



Department of Communications,
Marine and Natural Resources
Roinn Cumarsaids, Mara agus Acmhainni Nadura

Bioenergy in Ireland



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December 2004

A Strategic Report of the Bioenergy Strategy Group for the Department of Communications, Marine and Natural Resources

Preface

A strength of this report is the make up of the Group responsible for its preparation. Members comprised officials with energy, environment and agriculture responsibilities, SEI, bioenergy users and experts. I would like to thank all members for their contributions, commitment and the consensus achieved.

I would especially mention Pearse Buckley for his work on the resource data, its presentation and interpretation and Brian Motherway for authoring our report so effectively.

It has been a pleasure and a privilege to act as Chair of the Bioenergy Strategy Group.

Dr Kevin Brown

Executive Summary

Background and policy issues

The Bioenergy Strategy Group was established by DCMNR in December 2003 to consider the policy options and support mechanisms available to Government to stimulate increased use of biomass for energy conversion, and to make specific recommendations for action to increase the penetration of bioenergy in Ireland. This report presents the findings of the Group setting out options for action recommended to DCMNR.

Bioenergy is the general term used to describe renewable energy derived from biomass, which covers the biodegradable fraction of products and residues from agriculture, forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste. It also includes crops specifically grown for energy use.

More than any other area of renewable energy, bioenergy is an inter-departmental issue, touching on many policy areas. Thus, while led by renewable energy goals, the task of promoting bioenergy both merits and requires an inter-departmental response.

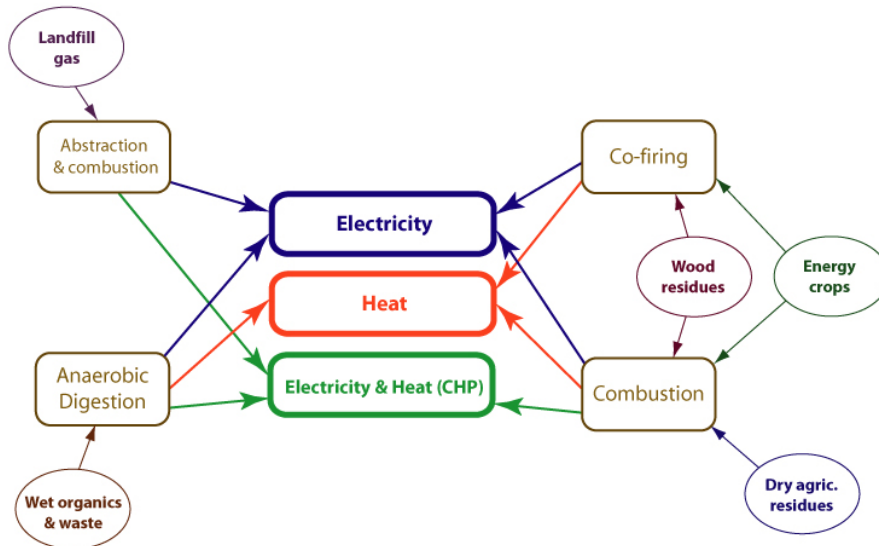
Bioenergy supports a wide range of national policy goals:

- Key energy goals including security and diversity of supply and the development of indigenous renewable energy sources
- Key environmental goals such as greenhouse gas emissions reduction and waste management
- Key agricultural goals offering new opportunities for farmers in the context of CAP reform
- Key social goals such as employment generation in rural areas and enhancement of local economies

Internationally, bioenergy is now the major focus of renewable energy policies and strategies and a future in which biomass is a key energy resource is envisaged. Most EU states have strong targets for bioenergy deployment over the coming ten to thirty years, supported by strong programmes of Government action. Bioenergy is seen by the EU as central to meeting EU-wide renewable energy targets. Ireland's exploitation of bioenergy is among the lowest in the EU, despite the considerable indigenous bioenergy resources available. DCMNR has convened a Renewable Energy Development Group that is currently working to examine how best to support renewable energy development, with a focus on 2010 targets.

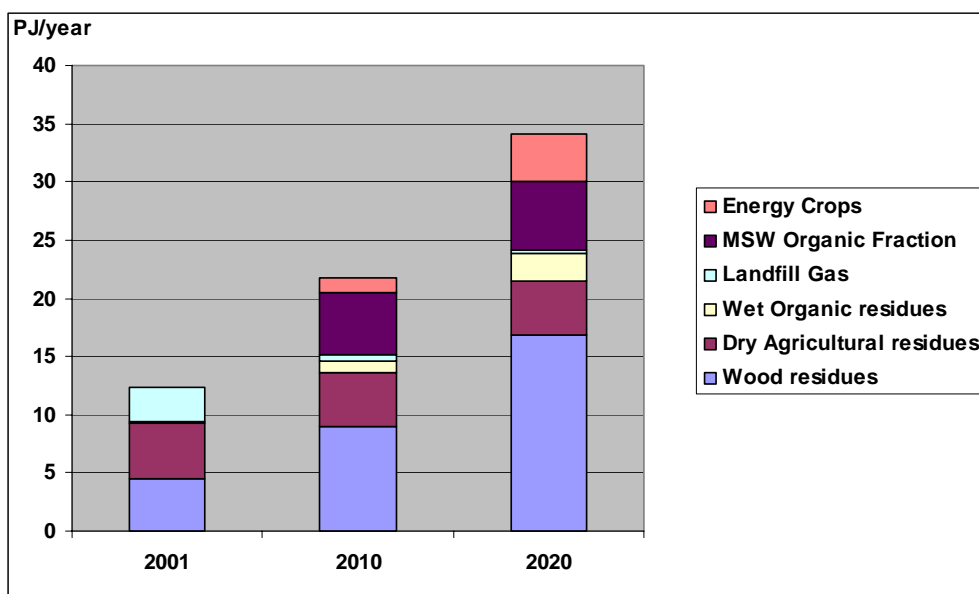
Bioenergy Pathways and Resources

There are many potential bioenergy fuel sources, and several conversion alternatives. The following diagram summarises the main bioenergy pathways of relevance in Ireland:



All dry resources can be combusted to produce heat, electricity or both (through CHP), and could also be co-fired in existing solid fuel fired systems. Dry resources include wood and wood residues (forest residues or sawmill residues) and dry agricultural residues such as straw. Energy crops, principally short rotation coppice, can also produce dry fuels for combustion. Wet resources can be processed through anaerobic digestion, producing a methane-rich gas for combustion. Such resources include agricultural slurries, sewage sludge, food and catering wastes and the biodegradable fraction of municipal solid waste. An additional particular bioenergy resource is landfill gas, which can be collected at landfill sites and then combusted to extract its energy value.

Estimates of the likely practical bioenergy resource in Ireland (above that already utilised) are as follows:



This degree of bioenergy uptake would represent contributions to total primary energy requirement of 3.4% and 4.8% in 2010 and 2020 respectively. This is a mid-range projection that assumes improved relative prices between bioenergy and conventional fuels and corresponding change in policy and market conditions. Major improvements in these conditions could overcome many practical barriers and bring considerably more resources to the market.

Barriers to Bioenergy Growth

There is currently very little deployment of bioenergy in Ireland. The only areas where bioenergy has penetrated to any extent are in traditional wood fuel use in homes and in the use of wood residues at sawmills and board plants, mostly for generating heat for use on site. There is also some exploitation of landfill gas for energy and several anaerobic digestion plants at industrial sites, sewage treatment plants and farms.

Some of the characteristics of the sector include the range of actors involved in a typical pathway from fuel supply, through conversion to energy consumption. On the supply side, fuel resources of sufficient quality and quantity need to be collected, transported and stored, all at low cost. Thus geographical factors can be important, and a well-established market of growers, brokers, intermediaries and technical experts is required. On the energy demand side, selling electricity in the new market raises access and pricing issues, and selling heat depends on local demand of sufficient size and dependability. Some of these issues are common to all renewable energy sources, but many have features unique to bioenergy, and require scale and experience, and some specific interventions, to overcome them.

Prospective developers of bioenergy projects face many barriers, some of which could be relatively easily lowered by appropriate policy and support interventions. The most notable barrier is the absence of a clear and visible Government policy and lead on bioenergy, which exacerbates problems in relation to awareness, confidence, administrative complexity, costs and access to finance. Government has already started to act on these needs, including through the establishment of this Group.

The other main barrier to greater penetration by bioenergy is economic. At current relative prices between biomass fuels and conventional fossil fuels, most bioenergy pathways and technologies are not competitive. However, many are close to being so. If what is now a nascent market could build critical mass, it would allow experience and confidence to grow and reliable supply and demand chains to become established. It would also bring benefits from economies of scale. Thus supports are required to kick-start the bioenergy market and allow this environmentally and strategically important sector to develop to its full potential.

Other barriers faced by bioenergy project developers include the range of permissions and licences required and the difficulty in obtaining consistent and transparent treatment. Bioenergy projects need to fulfil all legal requirements and meet all required standards, but many developers report difficulties in understanding how decisions are made, what information is required, and the likelihood of projects successfully meeting all regulatory requirements. This could be addressed through concerted State action to create consistent and transparent procedures. As with many other barriers, the lack of an articulated policy is the core problem. The important first step is the development of a national bioenergy policy, within an overarching renewable energy policy, with strong targets underpinned by a strategy of supports and accompanying measures to lower barriers and address market failure.

Recommendations

Bioenergy could contribute significantly to Irish renewable energy targets, including the 2010 RES-E Directive target for renewable electricity, and should be seen as an important component of the least-cost path to improved sustainability of the Irish energy economy. However, a proactive policy and support structure is required to allow this to happen. A visible bioenergy policy needs to be put in place. This policy should be backed by an implementation strategy with strong but realisable targets. The aims of such a strategy should be to ensure consistency across all policy areas and all public bodies, to focus on lowering of key barriers and to improve the economics of bioenergy through valuing its full benefits and costs.

The new bioenergy policy and implementation strategy should be delivered through a new cross-departmental bioenergy committee, chaired by DCMNR and supported by SEI. One of the priority tasks of such a committee should be to seek consistent treatment of bioenergy across all policy areas and in all public bodies dealing with relevant permissions and supports.

Financial support to stimulate growth in the bioenergy market is merited on the basis that a strategically important sector is in its infancy and requires state support to develop. It is also merited in order to capture the many benefits accruing from bioenergy exploitation that are not currently priced by the market (externalities). Without financial support little growth in bioenergy in Ireland can be expected.

The aim of any intervention is to improve the project investment in terms of rate of return or payback, hence attracting developers to projects and making it easier to secure finance. Support for electricity production is best linked to output through price support. Of the available price support mechanisms, feed-in tariffs are recommended. Feed-in tariffs can be set at levels that provide the appropriate support to renewable energy, and at different levels for different resources or technologies, according to policy goals or market conditions. Nine EU states have used feed-in tariffs to successfully support bioenergy penetration. Their effectiveness is well proven, they have low administrative costs and could make a significant impact on the generation of electricity from bioenergy by 2010. Depending on the level at which fee-in tariffs are set, capital grants may also be required to provide an adequate rate of return to developers. After 2010, re-evaluation should be undertaken to identify the most appropriate support mechanisms for new projects.

Heat does not have a centralised market nor is the supply of heat usually metered, and so is best supported in ways other than centralised price support. It seems clear that, due in large part to market failure, the bioheat market will not develop without support to reduce capital costs. Such support could bring early market growth, leading to increased competence and confidence and to economies of scale. Thus it is recommended that a grant scheme be put in place to support bioheat systems for buildings at the domestic and small commercial levels. Such a scheme should aim to provide initial market stimulation to counteract market failures and should be of fixed duration or fixed total funding.

An additional requirement for financial support exists in relation to the growing of energy crops. Until the bioenergy market increases in scale, the demand side cannot develop without secure supply, but supply of energy crops will not be put in place until demand is perceived to be strong and reliable. Hence growth in supply needs to be stimulated through financial support so that farmers become willing to plant before seeing a fully developed demand market. A fiscal incentive for growing energy crops is recommended, to be delivered through the next phase of the rural development support framework (2007 – 2013). Mechanisms to deliver support in the shorter term should also be considered.

Other recommendations relate to building critical mass in the bioenergy sector and hence developing market competence. Appropriate actions include looking to the public sector to take the lead in the installation of bioenergy systems (especially heat systems in public buildings), thus building supply and demand chains and demonstrating technologies. Various marketing, information and support actions are also recommended.

Certain bioenergy pathways suggest themselves as priorities based on the scale of their potential contribution, economic attractiveness, timeliness, benefits and their importance in preparing for the long-term future of bioenergy. These priority pathways are as follows:

- *Co-firing in electricity generation* – at peat-fired stations in particular. Biomass fuel is competitive with peat fuel. Co-firing would serve to build the market by providing strong, flexible demand for biomass fuels. It is the focus of policy attention across Europe, offering the opportunity to increase electricity production from biomass in a short timeframe, with minimal technical and cost implications for generating stations.
- *Industrial wood residue CHP* – many suitable sites exist and could employ well-proven CHP technologies to produce both heat and electricity from on-site or imported fuels. Progress in this area could come quickly if key barriers can be addressed.
- *Anaerobic digestion* – offers important waste management solutions in certain situations and could bring benefits in the short term
- *Landfill gas* – many suitable landfill sites exist, and if the resource is not exploited it will be lost. This is another path to biomass fuelled electricity that is easy to capture in a short timeframe.
- *Wood heat in buildings* – a major opportunity for market growth though the delivery of high-quality energy solutions in a range of buildings, from houses up to large public and commercial buildings
- *Energy crops* – attention is needed now to ensure development of this sector, which will be the centre of bioenergy and biomaterials into the future and is a focus of significant attention internationally.

Among these pathways, co-firing, industrial wood residue CHP and landfill gas could have a significant impact on electricity generation from bioenergy by 2010.

	Recommendation	Pathways	Supply/demand	Actors
Policy and institutional issues				
1	Publish a strong clear Government policy	All	All	DCMNR
2	Publish national targets for bioenergy	All	All	DCMNR
3	Publish and implement a strategy for action based on this report	All	All	DCMNR/SEI
4	Establish an inter departmental bioenergy group	All	All	DCMNR/DoE HLG/DAF/SEI
5	Push for clarity in and offer informational support on planning and licensing processes	All	All	DCMNR/DEH LG
6	Commission studies of regional bioenergy potential, then establish regional targets	All	All	DCMNR/SEI
7	Facilitate and promote co-firing at peat fired electricity plants	Co-firing	Electricity	DCMNR
8	Support grid recommendations of CHP Policy Group particularly regarding embedded generation	All	Electricity; CHP	DCMNR/CER
Financial Support				
9	Establish price supports for electricity (feed-in tariffs), also possibly capital grants	All	Electricity; CHP	DCMNR to champion
10	Establish capital grants or tax incentives for domestic and small commercial heat systems	Wood heat	Heat	DCMNR to champion

11	Establish fiscal incentives for growing energy crops	Energy crops	Supply	DCMNR, DAF
<i>Building critical mass</i>				
12	Develop public building heat exemplar projects	Wood heat/CHP	Heat/CHP	DCMNR/OPW
13	Oblige all large developments to assess bioenergy possibilities	All	All	DCMNR/DoEHLG
14	Encourage EPA to use landfill licences to ask for LFG assessment	LFG	Mainly electricity	EPA
<i>Developing market competence</i>				
15	Create a specific bioenergy support and promotion unit, with its own resources and identity	All	All	SEI
16	Increase general marketing and information activities	All	All	SEI
17	Produce guidance materials for developers on planning, licensing and supports	All	All	SEI
18	Develop model contracts in key areas	Energy crops & others	Supply	DCMNR/SEI
19	Offer a one stop shop service to support delivery through the new bioenergy promotion unit	All	All	SEI/DCMNR
20	Examine ways to offer project contact facilitation services	All	All	SEI
21	Produce feasibility study guidance for developers	All	All	SEI
22	Examine new training initiatives	All	All	SEI
23	Consider certification of training and education	All	All	DCMNR/SEI
24	Commission additional research and information projects	All	All	SEI
25	Support bioenergy in EU FP7	All	All	DCMNR/SEI

Conclusions

The Bioenergy Strategy Group believes that the case for bioenergy is proven. With appropriate action taken now, it could quickly become an important element of the development of renewable energy in Ireland, bringing many additional benefits over other energy sources. The sector is poised for growth, but support is required to allow this growth to take place. With such support, bioenergy could make a significant contribution to renewable energy targets in 2010 and beyond. A Government policy on bioenergy, underpinned by an implementation strategy with strong targets, should be the framework for support and promotion of bioenergy.

By 2010, bioenergy is capable of contributing to renewable energy targets through a total input to primary energy requirement of **22 PJ**, or about 3.5% of Ireland's total primary energy requirement (excluding the potential municipal waste-to-energy contribution). This is the Group's recommended target for bioenergy. It is envisaged that this would include an additional installed capacity of 140 MWe of electricity generation providing 822 GWh of electricity.

SEI's economic analysis suggests that this could be achieved at a cost of the order of €145M (further refinement of this estimate is required). The Group's target would also add 2110 GWh of renewable heat above the current contribution of 1825 GWh per annum.

Overall, this target would bring additional annual abatement of carbon dioxide emissions of 820,000 tonnes. This target is very realisable, but will require prompt and concerted Government action to develop market and policy conditions. The Group's vision for such conditions in 2010 is as follows:

- A clearly articulated policy, with consistent and transparent treatment of bioenergy, and a stable policy context
- Recognition of the value of heat as an opportunity for renewable energy
- An electricity market that allows access for renewable energy and values its contributions according to its full benefits
- A pricing system that better internalises all costs and benefits of energy from alternative sources
- A bioenergy market based on experience and expertise, with active supply chains, many visible success stories, and confidence among developers, financiers and customers

Internationally, bioenergy is growing in importance and will become a key element of the enhanced sustainability of the energy economy. It is important that steps be taken now to ensure that Ireland participates in these developments.

Bioenergy Strategy Group

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1. Introduction

1.1 A Bioenergy Strategy for Ireland

Bioenergy is the general term used to denote renewable energy derived from biomass. Biomass is the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste¹. It also includes crops specifically grown for energy use.

The OECD argues that a significant shift is likely, and desirable, from fossil fuel based energy to biomass based energy into the future². In the shorter term, the EU White Paper on Renewable Energy argues that bioenergy is soon to become the major growth area in renewable energy³. Within the EU, bioenergy is seen as key to the achievement of the 2010 renewable energy targets for heat and electricity⁴.

In Ireland, wind is currently the largest contributor to renewable electricity, but bioenergy remains the most significant renewable energy resource overall, accounting for 61% of primary energy from renewables in 2002⁵. Into the future, many bioenergy sources are ready to make major further contributions to Ireland's renewable energy targets through both electricity and heat.

More than any other form of renewable energy bioenergy is an inter-departmental issue for Government, having implications for and being affected by a broad range of policy areas. It is an indigenous, renewable form of energy that positively contributes to:

- Key energy goals including security of supply and the development of renewable energy sources
- Key environmental goals such as greenhouse gas emissions reduction and management of diverse waste streams
- Key agricultural goals in the context of CAP reform, offering new opportunities for farmers
- Key social goals such as employment generation in rural areas and enhancement of local economies

An effective strategy for the development of bioenergy in Ireland depends on consistent supportive policy and implementation across a number of departments and agencies.

To date there has been no national policy or strategy specifically addressing bioenergy. Such a policy is required, with a strategy for action to promote its uptake and exploit its potential. This strategy should strive to raise awareness of bioenergy, remove key hurdles to its uptake, and provide support according to the environmental, economic and strategic benefits that accrue from its use.

1.2 Purpose and Scope of the Report

The Department of Communications, Marine and Natural Resources established the Bioenergy Strategy Group at the end of 2003 to consider the policy options and support mechanisms available to Government to stimulate increased use of biomass for energy conversion, and to make specific recommendations for action to increase the proportion of energy derived from biomass in Ireland. This report represents the outcome of the Bioenergy Strategy Group's work, and contains its recommendations to Government for a strategy for bioenergy promotion in Ireland. It is not a detailed technical review of bioenergy technologies, but rather an overview of the key issues for the

¹ From EU Directive on Electricity Production from Renewable Energy Sources, 2001/77/EC.

² OECD, 2004. *Biomass and Agriculture: Sustainability, markets and policies*. Paris: OECD.

³ European Commission, 1997. *Energy for the Future, Renewable Sources of Energy - White Paper for a Community Strategy and Action Plan*. Com (97) 599 final (26/11/1997)

⁴ European Parliament Working Paper STOA 115, July 2003.

⁵ SEI, 2004. *Renewable Energy in Ireland – Trends and issues 1990 – 2002*. Dublin: SEI.

uptake of these technologies. It considers the options most relevant to Ireland, with a focus on impact, firstly in the period to 2010 and then on to 2020.

The report presents background to the various bioenergy resources, pathways and technologies, and discusses the main issues affecting the sector's development. By identifying key barriers to growth the report makes specific recommendations for action to address these barriers and allow bioenergy to make a greater contribution to renewable energy production in Ireland, supporting a wide range of policy goals as it does so.

The scope of this report is the production of heat or electricity or both from biomass. The production of liquid biofuels for transport and other uses involves distinctly different issues, technologies and actors, and so is not considered here.

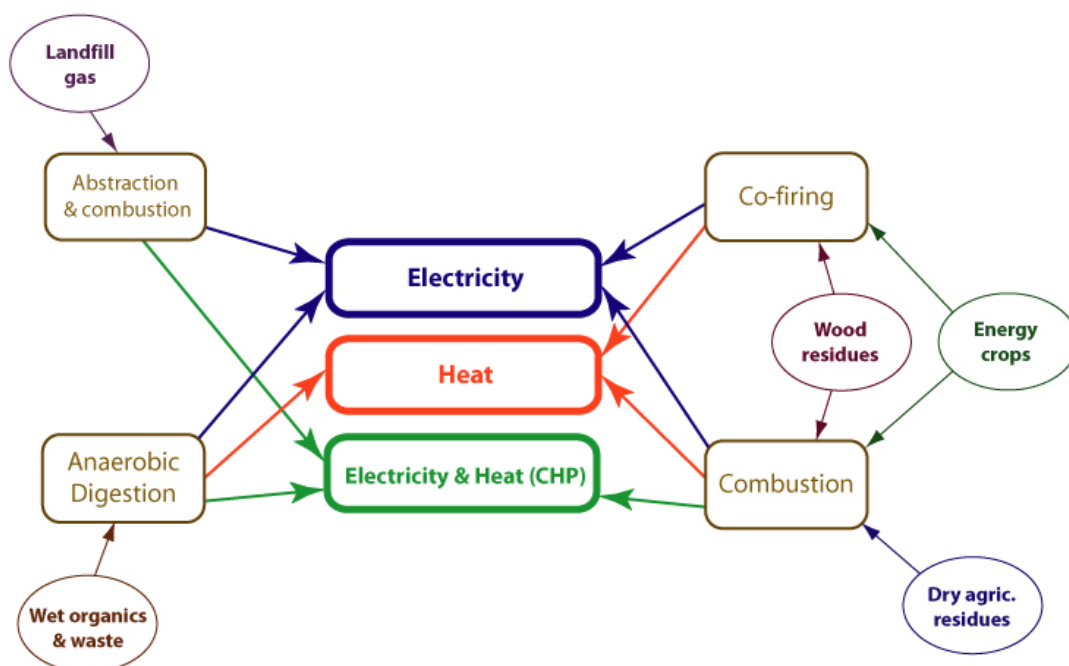
1.3 Resource to Energy – Bioenergy Pathways

Figure 1.3.1 below plots the prime pathways for the production of energy from biomass in an Irish context, starting with the range of possible fuels, through the available conversion processes to produce electricity, heat or both in combined heat and power (CHP) mode.

Among the range of fuels that could form the supply for bioenergy pathways, some are already available, while others are resources for the future. Forestry planting in Ireland has been considerable in recent years and wood and forestry residues are now ready to provide a significant fuel resource. Such residues – trimmings, loppings, bark, sawdust and chippings – are suitable for a range of combustion technologies for the production of heat, electricity or both. They can also be processed into chips or pellets and thus distributed as a higher value renewable fuel for use at all scales.

Several residue and waste products also represent potential fuel sources principally dry agricultural residues (straw, poultry litter, spent mushroom compost); wet organic residues and wastes (slurries and manures from farms, sewage sludge, catering waste, food industry residues); municipal solid waste (the biodegradable fraction) and landfill gas.

Figure 1.3.1 Principal bioenergy pathways



Into the future, crops grown specifically for energy use will become more and more important, and represent the principal long term sustainable bioenergy resource. The main alternatives are either short rotation coppice or field crops such as miscanthus grass. Such crops will also become the raw materials for a range of bioproducts such as plastics and other chemicals. Many EU states are focusing policy on exploiting energy crops for both their energy and bioproduct outputs.

1.4 Policy Benefits

Bioenergy does not deplete the world's finite resources, and hence is a sustainable energy source. It has a range of environmental, social and economic benefits, and supports a number of important policy objectives. Precise benefits vary according to fuel source and conversion technology, but the following table indicates the range of benefits associated with bioenergy:

Table 1.4.1 Main policy benefits of bioenergy

Issue	Bioenergy benefits	Main relevant policies
Climate change	Carbon neutral energy production Reduced methane emissions through processing of waste streams into energy and capturing of landfill gas. Reduced emissions through replacement of artificial fertiliser with digestate from anaerobic digestion	National Climate Change Strategy
Air pollution	Reduced emissions of SO _x and NO _x , compared to many other energy sources.	Strategy to Reduce Emissions of Transboundary Air Pollution by 2010
Waste management	Management of residues and wastes through anaerobic digestion or combustion. Capture and use of methane from landfill sites Bioremediation of wastes using energy crop plantations.	Waste management policy, <i>Changing our ways; Delivering Change</i> National strategy on biodegradable waste EU Landfill Directive
Energy security and diversity	Indigenous source of renewable energy Increased diversity and security of energy supply	Green Paper on Sustainable Energy Proposed EU directive on security of supply
Sustainable electricity	Bioenergy CHP and electricity generation promotes embedded generation, which can reduce system losses and address grid quality concerns. The bioenergy sector could become a significant component of an all-island energy market	Green Paper on Sustainable Energy Electricity Act All-island energy initiative
Renewable resources	A source of dispatchable renewable electricity, and renewable heat for all scales and applications Can offer local and flexible energy systems Based on a growing renewable resource	Green Paper on Sustainable Energy Electricity Act EU RES-E Directive DCMNR Consultation Options for future renewable energy policy, targets and programmes EU White Paper on renewable energy

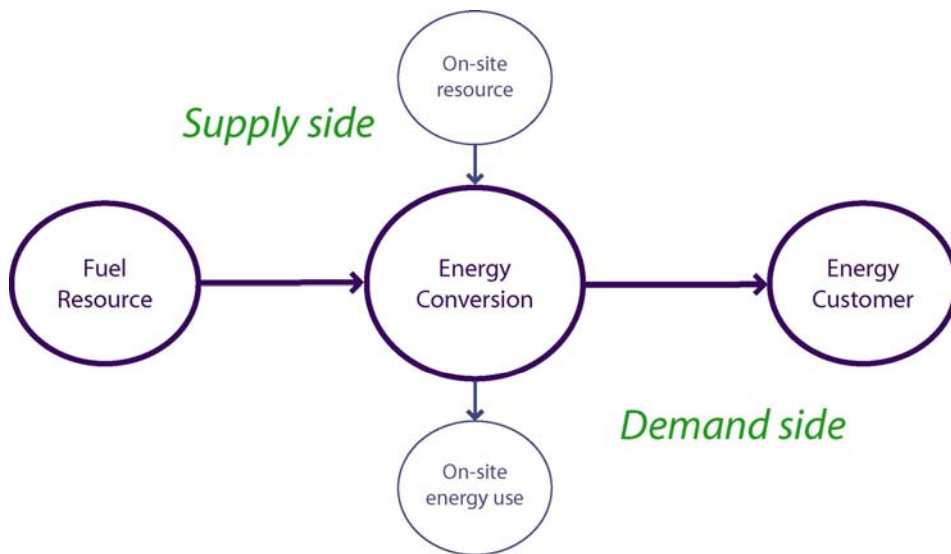
Agriculture	<p>New opportunities for farmers in context of CAP reform and decoupled payments</p> <p>Addressing nutrient management pressures through alternative processing of slurries and manures</p>	<p>EU Common Agricultural Policy, Mid term review</p> <p>EU Nitrates Directive</p>
Forestry	<p>Creating demand for forestry products and services in context of excess supply into the future</p>	<p>Forestry Strategy <i>Growing for the future</i></p> <p>Bacon Review of Forestry Strategy</p>
National economy	<p>Can offer cheaper fuel input or exploitation of waste streams leading to cost reduction and reduced imports</p>	
Employment and development	<p>Can promote local employment through focus on smaller regional businesses, and substitution of labour for imports.</p> <p>Also creates rural development opportunities by decentralising energy supply, creating new opportunities in fuel supply and services, and emphasising local supply and demand relationships. There is also potential for Ireland to become a leader in equipment supply and specialist expertise.</p>	

The bioenergy sector is poised for growth and could become the most important new area of renewable energy development over the coming decade. The correct policy and support interventions could stimulate strong growth in the production and use of bioenergy and bring the full set of benefits to Ireland.

2. The Bioenergy Sector – Issues, Policies and Actions

2.1 The Characteristics of Bioenergy

Bioenergy pathways exhibit unique attributes, bringing both benefits and challenges, that distinguish them from other renewable energy sources. These issues exist on both the supply and demand sides of the pathways:



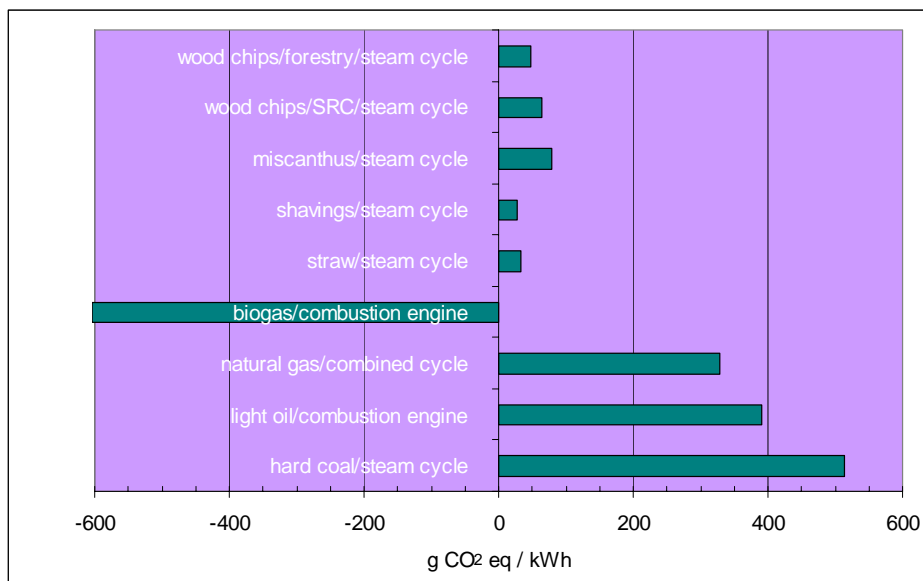
The supply side of bioenergy is about collecting, processing, storing and transporting fuel resources in sufficient quantity and making sure the supply is reliable, meets quality requirements, and is economic. This has geographical dimensions (matching fuel sources with local energy uses) and also requires a well developed market of producers/growers, brokers, intermediaries and technical experts. Many complications fall away if the fuel source, its conversion to energy and the use of this energy all happen on the same site. Thus most of the largest bioenergy projects developed to date are on industrial sites such as wood processors, board mills and food and dairy industries where residual materials are converted to energy (most commonly heat, but also sometimes heat and electricity together in CHP) for use in their own processes or space heating.

Where there is no fuel source on-site there may be potential for importing fuel and using the energy on-site, usually for space heating. Domestic use of wood is a simple example of this.

If there is no demand for the energy at the energy conversion site, then it must be exported and sold. Selling electricity in the new market raises access and pricing issues, and selling heat depends on local demand of sufficient size and dependability. Disaggregating bioenergy issues by supply side and demand side, between heat and electricity, informs the analysis of the market, the barriers in place and the policy and support needs for stimulating growth.

Bioenergy is largely carbon neutral (absorbing as much carbon dioxide in its creation as it emits when burned), although it usually does involve some fossil fuel consumption in activities such as collecting, growing and harvesting, and transportation. Life cycle analysis shows that bioenergy has strong environmental advantages over conventional energy. For example, replacing 1GWh of coal generated electricity by electricity from biomass would reduce CO₂ emissions by 4000 tonnes. The following graph illustrates the point:

Figure 2.1.1 Greenhouse gas implications of bioenergy pathways⁶



The bioenergy sector is different from other renewable energy sources in several important ways, bringing additional benefits but also in some cases raising new barriers:

Renewable heat

While much of the focus of renewable energy policy is on electricity, the potential to generate heat from renewable sources should not be overlooked. Heat can have lower conversion losses and meet local energy needs flexibly, cleanly and cheaply. It eliminates the complications and costs of making electricity grid connections and selling into the new market, and also brings many additional opportunities for renewables deployment. Heat represents about one third of total primary energy. All biomass fuels can be used to generate heat across a wide range of scales, technologies and applications.

Wider benefits

Bioenergy pathways offer benefits beyond the normal renewable energy issues, such as new economic opportunities for farmers, waste management (providing alternatives to current disposal routes), and increasing demand for forestry products. It also supports local economies and rural development.

Dispatchable electricity

Bioelectricity can be switched on or off as needed, in contrast to many other renewables, and has higher load factors (often almost double that of wind). It also offers other benefits to the electricity system, such as extending the scope of CHP beyond the gas grid, and bringing extra embedded generation⁷ opportunities.

Complex pathways

In contrast to many energy sources and conversion technologies, including other renewable energies, bioenergy involves several different potential pathways from resource production (growth of wood or crops, production of waste streams), through collection, transportation, storage and then conversion to useful heat or electricity. In many cases, these pathways involve several sets of actors

⁶ Emissions of CO₂, N₂O and CH₄, conversion via CHP (33% to electricity, 67% to heat) assumed. Biogas displays negative emissions due to the displacement of methane emissions. G. Jungmeier, *Success Stories in Bio-Energy*, Climate Change Solutions Conference 1st April 2004, NEC Birmingham, UK.

⁷ Matching local supply and local demand on the electricity grid, reducing system losses

(often from different sectors, such as farmers, energy commodity traders, and electricity generators), technologies, and many institutional issues and economic considerations. This presents developmental challenges, particularly when the sector is in its nascent state.

Competing uses

Most potential fuel inputs have competing uses both within and outside energy. Most fuels could be combusted for heat or electricity, or for both via CHP, using different technologies, and many can also be processed by anaerobic digestion. Biodegradable wastes could also be composted, slurries can be spread on land to return nutrients to the soil, and many wood residues can be used in the manufacture of material products such as chipboard. Additionally, any land given over to energy crops has many alternative uses.

Transportation issues

Biomass fuels tend to have low energy densities - typical wet biomass can have an energy density in the region of 1.4GJ/m³ as compared to coal with an energy density of 21.6 GJ/m³.⁸ This obviously has implications for transportation and storage costs. In general, bioenergy sites need to be able to source fuel within a short range of the site, typically less than 50km at present transport costs.

Long term commitments

Energy crops imply a 20 to 30 year commitment on the part of the farmer, and in the case of SRC a 4 year wait before the first harvest and the first income. There are also several ways in which these crops are different to more traditional crops in terms of their growing patterns, treatment, harvesting and storage. All of this presents barriers in persuading farmers to grow these crops, especially in the absence of certainty about future demand and prices.

Public acceptance

Projects that may be branded as incineration or waste disposal face challenges in persuading the public to accept such developments. Not all such projects are the same, however, and bioenergy projects need to distinguish themselves by stating the benefits they offer to communities and by clarifying their activities and implications.

In most cases, bioenergy is not currently competitive with conventional fossil fuel alternatives. However, like all renewable energy, bioenergy brings benefits not currently priced by the market – emissions abatement, supply security and so on – and thus government intervention to capture these benefits is justified and called for.

2.2 Bioenergy in Europe

Bioenergy is being promoted strongly in many states and is making significant in-roads into many markets:

- In the Netherlands, the target date of 2040 is the focus, with interim targets along the way. The ambition is that in 2040 biomass will provide 30% of the energy supply (and 20-45% of the raw materials for the chemical sector). These developments should also contribute to the knowledge economy, where the focus is on high-grade technological developments.⁹ The goal is to allow bioenergy to compete on an open market with other fuels, but the government will put value on the social and environmental benefits.
- The UK Royal Commission on Environmental Pollution recently published a report emphasising the benefits of bioenergy and called for strong future targets. It proposed the introduction of a new renewable heat obligation, the formation of a government/industry bioenergy forum, and that biomass CHP be considered in all new build developments. The report suggests that bioenergy could provide 10-15% of the UK's primary energy by 2050¹⁰.

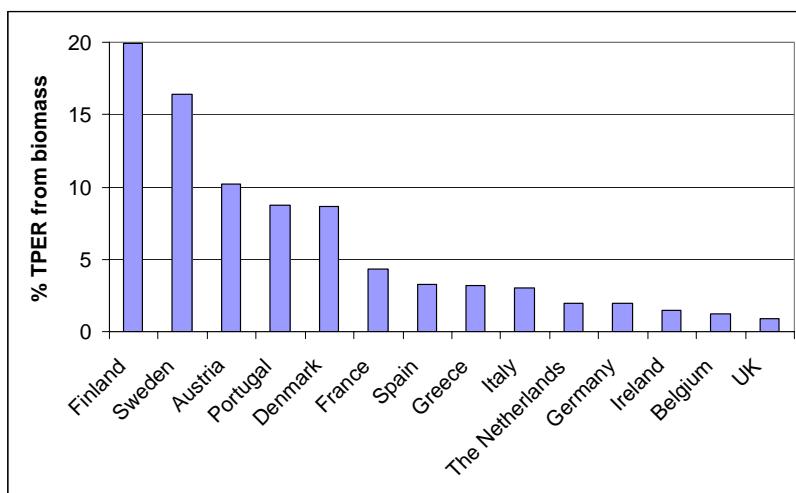
⁸ ILEX Energy Consulting, 2003. *Possible support mechanisms for biomass generated heat*. Report to UK DEFRA December, 2003

⁹ Kwant et al, 2004. *An Action Plan for the Implementation and a Transition with Biomass in the Netherlands*. Novem.

¹⁰ Royal Commission on Environmental Pollutions (RCEP), 2004. *Biomass as a Renewable Energy Source*. London: RCEP.

- The wood heat market has grown strongly in Austria since supports were introduced in the late 1990s. Most growth has been in the domestic sector – 22,000 wood pellet fired heating units were installed in 2003, mostly in single family homes. Subsidies are available for wood fired boilers (up to €2,200 if replacing an existing boiler, up to €2,600 for a new system). There is also an emphasis on ensuring the quality of the pellet fuels.
- There are 450 landfill gas energy units across the EU, producing 1050 Mtoe of energy¹¹
- Finland derives 23% of its total energy from renewable sources, and 84% of this renewable resource is from wood. At 267 PJ in 2001, Finland has Europe’s largest bioenergy sector. Exploitation is particularly strong in the wood processing sector itself; more than half of the electricity consumed in the forestry sector is generated from wood.¹² Co-firing for electricity production has also been strongly promoted. Nationally, peat and wood energy together account for almost the same as oil consumption.
- Energy crops have become a new focus for renewables policy in Northern Ireland, led in particular by the agriculture sector’s interest in new market opportunities for the future. Targets are for a capacity of 20MW from biomass by 2012, and moving towards the overall UK target for 2050.¹³ A new support system to stimulate the planting of SRC has recently been established.

Figure 2.2.1 Percentage of national total primary energy requirement from biomass in the EU¹⁴



Overall, exploitation of biomass for energy is considerably well advanced in many states:

Mainly due to traditional wood use, bioenergy accounts for more than half of renewable energy input across the EU (representing 98% of renewable heat and 9% of renewable electricity)¹⁵. Many different support mechanisms are employed. For example, electricity from biomass is supported in all EU states in various ways, feed-in tariffs being the most commonly employed mechanism:

¹¹ EU Commission, DG Transport and Energy

¹² Alakangas, E., 2002. *Renewable Energy Sources in Finland 2002*, OPET Finland.

¹³ OFREG & Northern Ireland Electricity, 2004. *The Biomass Manifesto*.

¹⁴ European Parliament Working Paper STOA 115, July 2003

¹⁵ European Commission, 2004: *EU Strategy and Instruments for promoting renewable energy sources*.

Table 2.2.1 Overview of electricity support systems (recent or current) across the EU¹⁶

Measure	States
Feed-in tariff	Austria, Belgium, Denmark, France, Germany, Greece, Netherlands, Portugal, Spain
Tax incentives	Finland, Netherlands, Ireland
Investment support	Greece, Portugal, UK
Bidding scheme	Ireland
Quota system	Italy, Spain, UK, Sweden

According to the EU Commission, the 2010 RES-E target depends on a 40% contribution from biomass, which will require annual growth rates in biomass electricity of 18%, as against recent average EU rates of 7% (Irish growth rate has been 3%)¹⁷.

2.3 EU Policy on Bioenergy

Two main policy documents set the agenda at EU level for increasing renewable energy deployment:

Energy for the Future, Renewable Sources of Energy - White Paper for a Community Strategy and Action Plan Com (97) 599 final (26/11/1997)
The white paper sets out EU strategy and an action plan to raise the share of renewable energy from 6 to 12 % (gross inland production) by 2010. It details the expected contributions from each renewable source and the expected impact on electricity, heat and transport energy markets. Many of these targets will not be met without an acceleration of uptake. ¹⁸
EU Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market 2001/77/EC
The RES-E Directive, as it is known, requires member states to contribute to goals to increase the consumption of renewable energy sourced electricity within the EU. The consumption targets are individual to each member state, Ireland's target is 13.2% of electricity produced from renewable sources by 2010. The directive also sets out goals to remove key barriers (economic returns and grid access) to the increased deployment of renewable energy technologies in electricity production. It calls for national support schemes and possibly also harmonised supports across the EU. It also calls for simplified authorisation systems and guaranteed access for renewable electricity to transmission and distribution systems

Other relevant directives include:

- *Emissions Trading Directive (2003/87/EC)*; electricity generators and many large energy users will be obliged to trade permits to cover their CO₂ emissions. The trading system starts in 2005. This should give positive price signal support to renewables.
- *CHP Directive (2001/91/EC)*; this directive promotes CHP, clarifies definitions and consolidates a range of policies and measures. Removal of barriers to uptake is the focus.
- *Biofuels Directive (2003/30/EC)*; promotes biofuels for transport and establishes indicative targets that will be challenging for Ireland. SEI has commissioned an implementation study, and inter-departmental discussions have commenced.
- *Buildings Directive (2002/91/EC)*; targets energy performance in buildings through minimum efficiency standards for new buildings and a new system of energy certification. Public sector buildings should act as exemplars. Also, Member States should ensure that developers of new buildings with a total useful floor area over 1,000 m² examine the feasibility of alternative energy

¹⁶ Adapted from DCMNR Consultation Document, 2004. *Options for future renewable energy policy, targets and programmes*. Luxembourg is excluded from the analysis.

¹⁷ DG Energy and Transport, Presentation to *International Conference for Renewable Energies*. Bonn, June 2004.

¹⁸ Zervos, A., 2004. *Renewable Energy Development and Prospects in the EU15*. European Conference for Renewable Energy, Berlin January 2004

systems, including CHP, decentralised energy supply based on renewables, district or block heating or cooling and heat pumps.

Other proposed Directives of relevance include Security of Electricity Supply, Security of Gas Supply, and the Energy Services Directive, which would impose mandatory efficiency targets and promote efficiency services to end users.

2.4 Current Irish Policy and Support Measures

The following are the key statements on Irish policy towards renewable energy:

- Green Paper on Sustainable Energy - 1999
- Electricity Regulation Act – 1999
- National Climate Change Strategy – 2000
- Sustainable Energy Act – 2002
- DCMNR consultation document; *Options for future renewable energy policy, targets and programmes* - 2004

This last document gives a full overview of Irish policy on renewable energy. It sets out current targets and goals as follows:

- increasing the percentage of Total Primary Energy Requirement (TPER) derived from renewable sources from 2% in 2000 to 3.75% by 2005
- increasing the installed renewable energy electricity generating capacity by an additional 500 MW between 2000 and 2005
- limiting greenhouse gases emissions to a 13% increase over 1990 levels by 2008-2012
- reducing annual CO₂ emissions by 1 million tonnes from the 'business as usual' case through increased deployment of renewable energy (predating the RES-E Directive) of 31 MW installed per year from 2000 to 2010. The additional 1 million tonnes represents achievement of the 2005 Green Paper target only
- an indicative target to contribute a minimum of 13.2% of green electricity to total electricity consumption by 2010
- exploring and developing the offshore resources
- regional sustainability and environmental protection

A Renewable Energy Development Group (REDG), convened by DCMNR, is currently considering policy and support needs for all renewable energy sources, with a focus on delivery of the RES-E Directive target. The following graph, from the DCMNR consultation document, indicates current thinking on how different renewable energy sources may contribute to current targets. It shows that biomass is considered a resource of increasing importance into the future.

A number of support mechanisms are currently in place to underpin these objectives. One of the most significant measures in recent years has been the Alternative Energy Requirement (AER). This scheme offers fixed price electricity purchase contracts to green electricity generators, based on a competitive price bidding system. There have been six call rounds since its inception in the mid-1990s. The most recent, AER VI in 2003, included categories for biomass CHP, anaerobic digestion, with price caps of €0.07 per kWh, and landfill gas, with a price cap of €0.06412. The AER VI competition attracted bids totalling 49.695 MWe¹⁹. Following evaluation, awards totalling 34.335 MWe²⁰ were made.

¹⁹ 26.83 MWe of biomass CHP; 10.862 MWe of anaerobic digestion; 12.003 MWe of landfill gas.

²⁰ 26.83 MWe of biomass CHP; 2.022 MWe of anaerobic digestion; 5.483 MWe of landfill gas.

Table 2.4.1 details the renewable electricity capacity (MWe) delivered to date by AER:

Figure 2.4.1 Projected renewable energy inputs for Ireland

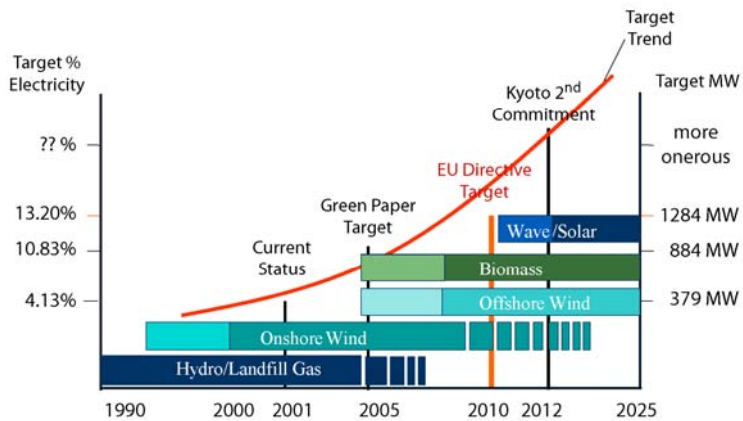


Table 2.4.1 Renewable energy capacity delivered by AER schemes²¹

Technology	AER I Commissioned	AER II ^a Commissioned	AER III Commissioned	AER IV Commissioned	AER V ^e Commissioned/constructed	AER V ^e Under construction	AER VI Commissioned/constructed	AER VI Under construction
Combined Heat & Power	10.716	-	-	18.353	-	-	-	-
Small scale Hydro	2.304	-	1.67	-	-	-	0.04	0.594
Landfill Gas	11.804	-	2.928	-	-	-	6.755	-
Wind energy	45.8	-	37.51	-	52.29	7.55	31.04	124.95
Anaerobic digestion ^b					-	-	-	-
Biomass CHP ^c					-	-	2.875	-
Offshore wind ^d					-	-	-	-
Totals MWe	70.62	0	42.11	18.353	52.29	7.55	40.71	125.544

^a AER II was in respect of a waste to energy station only. The winning project did not proceed.

^b Biomass AD supported in AER VI only

^c Biomass CHP supported in AER VI only

^d Offshore wind (two 25MW demonstration projects) supported in AER VI only, not under construction yet

^e AER V projects were permitted to re-enter the AER VI competition. Hence the overall deliverable capacity in AER V will only take account of those projects which did not receive a PPA offer in AER VI.

²¹ Source: DCMNR.

In some rounds of AER, failure rates of projects have been high, and overall results have been mixed. While wind energy has achieved significant penetration in recent years, the bidding approach has had very limited impacts on bioenergy pathways (with the notable exception of LFG).

Besides the AER Programme, renewable energy based electricity plant (but not bioenergy plant) have also been built with assistance from the EC VALOREN and THERMIE Programmes. Other support measures in place include:

- Investment tax relief via Section 486B of the Finance Act 1998, and the Business Expansion Scheme (BES)
- The SEI Renewable Energy RD&D programme, supporting innovative renewables projects, as well as technical and economic studies (€3.745M spent, €6.5M committed by the end of November 2004). 39% of the funding under this programme has gone to support bioenergy

To date the impact of these measures has been very limited, and renewables penetration remains lower than other EU states, and below Irish target levels. According to the Ernst and Young *Renewable Energy Country Attractiveness Indices*, Ireland ranks the third lowest of the EU15 states for bioenergy projects. The index is based on the quality of power purchase agreements available, the fiscal climate in terms of attractiveness to investors and Government policy and targets. Ireland scores better (8th of EU 15) in the *overall renewable index* due to the stronger performance of wind energy²².

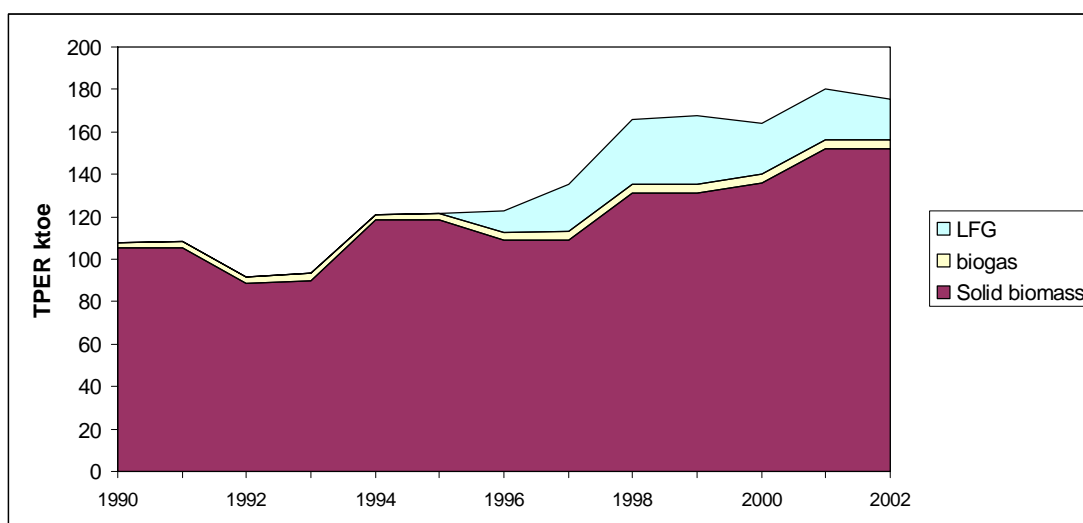
²² Ernst and Young, *Renewable Energy Country Attractiveness Indices*, September 2004.

3. The Bioenergy Resource and Market Potential

3.1 Bioenergy Resources in Ireland

The following chart illustrates the contribution to Ireland's total primary energy requirement (TPER) of the bioenergy resources currently being exploited; solid biomass (wood residues), biogas and landfill gas:

Figure 3.1.1 Bioenergy contribution to Irish total primary energy requirement



In 2002, bioenergy represented 61% of all renewable energy and 1.2% of total primary energy requirement. Most of this came from the category of solid biomass, of which about 70% is industrial heat at sawmills and related industries, the rest being domestic wood heat. This category grew at an average rate of 3% per annum between 1990 and 2002. The biogas resource was also deployed as heat (mainly through four industrial anaerobic digestion units) and the landfill gas resource was all deployed as electricity²³.

Forestry wood products

The expansion of the Irish forestry sector has created a strong supply of wood and wood residues into the coming decades, for which there is unlikely to be full demand in existing markets²⁴. This represents a particular opportunity for bioenergy development based on wood products.

The wood for energy sector divides into direct biomass (the trees themselves); indirect biomass (processing by-products and residues) and post-consumer recovered wood²⁵:

Direct biomass

The supply of pulpwood is set to grow steadily and outstrip demand for current uses, thus creating a resource for energy purposes²⁶. Whole tree chips represent higher efficiency extraction than residues, but there may be problems of availability of appropriate machinery for Irish conditions and scales.

²³ SEI, 2004. *Renewable Energy in Ireland 1990 - 2002*.

²⁴ Electrowatt-Ekono (UK) & Tipperary Institute. *Maximising the Potential of Wood Use for Energy Generation in Ireland*. Unpublished Coford Strategic Study.

²⁵ Clearly SRC produces wood which, once converted to chips or pellets, is indistinguishable from wood from other sources. The discussion here focuses on wood from forestry in supply terms and treats SRC separately, but conversion processes are identical for all wood

²⁶ Electrowatt-Ekono (UK) & Tipperary Institute. *Maximising the Potential of Wood Use for Energy Generation in Ireland*.

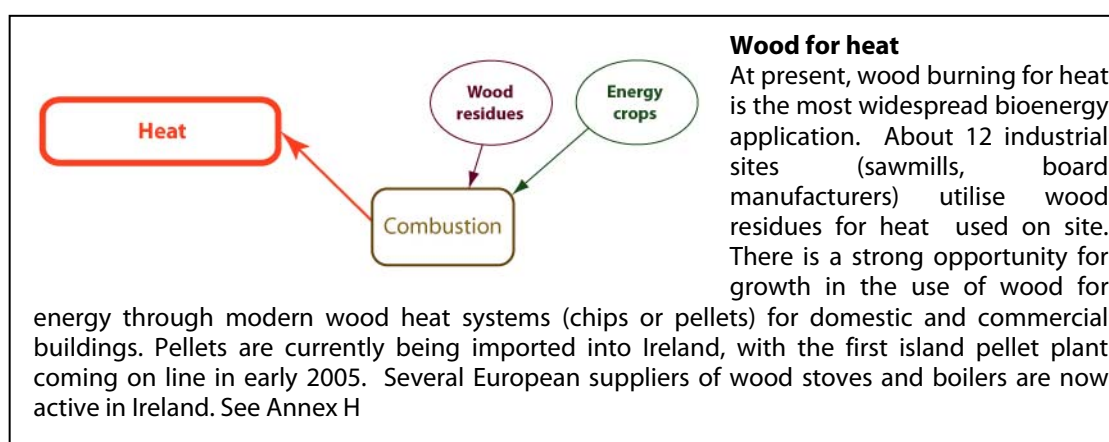
Forest residues are currently an untapped resource, but again availability of suitable machinery and harvesting practicalities may pose problems.

Indirect biomass

This refers to sawdust, woodchip, bark and slabwood, from primary and secondary processing. Several sawmills already utilise this resource to generate heat.

Recovered wood

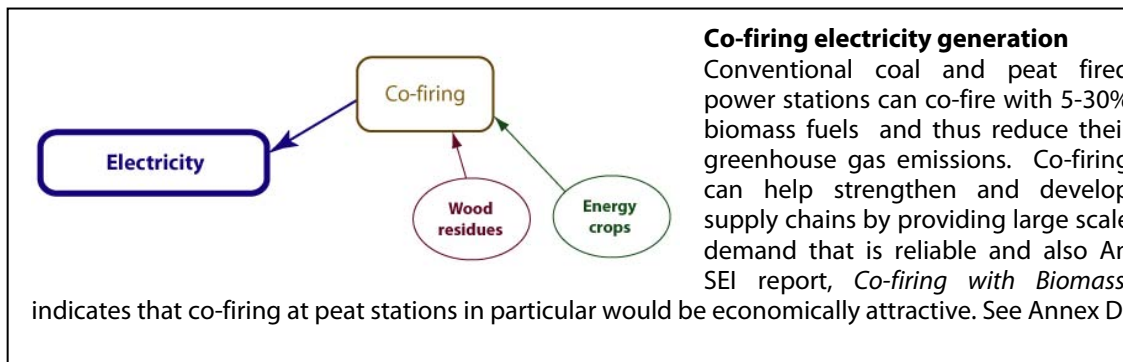
The main sources are old pallets, packaging and waste from construction and demolition. Problems can arise with segregation and contamination, but burner technologies (combustion and flue gas cleaning) are available even for contaminated sources. Recovered wood is dry and thus has an energy content typically double that of the same mass of the other wood sources mentioned above.



Forests for harvest up to 2020 are already planted, so good data is available on the size of the resource, and the resource is literally growing in size every year. Data on resource size are less reliable for recovered wood. Estimates of resources available to energy uses usually assume current uses (such as wood products for chipboard) continue. There are also some possible new uses for similar resources, including extruded wood and horticultural products.

Across Europe, wood fuel has been used to produce heat and electricity in CHP plant, and also for electricity production by co-firing in existing power stations, displacing fossil fuel use. Many EU states have also seen particular growth in the wood for heat sector. Wood for heat technology usually involves processing the wood into either chips or pellets, which are then sold as a fuel. Pellet manufacture produces a high quality (consistent, higher density and higher energy content) predictable fuel that produces very little ash. However production costs are higher and so each particular use must balance cost against quality advantages. As well as lower cost, it can be argued that wood chips bring more benefits to local farmers in the chain, since they produce the final product rather than value being added elsewhere in pelleting plants. Both fuel forms could play important roles in the market, and different applications will suit either or both.

Heating units are now available in all size ranges, including single house units, and several well proven and attractive technologies are available in Ireland. However, capital costs remain significantly higher than conventional systems, and established fuel supply systems are not yet in place. Nonetheless, biomass fuelled heat generation is likely to be a key growth market in the coming years.



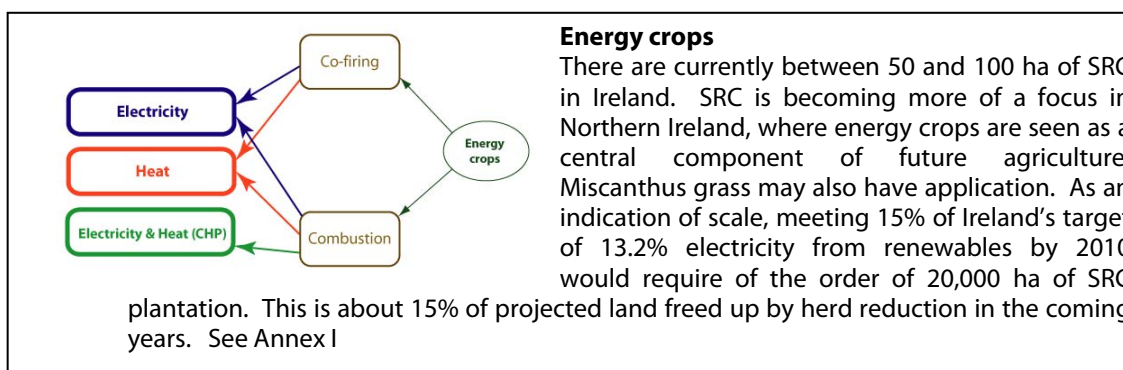
Energy Crops

One way of storing solar energy for future use is to encapsulate it in growing plants that can then be processed (combusted, gasified or digested) to extract the energy content. As the bioenergy sector expands in the future and waste and residual streams become fully exploited, growing biomass for energy will be the main pathway for extending the resource available. The introduction of the Single Payment Scheme for Irish farmers in 2005 will see farmers receiving an annual single payment that will no longer be linked to agricultural production. This will level the playing field for energy crops. In the past the growing of energy crops could not compete economically with alternative subsidised activities, but in the future farmers will make planting choices according to market conditions as opposed to subsidy regimes. As the biomass sector develops, energy crops will become increasingly important.

The main energy crops available for growth in Ireland are miscanthus and short rotation coppice (SRC). Miscanthus is a fast growing grass with good energy properties in terms of density and moisture content. Compared to SRC, it requires relatively little change in practices or equipment for farmers used to growing annual field crops such as cereals. It is a temperate zone crop but nonetheless generally requires drier and warmer conditions than those available in more northern parts of the country.

SRC is based on the planting of fast growing tree saplings (willow is by far the most common species used), and then the cutting back of first year growth to encourage rapid, thick growth in subsequent years. Harvesting starts in the fourth year, and can continue over twenty to thirty years. Willow has been grown for energy in Scandinavia for many years, and so is well understood in terms of growing, harvesting and energy properties²⁷. SRC plantations are more ecologically positive than either field crops or traditional forestry, in that they support greater biodiversity.

Economically, energy crops currently find it difficult to compete with fossil fuels at their current prices and few plantings have occurred in Ireland to date. However, it is likely that interest would develop quickly if the economic returns improved and markets for energy crops appeared to be reliable. Growing crops can also be employed in bioremediation – the treatment of waste streams by spreading on land, and this can provide an additional income from waste disposal fees.



²⁷ RCEP, 2004.

Dry agricultural residues

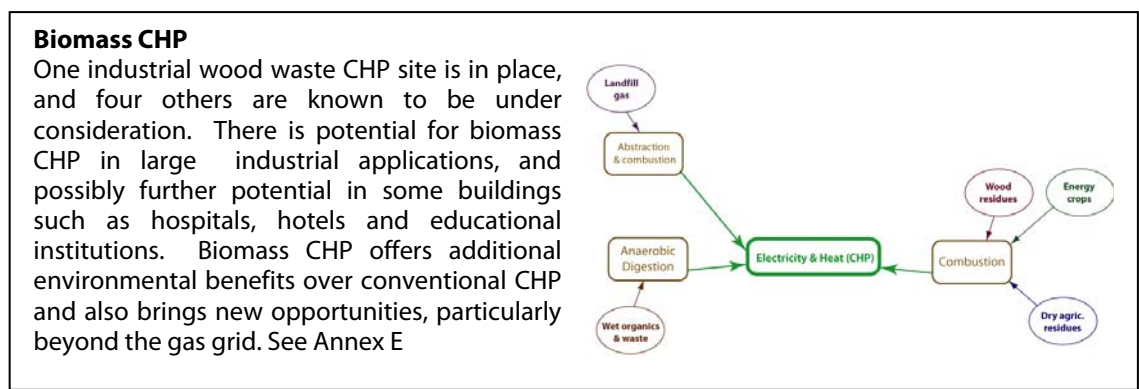
Ireland's agricultural sector creates significant quantities of dry residues, principally straw, poultry litter and spent mushroom compost, all of which can be combusted to produce electricity, heat or both.

Total **straw** production in Ireland is of the order of 1.1 to 1.4 Mt (agricultural reform should see the total resource shrinking over time). Current uses are animal bedding, the production of mushroom compost, and ploughing back. Analysis of the likely energy resource has focused on this third use as the most likely to be available for diversion to bioenergy uses²⁸. Geographical factors are also important; cereal production is most intense in the east and south-east, and the economics of straw utilisation depend heavily on transportation costs.

With a typical energy value of 13.5 MJ/kg (at a moisture content of 20%), the theoretical straw energy resource is calculated to be about 16-20PJ (4500-5500 GWh). The SEI study examining the resource estimated that in reality about 10% of this would be available for utilisation on a practical and economic basis, i.e. 1.8PJ, or 500 GWh.

Much straw is simply ploughed back in to the land, as demand does not exist at good prices for the farmer. Below a price of €30-35 per tonne of wheaten straw delivered, farmers are unlikely to change ploughing in behaviour. But if markets were stable and predictable, prices would not need to rise much to attract significant interest.

Another agricultural residue with significant energy value is **poultry litter**. There are about 14 million birds in the Irish poultry sector at any given time, and an estimated 140,000 tonnes of spent litter is produced annually. At present, the only value added usage for this material is as an input to mushroom compost, which uses 40-70% of the resource, the rest being spread on land for disposal. The key issue is the relative returns from either energy use or land spreading, which will depend on energy prices, land spreading costs, and transport costs. This has a strong geographical dimension. Almost 64% of the total litter resource is produced in County Monaghan, and this region has a limited amount of land available for spreading. In other areas where land spreading is easier, it will be more difficult to attract material away from this easy and established disposal route.



A large bioenergy project is proposed for Monaghan aiming to build a plant to combust poultry litter and wood waste to produce electricity. This project has secured AER VI support, and is currently in the planning phase.

The practical poultry litter resource available for energy is estimated to be 25,000 to 40,000 tonnes. This order of resource could feed an electricity generation plant of size 2.1 to 3.5 MW.

²⁸ Bioenergy resources from dry agricultural residues have been estimated in detail in an SEI study, *An Assessment of the Renewable Energy Resource Potential of Dry Agricultural Residues*. 2004.

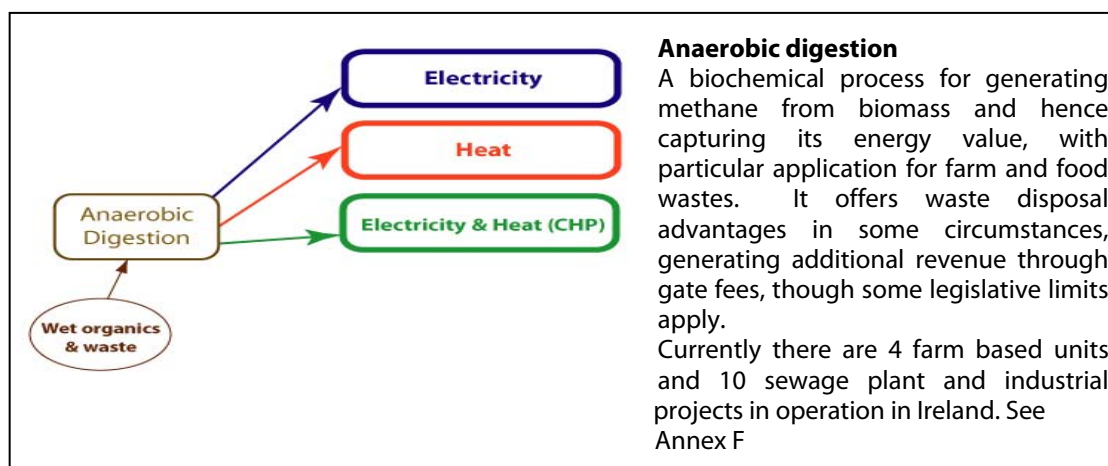
The Irish mushroom growing sector produces about 290,000 tonnes of **spent mushroom compost** annually. Most (over 80%) of this resource is currently disposed of through land spreading, and so should be divertible to energy uses. Again, there are areas of high production where land available for spreading is very limited (principally Cavan and Monaghan). The best estimate for the practical resource is about 62,000 tonnes (utilisation obviously depends on the relative economics of spreading and energy production). This represents an energy value of about 0.2 PJ (i.e. it could supply an electricity plant of size 1.85 MW).

Wet residues

Four main types of wet residues serve as possible bioenergy fuels:

- Manures and slurries – produced on farms and currently mostly managed by land spreading. In some areas of the country, land availability puts pressure on this management method (and the Nitrates Directive will increase such pressure), and energy conversion could help provide solutions.
- Food industry residues – Dairy and meat processing industry residues, and catering wastes²⁹. These are currently a waste stream with disposal costs, but are often available in large or concentrated form amenable to energy conversion through anaerobic digestion. Meat and bonemeal (MBM) is a special subcategory, where high temperature disposal is now required, and energy extraction in this process should be an important element.
- Sewage sludge – many sewage treatment works already employ anaerobic digestion to process treatment residues otherwise sent to landfill, and usually utilise the heat produced on site. Such activities could be expanded, particularly as pressure to divert materials away from landfill grows. This again represents a resource available in large quantities at specific sites.
- Organic fraction of municipal solid waste – organic waste is available for either composting or anaerobic digestion, and both pathways should grow strongly in the face of strong landfill reduction targets.

All these wet residues have potential deployment in combustion or digestion processes for energy production, and their processing can bring additional environmental benefits in terms of reducing the volumes and potencies of the waste streams. They can also benefit from gate fees where waste disposal costs are avoided and waste owners are ready to pay for their treatment. However, the resource can be dispersed and difficult to gather in sufficient quantities (especially farm wastes). There are also legislative, political and social hurdles in treating such materials, especially through combustion.



²⁹ The use and disposal of AD residues based on animal by-products or catering wastes must comply with Regulation (EC) No. 1774/2002 laying down health rules concerning animal by-products not intended for human consumption. It must also take national legislation into account, notably the prohibition on the Use of Swill Order, 2001 (S.I. 597 of 2001) and the Transmissible Spongiform Encephalopathies (TSE) and Meat and Bone Meal and Poultry Offal Order, 2002 (S.I. 551 of 2002).

Landfill gas

The decomposition of organic wastes in landfills releases large quantities of gas, mostly methane, which can be captured and combusted to produce energy. This is a low cost energy source, requiring only the technical installation to capture and convert the gas.

There are currently 5 landfill gas utilisation projects in Ireland, all operated by one company and all supported under AER. These represent a total capacity of 14.7MWe, with a further 6.755 MWe coming from two projects supported under AER VI. Many other sites could be exploited, but timing for extraction is crucial; the resource must be utilised in the coming decade or it will be lost. On a given site, utilisation depends on gas quality, yield and economics of extraction, which in turn are related to scale. Into the future, policy is moving strongly away from landfill and this will reduce the available resource. On the other hand, any new landfill sites will be larger and more modern in design and management than the typical current site, and so exploitation of the resource will become more economically viable.

3.2 The Extent of the Resource

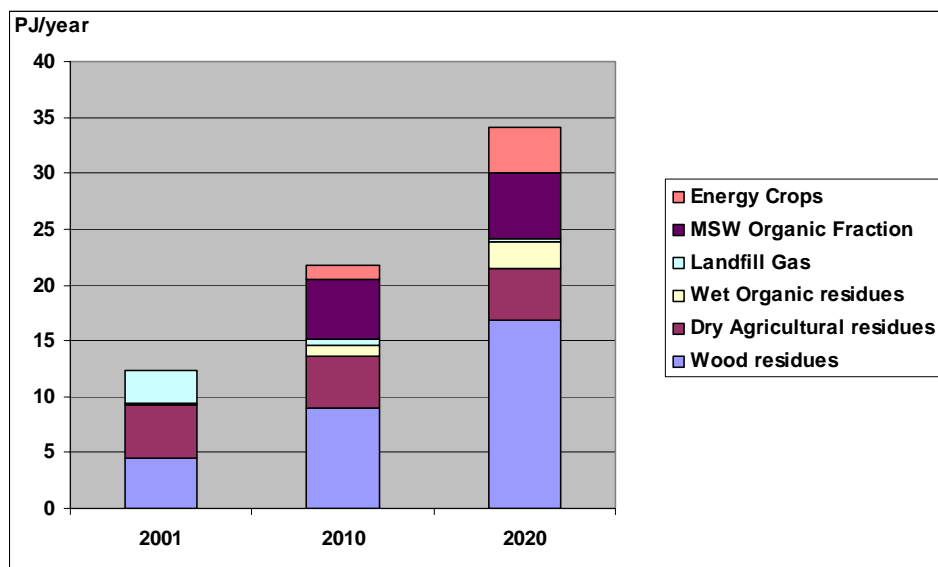
Biomass resource data must be used with care and qualified with the assumptions made to generate them. Here, resources have been estimated by first assessing the theoretical resource, meaning the full extent of the resource irrespective of other uses, or practical or economic questions about collection and energy use. This is then translated into an estimate of the practical resource by considering technical, practical and economic constraints on the full exploitation of the theoretical resources. The detailed calculations for each resource are given in Annex K.

This analysis suggests a total practical energy resource of 21.71 PJ in 2010 and 34.09 PJ in 2020. The practical resource estimates are not absolute and depend on:

- Relative prices between conventional and bioenergy
- Competing uses of biomass (e.g. board manufacture, mushroom compost from straw)
- The practical challenges and costs of extraction, collection, collation and storage
- There are geographical limitations on transportation from source to energy use
- Likely growth of energy crop planting takes account of agricultural policy and supports
- Likely energy conversion pathways for each resource

The practical resource would increase with appropriate economic or policy drivers. Representing these resource estimates in graphical form shows the relative importance of different resources and the increasing size of the total resource over time:

Figure 3.2.1 The growing bioenergy resource



Total primary energy consumption, excluding transport, was 430 PJ in 2002.³⁰

Wood residues are expected to be the most important resource throughout the period in question, barring more significant development of energy crops. Landfill gas will diminish as the resource is tapped and as the use of landfill for biodegradable waste decreases. Energy crops should increase their contribution, especially between 2010 and 2020.

These estimates represent 3.4% of projected total primary energy requirement for Ireland in 2010 and 4.8% for 2020.

This baseline estimate of the practical resource is translated into three scenarios as follows:

- A LOW Scenario – this assumes some improvement in relative prices for renewable energy, some effort to address institutional barriers and limited market competence.
- A MEDIUM Scenario – significant improvement in relative prices for renewable energy, significant movement to address institutional barriers and improved market competence.
- A HIGH Scenario – major improvement in relative prices for renewable energy, success in removal of institutional barriers and the development of a high level of market competence.

Table 3.2.1 Scenarios for bioenergy uptake³¹

	2010			2020		
	PJ/year Low	PJ/year Med	PJ/year High	PJ/year Low	PJ/year Med	PJ/year High
Wood residues						
-Pulpwood residues	0.59	2.95	4.43	1.51	7.56	11.34
-Sawmill residues	0.38	1.89	2.84	0.65	3.24	4.86
-Forest residues	0.52	2.61	3.92	0.63	3.15	4.73
-Recycled wood -C&D residues	0.29	1.46	2.19	0.57	2.86	3.37
	1.78	8.91	13.37	3.36	16.81	24.29
Dry Agricultural residues						
-Straw	0.34	1.69	2.53	0.32	1.62	2.43
-Poultry Litter	0.02	0.09	0.14	0.02	0.09	0.14
-Spent Mushroom Compost	0.01	0.05	0.07	0.01	0.05	0.07
-Meat & Bonemeal	0.49	2.45	3.67	0.49	2.45	3.67
	0.85	4.27	6.41	0.84	4.20	6.31
Wet Organic residues						
-Cattle/pig manures, slurries	0.08	0.33	0.82	0.32	0.80	1.61
-Poultry manure	0.11	0.12	0.16	0.18	0.20	0.23
-Food beverage & tobacco sludges	0.12	0.19	0.24	0.20	0.36	0.46
-Sewage sludges (dry solids)	0.01	0.01	0.02	0.01	0.02	0.02
-Biodegradable MSW	0.09	0.23	0.37	0.40	0.79	0.95
	0.42	0.89	1.61	1.11	2.18	3.27
Landfill Gas						
-Landfill gas	0.43	0.57	0.86	0.16	0.21	0.31
	0.43	0.57	0.86	0.16	0.21	0.31
Waste-to-Energy MSW						
-Waste-to-Energy MSW	4.06	5.41	5.95	4.44	5.93	6.52
	4.06	5.41	5.95	4.44	5.93	6.52
Energy Crops						
-Short Rotation Coppice	0.05	0.59	0.99	0.99	3.51	6.75
	0.05	0.59	0.99	0.99	3.51	6.75
Total	7.59	20.65	29.19	10.90	32.84	47.45

³⁰ SEI, 2004.

³¹ The medium scenario illustrated here is identical to the practical resource estimate with a small adjustment to the energy crops figure: reducing assumed hectare coverage in 2010 from 5000 to 3000. See Annex L.

Table 3.2.1 above summarises the analysis of resource availability under each of these scenarios for 2010 and 2020. It is important to note here that the estimates of bioenergy in these scenarios are additional to the reference case³². The details of all contextual changes in each scenario are not defined in full, but are intended to represent three broadly different cases. The extent of resources available in the low and high scenarios are defined relative to the medium scenario, which is almost identical to the practical resource analysis outlined above. Full detail on the methods used to arrive at these figures is given in Annex L.

3.3 Demand Considerations

Final energy demand (2003) in the main sectors is as follows:

Table 3.3.1 Final energy demand (PJ) in Ireland, 2002³³

	Industry	Commercial & public	Domestic
Electricity ³⁴	25.5	30.0	25.1
Gas	16.7	13.9	22.6
Oil	27.7	33.9	43.2
Coal	11.1	1.5	12.1
Peat & briquettes	-	-	11.3
Renewables	4.6	-	1.8

These figures give a sense of the relative scales of energy demand against likely bioenergy input. Biomass heat markets come mostly from existing solid fuel use with a focus on buildings, which may include large boilers in commercial or public sector buildings (offices, local authorities, schools, colleges), and facilities such as swimming pools, hospital or hotels which have particularly strong heat demands. In the early stages of market development, some large own-use industrial heat applications are the most likely to come on stream first.

At the smaller end of the scale, all 1.29 million households in Ireland (each consuming about 20 MWh of thermal fuels and 5 MWh of electricity per year) represent potential heat users. Additional demand comes through CHP, where again some key industrial sites may be the first users.

Electricity generation from biomass is very unlikely to be demand limited in terms of overall electricity demand, but there may of course be local issues such as grid capacity and connections. The CHP Policy Group is addressing some of the difficulties that independent power producers face in gaining access to the electricity market and securing buyers for the power they generate. Specific CHP opportunities are often determined by the nature of the heat demand, and this places a limit on the number of suitable sites. Co-firing is also of early interest, and is limited more by fuel resources than by potential demand.

3.4 Technology, Expertise and Actors

Technologies for all major bioenergy pathways are well established and proven, and no significant technical barriers exist. However, most technologies have not been well demonstrated and proven in Ireland, and this has an impact on market confidence.

The Irish bioenergy sector is under-developed in terms of expertise and experience. However, the independent energy sector has been growing over recent years, and the renewables sector generally is well established. Many Irish market actors have links with European companies, and across the EU

³² The reference case is defined as existing bioenergy contribution to Ireland's Total Primary Energy Requirement (TPER) plus anticipated developments from existing support programmes (AER V and AER VI)

³³ DCMNR, Provisional energy balance 2003.

³⁴ Electricity figures are final demand; input energy requirements for generation would be about three times these figures

expertise and experience in bioenergy is readily available, and many companies are already looking to Ireland for new business.

Possibly more of a concern is experience on the supply side, particularly for the Irish specific dimensions of energy crops, waste exploitation, harvesting and extraction. For instance, plantings of SRC have been confined to a small number of trials and pilot projects (though SRC has been researched extensively in Northern Ireland), and little work has been done on the suitability of miscanthus grass in Ireland. Similarly, much of the technical development in forestry residue extraction and transport has been in Scandinavia, where ground conditions and scale are very different to Ireland.

The complex nature of bioenergy pathways and the range of raw materials involved mean that there is a large number of actors involved, both on the public sector side and in the markets themselves:

- Government departments – DCMNR; Environment, Heritage and Local Government; Agriculture and Food; Finance
- Public agencies and regulators – Commission for Energy Regulation; Environmental Protection Agency; Sustainable Energy Ireland
- Public bodies – Coford; Teagasc; local authorities; Office of Public Works
- Industry associations – Irish Bioenergy Association and others
- Energy companies; agricultural and forestry interests; the wood processing sector; developers, investors, waste companies, farmers and banks

The tendency of bioenergy issues to cross many sectoral lines is a particular issue for development, as it raises barriers through complexity of regulation, the range of actors involved and the costs of dealing with all relevant agencies or companies. It also necessitates new business relationships, such as farmers selling to power companies or energy brokers, or local authorities or industries passing waste for processing to community based AD schemes.

This creates a need for intervention to minimise the difficulties that arise and to improve coherence and consistency, particularly across the public bodies involved. This will be discussed further in Section 4 of this report.

3.5 What could be achieved – 2010 and 2020

As has been seen, in practical terms there are no demand constraints on the exploitation of the full practical bioenergy resource and more. For most pathways, improved financial returns would generate activity quickly and set the sector on a strong growth path, with positive feedback in awareness, confidence and hence investment activity.

However, a number of important barriers remain in place inhibiting the growth of the bioenergy sector, ranging from economic factors to policy, legislative and institutional issues and barriers in awareness, experience, confidence and market readiness. Section 4 of this report details these barriers as identified by this Group, and Section 5 makes recommendations for addressing these hurdles.

It is the view of this Group that if no action is taken and policy remains as it is now, very little growth in bioenergy will occur, and even the low scenario described in 3.2 is as much as could be hoped for. However, the medium scenario is based on conservative assumptions about price and policy changes, and thus should be achievable. The high scenario is more challenging but still represents something that is well within reach.

SEI has developed an economic model for renewable energy in Ireland. This is still under development, but has been used in analysis for DCMNR's Renewable Energy Development Group. The principles employed in calculating long run levelised costs for bioenergy pathways are set out in Annex L. It should be emphasised that there are many sensitivities in the model, and some elements may change as model development continues. Nonetheless it is useful to consider the results here. Costs cited are considered to be based on conservative assumptions and may overstate the support required.

The analysis indicates that most bioenergy pathways would be able to bring electricity to the grid at prices in the range 9.5 to 11 cents per kWh (with 'best new entrant' gas-generated electricity priced at 5.36 cents).³⁵ Landfill gas is more competitive than other pathways, and the AER VI price of 6.412 cents per kWh should be sufficient to incentivise it.

The Group's target for 2010 (see Section 5.7) is based on the medium scenario of the resource and economic modelling (Annexes K and L) and envisages:

- 22 PJ total primary energy derived from bioenergy
- 822 GWh electricity generated from bioenergy (based on capacity of 140 MWe)
- 3935 GWh heat generated from bioenergy
- Total additional CO₂ emissions abatement from useful heat and electricity generation of 820,000 tonnes per annum³⁶

For the electricity side, modelling suggests that the support costs required to bring this bioelectricity to the market would be of the order of €145 million in total. These are levelised costs, in 2005 terms, over 15 years. CO₂ savings associated with this bioelectricity are estimated at 414,000 tonnes for each of the 15 years. This represents CO₂ abatement costs of about €23 per tonne. Allowing for the useful heat from biomass CHP included in this cost would reduce the figure to €18 per tonne of CO₂. These figures do not include the value of any of the wider benefits of bioenergy. Broadening the analysis to include the use of biomass for heat and all costs associated with the recommendations set out in Chapter 5 gives an estimate of total costs of the order of €190M and CO₂ abatement costs of €16 per tonne.

³⁵ Costs, in 2005 terms, of each kWh produced over project lifetime, counting all capital and running costs. See Annex K.

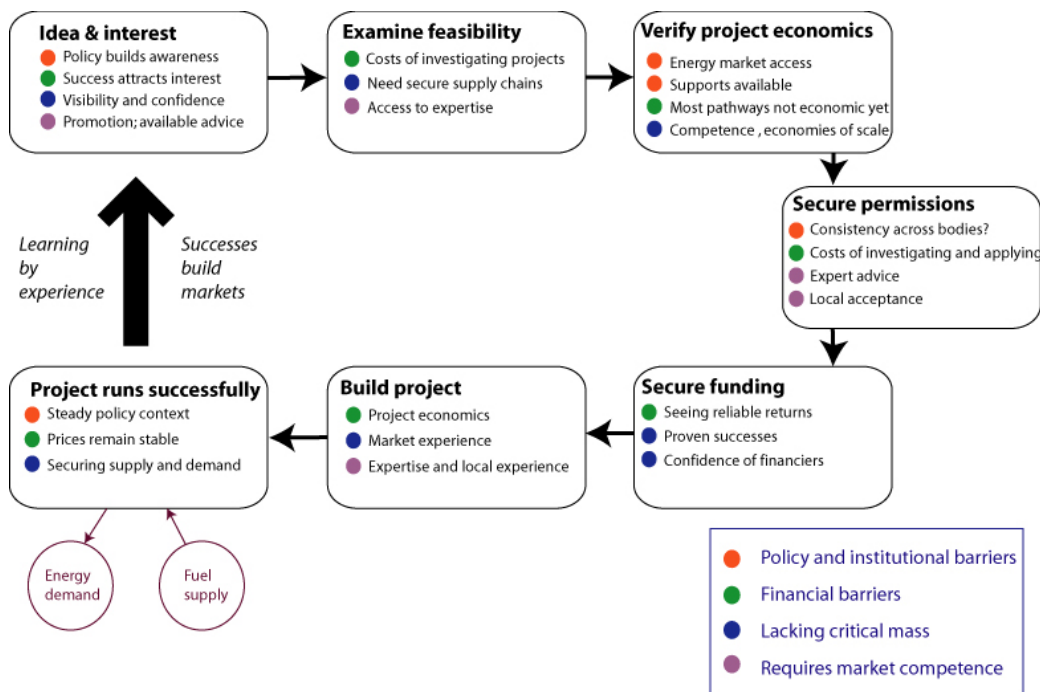
³⁶ Additional to the CO₂ abatement associated with current bioenergy usage. Electricity displaced by new bioenergy is assumed to be generated by the average national fuel mix. Bioenergy heat is assumed to displace oil fuelled heating.

4. Overcoming the Barriers, Developing the Market

4.1 Developing a bioenergy project

Many potential barriers exist for a prospective bioenergy project developer working from the initial interest in such a project through to successful commissioning and operation of bioenergy plant:

Figure 4.1.1 Barriers to bioenergy project development



Some barriers relate to the nascent state of the market, some to the inherent complexities of bioenergy pathways. Not all can be removed, but there are clearly a number of intervention points for government action to minimise barriers and maximise growth. These issues are considered in more depth in the following sections.

4.2 Capital, Equipment and Finance

Capital costs are nearly always higher for bioenergy projects than for conventional fossil fuel equivalents, often by a factor of 2 to 3³⁷. This is largely due to the relatively new technologies involved and the poorer economies of scale compared to conventional energy technologies. Such costs should fall over time, but will remain the principal barrier to bioenergy development for the foreseeable future.

As with most energy projects, rates of return are often low and long project lifetimes are required to make them attractive. This requires security of both supply and demand over many years.

³⁷ RCEP, 2004.

Clearly then, attracting project finance can be difficult, even when the project looks good on paper and a developer is willing to proceed. New technologies, with few local case studies to point to, are often not considered 'safe bets'. As well as doubts about the technologies, the complexities of the supply chain creates uncertainty about viability, as does concern about the security of energy sales over the project lifetime. Long term electricity contracts are one example of a way to address this particular problem, but they must be secure and solid ('bankable') in terms of helping to secure finance.

Although most pathways are not currently economically attractive, many are very nearly so. In several instances, small relative changes in price between fossil fuels and biomass fuels would make bioenergy competitive³⁸. Also, current pricing does not internalise many of the important benefits of bioenergy, including emissions abatement (to be partly addressed in the forthcoming EU emission trading system), strategic advantages (security and diversity of energy supply), and rural development and employment benefits.

4.3 The Supply Chain

Bioenergy pathways involve new relationships among actors traditionally from different sectors. Farmers and energy commodity intermediaries or power stations are not used to dealing with each other, and even simple things like how to contract fuel supply are untested and likely to create nervousness. Until there is scale and experience in these markets, such nervousness will remain.

For wood products and energy crops, the first step in the supply chain is the grower. Growth in forestry planting in recent years means a substantial resource is coming to maturity and it is looking for markets. Forestry growers are now used to providing relatively large amounts of product to board plants and the market is well developed in terms of intermediaries and market experience. It is likely that if large scale buyers were to emerge through energy projects, stable supply chains could be established quickly. However, this is untested. Most large wood energy projects to date are based at wood processing plants, where the supply chains are already in place.

At present, most forestry residues, such as thinnings and stumps, are left on the forest floor; extraction is not economic and demand is low. Technologies for such extraction, developed in Scandinavia, tend to require very large scale operations, and also often do not suit the wet, soft conditions of Irish forests. There may be a technology deficit here, or it may be the case that technologies are available if they could be imported say by a group of foresters to make them economic.

Now is a good time to be approaching farmers about new crops and new opportunities. CAP reform and the single farm payment make innovation and change more attractive and less risky. Farmers can receive their single farm payment and then try growing energy crops for additional income (it is also possible to retain payments when planting conventional forestry). Setaside land can also be planted with such crops. However, both SRC and particularly miscanthus need relatively good quality land.

For farmers to become interested in energy crops, they must see stable markets that will buy the crop at an acceptable price and will continue to do so over several years. The RCEP report sets out the range of factors determining the economic viability of growing energy crops³⁹:

- crop yields
- the level of grants available for establishing the crop
- set aside payments for land used
- the costs of maintaining and harvesting the crop
- the market for the fuel and payments made for it
- costs of removing the crop at the end of the growing cycle.

In terms of security of markets, there is some experience in the UK that indicates what is required. Contracts with two to three year horizons (post-harvest) seem to offer enough security to farmers, and government guarantees to buy crops in the event of project failure can clearly raise confidence.

³⁸ E4Tech, 2003. *Biomass for heat and power in the UK, a techno-economic assessment of long term potential*. London: DTI Renewables Innovation Review.

³⁹ RCEP, 2004

For agricultural residues, much of the resources (in spent mushroom compost, poultry litter and pig slurry in particular) are concentrated in a small number of geographical areas, and so collection and transportation should not represent a major barrier to their use for energy. However, the energy quality of these materials is poor, and the total extent of the resource will not support many large projects. For other such residues, such as straw or cattle slurry, the resource is more dispersed, and smaller projects, possibly farm based with several farmers contributing resources, are more likely to be practicable. This model is commonly employed for farm residue AD projects.

For waste in general, disposal is already in crisis and new sinks for waste should find it easy to secure supply, and indeed to charge gate fees. However, long term supply reliability may be difficult to achieve and gate fees may not provide reliable revenue into the future if the waste streams start to have positive value associated with them. There are some legislative issues about waste disposal and utilisation (of animal by-products for example, see footnote 29). Sewage sludge represents a resource that is already collected and centrally processed in large quantities, and indeed many such processing operations already employ AD. Many of these AD units are known to be interested in or capable of taking in other additional resource streams.

Issues vary for different pathways, but the common imperative is to establish new markets and relationships, and build scale and confidence. There is circularity here, reliable markets need projects and experience, but projects will not emerge until developers and financiers see evidence of reliable supply chains. Special large projects, such as a co-firing project at a large plant, with appropriate state backing (at least in terms of guarantees), could kick start supply chains and develop interest, but run the risk of excessive dependency.

A specific barrier exists in relation to co-firing at peat fired generation plants. Edenderry Power and the two new ESB peat stations all have long term fuel supply contracts with Bord na Mona. It may be the case that if these plants decided to reduce their peat fuel input in preference for biomass they would still be liable to pay their supplier for the fuel displaced. If this were the case, the economics of co-firing would clearly be undermined.

4.4 Information, Market Awareness

Interest in renewable energy has grown strongly in recent years, due in part to strong public marketing programmes, the AER process, and growing international interest. For wind energy in particular, there are many interested developers, land owners and communities, although some of this interest has been negative as many communities have reservations about large wind turbines in their localities.

The activity in the wind sector has developed market interest and competence, and this could become the nucleus for growth in the bioenergy sector. Many companies are already looking at bioenergy opportunities in Ireland.

Demonstration projects and case studies are an important means of building awareness and confidence. SEI and its REIO are active in this area, but there are limited published case studies, and stories of high profile failures can have more of an impact than many small, low key successes. There is a need to disseminate more of the successes and good news stories.

Domestic expertise in many aspects of bioenergy is low, but there is plenty of international expertise and experience available, and the lack of domestic expertise does not seem to represent a major barrier. Developers report ready access to the expert advice they require. Lack of awareness among financiers is probably a greater barrier. State action in raising awareness, building confidence and reducing perceived and actual risk is a priority. As with many barriers, if economic returns improved, it is likely that activity would develop quickly. This would bring the benefits of building awareness and confidence as technologies are demonstrated and supply chains and intermediaries prove themselves.

4.5 Institutional Hurdles

A strong message the Group heard from developers and prospective developers is that treatment of bioenergy by public agencies and departments is not perceived to be consistent or transparent. Projects will need to investigate planning permissions, waste or IPPC licences, electricity market rules, grants or other supports available (ranging from R&D funds and tax incentives to agricultural supports). Developers often find it difficult to perceive that basis on which the agencies involved are evaluating their proposals. It is widely perceived as difficult to obtain guidance on whether planning permissions or licences will be attainable, or what might be the key issues to address, and this can mean going through lengthy and expensive processes with no certainty about the outcomes. Developers seek some guidance early in the process to help them understand what is required of them.

At a higher policy level, the lack of a national bioenergy policy, with visible Government interest in bioenergy and a common national approach, has many impacts on market development. Many policy areas have an impact on the potential for bioenergy:

- Environmental policy – waste policy (landfill, waste to energy, composting, treatment of special wastes), pollution policy (air emissions, licensing) planning and public involvement
- Agricultural policy – strategic priorities for farming, policy towards spreading of slurries and wastes, supports and guidance available
- Energy policy – renewable energy goals, priorities among renewables, prioritisation of heat or power, strategic goals such as indigenous energy supply, electricity market arrangements
- Financial policy – grants, fiscal incentives, carbon tax and emissions trading
- Enterprise and employment policy – local and rural development

This list is by no means exhaustive, but demonstrates the range of policy areas that have an impact on bioenergy – either in terms of bioenergy furthering policy goals or policies in these areas affecting bioenergy pathways. To date a coherent examination of bioenergy interests across all these areas has not been carried out.

4.6 Education and Training

For renewable energy, there are many informal and ad hoc training opportunities in Ireland, such as conferences and short courses. There is also a very small number of renewable focused formal courses, such as the Tipperary Institute's Certificate in Renewable Energy. New courses are being developed at present, including new degree programmes with a focus on renewable energy.

The DCMNR renewable energy consultation document emphasises the importance of training in the sector and the possible need for intervention to stimulate its progress. A bioenergy training needs assessment exercise has been commissioned by SEI.

A strong need is a greater renewables component in many conventional technical courses, rather than specialist courses per se. There is a particular need for training for technicians. All energy equipment installers should receive at least some training in new bioenergy technologies. Some one-off courses are already taking place, in topics such as installing wood fuelled heating systems. Architects and specifiers are also an important target audience. In addition, establishing quality assurance and certification systems may be as important as developing new training courses.

A training and certification scheme for professionals involved in renewable energy projects has been undertaken by SEI and Action Renewables, supported by the EU Interreg Programme. The Renewable Energy Academy, as the project is called, will train and certify professionals, focusing on installers and designers. It should build confidence in the professional services available for renewable energy technology installation.

5. Conclusions & Recommendations – Realising the Potential

5.1 Introduction

Wind energy in Ireland has grown from a very low base in 1996 to 229 MWe of installed capacity (including a large recent contribution of 25 MWe from offshore wind), an annual growth rate of 55%. This compares with an annual growth rate in bioenergy deployment of 3% in the same period. It is important to ask if lessons can be learned for bioenergy.

The EC ascribes wind energy's success across Europe to programmes that put attractive supports in place, removed administrative barriers and guaranteed fair access to the electricity grid⁴⁰. Similar issues of importance were identified by the Irish Wind Energy Strategy Group, established by the Minister for Public Enterprise, which published its findings in 2000. Its report identified three key elements for ensuring wind energy's growth; the electricity market, the electricity network, and spatial planning (this latter being a major issue at the time but now seen as largely solved). It is also the case that wind energy is generally the most economically competitive among renewable electricity technologies, and that the AER scheme has been successful in bringing many developments to fruition. The Strategy Group recommended that a proactive pro-wind energy policy be put in place that would help address the key issues in a co-ordinated and coherent manner⁴¹.

A similar approach to bioenergy is now called for. A strong policy needs to be put in place that will lead towards enhanced awareness, improved coherence and co-ordination and new momentum in the market. This policy should be backed by an implementation strategy with strong but realisable targets aiming to ensure consistency across all policy areas and all public bodies; focus on lowering of key hurdles; and improve the economic returns of bioenergy projects by valuing their full benefits.

The following sections bring together the full recommendations of this Group to address these key imperatives. Some interventions relate to all bioenergy, others to specific pathways. They may relate to the environment for bioenergy as a whole (such as supportive policy) or may aim to address specific barriers on either the supply or demand side.

5.2 Priority Bioenergy Pathways

The following bioenergy pathways have been selected as appropriate priorities for attention and the most likely to achieve success in Ireland. This analysis is based on the scale of their potential contribution, economic attractiveness, timeliness, benefits and their importance in preparing for the long term future of bioenergy. The assessment of priorities also includes qualitative judgements as to which pathways are closest to market readiness, face fewest barriers, and are of adequate scale to justify developmental effort.

⁴⁰ DG Energy and Transport, Presentation to *International Conference for Renewable Energies*. Bonn, June 2004

⁴¹ Renewable Energy Strategy Group, 2000. *Strategy for Intensifying Wind Energy Deployment*.

Pathway	Scale of potential contribution & timeframe	Amenable to intervention	Comments
Co-firing	High potential in short term	Opportunity for policy intervention to push co-firing in peat fired electricity plants in particular, also possibilities for co-fired heat	Could quickly develop scale and security in supply chains and have a significant impact by 2010
Industrial wood residue CHP	High potential in short term	Many sites ready if returns improve	Biomass CHP extends range of CHP and brings additional benefits. Could have a significant impact by 2010
Anaerobic digestion	Lower potential, but could deliver impacts in short term	Role for the Department of Agriculture and Food in reviewing restrictive legislation, and also possibly in information	Many additional environmental benefits, amenable to farm and community based units
Landfill gas	Ready for quick implementation	Could be driven through waste policy and also supported for electricity sales	A significant resource that should be exploited rather than allowed to dissipate. Could have a significant impact by 2010
Wood heat in buildings	High potential, available in short term	Public sector initiatives to kick-start, also targeting the domestic and commercial sectors	Could allow bioenergy to become established across all sectors, and exploit Ireland's strong wood resource advantage. Plenty of private sector potential also.
Energy crops	High potential, but over longer time	Support via agriculture policy	Important for agricultural development and essential to build the resource for the future

5.3 Policy, Strategy and Institutional Recommendations

Bioenergy is ready to grow strongly in significance as a source of renewable energy, and it is environmentally and strategically important that this happens. The first step in this is a strongly articulated Government policy backed up by a strategy for action with ambitious but realisable goals.

Both policy and strategy should be based on the following principles:

- Rationality and consistency – across all Government Departments and Agencies, and treating all alternative energy pathways on the same basis of economic, environmental and strategic evaluation
- Acknowledging the wider national benefits – seeking to capture benefits not currently priced
- Setting a road map and implementing the actions required to deliver the targets
- Harnessing the capabilities that already exist in Ireland, in both the public and private sectors
- Building on experience and learning over time – allowing for flexibility and learning by doing

This should be led by DCMNR, supported by SEI. Each Department (especially DCMNR, DAF and DoEHLG) would then need to take full responsibility for aspects relevant to them. Such a process should start with a signal of strong, long-term Government support, preferably from the highest level.

In order that such a strategy is delivered coherently and effectively, this Group strongly recommends the establishment of a Cross-Departmental Bioenergy Group charged with co-ordinating delivery of measures, monitoring progress and achieving the goals.

Developers perceive difficulties in understanding the needs of planning permission processors or in seeing consistent treatment of bioenergy projects. Interventions should be considered that will bring transparency and consistency to the process. The best mechanism to achieve this is currently the subject of discussions between SEI and DoEHLG. Developers have expressed similar concerns about EPA licensing procedures, and again ways to bring transparency and offer guidance should be considered. SEI should engage EPA and DoEHLG in further discussions on this issue.

Targets for the development of bioenergy on a regional basis would be strong incentives for local action and would promote positive approaches to planning issues. Such targets should be based on studies carried out with the close involvement of the local community and all stakeholders.

Co-firing at electricity generating stations could prove to be a major boost to the development of bioenergy, creating strong demand and allowing supply chains to develop. It is established that co-firing at existing and new peat fired generators is both feasible and economically attractive; the actual costs of peat and biomass fuels are similar. However, it seems likely that contractual arrangements with the peat fuel supplier, Bord na Mona, and Public Service Obligation arrangements could represent barriers to such co-firing. The potential benefits are such that DCMNR should address these issues to ensure co-firing can be taken forward.

An environment that recognises and values all of the benefits of different energy pathways will support renewables and CHP to the correct extent, and the central goal is to create market conditions that allow this to occur. In this regard, the Group supports the recommendations of the CHP Policy Group that seek to ensure appropriate treatment of embedded generation and green autoproducers in the market. Key issues are clarity and appropriateness of procedures, delays in getting grid connections and the costs of connection.

	Recommendation	Pathways	Supply/demand	Actors
1	Publish a strong clear Government policy	All	All	DCMNR
2	Publish national targets for bioenergy	All	All	DCMNR
3	Publish and implement a strategy for action based on this report	All	All	DCMNR/SEI
4	Establish an inter departmental bioenergy group	All	All	DCMNR/DoEHLG/DAF/SEI
5	Push for clarity in and offer informational support on planning and licensing processes	All	All	SEI/DCMNR/DEHLG/EPA
6	Commission studies of regional bioenergy potential, then establish regional targets	All	All	DCMNR/SEI
7	Facilitate and promote co-firing at peat fired electricity plants	Co-firing	Electricity	DCMNR
8	Support grid recommendations of CHP Policy Group particularly regarding embedded generation issues	All	Electricity; CHP	DCMNR/CER

5.4 Financial Supports

Financial support for bioenergy is merited because there is not yet a mature, fully functional market in place. It is an infant industry that needs support to allow confidence and experience to grow into its potential as a valuable and strategically important sector. Current market prices fail to value many of the benefits of bioenergy, and the state should pursue these benefits. Across Europe, financial support has been found to be effective and indeed essential to establishing bioenergy on a strong footing.

Government has now made a decision not to proceed with the proposed carbon tax and to ensure compliance with Kyoto related emissions abatement targets through other programmes and

measures. EU ETS will bring some carbon rationality to energy prices, although only time will indicate to what extent, and not all emissions are covered.

This Group believes that a bidding type system is not the appropriate mechanism for future incentivisation of electricity production from biomass; it has had limited impact to date.

Supporting the demand side – Electricity

The aim of any intervention is to improve the project investment in terms of rate of return or payback, hence attracting developers to projects and also making it easier to secure finance. This is often best done at the point of selling the output, to link the support directly to the benefits obtained. For electricity from biomass, this means some form of price support and secure access to the electricity market. Several options are available, and each has strengths and weaknesses.⁴² This Group believes that the best option at this time would be feed in tariffs, with tradable renewable obligation certificates (ROCs) as a second option. SEI's economic analysis suggests that feed-in tariffs in the range of 9.5 cents to 11 cents would be adequate to achieve impacts, with the exception of LFG, which is more competitive and should be incentivised adequately by the AER VI price of 6.412 cents per kWh. Ongoing economic analysis is expected to refine these price estimates (see Section 3.5).

Feed in tariffs can be set at levels that provide the appropriate support to renewables in terms of requisite rates of return and project security. Such tariffs are more bankable than other supports (including ROCs), and offer transparency and certainty to developers. They can be set at different levels for different resources or technologies, according to policy goals or market conditions. However, since the tariffs are set by the administrators and not subject to competition, it is important that they are set at the right level to avoid over-paying for the benefits. It is possible to set feed in tariffs that decrease over time, or that are linked to project rates of return. Nine EU states have used feed-in tariffs to successfully support renewables penetration. They are well proven in their effectiveness, have low administrative costs, and proven models are available.

ROCs can be driven by and linked directly to targets for renewable energy; the market sets prices required to meet the targets and the mechanism can sit in parallel to the electricity market without affecting the market operation. ROCs can cover both heat⁴³ and electricity, and even allow for inter-exchange at a carbon rational exchange rate. A system of guarantees of origin is required under the RES-E Directive (Article 5), so much of the work of setting up the system is going to happen anyway (preparatory work is underway by CER). Evidence from the UK is that ROCs can deliver strong support to the renewables sector. Northern Ireland is in the process of implementing ROCs and so the possibility exists for a future all-island market. However, some states have come to the conclusion that tradable certificates are not necessarily the lowest cost way to support renewables. Also, they rely on a strong degree of competition in electricity supply, a condition that may not yet be met in Ireland. No state has set banded ROCs, so they are always neutral as to which source of renewable energy is supported. This has meant that they tend to support the source that is currently cheapest, usually wind, and not the wider set of renewable energy sources that merit support for a range of reasons.

Support needs to be visible and dependable when investment is being considered or finance is being sought – it needs to be 'bankable'. Thus any price support mechanism needs long term reliability and needs to be underpinned by well designed rules of access to the grid, and power purchase agreements. For industrial companies there is ongoing competition for capital and acceptable rates of return must be achieved. Feed-in tariffs may not be adequate in some cases and capital support (grants, tax incentives) maybe be required. After 2010, re-evaluation will be required to identify the most suitable support mechanisms for the subsequent period.

Supporting the demand side – Heat

Heat does not have a centralised market nor is the supply of heat usually metered, and so must be supported in ways other than centralised price support. Also, the heat market extends to smaller and more diverse situations, with particular potential for bioheat systems for houses and commercial

⁴² See DCMNR consultation document for further discussion

⁴³ ROCs can extend to heat if remote monitoring metering is installed, but no EU states have developed such a system to date. The RCEP has recommended such a system to support bioenergy in the UK.

buildings. Bioenergy heat systems (mostly wood fuelled) are now widely available, but their capital costs are considerably higher than oil or gas fired equivalents. At the smaller end of the market, additional market failure exists in that most investment decisions are not made on a life cycle cost basis but simply (or mostly) on initial costs, so the financial benefits that may accrue to a bioheat system are not considered. It seems clear that the bioheat market will not develop without support to reduce capital costs. Such *pump-priming* support could allow for early market growth, leading to increased competence and confidence and to economies of scale. At this point, the capital support would no longer be required.

Thus the Group recommends grants or fiscal incentives to support bioheat systems for buildings at the domestic and small commercial levels. Grants could be made available for the installation of specific named bioheat systems, with suppliers applying to have their systems included on the list. These grants should be capped to the appropriate scale and should be available for a fixed period of time (probably of the order of 3 to 5 years at most), or be based on a fixed fund. Such grants could be administered very efficiently, for example through licensed equipment suppliers, or could take the form of tax incentives. As an indication of scale, grants or tax incentives of about €2000-€3000 may be required to support domestic wood fired boilers (this is typical of grants employed in other states). Thus if a penetration of 2000 households were the target, a fund of about €5M may be required.

Supporting the supply side – Energy Crops

Once demand is strong and chains are well developed, farmers should be interested in planting energy crops for their economic returns. However, until the market grows, a disjuncture exists where the demand side cannot grow without supply, and supply will not be put in place until demand is seen to be reliable. To fix this problem, growth in supply needs to be stimulated through financial support so that farmers become willing to plant before seeing a fully developed demand market. As with the proposed bioheat supports, such support can be for a fixed period of time, as it should not be required once the sector is fully up and running. The Group recommends that a grant or other fiscal incentive for growing energy crops be incorporated into the framework of rural development support. Ireland should continue to lobby for the inclusion of such a measure in EU discussions on the next phase of rural development support, 2007 – 2013⁴⁴. Mechanisms to deliver support in the shorter term should also be considered. The Northern Ireland SRC Challenge is a good model of using a fixed fund to maximise interest and planting in the early stages of market development, and indicates the scale of support required. Grants are expected to be of the order of €3000 per ha in this scheme (considered quite generous by international standards). At this price, a fund of €15M would be required to stimulate the planting of 5000 ha.

	Recommendation	Pathways	Supply/demand	Actors
9	Price supports for electricity (Feed in tariffs, capital supports recommended)	All	Electricity; CHP	DCMNR to champion
10	Capital grants or tax incentives for domestic and small commercial heat systems	Wood for heat	Heat	DCMNR to champion
11	Fiscal incentives for growing energy crops	Energy crops	Supply	DCMNR, Dept of Agriculture & Food

5.5 Building Critical Mass

While the bioenergy sector remains at its current small scale, a circular pattern exists of demand waiting for the supply side to grow and the supply side needing stronger demand in order to grow.

⁴⁴ A draft Commission proposal for a Council Regulation outlining a suggested framework for rural development support for the period 2007-2013 was issued in July 2004 (COM(2004)490 final, 14.7.2004). Comments on the draft proposal from the Irish delegation were submitted to the Commission in October 2004, including a reference that the proposed Council Regulation address the promotion of the production of biomass.

The market will find it difficult to break this pattern, and public intervention can serve to quickly create demand in specific, local situations that will allow supply chains to develop and confidence to grow.

In the first instance, public sector buildings should take the lead in developing bioenergy systems, particularly wood fired heat (and, where appropriate, biomass CHP). The technology for these systems is well developed and well proven, and can be incorporated in new or existing buildings with little technical modification and little change of current energy practices (particularly for buildings used to coal or oil). Capital costs are higher than for conventional systems, but will pay back over time through lower fuel costs, and the public sector should be in a position to accept slightly longer paybacks to demonstrate systems with wider benefits. The current Government decentralisation programme presents an ideal opportunity for the Office of Public Works to take a lead in promoting bioenergy in new or refitted public buildings. Public housing may also be a target sector.

Beyond demonstration in the public sector, wood heat and other bioenergy systems could have very wide application in many commercial buildings. Planning processes could oblige developers to consider such options, and this will also be driven by the Buildings Directive, which contains a similar requirement. SEI, DCMNR and DEHLG are looking at mechanisms to deliver this, and this is to be encouraged.

A specific recommendation for promoting landfill gas is to encourage all landfill sites to look at gas extraction and exploitation for energy. All landfill developments are obliged to do this under the Landfill Directive,⁴⁵ and the licensing system can best ensure it actually happens. We would encourage EPA to ensure that the licensing system stimulates action and leads to meaningful assessments that properly evaluate LFG opportunities.

	Recommendation	Pathways	Supply/demand	Actors
12	Public building heat exemplar projects	Wood for heat/CHP	Heat/CHP	DCMNR/OPW
13	All large developments to assess bioenergy possibilities	All	All	DCMNR/DEHLG
14	EPA landfill licences to ask for LFG assessment	LFG	Elec (mostly)	EPA

5.6 Developing Market Competence

Significant marketing and promotional activities, and the RE RD&D Programme, are already carried out by SEI, both through its Dublin office and the Renewable Energy Information Office. However, these are part of the general renewable energy activity and carry no specific bioenergy branding. It is recommended that a specific bioenergy identity be introduced ('Bioenergy Action' for example) to bring together both current activities and the new measures recommended below. Resources (staffing and funding) should be ringfenced for bioenergy. If all of the recommendations made here are to be implemented, resources devoted to bioenergy by SEI will need to increase.

There is a long established trade association for the bioenergy industry – the Irish Bioenergy Association (IrBEA). This organisation should be encouraged and supported, as should its co-operation with SEI.

The Group recommends increased marketing activity to develop awareness among all target groups and to provide information and support. Market actors in the renewables sector are generally already aware of and interested in bioenergy, and many are simply waiting for market condition to improve. Key target groups for awareness include potential bioenergy customers (large buildings, public bodies, industry and also householders); and potential actors in the supply chain, such as consultants

⁴⁵ Landfill Directive (99/31/EC); Annex 1, Section 4

and fuel intermediaries. Another key group is the general public, with the need to proactively address potential community concerns about bioenergy projects.

Few involved in bioenergy development are expert in all aspects of the process. Guidance materials for developers should be produced helping them through technical and economic evaluation of bioenergy projects, and the requirements of planning and licensing procedures. Guidance should include model contracts for various key relationships, such as between farmers and power stations, or local authorities and AD systems accepting waste.

Delivery of such guidance and information should be through a 'one stop shop' approach to help overcome the difficulties arising from the wide range of bodies, regulations and permissions that need to be engaged with in project development. The proposed bioenergy promotion unit of SEI could deliver this service. This would also help to address issues relating to obtaining permissions and licences by offering information and guidance to developers.

For a project to proceed the developer, equipment suppliers, resource suppliers and energy users all need to come together in the right way. This can be difficult in a nascent market. SEI should consider how these contacts and relationships can be stimulated and facilitated, possibly through selected consultants or local energy agencies.

A number of bioenergy feasibility studies have been supported by SEI. It is recommended that a guide be produced on how to undertake a feasibility study, based on the lessons learned from these supported studies. This guide for prospective developers could highlight the factors to be considered, questions to be asked, and main sources of information. Feasibility studies should continue to be supported, especially where novel approaches are being taken or where SEI believes national benefits will accrue from the studies.

It is important that the Irish bioenergy industry is in accordance with best international practice. Adherence to best practice guidelines and international and national standards should be pursued, as should accreditation of installers and installations. New training initiatives should be considered on foot of SEI's training needs study currently underway.

Research should be commissioned on the issues for community acceptance of potentially controversial projects and the best ways to address community involvement and information. Another important topic is the harvesting of forestry and energy crops in Irish specific conditions, adapting technologies and practices from other countries. Research is also required into demand and potential for bioenergy in key areas and through key pathways. Ireland should argue for a strong bioenergy component in the EU's Seventh Framework Programme for R&D. This programme will run from 2006-2010, with negotiations taking place across 2005 and 2006. This new programme presents an opportunity to enhance the supports available to bioenergy R&D, for both the technical and socio-economic aspects.

	Recommendation	Pathways	Supply/demand	Actors
15	Create a specific bioenergy support and promotion unit, with its own resources and identity	All	All	SEI
16	Increase general marketing and information activities	All	All	SEI
17	Produce guidance materials for developers on planning, licensing and supports	All	All	SEI
18	Develop model contracts in key areas	Energy crops & others	Supply	DCMNR/SEI
19	Offer a one stop shop service to support delivery through the new bioenergy promotion unit	All	All	SEI/DCMNR
20	Examine ways to offer project contact facilitation services	All	All	SEI

21	Produce a guide to feasibility studies for prospective developers	All	All	SEI
22	Examine new training initiatives	All	All	SEI
23	Consider certification of training and education	All	All	DCMNR/SEI
24	Commission additional research/information projects	All	All	SEI
25	Support bioenergy in EU FP7	All	All	DCMNR/SEI

5.7 Concluding Remarks

The Bioenergy Strategy Group believes that the case is proven for bioenergy as an important element of the development of renewable energy in Ireland. It brings many additional policy benefits over other energy sources, and Ireland possesses both the resources and the demand for exploitation. With appropriate support, bioenergy is now ready to grow rapidly and make a significant contribution to renewable energy targets.

By 2010, bioenergy is capable of contributing to renewable energy targets through a total contribution to primary energy of **22 PJ**, or about 3.5% of Ireland's expected total primary energy requirement. This is the Group's recommended target. It is envisaged that this would include 140MWe of installed electricity generation capacity, providing 822 GWh of biomass electricity⁴⁶.

For 2020, the Group recommends a target of 35.6 PJ, which includes an electricity generation capacity of 375 MWe. These targets are based on the medium scenario of the Group's analysis, with further consideration of the potential contribution from each bioenergy pathway.

Renewable heat is an important dimension of these targets. From a current contribution of 1825 GWh per annum, these targets would see an additional contribution from renewable heat of 2110 GWh in 2010 and 4940 GWh in 2020.

If these targets are met, they will result in additional annual abatement of carbon dioxide emissions from energy production and consumption of 0.82 Mt in 2010 and 2.2 Mt in 2020.

These targets are very realisable, but will require some developments in market and policy conditions. The Group's vision for such conditions in 2010 are as follows:

- A clearly articulated policy, with consistent and transparent treatment of bioenergy, and a stable policy context
- Recognition of the value of heat as an opportunity for renewable energy
- An electricity market that allows access for renewable energy and values its contributions according to its full benefits
- A pricing system that better internalises all costs and benefits of energy from alternative sources
- A bioenergy market based on experience and expertise, with active supply chains, many visible success stories, and confidence among developers, financiers and customers

Internationally, bioenergy is growing in importance and will become a key element of future sustainability for both energy and materials. It is timely to take steps now to ensure that Ireland is not left behind its EU partners, but instead participates fully in these developments and gains the full benefits offered.

⁴⁶ These targets do not include the contribution of Waste to energy, since it is subject to factors outside the remit of this group. Waste to energy may contribute an additional 5.4 PJ of bioenergy by 2010.

Annex

- A. Bioenergy Strategy Group terms of reference
- B. Bioenergy Strategy Group participation
- C. Abbreviations and conversion factors
- D. Co-firing pathway
- E. Biomass CHP pathway
- F. Anaerobic digestion pathway
- G. Landfill gas pathway
- H. Wood heat in buildings pathway
- I. Energy crops
- J. Future technologies
- K. Resource estimation methods
- L. Economic model - Inputs and analysis

Annex A

Bioenergy Strategy Group Terms of Reference

Increased utilisation of biomass for energy use could make a significant contribution to the reduction of Ireland's greenhouse gas emissions whilst increasing security of supply in Ireland (through fuel diversity). Estimates show there to be significant indigenous resources of biomass in Ireland though current usage is low.

The primary objective of the BSG is to consider the policy options and support mechanisms available to Government to stimulate increased use of biomass for energy conversion, and to make specific recommendations for action to increase the penetration of biomass energy in Ireland.

Biomass can be subdivided into wastes (residues from forestry and related industries, recycled wood, agricultural residues and agrifood effluents, manures, the organic fraction of municipal solid waste); and purpose grown energy crops including short rotation coppice and miscanthus grass. The use of biomass as fuel for generation of both electricity and heat are within the remit of the BSG. The use of biomass for production of liquid biofuels (usually for transport fuels) is excluded at this time.

BSG will produce a Strategy Report for publication meeting the objective set out above, comprising text backed up by Appendices. It will contain a road map for development with the identification of staged, achievable targets.

Annex B

Bioenergy Strategy Group Participation

Members of the Bioenergy Strategy Group

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Dr Brian Motherway (Secretary)
Pearse Buckley, Sustainable Energy Ireland
Malcolm Dawson, Department of Agriculture and Rural Development Northern Ireland
Bob Hanna, Department of Communications, Marine and Natural Resources
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Annex C

Abbreviations and Conversion Factors

AD	Anaerobic digestion
AER	Alternative Energy Requirement
CER	Commission for Energy Regulation
CH ₄	Methane
CHP	Combined heat and power
CO ₂	Carbon dioxide
DAF	Department of Agriculture and Food
DCMNR	Department of Communications, Marine and Natural Resources
DoEHLG	Department of Environment, Heritage and Local Government
EC	European Commission
EPA	Environmental Protection Agency
ESB	Electricity Supply Board
EU	European Union
EU-ETS	EU Emissions trading scheme
GHG	Greenhouse gas
GJ	Gigajoule
GWh	Gigawatt-hour
Ha	Hectare
IPPC	Integrated Pollution Prevention and Control
ktoe	Kilotonnes of oil equivalent
kWe	Kilowatt electrical
kWh	Kilowatt-hour
LFG	Landfill gas
MJ	Megajoule
Mtoe	Millions of tonnes of oil equivalent
MWe	Megawatt electrical
MWh	Megawatt-hour
MWth	Megawatt thermal
MSW	Municipal solid waste
NCCS	National Climate Change Strategy
NOx	Oxides of nitrogen
PPA	Power purchase agreement
PSO	Public service order
R&D	Research and development
RCEP	Royal Commission on Environmental Pollution, UK
RES-E	Renewable electricity source – electricity
ROC	Renewable obligation certificate
SEI	Sustainable Energy Ireland
SOx	Oxides of sulphur
SRC	Short rotation coppice
TFC	Total final consumption
TPER	Total primary energy requirement
UNFCCC	United Nations Framework Convention on Climate Change
WtE	Waste to energy

Energy units

1 PJ (peta joule) is 10¹⁵ joules

1 GJ (giga joule) is 10⁹ joules

1 GWh (giga watt hour) is 10⁶ kWh, or 1000 MWh

Conversions:

1 toe (tonne of oil equivalent) is

⇒ 41.87 GJ, or

⇒ 11.63 MWh

In 2002, Ireland's primary energy requirement was

⇒ 14.793 million toe

⇒ 620 PJ

⇒ 172,000 GWh

Annex D

Co-firing Pathway

Introduction

Co-firing is the term applied to adding biomass to the fuel mix of existing energy systems whose main fuels are coal or peat. This discussion focuses on co-firing at electricity generating stations⁴⁷. Such generating stations usually require some technical adaptation to take new fuels, but this rarely represents a significant obstacle. Added percentages of biomass can be up to 30% in some cases. Fossil fuel generating stations can reduce their emissions trading costs and renewable electricity objectives are supported. Co-firing is seen by many EU states as a central component of strategies to meet the RES-E Directive targets. The Netherlands, for example, plan to deliver 34 PJ of bioenergy supply through co-firing by 2010⁴⁸.

Because it provides instant demand for relatively large amounts of biomass fuel, co-firing has the potential to provide significant penetration of biomass in the short term, and to create demand pull to develop supply chains for the wider bioenergy markets. However, experience elsewhere shows that the scale can also have disadvantages, including supplier dependency and competition from imported fuels.

The possibilities for co-firing in Ireland

SEI commissioned a study on the potential for co-firing in Ireland, with the objective of investigating co-firing biomass with traditional solid fuels and quantifying the costs and benefits. Four generating stations were examined in this study;

- Moneypoint – pulverised coal condensing power plant in County Clare, net electrical output of 855 MW
- Edenderry – milled peat fuelled, net electrical out put of 117 MW, operating since 1999 and Ireland's first independent power station.
- Lough Ree – currently under construction, to be commissioned in late 2004, peat fuelled, net power output of 91 MW
- West Offaly – due to be commissioned in early 2005, peat fuelled with a net output of 136 MW

All of these plants take in pulverised solid fuels as their inputs, and so the mixing of other pulverised fuels with the core fuel presents no fundamental problems. Some technical modifications are usually necessary, as different fuels have different properties with regard to burning, emissions, ash and so forth.

The peat fired plants are amenable to higher percentages of biomass co-firing than the coal fired station – Moneypoint could technically take 5% co-firing and Edenderry 20%. With modifications, these figures could rise to 15% and 30% respectively. However, practical and economic levels of co-firing are considerably below these theoretical levels. It is unlikely that it will be cost-effective for Moneypoint to co-fire with biomass in the near future, unless coal prices rise dramatically or emissions trading prices go above €30 per tonne of CO₂. For the peat fired plant, however, co-firing could indeed prove economically attractive. For all three peat plants examined in the study, co-firing up to 30% would be feasible, and is projected to be economically attractive (once emissions trading costs are factored in)⁴⁹.

⁴⁷ Opportunities also exist for co-firing heat systems. Irish industry consumed 266 ktce of coal and petroleum coke in 2003, the vast bulk in the cement industry. All coal or peat fired heat systems have the potential for co-firing with biomass.

⁴⁸ Novem, 2004.

⁴⁹ Supply of fuel would not be available at prices acceptable to the generators were emissions trading costs zero, but once such costs rise to €10 per tonne CO₂, sufficient supply is expected to be available at prices that make co-firing economically beneficial.

Issues for co-firing

If the Edenderry plant co-fired with wood residues up to 30%, this would consume 690 GWh of fuel annually. This compares to the estimated national wood energy resource of about 2500 GWh (8.91 PJ) under the medium scenario. This represents a high proportion of the total national resource, given that there would be constraints on the distance from the plant within which transportation would remain economically viable. It should also be noted that into the future the geographic catchment of the three peat fired plants will overlap, and thus they might be in competition for specific fuel resources. This scale shows both the advantages and disadvantages of co-firing as a route to building the bioenergy sector. No other pathway could provide such large demand for fuel with so little market development – one single buyer and use instead of many disparate customers, locations and uses for any other end use of the fuel. However, the wood sector would undoubtedly be under pressure to provide such a large amount of fuel and it would absorb all available resource in the region. On the other hand, Edenderry would be readily able to adjust its relative use of peat and biomass, and so allow for changes in supply. If existing wood products were the only fuel, it is very unlikely that all three peat stations would co-fire up to their feasible potential. Into the longer term, however, the model of growing energy crops as a fuel for co-firing will become increasingly important, and could represent the means to ensure adequate, reliable fuel provision.

While wood fuels are the most likely to be employed in co-firing, other fuels are possible, and Edenderry Power has shown interest in burning meat and bonemeal. This would extend the resource pool, and also might bring additional revenue through gate fees. The three peat fired stations discussed here have 15 year fuel purchase agreements with Bord na Mona⁵⁰. The agreements are taken to be effectively take or pay contracts, where the power plant must pay for the fuel whether it is taken or not. If these agreements cannot be adjusted, then clearly any co-firing is uneconomic while they remain in place. Since Bord na Mona is a state owned company, it is legitimate to ask the question as to whether public policy is optimally served if such contractual arrangements preclude capturing the benefits of co-firing.

Fuel input changes would entail certain procedural requirements; revision of IPPC licences in all cases and planning permissions in some cases. There may also be a need to review how the public service obligation (PSO) mechanism works in supporting peat fuelled electricity, since similar benefits are gained from biomass fuel. Biomass pathways bring local employment gains as well as the benefits of indigenous energy supply. In itself, it is fully competitive with peat, and it would be unfortunate if the PSO mechanism worked against its exploitation.

Estimates for the prices that the generators could afford to pay for biomass for co-firing in 2010 are of the order of €12.7 per MWh for the peat plants, equivalent to about €23 per tonne of fresh wood residue matter. Such prices are considered to be above the production costs of many wood fuels products and their transportation over reasonable distances (about 50 km), and so should render the supply of fuel economically attractive. However, current estimates of the production costs of SRC willow chips are over €23 per MWh, too high to match the likely demand prices available.

Fuel importation would also be an option for generating stations wishing to co-fire. It is likely that biomass fuels would be available internationally at rates competitive to indigenous supplies, even accounting for transport costs. If plants co-fired with imported biomass, the emissions benefits would remain, but other more local benefits such as the exploitation of indigenous fuels or local economic gain would be lost.

The use of peat for electricity generation is seen to bring employment benefits, and is supported as part of the Public Service Obligation appearing on the bills of all electricity customers. A move away from peat towards biomass as a fuel input is not expected to have significant negative impacts on employment in the relevant sectors, and indeed may bring benefits.

⁵⁰ As well as 15 year power purchase agreements with ESB PES

Annex E

Biomass CHP Pathway

Introduction

CHP is the simultaneous production of useable heat and electricity from an integrated thermodynamic process, usually turbine or engine based.

It is seen as an important technology for energy production since it maximises the extraction of usable energy from its input fuel, and can generate energy at many scales and at any location, whether connected to main grids or not. Most states, including Ireland, have policies and programmes to support the uptake of CHP and targets for its penetration.

The CHP Policy Group is currently considering the issues for CHP in Ireland, including updating targets and proposing new policies and measures for support. This group is dealing with the general issues for all CHP, many of which relate to electricity market and grid access arrangements.

A special category of CHP is that fuelled by biomass fuels. Biomass CHP brings all the benefits of conventional CHP (including optimal conversion efficiency, embedded generation and flexibility) but also brings wider benefits. These include the additional environmental gain of carbon neutrality, and the extension of CHP potential beyond the natural gas grid (the vast majority of CHP is gas fuelled, and projects are rarely considered where gas supply is not available).

Biomass CHP is most commonly fuelled by wood, either as chips or pellets derived from sawmill residues, recycled wood, or forestry thinning and residues. It may also be fuelled by other biomass inputs such as straw or, via anaerobic digestion, by wetter materials such as agricultural slurries.

Status and potential

There is currently 131.5 MWe of CHP in Ireland, spread across 105 units. There is only one biomass CHP unit at present, a 1.9 MWe (and 3.5 MWth) system fuelled by bark, sawdust and woodchips, based at a sawmill plant in County Cork. This system was commissioned in mid 2004. It was supported by grant aid, and also has a ten year power purchase agreement (at about €0.07 per unit).

Looking at the scale and geographical spread of the resource, there is probably scope for just 2 or 3 big projects in Ireland, then a larger number of mid range projects. The sawmills and boardmills are the obvious first target group for the larger systems⁵¹. A wider range of potential applications exist for mid range sites, including many industrial sectors such as agri-food, and possibly also in large commercial or public buildings.

Issues for biomass CHP

Most of the barriers that apply to uptake of CHP also apply to biomass CHP. These relate mostly to selling electricity; from grid connection issues to market access and pricing. There are important policy issues here, and these are being addressed by the CHP Policy Group. This discussion is limited to issues specifically relating to biomass CHP.

Large CHP units entail substantial fuel supply that must be secure and reliable. As an indication, a 20MW unit would require an input of about 10 tonnes of wood fuel per hour. This may impose a practical limitation. The scope for such large units in Ireland may be limited, but the scope for mid size units (of the order of 1 to 3 MWe) is considerably greater.

Grainger's Sawmill in County Cork have installed the first biomass fired CHP unit in Ireland. Using residues at the plant as fuel, the CHP plant is designed to generate 1.9 MW electrical energy and 3.5 MW of thermal energy. The thermal output is used for drying of construction timber in the sawmill kilns. The electricity is sold to the national grid, with a power purchase agreement attained in the AER process. The project was granted aided by SEI. The site already utilised residues in a heat boiler, and decided to look at CHP as an alternative to expanding the heat unit to fully meet its needs. Fuel input is bark, sawdust, peelings and forest residues and may have a moisture content as high as 65%. The CHP unit consumes about 20m³ of fuel per hour.

⁵¹ One of these could be Weyerhaeuser in Co. Tipperary, which consumes 650,000 green tonnes p.a. to make MDF. The site is already the largest bioenergy producer in Ireland, generating heat from wood wastes and recycled wood. It is currently investigating bio CHP as an option, and estimate that an additional 100,000 tonnes of wood would be required annually to fuel such a system.

Annex F

Anaerobic Digestion Pathway

Introduction

As an alternative to direct combustion, the energy value of wet organic materials can be extracted through anaerobic digestion – the breakdown of organic materials in an oxygen free (anaerobic) environment producing gas that is typically about 65% methane, which is then combusted to produce heat, electricity or both⁵².

Materials that can be processed in this way include agricultural manures and slurries, food processing and catering residues⁵³, the organic fraction of municipal waste, and sewage sludge.

As well as the gas from the process, a liquid digestate is produced which has the potential to be spread on land for its nutrient value (subject to compliance with National and European legislation). This digestate is nutritionally valuable as it contains inorganic forms of nitrogen, which are more easily absorbed by plants, is of consistent quality, and can be used throughout the year.

As well as its benefits as a carbon neutral fuel, it also reduces greenhouse gas emissions by capturing methane and converting it to carbon dioxide (also a greenhouse gas, but 21 times less potent than methane). If the conditions are right, AD can provide an integrated solution to waste processing, land spreading of nutrients and energy generation.

European experience

In Denmark, there are about 40 farm based plants, 20 co-operatively owned and 5 industrial plants, and 64 plants at sewage treatment works. Drivers have included legislation on nutrients to ground water and slurry storage, capital support grants, CO₂ taxes, and access to special loans. Experience points to the value of a co-ordinated support approach across relevant bodies.

In Germany, there are over 2000 farm based plants and over 4000 sewage works plants. This penetration has been driven by favourable electricity feed in tariffs and other supports. Growth has been very strong for over a decade. Austria is also strong in this area, with about 130 farm based, 25 industrial and 134 sewage works plants. Drivers here have been capital grant support, training programmes, and high general electricity prices.

Current state and future potential

In Ireland, biogas is currently produced at 4 farms and 10 sites in industry (food sector) and at sewage treatment plant. Biogas production increased from 2.3 ktoe to 4.3 ktoe between 1990 and 2002.

In theory very large amounts of digestible materials are available. The important analysis is that of estimating what proportions of these materials are likely to go to AD processes. All the main resources have competing uses.

National targets for reduction of materials to landfill, driven by the Landfill Directive, should see very significant decreases in landfilled MSW. This will be achieved by a combination of waste reduction and increased recovery. The recovery paths available are recycling (meaning composting for biodegradable wastes), AD for energy, or waste to energy thermal treatment. Thermal treatment is more appropriate for non-degradable fractions so the balance of interest here is that between composting and AD. This will be influenced by policy and market conditions.

For wet agricultural residues, management is either by means of land spreading or AD. Land spreading is predominant at present. Into the future, the Nitrates Directive will see more emphasis on nutrient management, and this may encourage AD of slurries and manures in some cases, particularly

⁵² The biogas can alternatively be used as a transport fuel, or even upgraded to pipeline quality for addition to the natural gas network

⁵³ See footnote 29 for legislative restrictions

at pig and poultry farms, where nutrients are created in high concentrations, often in areas with limited land available for spreading. As with biodegradable MSW, policy will direct which use dominates, and competing routes should be evaluated fully for all their costs and benefits.

Food and catering residues are generally considered wastes with no latent value, and thus should be more readily available as inputs into AD, although there are legislative issues, particularly for wastes with meat content. Similarly, sewage sludge is usually seen as waste with negative value, often sent to landfill at present. Again, it could represent a resource, possibly with additional gate fee revenues attached.

Issues & barriers

Technical barriers to AD development in Ireland include unfamiliarity with the technology, with a limited number of working examples. Some slurries are seasonal in their supply (with the notable exception of pig slurry), and the waste element remains subject to complex legislation. There are also financial barriers, including low AER prices, high cost of grid access, lack on internalisation of wider environmental benefits, and the difficulties and cost of accessing finance. Other barriers include the lack of an integrated public support framework and lack of awareness and training.

AD of animal manures is closely linked to the issue of land spreading, with the sizing and location of farm based AD units often determined by the land available for the spreading of the digestate produced. An advantage of this digestate over the undigested slurry is that the nitrogen content has been transformed from organic to inorganic form, which is more readily taken up by plants.

For small scale units, planning and licensing processes are relatively straightforward (though not simple), but awareness of and confidence in the technology remains a concern. For larger units, planning remains a barrier, with concerns about community support, and licensing and environmental impacts assessment is more complex. Finance can be difficult to attract, due to perceived risks. There may still be a role for demonstration of certain types of system to build market confidence⁵⁴.

Clonmel Borough's waste water treatment plant uses anaerobic digestion to process sludge produced at the plant. The treatment plant treats the sewage from about 17500 domestic population, plus an industrial waste-water burden of 35000 persons-equivalent. The sludge, which would otherwise require disposal at landfill, is transformed through AD into an agricultural fertiliser. The gas generated is used in a CHP unit to generate heat and power utilised in the AD system and treatment plant itself.

Use of the system results in a diversion of 700 tonnes of material away from landfill annually, along with the generation of 306 MWh of electricity (2003 figures).

Animal by-products and related legislation may present some difficulty. This legislation specifies many standards that must be complied with such as the type of feedstock material used, the specification of anaerobic digester and its premises, hygiene requirements, processing standards, record keeping, collection and transport of material, end-use of compost and digestion residues, approval and ongoing monitoring of plants by the Department of Agriculture and Food.

One aspect of the legislation that could seriously restrict the development of anaerobic digestion in Ireland is that concerning the source of feedstock materials which in turn determines the end-use of the product⁵⁵. For example, compost/digestion residues from an AD feedstock containing catering waste or animal products/by-products (except chocolate and pre-pasteurised milk or milk products/by-products) cannot be spread on or adjacent to any land or premises to which animals have access (i.e. most grassland and arable land adjacent to grassland). Another factor that should also be taken into account is that the legislation also prohibits the spreading of compost or digestate resulting from feedstock based on mammalian protein or poultry offal on any land.

However, the legislation does permit the use on any land of compost/digestate resulting from the anaerobic digestion of animal manures, cereal grains, edible material of plant or vegetable origin, bread and dough or chocolate as this feedstock is not defined as animal by-product. The legislation also permits compost and digestion residues to be used on horticultural land provided that adequate

⁵⁴ Collieran, E., et al., 2002 *Feasibility study for centralised anaerobic digestion for treatment of various wastes and wastewaters in sensitive catchment areas*. Wexford: EPA.

⁵⁵ The discussion here does not purport to be a legal interpretation.

measures are in place to ensure exclusion of livestock. The Department of Agriculture and Food recommends that if one intends to establish an anaerobic digestion facility a list of all intended feedstock, the sources of these materials and all intended end-uses should be sent to its Veterinary TSE and Animal By-Products Division.

It should be noted that legislation restricting the materials that can be used in AD is to be reviewed to allow greater flexibility in relation to the end use of the compost/digestion residue. This is being done in order for Ireland to reach the targets on the diversion of biodegradable waste set out in the Landfill Directive. The approval for the processing and end-use of animal by-products will be additional to existing Local Authority and EPA approvals.

Silver Hill Foods, Co Monaghan is one of the largest duck farming enterprises in Europe and generates approximately 70,000 tonnes of slurry per annum. It is currently installing an AD unit to process this slurry, producing dry fertiliser, heat, power and dischargeable effluent. The unit will have an electricity generating capacity of 150 kWe, and will be commissioned in mid 2005. The project has been supported by the EU LIFE programme.

Annex G

Landfill Gas Pathway

Introduction

Landfill gas is formed by the anaerobic breakdown of waste in landfills. It is typically about 60% methane and hence has a valuable energy content that can be captured. If it is not collected, it dissipates into the atmosphere, with consequent implications for global pollution. Methane is a greenhouse gas 21 times as potent as carbon dioxide.

Wells are inserted into the waste to collect the gas through a series of perforated pipes. A suction pump extracts the gas, which is then cleaned and combusted to extract its energy value. More modern landfills, which are fully lined and capped, give the best conditions for microbial degradation and for gas collection.

The timeframe for production and collection of landfill gas is 10 to 15 years from landfilling, with gas extraction peaking over about years three to six. One million tonnes of mixed waste will sustain a 1MW utilisation project for up to 15 years.

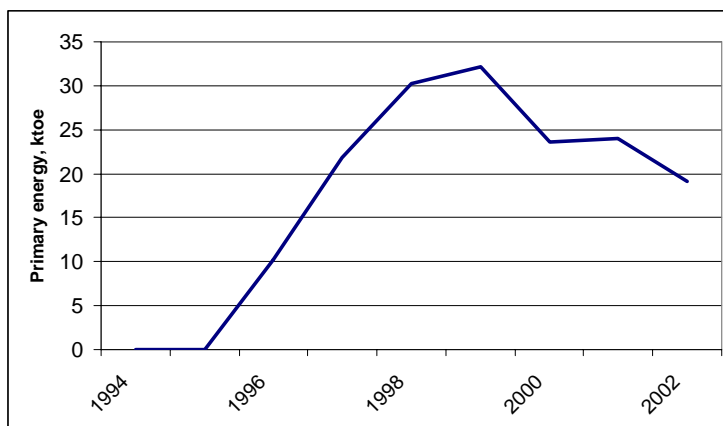
The gas extracted can be used directly for heat (e.g. boiler firing, kiln firing and cement manufacture) or in the production of electricity. In Ireland, all LFG projects to date involve electricity generation.

Status and future potential

In Ireland there are currently (end 2004) five landfill gas electricity generating plants operating with a combined installed capacity of 20.5 MWe. The same company currently operates all five plants. The first landfill gas sites were installed in 1996 and all sites were supported under AER programmes I, III and V. There is a further landfill gas plant currently under construction with an installed capacity of 1.3 MWe.

Figure G.1 plots the development of landfill gas exploitation in Ireland:

Figure G.1: Landfill gas exploitation in Ireland



All of this resource was converted to electricity. The electrical output from landfill gas has increased from zero in 1995 to 7 ktoe (81.4 GWh) in 2003 with a peak of 11.8 ktoe (137 GWh) in 1999.

At typical emissions of 700 g CO₂ per kWh, the 2003 contribution represents a displacement of about 57 kt of CO₂ emitted. There are also additional greenhouse gas benefits from the capturing of the methane that would otherwise have been emitted to the atmosphere⁵⁶.

⁵⁶ Each MWh of electricity generated represents an abatement about 4.7 tonnes (CO₂ equivalent) of greenhouse gases).

Any landfill site over 50,000-100,000 tonnes is a feasible LFG resource, although the economic feasibility of extraction will depend on both scale and quality of the site.

A 1997 study⁵⁷ estimated that the practical LFG resource in Ireland in electrical power terms was 18.3 MWe for 2000 and 39.8 MWe for 2020. A more recent analysis by Irish Power Systems gave company predictions of 25 MWe in 2005 and 30 MWe in 2010.

Landfill sites have a finite life of gas production, and now is the best time to exploit most of the existing sites. Beyond 2020, a fall off in LFG development is to be expected, due to a reduction in materials sent to landfill.

Issues

Growth in LFG exploitation has been steady but slow. New projects require investment in initial proving trials, typically €10,000 or more. If such trials prove successful, the normal next step has been to enter into discussions about AER contracts, power purchase agreements, grid connection and planning permission, and then to move forward on technical development. Lead times are typically of the order of 2 years.

To date, all LFG development has been within the AER framework, and power purchase agreements are likely to remain important in incentivising future projects. This may cause difficulties for the sector if AER type schemes are not continued. It may be appropriate to look at heat uses for LFG energy, but the feasibility of this depends on the availability of demand from suitable local applications.

⁵⁷ ESBI / ETSU, 1997. *Total Renewable Energy Resource in Ireland*. European Union, Altener Programme.

Annex H

Wood Heat in Buildings Pathway

Introduction

Burning wood for energy is the oldest energy pathway of all, and remains the dominant component of renewable energy across the world. In this report, the term wood is largely used to mean forestry related products – from tree trunks, thinnings and bark to sawdust – as distinct from wood from SRC, although the difference is on the supply side and chips or pellets derived from SRC are indistinguishable from those from any other wood sources. All are treated the same in terms of energy conversion.

The wood to heat energy pathway has a number of distinct characteristics that could bring advantages in many situations:

- Combustion technology is very well developed, widely available and relatively cheap, and is familiar to and well understood by users
- Heat can be totally decentralised and based on stand-alone systems in buildings that need no structural connections to external fuel supply or energy delivery
- Heat generation is flexible, and can match fluctuations in demand
- Systems can cover all scales from very small to very large
- In Ireland virtually all buildings need heat, so there is no shortage of possible applications or demand
- Local wood supply can be linked to local heat generation at a scale that will keep distances short and could offer opportunities for complete local systems

Wood heat systems have been the focus of growth in bioenergy in several countries, notably Austria, as mentioned in Section 2.2, where favourable supports have produced very strong uptake. Many suppliers are now active in Ireland, and several boiler or stove systems are available, although capital costs for wood burning systems remain considerably higher than for fossil fuel equivalents.

The diverse and decentralised nature of the pathway means that the market could take off and produce growth very quickly once conditions are right.

Current state and potential

Wood heat in industry and in buildings represents the bulk of bioenergy deployment in Ireland today. Renewable energy provides 1.6% of domestic energy demand (not including inputs to electricity), which is 1.8 PJ in final demand terms⁵⁸. Virtually all of this is wood burned for heat in open fires.

At a larger scale, most wood consumption, 109 ktoe or 4.6 PJ, is own-use energy generation in industry, which includes some space heating⁵⁹. There are very few examples of wood heated large buildings outside industry.

Virtually all space heating could in theory be fuelled by wood. Oil and solid fuel fired space heating could be seen as the first target market, as it is generally more costly than gas, and also involves storage systems similar to those for wood heat.

Domestic wood heat in Austria

A family home in Austria has a typical heating requirement of 12 kW. This can be delivered by a wood heat boiler or stove system consuming about 4,700 kg of pellets annually (requiring 5 m³ of storage). Annual fuel costs would be about €900. Installation costs for such a system are of the order of €9000, but grants are available up to 36% of these costs.

⁵⁸ SEI, 2004. *Energy in Ireland 1990-2002*.

⁵⁹ SEI, 2004. *Renewable Energy in Ireland 1990 – 2002*.

Issues for the Sector

The heat market is well developed and boilers and stoves are obviously well understood with long histories, and so this pathway faces few barriers in terms of acceptance of the conversion technologies. The innovative dimension is the use of wood as a fuel in chip or pellet form, and in larger scales such as commercial buildings. While wood heat competes well in cost terms with fossil fuels, particularly oil, a barrier remains in that modern wood-fuelled boilers and stoves are considerably more expensive than their oil- or gas-fired equivalents. This is because the technologies are relatively new and the market size is relatively small, and will change over time. At present, wood stoves and boilers can be several times the cost of an oil- or gas-fired equivalent. This could severely limit uptake in the short to medium term.

The second major issue influencing wood heat development is the fuel supply chain, its reliability, and confidence potential users have in it. If a householder were to install a modern wood boiler today, where would they get their chip or pellet supply? There are a small number of suppliers active in the market now, and users could access fuel, but not necessarily easily enough that would build confidence in future price and availability. Larger users would find it easier to access fuel now, but again may have concerns about price stability and security of supply. An ideal future would be one in which wood pellets or chips would be for sale at all scales – from annual deliveries in the manner of oil or coal, to buying a weekly supply in bag form at the local garage forecourt or convenience store. The challenge for the increased use of energy production from wood is to move from a situation of very low levels of supply and demand to a more fully developed market where larger quantities are involved, prices are relatively stable and there is a reliable supply chain.

Welsh Biofuels was established to create a renewable energy source in Wales, wood pellets, and to develop demand pull for biomass. Challenges faced included the need to create a new market for the product, the absence of a track record for either biofuels or the company in the region, and the high capital outlay requirements. The approach taken was to focus on provision of full solutions and to develop flagship projects to build confidence and awareness. Pellets were imported initially to build the market, and local authorities were targeted as a market for economically competitive systems with additional environmental benefits. Existing oil users were seen as the first target market.

A pellet plant is now up and running, making pellets from clean recycled wood, and will soon start sourcing forestry wood also. The first major customer is **Llandysul Sports and Leisure Centre**, a 260 kW system that was developed by the local authority with 50% capital grant support. The project is now a flagship for biomass in Wales and had generated considerable interest and likely future projects. Other residential projects have also been developed.

Once fuel supply markets are well developed, wood heat becomes an efficient, easy and clean option for many buildings applications. Storage requirements are no greater in size than for oil, automated supply systems can be installed bringing the fuel from a shed or tank into the boilers, and ash removal requirements are minimal and easy to handle. Energy managers used to coal systems would find conversion to wood particularly easy, and beneficial in many ways. Oil users would need no more space for storage, but would have to adapt their practices to some degree. For gas users, however, wood heat system may in many cases come across as less convenient, and possibly more expensive. Thus, existing coal and oil users, especially those not on the gas grid, would be the most likely to convert to new wood systems, and can be seen as the target market in the short to medium term.

Coillte Headquarters is located at large state-of-the-art premises at Newtownmountkennedy, Co. Wicklow. This building is the first all-timber office complex in Ireland and covers almost 25,000 square feet of floor space. As part of the building project, a new wood fired heating system was installed. The boiler can be fuelled by wood chips and wood pellets. The primary fuel will be pellets, but Coillte also intends to demonstrate the systems wood chip capabilities. The boiler, with an output capacity of 95kWth, will reduce CO₂ emissions by over 27 tonnes p.a. compared with natural gas. Installed cost of the unit equated to €283 per kW.

Annex L

Energy Crops

Introduction

The two main types of biomass energy crop available are energy grasses such as miscanthus, and short rotation coppice, both producing solid biomass for conversion to heat or heat and power. Clearly, conventional forestry grown for energy is also an energy crop, but this fuel is treated separately as the growing side of it is well developed for other reasons, and issues specific to bioenergy only arise in harvesting and usage.

Most SRC is based on species of willow (*Salix* spp.), and there are now two European breeding programmes producing varieties specifically developed for SRC, with better growth rates, yield and disease resistance than previous varieties. Some species of poplar are also being used. Willow SRC is the most widely planted biomass energy crop (over 15,000 ha in Sweden alone), and it is the best understood in terms of growing, harvesting and energy usage. It can be established easily and cheaply using cuttings. A plantation has a life of 15-20 years, and land can be returned to conventional use in 1 or 2 years. Different species and techniques will suit different areas and land types, and local knowledge is important in determining the best approach in a given location⁶⁰. It generally performs best in moisture retentive soils or where it has access to the water table. However, like any other arable crop it will give improved performance on better land.

Miscanthus grass is less developed as a biomass energy crop than SRC willow, but is attracting increasing interest. Some trials, and some commercial plantations, are in now place. Its main advantage is that it offers an annual harvest and as a crop it has a greater similarity to cereals and other conventional field crops than SRC, thus requiring less change on the part of the farmer. It can be cut and baled with a straw baler and stored in barns. However it is a perennial crop and its deep root structure means that reversion to a conventional crop requires some time and work on the land. Being originally a temperate zone crop, it generally requires better climatic conditions, and better soil, than SRC. Trials in Northern Ireland in the 1980s indicated that it was unsuitable for local weather and soil conditions. With improvements in the crop it is being re-evaluated in Northern Ireland and the different climatic and soil conditions in some parts of Ireland may prove more suitable for the crop.

Biomass energy crops generally require considerably less pesticides than conventional agricultural crops because higher levels of damage can be tolerated for an energy crop than for a food crop. This reduces input costs and also improves the energy balance and ecological impact. SRC is considered better for encouraging biodiversity than mono-cropped fields.

Internationally, most bioenergy policy and strategy is oriented towards a basis of energy crops into the medium to long term, and energy crops are seen as the main future source of biomass for energy.

Current State and Potential

There is very little land in Ireland under energy crops at present. Some trial plots are in place, covering less than 100 ha in total.

There is theoretically a huge amount of land that may be utilised were farmers to turn it over to these crops. About 4.4 million hectares of land in Ireland (64% of total land area), is used for agriculture. 80% of this is devoted to grass, 11% to rough grazing, and 9% (396,000 ha) to crop production. However it is neither practical nor desirable to imagine an Irish countryside dominated by coppiced willow.

⁶⁰ RCEP, 2004

In the context of CAP reform and decoupling, it is projected that 11,600 ha of land will be freed up due to a reduction in cereal production.⁶¹ At the same time, about 132,000 ha is expected to be freed up due to herd reduction. These figures give a sense of the extent of what might be termed 'available land' being far more than enough to meet projected energy crops needs.

Making assumptions about yield per ha and energy content of the dried product, the primary energy value of the crop can be estimated at about 2.34 PJ per 10,000 ha. This means, for example, that if 20% (26,400 ha) of the land to be freed up by herd reduction in the coming years were given over to energy crops, this would produce an energy resource of 6.2PJ. If all of this were used to generate electricity it would meet about 23% of the 2010 target of 13.2% of electricity produced from renewables.

This analysis is broad, but does indicate that energy crops could make a very significant contribution to bioenergy by 2010, and certainly by 2020, on the basis of ambitious but not fanciful degrees of uptake by farmers and with little impact on other crops.

Issues

Energy crops produce fuels identical to other wood or straw type materials produced as residues, and no unique issues arise with regard to energy conversion (SRC can be burned, used to make chips or pellets, and can even be used in anaerobic digestion). The important question for developing this resource is determining the conditions under which farmers will be encouraged to grow the crops.

For SRC, some change in practices are obviously required if a farmer is used to cereals or even conventional forestry. Harvesting in particular can be more difficult. Harvesting takes place in winter to minimise water content and to allow nutrient recovery from leaf shedding, but this can prove difficult if the ground is wet and soft. Much of the large scale harvesting equipment that has been developed in Sweden and Finland is designed to work on frozen ground and on large plantations, and could prove unsuitable for Ireland. However, the RCEP reports successful employment of a sugar cane harvester by a willow growers' group in the UK⁶². The economics are such that equipment is best shared among a group of growers, as is already done with combine harvesters. In Northern Ireland, the Government has purchased a harvester to support farmers and demonstrate the technology. Miscanthus requires little innovation, so may prove less daunting to farmers, although its suitability for all parts of the country is not yet established.

CAP reform should favour innovation by farmers in that their basic income is secure through the Single Farm Payment, and it is expected that they will become more market oriented in choosing what to grow to best supplement this income.

If the energy crop sector becomes a new and profitable activity for farmers it will add value to farming and the economy. Indeed many states are driving their bioenergy crop policy primarily with agricultural development in mind. If this sector could be fostered it would represent a truly indigenous element of the energy system, where farmers benefit from new markets, the national fuel mix is diversified and shifted towards indigenous inputs, and the environmental benefits of a carbon neutral resource are captured.

Costs and benefits

The key issue for farmers considering energy crops will be their expectation of a good economic return. This means both the size of the return, and the certainty of achieving it.

At present, projected returns per ha are less than many conventional crop choices⁶³. The fact that SRC does not produce revenue until the fourth year also dents its attractiveness. However, as yields increase through better varieties and techniques, the profitability of the crops should improve. A study in the UK suggested that a 30% improvement in yield would make energy crops competitive

⁶¹ FAPRI Ireland study on the effects of decoupling

⁶² RCEP, 2004

⁶³ The RCEP report refers to a recent study suggesting average annual returns of Stg £187-360 per ha over a 16 year period.

with barley⁶⁴. If oil and gas prices continue their recent upward trends, this will obviously also improve the profitability of energy crops as prices available for alternative fuels rise.

Additional revenue can be available through gate fees for waste remediation. SRC is very suitable for the bioremediation of wet wastes such as sewage sludge, although care has to be taken with regard to uptake of heavy metals and other materials that would cause problems if released during combustion.

The certainty of demand for the crop produced is as important to farmers as profit per hectare. While farmers will clearly not expect guarantees of demand for the lifetime of an SRC plantation, confidence that at least the first 2 to 3 years of harvest have a definite market is a very important factor in decision making. This is another instance of the circular challenges in bioenergy of supply side development needing better demand, but at the same time demand side development depending on supply increasing in size and reliability.

The Department of Agriculture and Rural Development in Northern Ireland has had an active research programme on SRC for many years, and has studied crop strains, disease resistance, and best practice growing and harvesting techniques. It also runs research and demonstration projects on the use of the wood fuel from SRC. A 100kWe installation has been running on Brook Hall estate since 1998. It consumes about 1.5 tonnes of wood per day.

⁶⁴ RCEP, 2004

Annex J

Future Technologies

Introduction

Current programmes for the utilisation of bioenergy focus on traditional conversion methods (combustion or anaerobic digestion followed by combustion) to provide heat and power and, to a lesser extent, fuels for transport. This is likely to continue as the model to 2010.

Beyond 2010, technologies now in the research and development phase are set to supplant the traditional methods. These new technologies will expand the range of both feedstocks and products, while at the same time bringing major improvements to the economic viability of bioenergy systems. In this coming era energy will be complemented by materials as products of biomass. A sense of this shift in the utilisation of biomass can be garnered from the following statement, which guides the thrust of bioenergy development in the US for the post 2010 era:

'While the growing need for sustainable electric power can be met by other renewables Biomass is the only renewable that can meet our demand for carbon-based liquid fuels and chemicals'⁶⁵

A similar theme is found in a recent OECD report on biomass⁶⁶ where development of bioenergy and biomaterials are seen as complementary strands to a long term rational policy evolution. The value added through this dual output approach is seen as reinforcing the economic viability of biomass as a vector for energy in a more environmentally sustainable world. There are a number of technologies currently under development that are considered to be central in this new bioenergy paradigm. Two pathways, in particular, are prominent.

1. Ethanol from lignocellulosic materials with the bioethanol being used as a transport fuel, as a raw material for the chemical industry and as an input for fuel cells. The technology is the subject of significant research effort, particularly in the USA and Canada, where pilot plant work is underway. Plans for a pre-commercial facility in Sweden are at an advanced stage and it is anticipated that a 75 million litre per year plant will be operational by end 2008. When the technology is commercial, a wide range of feedstocks will be acceptable, including wood based materials, straw and other lignocellulosic materials from various waste streams.
2. Gasification of biomass to produce synthesis gas (syngas) from which Fisher Tropsch diesel, methanol, hydrogen, synthetic natural gas (SNG) and chemical raw materials can be produced. While gasification followed by electricity generation has been much investigated and still offers significant potential once it has been effectively commercialised, the production of fuels and chemicals would considerably expand the range of outlets and improve the economic viability. There are active research programmes on both sides of the Atlantic in this area. The European Union's FP 6 programme has identified gasification to syngas as a priority area and an Irish university is actively involved in an Integrated Project being led by Volkswagen in Germany.

⁶⁵ Overend, R., 2004 *US Perspective on Bioenergy*. Presentation to the conference *Success Stories in Bio-Energy*, Birmingham, April 2004.

⁶⁶ OECD, 2004.

These technology pathways are central to the concept of the future “biorefinery” which could meet many of the material and energy needs of tomorrow. They are the two lynchpins of the proposed future US bioenergy development noted above. In developing a vision for biomass with a horizon to 2040 the Netherlands established a Biomass Transition project which engaged representatives from ‘government bodies, companies, environmental organisations and knowledge institutes’. The technological pathways described above are integral parts of this vision which sees the delivery of 30% of ‘energy supply and fuels for transport’ from biomass by 2040⁶⁷. It is important for Ireland to recognise this developing trend and to consider shaping a vision that embraces it. Climate and other factors favour the production of biomass here. The opportunities that will be on offer in this new era can be harnessed to deliver an enhanced level of sustainability based on the potential of biomass to provide sustainable energy and sustainable materials production.

⁶⁷ See footnote 9

Annex K

Resource estimation methods

A spreadsheet model of the biomass resources in Ireland has been developed in order to incorporate current information on each of the biomass streams and to provide an estimate of the scale of the resource that can be utilised for the production of bioenergy. Each of the sections below relates to a spreadsheet in the model. Considerable detail is shown, together with the sources of all data and the assumptions made in order to maximise transparency of the analysis. As more up-to-date data become available and assumptions change, it will be possible to update the model, which will remain a valuable tool. Two terms merit definition. *Theoretical resource* is the full extent of the resource irrespective of other users or practical or economic questions concerning collection and energy use. It should not be taken to be the resource likely to be utilised. The *practical resource* takes these factors into account and makes assumptions about practical and economic issues. This parameter is not definitive but is important in estimating what might be achieved.

K.1 Municipal Solid Waste (MSW)

The data for 2001 in terms of "Gross Qty available", "Qty landfilled" and "Qty recovered" is taken from table 4.5 in the National Waste Database Report 2001⁶⁸. In this analysis, the recovered waste for 2001 is divided between

- *Recov'd to Recyc.* (Recovered to Recycling),
- *Recov'd to BioTreat* (Recovered to Biological Treatment) and
- *Recov'd to WtE* (Recovered to Waste to Energy).

Table K1 Municipal solid waste flows in 2001

Municipal Solid Waste (MSW)							
Data from Table 4.5 - National Waste Database Report 2001							
Annual Average % growth rate	%	2001 -2020	3.8%	Data from National Waste Database Report 2001, Table 4.5	Assumed % going to Recycling, Biological Treatment & WtE		
2001							
Category	Gross Qty available	Qty landfilled	Qty recovered	Landfill rate	Recov'd to Recyc.	Recov'd to BioTreat	Recov'd to WtE
	ktonnes	ktonnes	ktonnes				
Paper	804	638	166	79.4%	100.0%	0.0%	0.0%
Glass	151	108	43	71.5%	100.0%	0.0%	0.0%
Plastic	237	221	16	93.2%	100.0%	0.0%	0.0%
Ferrous	39	38	1	97.4%	100.0%	0.0%	0.0%
Aluminium	19	18	1	94.7%	100.0%	0.0%	0.0%
Other metals	12	10	2	83.3%	100.0%	0.0%	0.0%
Textiles	60	56	4	93.3%	100.0%	0.0%	0.0%
Organics	578	556	22	96.2%	0.0%	100.0%	0.0%
Other	397	347	50	87.4%	100.0%	0.0%	0.0%
Total	2,297	1,992	305				
Biodegradable		1,250	192				
Non-Biodegradable		742	113				
Landfill rate		86.7%					
OUTPUTS							
Recycling - ktonnes					283		
Biological Treatment MSW - ktonnes - To Spreadsheet "WetBiomassResidues"						22	
Waste-to-Energy MSW - ktonnes - To Spreadsheet "DryBiomassResidues"							0
Landfilled MSW - ktonnes		1,992					

⁶⁸ EPA, 2003. National Waste Database Report 2001.

Table K1 includes assumed percentages of the recovered waste going to each of these three treatment options. From this, estimates of the quantities in tonnes that are recycled, biologically treated or fed to a Waste-to-Energy (WtE) plant are made. Since there was no Waste-to-Energy in 2001 its percentages are set to zero. In line with the National Waste Database Report 2001, the SEI assumption is that all recovered waste goes to recycling with the exception of the *Organics* category which goes to biological treatment (composting and anaerobic digestion). The Outputs "*Biological Treatment MSW*", "*Waste-to-Energy MSW*" and "*Landfill MSW*" are carried forward to the Wet Biomass Residues, Dry Biomass Residues and Landfill Gas spreadsheets respectively, for the year 2001.

For 2010, projections (shown in table K2) for gross waste arisings (*Gross Qty available*) were developed by assuming an annual growth rate for the period 2001 to 2010 of 3.8% (growth rate used in the Biodegradable Waste Draft Strategy Report⁶⁹). The landfill rates ("*Landfill rate*") are SEI assumptions, based on Department of the Environment, Heritage & Local Government documents

- "Changing Our Ways"⁷⁰ of 1998,
- Biodegradable Waste Draft Strategy Report, and
- National Overview of Waste Management Plans⁷¹.

Table K2 Municipal solid waste flows in 2010

Municipal Solid Waste (MSW)							
<i>Data from Table 4.5 - National Waste Database Report 2001</i>		Assumed landfill rates in 2010 based on "Changing Our Ways" and BMW Strategy.			Assumed % going to Recycling, Biological Treatment & WtE		
Annual Average % growth rate	2001 -2010						
	3.8%						
Category	2010						
	<i>Gross Qty available</i> ktonnes	<i>Qty landfilled</i> ktonnes	<i>Qty recovered</i> ktonnes	<i>Landfill rate</i>	<i>Recov'd to Recyc.</i>	<i>Recov'd to BioTreat</i>	<i>Recov'd to WtE</i>
Paper	1,125	281	844	25.0%	70.0%	4.0%	26.0%
Glass	211	53	158	25.0%	95.0%	1.0%	4.0%
Plastic	332	83	249	25.0%	40.0%	1.0%	59.0%
Ferrous	55	14	41	25.0%	95.0%	1.0%	4.0%
Aluminium	27	7	20	25.0%	95.0%	1.0%	4.0%
Other metals	17	4	13	25.0%	95.0%	1.0%	4.0%
Textiles	84	21	63	25.0%	50.0%	1.0%	49.0%
Organics	809	202	606	25.0%	0.0%	45.0%	55.0%
Other	555	139	417	25.0%	60.0%	1.0%	39.0%
Total	3,213	803	2,410				
Biodegradable		504	1,513				
Non-Biodegradable		299	897				
Landfill rate		25.0%					
OUTPUTS							
<i>Recycling - ktonnes</i>					1,192		
<i>Biological Treatment MSW - ktonnes - To Spreadsheet "WetBiomassResidues"</i>					316		
<i>Waste-to-Energy MSW - ktonnes - To Spreadsheet "DryBiomassResidues"</i>					902		
<i>Landfilled MSW - ktonnes</i>		803					

"Changing Our Ways" calls for significant levels of recycling and a 65% reduction in biodegradable waste going to landfill, while the Biodegradable Waste Draft Strategy Report projects that 76% of biodegradable waste will be diverted from landfill by 2009, and 55% of paper and cardboard will be recovered through recycling. In addition, the National Overview of Waste Management Plans indicates that landfilling of municipal solid waste should be reduced to levels of 15% and under between 2010 and 2014 in all of the waste management regions.

⁶⁹ Department of the Environment, Heritage & Local Government, 2004. *National Strategy on Biodegradable Waste – Draft Strategy Report*.

⁷⁰ The Department of the Environment and Local Government, 1998. *A Waste Management Policy Statement – Changing Our Ways*,

⁷¹ The Department of the Environment and Local Government, 2004. *National Overview of Waste Management Plans*.

Taking a somewhat more conservative approach it is assumed in this model that by 2010, a 75% diversion target for all MSW waste will be achieved. These assumptions produce the "Qty landfilled" and the "Qty recovered" in 2010 based on the "Gross Qty available" shown in table K2. SEI estimates of percentages going to "Recov'd to Recyc", "Recov'd to BioTreat" and "Recov'd to WtE" are generally in line with the Biodegradable Waste Draft Strategy Report. Significant biological treatment capacity should be in place, in addition to waste-to-energy facility development, including the proposed plant in Dublin. The Outputs "Biological Treatment MSW", "Waste-to-Energy MSW" and "Landfill MSW" are carried forward to the Wet Biomass Residues, Dry Biomass Residues and Landfill Gas spreadsheets respectively, for the year 2010.

For 2020, projections (table K3) for gross waste arisings (*Gross Qty available*) were developed by assuming an annual growth rate of 3.8% continuing from 2010 to 2020. For landfill rates it is assumed that by 2020, an 85% diversion target for all MSW will be achieved – as noted above the National Overview of Waste Management Plans indicates that this should be the minimum situation by 2014.

Table K3 Municipal solid waste flows in 2020

Municipal Solid Waste (MSW)							
<i>Data from Table 4.5 - National Waste Database Report 200</i>				Assumed landfill rates in 2020 based on "Changing Our Ways" and BMW Strategy		Assumed % going to Recycling, Biological Treatment & WtE	
Annual Average % growth rate	2010 -2020			3.8%			
Category	2020						
	Gross Qty available ktonnes	Qty landfilled ktonnes	Qty recovered ktonnes	Landfill rate	Recov'd to Recyc.	Recov'd to BioTreat	Recov'd to WtE
Paper	1,355	203	1,152	15.0%	77.0%	3.0%	20.0%
Glass	255	38	216	15.0%	95.0%	1.0%	4.0%
Plastic	399	60	340	15.0%	55.0%	1.0%	44.0%
Ferrous	66	10	56	15.0%	95.0%	1.0%	4.0%
Aluminium	32	5	27	15.0%	95.0%	1.0%	4.0%
Other metals	20	3	17	15.0%	95.0%	1.0%	4.0%
Textiles	101	15	86	15.0%	50.0%	1.0%	49.0%
Organics	974	146	828	15.0%	0.0%	60.0%	40.0%
Other	669	100	569	15.0%	60.0%	1.0%	39.0%
Total	3,872	581	3,291				
Biodegradable		365	2,066				
Non-Biodegradable		216	1,225				
Landfill rate		15.0%					
OUTPUTS							
Recycling - ktonnes					1,759		
Biological Treatment MSW - ktonnes - To Spreadsheet "WetBiomassResidues"						545	
Waste-to-Energy MSW - ktonnes - To Spreadsheet "DryBiomassResidues"							988
Landfilled MSW - ktonnes		581					

These SEI assumptions produce the "Qty landfilled" and the "Qty recovered" in 2020 based on the "Gross Qty available". Estimates of percentages going to "Recov'd to Recyc", "Recov'd to BioTreat" and "Recov'd to WtE" assume greater levels of recycling for paper and plastics and that more of the organic fraction will go to biological treatment, with limited additional waste-to-energy capacity compared to 2010. This is generally in line with the Biodegradable Waste Draft Strategy Report projections for 2016. The Outputs "Biological Treatment MSW", "Waste-to-Energy MSW" and "Landfill MSW" are carried forward to the Wet Biomass Residues, Dry Biomass Residues and Landfill Gas spreadsheets respectively, for the year 2020.

K.2 Dry Biomass Residues

Wood Residues

The "Theoretical resource" for each of "Pulpwood residues", "Sawmill residues" and "Forest residues" (in table K4) was derived from production forecasts in Gallagher & O'Carroll⁷², the Timber Industry

⁷² Forecast of round wood production from the forests of Ireland 2001 – 2015 – G. Gallagher & J. O'Carroll, COFORD study 2001.

Development Group⁷³ and from estimates in the COFORD study⁷⁴. The estimate of pulpwood and sawmill residues that could be available for energy as “Practical Resource” is based on the assumption that the energy market would not draw either material from existing non-energy markets (panel board mills, production of stakes, animal bedding, horticulture) and would be additional to that used for energy (in drying kilns) in sawmills in 2000. The “Practical Resource” for forest residues indicated in the COFORD study is informed by expert opinion from the UK. Conditions in the UK were considered to be quite close to those in Ireland and the principal limitations on recovery of the resource were the steepness of the terrain and the low bearing capacity of the soil.

Table K4 Wood Residues

	Moisture	C.V.	2001			2010			2020		
			Theoretical resource	Practical resource	Practical energy	Theoretical resource	Practical resource	Practical energy	Theoretical resource	Practical resource	Practical energy
	%	GJ/tonne	Mtonnes	Mtonnes	PJ	Mtonnes	Mtonnes	PJ	Mtonnes	Mtonnes	PJ
Wood Residues incorporates	Pulp Wood Residues, Forset Residues, Wood Industry Residues & C&D Wood Residues										
Wood Calorific Value @ 0% m.c.	GJ/tonne	18.0									
Practical recycled wood availability %	%	25%				60%			85%		
Annual growth in Recycled Wood 2001 to 2010	%					3.6%					
Annual growth in Recycled Wood 2010 to 2020	%								3.3%		
Category											
Pulpwood residues	60.0%	7.2	1.14	0.17	1.21	1.41	0.41	2.95	2.23	1.05	7.56
Sawmill residues	50.0%	9.0	0.98	0.09	0.80	1.27	0.21	1.89	1.42	0.36	3.24
Forest residues	50.0%	9.0	1.07	0.23	2.07	1.34	0.29	2.61	1.65	0.35	3.15
Recycled wood -C&D residues	23.0%	13.9	0.13	0.03	0.44	0.18	0.11	1.46	0.24	0.21	2.86

The “Theoretical resource” for “Recycled wood - C&D residues” for 2001 was derived from a COFORD study⁷⁵ dealing with these residues. The best estimate as determined by this study was that wood represented 3.5% of construction and demolition (C&D) waste. From the National Waste Database Report 2001, C&D waste arisings amounted to 3,651,400 tonnes, of which wood would amount to 127,800 tonnes. The COFORD study also shows that untreated wood represents about 53% of total wood. It is assumed that about half of this untreated wood was available as a practical energy resource in 2001, or about 25% of the estimated 127,800 tonnes of C&D waste wood produced. To derive a “Theoretical resource” for 2010, an annual increase of 3.6% is assumed (average from ESRI GDP growth projections⁷⁶ – 4% to 2005 and 3.3% to 2010) to 2010. This is extended to 2020 by using a growth beyond 2010 of 3.3%. Given the policy driver relating to C&D waste in “Changing Our Ways”, indicated above, the practical resource is assumed in this analysis to rise to 60% of the theoretical by 2010 and 85% by 2020. Pallet and packaging wood waste is included in the municipal solid waste under “Other” category – see tables K1, K2 and K3. The National Waste Database Report 2001 notes that of the 48,600 tonnes of wood generated, 85% was recovered with 6% being used for energy.

Dry Agricultural Residues

The data for “straw”, “poultry litter” and “spent mushroom compost” (shown in table K5) are taken from the SEI study ‘An Assessment of the Renewable Energy Resource Potential of Dry Agricultural Residues in Ireland’ in 2003. While straw production is expected to decline to the year 2012 and then remain steady beyond that date (due to the anticipated downward trend in cereal production), both poultry litter and spent mushroom compost levels are expected to remain stable into the foreseeable future. In terms of the practical resource for straw, the study proposes that a reasonable assumption would be that the quantity available for conversion to energy would remain constant at 10% of the theoretical resource because of competing demands for straw which are likely to continue into the future. The study determines the practical poultry litter resource, currently and into the foreseeable future, as that which is currently landspread, with the balance of this residue being used by mushroom compost producers. The quantity of spent mushroom compost available as a practical energy resource is also assessed as remaining constant into the future and consists of that amount for which a readily available landspreading option does not exist.

⁷³ Study by Timber Industry Development Group in 2001 – unpublished.

⁷⁴ Electrowatt-Ekono (UK) and Tipperary Institute, unpublished.

⁷⁵ Potential to Recover Wood from Construction and Demolition Activities in Ireland – COFORD, 2002.

⁷⁶ Fitzgerald, J., 2000. *Energy Demand to 2015*. The Economic & Social Research Institute (ESRI).

Table K5 Dry agricultural residues

	Moisture	C.V.	2001			2010			2020		
			Theoretical resource	Practical resource	Practical energy	Theoretical resource	Practical resource	Practical energy	Theoretical resource	Practical resource	Practical energy
	%	GJ/tonne	Mtonnes	Mtonnes	PJ	Mtonnes	Mtonnes	PJ	Mtonnes	Mtonnes	PJ
Dry Agricultural Residues incorporates	Straw, Poultry Litter, Spent Mushroom Compost (SMC) and Meat & Bonemeal (MBM)										
Straw Calorific Value LCV	GJ/tonne	13.5									
Poultry Litter Calorific Value LCV	GJ/tonne	9.0									
SMC Calorific Value LCV	GJ/tonne	3.2									
MBM Calorific Value LCV	GJ/tonne	16.3									
MBM qty change 2001/2010 - % change in cattle	%					-15%					
MBM qty change 2010/2020 - % change in cattle	%								-2%		
Category											
Straw			1.33	0.13	1.80	1.25	0.13	1.69	1.23	0.12	1.62
Poultry Litter			0.14	0.04	0.36	0.14	0.04	0.36	0.14	0.04	0.36
Spent Mushroom Compost			0.29	0.06	0.20	0.29	0.06	0.20	0.29	0.06	0.20
Meat & Bonemeal			0.15	0.15	2.45	0.13	0.13	2.08	0.12	0.12	2.04

Annual production of meat and bone meal (MBM) in Ireland is approximately 150,000 tonnes⁷⁷. This theoretical resource is likely to show a decline through 2010 to 2020, given that herd sizes are expected to be reduced over that period. Since there is no current use for this material, it having been banned as an animal feed, the practical resource is assumed to equal the theoretical resource. Although there is a possibility that confidence may be restored in terms of the use of MBM as animal feed, it is assumed here that this will not be the case and that therefore the practical resource in 2010 and 2020 is equal to the theoretical.

Municipal solid waste to WtE

The theoretical resource, which is set equal to the practical resource, for municipal solid waste in each year (in table K6) is derived from the **MSW1** Spreadsheet as described above – “Waste-to-Energy MSW” figure being carried forward. The resource in terms of energy is calculated based on a calorific value of 6 GJ / tonne to take account of only the organic fraction of MSW.

In 2001 there was no WtE capacity so the theoretical resource is set to zero. In 2010, the resource assumes that three conversion plants will be operational (the Dublin and North-East facilities and one of the four other regions noted in the Biodegradable Waste study). By 2020 a limited increase in capacity is assumed with the drivers for recycling and biological treatment being the dominant waste management methods.

Table K6 Municipal solid waste and waste-to-energy

	Moisture	C.V.	2001			2010			2020		
			Theoretical resource	Practical resource	Practical energy	Theoretical resource	Practical resource	Practical energy	Theoretical resource	Practical resource	Practical energy
	%	GJ/tonne	Mtonnes	Mtonnes	PJ	Mtonnes	Mtonnes	PJ	Mtonnes	Mtonnes	PJ
WtE Municipal Solid Waste includes	Organic & Non-organic component of Municipal Solid Waste (MSW)										
MSW Calorific Value	GJ/tonne	6									
MSW to WtE - 2001	%	0%									
MSW to WtE - 2010	%	100%									
MSW to WtE - 2020	%	100%									
Category											
Waste-to-Energy MSW		6.0	0	0	0.00	0.90	0.90	5.41	0.99	0.99	5.93

K.3 Energy Crops

The initial estimate of area under energy crops (short rotation forestry, miscanthus, hemp, other) was made based on short rotation forestry supplying 1% of total electricity (out of the 13.2% coming from renewables) by 2010, or 10,000 ha. This estimate was revised downwards to 5,000 ha on the basis that planting for the 2010 resource would need to take place by 2006 at the latest. The 2020 estimate is based on annual planting of 1,000 ha to 2016 (table K7).

⁷⁷ Report of Interdepartmental/Agency Committee on Disposal Options for Meat & Bone Meal – Department of Agriculture, 2003.

Table K7 Estimated energy crop resource

Category	2001			2010			2020		
	Total Area ha	Practical resource Mtonnes	Practical energy PJ	Total Area ha	Practical resource Mtonnes	Practical energy PJ	Total Area ha	Practical resource Mtonnes	Practical energy PJ
Short Rotation Coppice OR		0	0.000	5,000	0.07	1.170	15,000	0.23	4.050
Miscanthus		0	0.000	5,000	0.07	1.170	15,000	0.23	4.050

K.4 Wet Biomass Residues

In table K8, with the exception of poultry manure, the quantities of “Manures” and “Sludges” (Food Beverage & Tobacco and Sewage) for 2001 were taken from the National Waste Database Report 2001 while the “Biological Treatment MSW” quantity comes from the **MSW1** Spreadsheet as described above (from table K1). The figure for poultry manure was determined from discussions with the EPA⁷⁸ (82,000 tonnes of poultry manure per annum), and with the inclusion of output from the Silver Hill Foods⁷⁹ project (70,000 tonnes of manure per annum - the EPA calculations did not include duck manure).

Table K8 Bioenergy potential of wet biomass residues in 2001

Category	2001					
	Qty (ktonnes)	Biogas production Mm ³	Methane production Mm ³	Theoretical energy PJ/year	Practical energy PJ/year	
Cattle manure & slurry	34,754					
Pig slurry	2,413					
Total Cattle manure & slurry and Pig slurry	37,167	818	531.5	19.03	0.02	
Poultry manure	152	11	7.4	0.27	0.00	
Food Beverage & Tobacco sludges	67	20.1	13.1	0.47	0.12	
Sewage sludges (dry solids)	38	0.9	0.6	0.02	0.01	
Biological Treatment MSW	22	2.8	1.8	0.06	0.01	

Typical gas yields, methane content and methane calorific value (table K9) were taken from the literature⁸⁰ to estimate the “Theoretical energy” for each of the five categories (Cattle/pig Manure & Slurry, Poultry Manure, Food Beverage & Tobacco Sludges, Sewage Sludge and Biological Treatment MSW). The “Practical energy” was estimated by assuming recoverable quantity to AD percentages (table K10) as follows:

- Following discussions with the Department of Agriculture and Teagasc, low take up of AD for cattle manures and slurries was assumed in 2010 due to the simplicity and low cost of the land spreading alternative, resulting in low percentage for cattle/pig manures, rising to only 5% in 2020. Conversely, given the Silver Hill Foods development (46% of the total), the application of anaerobic digestion to poultry manure is assumed to be high, although it should be remembered that the resource is quite limited.
- It was assumed that the Food/Beverage/Tobacco industry would have high take up of AD due to the added value of the energy generated.

⁷⁸ Jane Brogan, EPA, 2004 – private communication.

⁷⁹ Silver Hill Foods, <http://www.silverhillfoodslife-env.com/html/project.asp>

⁸⁰ Centralised Biogas Plants – a contribution to sustainable agriculture, www.lr.dk/planteaul/diverse/biogas_eng.pdf: Feasibility Study for centralised anaerobic digestion for treatment of various wastes and wastewaters in sensitive catchment areas, EPA, 2002: Anaerobic Digestion – a detailed report on the latest methods and technology for the anaerobic digestion of municipal solid waste, Institute of Wastes Management, 1998: Anaerobic Digestion calculator, www.esru.strath.ac.uk/EandE/Web_sites/03-04/biomass/case%20study2.html.

- It was assumed that Sewage Sludges would have high take up of AD due to the added value of the energy generated.
- It was assumed that AD would achieve a 50% share (in competition with composting) of biodegradable MSW by 2010, rising to 75% in 2020 based on better value added from the production of energy.

Table K9 Data for gas yields, methane content & methane calorific value⁸¹

Cattle/Pig manures/slurries - gas yield	Nm ³ /tonne	22.0
Poultry manure - gas yield	Nm ³ /tonne	75.0
Food beverage & tobacco sludges - gas yield	Nm ³ /tonne	300
Sewage sludge - gas yield	Nm ³ /tonne	25
Biodegradable MSW - gas yield	Nm ³ /tonne	125
Methane content of Biogas	%	65%
Methane Calorific Value	MJ/m ³	35.8

Table K10 Quantities of feedstocks going to AD

		2001	2010	2020
Cattle/Pig manures/slurries - recoverable quantity to AD	%	0.1%	2%	5%
Poultry manure - recoverable quantity to AD		0.0%	50%	75%
Food beverage & tobacco sludges - recoverable quantity to AD	%	25%	40%	75%
Sewage sludge - recoverable quantity to AD	%	25%	60%	85%
Biodegradable MSW - recoverable quantity to AD	%	10%	25%	50%

The SEI assumptions in table K10 form the basis of the estimated practical energy resource from Wet Biomass Residues.

In deriving the quantities for each Wet Biomass Residues (excluding biodegradable MSW) category for 2010 and 2020 the percentage changes shown in table K11 were used.

- The percentage changes in animal numbers for cattle and pigs (from which the changes in manure output are estimated) for 2010 were taken from the FAPRI Report⁸²; the SEI percentage assumptions to 2020 are based on numbers in that year being the same as 2012, the last year covered by the FAPRI report. For poultry manure the percentage changes are based on changes in poultry meat production as projected by the FAPRI report.
- Sludges from the Food/Beverage/Tobacco industry were assumed to grow in line with GDP as estimated by the ESRI⁸³ report; it is assumed that the projected GDP growth rate from 2005 to 2010 will continue to 2020.
- Sewage sludge quantities were assumed to grow in line with population growth projections by the CSO⁸⁴.

⁸¹ Cattle/pig manures/slurries and Poultry manure gas yields derived from *Centralised Biogas Plants – a contribution to sustainable agriculture*, www.lr.dk/planteaul/diverse/biogas_eng.pdf AND *Feasibility Study for Centralised AD for treatment of various wastes and wastewaters in sensitive catchment areas*, EPA 2002, R&D Report Series No. 16. Food beverage & tobacco sludges, Sewage sludge and Biodegradable MSW gas yields derived from *Anaerobic Digestion: a detailed report on the latest methods and technology for the anaerobic digestion of municipal solid waste*, Institute of Waste Management, 1998. Methane content of Biogas derived from *Biogas upgrading and utilisation*, IEA Bioenergy Task 24, undated, AND *Anaerobic digestion of agro-industrial wastes: information networks – technical summary on gas treatment*, AD-Nett, 2000, AND *Biogas and Natural Gas fuel mixture for the future*, uk.dgc.dk/Sevilla2000.pdf. Methane Calorific Value derived from *Biogas upgrading and utilisation*, IEA Bioenergy Task 24, undated.

⁸² *The Luxembourg CAP Reform Agreement: Analysis of the Impact on EU and Irish Agriculture*, FAPRI-Ireland Partnership, October 14th 2003.

⁸³ Refer to Footnote 76.

Table K11 Projected changes in feedstock quantities to 2010 & 2020

		2001	2010	2020
Animal numbers change 2010 to 2020				
-cattle	%			-2.0%
-pigs				-4.0%
-poultry				1.5%
Food beverage & tobacco sludges - change 2001 to 2010			3.6%	
Food beverage & tobacco sludges - change 2010 to 2020				3.3%
Sewage sludge - change 2001 to 2010			0.9%	
Sewage sludge - change 2010 to 2020				0.6%

As before the quantity of "Biological Treatment MSW" comes from the **MSW1** Spreadsheet (table K2 & K3).

Applying these percentages produces the outputs in terms of practical energy resource as shown in table K12 (2010) and table K13 (2020).

Table K12 Bioenergy potential of wet biomass in 2010

Category	Qty (ktonnes)	2010			
		Biogas production Mm ³	Methane production Mm ³	Theoretical energy PJ/year	Practical energy PJ/year
Cattle manure & slurry	29,541				
Pig slurry	2,582				
Total Cattle manure & slurry and Pig slurry	32,123	707	459.4	16.44	0.33
Poultry manure	141	11	6.9	0.25	0.12
Food Beverage & Tobacco sludges	92	27.6	18.0	0.64	0.26
Sewage sludges (dry solids)	41	1.0	0.7	0.02	0.01
Biological Treatment MSW	316	39.5	25.7	0.92	0.23

Table K13 Bioenergy potential of wet biomass residues in 2020

Category	Qty (ktonnes)	2020			
		Biogas production Mm ³	Methane production Mm ³	Theoretical energy PJ/year	Practical energy PJ/year
Cattle manure & slurry	28,950				
Pig slurry	2,479				
Total Cattle manure & slurry and Pig slurry	31,429	691	449.4	16.09	0.80
Poultry manure	143	11	7.0	0.25	0.19
Food Beverage & Tobacco sludges	127	38.2	24.9	0.89	0.67
Sewage sludges (dry solids)	43	1.1	0.7	0.03	0.02
Biological Treatment MSW	545	68.1	44.2	1.58	0.79

⁸⁴ Regional Population Projections 2001 – 2031, Central Statistics Office, 18 June 2001.

K.6 Resource Summary

Table K15 below summarises the estimated resources in Ireland in the three time snapshots.

Table K15 Summary of estimated bioenergy resources

Biomass Resource Category	Practical Energy Resource		
	2001 PJ/year	2010 PJ/year	2020 PJ/year
Wood residues			
-Pulpwood residues	1.21	2.95	7.56
-Sawmill residues	0.80	1.89	3.24
-Forest residues	2.07	2.61	3.15
-Recycled wood -C&D residues	0.44	1.46	2.86
	4.52	8.91	16.81
Dry Agricultural residues			
-Straw	1.80	1.69	1.62
-Poultry Litter	0.36	0.36	0.36
-Spent Mushroom Compost	0.20	0.20	0.20
-Meat & Bonemeal	2.45	2.45	2.45
	4.80	4.69	4.62
Wet Organic residues			
-Cattle/pig manures, slurries	0.02	0.33	0.80
-Poultry manure	0.00	0.12	0.19
-Food beverage & tobacco sludges	0.12	0.26	0.67
-Sewage sludges (dry solids)	0.01	0.01	0.02
-Biodegradable MSW	0.01	0.23	0.79
	0.15	0.95	2.47
Landfill Gas			
-Landfill gas	2.84	0.57	0.21
	2.84	0.57	0.21
Waste-to-Energy MSW			
-Waste-to-Energy MSW	0.00	5.41	5.93
	0.00	5.41	5.93
Energy Crops			
-Short Rotation Coppice	0	1.17	4.05
	0	1.17	4.05
Total Practical Resource	12.31	21.71	34.09

Annex L

Economic model - Inputs and analysis

In order to provide inputs to the economic model that has been developed, three resource scenarios have been postulated for each of the years 2010 and 2020 based on the **Biomass Resources in Ireland**. These are as follows:

- A LOW Scenario – this assumes some improvement in relative prices for renewable energy, some effort to address institutional barriers and limited market competence.
- A MEDIUM Scenario – significant improvement in relative prices for renewable energy, significant movement to address institutional barriers and improved market competence.
- A HIGH Scenario – major improvement in relative prices for renewable energy, success in removal of institutional barriers and the development of a high level of market competence.

It is important to note here that the estimates of bioenergy in these scenarios **is additional to** the reference case. The reference case is defined as existing bioenergy contribution to Ireland's Total Primary Energy Requirement (TPER) plus anticipated developments from existing support programmes (AER V and AER VI). This reference case is set out in Table L1 below.

Table L1: Reference case for biomass contribution to Ireland's energy supply.

Biomass type	Primary energy 2002 ⁸⁶ (PJ/year)	Add to reach reference case (PJ/year)	Reference case (PJ/year)
Dry residues (wood & dry agricultural)	6.37	1.41 ⁸⁷	7.78
Wet residues	0.18	0.3 ⁸⁸	0.48
Landfill gas	0.8	0.44 ⁸⁹	1.24
Waste-to-energy	0	0	0
Energy crops	0	0	0
Total	7.35	2.15	9.5

⁸⁶ Data from *Renewable Energy in Ireland - Trends and Issues 1990 – 2002*, SEI, August 2004.

⁸⁷ Assumed 60% success rate for Biomass CHP category in AER VI -> $26.8 \times .6 = 16.0 \text{ MW}_e$. Since Graingers (1.9 MW_e) is developed, therefore a balance of 14.1 MW_e to be developed. Based on a load factor of 66.5%, Graingers input energy is 0.23 PJ / year, while for the 14.1 MW_e , with a conversion efficiency of 25%, the input energy would be 1.18 PJ.

⁸⁸ Ringsend AD plant (4 MW_e) plus 50% success rate for AD in AER VI (2 $\text{MW}_e \times 50\%$) gives 5 MW_e total. A load factor of 61.8% and a conversion efficiency of 35% gives an input energy of 0.3 PJ.

⁸⁹ Landfill gas projects in AER V and AER VI that have been developed or are expected to be developed give a total of 7.5 MW_e . A load factor of 64.8% and 35% conversion efficiency gives an input energy of 0.44 PJ.

The **additional** bioenergy potential under each scenario by 2010 is shown in table L2. The development of the details for these scenarios is presented in the following sections.

Table L2: Additional bioenergy potential by 2010.

Biomass type	Reference case (PJ/year)	Additional 2010 LOW (PJ/year)	Additional 2010 MEDIUM (PJ/year)	Additional 2010 HIGH (PJ/year)
Dry residues (wood & dry agricultural)	7.78	2.63	13.18	19.78
Wet residues	0.48	0.42	0.89	1.61
Landfill gas	1,24	0.43	0.57	0.86
Waste-to-energy	0	4.06	5.41	5.95
Energy crops	0	0.05	0.59	0.99
Total	9.5	7.59	20.65	29.19

While most of the 9.5 PJ (or about 1.5% of TPER) in the reference year is in heat only applications, it includes an installed electricity generating capacity of 43.5 MW_e.

The additional 7.59 PJ in the LOW scenario for 2010 could add an extra 76 MW_e of electricity generating capacity, with an additional 19 MW_{th} of heat from CHP applications and 90,000 tonnes of wood chips and 20,000 tonnes of wood pellets, all of which would displace fossil fuelled heating. The contribution to TPER in this case would be about 2.8%.

The additional 20.65 PJ in the MEDIUM scenario for 2010 could add an extra 183 MW_e of electricity generating capacity, with an additional 153 MW_{th} of heat from CHP applications and 470,000 tonnes of wood chips and 80,000 tonnes of wood pellets, all of which would displace fossil fuelled heating. The contribution to TPER in this case would be about 5%.

The additional 29.19 PJ in the HIGH scenario for 2010 could add an extra 259 MW_e of electricity generating capacity, with an additional 236 MW_{th} of heat from CHP applications and 700,000 tonnes of wood chips and 120,000 tonnes of wood pellets, all of which would displace fossil fuelled heating. The contribution to TPER in this case would be about 6%.

L.1 Dry Biomass Residues

For the “Dry Biomass Residues” the MEDIUM Scenario is taken as the practical resource that has been estimated in Annex K. The LOW Scenario is assumed to be 20% and the HIGH Scenario 150% of the MEDIUM Scenario. An exception is made for the Waste-to-Energy (WtE) MSW category where the LOW and HIGH Scenarios are assumed to be 75% and 110% respectively of the MEDIUM Scenario – the technology is technically and economically viable, while pressures for more recycling and biological treatment could constrain the quantity that would be directed to WtE. Table L3 presents the practical energy under the three scenarios for 2010 and 2020. The HIGH scenario (118% of MED) for *Recycled wood C&D residues* in 2020 is constrained by the estimated theoretical resource in that year.

Table L3: Input dry biomass residue resource data for scenarios.

	LOW	2010 MED	HIGH	LOW	2020 MED	HIGH
Percentage of Practical Resource						
	20%	100%	150%	20%	100%	150%
Wood Residues	PJ/yr	PJ/yr	PJ/yr	PJ/yr	PJ/yr	PJ/yr
Pulpwood residues	0.59	2.95	4.43	1.51	7.56	11.34
Sawmill residues	0.38	1.89	2.84	0.65	3.24	4.86
Forest residues	0.52	2.61	3.92	0.63	3.15	4.73
Recycled wood -C&D residues	0.29	1.46	2.19	0.57	2.86	3.37
Percentage of Practical Resource						
	20%	100%	150%	20%	100%	150%
Dry Agricultural Residues	PJ/yr	PJ/yr	PJ/yr	PJ/yr	PJ/yr	PJ/yr
Straw	0.34	1.69	2.53	0.32	1.62	2.43
Poultry Litter	0.02	0.09	0.14	0.02	0.09	0.14
Spent Mushroom Compost	0.01	0.05	0.07	0.01	0.05	0.07
Meat & Bonemeal	0.49	2.45	3.67	0.49	2.45	3.67
Percentage of Practical Resource						
	75%	100%	110%	75%	100%	110%
WtE Municipal Solid Waste	PJ/yr	PJ/yr	PJ/yr	PJ/yr	PJ/yr	PJ/yr
Waste-toEnergy MSW	4.06	5.41	5.95	4.44	5.93	6.52

L.2 Energy crops

The scenarios for the Energy Crops were developed as shown in table L4 based on SEI assumptions. Given the lead time to the first energy crop harvest (typically 4 years after planting in the case of short rotation forestry), the practical resource that has been estimated in Annex K for 2010 (5,000 ha) is taken to be the HIGH case here.

Table L4: Input energy crops resource data for scenarios

ECONOMIC MODEL INPUT DATA							
		2010			2020		
		LOW	MED	HIGH	LOW	MED	HIGH
Average Yield	DryT/ha	9.00	11.00	11.00	11.00	13.000	15.00
Area producing energy crops	ha	300	3,000	5,000	5,000	15,000	25,000
Practical energy	PJ/yr	0.05	0.59	0.99	0.99	3.51	6.75

L.3 Wet Biomass Residues

For Wet Biomass Residues, SEI assumptions on quantities of feedstock going to anaerobic digestion defined the LOW, MEDIUM and HIGH scenarios. These are shown in table L5. The percentages in the Med. case are the same as those used to define the practical resource in the Annex K.

Table L5: Feedstock percentages going to AD.

	2010			2020		
	Low	Med	High	Low	Med	High
Cattle/Pig manures/slurries - recoverable quantity to AD	0.5%	2.0%	5.0%	2.0%	5.0%	10.0%
Poultry manure - recoverable quantity to AD	46.0%	50.0%	65.0%	65.0%	75.0%	85.0%
Food beverage & tobacco sludges - recoverable quantity to AD	25.0%	40.0%	50.0%	40.0%	75.0%	95.0%
Sewage sludge - recoverable quantity to AD	50.0%	60.0%	70.0%	60.0%	85.0%	95.0%
Biodegradable MSW - recoverable quantity to AD	10.0%	25.0%	40.0%	25.0%	50.0%	60.0%

The resulting practical energy quantities under the three scenarios for 2010 and 2020 are shown in table L6.

Table L6: Input wet biomass residue resource data for scenarios

	2010 - LOW	2010 - MED	2010 - HIGH
	Practical energy PJ/year	Practical energy PJ/year	Practical energy PJ/year
Cattle manure & slurry			
Pig slurry			
Total Cattle manure & slurry and Pig slurry	0.08	0.33	0.82
Poultry manure	0.11	0.12	0.16
Food Beverage & Tobacco sludges	0.12	0.19	0.24
Sewage sludges (dry solids)	0.01	0.01	0.02
Biodegradable MSW	0.09	0.23	0.37
	2020 - LOW	2020 - MED	2020 - HIGH
	Practical energy PJ/year	Practical energy PJ/year	Practical energy PJ/year
Cattle manure & slurry			
Pig slurry			
Total Cattle manure & slurry and Pig slurry	0.32	0.80	1.61
Poultry manure	0.18	0.20	0.23
Food Beverage & Tobacco sludges	0.20	0.36	0.46
Sewage sludges (dry solids)	0.01	0.02	0.02
Biodegradable MSW	0.40	0.79	0.95

L.4 Landfill gas

For the “Landfill Gas” the MEDIUM Scenario is taken as the practical resource that has been estimated in Annex K. The LOW Scenario is assumed to be 75% and the HIGH Scenario 150% of the MEDIUM Scenario.

Table L7: Input landfill gas resource data for scenarios.

	2010			2020		
	LOW	MED	HIGH	LOW	MED	HIGH
Percentage of practical resource	75%	100%	150%	75%	100%	150%
	0.43	0.57	0.86	0.16	0.21	0.31

L.5 Model input data summary

Table L8 summarises the practical resource data under the three scenarios for 2010 and 2020 from the previous sections.

Table L8: Summary of model input scenario resource data.

	2010			2020		
	PJ/year Low	PJ/year Med	PJ/year High	PJ/year Low	PJ/year Med	PJ/year High
Wood residues						
-Pulpwood residues	0.59	2.95	4.43	1.51	7.56	11.34
-Sawmill residues	0.38	1.89	2.84	0.65	3.24	4.86
-Forest residues	0.52	2.61	3.92	0.63	3.15	4.73
-Recycled wood -C&D residues	0.29	1.46	2.19	0.57	2.86	3.37
	1.78	8.91	13.37	3.36	16.81	24.29
Dry Agricultural residues						
-Straw	0.34	1.69	2.53	0.32	1.62	2.43
-Poultry Litter	0.02	0.09	0.14	0.02	0.09	0.14
-Spent Mushroom Compost	0.01	0.05	0.07	0.01	0.05	0.07
-Meat & Bonemeal	0.49	2.45	3.67	0.49	2.45	3.67
	0.85	4.27	6.41	0.84	4.20	6.31
Wet Organic residues						
-Cattle/pig manures, slurries	0.08	0.33	0.82	0.32	0.80	1.61
-Poultry manure	0.11	0.12	0.16	0.18	0.20	0.23
-Food beverage & tobacco sludges	0.12	0.19	0.24	0.20	0.36	0.46
-Sewage sludges (dry solids)	0.01	0.01	0.02	0.01	0.02	0.02
-Biodegradable MSW	0.09	0.23	0.37	0.40	0.79	0.95
	0.42	0.89	1.61	1.11	2.18	3.27
Landfill Gas						
-Landfill gas	0.43	0.57	0.86	0.16	0.21	0.31
	0.43	0.57	0.86	0.16	0.21	0.31
Waste-to-Energy MSW						
-Waste-to-Energy MSW	4.06	5.41	5.95	4.44	5.93	6.52
	4.06	5.41	5.95	4.44	5.93	6.52
Energy Crops						
-Short Rotation Coppice	0.05	0.59	0.99	0.99	3.51	6.75
	0.05	0.59	0.99	0.99	3.51	6.75
Total	7.59	20.65	29.19	10.90	32.84	47.45

L.6 Energy streams distribution

SEI estimates of the distribution of the bioenergy resources in table L8 to the final energy streams are shown in table L9. These are clearly open to debate, but are given for illustrative purposes.

Table L9: Distribution of resources to energy streams.

	HEAT Wchips %	HEAT Pellets %	2010 ELEC %	CHP %	OTHER	HEAT Wchips %	HEAT Pellets %	2020 ELEC %	CHP %	OTHER
Wood residues										
-Pulpwood residues	60%	0%	20%	20%	0%	30%	0%	20%	50%	0%
-Sawmill residues	0%	75%	0%	25%	0%	0%	75%	0%	25%	0%
-Forest residues	60%	0%	20%	20%	0%	30%	0%	20%	50%	0%
-Recycled wood -C&D residues	60%	0%	20%	20%	0%	20%	0%	30%	50%	0%
Dry Agricultural residues										
-Straw	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Poultry Litter	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Spent Mushroom Compost	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Meat & Bonemeal	0%	0%	50%	50%	0%	0%	0%	25%	75%	0%
Wet Organic residues										
-Cattle/pig manures, slurries	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Poultry manure	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Food beverage & tobacco sludges	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Sewage sludges (dry solids)	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
-Biodegradable MSW	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%
Landfill Gas										
-Landfill gas	0%	0%	100%	0%	0%	0%	0%	100%	0%	0%
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0%	0%	100%	0%	0%	0%	0%	0%	100%	0%
Energy Crops										
-Short Rotation Coppice	50%	0%	0%	50%	0%	25%	0%	0%	75%	0%

Solid fuels (as wood chips or pellets) for heat only applications are considered to come exclusively from wood residues. Generation of electricity is foreseen as being in both condensing mode and CHP mode for 2010 and 2020.

L.7 Energy output

In order to convert the practical energy in each scenario to energy available for final energy consumption, the assumptions on conversion efficiency and fuel calorific value shown in table L10 are applied.

Table L10: Assumptions on conversion efficiency and calorific value used in model.

	Non-MSW		MSW only	
	2010	2020	2,010	2,020
Electricity co-firing conversion efficiency	38%	40%	25%	30%
Biomass CHP electricity conversion efficiency	25%	35%	20%	25%
Biomass CHP heat conversion efficiency	55%	55%	50%	50%
CV of tonne of pellets in GJ/tonne	18.0	18.0		
CV of tonne of wood chips in GJ/tonne	9.0	9.0		
AD electricity conversion efficiency	35%	35%		
AD heat conversion efficiency	35%	35%		
Landfill Gas electricity conversion efficiency	35%	35%		
Landfill Gas heat conversion efficiency	35%	35%		

The outputs in terms of tonnes of fuel (wood chips or pellets for heat only applications) and MWhs of electricity and heat for each scenario are presented in tables L11 through L13.

Table L11: Energy output as final energy consumption for LOW scenario.

	2010 - LOW					2020 - LOW				
	HEAT Wchips Mtnes/yr	HEAT Pellets Mtnes/yr	ELEC MWh	CHP Elec MWh	CHP Heat MWh	HEAT Wchips tonnes/yr	HEAT Pellets tonnes/yr	ELEC MWh	CHP Elec MWh	CHP Heat MWh
Wood residues										
-Pulpwood residues	0.04	0.00	12,464	8,200	18,040	0.05	0.00	33,600	73,500	115,500
-Sawmill residues	0.00	0.02	0	6,563	14,438	0.00	0.03	0	15,750	24,750
-Forest residues	0.03	0.00	11,020	7,250	15,950	0.02	0.00	14,000	30,625	48,125
-Recycled wood -C&D residues	0.02	0.00	6,168	4,058	8,928	0.01	0.00	19,090	27,840	43,749
	0.09	0.02	29,652	26,071	57,355	0.08	0.03	66,690	147,715	232,124
Dry Agricultural residues										
-Straw	0.00	0.00	0	23,438	51,563	0.00	0.00	0	31,500	49,500
-Poultry Litter	0.00	0.00	0	1,250	2,750	0.00	0.00	0	1,750	2,750
-Spent Mushroom Compost	0.00	0.00	0	689	1,516	0.00	0.00	0	964	1,516
-Meat & Bonemeal	0.00	0.00	25,808	16,979	37,354	0.00	0.00	13,583	35,656	56,031
	0.00	0.00	25,808	42,356	93,182	0.00	0.00	13,583	69,871	109,797
Wet Organic residues										
-Cattle/pig manures, slurries	0.00	0.00	0	7,994	7,994	0.00	0.00	0	31,285	31,285
-Poultry manure	0.00	0.00	0	10,974	10,974	0.00	0.00	0	17,016	17,016
-Food beverage & tobacco sludges	0.00	0.00	0	11,778	11,778	0.00	0.00	0	19,466	19,466
-Sewage sludges (dry solids)	0.00	0.00	0	1,072	1,072	0.00	0.00	0	1,294	1,294
-Biodegradable MSW	0.00	0.00	0	8,943	8,943	0.00	0.00	0	38,500	38,500
	0.00	0.00	0	40,760	40,760	0.00	0.00	0	107,560	107,560
Landfill Gas										
-Landfill gas	0.00	0.00	41,734	0	0	0.00	0.00	15,087	0	0
	0.00	0.00	41,734	0	0	0.00	0.00	15,087	0	0
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0.00	0.00	281,907	0	0	0.00	0.00	0	308,654	617,308
	0.00	0.00	281,907	0	0	0.00	0.00	0	308,654	617,308
Energy Crops										
-Short Rotation Coppice	0.00	0.00	0	1,688	3,713	0.03	0.00	0	72,188	113,438
	0.00	0.00	0	1,688	3,713	0.03	0.00	0	72,188	113,438

Table L12: Energy output as final energy consumption for MED scenario.

	2010 - MED					2020 - MED				
	HEAT Wchips Mtnes/yr	HEAT Pellets Mtnes/yr	ELEC MWh	CHP Elec MWh	CHP Heat MWh	HEAT Wchips tonnes/yr	HEAT Pellets tonnes/yr	ELEC MWh	CHP Elec MWh	CHP Heat MWh
Wood residues										
-Pulpwood residues	0.20	0.00	62,320	41,000	90,200	0.25	0.00	168,000	367,500	577,500
-Sawmill residues	0.00	0.08	0	32,813	72,188	0.00	0.14	0	78,750	123,750
-Forest residues	0.17	0.00	55,100	36,250	79,750	0.11	0.00	70,000	153,125	240,625
-Recycled wood -C&D residues	0.10	0.00	30,842	20,291	44,640	0.06	0.00	95,451	139,200	218,743
	0.47	0.08	148,262	130,353	286,777	0.42	0.14	333,451	738,575	1,160,618
Dry Agricultural residues										
-Straw	0.00	0.00	0	117,188	257,813	0.00	0.00	0	157,500	247,500
-Poultry Litter	0.00	0.00	0	6,250	13,750	0.00	0.00	0	8,750	13,750
-Spent Mushroom Compost	0.00	0.00	0	3,444	7,578	0.00	0.00	0	4,822	7,578
-Meat & Bonemeal	0.00	0.00	129,042	84,896	186,771	0.00	0.00	67,917	178,281	280,156
	0.00	0.00	129,042	211,778	465,911	0.00	0.00	67,917	349,353	548,984
Wet Organic residues										
-Cattle/pig manures, slurries	0.00	0.00	0	31,976	31,976	0.00	0.00	0	78,213	78,213
-Poultry manure	0.00	0.00	0	11,928	11,928	0.00	0.00	0	19,633	19,633
-Food Industry Residues	0.00	0.00	0	18,844	18,844	0.00	0.00	0	35,333	35,333
-Sewage sludges (dry solids)	0.00	0.00	0	1,286	1,286	0.00	0.00	0	1,822	1,822
-Biodegradable MSW	0.00	0.00	0	22,357	22,357	0.00	0.00	0	76,999	120,999
	0.00	0.00	0	86,392	86,392	0.00	0.00	0	212,001	256,001
Landfill Gas										
-Landfill gas	0.00	0.00	55,645	0	0	0.00	0.00	20,116	0	0
	0.00	0.00	55,645	0	0	0.00	0.00	20,116	0	0
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0.00	0.00	375,875	0	0	0.00	0.00	0	411,538	823,077
	0.00	0.00	375,875	0	0	0.00	0.00	0	411,538	823,077
Energy Crops										
-Short Rotation Coppice	0.03	0.00	0	20,625	45,375	0.10	0.00	0	255,938	402,188
	0.03	0.00	0	20,625	45,375	0.10	0.00	0	255,938	402,188

Table L13 Energy output as final energy consumption for HIGH Scenario

	2010 - HIGH					2020 - HIGH				
	HEAT Wchips Mtnes/yr	HEAT Pellets Mtnes/yr	ELEC MWh	CHP Elec MWh	CHP Heat MWh	HEAT Wchips tonnes/yr	HEAT Pellets tonnes/yr	ELEC MWh	CHP Elec MWh	CHP Heat MWh
Wood residues										
-Pulpwood residues	0.30	0.00	93,480	61,500	135,300	0.38	0.00	252,000	551,250	866,250
-Sawmill residues	0.00	0.12	0	49,219	108,281	0.00	0.20	0	118,125	185,625
-Forest residues	0.26	0.00	82,650	54,375	119,625	0.16	0.00	105,000	229,688	360,938
-Recycled wood -C&D residues	0.15	0.00	46,263	30,436	66,960	0.07	0.00	112,296	163,764	257,344
	0.70	0.12	222,393	195,530	430,166	0.61	0.20	469,296	1,062,827	1,670,157
Dry Agricultural residues										
-Straw	0.00	0.00	0	175,781	386,719	0.00	0.00	0	236,250	371,250
-Poultry Litter	0.00	0.00	0	9,375	20,625	0.00	0.00	0	13,125	20,625
-Spent Mushroom Compost	0.00	0.00	0	5,167	11,367	0.00	0.00	0	7,233	11,367
-Meat & Bonemeal	0.00	0.00	193,563	127,344	280,156	0.00	0.00	101,875	267,422	420,234
	0.00	0.00	193,563	317,667	698,867	0.00	0.00	101,875	524,030	823,476
Wet Organic residues										
-Cattle/pig manures, slurries	0.00	0.00	0	79,941	79,941	0.00	0.00	0	156,427	156,427
-Poultry manure	0.00	0.00	0	15,507	15,507	0.00	0.00	0	22,251	22,251
-Food Industry Residues	0.00	0.00	0	23,555	23,555	0.00	0.00	0	44,755	44,755
-Sewage sludges (dry solids)	0.00	0.00	0	1,500	1,500	0.00	0.00	0	2,036	2,036
-Biodegradable MSW	0.00	0.00	0	35,771	35,771	0.00	0.00	0	92,399	92,399
	0.00	0.00	0	156,274	156,274	0.00	0.00	0	317,868	317,868
Landfill Gas										
-Landfill gas	0.00	0.00	83,468	0	0	0.00	0.00	30,174	0	0
	0.00	0.00	83,468	0	0	0.00	0.00	30,174	0	0
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0.00	0.00	413,463	0	0	0.00	0.00	0	452,692	905,385
	0.00	0.00	413,463	0	0	0.00	0.00	0	452,692	905,385
Energy Crops										
-Short Rotation Coppice	0.06	0.00	0	34,375	75,625	0.19	0.00	0	492,188	773,438
	0.06	0.00	0	34,375	75,625	0.19	0.00	0	492,188	773,438

Based on conservative, technology specific load factors the power output in electricity and heat (heat in CHP applications) for the three scenarios are given in tables L14, L15 and L16.

Table L14: Power output as final energy consumption for LOW scenario.

	2010 - LOW					2020 - LOW				
	HEAT Wchips Mtnes/yr	HEAT Pellets Mtnes/yr	ELEC MW	CHP Elec MW	CHP Heat MW	HEAT Wchips tonnes/yr	HEAT Pellets tonnes/yr	ELEC MW	CHP Elec MW	CHP Heat MW
Wood residues										
-Pulpwood residues	0.04	0.00	1.80	1.41	3.10	0.05	0.00	4.84	12.62	19.83
-Sawmill residues	0.00	0.02	0.00	1.13	2.48	0.00	0.03	0.00	2.70	4.25
-Forest residues	0.03	0.00	1.59	1.24	2.74	0.02	0.00	2.02	5.26	8.26
-Recycled wood -C&D residues	0.02	0.00	0.89	0.58	1.53	0.01	0.00	2.75	4.78	7.51
	0.09	0.02	4.27	4.36	9.85	0.08	0.03	9.61	25.36	39.85
Dry Agricultural residues										
-Straw	0.00	0.00	0.00	4.02	8.85	0.00	0.00	0.00	5.41	8.50
-Poultry Litter	0.00	0.00	0.00	0.21	0.47	0.00	0.00	0.00	0.30	0.47
-Spent Mushroom Compost	0.00	0.00	0.00	0.12	0.26	0.00	0.00	0.00	0.17	0.26
-Meat & Bonemeal	0.00	0.00	3.72	2.91	6.41	0.00	0.00	1.96	6.12	9.62
	0.00	0.00	3.72	7.27	16.00	0.00	0.00	1.96	11.99	18.85
Wet Organic residues										
-Cattle/pig manures, slurries	0.00	0.00	0.00	1.48	1.48	0.00	0.00	0.00	5.78	5.78
-Poultry manure	0.00	0.00	0.00	2.03	2.03	0.00	0.00	0.00	3.14	3.14
-Food beverage & tobacco sludges	0.00	0.00	0.00	2.18	2.18	0.00	0.00	0.00	3.60	3.60
-Sewage sludges (dry solids)	0.00	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.24	0.24
-Biodegradable MSW	0.00	0.00	0.00	1.65	1.65	0.00	0.00	0.00	7.11	7.11
	0.00	0.00	0.00	7.53	7.53	0.00	0.00	0.00	19.87	19.87
Landfill Gas										
-Landfill gas	0.00	0.00	7.35	0.00	0.00	0.00	0.00	2.66	0.00	0.00
	0.00	0.00	7.35	0.00	0.00	0.00	0.00	2.66	0.00	0.00
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0.00	0.00	41.52	0.00	0.00	0.00	0.00	0.00	61.81	123.63
	0.00	0.00	41.52	0.00	0.00	0.00	0.00	0.00	61.81	123.63
Energy Crops										
-Short Rotation Coppice	0.00	0.00	0.00	0.29	0.64	0.00	0.00	0.00	12.39	19.47
	0.00	0.00	0.00	0.29	0.64	0.00	0.00	0.00	12.39	19.47

In the LOW Scenario, 90,000 tonnes of wood chips and 20,000 tonnes of wood pellets are produced in 2010 for heat applications. These quantities change to 80,000 tonnes of wood chips and 30,000 tonnes of wood pellets by 2020.

Electricity generation in condensing mode provides 57 MW_e, falling to 15 MW_e in 2020. CHP applications are estimated to provide 19 MW_e and 34 MW_{th} in 2010, increasing to 130 MW_e and 222 MW_{th} in 2020.

Table L15 Power output as final energy consumption for MED scenario.

	2010 - MED					2020 - MED				
	HEAT Wchips Mtnes/yr	HEAT Pellets Mtnes/yr	ELEC MW	CHP Elec MW	CHP Heat MW	HEAT Wchips tonnes/yr	HEAT Pellets tonnes/yr	ELEC MW	CHP Elec MW	CHP Heat MW
Wood residues										
-Pulpwood residues	0.20	0.00	8.98	7.04	15.48	0.25	0.00	24.21	63.09	99.13
-Sawmill residues	0.00	0.08	0.00	5.63	12.39	0.00	0.14	0.00	13.52	21.24
-Forest residues	0.17	0.00	7.94	6.22	13.69	0.11	0.00	10.09	26.29	41.31
-Recycled wood -C&D residues	0.10	0.00	4.45	2.92	7.66	0.06	0.00	13.76	23.90	37.55
	0.47	0.08	21.37	21.82	49.23	0.42	0.14	48.06	126.79	199.23
Dry Agricultural residues										
-Straw	0.00	0.00	0.00	20.12	44.26	0.00	0.00	0.00	27.04	42.49
-Poultry Litter	0.00	0.00	0.00	1.07	2.36	0.00	0.00	0.00	1.50	2.36
-Spent Mushroom Compost	0.00	0.00	0.00	0.59	1.30	0.00	0.00	0.00	0.83	1.30
-Meat & Bonemeal	0.00	0.00	18.60	14.57	32.06	0.00	0.00	9.79	30.60	48.09
	0.00	0.00	18.60	36.35	79.98	0.00	0.00	9.79	59.97	94.24
Wet Organic residues										
-Cattle/pig manures, slurries	0.00	0.00	0.00	5.91	5.91	0.00	0.00	0.00	14.45	14.45
-Poultry manure	0.00	0.00	0.00	2.20	2.20	0.00	0.00	0.00	3.63	3.63
-Food Industry Residues	0.00	0.00	0.00	3.48	3.48	0.00	0.00	0.00	6.53	6.53
-Sewage sludges (dry solids)	0.00	0.00	0.00	0.24	0.24	0.00	0.00	0.00	0.34	0.34
-Biodegradable MSW	0.00	0.00	0.00	4.13	4.13	0.00	0.00	0.00	14.22	22.35
	0.00	0.00	0.00	15.96	15.96	0.00	0.00	0.00	39.16	47.29
Landfill Gas										
-Landfill gas	0.00	0.00	9.80	0.00	0.00	0.00	0.00	3.54	0.00	0.00
	0.00	0.00	9.80	0.00	0.00	0.00	0.00	3.54	0.00	0.00
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0.00	0.00	55.37	0.00	0.00	0.00	0.00	0.00	82.42	164.84
	0.00	0.00	55.37	0.00	0.00	0.00	0.00	0.00	82.42	164.84
Energy Crops										
-Short Rotation Coppice	0.00	0.00	0.00	3.54	7.79	0.00	0.00	0.00	43.93	69.04
	0.00	0.00	0.00	3.54	7.79	0.00	0.00	0.00	43.93	69.04

In the MEDIUM Scenario, 470,000 tonnes of wood chips and 80,000 tonnes of wood pellets are produced in 2010, changing to 420,000 tonnes of wood chips and 140,000 tonnes of wood pellets by 2020.

Electricity generation in condensing mode provides 105 MW_e, reducing to 62 MW_e by 2020.

CHP applications are estimated to provide 78 MW_e and 153 MW_{th} in 2010 increasing to 352 MW_e and 573 MW_{th} 2020.

Table L16 Power output as final energy consumption for HIGH scenario.

	2010 - High					2020 - HIGH				
	HEAT Wchips Mtnes/yr	HEAT Pellets Mtnes/yr	ELEC MW	CHP Elec MW	CHP Heat MW	HEAT Wchips tonnes/yr	HEAT Pellets tonnes/yr	ELEC MW	CHP Elec MW	CHP Heat MW
Wood residues										
-Pulpwood residues	0.30	0.00	13.47	10.56	23.23	0.38	0.00	36.32	94.63	148.70
-Sawmill residues	0.00	0.12	0.00	8.45	18.59	0.00	0.20	0.00	20.28	31.86
-Forest residues	0.26	0.00	11.91	9.33	20.54	0.16	0.00	15.13	39.43	61.96
-Recycled wood -C&D residues	0.15	0.00	6.67	4.39	11.49	0.07	0.00	16.19	28.11	44.18
	0.70	0.12	32.05	32.73	73.84	0.61	0.20	67.64	182.45	286.70
Dry Agricultural residues										
-Straw	0.00	0.00	0.00	30.17	66.38	0.00	0.00	0.00	40.56	63.73
-Poultry Litter	0.00	0.00	0.00	1.61	3.54	0.00	0.00	0.00	2.25	3.54
-Spent Mushroom Compost	0.00	0.00	0.00	0.89	1.95	0.00	0.00	0.00	1.24	1.95
-Meat & Bonemeal	0.00	0.00	27.90	21.86	48.09	0.00	0.00	14.68	45.91	72.14
	0.00	0.00	27.90	54.53	119.97	0.00	0.00	14.68	89.96	141.36
Wet Organic residues										
-Cattle/pig manures, slurries	0.00	0.00	0.00	14.77	14.77	0.00	0.00	0.00	28.89	28.89
-Poultry manure	0.00	0.00	0.00	2.86	2.86	0.00	0.00	0.00	4.11	4.11
-Food Industry Residues	0.00	0.00	0.00	4.35	4.35	0.00	0.00	0.00	8.27	8.27
-Sewage sludges (dry solids)	0.00	0.00	0.00	0.28	0.28	0.00	0.00	0.00	0.38	0.38
-Biodegradable MSW	0.00	0.00	0.00	6.61	6.61	0.00	0.00	0.00	17.07	17.07
	0.00	0.00	0.00	28.87	28.87	0.00	0.00	0.00	58.72	58.72
Landfill Gas										
-Landfill gas	0.00	0.00	14.70	0.00	0.00	0.00	0.00	5.32	0.00	0.00
	0.00	0.00	14.70	0.00	0.00	0.00	0.00	5.32	0.00	0.00
Waste-to-Energy MSW										
-Waste-to-Energy MSW	0.00	0.00	60.90	0.00	0.00	0.00	0.00	0.00	90.66	181.32
	0.00	0.00	60.90	0.00	0.00	0.00	0.00	0.00	90.66	181.32
Energy Crops										
-Short Rotation Coppice	0.00	0.00	0.00	5.90	12.98	0.00	0.00	0.00	84.49	132.77
	0.00	0.00	0.00	5.90	12.98	0.00	0.00	0.00	84.49	132.77

In the HIGH Scenario, 700,000 tonnes of wood chips and 120,000 tonnes of wood pellets are produced in 2010. These quantities change to 610,000 tonnes of wood chips and 200,000 tonnes of wood pellets by 2020.

Electricity generation in condensing mode provides approximately 136 MW_e in 2010. This is considered to fall to 88 MW_e in 2020 as all generation is assumed to be CHP by that date.

CHP applications are estimated to provide 123 MW_e and 236 MW_{th} in 2010, increasing to 506 MW_e and 801 MW_{th}.

L.8 Economic Modelling

The bioenergy funding estimates are based on economic modelling of the Irish renewable energy market carried out by SEI's economic analysts. The analysis is based on determining levelised costs for each one of the bioenergy technologies considered in the report. These levelised costs are then applied to the Low, Medium and High scenarios discussed above, with an assumed deployment schedule over the period in question. Using this schedule, annual support costs are calculated on the basis of the spread between a technology's levelised cost and the Best New Entrant (BNE) cost. Using discounted cash-flow techniques, these annual costs are discounted to a 2005 present value.

Levelised cost (LC) is the long-run average cost (in cents per kWh) of a generating plant's expected electrical output using operating, capital, and fuel costs which are annuitised at an appropriate discount rate over the life of the plant. LC is the ratio of present value costs and present value outputs, and is a standard metric in the energy industry. The weighted average cost of capital is taken as 15%.

The CER has determined that the LC of the Best New Entrant (BNE) technology will be 5.36ct/kWh in Ireland in 2005. The CERs BNE is the 'gate price' for electricity from a 390-400MW CCGT plant. This figure includes an allowance of 0.11ct/kWh for carbon costs related to the pending Emissions Trading Scheme and also an allowance for grid maintenance costs.

Levelised costs for various bioelectricity pathways are estimated to be in the range of 9.5 to 11 cents per kWh, i.e. about 4 to 5.5 cents above BNE. The exception is landfill gas, which should be competitive at the bid price offered in AER VI, 6.412 cents per kWh:

Table L17 SEI estimates of levelised costs for bioenergy pathways

Generation type	LC ct/kWhe	Difference vs CER BNE ct/kWhe
Co-firing peat (30%)	9.87	4.51
Agricultural residue CHP	10.17	4.81
Wood industry residue CHP	10.66	5.30
Forest residue CHP	10.66	5.30
Energy crop CHP	10.46	5.10
AD CHP	9.77	4.41

Determining the LC of electricity from electricity-only generating plant is straightforward. However, with CHP plant the high cost of electricity is offset by the value of the heat. The LCs of biomass CHP electricity take into account the forgone cost of separate heat generation (such as a steam boiler), assuming that all of the heat generated is useful. It is also assumed that the CHP plant is only used when there is a heat load, resulting in low average load factors (~66.5%) used in calculating the LCs. The LC of biomass CHP electricity is derived as follows:

[LC of CHP energy with all heat dumped] - [LC of forgone heat boiler x Heat-to-Power ratio] x % useful heat.

It can be seen from this formula that decreasing the “% of useful heat” raises the LC of the electricity produced. Also, the formula does not take into account the cost of any backup heat requirement.

What is the assumed deployment schedule?

The majority of the bioenergy capacity identified in the low, medium, and high scenarios is assumed to deploy under a “post-AER VI” programme. Plant is assumed to rollout annually in four equal portions from 2006 to 2009. For the 2020 scenarios, plant rolls out the same way from 2010 to 2019. Under all scenarios 22.5MW of capacity is assumed to come on line in 2005 and 2006 under AER VI. Also, one 2.25MW LFG gas project is deployed in 2004 under AER V. An important assumption is that all of the bioenergy capacity identified in this report is deployed and supported within a national scheme.

How is the 2005 present value of support determined?

Annual support costs are calculated on the basis of the spread between each bioenergy technology’s levelised cost and the Best New Entrant (BNE) cost. This margin is then scaled up by the total incremental GWhs of electricity associated with that technology in that scenario.

For example, if Biogas CHP produces 68GWh per annum thus replacing an equal amount of CCGT (BNE) generation, the annual cost of support would be as follows, based on an electricity price of 9.77 cents per kWh for biogas CHP electricity:

$$(9.77 - 5.36) \times 68 \times 10^4 = \text{€}3 \text{ million}$$

Thus, €3m would be the annual support required. This cost must be recovered, presumably through the PSO-levy, to support the payment of 9.77ct/kWh to the biogas CHP plant. Using the discounted cash-flow method the annual support cost (say, €3M/yr for 15 years) is discounted to a 2005 present value. It is important to distinguish between the support costs and the actual payments made to the bioenergy plant operator. An alternative way to describe the support cost calculation is as the payment to the plant operator net of the forgone BNE plant costs.

In reality an incremental unit of biogas CHP electricity would not exactly offset one unit of centrally dispatched CCGT plant. The model used to generate the support costs determines what that offset ratio would be. Also, the actual cost of support formula would account for any relevant contract terms.

Issues to note

Co-firing biomass with peat could represent a big component of the overall cost of support. In this report, co-firing is quite unfavourably compared to the BNE. It could be argued that co-firing with peat should be compared with the levelised cost of peat generation, and on this basis it is fully

competitive. This issue depends on how the public service obligation would operate if co-firing at peat stations were undertaken. The support figures quoted in this report remove the element associated with this co-firing.

Biomass CHP is very sensitive to fuel costs. Decreasing fuel costs by 10% from current level of 3ct/kWh would decrease the levelised costs by approximately 15%.

Results are very sensitive to BNE. Small changes in the BNE have large impacts on support costs. While LCs for bioenergy technologies are likely to fall in the future, BNE is likely to increase in the future, and this would greatly reduce the required support costs.

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