The Potential and Challenges of Growing Short Rotation Coppice Willow for Energy Purposes in the Republic of Ireland

by

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ABSTRACT

Burning of fossil fuels is believed by a large number of scientists to be a major cause of the increases in greenhouse gas emissions and to the change in the Earth's climate system.

Fossil fuels especially oil and natural gas are rapidly depleting resources. World prices of natural gas and oil have risen sharply in the last number of years. Ireland is heavy dependent on imported fuel especially oil, natural gas and coal for its energy requirements. Renewable energy can play an important role in relieving this dependency. By examining Irish government policy and programmes this study shows that renewable energy is an underdeveloped sector and that renewable energy policy has focused largely on the production of electricity with little attention to heat production. One of renewable energy options available in this country is short rotation coppice willow grown for energy purposes. The willow wood chip produced is used as a fuel in heating systems.

This study investigated the economics of growing willow coppice in Ireland. This enterprise is at present at a pioneering stage with high establishment and harvesting costs. Government financial assistance is required to encourage farmers to grow this crop. The application of sewage sludge to willow cropland with an associated gate fee offers additional revenue to this enterprise. In a cost comparison of a 100kw heating installation, wood chip heating systems were shown to have lower heating costs per year than wood pellet, oil and natural gas heating systems.

Codes of practice and publications on all health and safety aspects of growing, harvesting and storing short rotation coppice willow are not available in this country. A check list of the main health and safety issues associated with this crop was developed to aid those involved in the industry.

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SECTION 1: INTRODUCTION

Over the billions of years that life has been on the planet, the climate has always been changing. In recent decades, however, the rate of climate change has been speeded up. The Intergovernmental Panel on Climate Change (IPCC, 2001) is a panel that draws on the work of hundreds of experts from all regions of the world. The panel has concluded that the burning fossil fuels for energy is a major world contributor to climate change as it releases vast amounts of greenhouse gases, mainly carbon dioxide.

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted by more than 150 countries in Kyoto, Japan, on 11th December 1997. It is an international treaty containing binding constraints on greenhouse gas emissions (GHG). Under the Kyoto Protocol, industrialized countries and countries with economies in transition agreed to reduce their combined GHG emissions by at least five per cent below their 1990 levels by the first commitment 2008 to 2012. Ireland's target under the Kyoto Protocol is to limit annual GHG emissions to 13% above 1990 levels by the period 2008 - 2012.

Fossil fuels such as oil, natural gas and coal are finite resources from the geological past that are inevitably subject to depletion (Campbell, 1997). World economies are highly dependent on these fuels for energy purposes. Ireland is in the unenviable position of having an 89% dependency on imported fuels. The majority of these imports are fossil fuels. Rising fossil fuel prices and continuing rapid oil and gas price fluctuations in uncertain global markets are combining to have an increasing negative impact for businesses and householders using fossil fuels in Ireland (Howley and Ó Gallachóir, 2004).

Renewable energy can play a major role in replacing fossil fuels and also reducing GHG emissions. 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. According to Kuusela (1994), Ireland has the fastest growth rates for biomass (trees and other plant species) in Europe and also the highest potential annual yield of wood in Europe.

One form of renewable energy in the biomass area is Short Rotation Coppice (SRC) willow. SRC consists of fast-growing deciduous trees grown in plantations and coppiced every three to five years to provide wood fuel. Coppicing comes from the French word couper, to cut. The coppice trees which are all deciduous respond to cutting by sending up multiple stems from the stool.

The practice of coppicing in Europe can be traced back to Neolithic times (4500 BC). Woodland needs were fulfilled not by the felling of trees but by the periodic harvesting of managed coppice plots. Willow coppices were used as a wood fuel, in the manufacture of charcoal, farm fencing and in basketry. Coppicing remained the most widespread method of woodland management until the mid 1800s. The reason for its importance over such a long period was that it allowed the woodland crop to be harvested and utilized with simple hand tools. From the 18th century, coppicing began to decline. There was a trend towards cutting mature trees for timber production. From the mid 19th century, some of the most important traditional uses of coppice products diminished as coke and coal replaced charcoal and wood for fuel. Changes in farming practices meant that less willow was needed for fencing (Rackham, 1990).

Short rotation coppice for wood fuel has been developed in Sweden since the 1970's. Willow plant breeding programmes have produced high yielding and frost resistant plant varieties. The SRC plantations are densely planted at up to 15,000 plants per hectare and coppicing takes place on a three year rotation. SRC has been grown in other European countries including Denmark, United Kingdom and to a much lesser extent in the Republic of Ireland.

The purpose of this study is to investigate the potential and challenges of growing SRC willow for energy purposes in the Republic of Ireland. The study examines the climatic conditions and crop husbandry required to grow SRC willow. The machinery involved in harvesting and storage of the wood chip crop and the technologies available to utilize the wood fuel are examined. Climate change policies and programmes are studied and wood fuel's potential in reducing greenhouse gas emissions asssessed. Irelands energy sector including policies and programmes are investigated and the potential of various renewable energies including SRC willow examined. The factors influencing the uptake of SRC willow in the Republic of Ireland are investigated. The health and safety aspects of growing harvesting and storing SRC willow are also assessed.

SECTION 2: AN OVERVIEW OF SHORT ROTATION COPPICE

2.1 Short Rotation Coppice (SRC)

Short Rotation Coppice (SRC) consists of densely planted, high –yielding varieties of usually willow or popular, harvested on a 2-3 year cycle to provide wood fuel. The willow used in energy crops belong to the sub-species *Salix,* which are generally bushy in nature and grow to 5-7 m in height and have numerous shoots. Willows are planted in the Spring as stem cuttings measuring 18-20 cm in length. The willow will grow rapidly in the first year reaching up to 2m in height. During the winter following planting the plants are cut back to ground level to encourage the growth of multiple stems i.e coppiced. Generally three years after cutback and again during the winter the crop is harvested and 7-9 harvests may be achieved over a 30 year plantation period (DEFRA, 2002).

Figure 2.1 SRC willow plantation in the United Kingdom.

Willow has been grown extensively in Scandinavia for fuel, and in Sweden some 16,000 hectares of land are dedicated to its production for renewable energy (Larsson and Dobrzeniecki, 2004). In the United Kingdom there are 1,500 hectares under SRC willow (Royal Commission on Environmental Pollution, 2004). Only small areas of SRC willow are grown on a pilot basis in the Republic of Ireland. According to Michael Doran (personal communication, 2005) total area of SRC willow on the island of Ireland is 400 hectares of which approximately 60 hectares is in the Republic of Ireland.

SRC Popular has also been used in plantations but difficulties have risen with the planting of shoots, harvesting of large diameter stems and the removal of stools at the end of its life (DEFRA, 2002).

2.1.1 Growing and Harvesting of SRC Willow

As with any crop, site selection, good management in the establishment, growing and harvesting of the crop is essential to produce a high yield of good quality wood chip.

<u>Choice of site and soil Type</u>

For ease of operations the ideal site should be flat with a slope of no more than 7%. It is strongly recommended that the slope of a field should not exceed 15%. Appropriate access must be available for all machinery involved in establishing and harvesting the crop. SRC can be grown on a wide range of soil types from heavy clay to sand including land reclaimed from gravel extraction. Clay or sandy loams that retain moisture but are well aerated are ideal soils. Soil pH should be in the range 5.5-7 (DEFRA, 2002). Demonstration programmes carried out in the 1980's by Bord na Mona indicated that cutaway peatlands in Ireland were not suitable for growing broadleaved tree species on a short rotation coppice basis (Bord na Mona, 2004). Trials are now being carried out growing willows on cutaway bogs with a thin layer of imported topsoil placed on top of the peaty layer.

Soil Moisture Content

Willow SRC will produce good growth where there is sufficient soil moisture available within 1 metre of the soil surface. It can withstand seasonal flooding but not permanent water-logging. Annual rainfall of 600-1000mm is ideal (DEFRA, 2002). Most of the eastern half of Ireland has between 750 and 1000 millimetres of rainfall in the year. Rainfall in the West generally averages between 1000 and 1250 mm (www.met.ie).

Land preparation

Weed control is critical part of coppice establishment. Complete eradication of all invasive perennial weeds is essential prior to planting. One or two applications of glyphosphate-based herbicide, applied at the appropriate rate, is carried out in the Summer/Autumn prior to spring planting (DEFRA, 2002).

SRC is most susceptible to compaction damage when it is very young or is growing in shallow soils. Compaction if present in the main rooting zone needs to be alleviated prior to planting SRC (Souch *et al.*, 2004). If required the site should be sub-soiled and then ploughed. Power harrowing of the site should be carried out immediately before planting (DEFRA, 2002).

Planting

Rods or cuttings are taken from one-year old material that are harvested between December and March when the plants are dormant. They are either planted immediately or stored at -2 to -4 degrees C where cuttings will remain viable for several weeks and rods up to 3 months.

At present, the most commonly used machines are 'step planters'. Willow rods of 1.5-2.5 metres length are manually fed into the planter. The machine cuts the rods into 18-20cm cuttings, inserts the cuttings vertically into the soil and firms the soil around each cutting. 15,000 cuttings per hectare is the current standard commercial planting density using this method. Planting should ideally take place after the last frosts but as early as February if soil conditions allow (DEFRA, 2002).

Figure 2.2 SRC willow planting with a step planter.

General management

From each cutting 1 – 3 shoots will arise and reach up to 1.5 metres in height by the end of the first growing season. During the winter following planting the willow is usually cut back to within 10cm of ground level to encourage the development of the multi-stemmed coppice (DEFRA, 2002).

Figure 2.3 SRC willow being cutback

Application of fertiliser

No fertiliser is applied during the establishment year. The root system will not have fully developed and would not be able to utilise the additional nutrients (DEFRA, 2002). Annual fertiliser applications of 60-80 Kg/ha Nitrogen, 10 Kg/ha Phosphorus and 35 Kg/ha Potassium have been recommended by Danfors *et al.* (1998).

According to British Biogen (1999) economic benefits of applying chemical fertilisers on SRC willow are marginal. Winter harvesting ensures that nutrients in the leaves are returned to the soil. Treated sewage sludge has been applied to willow crops at cutback and after harvesting as an organic fertiliser (Hasselgren, 1998). About 50 % of all harvested plantations in Sweden are fertilised by sewage sludge (Larsson and Dobrzeniecki, 2004). Waste water from sewage treatment plants has been applied to willow crops during the growing season in experiments carried out on a number of sites across Europe including Culmore, Londonderry, Northern Ireland. The results of these experiments indicated that biomass production in willow plantations could be enhanced with the application of waste water (Cuignet *et al.*, 2003).

According to European Council Directive 86/278/EEC on the protection of the environment, in particular of soil when sewage sludge is used in agriculture, agriculture is defined as "the growing of all types of commercial food crops including for stock-rearing purposes" (European Parliament and Council, 1986). Growing of SRC willow does not fall under this definition of agriculture. The Department of Environment and Local Government, Code of Good Practice for the use of Biosolids in Agriculture states that biosolids can be applied as a fertiliser to lowland forestry. Biosolids is defined as the organic by-product of urban wastewater treatment. As SRC willow is forestry grown on short rotations, the land spreading practices and application rates provided in this code of good practice must be adhered to when applying biosolids to SRC plantations (Department of Environment and Local Government, 1998).

Diseases and Pests

Rust is the most important disease of SRC, caused by fungi called *Melampsora.* Monocultures of willow, i.e. block planting of single varieties, are highly susceptible to rust damage. The use of fungicides is not recommended for economic, practical and environmental reasons. A strategy of planting at least five varieties per site helps to minimise the effects of the disease and breeders are endeavouring to produce more resistant varieties (McCracken *et al.*, 2001).

Wllow beetles are the most important insect pest of willow SRC. A local application of an appropriate insecticide directed specifically to where the beetles are congregating or a spray applied from the edges of the coppice if the beetles are more dispersed, will help to protect the crop from further damage. Leaterjackets can damage willow planted after grass or long-term set-aside, and an insecticide spray is sometimes needed (DEFRA, 2002).

Browsing animals such as rabbits and deer can also cause damage to SRC but mainly during establishment. Rabbit proof fencing can form a large proportion of the costs of establishing the crop, particularly for small plantations. In Sweden, fencing is not considered economic and only land with low rabbit populations is used for willow (SAC, 2001).

<u>Harvesting</u>

Harvesting generally takes place on a 3-year cycle, the first harvest being 3 years after cutback. The work is carried out during the winter, after leaf fall and before bud-break, usually mid-October to early March. Traditionally willow were harvested as rods. These rods had about 55% moisture content. Rods were stacked at the end of the crop plantation and left to dry out naturally over the summer months to approximately 35% moisture content. Rod harvesting is labour intensive and impractical for large areas. End-users will generally require the fuel in the form of wood chip. Direct chip harvesting is the most common method to harvest commercial SRC willow. Specifically designed SRC headers for direct chipping of the crop have been fitted to forage harvesters. The stems are cut, chipped and then blown into an accompanying trailers as shown in Figure 2.4. Woodchips are usually 5 x 5 x 5 cm in size.

Figure 2.4 SRC willow harvesting

SRC yields

SRC yields will vary according to the location of the site, soil type, water availability and general crop husbandry. Yield following the first harvest of a number of commercial sites in the United Kingdom was in the range of 5-9 tonnes dry matter/ha/yr (DM/ha/yr). However, planting densities at these sites were 12,000 cuttings/ha rather than the current standard of 15,000 cuttings/ha. Yields should also increase at second and third harvests. Average yields from experimental plots growing new varieties developed especially for British Isles conditions have reached more than 18 tonnes DM/ha/yr. Breeding programmes continue to produce varieties that out-perform older varieties (DEFRA, 2002).

Storage

Freshly harvested willow contains over 50% moisture. Dry material is preferred for combustion. Wood chips can be dried successfully and then stored with little further loss of dry matter. Grain drying techniques have been adapted for willow chips.

Ventilated floor driers operating at near-ambient temperatures can dry willow chips from 50% moisture to 15 % moisture in about three weeks. Driers using higher air flows and temperatures up to 40^0 C can dry willow in 1-2 days (SAC, 2001).

Removal of SRC

After the final winter harvest, the stools are left and allowed to shoot the following spring. When shoots have developed, the entire coppice is over-sprayed with a glyphosate-based contact herbicide to kill the willow. Running either a sub-soiler or a large diameter disc along the rows close to the stools will sever the main structural roots, which run horizontally from the stools. The stools themselves can be mulched by use of a heavy-duty grasstopper or pulveriser into the top layer of soil. The field can then be grassed for the first year following removal and (if appropriate) used for standard arable cropping the following year (DEFRA, 2002).

2.2 Short Rotation Coppice Willow as a Wood Fuel

2.2.1 Wood fuel technology

Willowchip is converted to energy using thermochemical processes (i.e. they involve both heat and chemical reactions) of combustion, gasification or pyrolysis.

Combustion technology is already well established. Gasification and pyrolysis are not new, but their use in generating energy from willow is still in the development stage (SAC, 2002).

Combustion

Combustion is generally the most economical way to produce heat from biomass. It involves burning the crop with enough oxygen to convert nearly all the material to carbon dioxide and water. The heat emitted can be used directly (e.g. to produce hot water in a central heating system) or it can raise steam and drive a steam engine or turbine to generate electricity. Equipment ranges from very small wood stoves used for domestic heating (e.g.15 kW thermal capacity, wood consumption 3.5 kg/hr) to very large systems producing several hundred MW of heat. Equipment design depends on the moisture content and particle size of the fuel (SAC, 2002). Wood stoves fed with chips by a screw stoking mechanism are commercially available up to several MW capacity. Air is supplied at different locations (primary, secondary, and sometimes tertiary air supply) to ensure complete combustion at high efficiency and to reduce flue gas emissions (SAC, 2002).

Fluidised bed combustion

Fluidised bed combustion is widely used in modern large installations. Fuel particles, together with an inert bed material such as sand, can be "fluidised" by air movement. In bubbling fluidised beds, the material behaves like a boiling fluid, but is not transported by the air stream. In a circulating fluidised bed, the gas velocity is higher so that part of the bed material leaves the reactor vessel; the solids are transported back to the reactor vessel via a cyclone and return pipe. Combustion temperature in a fluidised bed is relatively low and easily controlled, so that NOx emissions can be kept low. Additives such as limestone can be used to combine with sulphur and/or chlorine and thereby reduce emissions of sulphur dioxide and hydrogen chloride (SAC, 2002).

Gasification

Gasification involves the partial oxidation of biomass at high temperatures (800-900°C) producing a combustible gas, which is cleaned to remove tars, dust and particulates. It is not economic to transport or store the gas because it has a low calorific value in relation to its volume. The gas is normally used immediately in a furnace, gas engine or turbine. It can also be refined for use in fuel cells for transport and combined heat and power (CHP) applications.

Gasifiers can be classified by the manner in which the feedstock meets the gaseous reactant. Fixed bed gasifiers are divided into two types – (1) updraft, where the gas flows up against a downward flow of solid biomass and (2) downdraft, where both the solid and the gas move downward. With fluidised bed gasifiers, on the other hand, the biomass is mixed with inert sand which is suspended and violently agitated by a flow of air (SAC, 2002).

According to Michael Doran (personal communication, 2005) gasification units are commercially available but further research and development work is required to overcome reliability problems.

Pyrolysis

Pyrolysis involves heating in the absence of oxygen (rather like traditional charcoal production) to produce a liquid fuel and a solid char, together with combustible gas (SAC, 2002). According to Hoyne (2002a) this technology is still very much as the development stage and there is little work ongoing in Ireland at present.

2.2.2 Wood boiler efficiency

Over the past 20 years tremendous progress has been made in the design and manufacture of wood boilers. As shown in Figure 2.5, wood boiler efficiency is now 805-90%, same range as for oil or gas boilers. Emissions of state of the art boilers have been reduced to a hundredth of the original figures. Technical progress has also led to high reliability in automatic boiler operation (www.bioheat.info).

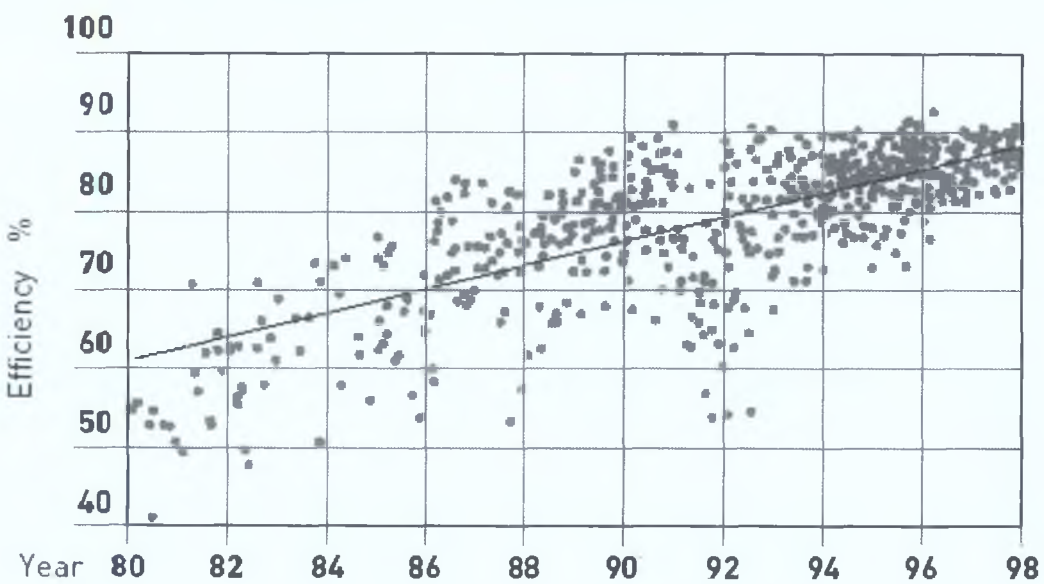

Figure 2.5 Efficiency factor of a wood fuel boiler (www.bioheat.info).

2.2.3 Wood fuel in Ireland

According to Hoyne (2002) 1% of the Total Primary Energy Requirement is supplied from wood fuel. The usage of wood fuel is low in comparison with Sweden, with combustible biomass, most of which is wood fuel, supplying 16% of Total Primary Energy Supply (IEA, 2005) and 11% in Austria (EREC, 2004a).

According to Hoyne (2002) wood fuel in Ireland is mainly used in the domestic sector for heating and in the wood processing industry to produce heat. However, for the domestic sector there has been an increasing move away from manual central heating systems towards oil and gas central heating systems which require little or no manual labour. Conversely there has been an increased development in the market for wood stoves and heating appliances in new and existing homes. Waterford Stanley, a manufacturer of ranges and stoves noted a 30% increase in stove sales from 1999 to 2001. Hoyne (2002) believes that this increase is due mainly to a number of factors including wood stoves now being 'in fashion', an increase in wealth due to the developed Irish economy and some awareness of the inefficiencies of open fires.

The domestic wood fuel supply industry in the Irish Republic has previously been assessed (Blackstock and Binggeli, 2000) to be at least 58,500m^3 per annum. It was acknowledged in the report that it was difficult to estimate the market potential of woodfuel as supply was mainly operated on a black market basis.

2.2.4 Sources of wood fuel in Ireland

Wood chip

In Ireland up until recently, securing a reliable source of wood fuel was difficult. Fortunately, there have been some improvements in this area. Companies such as Rural Generation Ltd, Natural Power Systems, Clearpower Ltd, are suppliers of woodchip and wood fuel boilers in Ireland (Irish Energy Centre, 2002).

Wood pellet

Balcas Ltd. in Enniskillen, Northern Ireland have opened a pellet production plant in 2004 producing 50,000 tonnes of pellets/ year. This company produces a large surplus of sawdust and woodchips, which are converted by the plant into small (2cm) pellets. These are burned in domestic and industrial boilers (Friel, 2004).

Feasibility studies for four other wood pellet plants are at an advanced stage in the Republic of Ireland. Galtee Fuels in Limerick and Celtic Flame in Dublin import and distribute wood pellets (SEI, 2004*a*).

2.2.5 Wood fuel heating installations in Ireland

A limited number of wood-fuel heating systems exist in Ireland. The more recent installations have received funding from Sustainable Energy Ireland. Listed below is a sample of the most recent wood fuel installations in the Republic of Ireland.

Independent Biomass Systems, a joint venture between SWS Group and Grainger Sawmills Limited, constructed an €8 million wood-fired biomass combined heat and power (CHP) plant output to generate green energy at Grainger's wood processing facility at Enniskeane in West Cork in 2004. The new combined heat and power plant produce 3.5 MW of heat for use in drying timber and 1.83 MW of green electricity per year enough for about 3,000 homes. The plant uses sawmill residue such as sawdust, shaving and bark (http://www.irishforests.ie/news.htm).

Camphill Jerpoint in Kilkenny run a 150kW wood fuelled heating system to supply space and hot water heating for two large houses, a separate community centre and office, and a food processing workshop. Clearpower (energy company) is supplying woodchip fuel to the facility (http://www.clearpower.ie/about.html).

Teagasc, Oak Park have installed a 100kW boiler powered by woodchips and will also be used to trial alternative fuels such as cereal straws, rape straw and miscanthus (http://www.nps.ie/news/archives/2005/03/).

Coillte Teoranta HQ has a recently constructed state-of-the-art premises located in Newtownmountkennedy, Co. Wicklow. Their new building contains a 100 kW wood pellet/wood chip fuelled boiler in conjunction with two arrays of solar thermal panels (http://www.nps.ie/news/archives/2005/03/).

Natural Power Supply Ltd., based in Waterford installed a 70kW boiler. It heats the office complex for 20 staff and an adjacent country house. The boiler can run on pellets or wood chips, and is currently fuelled by short rotation coppice willow chips (http://www.nps.ie/news/archives/2005/03/).

Inchydoney Island Lodge and Spa, Cork plan to install a 500kW wood pellet boiler in 2005 (SEI, 2004*b*).

SECTION 3: CLIMATE CHANGE

3.1 Introduction

Global warming poses an extraordinary challenge to all nations. The Intergovernmental Panel on Climate Change (IPCC, 2001) is a panel that draws on the work of hundreds of experts from all regions of the world. This panel has concluded that the Earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era, with some of these changes attributable to human activities. The atmospheric concentrations of key anthropogenic GHG i.e., carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and tropospheric ozone (O_3) reached their highest recorded levels in the 1990s. According to IPCC (2001) this was primarily due to the combustion of fossil fuels, agriculture, and land-use changes.

The *Climate Change Synthesis Report-2001* (IPCC, 2001) predicts a substantial dieback of tropical forests and grasslands. The release into the atmosphere of the carbon stored in these ecosystems will add to overall atmospheric carbon dioxide concentrations, accelerating climate change. Substantial decreases in water resources are expected in Australia, India, Southern Africa, most of South America and Europe, and the Middle East. Cereal yields are expected to increase slightly in Canada, China, much of Europe but the decreases in yields in Africa, India and the Middle East are likely to more than offset these slight increases. The annual numbers of people flooded in the world is expected to increase from approximately 15 million per annum to 90 million per annum, mainly in southern and south eastern Asia. Some low-lying oceanic islands are expected to become almost uninhabitable. Global human health can be expected to be reduced through the greater spread of vector-born diseases, including up to 300 million more people at risk from malaria. Countries that will be least in a position to meet the necessary adaptation costs are most vulnerable to the impacts of climate change.

A report was commissioned by the United States, Bush Administration, *Climate Change Science: An Analysis of Some Key Questions* (National Research Council, 2001). This report reviewed and evaluated the comprehensive climate change assessment produced by the Intergovernmental Panel on Climate Change (IPCC, 2001) and made a number of recommendations about research needs. At the most fundamental level, the National Research Council report indicated the need to better understand the causes of warming. The report stated that the changes observed over the last several decades are likely mostly due to human activities, but could not rule out some significant part of these changes are also a reflection of natural variability. The NRC report identified the areas where additional research is needed to advance understanding of climate change.

3.2 Climate Change Policies and Programmes.

3.2.1 International Policy

It was during the 1980's and early 1990's that scientific evidence linking greenhouse gas emissions from human activities to climate change arose concern. Governments held a series of international conferences and issued urgent calls for a global treaty to address the problem. The UN conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 involving 178 governments and over 500 non-government organizations led to the signing of the UN Framework Convention on Climate Change (UFCCC) (http://unfccc.int/resource/docs/convkp/conveng.pdf).

The UFCCC was adopted with the long term objective to prevent man-made interference with the climate system. This convention was recognised as a stepping stone for stronger action in the future. In 1995 the parties to the convention met in Berlin to negotiate a protocol containing measures to reduce GHG emissions. The negotiations held in Berlin in 1995 led to the signing of the Kyoto Protocol in Japan in 1997. The Protocol commits industrialised or developed countries to reduce their combined emissions of a basket of six greenhouse gases by at least 5% compared to 1990 levels by the first commitment period 2008-2012 (http://unfccc.int/resource/docs/convkp/kpeng.html).

3.2.2 EU and Ireland's Climate Change Policies and Programmes

Under the Kyoto Protocol, Parties are allowed to jointly fulfil their individual commitments. The EU has an overall reduction target of 8% below 1990 levels and has agreed a burden sharing agreement that recognises the different economic circumstances of each member state.

In March 2000 the Commission launched the European Climate Change Programme to prepare additional policies and measures, as well as an emissions trading scheme, to ensure that the EU achieves the 8% cut in emissions to which it is committed under the Kyoto Protocol (Department of Environment and Local Government, 2000).

Ireland's target under the Kyoto Protocol is to limit GHG emissions to 13% above 1990 levels by the period 2008 - 2012. The Department of Environment and Local Government (2000), published the National Climate Change Strategy (NCCS). This strategy provides a framework for achieving GHG emissions reductions in the most efficient and equitable manner while continuing to support economic growth.

The NCCS projects that in the absence of the measures in the strategy, Ireland is likely to overshoot the Kyoto target by approximately 13 Mt CO_2 or 37% above 1990 levels. The cumulative effect by 2010 of NCCS measures would be a reduction annually of 15.4 Mt CO_2 compared with the business as usual projections. Under this arrangement Ireland has agreed to a national target to limit the increase in GHG emissions to 13% above the 1990 levels in the period 2008-2012.

The NCCS calls for the maximisation of renewables capacity and commits to the setting of targets for the period 2005 - 2010.

The NCCS states in relation to the agriculture sector "The potential for developing short-rotation biomass for energy generation as an alternative land use where animal numbers are reduced, and for set-aside land, will be developed in conjunction with the renewable energy programme."

3.2.3 GHG emissions in Ireland

Figure 3.1 shows the trend in annual GHG emissions for the period 1990 – 2003 (Howley and Ó Gallachóir, 2004). The emissions are grouped according to individual source and include land use change and forestry, energy, industrial processes agriculture and waste. Increases in forestry cause a reduction in emissions and hence appear as a negative in the graph.

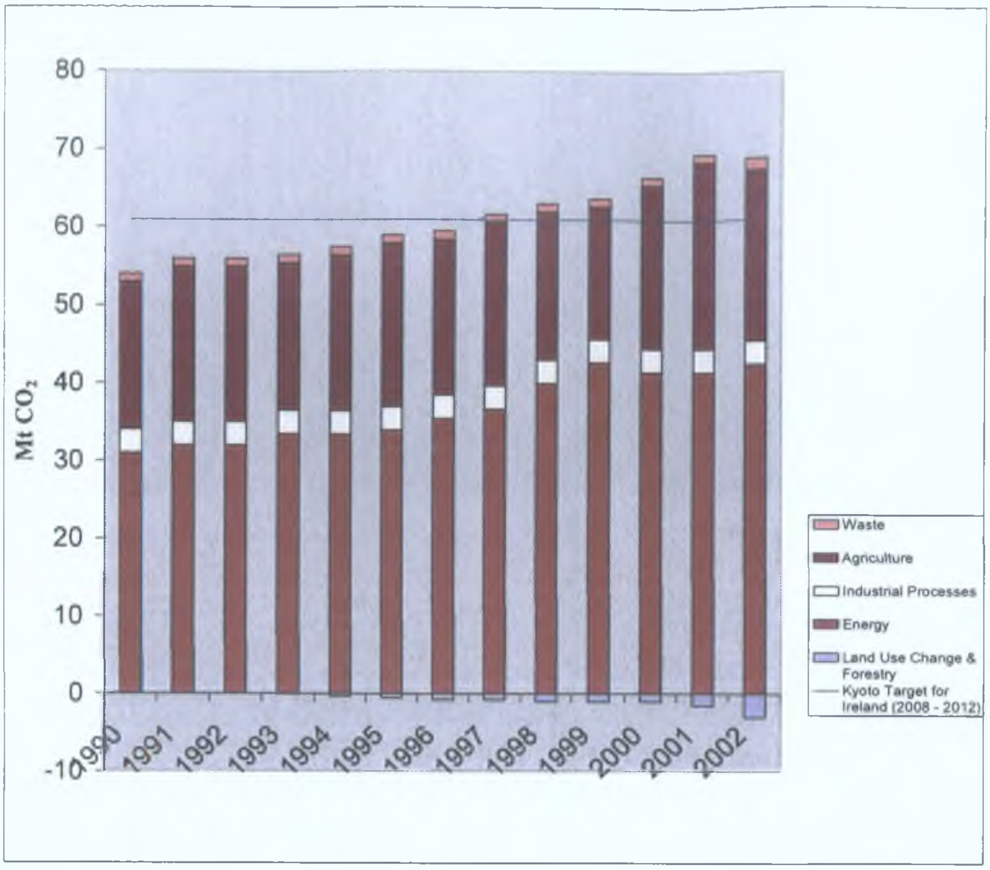

Figure 3.1 Greenhouse gas emissions by source 1990-2002 (Howley and Ó Gallachóir, 2004).

It is clear from Figure 3.1 that by 2001, Ireland's Kyoto target for annual GHG emissions peaked at 31% above 1990 levels. It is also evident from Figure 3.1 that the most significant area of growth is in energy-related emissions, in particular since 1995. In 2002 there was a reversal in the upward trend for the first time with GHG emissions dropping slightly to 29% above 1990 levels. This downward trend continued in 2003 reaching 25% above 1990 levels. 2003 was the first full year of operation for the two new combined-cycle gas turbine power plants and the first full year without fertiliser production in Ireland due to the closure of the IFI plant in Arklow in October 2002.

3.2.4 GHG emissions by source in Ireland

The share of GHG emissions arising from energy-related activities was 66% in 2003. The share from agriculture in the same period was 27%. These are shown in Figure 3.2.

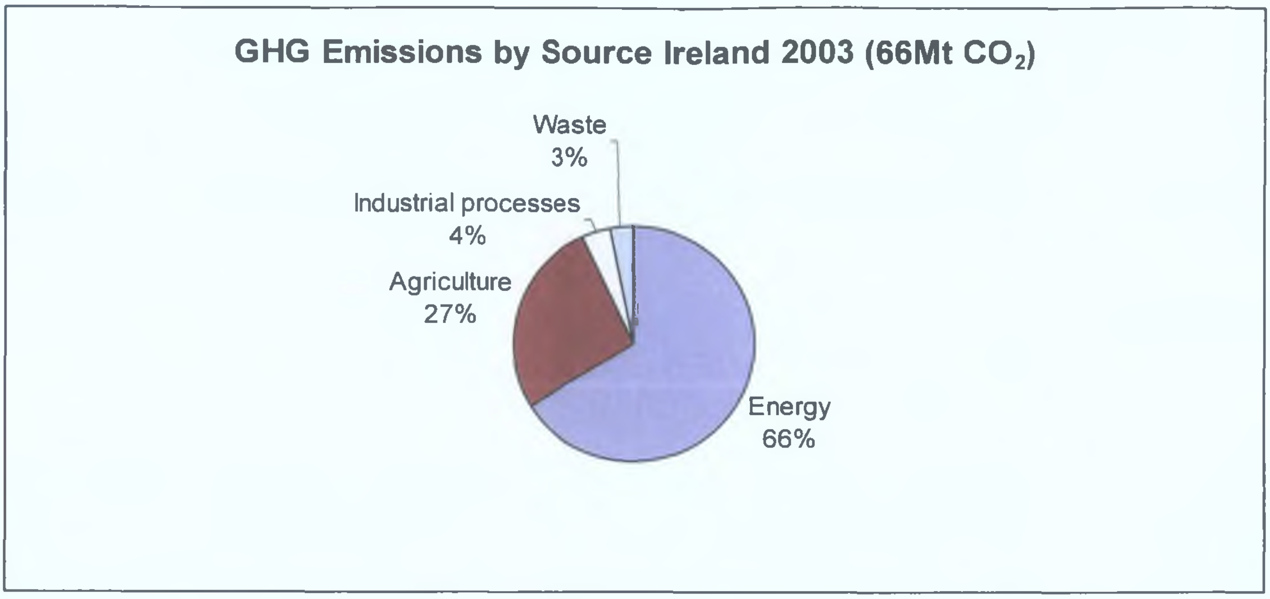

Figure 3.2 GHG Emissions in Ireland, 2003 (Howley and Ó Gallachóir 2004).

It is interesting to note that for the EU as a whole, energy production and use represented 80% of GHG emissions in 2004. The EU share from agriculture was 10%. (European Environment Agency, 2005). The significant role of agriculture in the Irish economy underlies Ireland's variance from the EU average. Emissions from the agriculture sector are projected to reduce significantly over the period from 2001 to 2012 based on EU agriculture policies in the period 2000 and 2005 and the recent adoption by the Irish government of Common Agriculture Policy reform based on full decoupling from production of direct payments to farmers (Department of Environment, Heritage and Local Government, 2004).

3.2.5 Role of woodfuel in lowering green house gas emissions

One of the principal sources of manmade carbon dioxide emissions is energy production from the traditional fossil fuel sources of coal, gas and oil (IPCC, 2001). If used to replace fossil fuels, wood fuel from sustainable sources offers significant opportunities to reduce carbon dioxide emissions .

There is a natural carbon cycle. Plants take carbon dioxide from the atmosphere as they grow. When plants are burned or decompose, the carbon dioxide is released to the atmosphere. As new plants grow, they again take carbon dioxide from the atmosphere. Renewable energy compares very favourably with fossil fuels in terms of emissions of carbon dioxide to the atmosphere. For wood fuel, there are small net emissions of carbon dioxide through operations such as harvesting and transport, and from the construction and decommissioning of the energy plant. For fossil fuels, much larger overall emissions result because, in addition to fuel extraction, transport and plant construction, carbon contained in the fuel represents a net increase carbon dioxide to the atmosphere (Royal Commission on Environmental Pollution, 2004).

The net carbon benefits of any particular energy system will depend on the carbon emissions associated with the energy system it replaces, the efficiency of the conversion techniques and the carbon balance associated with growing and transporting the fuel prior to combustion.

Short rotation coppice has life cycle emissions of 22 grams of CO_2 per kWh. This compares favourably to fossil fuels such as peat with life cycle emissions of 1,434 g/kWh, coal with emissions of 955g/kWh and oil with emissions of 722 g/kWh (British Biogen, 1999).

This comparison is shown in Figure 3.3 below.

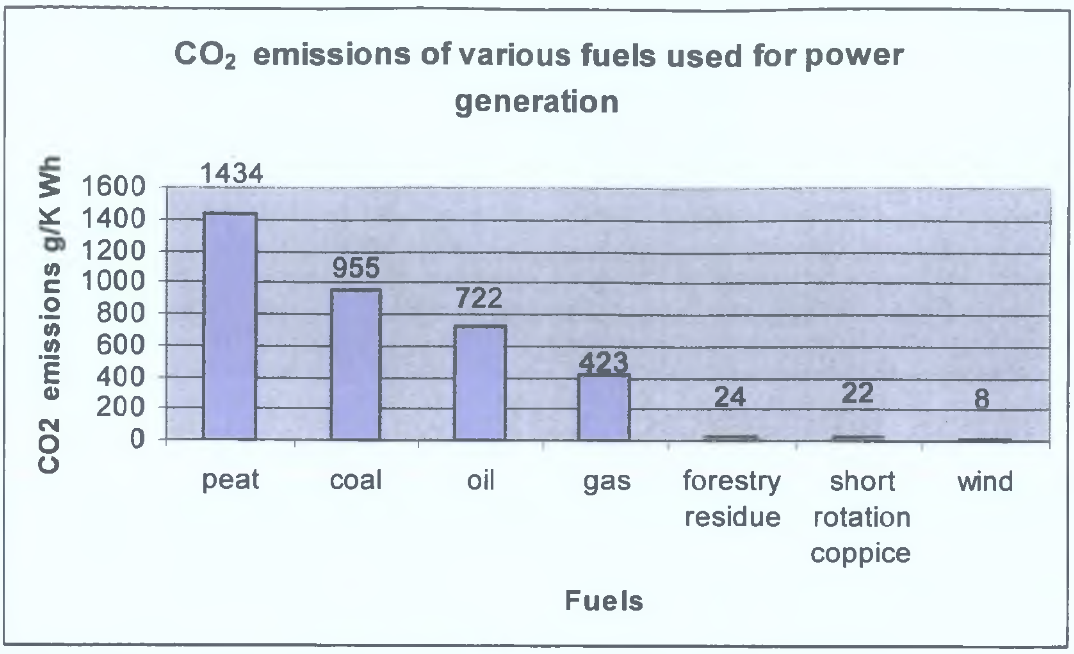

Figure 3.3 CO_2 emissions of various fuels used for power generation (British Biogen, 1999).

In comparison to fossil fuels, wood fuel also has a low sulphur and nitrogen content; this means that problems with acid rain may be reduced in some circumstances. The degree of emissions' reduction will be dependent on the type and scale of conversion equipment used (British Biogen, 1999).

SECTION 4: ENERGY

4.1 World Energy Sector

According to International Energy Agency *(2004a)* World Total Primary Energy Supply (TPES) for 2002 stood at 10,376 million tonnes of oil equivalents (Mtoe). This is shown in Figure 4.1. Fossil fuels of oil, coal and natural gas provide 80 % of the World's TPES. Combustible renewables and waste provide 10.9% of the World's TPES.

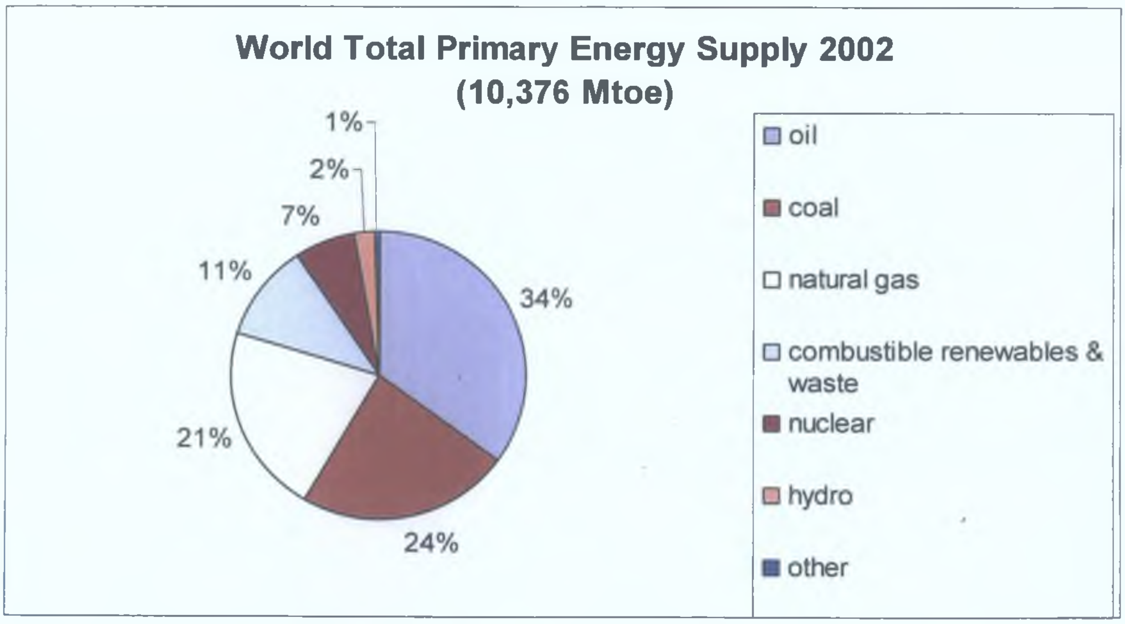

Figure 4.1 World TPES 2002

4.1.1 Fossil Fuels

Fossil fuels can be defined as hydrocarbon deposits, such as petroleum, coal, or natural gas, derived from living matter of a previous geologic time and used for fuel. All fossil fuels, whether solid, liquid, or gas, are the result of organic material being covered by successive layers of sediment over the course of millions of years. Oil and natural gas were formed from the slow decomposition and burying of planktonic marine plants and animals that sank to the muds of the sea floor. Coal is derived from the accumulation of partially decayed land plants. As the sediment solidifies into rock, the organic material decomposes under the influence of great pressure and high temperature (Ristinen, 1999).

The law of conservation of energy states that energy can not be created, only converted from one form to another (Jones, 2001). Fossil fuels were created when a finite amount of decayed organic matter were compressed underground millions of years ago. Fossil fuels are a finite resource.

4.1.2 How much Fossil Fuels are left in the World?

The late Dr. M. King Hubbert, geophysicist, is well known as a world authority on the estimation of energy resources and on the prediction of their patterns of discovery and depletion. The Hubbert peak theory, also known as peak oil theory, relates to the long-term rate of conventional oil and other fossil fuels production and depletion. It predicts that future world oil production will soon reach a peak and then rapidly decline (www.hubbertpeak.com). The theory is supported by other well known and respected geologists Deffeyes (2001) and Campbell (1997). Campbell (1997) argues that the big oil discoveries have all been made. The peak of discovery occurred in the 1960s and the discovery rate has fallen dramatically in recent years. He points out that every two barrels used, only one new one is found.

Hubbert (1971) created a mathematical model of petroleum extraction which predicted that the total amount of oil extracted over time would follow a logistic curve. This in turn implies that the predicted rate of oil extraction at any given time would then be given by the rate of change of the logistic curve, which follows a bell-shaped curve now known as the Hubbert's curve. Given past oil production data and barring extraneous factors such as lack of demand, the model predicts the date of maximum oil production output for an oilfield, multiple oil fields, or an entire region. This maximum output point is referred to as the peak. The period after the peak is referred to as depletion. The graph of the rate of oil production for an individual oil field over time follows a bell-shaped curve: first, a slow steady increase of production; then, a sharp increase; then, a plateau (the "peak"); then, a slow decline; and, finally, a steep decline.

Hubbert, in 1956, predicted oil production in the continental United States would peak in the early 1970s. U.S. oil production did indeed peak in 1970, and has been decreasing since then. According to Hubbert's model, U.S. oil reserves will be exhausted before the end of the 21st century (Campell, 1997). Hubbert peak theory is most often applied to oil but is applicable to other fossil fuels such as natural gas, coal and non-conventional oil.

In the energy industry there is some disagreement on Hubbert's Peak theory. According to Maugeri (2004) estimates do not take into account non-conventional oil even though the availability of these resources is huge and the costs of extraction, while still very high, are falling due to improved technology. Furthermore, he notes that the recovery rate from existing world oil fields has increased from about 22% in 1980 to 35% today due to new technology and predicts this trend will continue.

4.1.3 World crude oil reserves

According to OPEC's World Energy Model , total world oil demand in 2000 is put at 76 million barrels per day. As world economic growth continues, crude oil demand will also rise to 90.6m barrels/day in 2010 and 103.2m barrels/day by 2020 (www.opec.org).

According to an OPEC (2003) world proven crude oil reserves stood at 1,137,550 million barrels.

Making a estimate of the amount of conventional oil recoverable, if the world proven crude oil reserves of 1,137,550 million barrels is divided by crude oil demand of approximately 100 million barrels/day, that leaves 31 years of crude oil recoverable. Campbell (1997) estimate of the amount of conventional oil ultimately recoverable in 1997 was 1,900,000 million barrels. Up to 2003, 153,300 million barrels have been used leaving 1,746,700 million barrels. If this 1,746,700 million barrels is divided by crude oil demand of approximately 100 million barrels/day that leaves 47 years of crude oil available.

The Middle East remains the biggest player in oil industry. The region dwarfs the rest of the world, when it comes to oil reserves, ensuring its prominence on the global political stage (http://www.opec.org).

Saudi Arabia alone possesses around 25% of the world's proved reserves. The country is the world's biggest oil producer and, by far, the biggest exporter (www.bp.com).

Recent violence in Iraq and Saudi Arabia has again raised fears about an interruption to supplies (http://news.bbc.co.uk).

4.1.4 Natural Gas and Coal reserves.

According to Deffeyes (2001) proved reserves at current consumption rates gives a lifespan of 60 years for natural gas and 210 years for coal.

4.1.5 Oil Prices

Since 2004 the world oil prices have cleared $40, then $50, then $60 a barrel. On Friday August 12th 2005, American light crude oil topped $66 a barrel for the first time, due in part to fears of terror attacks in Saudi Arabia, an impasse over Iran's nuclear programme and problems in American refineries. As shown in Figure 4.2, while nominal prices are at record levels, in real (inflation-adjusted) terms they are still below those seen in the wake of the 1979 Iran hostage crisis, when the cost of a barrel of oil hovered around $90 a barrel in today's dollars (www.economist.com).

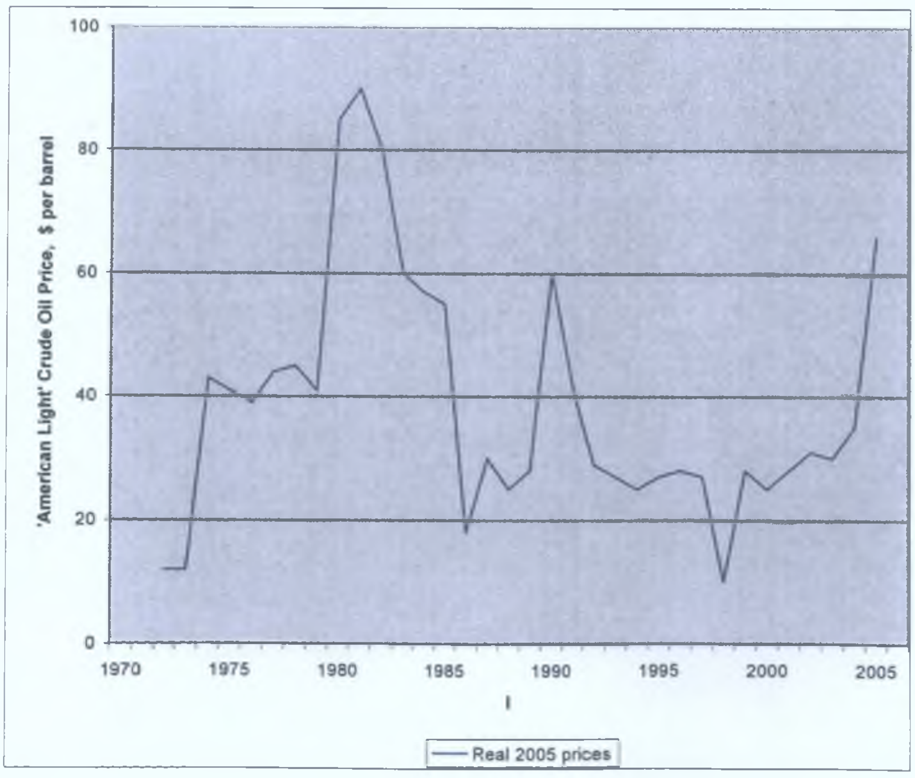

Figure 4.2 'American Lite' Crude oil prices 1970-2005

4.2 Ireland's Energy Sector

4.2.1 Irelands Energy Sector- An Overview

Ireland in 2003 spent over €7 billion on imported fossil fuels such as oil, coal and gas (O'Keefe, 2004). Electricity accounts for 30% of Ireland annual usage, transportation accounts for 35% and heating accounts for the remaining 35% (Hoyne, 2003).

According to Howley and Ó Gallachóir (2004) Ireland's TPER in 2003 was 14,790 Ktoe. Oil is the dominant energy source at 54.1% of TPER, followed by natural gas at 24% and coal at 13%. Renewables such as biomass, hydro and wind make up the 1.8% of TPER. This is shown in Figure 4.3

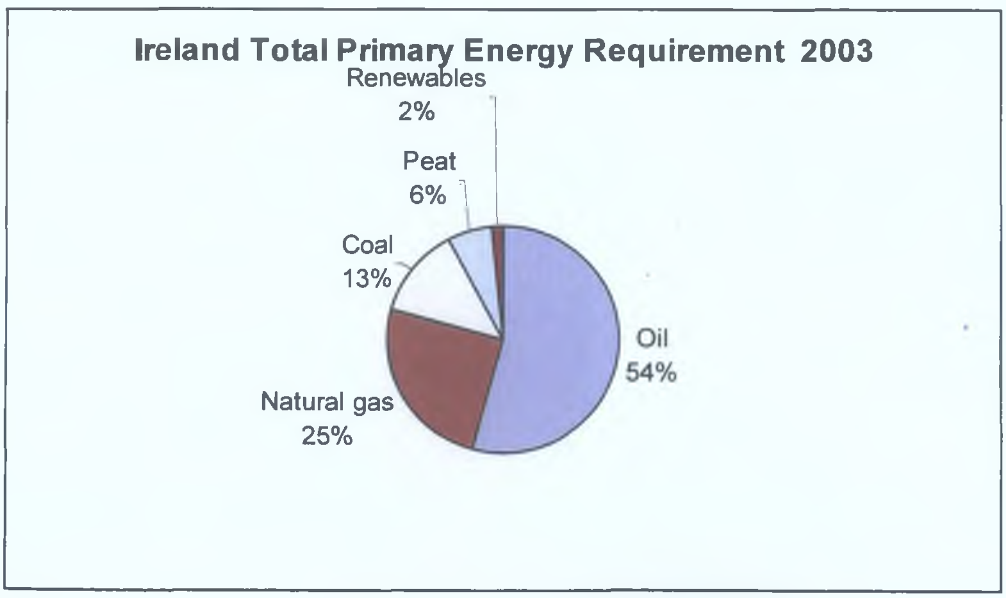

Figure 4.3 Total Primary Energy Requirement 2003, Ireland

Irelands is hugely dependent on imported energy. Irelands imported dependency reached 89% in 2003 (Howley and Ó Gallachóir, 2004). The EU-15 import dependency is 50 %. This is shown in Figure 4.4.

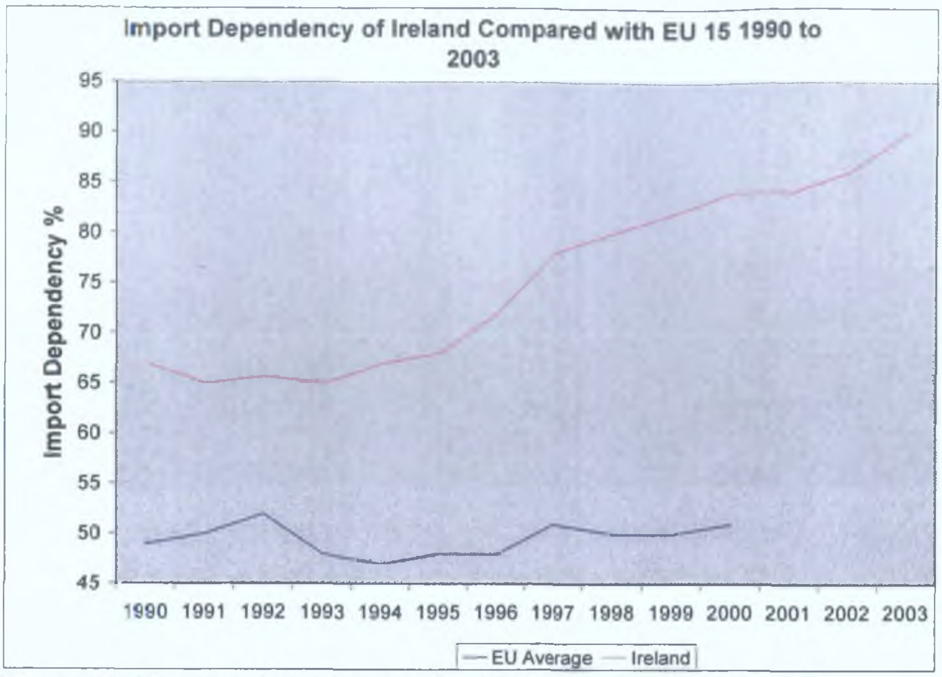

Figure 4.4 Import dependency of Ireland compared with EU 15

4.2.2 District heating.

District heating (DH) is heat distributed from a central boiler or CHP plant. This heating system is quite popular in countries such as Sweden and Austria. District heating has not had the same penetration in Ireland for a number of reasons. Ireland's relatively mild climate does not help the economics of installing DH on a large scale. Low density of housing even in cities makes it impractical to pump warm water over long distances (Anon., 2002).

In 2003 there was around 43MW thermal of district heating in Ireland and the majority of this was the Ballymun scheme which is not being replaced during the current regeneration project (Irish CHP Association, 2003).

4.3 Major Players in Irelands Energy Sector

4.3.1 Department of Communications Marine and Natural Resources

The Department of Communications Marine and Natural Resources key objectives are to develop a competitive energy supply industry, to ensure security and reliability of energy supply and to develop energy conservation and end-use efficiency (www.dcmnr.gov.ie).

4.3.2 Commission for Energy Regulation (CER)

The Commission for Energy Regulation (CER) is the independent body responsible for regulating and overseeing the liberalisation of Ireland's energy sector. The CER was initially established and granted regulatory powers over the electricity market under the Electricity Regulation Act, 1999. The enactment of the Gas (Interim) (Regulation) Act, 2002 expanded the CER's jurisdiction to include regulation of the natural gas market. The Commission, on the 9th of September 2005 approved an increase of 25.26% in Bord Gais tariffs for natural gas with effect from 1st of October 2005. The Commission also approved the Electricity Supply Board for an average price increase of 4.1% for electricity with effect from 1st January 2006 (http://www.cer.ie/cerdocs/)

CER also promotes the use of renewable, sustainable or alternative forms of energy (www.cer.ie)

4.3.3 Sustainable Energy Ireland

Sustainable Energy Ireland (SEI), formerly the Irish Energy Centre, is Ireland's national energy authority. The Authority promotes and assists environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy. SEI has been operating a renewable energy research, development and demonstration programme since 2002 with an indicative budget of €12m to the end of 2006.The programme has funded a number of feasibility studies, applied research projects, policy supporting studies and demonstration projects (www.irish-energy.ie).

4.3.4 Electricity Supply Board

The Electricity Supply Board (ESB) is 95 per cent owned by the Government of Ireland, with the remaining shares held by an employee share option trust. ESB includes a number of divisions, which operate independently in the electricity market.

ESB Power Generation operates 19 major power stations covering hydro-electric generation, and stations powered by coal, oil, gas and peat. A subsidiary, Hibernian Wind Power owns and operates wind farms. ESB Customer Supply is a major supplier of power to final domestic and business customers. ESB Networks is the owner of the high voltage transmission system and is the owner and operator of the medium and lower voltage distribution system (www.esb.ie).

4.3.5 Bord na Mona

In 1946 Bord na Móna was established as a statutory body, by the Turf Development Act. to develop Ireland's peat resources. Bord na Móna Energy Limited's current activities are based on harnessing primary energy from peat and from wind. The company supplies peat as a fuel for the generation of electricity; a range of peat-based fuels, coal and oil for residential and industrial heating (www.bnm.ie).

4.3.6 Bord Gáis

Bord Gáis Éireann (Bord Gáis) is a statutory body that was established under the 1976 Gas Act. The company is responsible for the transmission, distribution and supply of natural gas in Ireland. The company provides almost half a million homes in Ireland with natural gas. In addition, Bord Gáis has a further 17,679 industrial and commercial customers. Bord Gáis is involved in gas procurement and supply on the open market. It also has interests in combined heat and power and telecommunications infrastructure and is a wholesale supplier of electricity (www.bordgais.ie).

4.3.7 Other players

Teagasc

Teagasc is a semi-state organisation which provides integrated research, advisory and training services for the agriculture and food industry in Ireland. A limited amount of research has been carried by Teagasc into biomass as an alternative energy source (Rice, 2003).

Department of Agriculture and Food

The Department of Agriculture and Food's role is to lead the sustainable development of a competitive, consumer focussed agri-food sector and to contribute to a vibrant rural economy and society in Ireland (www.agriculture.gov.ie). The Department of Agriculture and Food implements EU Common Agriculture Policy schemes in Ireland. The Energy Crops Scheme is the only current form of financial assistance for growing energy crops such as SRC Willow and Miscanthus in Ireland. The rate of Aid is 45€/hectare and this scheme is operated by the Dept. of Agriculture and Food (http://www.agriculture.gov.ie/schemes/single).

4.4 Energy Sources in Irelands Energy Sector

4.4.1 Fossil fuels

Oil

According to Howley and Ó Gallachóir (2004) oil is the largest contributor to the country's TPES with 54.1% of the TPES in 2003. IEA (2004, *b*) predict a decline to 51.6% of TPES by 2010. Ireland does not possess indigenous oil reserves and is entirely dependant on imports to meet its oil energy demands. National Oil Reserves Agency (NORA) acts as an agent of the Minister for Communications, Marine and Natural Resources. NORA's function is to arrange for the holding of national strategic oil stocks at a level determined annually by the Minister (http://www.dcmnr.gov.ie/Energy/).

Coal

According to Howley and Ó Gallachóir (2004) Coal accounted for 13.1% of TPES in 2003. IEA (2004) expects this to fall to 5.2% of TPES by 2010. Ireland has no indigenous coal production (IEA, 2004*b*).

In recent years, coal has had a diminishing share of both the Irish industrial and the residential domestic market. Increases in the share of the markets are unlikely due to Department of the Environment legislation which places restrictions on the use of certain solid fuels including bituminous coal in urban areas. (http://www.environ.ie/DOEI/).

Coal imports originate largely from the US, Poland, UK and South Africa. Since its purchase of Coal Distributors Ltd, Bord na Mona is the largest importer to the residential domestic market. The main industrial users of coal is the ESB for use at its coal burning electricity generating plant at Moneypoint, Co Clare (http://www.dcmnr.gov.ie/Energy/).

Natural gas

Natural gas accounted for 25.1% of TPES in 2003 (Howley and Ó Gallachóir, 2004). Natural Gas use is expected to grow driven by both economic and environmental factors, reaching 35.1% of TPES by 2010 (IEA, 2004*b*).

Ireland is a net importer of natural gas, currently importing in the region of 85% of its natural gas requirements (IEA, 2004*b*). Gas is imported via two interconnectors connecting Dublin (Ireland) with Scotland in the UK. Interconnection with a country other than the UK is not feasible for Ireland, given its particular physical location, and the cost of construction of Liquefied Natural Gas facilities is a significant factor. To this extent, Ireland is severely limited in its efforts to diversify gas sources, and is heavily reliant on security of supply in the UK (Bord Gáis Transmission, 1999).

Ireland does have access to some indigenous gas currently exploited in the Kinsale field off the Southern coast . The level of indigenous gas was improved with the flowing of first gas from the new Seven Heads field off the Cork coast (reserves of 8.5

billion cubic metres) in 2003. The Corrib field off the coast of Mayo which is likely to flow gas in 2006-2007 has reserves of 25 billion cubic metres. The addition of these new sources of supply is likely to reduce Ireland's import dependency in the near future. In the long term however, and in the absence of other significant gas finds, Ireland will, in all probability, ultimately remain dependent on the UK as our single largest source of supply (IEA, 2004*b*).

Peat

In the amended European Commission on the Directive on the promotion of electricity from renewable energy sources in the internal electricity market the Commission adapted the definition of renewable energy sources excluding peat, stating that peat was clearly a fossil fuel (http://www.climnet.org).

According to Howley and Ó Gallachóir (2004) peat accounted for 5.9% of TPES in 2003. IEA (2004*b*) forecasts that peat supply will account for 5.1% of TPES by 2010. Apart from natural gas, peat is the only significant domestic source of energy in Ireland (Lappi and Byrne 2003). According to Feehan (1994) the peat fuel industry has been subsidised by the government because it has been seen to be important for the security and flexibility of energy supply and because of its contribution to the rural employment.

Bord na Móna is a state owned company and was established to manage the peat harvesting activities. Apart from private harvesting of peat for domestic fuel, Bord na Móna is the only producer of peat for energy production in Ireland (Foss *et al.* 2001). Of the 1.2 million hectares of peatlands in Ireland, Bord na Móna owns 80,000 ha or 7% of the total peatland reserve. The remaining time for peat extraction of these reserves is estimated to be 15-20 years (Bord na Móna, 2002). Harvesting of additional reserves is greatly limited by European Union environmental legislation including the Habitats Directive and the Birds Directive (European Parliament and Council, 1992 and 1979).

4.4.2 Nuclear energy

Irish government policy is opposed to the use of nuclear energy, as it believes the environmental, health and safety risks and impacts outweigh the benefits arising from this industry (www.environ.ie).

The 1999 Electricity Regulation Act , section 18, paragraph 6 prohibits the use of nuclear energy for the generation of electricity in Ireland (Department of Enterprise Trade and Employment, 1999).

4.4.3 Renewable Energy

Directive 2001/77/EC of the European Parliament (2001) states that renewable energy sources shall mean renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases)

Renewable energy accounted for 1.8% of TPES in Ireland in 2003 (Howley and Ó Gallachóir, 2004). According to Healion (2003) the single largest contribution is provided by biomass. Biomass, mostly wood is used to provide heat in the domestic sector and in the wood processing industry. Hydro electricity, electricity generation from landfill gas and wind power were the three other major renewable energy sources contributing to energy supply in 2002. It should be noted that the sources of geothermal, liquid biofuels and solar thermal also provide some supply but were not recorded in the sources used to produce Figure 4.5

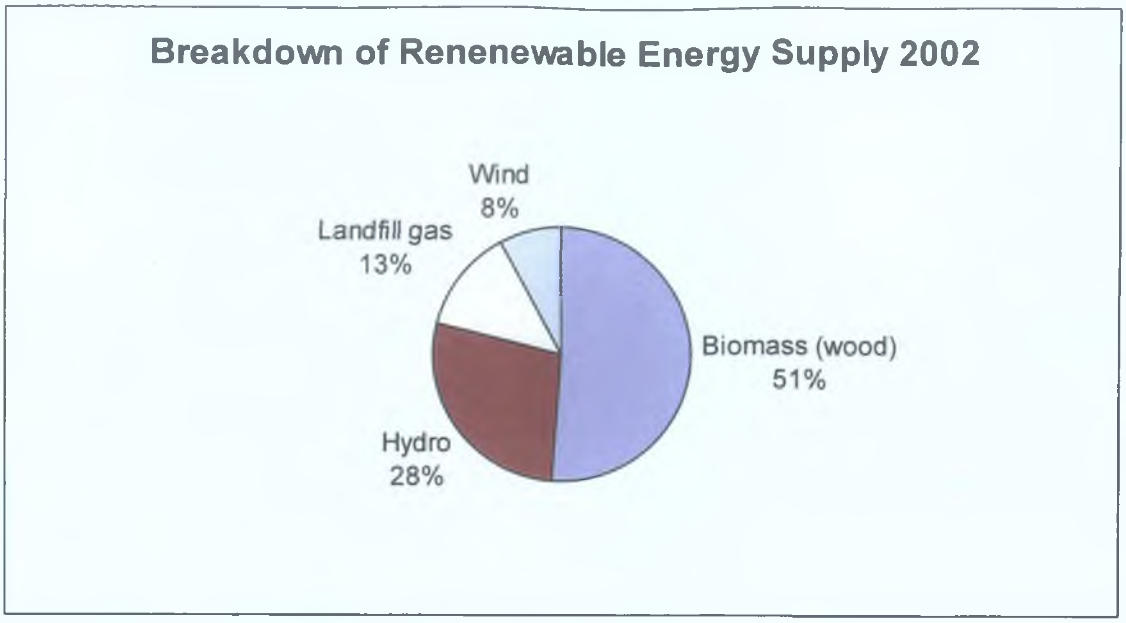

Figure 4.5 Renewable Energy Supply, Ireland 2002

Wind energy

Ireland had 339 MW installed wind power. With a total Irish electricity capacity approaching 6,000 MW, this means that wind is supplying approximately 5.5 % of overall electricity generating capacity (http://www.iwea.com).

A temporary cessation of new offers of wind connections was implemented in 2003 after advice from ESB National Grid. This was because of the rapid increase in applications for wind connections and concerns about the implications of this for the stability of the power system. The moratorium on new offers of grid connections to wind farms ended in July 2004 (http://www.eirgrid.com).

Hydro

There are five large - scale hydropower projects in Ireland having a combined installed capacity of 205.5 MW. The installed capacity are all owned by the state electricity utility, ESB. No new large hydro projects are planned. At the end of 2002, there was a total installed capacity of 34.09 MW small - scale plants in operation Combining small and large scale hydropower gives a total installed capacity in 2002 of 239.6 MW. With a total Irish electricity capacity approaching 6,000 MW, this means that hydro is supplying approximately 4 % of overall generating capacity (O' Leary *et al.*, 2004).

Active solar thermal systems

Active solar thermal systems harness the thermal energy of the sun, which can be used immediately or stored for later use. Solar energy collectors are normally placed on the roofs of buildings or in other areas that have good exposure to solar radiation. The collectors absorb energy and transfer it to a circulating fluid, which heats the water in a tank. Solar Thermal Final Consumption in 2002 in Rep of Ireland was quite small at 0.16Ktoe. Consumption is measured in 1000 tonnes oil equivalent (Ktoe) (O' Leary *et al.*, 2004).

Ambient Energy including geothermal

Ambient heat pumps extract heat from water, air or ground and use this energy for space or water heating. The heat pump, in effect, "pumps" heat from low temperature source and releases it at a higher temperature into a central heating system. Ambient energy is currently only a modest resource in Ireland. The Thermal Final Consumption associated with geothermal and heat pumps in 2002 was small at 0.24 Ktoe (O' Leary *et al.*, 2004).

Ocean Energy

Ocean energy includes wave energy, ocean current energy, tidal energy and ocean thermal energy. The ocean energy technologies are mostly relatively immature and have not secured the same levels of research funding as other new renewables.

Sustainable Energy Ireland is currently in the process of commissioning a tidal resource map for the island of Ireland and is engaged in a co-funded study with the Marine Institute on the economic and industrial possibilities for the ocean sector (O' Leary *et al.*, 2004).

4.4.3.1 Biomass

Biomass refers to cellular material from living or recently dead organisms. It is a widespread resource and can be divided into wastes and purpose grown material as follows.

- Waste streams include residues from forestry and related industries, recycled wood, agricultural residues and agri-food effluents, manures, the organic fraction of municipal solid waste, separated household waste and sewage sludge
- Purpose grown energy crops include short rotation forestry and miscanthus (www.irish-energy.ie).

Wood industry residues

The wood processing industry produces residues in sawmills and board factories in the form of wood chips, bark and sawdust. These residues are currently the only significant source of energy produced from biomass in Ireland (Rice *et al.*, 1997).

A total of about 400,000 tonnes of residues is produced by the wood processing industry each year. Of this, 100,000 tonnes is used as fuel within the wood industry. The remainder is sold for board manufacture and other uses at home and abroad (Lappi and Byrne, 2003). COFORD (2003*a*) estimated that 89,000 tonnes from the total amount of sawmill residues could be available for energy use outside the wood processing industry.

Forest residues

According to Rice (2003) about 600,000 ha of land in Ireland is afforested, and about 2 million m^3 of timber per year is harvested. A by-product is branch and treetop material, termed forest residues. Currently this is not utilised, and remains in the forest.

Forest residues without leaves constitute 23 - 35% of the above ground biomass of trees. So each year over 300,000 dry tonnes of residues are left in Irish forests. The availability of forest residues depends on the type of site and harvesting method used, and the size and distribution of individual harvest areas. Coillte have estimated that 200,000 tonnes could be available for collection. On some forest sites it is necessary to use the residues as brash mats for machinery traversing soft ground. According to Rice (2003) the removal of residues may affect nutrient availability in forest sites. If forest residue harvesting is to be considered the impact of on biodiversity and the productivity of the forest stand must be investigated. Also before this resource can be utilised, residue collection and transport systems are needed.

Straw

According to Rice (2003) the combustion of cereal straw for energy purposes has been widely practised in Denmark. If the moisture content is below 15%, the material stores and burns reasonably well. Ireland produces about 1 Million tonnes of straw. The mushroom industry requires about 100,000 tonnes. The remainder is either used on the farm or sold for animal feeding or bedding. Straw prices have always fluctuated widely, and large supplies are unlikely to be available at prices that would make its widespread use as a fuel economical (Rice, 2003).

Waste wood

A significant amount of recoverable wood is created by construction and demolition activities and also in the packaging of goods. In 1998, around 2.7 million tonnes of construction and demolition waste was generated. Of this waste, approximately 14% or 380 000 tonnes is wood and therefore can be potential source of energy (EPA, 2002). Part of this amount of wood has been treated with for example paints or solvents and can not be used in energy production as it is. Clean recovered wood is treated as carbon neutral fuel, but treated wood is not and therefore would not be of interest to energy producers. It has been estimated than approximately 100,000 tonnes of untreated wood, which could be used in energy production, was generated in 2000 in Ireland. A projected increases to 160,000 tonnes by 2005 is estimated (COFORD 2003b). Wood is also used extensively in packaging mostly by the commercial sector in the form of wood pallets, crates and boxes. In 1998, an estimated 85 000 tonnes of wood packaging was created. A significant share of that is already recycled, but part is still disposed of to landfills (EPA, 2002).

Waste Management (Packaging) Regulations, 2003 places responsibilities on producers of packaging to transfer wood packaging to recovery operators (Department of Environment and Local Government, 2003).

Anaerobic digestion (AD)

Anaerobic digestion (AD) is a natural process of decomposition and decay that takes place in the absence of oxygen and by which organic mater is broken down to its simpler chemical components. The AD process can be used to turn residues from livestock farming, food processing industries, waste water treatment sludge, water treatment plant sludge among other organic wastes into biogas. The biogas can be used to generate heat and/or electricity (DCMNR/SEI, 2004).

The energy potential of cattle, pig and poultry waste is estimated at some 2.759 million MWh of electricity per annum. This represents approximately 11% of the total electricity supplied in the Irish economy in 2001(DCMNR/SEI, 2004). Gannon *et al.* (1994) and Mahony *et al.* (2002) have considered in detail the feasibility of centralised anaerobic digestion as a component of a waste management plan for agricultural wastes. Both studies questioned the financial feasibility of AD.

Landfill Gas

Landfill Gas (LFG) recovery is a method of collecting methane from landfill waste disposal sites for energy conversion. This reduces methane greenhouse gas emissions that would otherwise be released into the atmosphere. According to Irish Energy Centre (2002) there are five landfill gas recovery stations in the Republic, each supported under the government Alternative Energy Requirement (AER) schemes. It is expected that there will be some further development of energy production from landfill gas under the future AER competitions. (Irish Energy Centre, 2002).

However, it is also expected that there may be some reduction in the amount of LFG resource available in the longer term, as the 1999, EU Landfill Directive (1999/31/EC) aims to reduce the amount of biodegradable material going to landfill (European Parliament and Council, 1999).

Liquid Biofuels

The EC Biofuels directive 2003/30/EC obliges member states to set targets for biofuel substitution of transport fuels .The European Commission's own recommendations is 2% in 2005 rising to 5.75% in 2010 (European Parliament and Council, 2003*a*).

According to Rice (2005) production of bio-ethanol from wheat or sugarbeet as an additive for petrol engines and biodiesel from the recovered vegetable oils offers the best long-term possibilities. Biodiesel from rapeseed oil is where initial progress will be made but it is limited due to the fact that rotations of this crop is not recommended more often than one in five years and rapeseed should not be grown within two years of sugar beet.

According to Hamelinck *et al.* (2004) technically, Ireland is capable of fulfilling the full biofuel directive targets with indigenously produced biomass. However, this would mean that part of agricultural productive land that is currently used for feed, is to be diverted to biofuel production. This will, in turn, induce additional feed imports. The amount of biofuels that can be produced from Irish residues is about half of the 2005 target. If, on top of this, currently unproductive set-aside land were used for biofuel production, about 79% of the 2005 and 23% of the 2010 target could be fulfilled with indigenous Irish biomass.

In August 2005 the Minisister of Communications Marine and Natural Resources , Noel Dempsey, announced that over €6m in excise relief will be provided for biofuel projects. The relief will cover 16m litres of biofuels over a two year period commencing in 2005 (www.dcmnr.gov.ie/Press+Releases).

Perennial energy crops

According to Rice (2003) the most appropriate species for perennial energy crops in Ireland are willow and poplar managed as short-rotation forestry or the C_4 grass species, miscanthus.

Miscanthus

Miscanthus is a woody, perennial grass originating from south east Asia, commonly called Elephant Grass. The grass can be grown commercially as an energy crop for use in power generation. Miscanthus is planted in spring and canes produced during the summer are harvested in winter. This growth pattern is repeated every year for the lifetime of the crop, which will be at least 15 years. Miscanthus requires adequate rainfall and frost free spring. It is intolerant of low winter temperatures and particularly susceptible to frosts (DEFRA, 2001). These traits make its suitability to be grown in large areas of Ireland questionable.

According to Rice (2003) little is known to date in Ireland about Miscanthus's moisture at harvest or the problems of storing/drying to meet a year-round demand. Low-cost crop establishment systems also need to be developed, and more information is needed about production costs and economics.

Short Rotation Coppice willow

Currently approximately 60 ha of short rotation coppice willow are grown in the Republic of Ireland. Total land area in Ireland is 7.01 million ha, of which agriculture accounts for around 4.41 million ha. According Buckley (2005) regarding the potential of energy crops in the Republic of Ireland, short rotation coppice is suitable for growing on 4.3 million hectares. Irelands has the fastest growth rates for biomass (trees and other plant species) in Europe. It has the highest potential annual yield of wood in Europe (Kuusela, 1994).

4.5 Ireland's Energy Policies and Programmes

4.5.1 Ireland's Energy policies and programmes 1980s -present.

Initial support for energy (including renewable energy) in Ireland arose in the form of research and development funding in the 1980s as a response to the oil crises of the 1970s as was the case in most countries. The overall trend of Government research and development expenditures for renewables peaked in the early 1980s and declined notably after 1983, with no significant funding between 1990 and 2001 IEA (2004).

In 1996 a policy document "Renewable Energy – A Strategy for the Future" was published by the Department of Public Enterprise. The policy introduced the Alternative Energy Requirement (AER) Programme, a programme to promote electricity from renewable energy sources. (See page Section 4.5.2)

Following the publication in 1997 by the EC of *The White Paper & Action Plan for Renewable Energy – Energy for the Future: Renewable Sources of Energy* (EC, 1997), the Irish government published its *Green Paper on Sustainable Energy* in 1999 (Department of Public Enterprise,1999). This Green Paper called for a significant increase in the contribution of renewable energy to meeting Ireland's energy needs. It sought to increase the proportion of the Total Primary Energy Requirement generated from renewable resources from 1.9% in 2000 to 3.75% by 2005.

The Green paper also set to increase the percentage of electricity generated from renewable sources from 6.3% in 2000 to 12.39% by 2005. This would require an extra installed capacity of 500 MW of electricity generated from renewable sources by 2005. The bulk of the capacity was expected to come from wind energy.

Further government recommendations followed in 2000, setting out an integrated approach to wind energy deployment in "A Strategy for Intensifying Wind Energy Deployment" (Department of PublicEnterprise, 2000).

In December 2003 the Minister for Communications Marine and Natural Resources, Dermot Ahern, T.D., launched a consultation process on the renewable energy sector with the publication of the consultation document *Options for Future Renewable Energy Policy, Targets and Program* (DEMNR, 2003). The purpose of the review was to stimulate debate in developing renewable policy in Ireland for the period 2005 to 2010 and beyond to 2020. The review mostly concentrates on developing renewable electricity generating policies in response to *Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market* (European Parliament and Council, 2001). The Directive sets a target of at least 13.2% of electricity consumption from renewable energy sources in the internal electricity market in Ireland by 2010.

The Department received 46 responses following a call for submissions on the consultation document. In May 2004 a Renewable Energy Development Group, chaired by this Department, was established. The Group's report will be submitted to the Minister Dempsey in 2005.

The Minister for Communications, Marine and Natural Resources, Noel Dempsey T.D. and his Northern Ireland counterpart Angela Smith M.P. have jointly issued a preliminary consultation paper on an all-island *2020 vision for Renewable Energy* which seeks views on the development of a joint Republic of Ireland / Northern Ireland strategy for the renewable energy aspects of the All-Island Energy Market, leading up to 2020 and beyond. The closing date for the consultation period is the 30th September 2005. (Department of Communications, Marine and Natural Resources Republic of Ireland / Department of Enterprise, Trade and Investment Northern Ireland, 2005).

The Energy Performance for Buildings Directive (EPBD) 2002/91/EC was adopted by the European Union on 16th of December 2002 (European Parliament and Council, 2002). The EPBD must be legally transposed in Ireland by national legislation and must generally be given practical effect by 4th of January 2006. However, the EPBD provides for a longer period , up to 4th January 2009 , for implementing the more complex provisions (Energy Performance Working Group, 2005).

The EPBD contains a package of mandatory measures designed to secure a significant reduction in CO_2 emissions from buildings. Building energy performance standards are required for new buildings and major refurbishment of existing buildings (Articles 3, 4 and 5). The calculation of energy performance of buildings in Annex 2a will include the positive influence from heating and electricity systems based on renewable energy if present.

Article 5 of EPBD requires a feasibility assessment of alternative energy systems for large new buildings over 1000 m^2. The technical, environmental and economic feasibility of alternative energy systems (e.g. renewable energy systems, CHP, district/block heating, heatpumps) must be considered before construction, either on a case by case basis or by reference to the results of recognised feasibility studies for building categories, e.g. schools, hotels. For Ireland, it is proposed to commission relevant national feasibility studies aimed at providing such generic reference resources to design teams in relation to such options (Energy Performance Working Group, 2005).

The "National Development Plan" allocates a total investment of €67 million for renewable energy in the period 2000-06 for the delivery of additional renewable-energy supply. Areas of investment include re-enforcing and up-grading of the electricity grid to accommodate increased use of renewable energy. Encouragement of new entrants to the renewable-energy market with financial support for small-scale projects.

The Electricity Act 1999 provided for full deregulation of the renewable electricity generating (green) market. Deregulation was introduced on a phased basis on the non-green electricity market with full deregulation achieved by 19th February 2005.

Also under this act as part of the public service obligation the Minister for Energy Communications and Natural Resources can impose obligations in the general economic interest on the electricity supply industry in respect of security of supply, regularity, quality and price of supplies, environmental protection, and use of indigenous energy sources. Priority will be given to stations using renewables, waste and combined heat and power (IEA, 2004*b*).

4.5.2 Alternative Energy Requirement (AER) programmes

The Alternative Energy Requirement programme was established to encourage renewable energy technologies to enter the electricity generating market. The programme was intended to address difficulties that renewable facilities encountered when seeking financing.

The underlying principle of the AER Programme is that prospective generators are invited to make a formal application to build, own and operate newly installed renewable energy based electricity generating plant, and to supply electricity from these to the Electricity Supply Board (ESB) under a Power Purchase Agreement of up to 15 years duration.

Since the Programme was launched in 1995, six AER competitions have been held and a total capacity of 233 Megawatts has been commissioned to date (June 2005). The technologies supported include wind energy, small-scale hydropower, combined heat and power (CHP) biomass (landfill gas), biomass-CHP; biomass-anaerobic digestion and offshore wind (www.dcmnr.gov.ie/Energy/Renewable).

4.5.3 Energy Taxation and other fiscal measures

All energy taxation in Ireland takes place at the federal level and is the responsibility of the Department of Finance. Taxation levels are shown in Table 4.1.

Fuel/ user	Exise tax €/ unit	VAT %
Light fuel oil / industry	47.36 / 1000 litres	0
Light fuel oil / households	47.36 / 1000 litres	13.5
Natural gas/ industry	0	0
Natural gas / households	0	13.5
Electricity / industry	0	0
Electricity / households	0	13.5
Wood logs and kindling/ industry	0	0
Wood logs and kindling/ households	0	13.5

Table 4.1 Energy taxation in Ireland (http://www.revenue.ie/).

The Minister for Finance, Mr Charlie McCreevy, T.D., announced in September 2004 that the Government had concluded it's examination of carbon energy tax proposals and had decided not to introduce such a tax. Ireland's commitment under the Kyoto Protocol requires an overall reduction in CO_2 emissions of 9 million tonnes per annum. Mr McCreevy stated that the direct effect of the carbon tax would have amounted to a possible maximum reduction of just over 0.5 million tones per annum

Instead, the government proposes support for emissions abatement mechanisms such as energy efficiency initiatives and also the purchase of additional carbon emission allowances on the international market (http://www.finance.gov.ie).

S.I. No. 65 of 1999 Finance Act, provides tax relief for corporate investment in certain renewable energy projects (Department of Finance ,1999). To qualify for the relief the energy project must be in the solar, wind, hydro or biomass technology categories, and be approved by the Minister for Public Enterprise. The relief is capped at the lesser 50 per cent of all capital expenditure or €9.5 million for a single project.

Investment by a company or group is capped at € 12.7 million per annum. The 2004 Budget extended the qualifying period for tax relief for corporate investment in certain renewable energy projects from 31st of December 2004 to 31st of December 2006 (http://www.revenue.ie).

In August 2005 The Minister for Communications, Marine & Natural Resources, Noel Dempsey T.D launched a scheme to provide Minister Oil Tax (MOT) relief for pilot biofuel projects under the Finance Act 2004. Under the scheme MOT relief will be provided for pilot biofuels projects in pure plant oil, biodiesel and bioethanol (www.dcmnr.gov.ie/Press+Releases).

4.6 Other Countries Energy Policies and Programmes.

4.6.1 Sweden

The Swedish energy sector has undergone major transformations during recent decades. According to Johansson (2002) in 1970, fossil fuel imports corresponded to 80 percent of the total energy supply in the country. By 2002, fossil fuel imports had been reduced to 36.5 percent, biomass accounted for 16 percent of the TPES in Sweden, as opposed to 9 percent in 1970 (See fig 4.6). During this period, Sweden's energy supply increased by 34 percent to 51 Mtoe. These trends indicate significant changes in the technical structure of the energy sector (IEA, 2005).

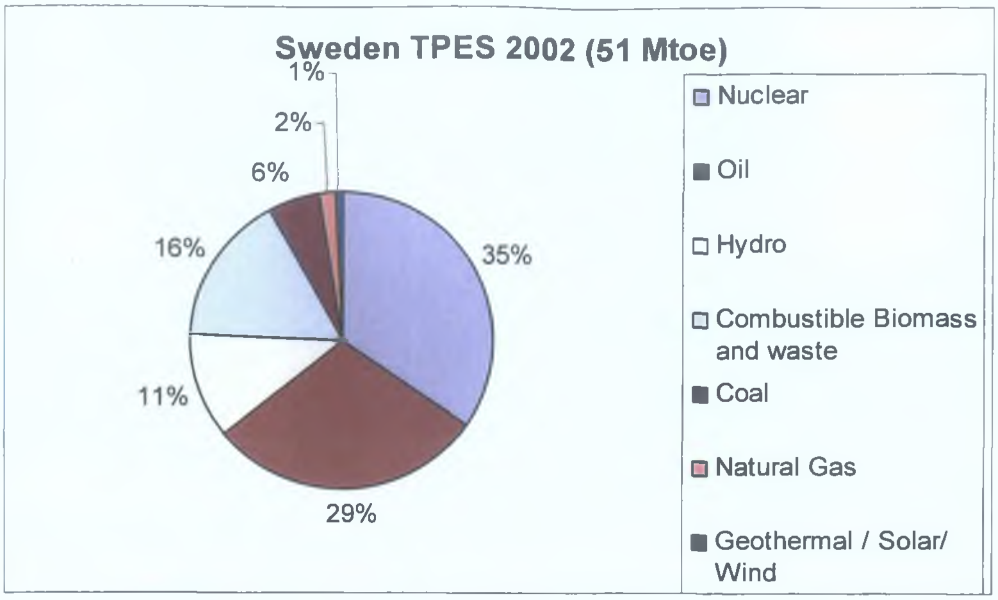

Figure 4.6 Total Primary Energy Supply, Sweden 2002.

Johansson (2002) states that the extensive use of biomass (mostly woodfuel) is a result of favourable geographical conditions, industrial structure and governmental policies. Forests represent 53% of the land area, 24 million ha, which significant amounts of biomass energy can be extracted (EREC, 2004*b*). Energy use in industry is heavily dominated by the forestry industry which enjoys excellent opportunities to utilize its by-products to respond to internal energy demand. Government policies have historically supported the development of hydro power and biomass energy. According to the Swedish National Energy Administration (2000), the most cost-effective way to use biomass is in large scale heating plants. The well developed district heating systems in Sweden therefore provide an important possibility to utilize biomass. Approximately 35% of the energy used for heating buildings comes from district heating .

Since the 1970s, significant increases in the use of nuclear power and biomass have allowed for a drastic reduction in the consumption of fossil fuels for electricity and heat generation. Swedish energy sector is now less vulnerable to fluctuations in international fossil fuel prices. It also has more flexibility and better environmental performance (Johansson, 2002).

A mix of government involvement and lightly-regulated market forces are used by the Swedish government to strive for its objective of providing its citizens with low-cost, reliable, secure and environment-friendly energy (IEA 2005).

Sweden uses energy taxation as an important tool for promoting certain energy sources while discouraging others. In connection with the 1990/1991 tax reforms, carbon taxes on fossil fuels were raised while other taxes, such as payroll taxes, were decreased by an equivalent amount. This process continues with the carbon tax on fuels being increased to 96€ per tonne of CO_2 on 1 January 2004. Biomass is one beneficiary of the green tax shift. From 1990 to 2002, Swedish biomass use increased by nearly 50%, rising from 12% to 16% of the country's TPES. Energy tax exemptions given to industry mitigate the effectiveness of the taxes in changing overall national energy behaviour. They were introduced to preserve the competitiveness of Swedish industry.

Investment grants for plants producing electricity from biomass were introduced in the 1990's. Many of those grant aided were cogeneration plants in district heating systems. This investment grant corresponds to a subsidy of approximately 0.8-1.0 cents/ kWh (IEA 2005).

Sweden has ambitious targets for increasing electricity generation from renewable energy technologies. It intends to raise annual generation from renewable plants by 10 Terawatt hours (TWh) from 2002 to 2010. The primary means of meeting this goal is the newly introduced electricity certificate scheme in which electricity suppliers are obliged to acquire electricity certificates from renewable plants equal to a certain percentage of the electricity they supply. This percentage level began at 7.3% in 2003 approximately equivalent to Sweden's existing level of renewable generation at that time – and will rise in steps to 16.9% by 2010. This scheme has a strong market component that will promote generation from the lowest-cost renewable energy technology and also foster competition and thus increase production efficiencies.

Swedish government expenditures on energy R&D rose by 100% from 1996 to 2002 (IEA 2005).

4.6.2 Austria energy sector, policies and programmes

Austria's energy supply is based on a balance mixture of energy sources in which the role of renewables is prominent. Renewables provide approximately a quarter of Austria's energy needs - the second highest level of renewables use in the European Union after Sweden. The country's commitment to non-nuclear energy combined with abundant hydro and biomass resources and Austrian environmentally friendly orientations, have encouraged this very high exploitation levels of renewable energy resources. The first source of renewable energy (12% of its total energy supply) is hydropower (EREC, 2004*a*).

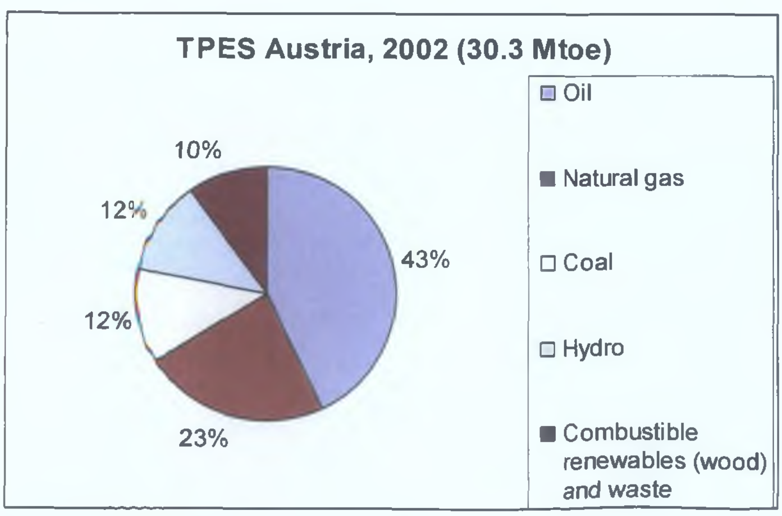

Figure 4.7 TPES, Austria 2002

The use of biomass as a source of energy is widespread in Austria, and biomass accounts for approximately 11% of TPES (significantly higher than the EU average). In 2001, 2.9 Mtoe of biomass (wood, wood waste and biogas) were used for energy purposes. By far the most important non-hydro renewable is wood as shown in Figure 4.7. Firewood accounts for the majority of biomass energy use. The use of wood chips is also increasing, and more than 20,000 heating systems using wood chips are operating. In 2000, 3,000 collective boilers using wood energy had a total capacity of 1 Giga Watt (EREC, 2004*a*).

The Austrian government have used a series of energy taxes and capital subsidies to promote the development of renewable energy technologies, particularly solar and biomass since the mid seventies and eighties. Austria introduced an energy tax on the use of gas (0.0435 € /m3 + 20 % VAT) and electricity (0.003 € /kWh + 20 % VAT) in 1996. The tax applies to small-scale as well as industrial users. Part of the tax revenue is made available to the regional governments and to the communities for the implementation of energy saving and environmental protection measures, including measures to promote renewable energy (EREC, 2004*a*).

Financial support is provided for biomass installations including district heating schemes. The support includes subsidies of 10–30 % of eligible costs through a national environmental support programme, support towards private households to subsidise the cost of connection to heating networks and special support programmes to encourage farmers to invest in biomass plants. New technological developments for biomass production processes are supported both within Austrian universities and in association with industry (EREC, 2004*a*).

Biomass use is very well established and accepted in Austria, both at the local level for small scale applications and at the industrial level, due to the country's extensive wood-based industries. At the larger-scale and industrial level, farmers are supportive of new biomass projects because of the additional income that will be generated. Wood users such as sawmills also benefit because they have an additional market for their wood wastes. These stakeholders, in particular the farmers, have been key in increasing public acceptance of biomass projects. At the local level, most regions carry out active dissemination activities to promote the economic and environmental benefits from using biomass as a fuel by individuals or communities. The overall result of these activities is that the general public is well informed about the benefits and use of renewables (EREC, 2004*a*).

SECTION 5: POTENTIAL OF SRC WILLOW

There are a number of factors that influence the uptake the growing of short rotation coppice willow in Ireland. These can be summarized under the following headings.

- Change in faming practice.
- Promotion / availability of information.
- Economics of growing SRC willow.

5.1 Change in Faming Practice

Total land area in the Republic of Ireland is 7.01 million ha, of which agriculture accounts for 4.41 million ha. Ireland's agriculture is grass based with 80% of the agricultural land either pasture, hay or silage. Principle agricultural enterprises in Ireland are cattle rearing for beef production, cattle rearing for milk production (dairying), sheep production and tillage. Only 9% of agricultural area is used for tillage (www.cso.ie). For many farmers growing a crop, especially a newly introduced one such as SRC, could be a challenging task.

With the sale of livestock or tillage crops the beef, sheep and tillage enterprises provide a financial return on an annual basis to farmers. Dairy farmers are paid on a monthly basis for the milk they supply to the creamery. It is four years after planting that the first sales of SRC wood chip can be made. It is then on a three year rotation that harvesting takes place and wood chips sold. The 3 to 4 year duration in wood chip sales could be off putting to farmers considering growing SRC willow. Due to the small number of wood fuel heating installations in the country there is not a well established market for woodchip. The lack of a market to stimulate production on the one hand and the lack of production to stimulate the market on the other is a significant barrier to the development of this industry.

The life span of SRC willow is quite long at 20 to 30 years with high establishment costs. According to Department of Agriculture and Food (2004) only 13% of Irish farmers are under 35 years of age and 40% of Irish farmers are over 55 years of age. Farmers, especially those that are mature or elderly, could have hesitations in committing to such a long-term investment.

A survey was carried out on attitudes of farmers to short rotation coppice willow in Northern Ireland and the Republic of Ireland (Healion et al., 2001). 70% of respondents stated that they had no knowledge or experience of SRC. 30 % of respondents would still not consider planting SRC even if financial grants were introduced to make it a viable farm enterprise. An additional 26% were unsure and would need further information. Reasons given in the survey for not wanting to become involved in SRC even if financially viable included, owner would consider planting timber a backward step in farm development, lack of knowledge and experience on farmers part, unknown pitfalls in this enterprise, reliance on third parties to plant and harvest the crop, negative experiences of farmers with other alternative enterprises, upcoming retirement and negative landscape impacts of SRC.

5.2 Promotion / availability of information

There is little promotion or information available on SRC willow at present in the Republic of Ireland. Institute of Technology, Tipperary run a Higher Certificate course in Renewable Energy. This course is targeted at those who are involved in renewable energy at a practical level (e.g. farmers, communities) and a strategic level (e.g. LEADER and County Council personnel).

Institute of Technology, Sligo are participants of an INTERREG project entitled ‘Renewable Energy Network for Environmental Welfare’. INTERREG is a European

Union initiative that promotes cross-border, transnational and inter-regional co-operation within the E.U. It is funded by the European Regional Development Fund. The project involves the establishment and production of SRC willow to provide a renewable fuel for conversion to heat in a range of boiler systems in the Republic of Ireland and Northern Ireland. It is intended that a range of wood fuel boilers from 500kW to 20kW will be installed in various demonstration sites. A proposal for a wood fuel boiler for the Institute of Technology, Sligo is currently being prepared.

It is envisaged as part of this project that a website, CD-ROM and brochure will be developed to promote the growing of willow and the use of wood fuel boilers. Information seminars on SRC willow are also planned with farmers as the target audience. Training of agricultural advisors in growing this crop is also planned. Domestic and commercial energy customers will also be able to see wood fuel heating systems at demonstration sites.

Sustainable Energy Ireland promotes and assists environmentally and economically sustainable production. Promoting SRC willow usually takes the form of presentations at farmer associations meeting's.

5.3 Economics of growing SRC willow

5.3.1 Economics of growing SRC willow in Republic of Ireland and Sweden

By far the most important consideration for a farmer in undertaking SRC willow is the profitability and sustainability of the enterprise.

According to Michael Doran (personal communication, 2005) total area of SRC willow on the Island of Ireland is 400 hectares. While Northern Ireland has been involved in research into the growing SRC willow since the 1970s the area of SRC grown in the country is still quite small at 340 hectares. The Republic of Ireland has a very small area of SRC willow planted at 60 hectares.16,000 hectares of land are dedicated to growing SRC willow in Sweden (Larsson and Dobrzeniecki, 2004). According to Rosenqvist and Dawson (2004) where willow coppice production is still at a relatively undeveloped scale (less than 1,000 ha), costs of production will be high in comparison with a region where there is significant activity in the coppice production sector.

To help illustrate this point the costs and returns of growing SRC willow in a region that is at an underdeveloped scale (Republic of Ireland) are compared with the costs and returns of growing SRC willow in a region with significant activity in the coppice sector (Sweden). The costs and returns were derived from a paper produced by Rosenqvist and Dawson (2004). This examined the economics of willow growing in Northern Ireland and in Sweden. As Northern Ireland's coppice sector is also at an underdeveloped scale, Northern Ireland costs and returns have been used to calculate costs and returns for the Republic of Ireland.

The following assumptions were made in the calculations

- A real interest rate of 6%.
- A yield level of 12 t DM /ha/ yr from year 4 onwards.
- A production period of 22 yr, 7 harvest cycles.
- Distance of road transport 20 km.
- Assumed price level of wood chips €60/ tonne DM.

An EU energy crop payment at €45 per hectare is available to SRC willow growers in the Republic of Ireland and Sweden. This payment and was also included in the calculation of returns from SRC willow (www.agriculture.gov.ie/).

Table 5.1 outlines the costs and returns associated with this crop in both the Republic of Ireland and Sweden. Crop establishment (including planting) is much higher in the Republic of Ireland at €253/ha in comparison with Sweden at €150/ha. Establishment of SRC willow involves ground preparation, purchase of plants (rods), planting, rabbit fencing, cutback after first years growth, weed and pest control. The costs of willow plants and planting with specialised machinery are higher in a region that is at an underdeveloped scale (Republic of Ireland) than a region with significant activity in the coppice sector (Sweden). Harvesting of SRC willow also involves specialised machinery. There are higher harvesting costs in the Republic of Ireland (€171/ha) than in Sweden (132/ha). Comparison of the costs of establishment (including planting) and harvesting in countries with different areas of SRC willow shows a clear connection between the level of activity in the sector and the cost of growing willow. The cost differences are due to economies if scale. The gross margin/ha/yr for SRC willow is calculated by subtracting the total costs from the total returns. The gross margin/ha/yr in the Republic of Ireland is minus (—) €22/ha/yr due to higher total costs than returns received. The gross margin/ha/yr in Sweden is 110/ ha/yr. This is shown in Table 5.1.

Description of Costs and returns in SRC willow	Ireland €/ha/yr	Sweden €/ha/yr
Crop establishment	237	150
Fertilizer	55	55
Fertilizer spreading	28	22
Road transport	100	100
Harvest	171	132
Field transport	48	48
Administration	10	10
Winding up	7	7
Total costs/ha/yr	**656**	**524**
A yield of 12 tonnes DM/ha/year from year 4 onward. price of dried woodchip @ 60 €/ tonnes DM.	589	589
EU Energy crop payment @ 45€/ ha	45	45
Total Returns /ha/yr	**634**	**634**
Gross margin/ ha/ yr	**– 22**	**110**

Table 5.1 Gross margin/ha SRC willow in the Republic of Ireland and Sweden.

5.3.2 SRC willow in a 'Disadvantaged Area' of the Republic of Ireland

A compensatory payment is available to farmers in the Republic of Ireland with land classified as disadvantaged. This is part EU/ part government funded. According to the Heritage Council of Ireland (1999) 75% of the agricultural land in Republic of Ireland is classified as disadvantaged. The rate of payment for forage area is €88/ ha/yr. Forage area is defined as land used for the grazing of livestock. Forage area can also include areas used for producing hay or silage. Areas under tillage, woods or SRC willow are not eligible for this payment. A minimum stocking rate of livestock/ forage area is required for this scheme. A livestock farmer in a disadvantaged area would have to forego €88/ha/yr on every hectare planted with short rotation coppice willow (http://www.agriculture.gov.ie/schemes/single).

The gross margins/ha for a livestock farmer in a disadvantaged area of the Republic of Ireland converting to SRC willow is examined in Table 5.2. The farmer would have to fore-go €88/ha/yr on every hectare planted with short rotation coppice willow. This leaves the gross margin/ha/yr at minus (−) €110/ha. This is shown in Table 5.2

	€/ha/yr
Total costs/ha/yr	656
Total Returns /ha/yr	634
Loss of Disadvantaged Area Scheme payment	− 88
Gross margin/ha/yr for a former livestock farmer situated in a 'Disadvantaged Area'	−110

Table 5.2 Gross margin/ha of SRC in a Disadvantaged Area

5.3.3 SRC willow with an establishment grant in the Republic of Ireland.

The European Union Energy Crops Scheme at €45/ha/yr is the only current form of financial assistance for growing Short Rotation Coppice Willow in the Republic of Ireland. This Energy Crops Scheme is available in other EU countries. Some of these other EU countries such as the United Kingdom have chosen to assist the SRC sector by providing additional financial grants and schemes to willow growers. In the Northern Ireland under the Challenge Fund Scheme, applicants are required to bid in the form of a tender for the money they need to establish Short Rotation Coppice for an energy end use. This is achieved by requiring successful applicants to provide a detailed breakdown of their costs when they submit claims for payment. Every application is judged in terms of its value for money in relation to the aims of the Challenge Fund. A judging panel awards grants to those schemes that best meet the aims of the Challenge fund Scheme, which offer best value for money and maximize public benefit (www.forestserviceni.gov.uk).

In England under the Energy Scheme grants are be paid at a flat rate of €2,400/hectare for SRC established on former livestock land and €1,500/hectare on other eligible land. Grants of up to 50% of the costs of establishing producer groups for SRC are also available. Activities eligible for assistance include legal costs, office accommodation, office equipment purchase, information technology equipment, recruitment costs and the purchase of harvesting machinery (www.forestserviceni.gov.uk).

Currently there is no establishment grant available to willow growers in the Republic of Ireland.

As shown in table 5.1 the gross margin/ha/yr for a willow grower in the Republic of Ireland is €132 less than the gross margin/ha/yr in Sweden. This is due to the high establishment and harvesting costs in the Republic of Ireland. To compensate for these economies of scale a situation is examined where a once off establishment grant of €3,000/ hectare is available in the Republic of Ireland. This financial assistance increases the gross margin for the grower in the Republic of Ireland to 114€/ha/yr, similar to the gross margin/ha/yr in Sweden. This is shown in Table 5.3.

	€/ha/yr
Total costs/yr with establishment grant of €3,000	520
Total Returns /ha/yr	634
Gross margin/ha/yr with establishment grant of €3,000/ha	114

Table 5.3 Gross margins/ha/yr with an establishment grant of €3,000/ ha .

5.3.4 Revenue generated from the application of sewage sludge to SRC willow

SRC willow has possibilities in a multifunctional role. These include acting as a recipient of sewage sludge and the biofiltration of waste from waste water facilities. Rural Generation Limited is a company based in Northern Ireland. It is involved in commercial planting and harvesting of SRC willow, use of willow coppice as a biofilter for effluent and use of willow coppice as a bioremediator for sewage sludge. The company has a contract to remove the sewage sludge from Derry City Council sewage treatment plant. This sludge is injected onto land growing SRC willow.

Additional revenue generated by the application of sewage sludge to willow crops was examined. Figures were derived from personal communication with Michael Doran, Business Development Manager, Rural Generation Ltd. (Doran, 2005) and also from a presentations made at the Irish Farmers Association's conference Renewable Energy-Opportunities for Biofuel Crops 2005 (Gilliland, 2005). The willow grower receives a gate fee of €60/ tonne @25% DM from the waste treatment facility for removing and utilizing the sewage sludge. Transport, landspreading and administration costs are deducted from this fee. All of the SRC plantation may not be suitable to accept the sewage sludge. This may be due to nutrient management issues or steep slopes. A 20% reduction in spreading area is included in the calculation. Sewage sludge can be applied to willow at cutback and also at harvesting. For a SRC crop with a life span of 22 years there are seven opportunities to apply sewage sludge onto the plantation. These calculations are shown in Table 5.4. The application of sewage sludge to SRC willow increases the gross margin/ha/yr by €401/ha.

Returns and Costs	**€**
Contract fee by willow grower for accepting sewage sludge @ 25% DM from sewage treatment plant.	60 € / tonne
Sewage sludge transport, administration and land spreading costs	−39 €/ tonne
Revenue/tonne	21 € / tonne
Revenue /ha/application before deductions due to non suitability of land.	1,575€/ha/ application
revenue/ha/application after deductions made due to non suitability of parts of land for spreading sludge, minus 20% (− 315 € / ha)	1,260€/ha/ application
Application of sewage sludge at cut back (1) and post harvesting (x 6) = 7 applications. 7 applications x 1,260 €/ ha	8,820 €/ha over 22 years
Additional annual revenue/ ha/ yr gained from the application of sewage sludge over 22 year lifespan of willow crop	**+401€/ha/yr**

Table 5.4 Additional annual revenue from the application of sewage sludge to SRC willow.

Depending on the fertilizer value of the sludge the application of chemical fertilizer may be reduced. A reduction in fertilizer costs of 30% was examined. Total costs of SRC were reduced by €16/ha/yr. This increased the gross margin/ha/yr to €542/ha/yr for the willow grower in Ireland and to €454/ha for the willow grower in the disadvantaged region. This is shown in table 5.7

According to Smith *et al* (2002) the amount of sewage sludge produced in the Republic of Ireland in 2002 was 33,559 tonnes dry matter (DM). Agriculture already accepts 15,155 tonnes DM of sewage sludge which is landspread. 18,052 tonnes DM is disposed of at landfill sites. 352 tonnes DM of is disposed of in an unspecified manner. This is shown in Table 5.5.

	Agriculture, Tonnes DM	**Landfill, Tonnes DM**	**Other or unspecified, Tonnes DM**	**Total Tonnes DM**
Sludge Quantity	15,155	18,052	352	33,559

Table 5.5 Tonnes DM of sewage sludge produced and disposal routes in Ireland 2002.

From this information 18,404 tonnes DM could be diverted from landfill sites and other unspecified routes to SRC willow cropland. A spreading rate of 75 tonnes sludge 25% DM/ ha of SRC willow would be equivalent to 18 tonnes DM sludge/ha of SRC willow.

18,404 tonnes DM sludge diverted to SRC willow crops divided by 18 tonnes DM sludge / ha would be equal to 1,022 ha SRC willow. As SRC willow is coppiced on a three year rotation this area of spreading land would only be available every three years. The area of ground required to take the diverted sewage sludge would be 1022ha x 3 working out at 3,067 ha SRC willow.

The land spreading practices and application rates provided in the Code of Good Practice for the use of Biosolids in Agriculture must be adhered to when applying sewage sludge to SRC plantations (Department of Environment and Local Government, 1998).

5.3.5 Gross margins/hectare/annum for SRC willow with other conventional farming enterprises in the Republic of Ireland.

Ireland joined the European Union in 1973. The EU Common Agricultural Policy (CAP) supported farm incomes through a number of methods including farm subsidies. Through out the 1980s and 1990s farmers received subsidies coupled to the number of eligible livestock they reared or area of eligible tillage crops they grew. These subsidies were called direct payments. In 2004 a major reform of the CAP took place. A Single Farm Payment (SFP) was introduced to replace the various direct payments. The SFP was based on the level of direct payments received by the individual farmer in the reference period of 2000 to 2002. These EU Single Farm Payments are made irrespective of whether the farmer rears livestock or grows tillage crops on the farm but are linked to environmental, food safety and animal welfare standards. Farmers now have the freedom to change their farming enterprises and continue to get their Single Farm Payments. Farmers intending to grow SRC willow will continue to receive their SFP (http://www.agriculture.gov.ie/).

REPS is a scheme designed to reward farmers for carrying out their farming activities in an environmentally friendly manner and to bring about environmental improvement on existing farms. Participating farmers receive annual payments of €200 per hectare for the first 20 hectares, €175 per hectare for the next 20 hectares, €70 per hectare for the next 15 hectares and €10 per hectare for the remaining hectares (http://www.agriculture.gov.ie/index). From several communications with Department of Agriculture and Food, clarification as to whether a willow grower would be eligible to participate in the scheme and avail of these payments could not be ascertained.

Gross margins/ha/yr for some of the conventional farming enterprises in the Republic of Ireland were compared with gross margins/ha/yr for SRC willow. The farming enterprises used in this comparison were sucklers cows, lowland mid season lamb production, hill sheep lamb production and barley. Suckler cows are defined as cows kept to produce and rear beef calves. These beef cows rear the calves to about 6 months old and then it is weaned. The gross margins for the conventional farming enterprises were based on actual farm data from the 2003 Teagasc National Farm Survey (Teagasc, 2004). This is shown in Table 5.6.

	Suckler cows	**Lowland mid season lamb production**	**Hill sheep lamb production**	**Spring Barley**
Gross margin per hectare	€ 143 / ha	€ 267 / ha	€ 4 / ha	− 11€/ ha

Table 5.6 Gross margins/ ha/yr for conventional agricultural enterprises

In calculating the gross margins for the farming enterprises European Únion Single Farm Payments are not included.

Short rotation coppice willow is not competitive with listed agricultural enterprises of sucklers cows, lowland mid season lamb production, hill sheep lamb production and barley. Short rotation coppice willow receiving a once off establishment grant of €3,000 gives higher gross margins/ha/yr than hill sheep lamb production and barley. Short rotation coppice willow receiving a once off establishment grant of €3,000 and also sewage sludge with a gate-fee of €60/ tonne @25% DM gives a higher gross margin than sucklers cows, lowland mid season lamb production, hill sheep lamb production and barley. A summary of gross margins/ ha from the scenarios mentioned previously can be found in Table 5.7

	Gross margin €/ha/yr	Gross margin with establishment grant of €3,000/ ha €/ha/yr	Gross margin with establishment grant of €3,000/ ha + application of sewage sludge. €/ha/yr	Gross margin with establishment grant of €3,000/ ha + application of sewage sludge and 30% less chemical fertliser used. €/ha/yr
SRC willow (Sweden)	110			
SRC willow (Rep. of Ireland)	– 22	114	515	542
SRC willow on livestock holding in disadvantaged area part of Rep. of Ireland	–110	26	427	454
Suckler cows (Rep. of Ireland)	143			
Lowland mid season lamb production (Rep. of Ireland)	267			
Hill sheep lamb production (Rep. of Ireland)	4			
Spring Barley (Rep. of Ireland)	– 11			

Table 5.7 Summary of gross margins/ha

5.3.6 Cost comparisons between operating a woodchip heating system and a heating system operated on other fuel sources, oil, natural gas and wood pellets

Cost comparisons between operating a woodchip heating system and a heating system operated on other fuel sources, oil, natural gas and wood pellets, were examined. This was done with the aid of an Altener BIOHEAT calculation sheet. The excel sheet calculates heat costs for biomass fuelled heating systems in comparison with heating systems supplied with fossil fuel . The heat cost calculations are based on the Verein Deutscher Ingenieure (VDI) 2067 standard. (www.bioheat.info). The tables and calculations associated with this cost comparison can be found in Appendix I.

The cost comparisons are for a 100kW boiler. A 100kW boiler would be suitable for a mid size school or small office complex but choice of size of boiler depends on many variables including the heat load of the building. Input data are all the variable and market dependent values. This data is based on Sustainable Energy Ireland's information sheet, *Commercial Fuels Comparisons of Energy Costs-July 2005.* (www.irish-energy.ie/content/content.asp). Main output data are the total heating costs for the different fuel alternatives.

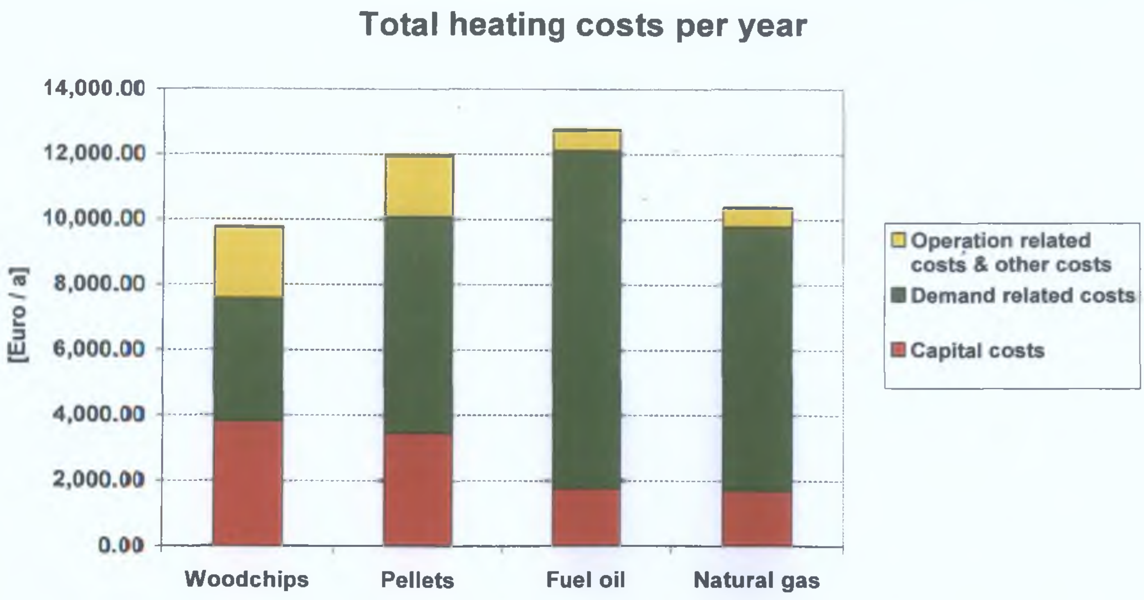

Figure 5.1 Total heating costs/ year of woodchip and other heating systems

Figure 5.1 shows that woodchip boiler has the lowest heating costs per year at €9,757 in comparison with wood pellets at €11,959, fuel oil at €12,758 and natural gas at € 10,369. Total heating costs can be divided into operational related costs, demand related costs and capital costs. The operating costs and capital costs were higher for both woochip and wood pellet boiler The investment costs of a woodchip heating system of €43,900 were much higher than for an oil (€21,800) or natural gas (€19,600). Capital costs per annum work out at €3,829 for wood chip, €3,448 for wood pellet, €1,764 for oil and €1,698 for natural gas. Operation related costs per annum work out at €2,189 for woodchip, €1,894 for wood pellets, €653 for oil and €596 for natural gas. Demand related costs (fuel costs) per annum were lower in woodchip heating systems at €3,738 than wood pellet at € 6,616, oil at €10,340 and natural gas at €8,075.

This high investment cost can be a deterrent for installing wood fuel boilers. In Austria 30% grants are available towards the capital costs of wood boilers. In the United Kingdom a scheme called Clear Skies is available. Clear Skies, funded by the Department of Trade and Industry, aims to give householders and communities a chance to realise the benefits of renewable energy by providing grants and access to sources of advice. Householders can obtain grants between €600 to €7,500 whilst not-for-profit community organisations can receive up to €75,000 for grants (www.clear-skies.org).

The only capital grants available in this country are a limited number of pilot projects funded through INTERREG or Sustainable Energy Ireland.

The VDI 2067 standard for cost comparisons of heating systems does not include a projected increase in various fuel prices. Due to the high demand of depleting fossil fuel resources it would be realistic to project higher oil and natural gas prices in the future. Wood fuel prices have historically remained very stable in comparison with volatile oil prices this is shown in Figure 5.1

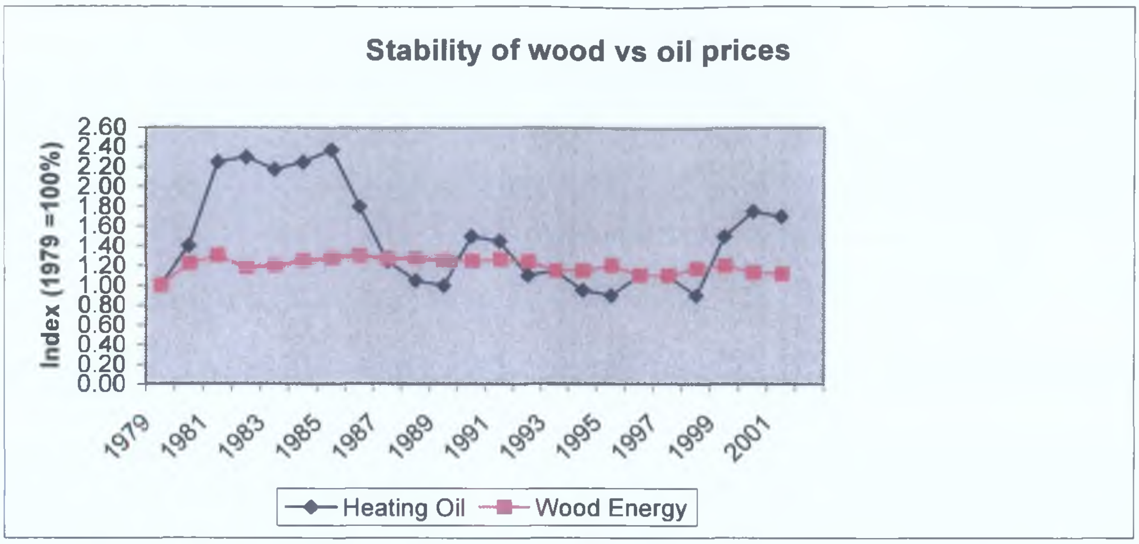

Figure 5.1 Wood prices versus oil prices (SEI, 2004b) and (www.tirol.gv.at/themen/umwelt/)

SECTION 6: HEALTH AND SAFETY ASPECTS OF GROWING AND HARVESTING SRC WILLOW.

Section 6.1 Introduction

Health and safety must be considered when designing and implementing safe systems of work with regard to growing, harvesting and storing willow. Under the terms of the Safety, Health and Welfare at Work Act (1989) and the Safety, Health and Welfare at Work Act (2005) which will commence on 1st of September 2005 all employers have a legal duty to provide a reasonably safe working environment not only for employees, but also to all others who may be affected thereby (Department of Enterprise Trade and Employment 1989 and 2005). The 2005 Act introduces on the spot fines of €1,000 for certain offences and penalties ranging from €3,000 to €3,000,000 and/or imprisonment for non compliance. Under section 20 of the 2005 Act every employer and person in control of a place of work is required to prepare a written safety statement. This statement is based on the identification of hazards and assessments of risks in the workplace. The safety statement must be brought to the attention of the employees at least annually and reviewed at least annually. An employer employing 3 of less employees can comply with section 10 of this act by observing the terms of a code of practice, if any, relating to the work activity being carried out rather than preparing a safety statement. This change in legislation will be particularly relevant to the farming sector and small businesses.

Code of practice and publications on all health and safety aspects of growing, harvesting and storing short rotation coppice willow are not available in this country. The Health and Safety Authority (2003) has published the *Code of Practice for*

Managing Safety and Health in Forestry Operations. This Code of Practice provides guidance as to the observance of the provisions of the Safety, Health and Welfare at Work Act, 1989 and the Safety, Health and Welfare at Work (General Application) Regulations, 1993 for forestry operations. (Department of Enterprise Trade and Employment ,1993)

In particular, the Code provides guidance on Section 7 (General duties of employers and self-employed to persons other than their employees) and Section 8 (General duties of persons concerned with places of work to persons other than their employees) of the 1989 Act and Regulation 6 (Duty to co-operate) of the 1993 Regulations. The Code of Practice came into effect on 1st July 2003.

The Health and Safety Authority (2002) has also produced a *Farm Safety Handbook*. This contains useful information on good practice in health and safety in agriculture.

A code of practice for working in confined spaces has been published by the Health and Safety Authority (2001).

The United Kingdom Health and Safety Executive has published several leaflets including Safe Use of Agricultural Pesticides (1999), Safe Working Near Overhead Powerlines in Agriculture (2005), Safe Use of Forage Harvesters (2000), Farmers Lung/ Allergic Alveolitis (1999), Entry to Confined Spaces (2002).

ESB Networks in co-operation with Electro technical Council of Ireland (2002) have published in relation to electrical safety and overhead power-lines a booklet entitled *Farm well-Farm safely*.

6.2 Specific hazards associated with SRC willow

6.2.1 Extrinsic allergic alveolitis

Moulds and spores present in the stacks of wet chip can create a health hazard. (British Biogen,1999). Extrinsic allergic alveolitis is a hazard associated with handling mouldy material. This is a disorder due to the inhalation of organic dust of plant origin resulting in alveolitis and lowering the transfer of gases in the respiratory system. Fungal spores (*Aspergillus fumigatus,* most widely studied) tend to be the causative agents. There is very limited research carried out in this area. (Sennekamp, 2004) .

Garstang *et al* (2002) carried out experiments to characterise factors affecting losses in large-scale non-ventilated bulk storage of wood chips. Also as part of this experiment spore measurements were taken in the vicinity of wood chip piles to asses the health risks of exposure to partly degraded woodchip. During the handling of wood chips a rise in the level of moulds was detected, of which *A. Fumigatus* was of most concern due to its well-publicised detrimental pulmonary health effects. The levels of bioaerosols observed were well below levels expected during handling operations in other activities like composting. It concluded that it was unlikely that handling woodchip in normal conditions would cause any significant health impacts to either the general public or workers. However it stated that, precautions such as drying of wet woodchip and the wearing of respiratory protective equipment should take place. Also risks should continually be assessed and remedial action taken. (Garstang *et al* 2002)

According to Garstang et al. (2002) the wood chip piles were only disturbed for approximately 5 minutes, whereas the samples were taken over several hours. A prolonged period may have resulted in more microorganisms being released into the atmosphere.

(Beffra *et al.* (1998) carried out experiments on the mycological control and surveillance of biological waste and compost. Compost heap would have similar properties to heaps of wet wood chip. The precise dose of allergenic /pathogenic microorganisms required to elicit adverse health effects in either healthy or sensitive individuals was not determined in this study . Further long-term epidemiological studies were required. (Beffra *et al.* 1998)

6.2.2 Farm machinery and equipment

Accidents involving farm machinery and equipment account for a large number of the fatal farm accidents every year. Out of the 13 fatalities in Agriculture and forestry in 2002 eight of the fatalities involved machinery and equipment. (HSA, 2003)

The prevention of accidents occurs on the day the equipment is bought. Section 10 of the Safety, Health and Welfare at Work Act, 1989 requires that "any person who designs, manufactures, imports or supplies any article (farm machinery/equipment is an article) for use at work to ensure so far is reasonably practicable, that the machine is designed, constructed, tested and examined so as to be safe and without risk to health when used by a person at a place of work." This section also requires that the person to whom the article is supplied be provided with adequate information on how to use it properly. All farm equipment and machinery must be supplied with all its appropriate guards in place and sufficient information as to how to use the equipment safely.

Section 10 also applies to second hand equipment. Second hand equipment must be upgraded, so far as is reasonably practicable, to conform to the latest developments in improved machinery safety. This is echoed in Section 16 of Safety, Health and Welfare at Work Act, 2005. If accidents are to be avoided the user of the farm machinery must keep in place all the guards provided with the machinery and must adhere to the safe work practices listed in the instruction manual. This is particularly relevant as much of the machinery involved in willow planting, fertiliser application, willow harvesting and woodchip storing are modified in workshops for these specialised activities.

Figure 6.1 Cutting header of willow harvester

Tractor and harvester cabs involved in willow crop operations should be fitted with Q-cabs. These have lower in cab noise levels for the operators. S.I. No. 157/1990, European Communities (Protection of workers) (Exposure to Noise) Regulations, 1990 is the current legislation governing noise exposure to workers (Department of Labour,1990). The Physical Agents (Noise) Directive (2003/10/EC) will replace the 1990 Regulations in February 2006. (European Parliament and Council, 2003*b*). Table 6.1 summarises the main requirements in these pieces of legislation.

Action required	**S.I. No. 157/1990, European Communities (Protection of workers) (Exposure to Noise) Regulations, 1990**	**Physical Agents (Noise) Directive (2003/10/EC)**
Provide information and training.	85dB(A)LAeq(8Hr)	80dB(A) LAeq (8Hr)
Make ear protection available.	85dB(A)LAeq(8Hr)	80dB(A) LAeq (8Hr)
Ear protection to be worn	90dB(A) LAeq(8Hr)	85dB(A)LAeq(8Hr)
Implement a program of control.	90dB(A) LAeq(8Hr)	85dB(A)LAeq(8Hr)

Table 6.1 Summary of the main requirements of relevant noise legislation

Harvesting of willow occurs from mid-October to March. Harvesting can involve movement of machinery from muddy fields onto public roads. This movement can bring dirt and mud onto the road resulting in dangerous driving conditions. Section 13 subsection 10 of the Roads Act 1993 states that it is an offence to place or deposit any material or thing on a public road (Department of Environment and Local Government, 1993).

Section 4 (1a) of S.I. No. 132/1995: Safety, Health and Welfare at Work (Signs) Regulations, 1995 states that it is the duty of every employer to provide safety signs where hazards cannot be avoided and to ensure that such signs are in place. (Department of Enterprise and Employment, 1995). Public warning signs should be placed along public roads where agricultural machinery will be trafficing at harvest-time.

A listing of the major hazards and remedial actions associated with growing, harvesting and storage of SRC willow is provided in Appendix II

SECTION 7: DISCUSSION

Short Rotation Coppice willow has potential as an alternative energy source and in reducing GHG emissions. According to Buckley (2005) SRC willow is suitable for 4.3 million hectares of the 4.4 million hectares of the agricultural land in the country. Irelands has the fastest growth rates for biomass (trees and other plant species) in Europe. It has the highest potential annual yield of wood in Europe (Kuusela, 1994).

However considerable barriers exist that prevent this potential from becoming a reality in the Republic of Ireland.

For farmers in the Republic of Ireland changing to such a different farm enterprise as SRC willow growing could be extremely challenging. In Sweden commercial forestry cover 55% of land area, in Austria 50% while in the Republic of Ireland 8% of land area (IEA, 2004*a*). Timber harvesting and use of wood fuel are well accepted as part of a normal agriculture enterprise in Austria and Sweden. Farmers planting farmland with a woody crop such as SRC willow would not have the same negative attitudes and uncertainties in Sweden or Austria as farmers in a grass based livestock rearing sector such as Ireland.

As shown in the survey on attitudes of farmers to growing short rotation coppice even if financially viable, (Healion *et al.,* 2001), resistance towards growing this crop exists in Ireland. Issues listed include: planting timber a backward step in farm development, lack of knowledge and experience on farmers part, unknown pitfalls in this enterprise, reliance on third parties to plant and harvest the crop, negative experiences of farmers with other alternative enterprises, upcoming retirement and negative landscape impacts of SRC.

Promotion and education are key in changing these attitudes amongst farmers According to Healion et *al.*(2001), 70% of survey respondents (farmers) stated that they had no knowledge or experience of short rotation coppice.

Promotion and education are also key in promoting wood fuel amongst domestic and commercial energy consumers. Unlike other countries like Austria and Sweden Ireland does not have a strong tradition of using wood fuel or extensive district heating systems.

Positive developments like the Renewable Energy course at Institute of Technology, Tipperary and the INTERREG project 'Renewable Energy Network for Environmental Welfare' will assist farmers in increasing their knowledge and understanding of growing short rotation coppice willow. These developments will also help to establish domestic and commercial market for wood fuel boilers and wood fuel including willow chip .

The poor profitability of SRC willow acts as a major barrier in the successful uptake of this crop in the Republic of Ireland. Currently due to economies of scale the gross margin/ha of SRC willow is not competitive with conventional agricultural enterprises in this country. According to Telenius and Westin (2004), total area of 100,000 hectares would reduce SRC willow growing costs by 20-25%. As the Republic of Ireland has only 60 hectares of SRC willow this target seems unattainable in the short term. However considerable cost reductions become evident at about 30,000ha. As the cost reductions will come from scale effects, they are permanent and hence constitute a strong argument for temporary subsidies in the phase of market introduction.

An introduction of a €3,000 establishment grant would increase the gross margin/ha to that above barley, hill sheep lamb production but below that of lowland mid season lamb production and suckler cow farming.

As in many new technological systems and new products, successful introduction may start in niche applications. Short Rotation has possibilities in a multifunctional role. These include acting as a recipient of sewage sludge and the biofiltartion of waste water from treatment facilities. However, location of these SRC plantations in relation to the wastewater or sewage treatment facilities may entail excessive transport cost and EU legislation placing further restrictions on the application of nutrients to land may reduce the profitability of the operation.

The various agriculture schemes in operation in the country at the moment can also affect the uptake of SRC willow in Ireland. The Single Farm Payment is a positive development in that it gives the farmers freedom to markets where there is strong demand. They are no longer constrained by the restrictions of the various direct payment schemes and are guaranteed their direct payments if they farm their land in an environmental and animal welfare manner. The Disadvantaged Area Scheme with its payment rate of €88/ha is a major incentive to livestock farmers to continue in their forage based enterprises. This scheme needs to be examined with regard to becoming more inclusive of the changing role of agriculture. Clarification is required from the Department of Agriculture and Food in relation to the eligibility of SRC willow growers to the Rural Environmental Protection Scheme. Greater co-operation between government departments such as Department of Communications, Marine and Natural Resources, Department of Finance, Department of the Environment, Heritage and Local Government and the Department of Agriculture and Food would be beneficial in shaping government policies, programmes and schemes.

Countries like Sweden and Austria have policies and programmes in place such as carbon taxes, financial support for biomass installations and electricity certificate scheme to provide incentives for renewable energy. Their energy sectors are less vulnerable to fluctuations in international fossil fuel prices, more flexibile and have better environmental performance.

The Irish government's energy policies and programmes are directed largely at electricity generation. The Alternative Energy Requirement programmes were established to encourage renewable energy technologies to enter the electricity generating market. The consultation document *Options for Future Renewable Energy Policy, Targets and Programmes* mostly concentrates on developing renewable electricity generating policies in response to *Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.* Electricity accounts for 30% of energy usage and heating 35% in Ireland.

The Minister for Finance, Mr Charlie McCreevy, T.D., announced in September 2004 that the Government had decided not to introduce a carbon tax. Instead, the government proposed support for emissions abatement mechanisms such as energy efficiency initiatives and also the purchase of additional carbon emission allowances on the international market.

The Energy Performance for Buildings Directive (EPBD) 2002/91/EC contains a package of measures designed to secure a significant reduction in CO_2 emissions from buildings. Some of these measures including Building Energy Rating in existing buildings and non residential buildings (when sold or let, and large public service buildings) will not be implemented until 2009. The reason given by the Department of the Environment is that it is that necessary that technical and administrative provisions are first put in place, to be followed by the training of the necessary relevant experts. This seems like quite a long time frame in a country with a highly educated workforce and a successful economy.

Regarding the purchase of additional carbon emission allowances on the international market, the EU Emissions Trading Directive (Directive 2003/87/EC) was introduced to help reduce greenhouse gases emissions. This Directive establishes an allowance-trading scheme for emissions to promote reductions of greenhouse gases, in particular carbon dioxide known as the EU Emissions trading System (ETS), which coming into effect on 1 January 2005

Member States have drawn up national allocation plans for 2005–2007 which give installations in each country permission to emit an amount of CO_2 that corresponds to the number of allowances received. The limit or 'cap' on the number of allowances allocated creates the scarcity needed for a trading market to emerge. Companies that keep their emissions below the level of their allowances are able to sell their excess allowances at a price determined by supply and demand at that time. Those facing difficulty in remaining within their emissions limit have a choice between taking measures to reduce their emissions or buying the extra allowances they need at the market rate.

The EU Emissions Trading System will be implemented in two stages: Phase 1 (2005-2007); and Phase 2 (2008-2012) which corresponds with the first commitment period of Kyoto. During phase 1, any emitter exceeding its greenhouse emission cap in any given year (after taking into account any emission reduction credits they have purchased to offset their emissions) will be subject to a fine of €40 per tonne of greenhouse gas emitted in excess of that cap and will have to purchase corresponding emission reduction credits to correct the excess in the following year. During phase 2, the fine will be increased to €100 per tonne in excess of the cap (http://europa.eu.int/comm).

The EU energy trading system scheme covers emissions from large emitters in the power and heat generation industry and in selected energy-intensive industrial sectors. Despite this EU scheme and other measures in the government's climate change strategy, Ireland will be a minimum of 3.7 million tonnes a year short of its Kyoto targets. The government plans to buy 3.7 million tonnes of carbon dioxide credits each year for the five years of the Kyoto protocol (2008 – 2012) on the international trading markets or 18.5 million tonnes in total. The current market price for a tonne of carbon dioxide allowances is €10, although this price could rise or fall. At €10/ tonne this would create a bill of €18.5 million (http://www.irish-forestry.ie).

A trading company, AgCert was founded to develop a standardised process for reducing GHG emissions from intensive livestock farms in developing countries. This company reduces GHG on livestock farms by implementing practice changes in animal waste management systems. The GHG emission reductions are pooled and sold to industrial emitters, governments and energy traders on the international markets.

Ireland's electricity supply Board (ESB), has signed an agreement to purchase carbon credits from AgCert (http://www.agcert.com). ESB is 95 per cent owned by the Government of Ireland. In this circuitous route farmers outside the state are being paid to assist in Ireland achieve its Kyoto targets. Renewable energy has a huge role to play in reducing GHG emissions in Ireland. If used to replace fossil fuels, wood fuel from sustainable sources such as SRC willow offers significant opportunities to reduce carbon dioxide emissions. SRC willow can provide a sustainable carbon neutral fuel for heating and in the case of combined heat and power plants, heating and electricity generation. A strong case exists for the Irish government to examine investing in renewable energy including SRC willow and wood fuel installations which can provide long-term environmental and economic benefits to the country rather than the purchasing carbon emission allowances on the international market.

Ireland dependency on imported energy is extremely high at 89%. Depleting fossil fuel reserves coupled with rising oil and gas prices leaves Ireland in a very vulnerable situation. Renewable energy only provides 1.8% of Total Primary Energy Requirement. As shown in a cost comparison between 100kw boilers, woodchip boilers had the lowest heating costs per year in comparison with wood pellets, fuel oil and natural gas. The operating costs and capital costs were higher for woochip but demand related costs (fuel costs) lower in comparison with fuel oil and natural gas boiler systems. This high capital cost is a deterrent for installing wood fuel boilers. In Austria and the United Kingdom grants are available towards the capital costs of wood boilers. The only capital grants available in this country is a limited number of pilot projects funded through INTERREG or Sustainable Energy Ireland. Government intervention is required in the form of installation grants for woodfuel heating systems. This will help overcome the deterrent of high capital costs and it will also generate a market for woodfuel including SRC willowchip.

Codes of practice and publications on all health and safety aspects of growing, harvesting and storing short rotation coppice willow are not available in this country. This issue needs to be rectified especially in light of the Safety Health and Welfare at Work Act (2005) which requires employers with three or less employees to adhere to the codes of practice associated with particular tasks. Further research work is required in relation to the health risks of extrinsic allergic alveolitis associated with stored damp woodchip. Machinery involved in the growing, harvesting and storing of willow chip have health and safety risks. These risks need to be identified and remedial actions taken.

In the application form for the Biofuels Mineral Oil Tax Relief Scheme, 2005, run by the Department of Communications Marine and Natural Resources, applicants are required to comply with all relevant stipulations of Health & Safety and Environmental Legislation (http://www.dcmnr.gov.ie/Energy/Mineral). Many of the applicants to this scheme are farmers involved in the growing and processing of biofuels such as oilseed rape, sugar beet and wheat. This health and safety stipulation should be placed on applicants to any government programme assisting SRC willow growers or wood fuel installations.

A list of the major hazards associated with growing, harvesting and storing SRC willow and remedial action required is presented in Appendix II.

In conclusion, short rotation coppice willow has potential in the Republic of Ireland as an energy source. Considerable barriers exist preventing this full potential being realised. Government intervention is required in the form of promotion, education and financial assistance to growers to assist this pioneering industry. Agriculture schemes needs to be examined to identify and remove any possible deterrents to farmers in growing SRC willow. Government policies and programmes needs to address electricity, heat and transport not just promoting electricity generation. Financial grants are also required for wood fuel heating installations as high capital costs can act as a deterrent to uptake these heating systems.

More research work, codes of practice and publications are required on the health and safety aspects of growing harvesting and storing SRC willow. Compliance with health and safety legislation should be a requirement on all applicants to any government programme assisting SRC willow growers or wood fuel installations.

Appendix I

Altener BIOHEAT Heating cost comparison based on VDI 2067 standard

Interest rate % p.a. nominal value	**3.5**		
Basic data	**time of use**	**annuity factor**	**annual repair costs**
	[years]	[%]	[%]
Boiler	**10**	12.0	**1.0**
Installations	**10**	12.0	**1.0**
Construction	**30**	5.4	**0.5**
Final energy demand	Heat load	Full power operation	Final energy demand
	[kW]	[h/a]	[kWh/a]
	100	**1,500**	150,000

Table I.1 Boiler data of wood chip, wood pellet, oil and natural gas and interest rate used in calulations.

	Heat load	Hours of full power operation		Final energy demand	
	[kW]	[h/a]		[kWh/a]	
	100	1,500		150,000	
		Wood chips	**Pellets**	**Fuel oil**	**Natural gas**
		[€ / kg]	[€ / kg]	[€ / liter]	[€ / m³]
Costs per unit		**0.073**	**0.165**	**0.550**	**0.408**
	€/m³	17.03	107.61		
Fuel costs per year	€/a	**3,678.31**	**6,556.40**	**10,290.26**	**8,025.06**
Fuel costs per MWh	€/MWh	**19.6**	**35.0**	**54.9**	**42.8**
Fuel costs per GJ	€/GJ	**5.4**	**9.7**	**15.2**	**11.9**
Fuel demand per year	[m³]	**216**	**61**	**19**	**19,669**
	[kg]	**50,388**	**39,736**	**15,810**	**15,342**
Annual boiler efficiency	%	**80**	**80**	**80**	**80**
Final energy demand	kWh/a	150,000	150,000	150,000	150,000
Primary energy demand	kWh/a	187,500	187,500	187,500	187,500
Water content	% (weight)	**25.0**	**8.0**	0.0	0.0
Hydrogen content	% (weight, dry matter)	6.0	6.0	13.4	23.6
Density of loose dry matter	kg/m³	**175**	**600**	845	0.78
Density of loose fresh matter	kg/m³	233	652	845	0.78
specific volume of fresh material	m³/1000kg	4.29	1.53	1.18	1,282.05
Upper heating value of dry matter	MJ/kg	20.0	20.0	45.7	49.2
	kWh/m³	972	3,333	10,715	10.7
Lower heating value of fresh matter	MJ/kg	13.4	17.0	42.7	44.0
	kWh/kg	3.7	4.7	11.9	12.2
	MJ/m³	3,126	11,079	36,078	34.3
	kWh/m³	868	3,077	10,022	9.5

Table I. 2 Fuel data of wood chip, wood pellet, oil and natural gas.

	unit	Woodchips	Pellets	Fuel oil	Natural gas
Boiler costs	[€]	17,500.00	17,500.00	5,800.00	6,600.00
Installation costs	[€]	4,400.00	4,400.00	3,000.00	3,000.00
Building costs	[€]	22,000.00	15,000.00	13,000.00	10,000.00
Total Investment	***[€]***	***43,900.00***	***36,900.00***	***21,800.00***	***19,600.00***
Annuity	[€/a]	3,829.46	3,448.86	1,764.95	1,698.03
Capital costs	***[€/a]***	***3,829.46***	***3,448.86***	***1,764.95***	***1,698.03***
Fuel costs	[€/a]	3,678.31	6,556.40	10,290.26	8,025.06
Electricity cost for boiler operation	[€/a]	60.00	60.00	50.00	50.00
Demand related costs	***[€/a]***	***3,738.31***	***6,616.40***	***10,340.26***	***8,075.06***
Repair costs	[€/a]	329.00	294.00	153.00	146.00
Personel costs	[€/a]	960.00	750.00	0.00	0.00
Chimney cleaner	[€/a]	250.00	250.00	200.00	150.00
Service contract	[€/a]	400.00	400.00	200.00	200.00
Insurance, other costs	[€/a]	250.00	200.00	100.00	100.00
Operation related costs & other costs	***[€/a]***	***2,189.00***	***1,894.00***	***653.00***	***596.00***
Total annual costs	**[€/a]**	**9,757**	**11,959**	**12,758**	**10,369**
Total costs per MWh	**[€/MWh]**	**65.0**	**79.7**	**85.1**	**69.1**

Table I. 3 Total costs calculations of wood chip, wood pellet, oil and natural gas.

Appendix II

Major hazards and remedial actions associated with growing, harvesting and storage of SRC willow

1. Application of herbicide, fungicide and pesticide

Low usage of herbicide, fungicide and pesticide is promoted in the growing of short rotation coppice willow. However if the site was previously grassland or longterm set-aside glyphosate-based herbicide will have to be applied. Willow beetle control sprays and fungicides may also need to be applied to the crop. The operator should be competent in the usage of tractor sprayers and in the safe handling of various chemical sprays. Manufacturer's instructions on the products must be adhered to. Adequate personal protection equipment should be worn. Courses are available from Teagasc in the safe operation of sprayers. The following points should also be noted.

<ins>Contamination of wells and drillings shall be avoided.</ins>

- The sprayer shall not be filled, rinsed or cleaned close to wells.
- The water supply must have a one-way valve to prevent water returning to the source

<ins>Reducing risks when adding plant protection products</ins>

Addition of the plant protection products to the sprayer shall take place in the field. This can :

- avoid using the same spot every time you handle concentrated chemicals.
- benefit from an active soil breakdown of minor spills.

- avoid any risks from transporting a full tank of spray solution.

Plant protection products shall be carried in safe lockers on the sprayer. It must be possible to collect any spillage that may occur from the containers.

2.Application of sewage sludge and wastewater.

Sewage sludge and waste water from municipal treatment plants are often applied as fertilizer to the willow crop. Exposure to sewage sludge or wastewater may result in a number of illnesses. These include:

- Gastroenteritis, characterised by cramping stomach pains, diarrhoea and vomiting
- Weil's disease, a flu-like illness with persistent and severe headache, transmitted by rat urine. Damage to liver, kidneys and blood may occur and the condition can be fatal
- Hepatitis, characterised by inflammation of the liver, and jaundice
- Occupational asthma, resulting in attacks of breathlessness, chest tightness and wheezing, and produced by the inhalation of living or dead organisms
- Infection of skin or eyes

<u>Entry of micro-organisms to the body.</u>

- The most common way is by hand-to-mouth contact during eating, drinking and smoking, or by wiping the face with contaminated hands or gloves, or by licking splashes from the skin.
- By skin contact, through cuts, scratches, or penetrating wounds. Certain organisms can enter the body through the surfaces of the eyes, nose and mouth.

- By breathing them in, as either dust, aerosol or mist.

Protecting workers from risks to health

Since micro-organisms are an inherent part of sewage, the hazard cannot be eliminated. Exposure to sewage sludge and wastewater should be minimised by for example, drying sludge before disposal and injection of sewage sludge into land rather than spreading; The following measures can further reduce risk of infection and illness:

- Ensure that operators and management understand the risks through proper instruction, training and supervision.
- Provide suitable personal protective equipment, that may include waterproof / abrasion-resistant gloves, footwear, eye and respiratory protection. Face visors are particularly effective against splashes.
- Adequate welfare facilities, including clean water, soap, nailbrushes, disposable paper towels, and where heavy contamination is foreseeable, showers shall be provided. For remote locations portable welfare facilities should be provided.

- Adequate first-aid equipment, including clean water or sterile wipes for cleansing wounds, and a supply of sterile, waterproof, adhesive dressings should also be provided.

Areas for storage of clean and contaminated equipment should be segregated and separate from eating facilities. The operator shall follow the Code of Good Practice for the Use of Biosolids in Agriculture 1999.

3. Electrical safety

Overhead power lines (OHPL) must be considered when selecting a site for the willow crop. Willow can reach a height of several metres before it is harvested, the crop can act as a conductor for electricity. If a piece of machinery or equipment gets too close to or comes into contact with an overhead cable, then electricity will be conducted through the machine or equipment to earth. It may also pass through anyone who is touching it. Electricity can arc, ie jump across gaps. Equipment or machinery do not have to touch the lines to get a serious or fatal shock.

Good management will reduce the risk of accidents happening. By planning carefully and putting controls in place, workers, contractors or visitors to the farm should not come into contact with OHPLs.

Controls to be put in place for:

- Safe use of machinery and equipment.
- Know the safe operating distances from OHPL.
- Use of alternative access points and routes which avoid OHPLs.
- Maximum height and vertical reach of all your machinery and equipment and used should be known.

Low precipitation sprinklers

These sprinklers are also often used for the application of water and wastewater to the willow crops. Risks include contact with OHPLs. This can occur when the pipes are being transported and put into position. Also when sprinklers are positioned too close to electrical lines so that water comes into contact with these lines. Water pipes should not be stored under or close to OHPLs. Aluminium water pipes can be to 10m long. They should not be left where the public or children can gain access to them. The pipes shall be moved horizontally as near to the ground as possible using two people to carry them.

Woodchip storage heaps

Wood chip or willow rods may be temporarily stored in heaps on the farm. These heaps should not be sited beneath or close to OHPLs as this reduces clearance between the lines and the ground.

4. Machinery

Since there is a considerable variety of machinery doing a range of jobs on the farm it is difficult to list all the hazards that are present on machinery.

Some of the more common machinery hazards and methods of guarding them are as follows:

- Chains and drives which are guarded by fixed guards. Fixed guards are also provided on V-belt and pulley drives.
- Rotating shafts and rotating ancillary equipment such as slip clutches etc. are also guarded by fixed guards.
- Other dangerous parts of machinery such as intakes etc. are designed to reduce the risk of operators coming in contact with the moving parts. In addition to the reduction of risk by design the manufacturer of the machinery will also supply the user with safe work practices to follow when operating the machinery. Safe work practices are specified when complete safeguarding of hazards cannot be provided. This information is usually provided in the operator's manual as operator's instructions.

Accidents occur when guards are not properly maintained or kept in place or when safe work practices are not adhered to.

Operators manual

Farm machinery is supplied with an operator's manual which gives instruction on the use of the machinery and how the machinery is to be operated, cleaned, maintained etc. safely. If the operator was not provided or lost the manual he should consult with his machinery dealer to provide him with a manual. Operators should follow the safe work practices listed in the manual.

Clothing

Loose or torn clothing should not be worn when working near machinery as there is a risk of entanglement in the machinery. Tight fitting overalls with zipped pockets are the preferred choice.

Harvesting of SRC willow

Equipment used in the harvesting of Short Rotation Coppice Willow can bring particular hazards. Most of this equipment are modified forage harvesters or beet harvesters. The most common is a forage harvester with a modified header. This cuts, chips and blows the woodchips into a separately towed trailer.

Figure II.1 Harvesting SRC willow

The risks from using harvesting equipment should be identified, precautions put in place to reduce them. All operators should be provided with the machinery instruction manuals. They should be particularly aware of the safe use of the machinery, clearing blockages and the recommended procedure for sharpening knives. Training should be provided where required.

Figure II. 2 Cutting head of a willow harvester

The hazards associated with willow harvesting are :

- the exposed rotating cutter head
- the moving drive mechanisms
- dangers associated with sharpening of knives in the cutter-box
- being trapped or injured by the header
- clearing blockages from the spout/header while the machine is in motion.
- noise and vibration.
- working on steep ground especially in wet conditions.
- Overhead powerlines (as mentioned in previous section)

The machinery must be maintained in good condition and serviced at the recommended intervals by competent persons. It is essential that all guards are in position and correctly fitted before starting work. Only those involved in the harvesting operation should be present in the field. If the header or chutes become blocked the reversing mechanisms should first be tried to wind out blockages from headers/ chutes. If this is unsuccessful the machine must be turned off and the keys removed from the ignition, sufficient run-down time of the cutting mechanism time shall be allowed before approaching the blockage. The manufacturer's recommendations and procedures for dealing with blockages and sharpening the knives should be followed. The operator should wear recommended personal protective clothing, eg safety goggles, when sharpening knives on the harvester. Tractor and harvester cabs should be fitted with Q-cabs. These have lower in cab noise levels. When blowing woodchip into a separately towed trailer the other driver must be considered ,sudden manoeuvres should be avoided.

Harvesting of willow occurs from mid-October to March. Daylight hours are shorter during these months. Machines and trailers should have adequate lighting to travel safely on public roads. Special care should be taken on narrow country roads. Harvesting can involve movement of machinery from muddy fields onto public roads. Public roads shall be maintained free of deleterious material. Warning signs shall be placed along public roads where harvesting machinery will be trafficing.

5.Storage of woodchip

The health and safety aspects of wood chip handling and storage needs careful consideration. Freshly harvested woodchips contain over 50% moisture. Dry material is preferred for combustion. Chips can be dried successfully and then stored with little further loss of dry matter. Stacks of wet chips quickly heat up and start to decompose. Temperatures of 60 degrees C or more can be reached within hours. This can cause spontaneous combustion to occur, a fire hazard. Moulds and spores present in the stacks of wet chip can create a health hazard. Extrinsic allergic alveolitis is a hazard associated with handling mouldy material. This is a disorder due to the inhalation of organic dust of plant origin resulting in alveolitis and lowering the transfer of gases in the respiratory system. Precautions such as drying of wet woodchip and the wearing of respiratory protective equipment should be take place. These risks shall continually be assessed and remedial action taken.

Additional difficulties of working safely in enclosed spaces occurs when woodchip is stored in silos, bunkers and storage sheds.

Hazards associated with confined spaces include:

- free flowing solids such as woodchip can partially solidify or 'bridge' in silos causing blockages which can collapse unexpectedly.
- presence of high levels of dust and fungal spores
- access and egress from the confined space.

These risks shall continually be assessed and remedial action taken. Careful consideration at the design stage can greatly improve working space, and safe access, by optimizing the layout and installation details of the fuel store components.

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