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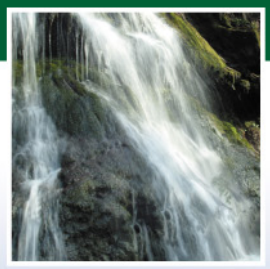

Chapter 3
Introduction to Renewable Energy

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3 Introduction to Renewable Energy

Clifford Guest, Tipperary Institute

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3.1 Objectives

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

- Understand key definitions relevant to renewable energy.
- Be familiar with current energy supply and use at global, EU and Irish levels.
- Understand the connections between energy use and climate change.
- Be able to identify key drivers for the development of renewable energy.

3.2 Introduction

Renewable energy sources are derived principally from the power of the sun's radiation. There are also non-solar renewables, namely tidal energy and geothermal energy. Solar power, both in the form of direct solar radiation and indirect forms such as wind, water and bioenergy, was the energy source which early human societies were based on. Prior to the industrial revolution, these sources were virtually the only forms of energy used by man. During the past 150 years, modern civilisation has become increasingly dependent on fossil fuels such as coal, oil and natural gas. These are finite resources which by their nature are limited in their availability into the longer term. Their combustion releases carbon dioxide into the atmosphere which is a key contributor to global warming. The various forms of renewable energy generally have lower environmental impacts than fossil fuel and they are naturally renewed providing the opportunity to provide energy indefinitely. They contribute to global primary energy demand in three main sectors; electricity production, heat and cooling, and transport.

3.3 Definitions

3.3.1 Alternative Energy

The term alternative energy refers to energy sources, which create less environmental damage and pollution than fossil fuels, and offer an alternative to non renewable resources.

3.3.2 Renewable Energy

Renewable energy (RE) comes from energy sources that are continuously replenished by nature. Renewable energy can be defined as “energy obtained from continuous or repetitive currents recurring in the natural environment” (Twidell and Weir, 1986).

3.3.3 Sustainable Energy

Sustainable energy is a term that is used to cover both renewable energy and the rationale use of energy (RUE). The rational use of energy is the efficient and effective use of energy independent of where the energy comes from. Sustainable energy in its broader context can be defined as energy providing affordable, accessible and reliable energy services that meet economic, social and environmental needs within the overall developmental context of the society for which the services are intended, while recognising equitable distribution in meeting those needs (Davidson, 2002).

3.4 Energy Supply and Use – Global

Energy supply and consumption has increased steadily across the globe in recent years and is set to continue with the continued growth of the world’s population and the increased energy needs of existing and developing economies such as China and India. In the period between 1973 and 2003, Total Primary Energy Supply (TPES) rose from 6,034 million tonnes of oil equivalent (Mtoe) to 10,579 Mtoe, an increase of almost 70% (McQuade, 2005). Table 3.1 details this growth by individual energy source. It shows a fall in the use of oil over that time, while there has been a significant rise in the use of natural gas and nuclear power. Overall, the percentage share of renewables and waste has declined slightly.

Energy Source	1973 % Share	2003 % Share
Oil	45.0	34.4
Coal	24.8	24.4
Natural Gas	16.2	21.2
Renewables and Waste	11.2	10.8
Nuclear	0.9	6.5
Hydro	1.8	2.2
Other	0.1	0.5
TOTAL Mtoe	6034.0	10579.0

Table 3.1 Fuel Shares of TPES 1973 and 2003
(IEA, 2005)

It is clear from the figures above that the world is heavily dependant on fossil fuels for its energy requirements. The question of when these finite resources are likely to run out is an important issue when studying renewable energy. At current rates of use, it has been estimated (BP, 2003) that proven coal reserves should last for about 200 years, oil for approximately 40 years and natural gas for 60 years. The availability of liquid fuels, however, is set to peak between 2005 and 2015.

This peak in liquid fuels has been referred to by many commentators as “peak oil”. In a recent publication commissioned by the Irish Semi State body “Forfás”, the issue of peak oil and its potential impacts on Ireland were analysed. The study explained that “peak oil” is not so much a potential future energy crisis so much as a “liquid fuels” crisis. It is expected that as global oil supply declines and demand increases, there will be significant impacts on the world’s economies, especially for global and national transportation networks (Forfás, 2006).

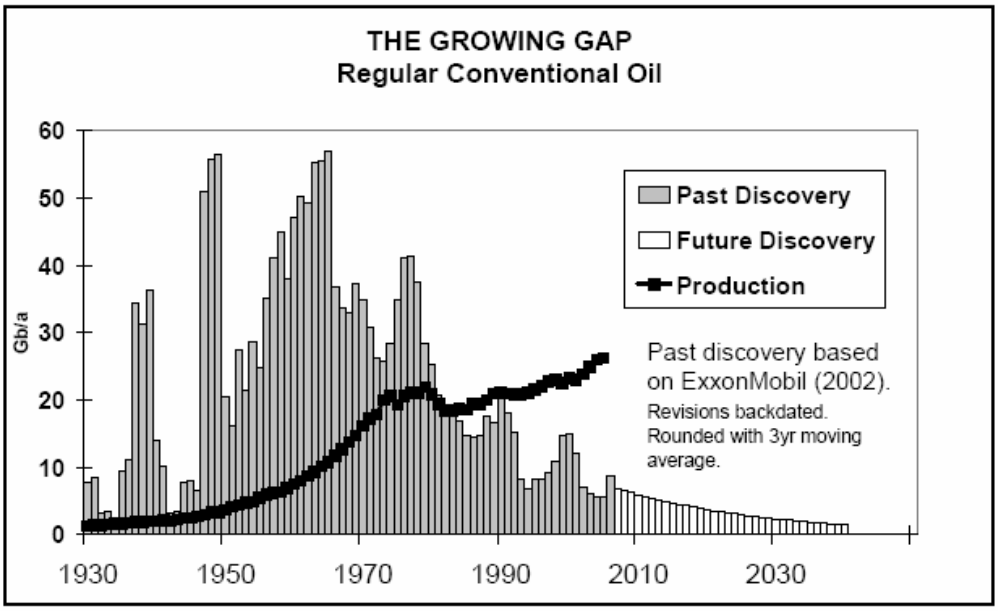

Figure 3.1 Discovery and Production of Conventional Oil
(ASPO, 2007)

The finite nature of fossil fuels is further illustrated in figure 3.2. It shows historical figures for the production oil rising sharply from 1930 and projections for production to peak in 2005 while natural gas peaks some years latter.

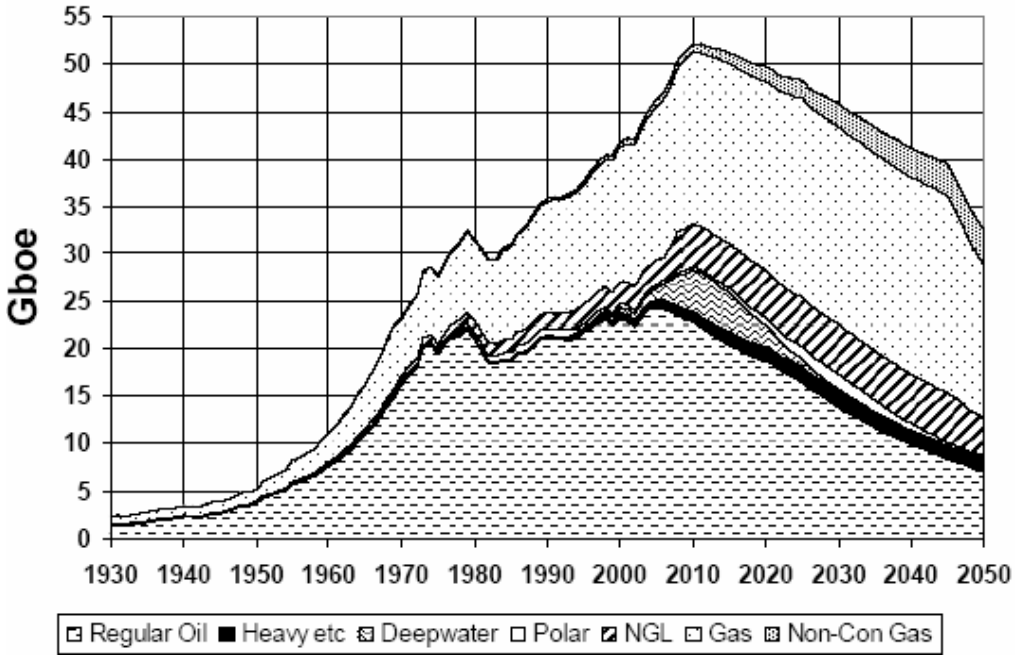

Figure 3.2 Oil and Gas Production Profiles
(ASPO, 2007)

3.4.1 Global Status of Renewable Energy

In a recent report by the International Energy Agency (2006), the current status of renewable energy is illustrated. The contribution of renewables to the worlds total primary energy requirement is identified at just over 13%. Of this figure, combustible renewables and waste represent 79.4% of total renewables followed by hydro at 16.7% (see Figure 3.3).

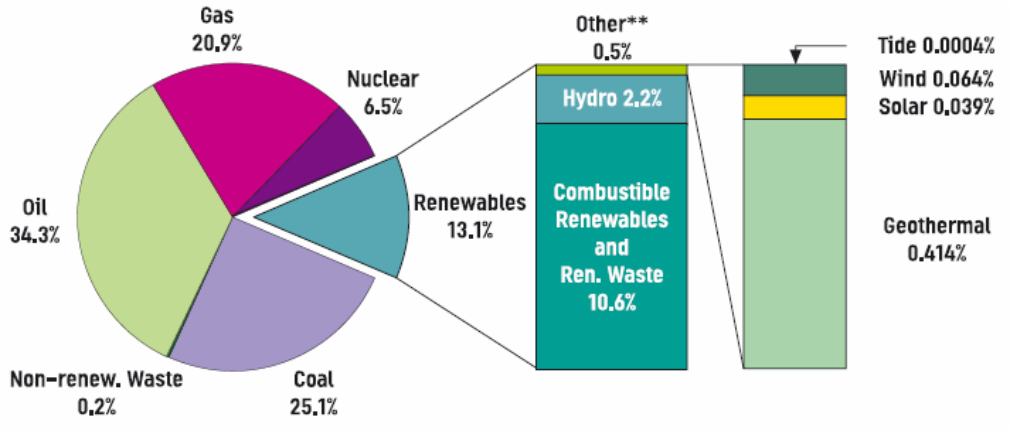

Figure 3.3 2004 Fuel Shares of World Total Primary Energy Supply*

* TPES is calculated using the IEA conventions (physical energy content methodology). It includes international marine bunkers and excludes electricity/heat trade. The figures include both commercial and non-commercial energy

** Geothermal, solar, wind, tide/wave/ocean. Totals in graph might not add up due to rounding.

(IEA, 2006)

3.5 Energy Supply and Use – Europe

In a baseline model looking at a business as usual scenario, the EU Commission depicts an EU future of increasing energy demand due to economic growth, but also identifies significant opportunities for energy savings. Primary energy demand for 2030 is projected to be 19% higher than that in the year 2000, while the structure of energy consumption will also change significantly. There will be a trend towards the use of more natural gas and to some extent renewables, to the detriment of solid fuels, oil and nuclear (European Communities, 2004).

The use of renewable energy across EU member states is very variable. Of the EU 15, Sweden and Finland have the highest percentages of renewables contributing to total energy supply while Luxembourg and Belgium have the

lowest. The biggest contributing energy sources to the share of renewables in the EU are biomass (with more than 90% of renewable heating) and hydro (with 85% of renewable power generation). The target set out in the White Paper on Energy from Renewable Energy Sources (1995) is to double renewable energy supply in the EU from 6% to 12% between 1995 and 2010. It is likely with current trends that these targets will be missed.

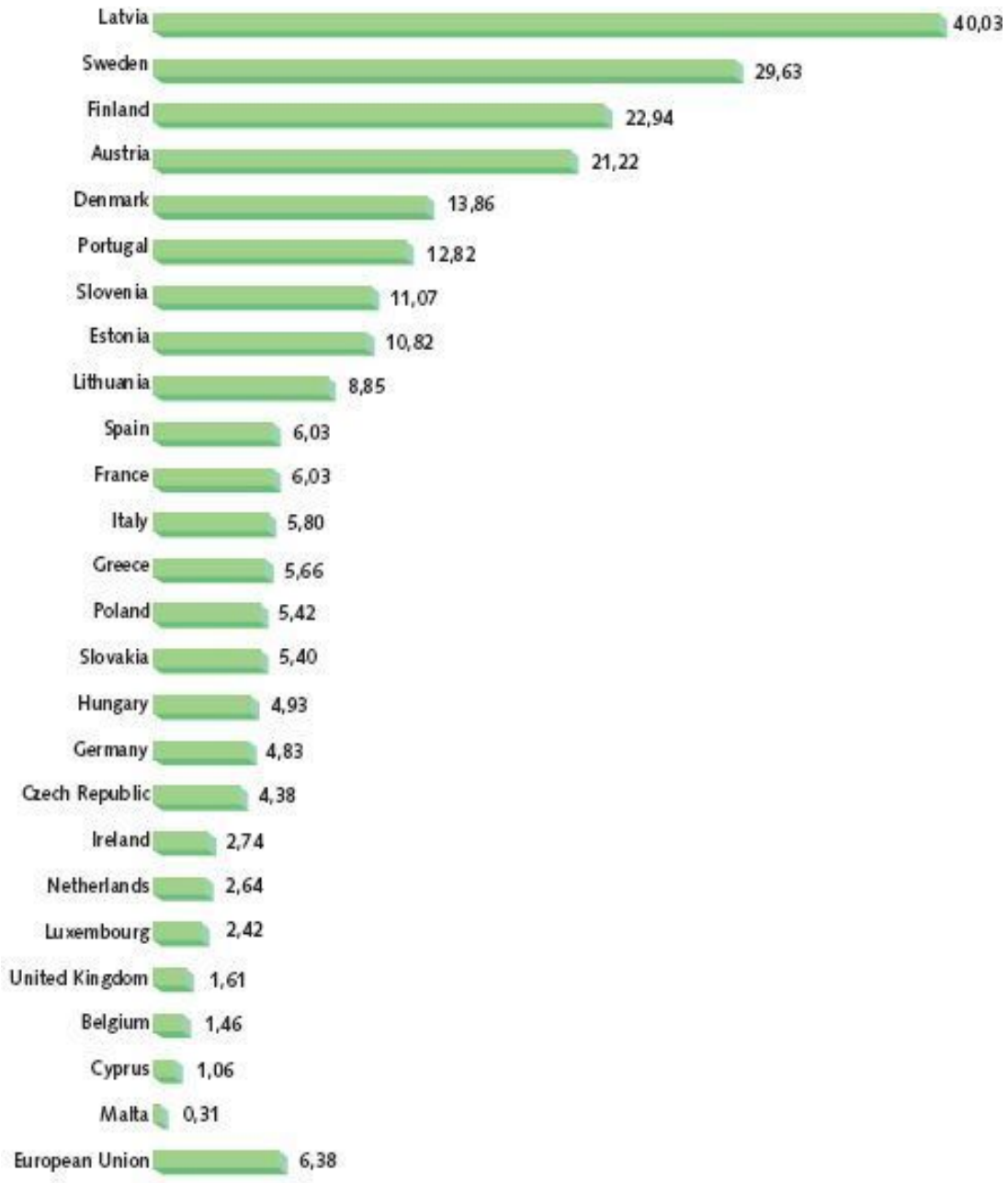

Figure 3.4 Proportions of RE in EU15 in relation to TPES, 2005 (EurObserv'ER, 2006)

The EU Green Paper on Security of Energy Supply (2001) states that EU energy self sufficiency will be impossible to achieve. It also notes that remaining EU's fossil fuel resources are limited. The Green Paper estimates that there is approximately eight years of oil reserves left in Europe and 20 years of natural gas reserves left. It notes that coal is still plentiful in the EU, but that the production cost of this coal is approximately 4-5 times that of world prices. Across all of the 25 EU member states, import dependency averages at just over 45%.

Figure 3.5 Import Dependency of Ireland and EU 15 & 25 (SEI, 2006a)

3.6 Energy Supply and Use – Ireland

Ireland's total primary energy use grew from 9.4 million tonnes of oil equivalent (mTOE) in 1990 to 14.6 mTOE in 2003. It is projected to reach approximately 16 mTOE by 2010. Primary energy demand in Ireland falls into the three major sectors of transport, electricity and thermal. In 2004, these three sectors were of similar size. This is illustrated by Figure 3.6 which identifies the changing contributions of these sectors from between 1990 and 2004.

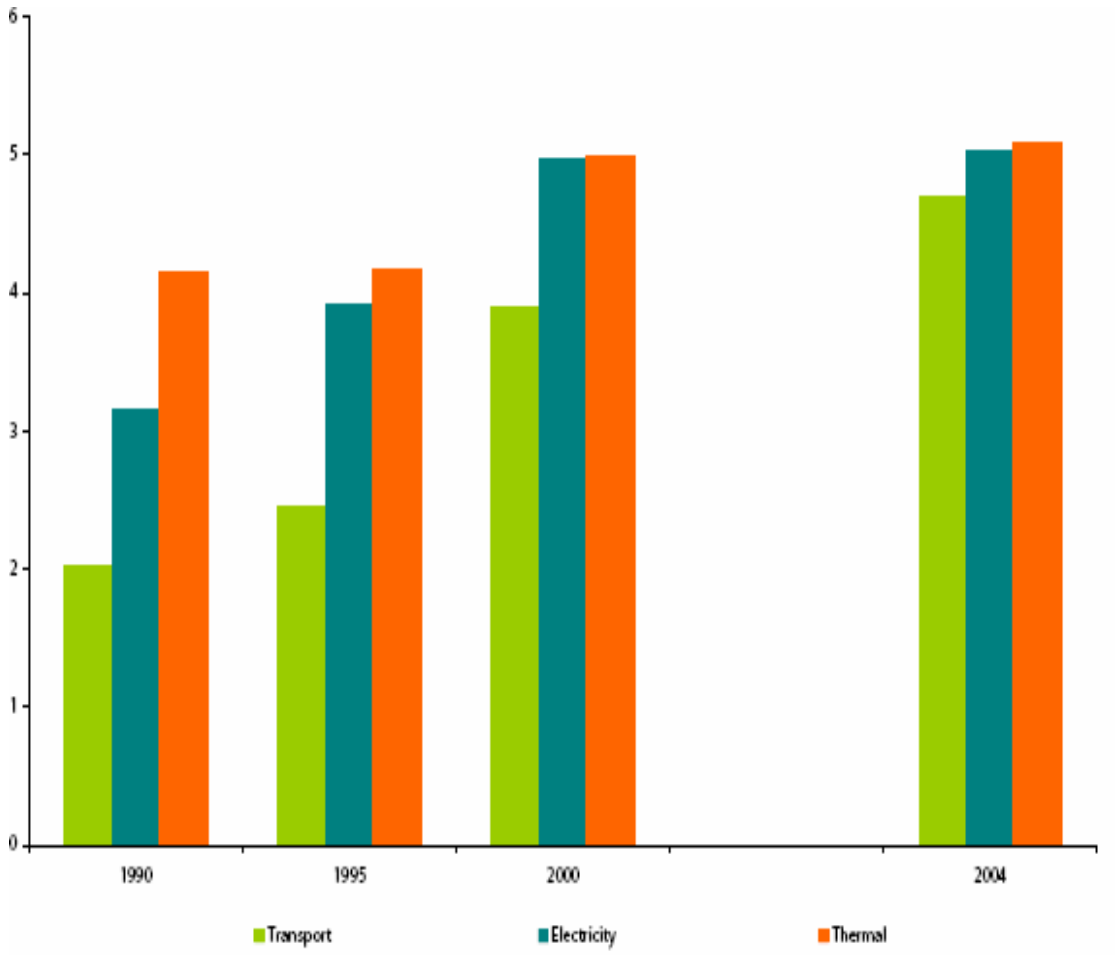

Figure 3.6 Primary Energy by Mode of Application – Ireland (SEI, 2006b)

In Ireland, over 97% of all primary energy is derived from fossil fuel, while the contribution from renewable energy resources is just over 2.2% (SEI, 2006). Compared with other fuels, renewable energy experienced the highest growth in 2004 with an increase of 18%. Between 1990 and 2004, renewable energy has grown by 92% (4.2% per annum on average) in absolute terms. This growth has been masked however by the significant increase in overall Total Primary Energy Requirement.

Oil is by far the most dominant energy source in Ireland and that dominance is increasing with a share of 46% in 1990 to a peak of 59% in 1999. Natural gas has also been increasing its contribution from 15% in 1990 to 24% in 2004, while the contribution of coal and peat has declined. The various contributions made to Ireland's Total Primary Requirement are seen in Figure 3.7.

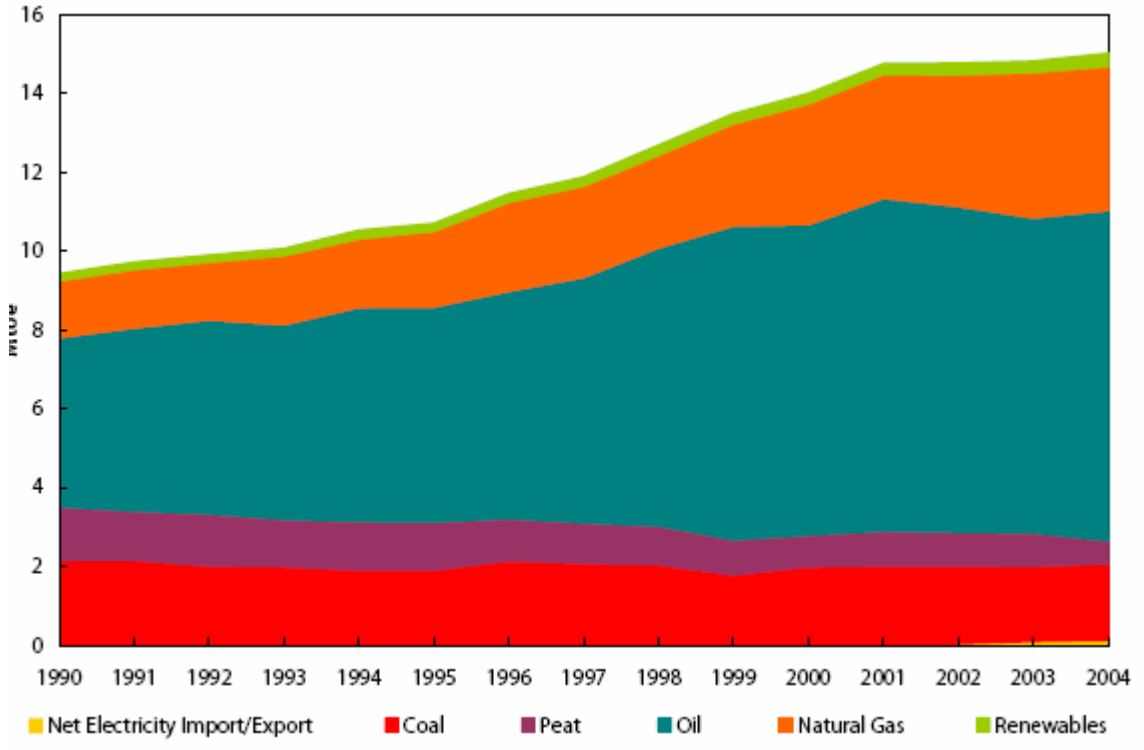

Figure 3.7 TPER by Fuel 1990-2004, Ireland
(SEI, 2006c)

The contribution made from renewable energy to TPER was 168 ktoe in 1990 and this rose to 325 ktoe in 2004 which is an increase of 94%. In 2004, the largest contribution to renewable energy was from solid biomass, followed by wind, hydro, landfill gas, biogas wastewater biogas, solar thermal and geothermal. The last fifteen years has seen a considerable increase in the mix of renewable energy sources contributing to TPER, with the growth of wind power being particularly noticeable. Figure 3.7 gives a breakdown of Ireland's renewable primary energy between 1990 and 2004.

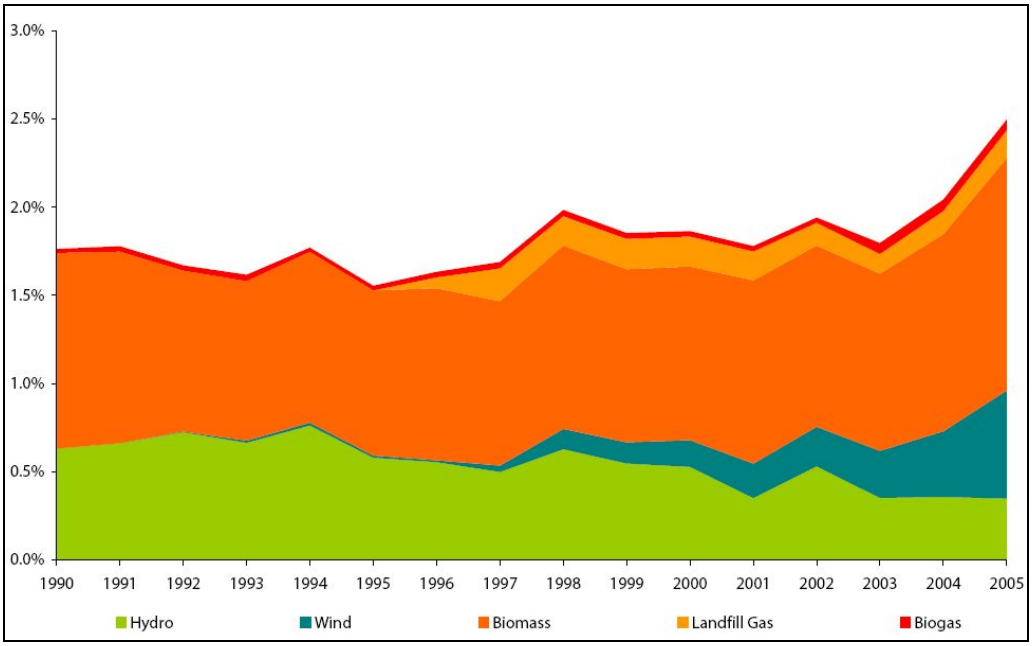

Figure 3.8 Renewable Primary Energy 1990 to 2004
(Howley *et al.*, 2006)

3.7 Energy and Climate Change

Since the industrial revolution, humans have been using ever increasing amounts of energy as part of our modern economies. A consequence of this has been the ever increasing levels of greenhouse gases going into the atmosphere. This is contributing to what many believe is human induced global warming. The principle contributor to these increased emissions is carbon dioxide from the combustion of fossil fuels. It can be seen in Figure 3.9 that global fossil carbon emissions have been rising substantially, especially in the last fifty years. Figure 3.10 looks at variations in the concentrations of CO_2 in parts per million by volume over a four hundred thousand time span and identifies a significant rise in levels since the start of the industrial revolution.

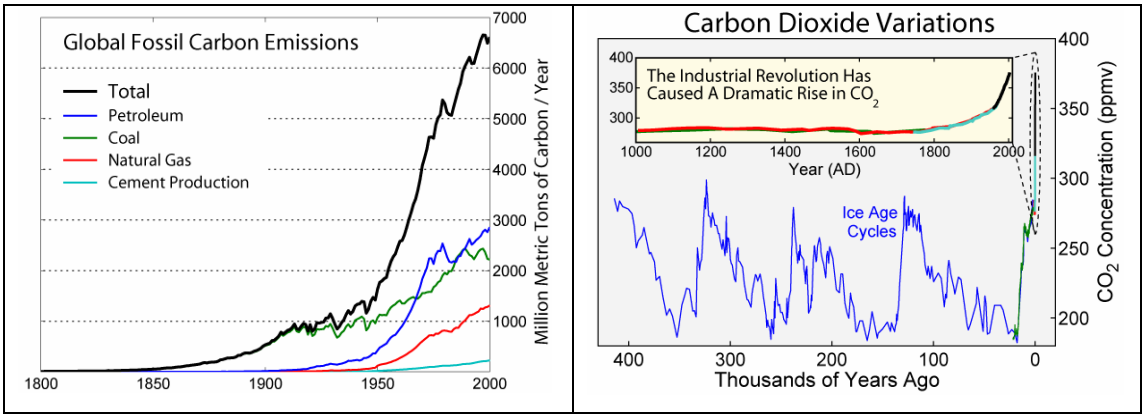

Figure 3.9 Global Fossil Carbon Emissions
Figure 3.10 Carbon Dioxide Variations
(Wikipedia, 2006a&b)

Scientists have estimated that, during the twentieth century, these emissions have caused a rise in the earth's global mean surface temperature of 0.6˚C (Boyle 2004). If these emissions are not curbed, it has been predicted that the surface temperature of the earth may rise by between 1.4 to 5.8˚C (depending on the assumptions made).

The threat of global climate change has lead to a growing consensus that reductions in these energy related emissions are now a matter of urgency. Reductions in carbon emissions to the atmosphere in the range of 60-80% may be needed by the end of the twenty-first century. A switch to low or zero-carbon energy sources such as renewables is seen by many as a priority.

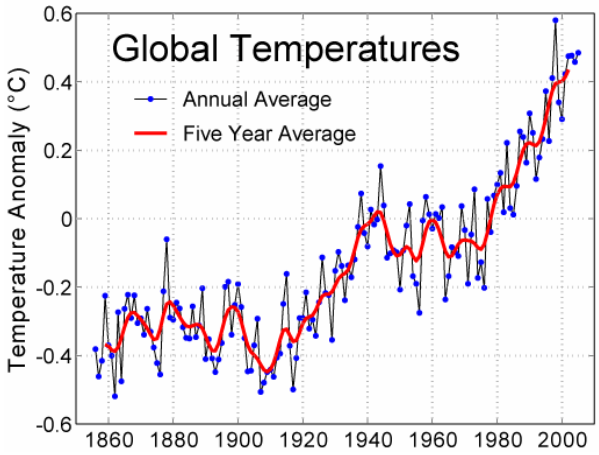

Figure 3.11 Global Temperatures over Time
(Wikipedia, 2006c)

At a UN climate conference held in December 1997, in Kyoto, Japan, the industrialised world agreed a Protocol to reduce greenhouse gas emissions. European Governments agreed to legally binding limits to the production of these polluting gases. The Kyoto agreement used 1990 as its benchmark year. In that year, Ireland produced approximately 54 million tonnes of

greenhouse gases. Since then, due mainly to significant economic growth, Irish output has increased by over 20%. At current rates, this will grow close to 40% above the 1990 figure by 2010. The commitment under the protocol was that Ireland would limit its emissions to just above 13% of our 1990 level. On this basis, we are already well ahead of this commitment (Department of the Environment and Local Government, 2000).

3.8 Summary

The majority of renewable energy sources originate from the power of the sun's radiation, in either direct or indirect form, while there are also non solar renewable energy sources such as geothermal and tidal. Renewable energy is continuous in its supply and is a sustainable source of energy. Prior to the industrial revolution which started in the late 18^{th} century, renewable energy (mostly in the form of wood energy) dominated society's energy supply. The use of fossil fuels such as coal and oil has allowed humans to grow economies at a far greater rate than previously experienced, but there are now two major issues in relation to fossil fuel use which are of great concern. The first is the finite nature of fossil fuels and the fact that at some stage in the future they will run out. The second is that the combustion of fossil fuels leads to the production of the greenhouse gas $CO_{2,}$ which is largely responsible for the phenomenon of global warming.

The world has been using ever increasing amounts of energy and this trend is set to continue with population growth and the development of emerging industrial economies. The potential for renewable energy to supply all projected energy requirements on a global basis is unlikely even in the medium term. There will be a need to reduce overall energy requirements in the running of our economies and to use energy more efficiently. In Europe, there is a drive to increase both energy efficiency and the contribution coming from renewable energy to total primary energy requirement. It has been recognised as a significant challenge and there is recognition from the European Commission that European self sufficiency will be virtually impossible to achieve.

Ireland is one of the most dependant countries in Europe on imported energy. Over 90% of our energy now comes from abroad. While there has been substantial growth of the renewable energy sector, it has been difficult to keep pace with the growth in our energy use overall during the last ten to twenty years. Renewable energy contributes only 2.2% to Total Primary Energy Requirement. However, Ireland is rich in potential and has one of the best environments in Europe for wind development. There is also substantial potential for various bioenergy crops. The challenge of developing the renewable energy sector to make a significant contribution to overall energy needs is a considerable one. It is evident, however, that the Irish Government is now taking more notice of the sector, and the recent Green Paper on Sustainable Energy (2006) has set the key goals for Ireland of energy security, environmental sustainability and competitiveness.

3.9 Sources of Further Information

World Energy Council:	http://www.worldenergy.org
International Energy Agency:	http://www.iea.org
Sustainable Energy Ireland:	http://www.sei.ie

3.10 References

Association for the Study of Peak Oil and Gas Ireland, 2007. ASPO Newsletter 74 – February 2007. Written by Dr Colin Campbell. Reproduced by kind permission.

Boyle, G., 2004. Renewable Energy, Power for a Sustainable Future. Oxford University Press, Oxford.

BP, 2003. BP Statistical Review of World Energy (Online) available at http://www.bp.com/productlanding.do?categoryId=6842&contentId=7021390, Accessed 25th October, 2006.

Davidson, O. 2002. Sustainable Energy and Climate Change: African Perspectives. In Davidson, O & Sparks, D (eds) Developing Energy Solutions for Climate Change: South African Research at EDRC. Cape Town: Energy and Development Research Centre: 145-152. (Secondary source in Energy for Sustainable Development: South African Profile (2004), Energy Research Centre, University of Cape Town.

Department of Communications, Marine and Natural Resources, 2006. Green Paper, Towards a Sustainable Energy Future for Ireland. Dublin.

Department of the Environment and Local Government, 2000. National Climate Change Strategy, Ireland. Dublin.

EurObserv'ER, 2006.6th Report, 2006, State of Renewable in Europe. EurObserv'ER, Paris.

European Commission, 1995. White Paper on Energy from Renewable Energy Sources. European Communities, Belgium.

European Commission, 2001. EU Green Paper on Security of Supply of Energy Supply. European Communities, Belgium.

European Commission, 2004. European Energy and Transport Scenarios on Key Drivers. European Communities, Belgium.

Forfás, 2006. A Baseline Assessment of Ireland's Oil Dependence, Key Policy Considerations. Forfás, Dublin.

Howley, M., O'Leary, F. and Ó Gallachóir, B., 2006. Energy in Ireland 1990 – 2005 - Trends, Issues, Forecasts and Indicators. Energy Policy Statistical Support Unit, SEI, Cork, Ireland.

International Energy Agency, 2006. Renewable In Global Energy Supply, An IEA Fact Sheet. IEA, Available at www.iea.org

McQuade, O. (Editor), 2005. Energy Ireland Yearbook 2006. Lagan Consulting, bmf Business Services, Dublin.

Sustainable Energy Ireland, 2006. Energy in Ireland 1990-2004, Trends Issues, Forecasts and Indicators. SEI Energy Statistical Support Unit, Dublin.

Twidell, J and Weir, A., 1996. Renewable Energy Resources. E & FN Spoon, London.

Wikimedia Foundation, 2006. Various pages [online]. Accessed at www.wikipedia.org in October 2007. Florida, USA.