while in the Western Region it is still an undemonstrated concept.

A long-term, stable feed-in tariff support scheme has boosted biomass CHP deployment in several countries.

When compared to the countries listed above, the current grant scheme and REFIT tariff in Ireland are favourable from a commercial viewpoint. However the regulatory environment in Ireland remains a serious obstacle to development.

It is clear that R&D investment stimulates local markets and the roll out of technology regionally. Austria report investment levels in bioenergy R&D well in excess of OECD averages.

There is a strong link between district heating and the deployment of biomass CHP. Denmark is a good example, where 60% of heating is through district heating networks and 50% of electricity generation is from CHP.

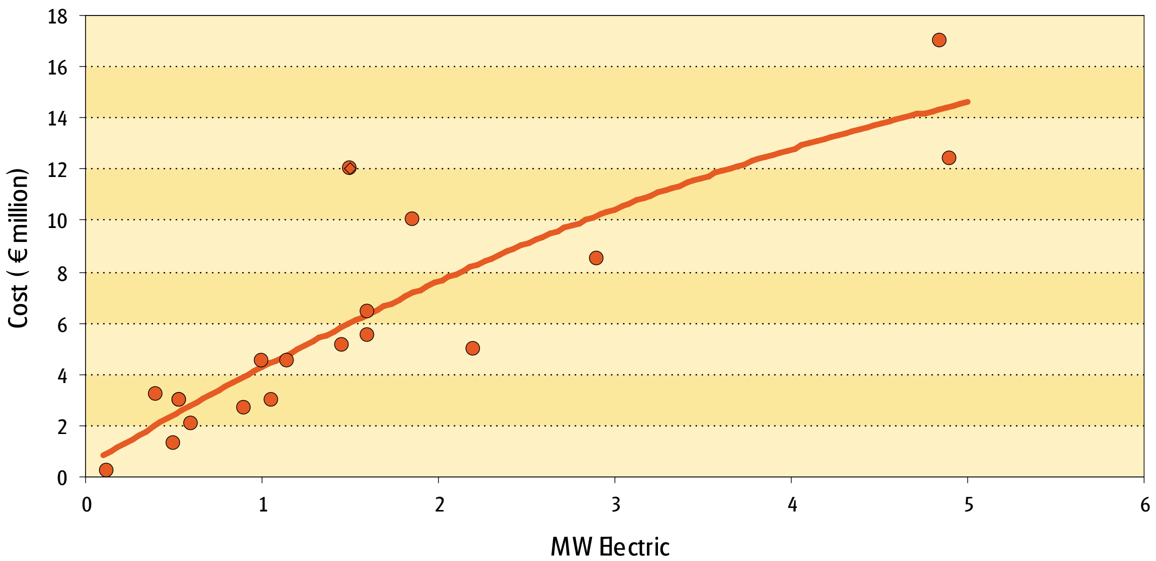
4.0 Economic assessment

The following section outlines the economic impact of growing the regional CHP market. The section presents the estimated gross investment, job creation and CO_2 reductions as a result of the CHP growth as stated in Table 10 of Section 3.2. These estimates are intended as indicative estimates and are based on the application of multipliers etc from other studies. A full economic impact study, as completed for the *Wood Energy Strategy*, would be required to present estimates with a high level of accuracy.

4.1 Direct investment estimates

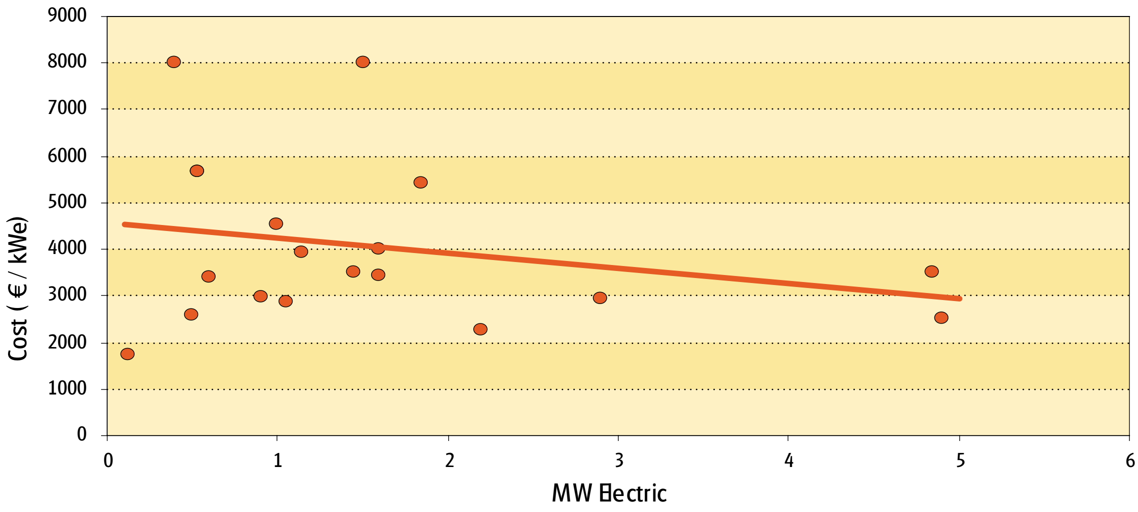
An analysis was conducted on all the installations listed in Appendix 1 and where information was available the cost was plotted against the size. This is shown in Figure 5 below. This information refers to the total installed cost and is taken from several countries over a number of years and for various biomass CHP technologies. Even though these figures are not adjusted for inflation, or other factors, there is a consistent trend that is observed.

Figure 5: Cost of biomass CHP



A different interpretation of this data is shown in Figure 6 which plots the specific cost per kW_e over the range of sizes.

Figure 6: Cost expressed as €/kW_e



By interpolating information from the graph in Figure 6, the following costs were calculated for units of the various sizes considered.

Table 15: Cost of various sized units

Size of unit	> 5 MW_e	1 – 5 MW_e	< 1 MW_e
cost (€/kW_e)	2900	3700	4400
cost / unit	€14.5 million	€9.3 million	€2.2 million

Under the scenarios outlined previously this would indicate significant direct investment in the Western Region, which is outlined in Table 16. These direct investment costs were calculated by multiplying the predicted installed capacity, summarised in Table 10 of the market potential, by the corresponding cost per kW_e in the table above.

Table 16: Direct investment scenarios for biomass CHP

	Low scenario	Medium scenario	High scenario
Total (MW_e)	19	42	69
Investment (gross)	€63 million	€138 million	€229 million

4.2 Job creation estimates

An estimate based on existing studies and methodologies of the direct, indirect and induced employment is outlined in this section.

The International Energy Agency gives a clear explanation of employment from biomass, (IEA, 2002): "*Direct employment results from operation and construction of conversion plants as well as production and transportation of biomass. Indirect employment is jobs generated within the economy as a result of expenditures related to biomass fuel cycles and induced jobs are secondary jobs created by increased spending in the region.*"

4.2.1 Full time equivalent (FTE) jobs

The most recent Irish study looking at job creation from bioenergy is the *Bioenergy Training and Education Needs Study (SEI, 2004)*. This study supports the conclusions of a previous Ecotec analysis, (Ecotec, 1999). The results of these studies should be treated as indicative of the likely scale of labour required, rather than as exact predictions. For this report it was decided to use the same Ecotec production functions to estimate FTE jobs in two categories, construction and installation, and fuel production. FTE jobs are defined as direct jobs resulting in more than 30 hours of work per week all year round.

Approximately 4.2 FTE jobs are created in construction and installation per million euro of capital investment. This is compared in Table 17 for the three scenarios outlined until 2020. In reality there will be a growing number of jobs in construction and installation over the period, which has been annualised over the period 2010 to 2020. Should these installation rates be reached, towards the end of the period there would be a temporary increase in the FTE jobs associated with construction and installation at that time.

Table 17: FTE jobs in construction and installation

	Low scenario	Medium scenario	High scenario
Investment (gross)	€63 million	€138 million	€229 million
FTE jobs in C & I	**22**	**48**	**80**

The *Economic Impact (ADAS, 2007)* accompanying the *Wood Energy Strategy and Action Plan* projects an average of 19 FTE jobs per annum in construction until 2020 (under their medium scenario). This includes construction jobs for biomass CHP and biomass heat installation, and is clearly lower than that suggested above.

Ecotec calculates 0.1 FTE jobs in fuel production from forest residues per GWh of produced energy. The installed MW_e projections have been converted into GWh using the following assumptions: all units have an electrical efficiency of 20%, an overall efficiency of 80%, and operate at an average of 80% load for 6,570 hours per year.

The *European biomass CHP in practice project (Evald et al., 2006)*, has details of a number of biomass CHP projects. Eight of these give information on the number of operational and maintenance (O&M) jobs created from each project. From this, an approximation was made that any plant under 5 MW_e will provide two full time O&M jobs and any plant over 5 MW_e will provide four full time O&M jobs. This gives a significant opportunity for local job creation and is a major economic development aspect of biomass CHP. By comparison fossil fueled CHP requires a minimum level of maintenance.

The table below summarises the potential for FTE jobs.

Table 18: FTE jobs in 2020 from biomass CHP

	Low scenario	Medium scenario	High scenario
Total (MW_e)	19	42	69
Construction and installation	22	48	80
Fuel production	49	109	180
CHP operation and maintenace	26	54	90
Total FTE jobs	**97**	**211**	**350**

4.2.2 Indirect and induced jobs

The *Economic Impact Report (ADAS, 2007)* gives job multipliers of 1.05 for indirect jobs and 1.5 for induced jobs. This is considered the best available data and was also used in this report. The table below shows estimates of indirect and induced jobs created based on the bottom-up analysis of CHP in the region.

Table 19: Summary of jobs created from biomass CHP by 2020

	Low scenario	Medium scenario	High scenario
total FTE jobs	101	221	366
indirect jobs	5	11	18
induced jobs	40	88	146
Total Jobs (2020)	**146**	**321**	**531**

The relatively low figures for indirect jobs are due to the assumption that CHP technology will be imported from outside the region. Should the region develop significant research and manufacturing capabilities for CHP technology this would lead to significant indirect job creation.

Displaced jobs and investment in other energy technologies were not considered in this report, as the majority of jobs and investment will be newly created rather than displacing jobs dependent on fossil fuel and related technology.

4.3 CO_2 savings

Based on average emissions factors for Ireland (SEI, August 2008), Table 20 gives a prediction of the potential yearly CO_2 savings to the Western Region by 2020 under the various scenarios. CO_2 savings are rounded to the nearest 10,000 tonnes.

Table 20: Annual potential CO_2 savings

	Low scenario	Medium scenario	High scenario
Total (MW_e)	19	42	69
Annual CO_2 savings (tonnes)	**160,000**	**370,000**	**610,000**

4.4 Summary of economic data

The biomass CHP market has the potential to create a significant impact on the economy of the Western Region. A medium growth scenario would result in an investment of €138 million, the creation of 321 full time jobs and an annual reduction of 370,000 tonnes of CO_2 emissions by 2020.

Table 21: Summary of economic data

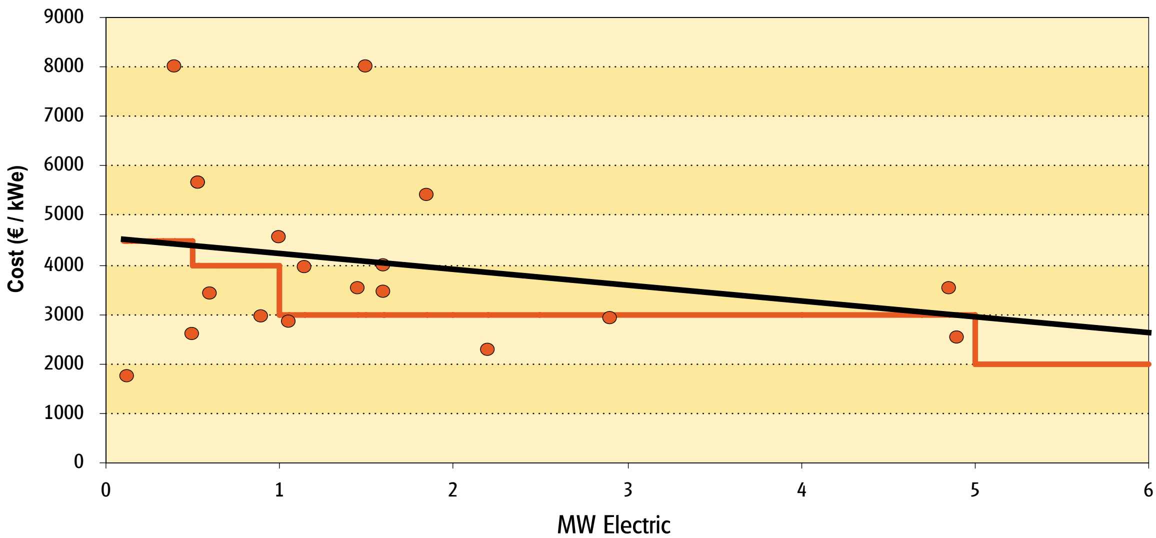
Scenario	Low	Medium	High
Total (MW_e)	19	42	69
No of sites (by 2020)	11	22	37
Total investment (by 2020)	€63 million	€138 million	€229 million
Total jobs created (annual average until 2020)	146	321	531
CO_2 savings / year (tonnes)	160,000	370,000	610,000
CO_2 valued at €16 per tonne	€25.6 million	€59.2 million	€97.6 million

4.5 Existing national policy supports

In January 2008, the DCENR announced a new REFIT (Renewable Energy Feed-in Tariff) price for electricity produced from biomass CHP or anaerobic digestion of €120 per MWh. This was an increase from €72 per MWh and gave developers a guaranteed price for electricity and hugely reduced one of the major uncertainties with biomass CHP.

The Biomass/Anaerobic Digestion CHP Deployment Programme (SEI, 2008) offers grant support of up to 30% of eligible capital costs for biomass CHP projects. Grant aid is capped at a maximum cost per installed unit of electrical generating capacity. Figure 7 shows this maximum level as a red line compared to the cost of projects already discussed. The total cost of projects often entails significant ancillary investment e.g. piping for district heating networks, that is not covered by the SEI grant. If ancillary investment is low the SEI grant will have a significant impact on a biomass CHP investment proposal.

Figure 7: Cost of biomass CHP compared to maximum grant support from SEI



This programme will not offer grant aid to units smaller than 100 kW_e and will only support five units smaller than 500 kW_e. At the 500 kW_e level a typical power to heat ratio would be 1:5, meaning that the installation would require a 2.5 MW thermal load. There are relatively few sites of this size therefore consideration should be given to modification of the current programme criteria.

The duration of the scheme may prove a barrier to development. Projects must be completed by 2010 in order to avail of support. Given the lengthy planning process and construction times that can be encountered by biomass projects, this is a significant restriction.

Other pre-conditions of the grant programme place significant cost and therefore risk with a project developer prior to application, such as the requirement that planning be lodged, that a power purchase agreement be in place and a grid offer applied for. The grant scheme does not cover district heating infrastructure. Perhaps a parallel support for district heating should be introduced, which would facilitate a greater number of potential CHP sites. The international experience as presented in Section 3.5 shows that uptake of district heating supports growth in the CHP market. Targeted interventions will need to be put in place to overcome the current barriers to district heating development.

In addition to a project's capital cost, SEI support up to 40% of the cost of feasibility studies for CHP projects under their CHP Deployment Programme.

The CHP Programme aims to deliver 10 to 15 MW_e biomass CHP by 2010, (DCMNR, 2007(2)). The Western Region contribution to this target could be met through one or two biomass CHP installations.

4.6 EU policy supports

The EU Commission's proposal (January 2008) for a directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources set top-line national and community-wide targets for renewable energy. It also formally recognised heat, whereas electricity was previously the primary focus of past renewable energy policy. The proposal contains considerable provision for potential support for biomass. It proposes that biomass fuel is to be burnt in the most efficient and sustainable way possible and looks for such efficient techniques to be researched and identified. Additionally, the directive puts in place the provision for biomass burnt in a co-generation process to be given priority for support.

In 2004, an EU CHP directive, (EU Commission, 2004) was published. It did not set new targets, but set up a framework for promotion of CHP. It encourages member states to carry out analyses of their potential for high efficiency co-generation.

Further information on legislation relevant to the promotion of CHP may be obtained at the website of the European Commission: http://ec.europa.eu/energy/demand/legislation/heat_power_en.htm

5.0 Typical case studies

This section looks at some of the benefits and challenges typically faced by biomass CHP installations by looking at two theoretical, generic, case studies. Two sizes are considered: a 5 MW_e installation and a smaller 500 kW_e project.

5.1 5 MW_e biomass CHP

Large energy users in the Western Region with a heating bill of €5 to €10 million could consider a 5 MW_e biomass CHP plant. The medium scenario of the market assessment estimates that up to five sites of this size could be operational by 2020.

When running at maximum output, a 5 MW_e plant would require up to 220 tonnes of chip per day (at 50% moisture content), equivalent to 10 articulated lorry-loads. To allow for breaks in the supply chain there should be on-site storage for at least four days supply, or 900 tonnes of woodchip. Stacked at a height of five meters in an open yard this requires one hectare (just under 2.5 acres) of storage space. Extra space is required for loading equipment and for lorries to turn. Up to two hectares (~ 5 acres) could be required for the entire CHP site. The cost of purchasing land, or lack of other income from an area already owned, is not included in this analysis.

Sites of this size need a consistent and predictable heat demand to achieve economic viability. As explained in Section 3 this is best served by industrial process heat demand or some level of district heating, either to a small number of major heat users, or more typically to include a larger number of domestic customers.

For this case study, an on-site demand for process heat is assumed that is matched to the output of the CHP plant. It is also assumed that the entire output (apart from the parasitic load that is required to run the CHP plant) is exported under a REFIT contract. The reality is that on-site electricity consumption should be the first option considered.

CHP users can either use the electricity they generate on-site or export it to the grid. In practice this will depend on the electricity tariff they are subject to and their daily usage pattern.

The table below shows some typical values for a 5 MW_e biomass CHP plant (numbers are rounded for clarity). Due to maintenance and downtime no plant will operate 100% of the time. It is assumed that this plant could run at an average of 80% of its total output for 6,570 hour / year.

Table 22: Outputs of 5 MW_e biomass CHP unit

Electrical output	26,000 MWh / year
Heat output	131,000 MWh / year
Combined output	105,000 MWh / year
Input	60,000 tonnes of chip / year
Jobs created	13 in fuel supply 4 in operation and maintenance
CO_2 savings	45,000 tonnes / year

A 5 MW_e CHP unit currently costs approximately €20 million on a greenfield site, (Joule, 2008). With the maximum grant available from SEI (capped at €1.5 million) this would reduce the cost to €18.5 million.

The savings below are based on the current REFIT price for electricity, and price of heat originating from a medium-fuel oil boiler, (SEI, July 2008). The cost of woodchip is at the lower range of costs from the *Wood Energy Strategy and Action Plan*.

Annual income and savings	
Sale of electricity @ €120/MWh	€3.2 million
Saving from heat (replacing medium fuel oil costing €73.2 /MWh)	€7.7 million
Total savings	**€10.9 million**
Annual costs	
Woodchip @ €55 / tonne (including delivery)	€3.3 million
Operation and maintenance	€0.5 million
Total costs	**€3.8 million**
Annual savings	**€7.1 million**

This gives a simple payback (capital cost / annual savings) for the CHP unit of approximately three years when compared to heat from an oil fuelled system and power from the national grid. While clearly project finance and other factors must be considered in a more detailed project-specific analysis, this indicates a very favourable payback.

As of August 2008, carbon is trading at approximately €24 per tonne (www.pointcarbon.com). If a large energy user who is part of the EU Emissions Trading Scheme was able to trade the carbon from a biomass CHP installation of this size, they would have an additional saving of €1.3 million per year.

5.2 500 kW_e biomass CHP

The market assessment identified 91 potential sites for CHP units under 1 MW_e and predicted 13 of these could be using biomass CHP by 2020 (medium scenario). These users could consider a small ORC or gasification unit.

As with the previous case study, this table gives some projected operational figures for a 500 kWe unit.

Table 23: Outputs of 500 kW_e biomass CHP

Running time	6,570 hours / year
Electrical output	2,600 MWh /year
Heat output	10,500 MWh / year
Combined output	13,100 MWh / year
Input	6,000 tonnes of chip / year
Jobs created	1 in fuel supply 2 in operation and maintenance
CO_2 savings	4 500 tonnes / year

A system of this size will use up to 22 tonnes of woodchip per day. If a minimum of four days storage is required the fuel store will need to be at least 450 m^3. This is similar in size to three large grain silos. Using specific cost estimates from Figure 5 the cost of a 500 kW_e unit will be approximately €2.2 million. A €600,000 grant is currently available, leaving the installed cost at €1.6 million.

An additional, and significant, short term benefit for users of less than 500 kW_e is that they can connect to the Irish electricity network without entering a gate or queuing system with the Commission for Energy Regulation (CER). This reduces financial cost and the time cost of the overall project.

The cost of woodchip is estimated at €65 per tonne. This is higher than in the previous example as it would be more difficult to obtain a low-cost supply for a smaller quantity.

Annual income and savings	
Sale of electricity @ €120/MWh	€315,000
Saving from heat (replacing gas oil costing €99.2 /MWh)	€1.0 million
Total savings	**€1.3 million**
Annual costs	
Fuel @ €65 / tonne (including delivery)	€400,000
Operation and maintenance	€200,000
Total costs	**€600,000**
Annual savings (compared to oil)	**€700,000**

This also indicates a commercially attractive payback period of less than three years.

6.0 Conclusions and recommendations

The authors have set out below some of the key conclusions of this study and offer some suggestions to further stimulate the biomass CHP market both nationally and within the Western Region.

It is difficult to predict trends and impacts as there is little or no history of biomass CHP either in the region or nationally.

Sectors with a potentially viable profile for biomass CHP and specific sites were identified in this assessment. Three scenarios were considered and the medium scenario predicts that there could be 22 installations, producing 42 MW_e, in the Western Region by 2020. This would result in a direct gross investment of €138 million and create approximately 321 jobs. This exceeds previous estimates for the region. Under the medium scenario, 500,000 tonnes of woodchip would be required and this would displace approximately 370,000 tonnes of CO_2-equivalent from fossil fuel sources.

Expertise and knowledge

The experience of biomass CHP in Ireland and awareness of technology is relatively low. The authors heard the same opinion repeated: *"biomass CHP only works in installations over 2-3 MW_e"*, most likely due to the fact that these are currently the minimum size installed commercially in Ireland to date. Training in biomass CHP technology should be considered for energy professionals in Ireland. This would be most effective as a national programme and could be delivered regionally. Adding experts to speak on relevant biomass CHP topics to the line-up for the existing workshops and seminars on energy and biomass would enhance the knowledge of biomass CHP in Ireland.

Biomass CHP at a smaller scale than 2-3 MW_e is becoming widespread. Many examples can be seen in Germany, Belgium, Austria and Denmark. This development is enabled by strong policy supports, usually in the form of feed-in tariffs and/or investment aid.

Organising study tours to sites abroad would help promote the various technologies. During this assessment a number of suppliers have suggested an interest in visiting Ireland and could give presentations in the region.

Market profile

Biomass CHP is increasing internationally. Between 2004 and 2006 there was an EU-wide growth rate of 11% in terms of electricity produced from biomass CHP.

A significant finding of this research is that with commercially available technologies, biomass CHP is possible for users with a continuous heat load of over 600 kW_{th}. Even so, a major challenge facing the promotion of biomass CHP in the Western Region will be to identify sites with a large enough 'year round' heat load. To a large extent, these are the same obstacles facing both fossil fuelled CHP and district heating. These are studied in previous reports (SEI, 2006; and WS Atkins, 2002).

The bottom-up market analysis identified 119 sites, of which potentially 22 could install biomass CHP under a medium development scenario. Of these, five could be greater than 5 MW_e, four between 1 and 5 MW_e and 13 less than 1 MW_e.

The sites above 5 MW_e are likely to be large industrial users, such as the board mills, pharmaceutical, cement and food manufacturers, and potentially one substantial district heating scheme.

The sites between 1 and 5 MW_e are likely to include a further selection of manufacturing sites, including food processors, medical devices and other industrial sites, as well as potentially one sizable district heating scheme.

The potential sites below 1 MW_e include a number of hospitals, hotels with over 150 bedrooms, a number of feed mills and other manufacturing sites.

Technology

The two Irish projects implemented to date use steam turbines in the range 2-3 MW_e and are made economic by the availability of large volumes of wood waste and year-round heat loads. If biomass CHP is to develop in the Western Region it will predominantly be through technologies other than traditional steam turbines. Steam engines, ORC units, gasification systems and perhaps hot air turbines should be considered on a project by project basis. Stirling engines may also be used, but initially below 100 kW_e.

Economics of biomass CHP

The cost of woodchip and natural gas are comparable at current levels. With the additional capital cost of biomass CHP equipment, it is exceptional that biomass CHP would be chosen where natural gas is available. However, biomass is substantially cheaper than oil or LPG and the additional capital cost may be offset by lower running costs.

The typical case studies indicate that under favourable heat load and fuel costs, biomass CHP represents a real commercial opportunity, with simple payback of approximately three years.

In order to promote decentralised CHP, projects must be located to exploit their proximity to both the biomass resource and significant heat users.

Research and development

Biomass CHP development is strongly influenced by regional research capacity on the topic. Many of the innovations first occurred in the areas where the technology was subsequently demonstrated and refined before looking to the export market. Even as new models come to market from commercial suppliers, these are first demonstrated in their home market. Every effort should be made to support regional research centres to further develop core research competences relevant for the combustion of biomass. Greater participation in relevant international research projects should be encouraged.

In the short term, all CHP technology will be imported. If the region develops significant research and manufacturing capabilities for CHP technology this would lead to significant indirect job creation.

Further feasibility

All sites with a continuous heat load above 600 kWth should be encouraged to investigate the applicability of biomass CHP technology. The market segments to be targeted have been identified within the report. Sites which should be prioritised for consultation and further investigation are the two wood processing factories: Finsa in County Clare and Masonite in County Leitrim; and the two largest sawmills: Earrai Coillte Chonnacht Teoranta (ECC) and Murray Timber Products both in County Galway.

District heating

The European markets demonstrate that there is a clear link between district heating networks and the application of CHP technology. If biomass CHP is to be seriously considered the barriers to district heating must be reduced. If large district heating networks are encouraged, Sligo and Letterkenny are the most favourable towns in the region due to their size, proximity to forestry and the fact that they are not connected to the natural gas network.

Support programmes

The 30% capital funding available through SEI's biomass CHP programme is a significant support to the industry, however the duration of this programme may prove a barrier to development. Projects must be completed by 2010 in order to avail of support. Given the lengthy planning process and construction times that can be encountered by biomass projects, this is a significant restriction.

Other pre-conditions of the grant programme place significant risk and cost with a project developer prior to application such as, the requirement that planning be lodged, that a power purchase agreement be in place, that a grid offer be applied for and other conditions. The current programme will only support five units smaller than 500 kW_e (SEI, 2008). A 500 kW_e unit would typically require a 2.5 MW thermal load. There are relatively few sites above this size, therefore consideration should be given to modification of the current programme criteria.

The level of grant funding for feasibility studies is the same for fossil fuelled CHP, biomass CHP and biomass boilers (40 %). As the technology is developing, the level of research required for a biomass CHP feasibility study is more involved and additional support would help projects get off the ground. As any successful projects in the Western Region are likely to stimulate more interest, it is felt that a higher level of funding for feasibility studies could be an economical way of stimulating the market.

The grant scheme does not cover district heating infrastructure. Consideration should be given to a parallel support for district heating and thereby facilitate a greater number of potential CHP sites.

The REFIT tariff of €120/MWh for biomass CHP is competitive, based on both economic analysis and by comparison with international schemes. Long-term, stable, feed-in tariff support schemes have had a very positive market impact in other countries. It is too early to estimate any immediate impact of both the REFIT tariff and the SEI biomass CHP scheme in the region, or the national.

To conclude

This report shows that there is potential to grow the biomass CHP market in the Western Region. A range of factors impact on the viability of biomass CHP and detailed feasibility is required on a site-by-site basis to progress projects. The purpose of this report was to review the available technology, identify market segments, assess potential market growth and examine issues for market development. This research provides public and private industry interest groups with useful CHP market information, and will hopefully stimulate further discussion and action at both a regional and national level.

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Appendix 1: Examples of biomass CHP (below 5 MW_e)

This is not an exhaustive list. Over 30 more units are described at: www.bios-bioenergy.at/en/references.html and a further 50 + at: www.turboden.it/en/projects.asp

Location	Size	Facility P = Power H = Heat	Supplier B = Boiler T = Turbine	Technology
Skarp Salling, Denmark[12]	28 kW_e	private farm		Stirling engine
Hjortshol, Denmark[13]	35 kW_e		B: Reka T: Stirling, Denmark	Stirling engine
Bologna, Italy	35 kW_e	school and sports facility	T: Stirling	gasification & Stirling Engine
Harper Adams University, UK	100 kW_e	university	Talbotts	hot air turbine
Rural Generation, Co Derry[14]	120 kW_e	demonstration		gasification
Beddington ZED, London[15]	130 kW_e	housing development	Biomass CHP	gasification
Hogild, Denmark[16]	130 kW_e		Herning Kommunale Vaerker	gasification (updraft)
Blackwater Valley, Co Armagh[17]	200 kW_e	P: to grid H: local museum	Biomass CHP	gasification
Lestijarvi, Finland[18]	300 kW_e	P: to grid H: fuel drying and district heating	Entimos	gasification
Tournai, Belgium[19]	300 kW_e	swimming pool	Xylowatt	gasification
Stockach, Germany	310 kW_e		Adoratec	ORC
Bokholt, Germany	315 kW_e		Adoratec	ORC
Tallon Lumber Inc. USA	320 kW_e		Puhdas Energia	gasification
Bayreuth, Germany	340 kW_e		Adoratec	ORC
Bad Toiz, Germany	355 kW_e		Adoratec	ORC
Admont, Austria[20]	400 kW_e	P: wood manufacturing company H: process heat and local monastery	Demonstration	ORC
Oberwart, Austria	420 kW_e		Adoratec	ORC
North Yorkshire Moors NP, UK[21]	500 kW_e	demonstration plant	Bioflame Ltd	steam turbine

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12 *Small-scale biomass CHP technologies. Situation in Finland, Denmark and Sweden*, OPET Report 12, April 2004. p 69
13 www.stirling.dk/default.asp?ID=142
14 http://bio-chp.dk-teknik.dk/plants/bhe.mht
15 www.biomass-chp.ltd.uk
16 *Small-scale biomass CHP technologies. Situation in Finland, Denmark and Sweden*, OPET Report 12, April 2004. p 69
17 www.biomass-chp.ltd.uk/blackwater.htm
18 www.entimos.fi/news.htm
19 www.xylowatt.com/MainReferencesEN.htm
20 http://bio-chp.dk-teknik.dk/plants/admont.mht
21 Personal communication. Alex Thornton, Bioflame Ltd. June 08

Location	Size	Facility P = Power H = Heat	Supplier B = Boiler T = Turbine	Technology
Tervola, Finland[22]	500 kW_e	municipality of Tervola	Entimos	gasification
Tamsweg, Austria[23]	500 kW_e		BIOS	ORC
Wittlich, Germany[24]	530 kW_e		B: Schmid AG	ORC
Bad Durkeim, Germany[25]	530 kW_e		B: Schmid AG	ORC
Pfalzgrafenweiler, Germany	545 kW_e		Adoratec	ORC
Schoneck, Germany	555 kW_e		Adoratec	ORC
Hjordkaer, Denmark[26]	600 kW_e	H: district heating	various	steam turbine
Radermecker, Belgium[27]	600 kW_e		Xylowatt	gasification
Oerlinghausen, Germany[28]	600 kW_e		Kohlback	ORD
Mann Naturenergie, Germany[29]	650 kW_e	P: to grid H: drying and district heating	B: Lambion Engine: Spilling	steam engine
Olang, Italy	688 kW_e		Adoratec	ORC
Marienbourg, Belgium[30]	700 kW_e	P & H: sawmill	Xylowatt	gasification
Paper factory, Switzerland[31]	700 kW_e	P: paper factory H: process Steam	B: Foster Wheeler T: KKK	steam turbine
Hartberg, Austria[32]	730 kW_e	demonstration		screw-type steam engine
Allensteig, Austria	850 kW_e		Adoratec	ORC
Kiuruvesi, Finland[33/34]	900 kW_e	P: sawmill H: district heating	Sermet Oy, Owned by Wartsila	steam engine
Lienz, Austria[35]	1 MW_e	H: district heating	various	ORC
Karstual, Finland[36]	1 MW_e	P: sawmill H: 33% sawmill; 33% process steam; 33% district heating	Sermet Oy, Owned by Wartsila	steam engine
Netherlands[37]	1.05 MW_e	H: drying and space heating	Vyncke	steam turbine

22 *Small-scale biomass CHP technologies. Situation in Finland, Denmark and Sweden*, OPET Report 12, April 2004. p 27
23 Personal communication. Alex Slane, Imperative Energy. July 08
24 Personal communication. Alex Slane, Imperative Energy. July 08
25 Personal communication. Alex Slane, Imperative Energy. July 08
26 http://bio-chp.dk-teknik.dk/plants/hjordkaer.mht
27 www.xylowatt.com/MainReferencesEN.htm
28 www.kohlbach.at/?siid=40&sip=4&laid=2
29 http://bio-chp.dk-teknik.dk/plants/langenbach.mht
30 http://www.xylowatt.com/MainReferencesEN.htm
31 http://bio-chp.dk-teknik.dk/plants/ppag.mht
32 BIOS Bioenergyiesysteme Gmbh
33 http://www.wartsila.com/,en,solutions,0,generalcontent,1D1B1013-2AB9-41D7-9702-94DC7A6C939F,044FB44B-46D8-4693-8936-3C8A7A509C3D,,4800.htm
34 http://www.tekes.fi/opet/pdf/Kiuruvesi%20OPET.pdf
35 http://bio-chp.dk-teknik.dk/plants/lienz.mht
36 http://www.aster.it/opet/doc/rts_finland_factory_town.pdf
37 http://bio-chp.dk-teknik.dk/plants/bes.mht

Location	Size	Facility P = Power H = Heat	Supplier B = Boiler T = Turbine	Technology
Biokraft Oy, Finland[38]	1.3 MW_e		Wartsila	
VKW Kaufmann, Austria[39]	1.4 MW_e	H: wood drying and municipal centre	Lambion Gmbh	steam turbine
Harboore, Denmark[40]	1.4 MW_e	H: district heating	BWV	gasification (Updraft)
Lelystad, Netherlands[41]	1.5 MW_e	H: district heating (3,000 houses)	various	steam turbine
Bruckmuhl, Germany[42]	1.5 MW_e		Adoratec	ORC
Sagewerk Schwaiger, Germany[43]	1.5 MW_e	sawmill	Konlback	ORC
Tranas Energi, Sweden[44]	1.6 MW_e	H: district heating (8 00 customers)	Wartsila	steam turbine
Ludwigsfelde, Germany[45]	1.6 MW_e		Schmid AG	ORC
Grainger Sawmill, Cork[46]	1.83 MW_e	P: to grid H: drying timber	Vyncke	
Austria[47]	1.85 MW_e	H: district heating	demonstration	gasification
Green Power, Murayama, Japan[48]	2 MW_e		BWV	gasification
Eccleshall, Staffordshire, UK[49]	2 MW_e		Talbotts	steam turbine
Myresjohus, Vattenfall AB, Sweden	2 MW_e	P: sawmill & grid at night H: wood drying & district heating		
Stellsen, Germany[50]	2.2 MW_e		B: Schmid AG	steam turbine
Austria[51]	2.3 MW_e	H: wood processing	B: Waagner Biro T: Siemens	steam turbine
Mariehamns Bioenergi, Sweden[52]	2.4 MW_e		KMW Energi	
Balcas, Enniskillen[53]	2.7 MW_e	P: on-site and to grid H: pellet production	Vyncke	steam turbine

38 *BioEnergy International* No 11, December 2004 / www.bioenergyinternational.com
39 http://bio-chp.dk-teknik.dk/plants/kaufmann.mht
40 http://bio-chp.dk-teknik.dk/plants/harbooere.mht
41 http://bio-chp.dk-teknik.dk/plants/bmc.mht
42 www.adoratec.com
43 http://www.kohlbach.at/?siid=40&sip=4&laid=2
44 http://bio-chp.dk-teknik.dk/plants/tranås.mht
45 Personal communication. Alex Slane, Imperative Energy. July 08
46 http://www.wartsila.com/,en,solutions,0,powerindustry_reference,6D0C4A1B-0B03-4B38-AF4A-11BEC1369D19,FA81B082-0C24-4E87-99DA-9D3061B05940,,.htm
47 http://bio-chp.dk-teknik.dk/plants/güssing.mht
48 BioEnergy International No 26, 3 – 2007 / www.bioenergyinternational.com
49 www.talbotts.co.uk/bpower.htm
50 Personal communication. Alex Slane, Imperative Energy. July 08
51 http://bio-chp.dk-teknik.dk/plants/wiesner-hagen.mht
52 hwww.kmwenergi.se/referens_show.php?id=58
53 www.balcas.com/articles/chp.html & *Irish supply chain capability for CHP applications.*, Lagan Consulting for the CHP policy group, June 2006

Location	Size	Facility P = Power H = Heat	Supplier B = Boiler T = Turbine	Technology
Vippula Sawmill, Sweden[54]	2.9 MW_e		Warstilla	steam turbine
Mala, Sweden[55]	3 MW_e			steam turbine
Vejen, Denmark[56]	3.1 MW_e		B: Ansaldo Vound T: AEG Kanis	steam turbine
Torgau, Germany	3.1 MW_e		Adoratec	ORC
Marka Varme AB, Sweden	3.5 MW_e		Wartsila	steam turbine
Trollhattan, Sweden	3.6 MW_e		Wartsila	steam turbine
Lextorp, Sweden	3.7 MW_e		Wartsila	steam turbine
Neufahm, Germany[57]	4 MW_e	P: to grid H: large bakery and district heating	B: Bertsch Gmbh T: Alstom	steam turbine
Southern Italy	4 MW_e		BWV	gasification & steam cycle
Novopan, Denmark[58]	4.2 MW_e			
Assens, Denmark[59/60]	4.85 MW_e	P: to grid H: district heating (2362 customers)	Volund	steam turbine
Kuhmo, Finland[61]	4.9 MW_e	P: Kuhmo town H: Kuhmo sawmill and district heat	B: Foster Wheller	steam turbine

54 BioEnergy International No 11, December 2004 / www.bioenergyinternational.com
55 *Small-scale biomass CHP technologies. Situation in Finland, Denmark and Sweden*, OPET Report 12, April 2004. p 52
56 *Wood for Energy Production*, COFORD, 2005. p 51
57 http://bio-chp.dk-teknik.dk/plants/neufahrn.mht
58 *Wood for Energy Production*, COFORD, 2005
59 www.volund.dk/solutions_references/biomass_solutions/references
60 http://bio-chp.dk-teknik.dk/plants/assens.mht
61 *Small-scale biomass CHP technologies. Situation in Finland, Denmark and Sweden*, OPET Report 12, April 2004. p 30

Appendix 2: Most relevant technology providers (August 2008)

Turnkey installations

1. Babcock & Wilcox Volund Aps

Babcock & Wilcox Volund are working on a range of gasification technologies. An interesting product example is a 4 MW_e gasification system in Italy, running a gas engine followed by a steam cycle, (Volund, 2008). This is designed to have an electrical efficiency of 40%.

Power range: > 1 MW_e

Budget cost: €9 million for 1 MW_e unit (Boisen, 2008)
€12 million for 2 MW_e unit
€20 million for 4 MW_e unit

Website: www.volund.dk

Location: Denmark

2. BIOS Bioenergiesysteme Gmbh / Imperative Energy

Imperative Energy is the Irish representative of the Austrian firm BIOS Bioenergiesysteme GmbH who specialise in the design and implementation of biomass CHP plants. BIOS has designed and implemented over twenty biomass CHP plants with an electrical output range of 400kW_e to 26MW_e. Schmid AG of Switzerland, Imperative Energy's principle biomass boiler technology provider, has also commissioned four biomass CHP plants using both ORC and steam turbine technologies. Imperative Energy is currently working with BIOS and Schmid on biomass CHP projects in Ireland and the UK, (Slane, 2008).

Power range: 400 kW_e to 26 MW_e

Website: www.bios-bioenergy.at www.imperativeenergy.ie

Location: Austria Ireland

3. Kohlbach

Kohlbach have good experience in biomass heating and over 40 Biomass CHP reference sites. 31 of Kohlbach sites use Turboden ORC units.

Power range: 600 kW_e – 1.5 MW_e

Website: www.kohlbach.at

Location: Austria

4. Vyncke Energietechniek N.V

Vyncke provided the CHP unit for Balcas.

Power range: 2 - 10 MW_e

Website: www.vyncke.com

Location: Belgium

5. Warstilla BioPower

Warstilla BioPower supplied a BP2 (2 MWe) CHP unit to Grainger's Sawmill in County Cork. The capital cost of this unit is very close to that of the BP5 (5.5 MW_e) unit, and Warstilla BioPower recently decided to concentrate on the larger models: BP5 and BP10 (11.2 MW_e) and to not supply the smaller model, (Joule, 2008).

Warstilla are represented in Ireland and the UK by Joule Power Ltd (www.joulepower.com).

Power range: > 5 MW_e
Budget cost: €20 million for 5 MW_e unit
Website: www.wartsilla.com/biopower
Location: Finland

6. Xylowatt

Xylowatt produce two gasification units: a 300 kW_e model, which is on sale internationally and a 1.5 MW_e unit, which is only available in Belgium. The system is modular so larger sizes can be assembled. Plants have been operational in Belgium for a number of years.

Power range: 300 kW_e – 1.5 MW_e
Budget cost: €3,000 - €4 500 / kW_e installed
Website: www.xylowatt.com
Location: Belgium

Steam turbines and steam engines

1. Siemens

Siemens produce a range of steam turbine sizes and models with a minimum size of 400 kW_e.

Website: www.powergeneration.siemens.com/products-solutions-services/products-packages/steam-turbines/scale+smaller+150mw/

2. Spilling

Spilling based in Germany supply steam turbines and steam engines. The smallest available steam turbine produces 525 kW_e and costs just over €500,000. A 2 MW_e model costs approximatley €700,000.

Steam engines are available in a range of sizes and are cheaper than steam turbines at sizes up to 1 MW_e. The smallest steam engine produces 140 kW_e and costs €220,000.

Website: www.spillingwerk.de/english/

Organic Rankine Cycle Units

1. Adoratec

Adoratec supply Organic Rankine Cycle units for use with biomass boilers. Adoratec's ORC units are typically combined with heat transfer equipment supplied by their parent company, Maxxtec (www.maxxtec.com). They have 11 reference sites on their website and offer a range of 14 models.

Power range: 315 kW_e – 1.6 MW_e
Website: www.adoratec.com
Location: Germany

2. Turboden

Since 1980 Turboden have developed, designed and produced ORC plants. In 1992 they started to produce standardised models with low maintenance and operational costs. Six sizes ranging from 500 kW_e to 2 MW_e are currently available. A smaller 200 kW_e unit is announced on their website but is still undergoing testing and is not yet commercially available, (Peretti, 2008).

Currently there are 75 Turboden biomass fired ORC CHP plants in operation and a further 30 plants are under construction. The availability of the plants currently in operation exceeds 98% and more than 1,000,000 operating hours have been reached.

Turboden have worked with nine separate thermal oil boiler suppliers including:

Table 24: Thermal oil boiler suppliers working with Turboden

Company	Website	No. installed	No. under construction
Kohlbach GMbh	www.kohlbach.net	**31**	**10**
Verfahrenstechnik	www.vas.co.at	**6**	**5**
Polytechnik	www.polytechnik.com	**4**	**3**
Mawera	www.mawera.at	**3**	**2**
Schmid	www.holzfeuerung.ch	**2**	**2**

Power range: 200 kW_e - 2 MW_e
Website: www.turboden.it
Location: Italy

Appendix 3: Additional providers of biomass CHP solutions

Steam turbines

Bioflame Ltd

Bioflame supply a 2.5 MW_e CHP plant designed to burn low grade waste wood. It complies with all UK waste directives. The boiler produces steam that drives a Siemens turbine, however the low grade heat may not be suitable for industrial applications.

Bioflame have a 500 kWe demonstration plant in North Yorkshire Moors National Park and are currently constructing two 2.5 MW_e units. They have a further eight firm orders. The boiler requires approximately 30,000 tonnes of timber if running 24 hours a day.

Power range: 2.5 MW_e
Budget cost: £7 million = €8.86 million for 2.5 MW_e unit[62]
Website: www.bioflame.com
Location: North Yorkshire, UK

KMW Energi

Install large scale biomass CHP boilers. KMW were contacted, however they focus on the Nordic and North American markets and currently do not have the resources to work outside these areas.

Power range: > 2.4 MW_e
Website: www.kmwenergi.se
Location: Sweden

Gasification

Biomass CHP

Biomass CHP (formerly Exus Energy) has some interesting technology for small scale gasification CHP units. They were contacted several times in the course of the project but were unable to supply further information.

Power range: 130 – 200 kWe
Website: www.biomass-chp.ltd.uk
Location: Larne, County Antrim

Ethos Energy

Ethos Energy advertise a gasification system on their website, with a good animated description. They have a demonstration plant in Avonmouth near Bristol.

Power range: 350 kW_e – 8 MW_e
Website: www.ethosenergy.co.uk
Location: Bristol, UK

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[62] Personal communication. Alex Thornton, Bioflame Ltd, June 2008

Entimos

Entimos have patented a small scale gasification system. The first commercial application of this was to the municipality of Tervola, Finland, in 2002[63]. The CHP unit is designed to supply 90% of the district heating and 10% of the power needed by Tervola. Further details were sought but were not available.

Power range: 1 – 7 MWe
Website: www.entimos.fi
Location: Finland

Innovation Technologies (Ireland) Ltd

Conduct research and development of gasification. Units are advertised on their website.

Power range: 15 – 550 kW_e
Website: www.innovation-tech.co.uk
Location: Carrickfergus, Northern Ireland

Puhdas Energia Oy

A gasification CHP unit is explained on their website.

Power range: ~ 320 kW_e
Website: www.puhdasenergia.com
Location: Finland

Schmitt Enertec / F4 Energy

Schmitt Enertec produce gas engines and fossil fuel CHP plants in their German factory. They installed a wood gasification unit in Japan in 2001 and are currently constructing two units for Italian customers. Schmitt Enertec's partner in Ireland is F4 Energy who have installed a number of fossil fuel CHP plants.

Power range: 250 kW_e – 1 MW_e
Budget cost: £1.3 million for 250 kW_e - €4 million for 1 MW_e[8]
Website: www.schmitt-enertec.com www.f4energy.com
Location: Germany Cork, Ireland

SilvaGas Corporation

Power range: concentrate on 10 – 50 MW_e, but have patents for 1 – 5 MW_e
Website: www.fercoenterprises.com
Location: Atlanta, USA

[63] OPET Report 12, April 2004. p 27

Stirling engines

Stirling Denmark ApS

Stirling Aps manufacture and supply Stirling engines. The first of these Stirling engines were incorporated with biomass heating in 2007 to produce a small scale CHP unit.

Power range: 35 kW_e
Website: www.stirling.dk
Location: Denmark

Sunmachine Gmbh

A small Stirling engine running on woodpellets.

Power range: 3 kW_e
Price: €22 500 (ex VAT)
Website: www.sunmachine.com
Location: Germany

KWB

KWB supply reliable commercial biomass boilers in Ireland. They are working on a 1 kW_e Stirling engine, however it will be possibley two years before this is available on the Irish market[64].

Power range: 1 kW_e
Website: www.kwb.at
Location: Austria

Hot air turbines

Talbotts

Talbots are producing a 100 kW_e CHP unit that runs a hot air turbine. A demonstration unit is operating in Harper Adams University and three other units are installed elsewhere. Two further units are currently being commissioned and they have confirmed orders for another eight.

Power range: 100 kW_e
Budget cost: £410,000 = €520,000 for 100 kW_e unit
Website: www.talbotts.co.uk
Location: Stafford, UK

[64] Personal communication. Tim Carroll,NPS, Waterford. July 2008

Appendix 4: List of IPPC sites

This list was compiled by listing all companies with an IPPC licence and removing those in the Energy Trading Scheme and SEI's Large Industry Energy Network.

Links of relevance include:

- IPPC: http://www.epa.ie/terminalfour/ippcApril/index.jsp
- Energy Trading Scheme: http://www.epa.ie/whatwedo/climate/etscheme/current%20permits/
- Large Industry Energy Network: http://www.sei.ie/index.asp?locID=198&docID=-1

Name	County	Principal class of activity
Broderick Manufacturing Limited T/A Kilrush Trading	Clare	surface coatings
Chemifloc Ltd	Clare	surface coatings
Clogrennane Lime Limited	Clare	other activities
Devcon Limited	Clare	chemicals
Essidev S.A. T/A Organic Lens Manufacturing	Clare	chemicals
Galvotech (International) Limited	Clare	surface coatings
Heraeus Metal Processing Limited	Clare	metals
Lufthansa Technik Painting Shannon Limited	Clare	surface coatings
Lufthansa Technik Turbine Shannon Ltd	Clare	surface coatings
Molex Ireland Limited	Clare	surface coatings
Saint-Gobain Performance Plastics Ireland	Clare	surface coatings
Schwarz Pharma Limited	Clare	chemicals
Shannon Aerospace Limited	Clare	surface coatings
Shannonside Building Supplies Limited	Clare	wood, paper, textiles and leather

Name	County	Principal Class of Activity
McCools Sawmills Limited	Donegal	wood, paper, textiles and leather
MDR Leictreonach Teoranta	Donegal	other activities
Unifi Textured Yarns Europe Limited	Donegal	wood, paper, textiles and leather

Name	County	Principal class of activity
APW Galway Limited	Galway	metals
Byrne-Mech Limited	Galway	metals
Cold Chon (Galway) Ltd	Galway	chemicals
Earrai Coillte Chonnacht Teoranta	Galway	wood, paper, textiles and leather
Green Isle Foods Limited	Galway	food and drink
Heiton Buckley Limited	Galway	wood, paper, textiles and leather
Hygeia Chemicals Limited	Galway	chemicals
Irish Finishing Technologies Limited	Galway	surface coatings
Jedcoe Stoves	Galway	metals
Medtronic Vascular Galway Limited	Galway	surface coatings
Mr John English	Galway	wood, paper, textiles and leather
Murray Timber Products Limited	Galway	wood, paper, textiles and leather
Sean Duffy (Exports) Limited	Galway	food and drink
Sperrin Galvanisers (Ireland) Limited	Galway	metals

Name	County	Principal class of activity
A.S. Richardson & Company Limited	Leitrim	wood, paper, textiles and leather
Glenfarne Wood Products Limited	Leitrim	wood, paper, textiles and leather
Valspar Industries (Ireland) Limited	Leitrim	surface coatings

Name	County	Principal class of activity
Asahi Synthetic Fibres (Ireland) Ltd	Mayo	wood, paper, textiles and leather
Fort Wayne Metals Ireland Limited	Mayo	metals
Glanbia Farms Limited	Mayo	intensive agriculture
Johnson Manufacturing Limited	Mayo	metals
Pat Regan Newbrook Limited	Mayo	wood, paper, textiles and leather
Thomas Archer (Ballina) Limited	Mayo	wood, paper, textiles and leather

Name	County	Principal class of activity
Arran Chemical Company Limited	Roscommon	chemicals
Glanbia Fresh Pork Limited	Roscommon	food and drink
Irish Rubber Components Limited	Roscommon	chemicals
Kepak Athleague	Roscommon	food and drink
Laragan Farms Limited	Roscommon	intensive agriculture

Name	County	Principal class of activity
Basta Parsons Limited	Sligo	surface coatings
Cold Chon (Galway) Ltd, Sligo Depot	Sligo	chemicals
Fort Dodge Laboratories Ireland Limited	Sligo	chemicals
G. Bruss GmbH Dichtungstechnik	Sligo	chemicals
Mr Antone Kiernan	Sligo	intensive agriculture
Saehan Media (Ireland) Ltd	Sligo	surface coatings
Supershrone Limited	Sligo	wood, paper, textiles and leather
TopChem Pharmaceuticals Limited	Sligo	chemicals

Appendix 5: Growth scenarios outlined in the wood energy strategy

'Do nothing' scenario

Static market environment and no additional public intervention; the current SEI boiler installation grant scheme is discontinued in 2010 as the current programme ends.

Low scenario

A static market environment for wood energy but an action plan is implemented to promote market development; the current SEI grant support for boiler installation is continued after 2010.

Medium scenario

The action plan is implemented to support market development and fossil fuel prices continue to rise above the rate of general inflation in the economy. More supportive policy and regulation, and the current SEI grant support for boiler installation is continued after 2010.

High scenario

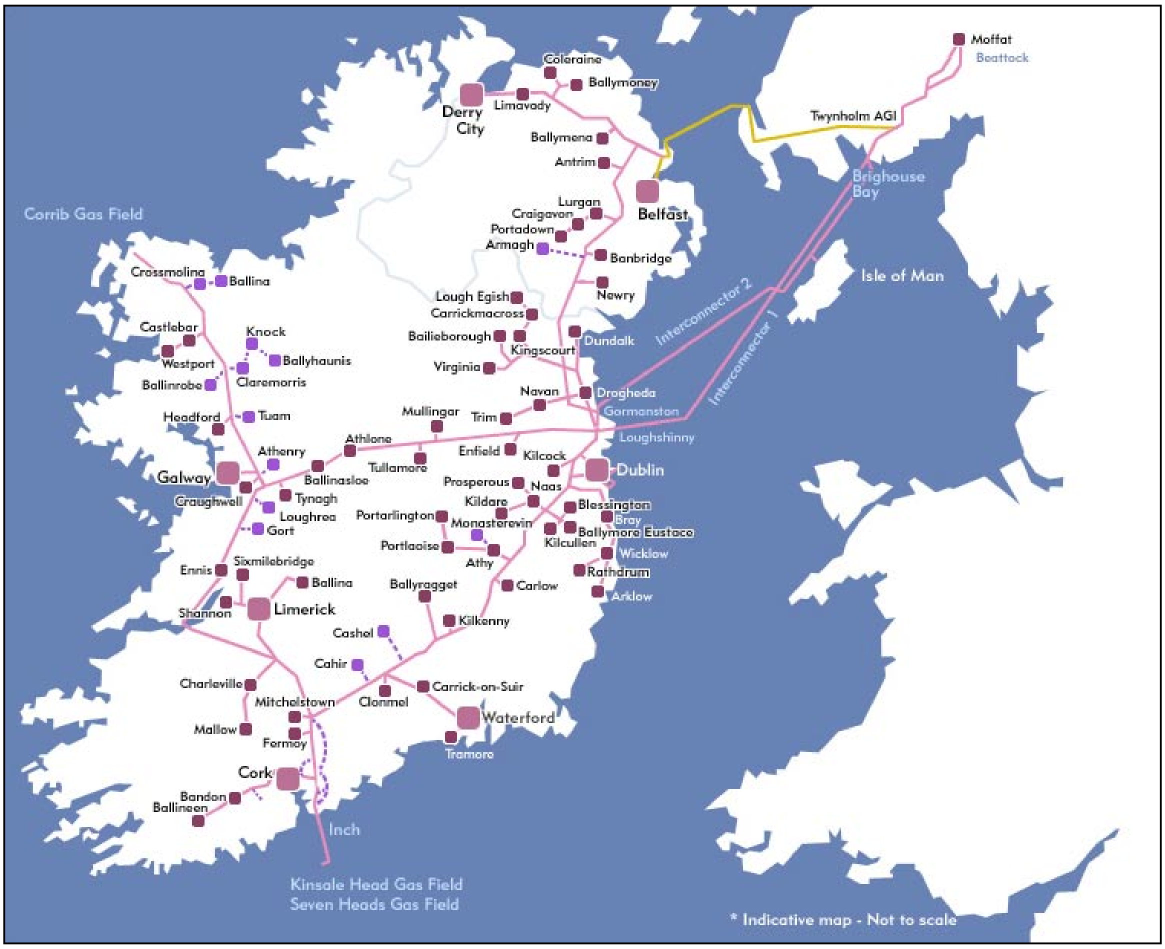
The action plan is implemented to support market development and fossil fuel prices increase at 15% per year. Carbon taxation is introduced with aggressive renewable energy targets, additional polices and very supportive regulations. The current SEI grant support for boiler installation is continued after 2010.

Appendix 6: Electricity from CHP in EU countries

Table 25: Gross electricity production from CHP using solid biomass in the EU (*EUROBSERVER*)

(TWh)	2004	2006	Growth (%)
Finland	8.872	8.600	-3.1
Sweden	6.614	7.500	13.4
Germany	3.900	6.500	66.7
Netherlands	1.756	1.141	-35.0
UK	0.000	0.000	0.0
Italy	1.188	0.979	-17.6
Austria	1.145	1.533	33.9
Denmark	1.834	1.716	-6.4
France	0.819	1.423	73.7
Spain	0.881	0.712	-19.2
Portugal	1.201	1.302	8.4
Poland	0.419	0.352	-16.0
Belgium	0.259	0.327	26.3
Hungary	0.007	0.028	300.0
Czech Republic	0.337	0.443	31.5
Slovenia	0.090	0.074	-17.8
Slovakia	0.033	0.004	-87.9
Ireland	0.008	0.008	0.0

Appendix 7: Map of national gas pipeline



Design: JDK Design 071 912 0905

For further information please contact:

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E-mail: info@wdc.ie
Websites: www.wdc.ie www.LookWest.ie

NDP National Development Plan 2007 - 2013

WDC Western Development Commission Coimisiún Forbartha an Iarthair