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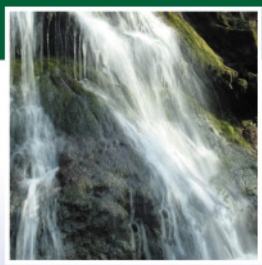

Chapter 10
Wood Fuel

TIPPERARY INSTITUTE

NATIONAL DEVELOPMENT PLAN

EUROPEAN UNION STRUCTURAL FUNDS

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10 Wood

Kevin Healion, Tipperary Institute

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10.1 Objectives

Having completed this section of the training course and manual, learners should:

- Have an overview of wood fuel sources and forms.
- Have an overview of the conversion technologies available.
- Understand the impact of moisture content on the energy content of wood fuel.
- Be able to calculate the fuel requirement for a wood heating system.
- Understand the requirement for high quality in wood heating systems and wood fuel.
- Know the status and potential of wood energy in Ireland.
- Know the policies related to wood energy in Ireland.

10.2 Wood energy technology

10.2.1 Introduction

Wood has been the most important fuel used by humans for thousands of years. With the harnessing of fossil and nuclear fuels the use of wood declined. However, wood is still a major source of energy world-wide, both in developed and developing countries. Technological advancements in the conversion of wood into both electrical and heat energy have removed many of the barriers to the greater use of wood as a fuel source. The renewed interest in wood fuel is being driven largely by economic and environmental concerns – wood fuel is increasingly price competitive with fossil fuel alternatives and the environmental benefits of wood fuel are now recognised and valued. The production and use of wood fuel provides social benefits too, including the creation of additional employment, especially in rural areas.

10.2.2 Stored solar energy

Plants (including trees) convert sunlight into plant matter (including wood). Wood is, in effect, stored solar energy. This energy can be re-released for human use with the right technology. Using wood as a fuel does produce carbon dioxide (the main greenhouse gas) but this CO_2 contains carbon that was absorbed relatively recently from the atmosphere by the growing tree (Figure 10.1). The combustion of fossil fuels, in contrast, releases carbon that has been locked away for millennia. Provided that existing forest carbon stocks are not reduced, replacing fossil fuels with wood fuel from sustainable sources reduces CO_2 emissions. Utilising the Republic of Ireland's wood for energy potential could reduce CO_2 emissions by up to one million tonnes per year by 2015, representing 8% of Ireland's present commitment to the EU for reductions in CO_2 emissions (Electrowatt-Ekono and Tipperary Institute, 2003).

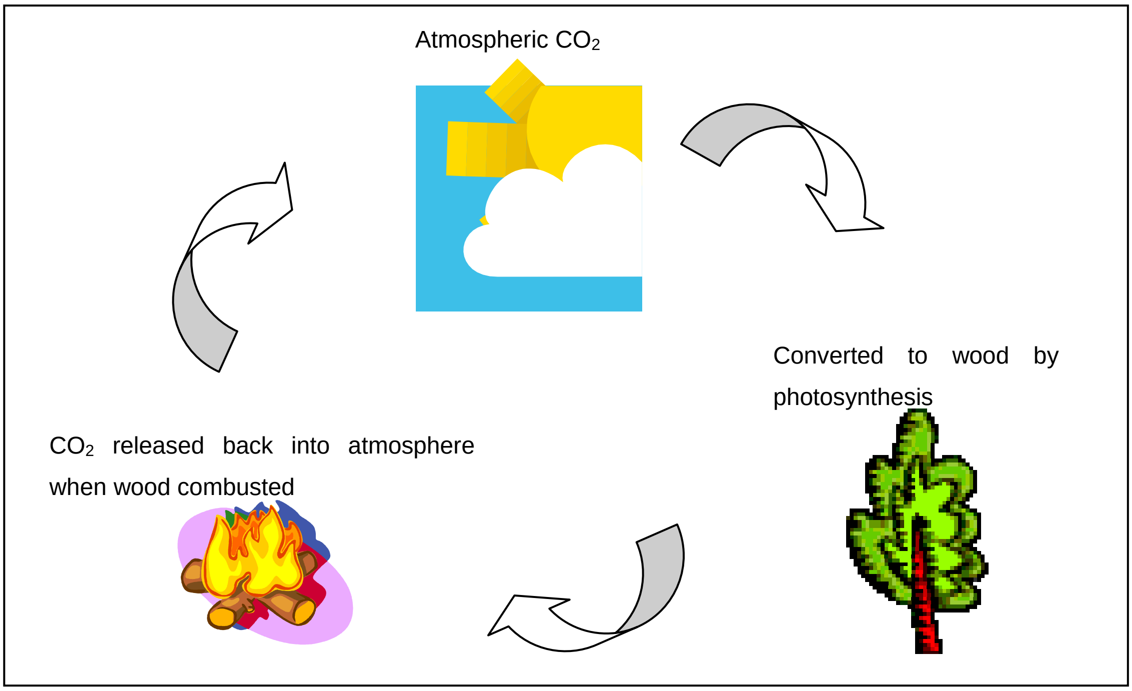


Figure 10.1 The cycle of carbon in a wood energy system

10.2.3 Moisture content of wood

When dealing with the topic of wood fuel, it is essential to understand the concept of moisture content. A sample of wood can be placed in a metal tray and dried in a laboratory oven until it has zero moisture content. The sample of wood is then described as “oven dry”. The weight loss is the weight of water that was in the sample. The moisture content of the wood sample can be expressed on either a wet (total) weight basis or a dry weight basis. Wet weight is the basis most commonly used in the renewable energy sector. To calculate moisture content on a wet weight basis (MC_{wb}), the weight of water is expressed as a percentage of the total weight of the wood fuel sample (Formula 10.1). Example 10.1 shows the application of Formula 10.1 to real data for a sample of wood chips from the Tipperary Institute willow plantation.

$$MC_{wb}\ \% = \text{Weight of water} \times 100 \div \text{Weight of sample}$$

Formula 10.1 Moisture content on a wet weight basis

Results of weighings:

Mass of tray:	136.36 g
Mass of tray and wet chips:	352.43 g
Mass of tray and dry chips:	241.21 g

Calculations:

Mass of wet chips = 352.43 - 136.36 = 216.07 g

Mass of dry chips = 241.21 - 136.36 = 104.85 g

Mass of water = 216.07 - 104.85 = 111.22 g

MC_{wb} % = Weight of water x 100 ÷ Weight of sample

MC_{wb} % = 111.22 x 100 ÷ 216.07

MC_{wb} % = 51.5%

Example 10.1 Calculation of moisture content on a wet weight basis

The moisture content of freshly harvested wood varies considerably according to species. Ash (*Fraxinus excelsior*) when felled can have a moisture content of only 33% on a wet weight basis, whereas poplar (*Populus spp.*) can be up to 60% moisture content on a wet weight basis. There can be very wide variations in moisture content within a tree species, due for example to regional and seasonal factors (Healion, 2002).

10.2.4 Energy content of wood

The number of units of energy produced by the complete combustion of a unit mass of a fuel is termed its calorific value (Centre for Biomass Technology, 1999) or energy content. The calorific value of wood can be expressed as:

- Gross Calorific Value of dry wood
- Net Calorific Value of dry wood
- Net Calorific Value of wet wood

The Gross Calorific Value is defined as the amount of energy produced by the complete combustion of a unit amount of wood at constant pressure, with condensation of the water vapour that is formed during combustion. Condensing the water vapour increases the amount of energy recovered from the wood (this is why a condensing boiler is more efficient than a normal boiler). The water vapour can arise from two sources: the moisture content of the wood, and the formation of water from the hydrogen contained in the wood (about 0.5 tonnes of water are formed from the hydrogen content of one tonne of oven dry wood). The Gross Calorific Value is also termed the Higher Heating Value (HHV).

The Net Calorific Value (NCV) is defined as the amount of energy produced by the complete combustion of a unit amount of wood at constant pressure, with the water vapour that is formed during combustion remaining in a gaseous state. The NCV is also termed the Lower Heating Value (LHV).

The Gross Calorific Value of oven dry wood is about 20 gigajoules (GJ) per tonne (Centre for Biomass Technology, 1999), equivalent to 5.6 kWh per kilogram. There is little difference in the Gross Calorific Values of oven dry wood from different tree species, but bark does have a lower energy content than pure wood. The NCV of oven dry wood is about 19.5 gigajoules (GJ) per tonne (equivalent to 5.4 kWh per kilogram) – some energy is lost in the uncondensed water vapour arising from the hydrogen content of the wood.

The NCV of wet wood is perhaps the most practical measure of energy content. The higher the moisture content of wood, the lower its dry matter content. The moisture content of wood fuel is evaporated as it burns - that process requires energy, so the higher the moisture content the greater the amount of energy required for evaporation. If the wood is burned in a non-condensing boiler, the energy required for evaporation is lost to the user (as well as the energy lost in the uncondensed water vapour arising from the hydrogen content of the wood). The amount of useful energy released per kilogram of wood fuel at various moisture contents is shown in Figure 10.2.

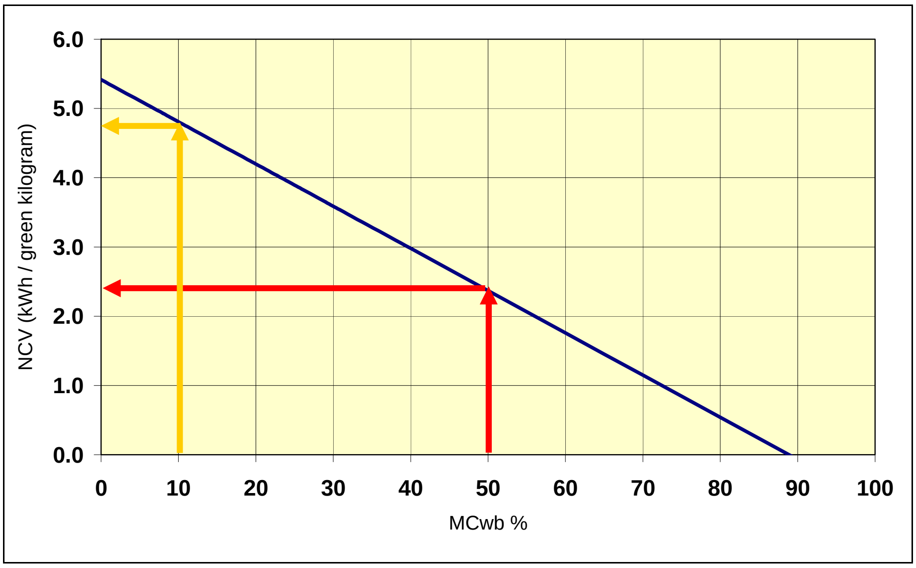


Figure 10.2 Net calorific value vs. moisture content

The red arrows in Figure 10.2 show the energy content for wood at 50% MC_{wb} (2.4 kWh per kilogram), and the yellow arrows show the energy content for wood at 10% MC_{wb} (4.8 kWh per kilogram). This demonstrates the impact of moisture content on energy content – for example, wood pellets at 10% MC_{wb}

have twice the energy content per kilogram of wood chips at 50% MC_{wb}. Small-scale wood boilers, including domestic systems, are normally (though not always) of the non-condensing type. Therefore it is very important to use wood of low moisture content to maximise the amount of useful energy produced per kilogram of wood fuel. Domestic firewood should be seasoned for at least one year, and preferably two, before being used. The wood used to produce wood chips should be allowed to dry before being chipped. The sawdust used to produce wood pellets is dried before pelletising.

10.2.5 Sources of wood fuel

Table 10.1 lists existing or potential sources of wood for fuel in the Republic of Ireland (Healion, 2002).

Wood Fuel Source	Description
Firewood	Generally sourced from hardwood species, either from thinnings or the tops, branches and butt ends resulting from clear-felling.
Sawmill Residues	Bark, slabs, brown chips, white chips, sawdust and wood shavings produced in the sawmilling sector. Existing markets for sawmill residues include raw material for panel board products, mulch, animal bedding and fuel.
Wood Industry Residues	Offcuts, sawdust, shavings, trimmings, sandings and reject product from wood product and panel board manufacture. Uses at present include fuel for plant and process heating.
Arboricultural Residues	Tree surgery residues from the maintenance of parks, gardens and hedgerows. May be used for mulch or fuel, but sometimes disposed of.
Small Diameter Roundwood	Small diameter roundwood arising from early thinnings, the clearing of pre-mature or damaged stands, or removal of nurse trees. May have a market as pulp wood. New harvesting methods have been developed for small diameter roundwood, including feller-bunchers and whole tree chipping.
Forest (Logging) Residues	Often referred to as “brash” or “lop and top” – the tops and branches of the tree left after harvesting of the main stem. Not recovered in Ireland at present. Can be harvested in integration with the roundwood harvesting operation, or as a subsequent second-pass operation. Residue bundling and baling systems have been developed.

Unmerchantable Timber	Wood that is not of a high enough quality for sale as roundwood, but that could be used for fuel (e.g. dead or crooked stems).
Short Rotation Forestry (SRF)	Production of fuel wood from certain tree species (generally willow or poplar) which are harvested in rotations of generally two years or more. Usually managed as a coppice system (Short Rotation Coppice - SRC).
Waste Wood	Includes broken pallets, crates, and waste timber from building and demolition work. Some clean waste wood is chipped and used as fuel or raw material in panel board manufacture. Contaminated waste wood is generally landfilled and would require special management if used as fuel.

Table 10.1 Potential wood fuel sources

10.2.6 Short Rotation Coppice

Many tree species, mainly broadleaves, have the ability to "coppice", that is, to produce new shoots from their stumps when the main stem has been removed. These trees do not have to be re-established after each harvest. SRC is a system of forest management in which fast-growing, closely-spaced, intensively-managed trees are coppiced, and then harvested a number of times on a rotation length of less than ten years. Willow (*Salix spp.*) and poplar (*Populus spp.*) are two trees often grown in SRC systems (Figure 10.3).

Figure 10.3 SRC plantation, planting and harvesting
(Tipperary Institute, various dates)

10.2.7 Forms of wood fuel

Table 10.1 listed potential sources of wood for fuel. The wood from some sources can be used as fuel without any further processing. As examples: many furniture factories have small wood combustion units to provide space heating, fuelled by offcuts from the factory; the panel board industry uses wood residues as fuel. In general however wood undergoes further processing before being marketed as fuel. The most common forms into which wood is converted are firewood, wood chips, wood briquettes and wood pellets (see Figure 10.4). These conversion processes make the fuel easier to handle. The European Committee for Standardization (CEN) has published Technical Specifications for solid biofuels, including firewood, chips, briquettes and pellets.

Firewood	Wood chips	Briquettes	Pellets
			
Wikimedia, 2007	Tipperary Institute	Greenheat, 2007	Wikimedia, 2007

Figure 10.4 Forms of wood fuel

10.2.8 Conversion technologies

The energy content of wood can be released in two principal ways:

- Direct combustion. Combustion is a thermochemical process in which the wood is combined with oxygen and converted to carbon dioxide and water (and other minor constituents), releasing energy. The energy can be used for heating, for electricity generation, or to produce both heat and electricity (Combined Heat and Power (CHP)).

- Gasification or pyrolysis. These are also thermochemical processes which convert wood into a gaseous or liquid fuel. The gaseous or liquid fuel is then combusted in a second step to release energy. Gasification and pyrolysis open up several possibilities for wood as a fuel: to increase the energy efficiency of large scale electricity generation; to allow economic CHP production at small scales; and to produce wood-based fuels for transport applications.

Conversion options are shown schematically in Figure 10.5, with pictures of examples given in Figure 10.6. Development work is also underway on using biochemical processes to convert wood into ethanol, which could then be used in an internal combustion engine for transport applications.

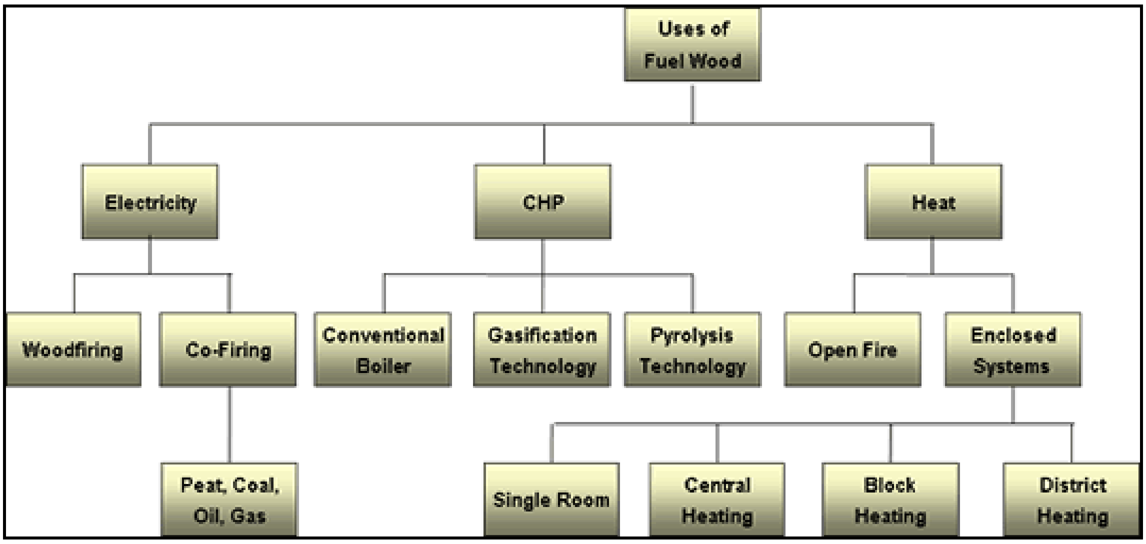


Figure 10.5 Schematic of conversion technology options
(Electrowatt-Ekono and Tipperary Institute, 2003)

SEI (2007) give the following indicative price ranges (including VAT) for domestic wood-fuelled heating technologies: pellet stove €2,000 to €5,000; pellet stove with integral boiler €4,000 to €8,000; wood pellet boiler €9,000 to €16,000. Figure 10.11 gives estimates of capital costs for larger wood-fuelled boilers.

Stove (firewood, briquettes)

Waterford Stanley, 2007

Range (firewood, briquettes)

Waterford Stanley, 2007

Glass-fronted stove (firewood, briquettes)

Waterford Stanley, 2007

Masonry stove (kachelofen) (firewood, briquettes)

Biofire, 2007

Logwood (gasifying) boiler (firewood, briquettes)

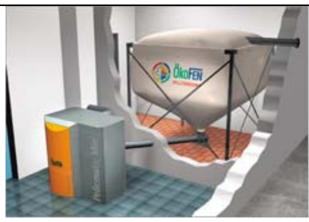
The Sustainable Landuse Company, 2007

Pellet stove

Greenheat, 2007

Chip boiler with fuel feed

National Biofuels, 2007



Pellet boiler with pellet silo

The Organic Energy Company, 2007

Wood CHP plant at Grainger Sawmills, Co. Cork, Ireland

Tipperary Institute

Figure 10.6 Energy conversion technologies for wood fuels

10.2.9 Theory of combustion

Combustion is the principal method used today to release energy from wood, with applications ranging in scale from burning wood in a domestic open fire to the use of wood residues for large-scale CHP production in the forest industry. The combustion of a wood particle occurs in three stages (Centre for Biomass Technology, 1999):

- Drying. The wood particle is heated, water evaporates and the fuel dries.
- Pyrolysis, gasification and combustion of volatiles. At 100°C to 105°C gasification and pyrolysis processes start. The volatile components of the wood evaporate and the wood surface becomes porous. At 500°C to 600°C the volatile components (now gaseous) start to combust – this process is visible as long flames above the fuel. Most (75 to 80%) of the energy produced from wood results from the combustion of the volatiles.
- Charcoal burnout. At 800 to 900°C the glowing charcoal burns out leaving ash.

The objective of a good combustion process is to ensure that the volatile and charcoal contents of the wood are converted completely to ash. Good combustion is that which:

- maximises the energy output from the wood,
- minimises the amount of fuel required,
- minimises emissions of unburnt volatiles and carbon monoxide to the environment,
- minimises unburnt charcoal in the ash,
- minimises tar and soot deposits in the chimney / flue.

The requirements for efficient and complete combustion are time, turbulence (to ensure mixing of air and volatiles), temperature and controlled oxygen (air) to fuel ratio. The combustion equipment must be designed to ensure that these requirements are met.

10.2.10 Heating system design considerations

Minimising the building's energy demand must be the first step in the planning of a wood-fuelled heating system. There are then many considerations in the design of the system itself. These include: estimation of heat demand; boiler sizing; fuel choice; fuel delivery, storage and transfer; boiler room design; heat storage; heating circuit design; chimney design; maintenance (including regular cleaning); management of ash; and service support. Expert advice should be sought. In order to minimise emissions to the environment, it is essential that wood-fuelled heating equipment is well designed, constructed, installed, operated and maintained, and that good quality wood fuels from sustainable sources are used.

10.3 National installed capacity

In 2005, renewable energy contributed 2.5% to the Republic of Ireland's Total Primary Energy Requirement (TPER) of 15.6 MTOE (655 PJ) (Howley *et al.*, 2006). "Biomass" is the largest renewable contributor (see Figure 10.7). The "biomass" category is made up of wood (78%) and tallow (22%) (O'Leary *et al.*, 2006). The contribution of wood to TPER was 1% in 2004 (6 PJ).

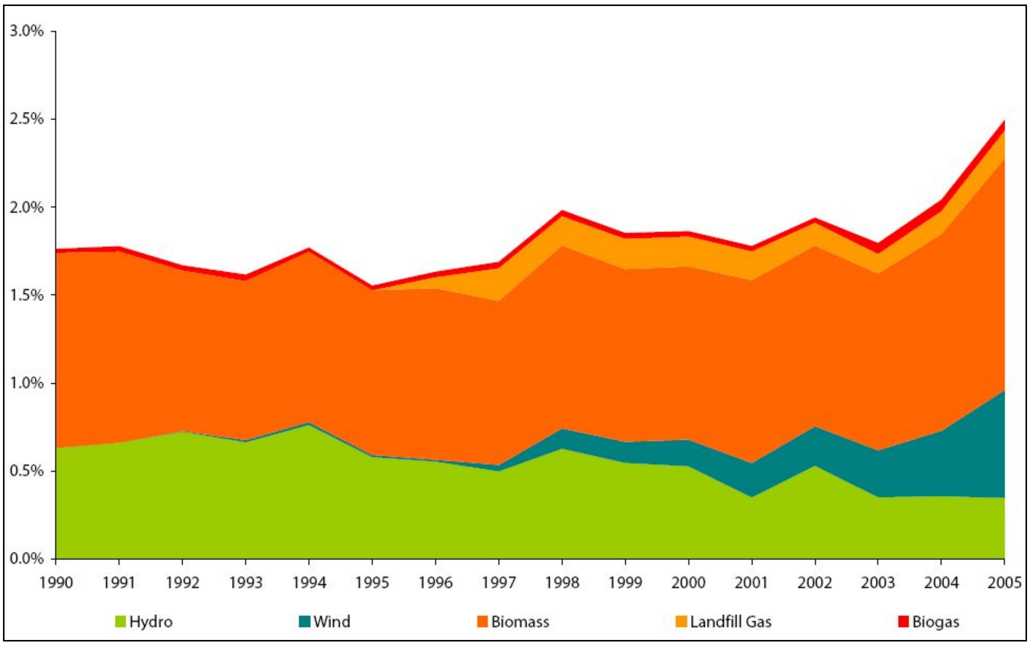


Figure 10.7 Renewable energy contribution to TPER in ROI
(Howley *et al.*, 2006)

There is only one plant generating electricity from wood in the Republic of Ireland – a CHP plant in Co. Cork with an installed capacity of 2.9 MWe (see Figure 10.6). Most of the wood used as fuel in the Republic of Ireland is for heating – mainly in the wood processing and domestic heating sectors. The data on installed wood heating capacity is poor – 750 MW_{th} is an estimate indicative of the likely scale (based on Healion *et al.,* 2005).

10.4 National potential

Figure 10.8 shows the likely practical additional bioenergy resource in the Republic of Ireland, as stated in the mid-range projection of the Bioenergy Strategy Group report (2004). Taken together, the categories of "wood residues" and "energy crops" could supply an additional 10 PJ per year. Compared to the existing contribution from wood of 6 PJ per year, it is clear that a doubling in the use of wood for energy is possible in the short term to 2010, and a quadrupling by 2020.

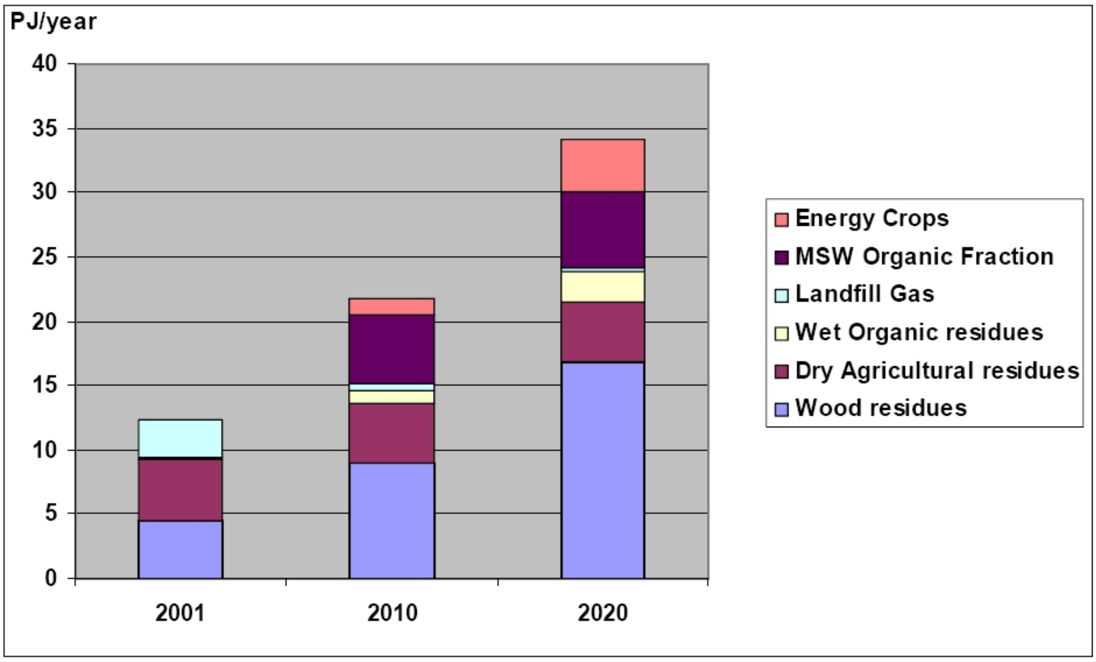


Figure 10.8 Likely practical additional bioenergy resource in ROI
(Bioenergy Strategy Group, 2004)

10.5 Barriers to adoption

The Bioenergy Strategy Group report (2004) listed the following among the barriers to bioenergy development:

- Absence of a clear and visible Government policy and lead on bioenergy
- Most bioenergy pathways and technologies are not competitive
- The range of permissions and licences required and the difficulty in obtaining consistent and transparent treatment
- The long term commitment and delay to first income for some energy crops (e.g. SRC)
- Capital costs are nearly always higher for bioenergy projects than for conventional fossil fuel equivalents (e.g. modern wood-fuelled boilers and stoves are considerably more expensive than their oil- or gas-fired equivalents)
- Lack of awareness among financiers
- For CHP, barriers related to selling electricity; from grid connection issues to market access and pricing
- For co-firing (e.g. wood with peat in a peat-fired power station), contractual arrangements with the peat fuel supplier and Public Service Obligation arrangements

However it is clear that at least some of these barriers have been lowered in the two years since the Bioenergy Strategy Group report. For example, a Ministerial Task Force on Bioenergy was established in July 2006 and published a National Bioenergy Action Plan in March 2007. The competitiveness of bioenergy versus fossil fuels has improved considerably with the recent increases in oil and gas prices.

10.6 Relevant policy and legislation

There was a specific target in Ireland's 2006 Green Paper on Energy for 50% of the renewable heat target (5% of the fuel used for heat from renewables by 2010) to come from biomass.

Wood energy projects are subject to the same planning and environmental impact assessment legislation as other developments. If waste wood is being used as fuel, waste management legislation will apply.

10.7 Government supports

Table 10.2 lists current programmes which provide support specifically for wood energy in the Republic of Ireland. There are other programmes which could also provide support, although not specifically targeted at wood energy (for example, the Sustainable Energy Ireland (SEI) Renewable Energy Research, Development and Demonstration (RD&D) Programme).

Programme	Summary
SEI Greener Homes Scheme	Provides grants towards the cost of new wood-fuelled domestic heating systems: €1,100 for wood chip or pellet stove, €1,800 for wood chip or pellet stove with integral boiler, €4,200 for wood chip or pellet boiler.
SEI Renewable Heat Deployment Programme	Provides grant towards the cost of new wood-fuelled non-domestic boilers. Up to 30% of eligible costs provided.
RE-FIT (Renewable Energy Feed in Tariff)	Provides support for the generation of electricity from wood. Sets a reference price of 7.2 cent per kWh for “Other Biomass” (including wood) (DCMNR, 2006).
SEI CHP Deployment Programme	This Programme will ultimately include biomass, through specific calls for proposals.

Table 10.2 Government programmes for wood energy

An establishment grant scheme for willow and *Miscanthus* was launched in February 2007. Support for purchasing wood fuel harvesting equipment is due in the near future.

10.8 Case study on financial viability

Tipperary Institute (TI) is currently examining the feasibility of using wood fuel to provide space heating and hot water for its main building on the campus in Thurles town. At present the main building is heated by two oil-fired boilers, each rated at 700 kW_{th} maximum output which use a total of 40,000 litres of kerosene per year (Figure 10.9). The boilers operate alternately – the heat demand of the building does not require both to operate simultaneously.

Figure 10.9 TI (Thurles campus), oil tank and oil-fired boilers
Photographs by Tipperary Institute

In this initial pre-feasibility assessment the following steps are taken:

1. Calculate the current primary energy use and cost
2. Calculate the current net energy use
3. Calculate the primary energy requirement for a new wood-fuelled boiler
4. Calculate the number of tonnes of wood chips or wood pellets needed to provide the primary energy requirement
5. Calculate the wood fuel expenditure savings compared to kerosene
6. Estimate the capital cost of the new wood-fuelled boiler
7. Calculate the simple payback period for the wood boiler
8. Out of interest, estimate the area of willow coppice required to produce enough wood chips for TI

Step 1

SEI (2006) give the current cost of kerosene as 73.3 cent per litre, with an energy content of 10.56 kWh per litre. This means that the building consumes 422,400 kWh per year of primary energy per year in the form of kerosene (40,000 litres x 10.56 kWh per litre) at a cost of €29,320 (40,000 litres x €0.733 per litre).

Step 2

The oil boilers are 80% efficient, so the net energy output to the TI building is less than the primary energy input (Figure 10.10).

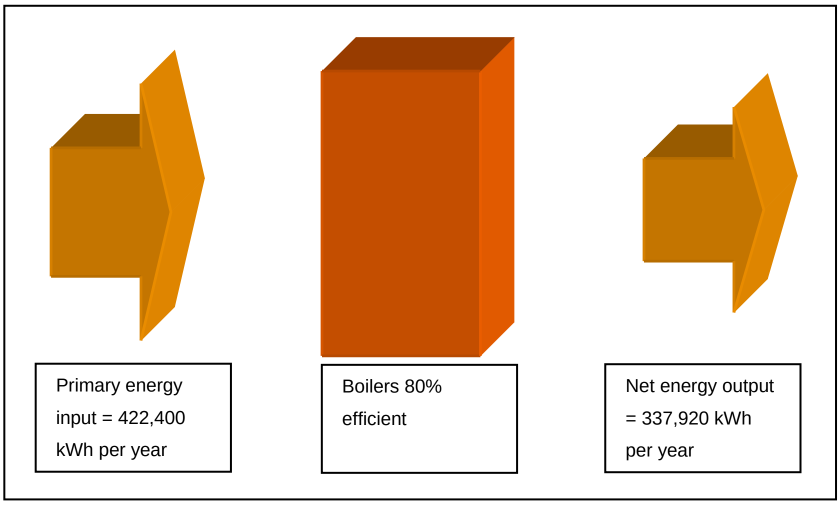


Figure 10.10 Energy input, conversion efficiency and energy output

Step 3

Note: This case study was written when the SEI Bioheat Boiler Deployment Programme was in place, the terms and conditions of that Programme are used herein. The Bioheat Programme has since been replaced by the SEI Renewable Heat Deployment Programme.

Under the SEI Bioheat Boiler Deployment Programme, the efficiency must be 90% or more for wood boilers larger than 200 kW. If it is assumed that the new boiler will be 90% efficient, less primary energy input will be needed for the same net energy output to the TI buildings. The primary energy input required for the new boiler will be: 337,920 kWh ÷ 0.90 (90%) = 375,467 kWh.

Step 4

TI is examining two possible forms of wood fuel – wood chips and wood pellets. Once the primary energy requirement is known, the number of tonnes of wood chips or wood pellets required per year to fuel the new boiler can be calculated using Formula 10.2, as shown in Table 10.3.

Fuel mass input (kg) = Fuel energy input (kWh) ÷ Fuel NCV (kWh / kg)

Formula 10.2 Fuel mass input

Pellets	Chips
MC_{wb} = 10% NCV = 4.8 kWh per kilogram Pellets input (kg) = 375,467 kWh ÷ 4.8 kWh / kg = 78,222 kg = 78.2 tonnes	MC_{wb} = 28% NCV = 3.7 kWh per kilogram Chips input (kg) = 375,467 kWh ÷ 3.7 kWh / kg = 101,478 kg = 101.5 tonnes

Table 10.3 Wood fuel requirements

Table 10.3 shows the impact of moisture content on energy content, and thus on the wood fuel requirement. Wood pellets have a low moisture content relative to wood chips, and thus a smaller quantity of wood pellets are required to provide a certain quantity of primary energy.

Step 5

The saving in annual expenditure on fuel can now be calculated (Table 10.4). The delivered prices for wood pellets and wood chips are from SEI (2006).

Pellets	Chips
Cost €170 tonne bulk 78.2 tonnes x €170/t = €13,294 Fuel saving: €29,320 - €13,294 = €16,026	Cost €100 tonne bulk 101.5 tonnes x €100/t = €10,150 Fuel saving: €29,320 - €10,150 = €19,170

Table 10.4 Fuel savings by replacing oil with wood fuel

Step 6

A first estimate of the capital cost of wood-fuelled boilers can be obtained from the documentation for the SEI Bioheat Boiler Deployment Programme. The Programme sets maximum qualifying costs on a per kW basis, as shown in Figure 10.11. Eligible costs include the cost of the boiler, feed mechanism, storage and installation / commissioning. Additional costs would be incurred for the design of the system. However, the costs from the Programme are considered adequate for this pre-feasibility study. TI reckon that a new wood-fuelled boiler would not need to be as large as the existing oil boilers, and that 350 kW_{th} capacity would be sufficient. From Figure 10.11, it is estimated that such a boiler would cost €423 per kW. Its total cost would therefore be: €423 per kW x 350 kW = €148,050.

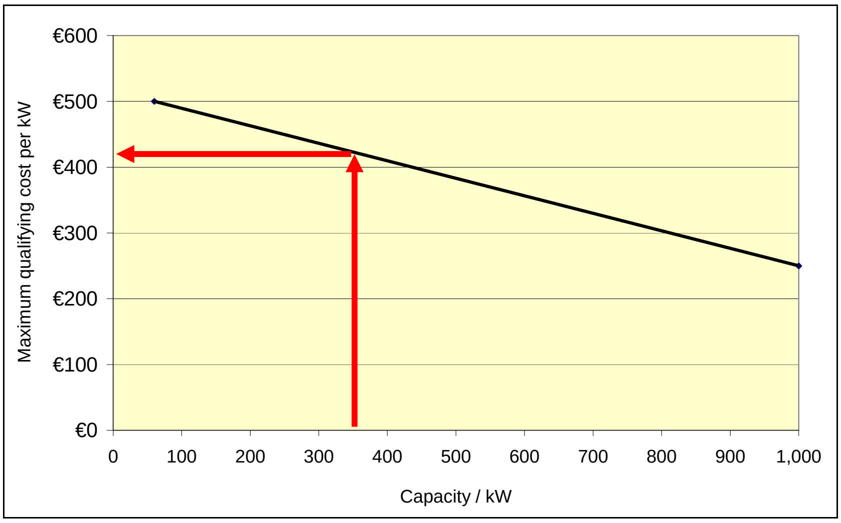


Figure 10.11 SEI Bioheat Boiler Deployment Programme costs

Step 7

The simple payback period can be calculated by dividing the cost of the new boiler by the annual saving in fuel expenditure, as per Table 10.5 (assuming that the non-fuel operational costs of the wood boiler will be the same as those for the oil-fired boilers).

Pellets	Chips
€148,050 ÷ €16,026 = 9.2 years	€148,050 ÷ €19,170 = 7.7 years

Table 10.5 Simple payback period for wood energy options

The SEI Bioheat Boiler Deployment Programme gives capital investment support of 30% for eligible costs. If such support was obtained, the net cost of the new boiler would be €148,050 x 70% = €103,635, and the simple payback periods would be reduced, as per Table 10.6.

Pellets	Chips
€103,635 ÷ €16,026 = 6.5 years	€103,635 ÷ €19,170 = 5.4 years

Table 10.6 Simple payback period with grant aid

Step 8

The wood chips required for a new wood-fuelled boiler could be provided from local plantations of willow short rotation coppice. It is therefore of interest to estimate the number of hectares of willow that would be needed. An average yield of 10 oven dry tonnes per hectare per year would be a reasonable assumption. However, the willow when harvested will not be oven dry – on the contrary - it will have a moisture content of about 50% on a wet weight basis. The willow fuel should be dried before storage and use, ideally to 30% MC_{wb} or less (the previous steps assumed wood chips at 28% MC_{wb} were used). Figure 10.12 shows that a yield of 10 oven dry tonnes per hectare per year is equivalent to:

- 20 green tonnes per hectare per year at 50% MC_{wb} and
- 13.9 green tonnes per hectare per year at 28% MC_{wb}

The area of willow plantations required to supply TI with wood chips is therefore: 101.5 green tonnes per year ÷ 13.9 green tonnes per hectare per year = 7.3 hectares.

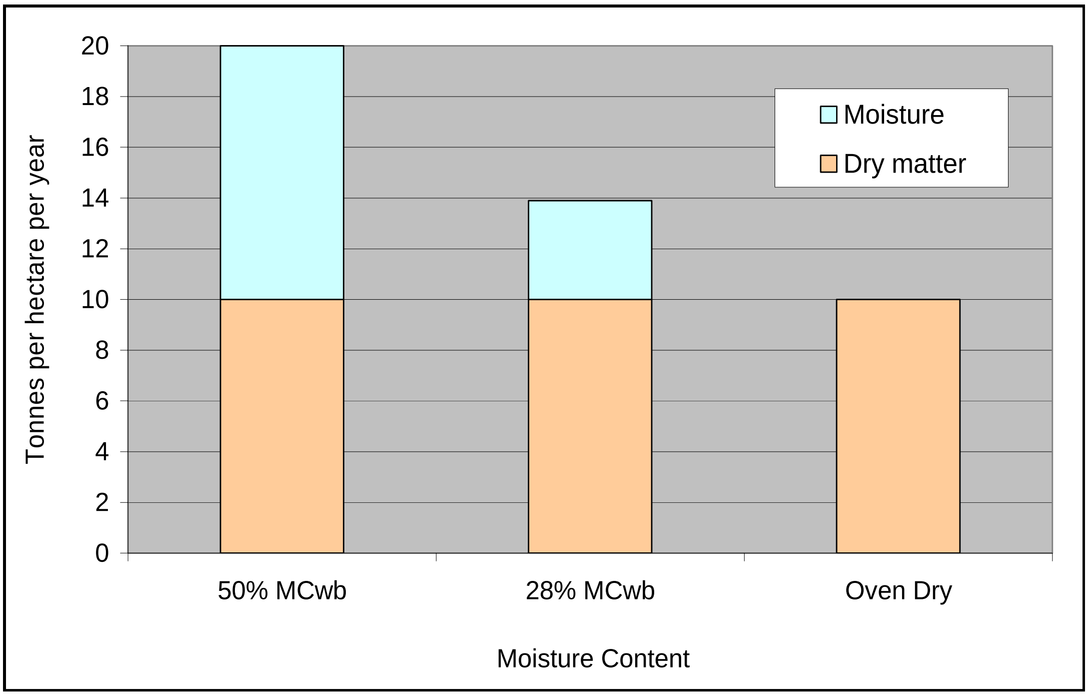


Figure 10.12 Willow yields expressed at different moisture contents

The section on "Sources of further information" lists pre-feasibility software tools that can be used to assess the viability of wood energy in more detail.

10.9 Summary

There are many potential sources of wood for fuel, and several convenient forms into which the wood can be converted. Conversion technologies are generally based on combustion, but come in many sizes and can produce heat, electricity or both. The lower the moisture content of wood the higher its energy content per tonne. Wood energy is increasingly competitive as the costs of fossil fuels rise, and policy and supports for wood energy are improving. Ireland has the potential to substantially increase its use of wood energy.

10.10 *Sources of further information*

The following websites have much information on bioenergy:

- Sustainable Energy Ireland (http://www.sei.ie)
- COFORD (http://www.coford.ie and http://www.woodenergy.ie)
- Irish Bioenergy Association (http://www.irbea.org)
- WESST (Wood Energy Supply Systems Training) (http://www.wesst.com)
- Educational web site created by IEA Bioenergy Task 29 (http://www.aboutbioenergy.info)
- Bioenergy International (http://www.bioenergyinternational.com)

The Dwellings Energy Assessment Procedure (DEAP) software for Building Energy Rating in Ireland also calculates the cost of fuel for a dwelling, including wood fuels (http://www.epbd.ie).

The RETScreen pre-feasibility software is supported by detailed guidance and case studies. It is available free at http://www.retscreen.net.

The BIOHEAT project website (http://www.bioheat.info/) has brochures and a pre-feasibility software tool available for download (http://www.bioheat.info/handbook/heatcost_el.html).

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