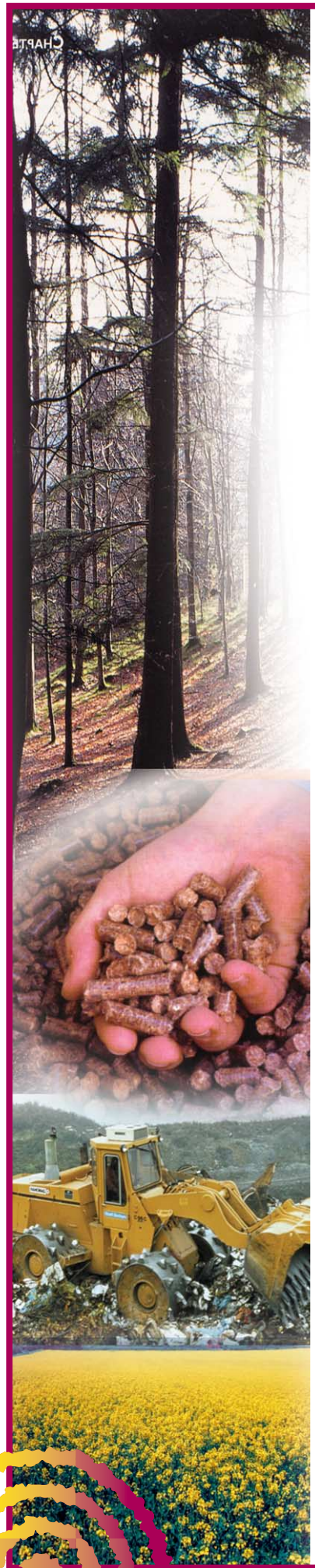


SUSTAINABLE ENERGY IRELAND
Renewable Energy Information Office

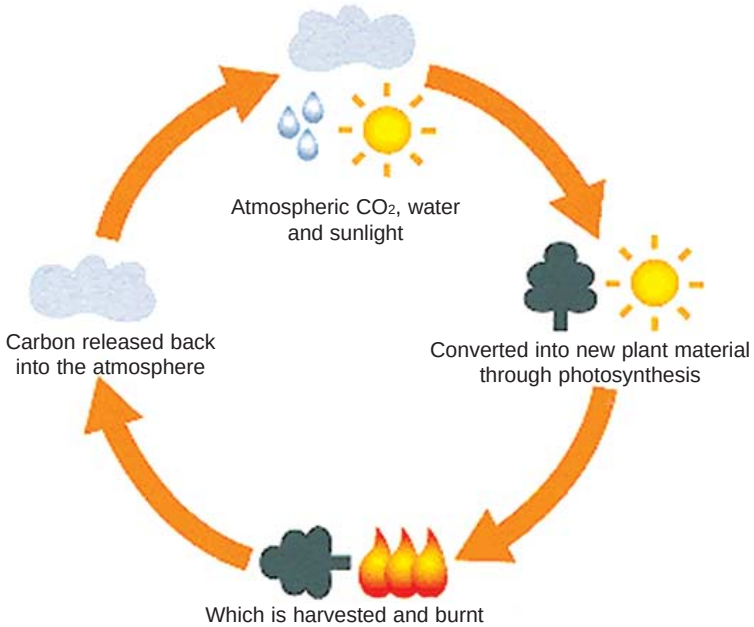
What is Biomass?

Biomass is the oldest fuel used by mankind. Wood has been used as a fuel for cooking and heating for over 500,000 years, but has suffered a decline in the last century as the use of fossil fuels increased. However, the environmentally harmful effects of burning fossil fuels coupled with the need to secure indigenous renewable sources of energy has resulted in a return to using natural and clean sources of energy such as biomass.

Definition of Biomass

The term biomass encompasses a variety of fuels and technologies used to produce renewable energy. Biomass refers to land and water-based vegetation, organic wastes and photosynthetic organisms. These are non-fossil, renewable carbon resources from which energy can be produced and used as fossil fuel substitutes. Examples of biomass include: wood, grasses, crops, agricultural and municipal wastes. Biomass can be burned to produce heat that is used to create steam to turn turbines to produce electricity. Therefore, energy from biomass can produce electricity and/or heat. Liquid biofuels can also be derived from biomass crops such as oilseed rape.

Energy from biomass and waste is often referred to as bioenergy. When plant material is burned for energy purposes carbon dioxide is released. However, because plants absorb carbon dioxide during their life cycle, the net emissions of carbon dioxide are zero. In this way, wood is said to be carbon neutral.



Source: British BioGen, the UK Trade Association for Bioenergy.

Multiple Benefits from Biomass

We take the ready availability of heat and electricity for granted. We are unaware of the environmental damage that results from the production of heat and power from fossil fuels such as coal and natural gas. There are many environmental, economic and social benefits associated with the development of biomass as an energy source:

- Net reduction in CO_2 emissions - biomass is carbon neutral (there is no net increase in CO_2, the main greenhouse gas, in the atmosphere) and can save millions of tonnes of CO_2 emissions per annum.

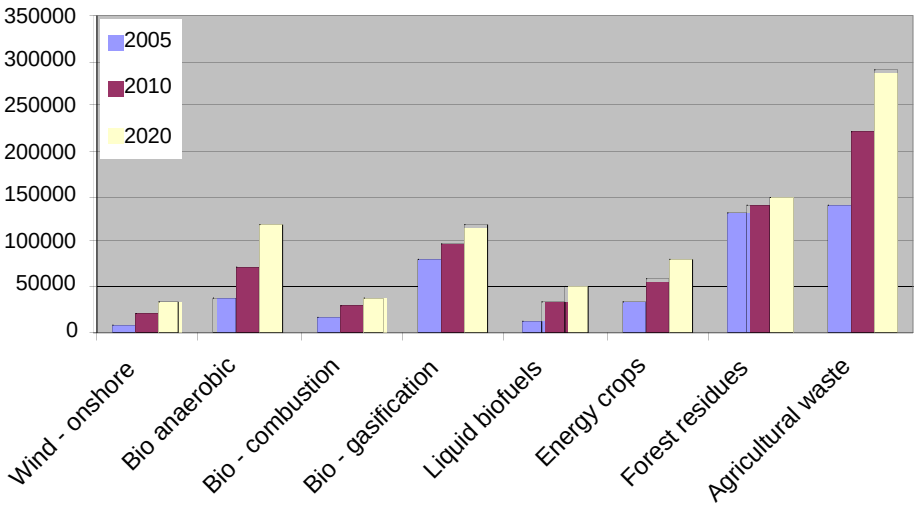
- Indigenous resource - which can reduce our current state of over-dependence on fuel imports. Ireland currently imports 86% of its fuels, making us the most import dependent country in the EU.

- Secure energy supply - as an indigenous and self-sufficient source of energy, there is no risk of cut off in supply.

- Employment

Biomass developments provide a valuable source of employment, especially in remote rural areas. The main employment categories created are:

- Fuel supply - cultivation of energy crops, recovery and transportation of wood wastes, forest residues, agricultural wastes etc.
- Engineering consultants - feasibility studies, design and engineering/construction management
- Environmental services - environmental impact assessments
- Construction - roads, buildings, electrical infrastructure etc.
- Legal/Financing - planning, contractual and financing
- Manufacturing - while there are some manufacturing companies in Ireland e.g. pellet equipment, there is significant potential for establishment of manufacturers of the various components of biofuel systems.
- Maintenance, servicing and administration



Projected employment in the EU for biomass technologies. Wind is included for comparison.
Source: EU Altener Report: Impact of RES on Employment, 2000.

- Environmental gains
  - biomass is sustainable and does not deplete future resources.
  - energy forestry crops have a much greater diversity of wildlife and flora than arable or pasture land and careful design of energy crops will enhance local landscapes and provide recreational facilities.

Rufus Sage/ Game Conservatory Trust

- Solution to surplus waste problem
  - useful bioenergy can be recovered from wood wastes (e.g. from sawmills), forest residues (e.g. wood chips, bark), household and agricultural residues (e.g. slurry and poultry waste) to generate heat and electricity, while at the same time dealing with the problem of waste disposal.

Biomass feedstocks/ sources of biomass

Biomass sources can be divided into two main streams:
- energy crops
- organic residues

Energy Crops are grown specifically for energy purposes

- Short Rotation Forestry (SRF) – this is the production of wood fuel through the cultivation of high-yielding trees at close spacing on short time rotations. Species such as Willow and Poplar are ideal for SRF, as they are easy to establish, fast growing, suitable for a variety of sites and resistant to pests and disease. Land for short rotation forestry is likely to come from two sources, namely: non-rotational arable set aside land and land outside the existing arable pool – presently in beef or sheep production.

Willow

Poplar

Hemp

- Other energy crops such as Hemp and Miscanthus (Elephant grass) have been investigated for their suitability as a source of biomass fuel. Cultivation of Hemp has the advantage in that being an annual plant, farmer's experience of dealing with annual tillage crops could easily be applied to it and existing farming machinery used for harvesting etc.

Miscanthus

- Liquid biofuel energy crops – these crops are grown for the production of liquid transport fuels. Different conversion techniques are used to produce (a) biodiesel, (b) bioethanol and (c) biomethanol. Biodiesel is derived from oil crops such as oilseed rape and camelina (an oil-seed crop with an oil yield similar to that of oilseed rape). Bioethanol is produced from crops such as wheat, sugarbeet, sweet sorghum and woody crops. Research on the production of biomethanol from various biomass sources such as grasses, short rotation forestry, crop residues and municipal solid waste is ongoing. Liquid biofuels can be incorporated as blends with petrol/diesel fuels or used on their own as a replacement fuel.

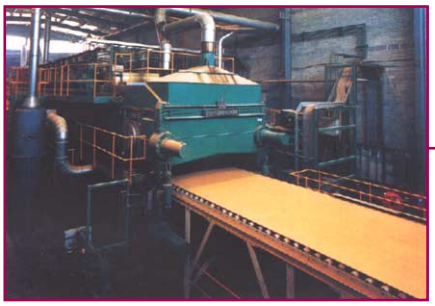
Oilseed Rape

Organic Residues


Forest Residues as a wood fuel in Finland

- Forest residues – these consist of the tree tops and branches remaining after timber is harvested. Some forest residues need to be left on the forest floor to decompose and return nutrients to the soil and also to act as brash mats, which allow machinery to travel across soft ground. However, a lot of this material could be harvested with suitable machinery and used as a renewable fuel for energy production.

- Wood wastes or by-products from wood processing industries e.g. chips, bark and sawdust. These are used within sawmills and boardmills to provide heat for drying or space heating and to raise steam for the manufacturing process. However, surplus quantities are actually being exported from some Irish sawmills at present.



For Example….
Wood wastes from a medium density fibreboard (MDF) facility at Willamette, Clonmel, Co. Tipperary are used in a 19 megawatt wood-burning furnace to supply heat to the plant.

- Agricultural residues e.g. animal slurry and manure, chicken litter, spent mushroom compost and straw. Disposal of some of these residues poses an environmental problem. It is estimated that the total amount of agricultural waste in Ireland in 1998 was approximately 65 million tonnes*. Wet wastes such as cattle and pig manure are suitable for anaerobic digestion, while wastes with a lower moisture content e.g. chicken litter and spent mushroom compost can be combusted.


Poultry-fired combustion plant at Fife, Scotland

- Municipal solid waste (MSW), food processing waste, and sewage sludge – all of these wastes can be converted to energy, in the form of biogas, through the process of anaerobic digestion. The organic fraction of MSW is collected from households and commercial premises etc. It is estimated that over two million tonnes of MSW were produced in Ireland in 1998*. Sewage sludge is a by-product of wastewater treatment. With EU regulations influencing the treatment of waste, increased amounts of wastes are available as a source of affordable biomass fuel.

- Waste vegetable oil - from the catering industry.
A portion of this goes into animal feed production but the rest is dumped. Waste oil can be processed to produce biodiesel and the successful use of this as a transport biofuel has been demonstrated in light vehicles at Teagasc, Oakpark, Co. Carlow.

- Tallow – this is animal fat of variable quality. Previously, much of this would have been used for animal feed production, but with restrictions regarding the use of bovine offals due to BSE, increased quantities are available for alternative use. Investigation of the possibility of using tallow as a biofuel has been conducted at Teagasc. While further research is required, indications are that tallow can be used in small quantities in blends with waste vegetable oil and camelina.

* EPA Ireland's Environment: A Millenium Report

How is Biomass converted to Energy?

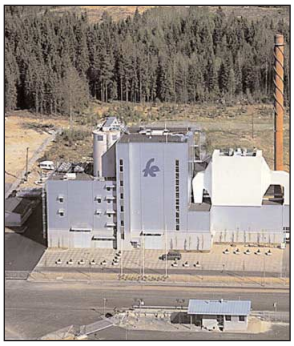
Biomass can be converted to different forms of energy including heat, power, combined heat and power (CHP) or liquid biofuels. There are a number of processes that can be used to recover energy from biomass fuels:

- Direct combustion of biomass material. Some processing of biomass may be carried out prior to combustion e.g. sorting, chipping, pelleting or drying.

Woodchips, sawdust, bark and pellets

- Thermochemical processes - where solid biomass is upgraded to a liquid or a gas by pyrolysis and gasification.
- Decomposition of solid biomass to liquid or gaseous fuels by processes such as anaerobic digestion and fermentation.

Forssa Wood-Fuelled CHP Plant, Finland



Combustion

Fuel + oxygen = carbon dioxide + water + energy

This is the simplest way to produce heat energy from biomass. The heat, often in the form of steam, can be converted to electricity and/or it can be used for heating houses and buildings. Technology used for combustion varies depending on the scale of the plant. On a domestic scale wood stoves burn wood waste efficiently. For larger industrial scale facilities such as wood processing industries or apartment complexes, the use of a wood-fired boiler would be more appropriate to meet higher heat demands. Of course, using combined heat and power (CHP) for such large-scale facilities would be the most efficient method of producing energy (CHP facilities have efficiencies of over 85%).

Burning Wood in a Real Fireplace

In Ireland we currently rely too much on harmful, expensive fossil fuels, such as coal and oil, for the majority of our heating. These fossil fuels took millions of years to form and are burnt at an ever increasing rate, releasing millions of tonnes of harmful greenhouse gases and polluting the air around us.

Wood is an eco-friendly fuel, which comes from local woodlands and forests, taking just a few years to grow. Wood is still one of the most inexpensive fuels in Ireland and is readily available from farmers and local suppliers. Compared to oil or electric heating, the wood stove or fireplace can give you a nice saving on your heating bill.

Wood stoves

Most Irish houses have a fireplace, which can easily accommodate a highly efficient traditional woodstove or a compact modern wood fireplace ‘insert’. A modern stove can convert over 80 percent of the energy content of the wood into heat, compared to a standard Irish fireplace which is only 20 percent efficient. A fireplace insert can give you all the benefits of the traditional fireplace look, as well as all the advantages of a highly efficient wood stove. High efficiency means fewer trips to the wood shed and lower fuel bills! Homes using wood heating alongside oil or gas save around 15% in their heating bills.
A list of wood stove suppliers is available in the REIO factsheet - “Heating with Wood”.

Gasification

This is an advanced conversion process that offers a method of power generation with higher efficiencies than combustion-based steam cycles. It is a process in which biomass is converted to higher grade fuels prior to combustion. Basically biomass is partially oxidised at high temperatures to produce biogas. This biogas contains a mixture of carbon monoxide, hydrogen and methane. The advantage of this process is that undesirable particulate matter and pollutants are removed. A variety of gasification systems are available e.g. fixed bed, fluidised bed gasifiers and pressurised gasifiers.

Although not yet demonstrated in Ireland, large-scale gasification of wood with subsequent use of a gas turbine and combined cycle generating plants to produce electricity has been demonstrated with success in Europe.

Pyrolysis

This is a means of converting solid organic material into a liquid biofuel by heating at high temperatures in the absence of oxygen. The resulting pyrolytic or 'bio-oil' can be refined to products in a manner similar to refining crude oil and can be used for electricity production in diesel engines. Pyrolysis oils are easy to transport and store. However, some improvements in the properties of pyrolysis oils, followed by standardisation of the quality of oils, are needed for successful introduction to the commercial market.

Anaerobic Digestion at Ballyshannon Farms, Co. Wexford

Anaerobic Digestion

Biomass is converted to biogas by Anaerobic Digestion (AD). This is the breakdown of organic waste by bacteria in an oxygen-free environment. AD can take place in a specially designed AD plant or naturally at landfill sites. Farm, municipal or industrial-based AD plants process waste material into biogas (containing methane and carbon dioxide). The waste/feedstock is placed in an airtight container (digester) along with bacteria. Depending on the waste and system design biogas typically contains 55-75% pure methane. This biogas can be upgraded to fossil ("natural") gas, which typically contains 70-96% methane. The liquid fraction of the remaining digested feedstock can be returned to the land as a fertiliser and solid fibre used as a soil conditioner.

Landfill Gas

At landfill sites, AD of the organic component of waste occurs naturally, and more slowly than in anaerobic digestion, releasing landfill gas (which contains methane and carbon dioxide) into the atmosphere. Methane in landfill gas has 21 times the global warming potential of carbon dioxide! To avoid the environmentally harmful effects of this, landfill gas can be collected and used as an energy source for heat and/or power. Wells are inserted into the waste to collect the gas through a series of perforated pipes. A suction pump collects the gas, which is then cleaned and ready to be used a source of energy. Currently, there are five landfill gas recovery facilities in operation in Ireland.

There are now five operational landfill gas plants in Ireland with:

- a combined electrical capacity of 15 MWe
- enough energy to meet the needs of 29,000 households

These plants provide major reductions in harmful greenhouse gas emissions in excess of 500,000 tonnes of CO_2 equivalent/year (the development of additional landfill gas plants is expected).

Conversion to Liquid Biofuels

Conversion of biomass to alcohols

Biomass is converted to alcohol by the process of fermentation. This is where bacteria convert carbohydrates in plant material from crops such as sugar beet and sugar cane into bioethanol. Grain crops such as wheat and maize can also be used for bioethanol production, but their carbohydrates are in the form of starch and so must be converted to sugars prior to fermentation. The production of bioethanol from the cellulosic element of other crops such as miscanthus, reed canary grass, hemp and switchgrass is being researched.

Biodiesel-fuelled vehicle in Glenveagh National Park, Co. Donegal. (Courtesy of Teagasc)

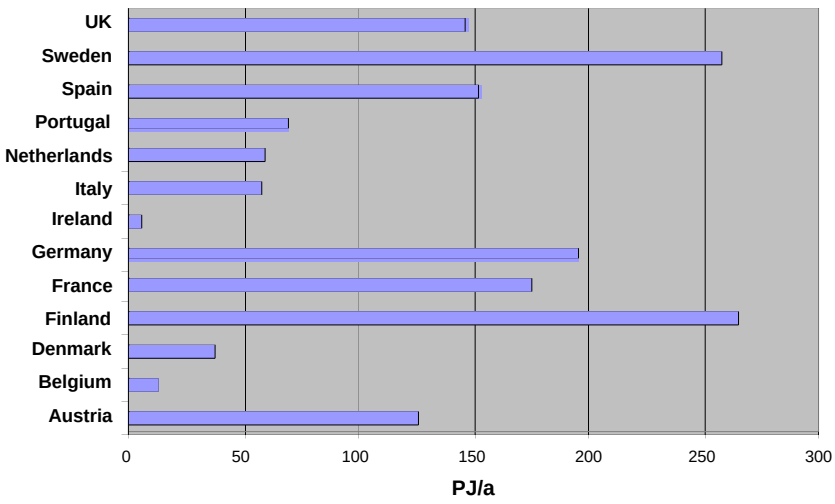
Biomethanol is produced from a synthesis gas (a mixture of carbon monoxide and hydrogen) that is derived from biomass sources such as crop residues, grasses, short rotation forestry and municipal forest waste through the process of gasification. Further research on aspects of synthesis gas production will help to make biomethanol production more cost effective.

Conversion of vegetable oils to biodiesel

Biodiesel can be produced from different types of vegetable oils e.g. oilseed rape, sunflower oil, palm oil, soybean oil and waste vegetable oil. The oil is first pressed from plant material and then converted to biodiesel by a transesterification process. This process involves combining the oil with an alcohol in the presence of a catalyst. Costs of feedstock production can be high in some cases, but the use of waste vegetable oil offers a low cost alternative.

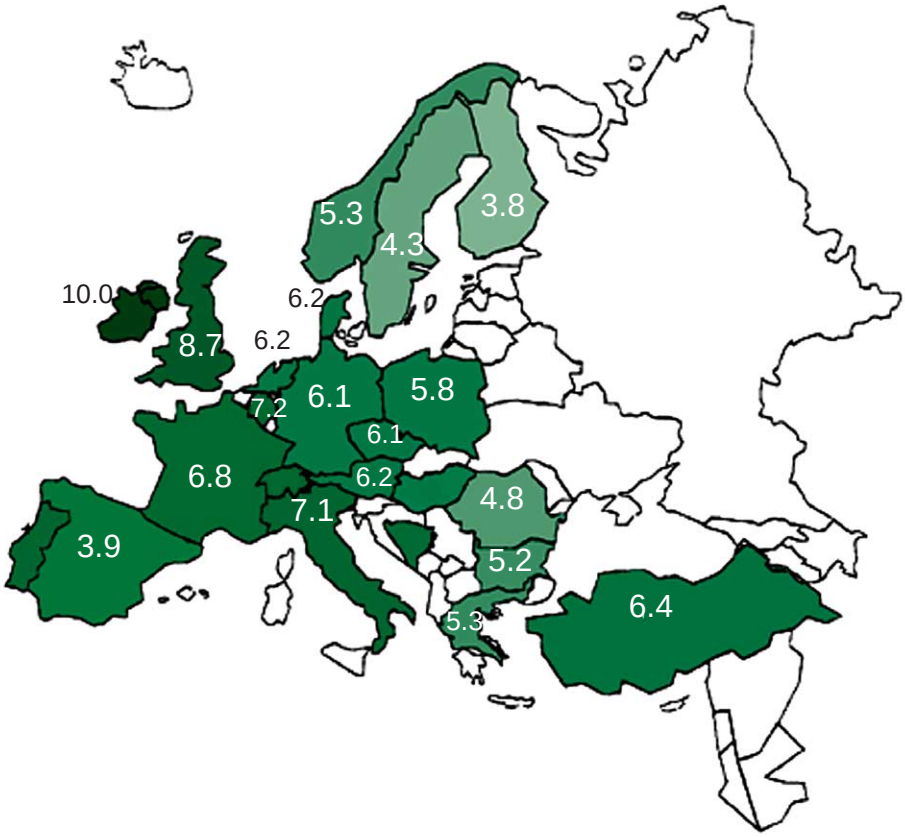
Current Use of Biomass in Ireland

At present, most biomass use is from burning industrial wood wastes to produce heat. Approximately 2% of Ireland's energy supply comes from renewable resources and 1.3% of this is from biomass. Use of biomass is far greater than this in other European countries.



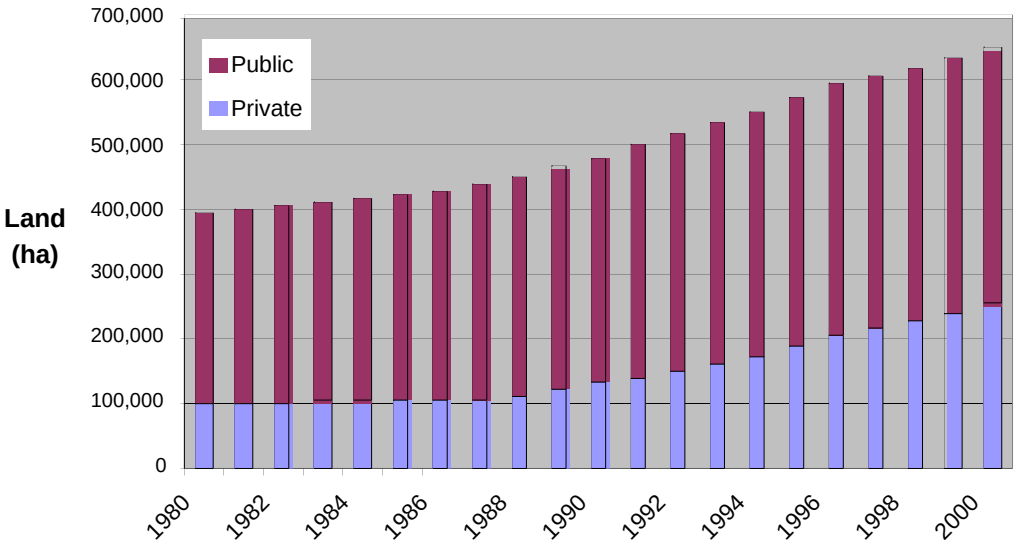
Use of Biomass in European Countries. Source: AFB-net Report, 2001

The potential to develop our use of biomass for energy cannot go unrecognised. Ireland has the best growth climate in Europe. Our potential annual yield of wood is almost three times that of Finland, where the energy use from biomass is 18%! We need to realise this potential and develop our natural biomass resources.

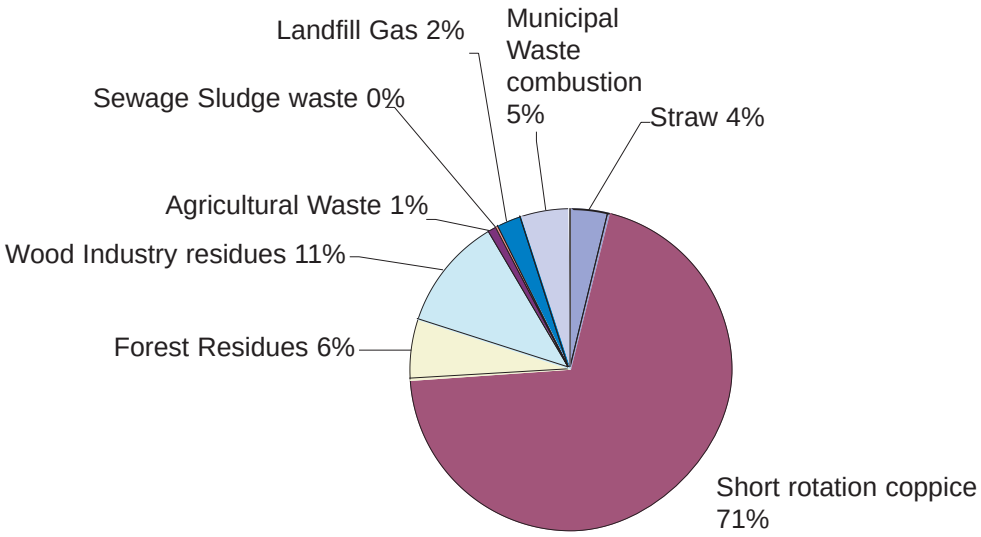


Ireland has the highest potential annual yield of wood in Europe (figures are based on Paterson's Climatic Index m^3/ha). Source: Forest Resources in Europe 1950-1990, 1994.

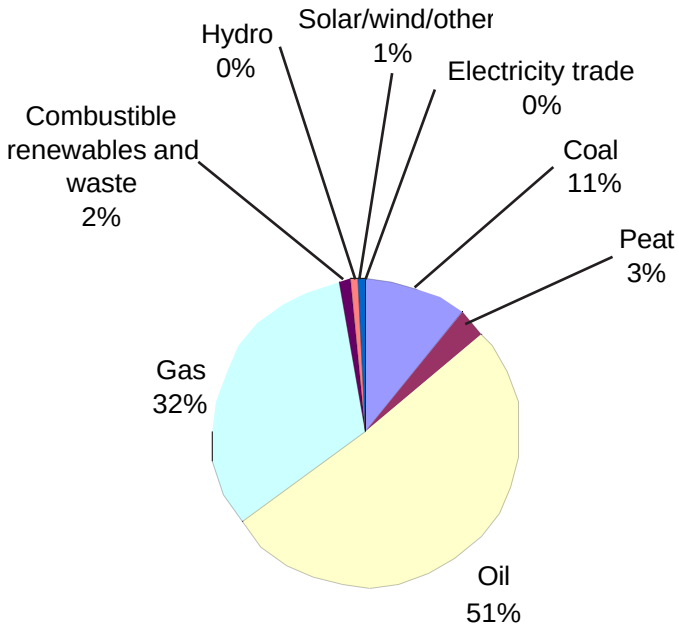
Forestry in Ireland



The total land area under forestry in Ireland is 9.4%. The increasing trend in the amount of land under forestry shown above is set to continue, with a significant rise in the market share of private forestry forecasted. Source: Department of Marine and Natural Resources, 2001.



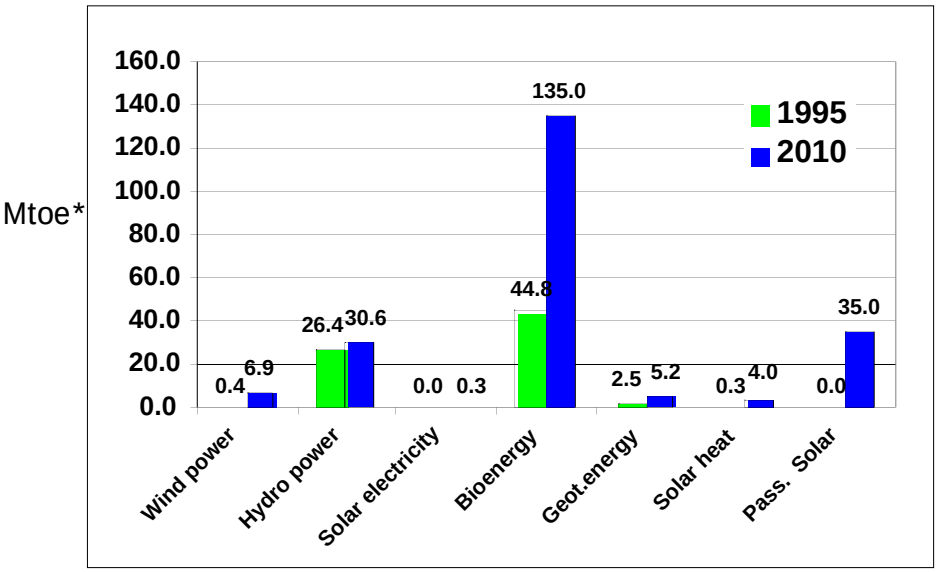
The total projected practicable biomass resource in 2010 is **27TWh**. This practical resource would be sufficient to meet 14% of our total primary energy supply in 2010.
Source: Potential practicable biomass energy supply data for 2010 from EU Altener Report - Total Renewable Energy Resource in Ireland, 1997.



The total projected primary energy supply in 2010 (Business as usual scenario) is **194 TWh**
Source:International Energy Agency - Energy Policies of IEA Countries - Ireland Review 1999.

EU Policy

The EU Commission in its Renewable Energy White Paper (1997) has set a target to double the use of renewable energy from 6% to 12% of the EU's consumption by the year 2010. According to the White Paper more than 80% of the increase will come from biomass.



Growth of energy (electricity and heat) from renewable sources in the EU.
Mtoe – Million tonnes of oil equivalent. Source: EU White Paper, 1997.

In line with their White Paper, the EU drafted initial targets to 2003, which outline methods of doubling the use of renewable energy by 2010. The targets for biomass include:

CHP	10,000 MW
Heated Dwellings	1,000,000 houses
Biogas Installations	1,000 MW
Liquid Biofuels	5 Million tonnes

The EU RE Electricity Directive has just been passed. The main aim of this directive is for the EU to generate a total of 22% of its electricity from renewable sources i.e. green electricity, by 2010, in order to comply with the Kyoto Protocol. This equates to a target of 13.2% green electricity for Ireland. Currently Ireland's green electricity production is only 6%.

Irish Policy

In support of the EU White Paper, Ireland has produced the Green Paper on Sustainable Energy (1999), which aims to install an additional 500 MW of electricity capacity from renewable energy by 2005. The government currently uses Alternative Energy Requirement (AER) tendering competitions to provide an economic incentive for energy recovery from renewables. Under this competition a long-term contract is offered to successful bidders for the production of electricity from renewable resources. To date there have been four such competitions with a total of 15 MW of electricity being supported under the heading of biomass. All of this electricity is produced from landfill gas sites, of which there are five. The government is currently inviting proposals for renewable energy projects. The Green Paper also provides for the establishment of a renewable energy strategy group to examine all aspects of RE technologies.

The Electricity Regulation Act (1999) allows for the sale of electricity from renewable energy sources directly to final customers.

The National Climate Change Strategy (2000) identifies methods of meeting Ireland's commitments under the Kyoto Protocol i.e. to limit the increase of greenhouse gas emissions to 13% of levels in 1990. The greatest proposed carbon dioxide reductions are for the energy (5.65 Mt) and transport (2.67 Mt) sectors.

The Greenhouse Gas Abatement Strategy is awaited from the Department of the Environment.

Barriers to Biomass

- Lack of experience and familiarity with biomass technologies amongst key players such as policy makers, local authorities and resource owners inhibits development of biomass systems in Ireland. Misconceptions can hinder development of biomass as a renewable energy source. Demonstration of successful or best practice examples of biomass facilities will help to build confidence.

- The attitude of the electricity, heat and fuel supply industries to biomass technologies is poor. These industries prefer to avoid risk, use familiar energy technologies and maintain the status quo.

- Initial capital costs of solid biofuel systems and the interest associated with these costs are much higher than for liquid or gas fuelled systems. This can act as a significant barrier to development of energy production from biomass.

- Uncertainty as to the availability of biomass resources e.g. farmers doubt the stability of the biofuel market, resulting in a reluctance to change over to the production of energy crops.

- There is a need for an integrated biomass policy to incorporate the agricultural, environmental, rural and transport sectors. Energy crops should be given the same stability as conventional forestry and food crops and not used as part of set-aside to counter surpluses in food production.

- The low prices of fossil fuels make biomass fuels appear non-competitive. If biomass technologies were to receive the same level of subsidies as fossil fuels this would increase their cost competitiveness considerably.

- Taxes on renewable energy systems. Value Added Taxes on renewable energy systems and their components reduce the competitiveness of biomass technologies in relation to fossil fuel technologies. In countries such as the Netherlands domestic consumers of 'green' energy pay a lower VAT rate, which enables renewable energy technologies to compete well with fossil fuel technologies. The introduction of tax incentives such as this, as well as the exemption of biomass-derived fuels from energy taxes in Ireland, will attract investors.

- Lack of subsidies for research, development and demonstration. Certain biomass technologies e.g. anaerobic digestion are well established and therefore require support for demonstration, while others are at an earlier stage of development e.g. growth of Miscanthus as an energy crop and require support for research.

- Lack of information, education and training, which is fundamental to overcoming all of the above barriers.

Production of energy at a centralised AD plant at Camphill Community, Callan, Co. Kilkenny commenced in October 2000. Cattle manure and industrial waste from local farms and industry provide the fuel source. Although there is heat only production at present, combined heat and power is intended for the future. Heat is used for space and water heating in the Community's houses.

The Renewable Energy Information Office

The Renewable Energy Information Office is a service of Sustainable Energy Ireland.
Its objective is to support the development of renewable energy in Ireland by providing independent and expert advice as well as information on related financial, environmental and technical issues.

Five ways to contact us:

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VISIT OUR WEBSITE: www.sei.ie/reio.htm

Sustainable Energy Ireland is a joint initiative of the Department of Public Enterprise and Enterprise Ireland and is supported by the EU through the Community Support Framework.

I want to know more about Energy from Biomass

Further reading

Free factsheets available directly from us or our website:

* Wind Energy
* Bioenergy
  - Biomass
  - Landfill Gas
* Hydropower
* Green Electricity
* Renewable Energy for Buildings & Industry:
  - Passive Solar Design
  - Heat Pumps for Your Home
  - Heat Pumps for Commercial Buildings
  - Heat Pumps for the Health Sector
  - Solar Water Heaters
  - How to Heat with Wood

All these brochures can be downloaded from our website:
http://www.irish-energy.ie/reio.htm

If you have any questions, or would like to find out more, please contact the Renewable Energy Information Office, or see the references given overleaf:

Publications:

New publication available from REIO: **Wood Fuels Basic Information Pack**
This book provides essential information on the procurement of wood for energy purposes. Properties of wood as a fuel, wood energy supply systems, wood fuel production techniques and the use of wood fuels in heat and power production are outlined in detail. All information is based on experiences and practices in Finland, Sweden and other European countries advanced in their use of wood fuels for energy.

This book is currently available from the REIO at the discounted price of 38 Euro incl. p&p.

Free publications available directly from us or our website

Guides

Wood for Energy Production
Wood Fuel from Forestry and Arboriculture
Short Rotation Coppice for Energy Production
Straw for Energy Production
Landfill Gas Development
An Introduction to Household Waste Management
Anaerobic Digestion of Farm and Food Processing Residues
Danish Centralised Biogas Plants

Case Studies

Landfill Gas Utilisation Project, Dublin
Anaerobic Digestion at Ballyshannon Farms
Use of Wood Waste for Heat Production at the Willamette Plant

Websites

Agriculture and Forestry Biomass Network (AFB-Net)	http://www.afbnet.vtt.fi
Austrian Biofuels Institute	http://www.biodiesel.at/index2.html
Bioenergy in Finland	http://www.finbioenergy.fi
Bioenergy Information Network	http://bioenergy.ornl.gov/
British BioGen	http://www.britishbiogen.co.uk/
Caddet	http://www.caddet.co.uk/
CARMEN	http://www.carmen-ev.de/
Catalogue of Euro organisations for wood fuel development	http://www.biomasse-normandie.org/
ETSU	http://www.etsu.co.uk
International Energy Agency	http://www.ieabioenergy.com
Irish Bioenergy Association	http://www.irbea.org
REIO	http://www.irish-energy.ie/reio.htm
Tekes	http://www.tekes.fi
UK Biogas Association	http://www.biogas.org.uk/

TV Series Videos

'Engine Earth' - a 4 Part Irish Renewable Energy TV Series available from the Renewable Energy Information Office at cost of 9 Euro including p&p
'Wood from the Trees' – a 7 Part TV Series on Renewable Materials & Energy, available from the Renewable Energy Information Office at a cost of 9 Euro including p&p
'The State We're In' – a 7 Part TV Series Comparing Irish & EU Environmental Issues & Performance, available at a cost of 30 Euro (including p&p) from Time Horizon Productions, 13 Windsor Place, Dublin 2 – Tel 01-6621082 Email timehorizon@eircom.net