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NDP NATIONAL DEVELOPMENT PLAN

Renewable Energy in Ireland Trends and Issues 1990 - 2002

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Energy Policy Statistical Support Unit

Renewable Energy in Ireland

Trends and Issues 1990-2002

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August 2004

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Action Renewables
the future of energy, today

Sustainable Energy Ireland

Sustainable Energy Ireland (SEI) is Ireland's national energy authority. Established on May 1st 2002 under the Sustainable Energy Act 2002, SEI has a mission to promote and assist the development of sustainable energy. This encompasses environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy. Its remit relates mainly to improving energy efficiency, advancing the development and competitive deployment of renewable sources of energy and combined heat and power, and reducing the environmental impact of energy production and use, particularly in respect of greenhouse gas emissions.

SEI is charged with implementing significant aspects of the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan.

SEI manages programmes aimed at

- assisting deployment of superior energy technologies in each sector as required,
- raising awareness and providing information, advice and publicity on best practice,
- stimulating research, development and demonstration,
- stimulating preparation of necessary standards and codes,
- publishing statistics and projections on sustainable energy and achievement of targets.

SEI is responsible for advising Government on policies and measures on sustainable energy; implementing programmes agreed by Government and stimulating sustainable energy policies and actions by public bodies, the business sector, local communities and individual consumers.

Energy Policy Statistical Support Unit

SEI has a lead role in developing and maintaining comprehensive national and sectoral statistics for energy production, transformation and end use. This data is a vital input to meeting international reporting obligations, for advising policy makers, and informing investment decisions. Based in Cork, the Energy Policy Statistical Support Unit is SEI's specialist statistics team. Its core functions are to

- collect, process and publish energy statistics to support policy analysis and development in line with national needs and international obligations,
- conduct statistical and economic analyses of energy services sectors and sustainable energy options,
- contribute to the development and promulgation of appropriate sustainability indicators.

Action Renewables

Action Renewables is a joint initiative in Northern Ireland between the Department of Enterprise Trade and Investment (DETI) and the Viridian Group. It was created in response to European, National and Northern Ireland Government commitments to renewable power as one strand of the policy to combat climate change, reduce environmental pollution and increase fuel diversity. The project was initially funded for the period July 2003 to March 2005. The Northern Ireland Electricity (NIE) Eco Energy Fund and the Northern Ireland Housing Executive have also contributed funding to the Community Action Renewables programme.

Action Renewables objectives are to significantly raise awareness of the potential consequences of climate change, to stimulate awareness of the issues associated with conventional energy use and to promote renewables generally in the context of a possible solution. Action Renewables will also provide active support for developers of renewable energy based projects, and provide and publish information and research material to facilitate the development of the most effective renewable energy projects.

In 2003 - 04 the framework for the action plan comprised four distinct work areas: awareness raising, support and information provision, conferences and events and the publication of relevant reports and research material.

Highlights

Energy Consumption and Emissions In Ireland

- Over the period 1990 - 2002, the average annual growth rate of energy consumption in Ireland was 3.8%, largely attributed to an average annual economic growth rate of 7.1%.
- Energy consumption in 2002 and 2003 remained at 2001 levels despite economic growth of 10% over this two year period.
- Greenhouse gas emissions in Ireland reached 31% above 1990 levels in 2001 and have reduced since then to 25% above 1990 levels.
- In 2002, oil accounted for 56% of Ireland's primary energy consumption, followed by natural gas (23%), coal (13%), peat (6%) and renewable energy (2%).

Renewable Energy In Ireland

- Renewable energy accounted for 1.9% of Ireland's 2002 primary energy requirement compared with 1.8% for 1990. The EU White Paper target is to achieve a 12% contribution EU - wide from renewables to TPER by 2010.
- In absolute terms the primary energy for renewable energy grew from 168 ktoe in 1990 by over 71% (4.9% per annum) to 288 ktoe in 2002. There was a 10% increase in the year 2002, compared with 2001 figures.
- The *primary energy equivalent* for wind and hydro represents the amount of energy that would be necessary to generate an identical amount of electricity in conventional power plants. The primary energy equivalent for renewable energy in 2002 was 441 ktoe, 53% higher than the primary energy from renewables.
- Based on the primary energy equivalent approach, it is estimated that the amount of CO_2 emissions avoided by renewable energy in Ireland was 1.5 Mt in 2002, compared with 1.0 Mt in 1990.
- Renewable energy accounted for 5.3 % of Ireland's gross electricity consumption in 2002 compared with 4.9 % in 1990. The share dropped in 2003 to 4.0% due to reduced hydro output associated with low rainfall levels.
- Renewable energy accounted for 3.2 % of Ireland's thermal energy consumption in 2002 compared with 2.6 % in 1990, due to the increase in solid biomass consumption compared with lower growth rates in overall thermal energy consumption.
- Ireland's trend in the contribution of renewable energy to TPER and electrical consumption is quite low compared to many other industrialised counties and in particular the EU - 15 average. The trends are increasing slightly and further increases are anticipated as additional wind power comes online.
- Based on the amount of additional AER V and AER VI capacity and current status of grid connection agreements, it appears likely that the Green Paper 500 MW target will be met by 2007 (i.e. during 2006) rather than by 2005.
- Based on the current deployment rates it is anticipated that the share from renewables of gross electricity consumption will reach between 6% and 7%, at most, in 2005.

Highlights

Biomass

- Biomass remains the most significant renewable energy resource in Ireland, accounting for 61% of primary energy for renewables in 2002.
- The largest biomass source, solid biomass, increased from 105 ktoe in 1990 to 152 ktoe in 2002, an increase of 44% (3% per annum). The bulk (72% in 2002) of solid biomass is consumed in the wood industry and the remainder in the residential sector.
- Biogas is currently produced at 4 sites in the food industry in Ireland, with a small contribution from anaerobic digestors at sewage treatments plants and on farms. Biogas production increased from 2.3 ktoe to 4.3 ktoe between 1990 and 2002, an increase of 89% (5.4% per annum).
- The electrical output from landfill gas has increased from 0 ktoe in 1995 to 7 ktoe in 2003 with a peak of 11.8 ktoe in 1999.

Hydropower

- Total installed capacity of hydropower was 240 MW in 2003, an increase of 6.2 MW on 1990 (2.7%).
- The main reason for annual changes in renewable generated electricity is associated with variations in rainfall levels. Electricity generation from hydropower increased by 53% in 2002 compared with 2001 levels and subsequently decreased in 2003, also by 53%.
- The contribution that hydropower made to the total amount of electricity consumed has fallen from 4.9% to 2.2% over the period 1990 to 2003.

Wind

- By August 2004, there were 37 wind farms operational in Ireland, with a combined installed capacity of 229 MW (including a 25 MW off-shore plant). There are a further 259 MW under construction, emphasising the recent rapid acceleration in deployment.
- In addition to operational wind farms, there are connection agreements in place for 594 MW, live offers totalling 39 MW, 1369 MW of applications being processed and 271 MW of applications that are being checked by ESB National Grid (ESBNG).
- The electrical output from wind energy in 2003 was 454 GWh an increase of 17% on 2002.
- The contribution from wind to gross electricity consumption has risen from 0% to 1.5% over the period 1992 to 2002.

View from Northern Ireland

- Total Primary Energy Requirement (TPER) in Northern Ireland in 2002 was 4.9 Mtoe.
- Renewable energy electricity generation in 2002 made up a small percentage of TPER with 9.8 ktoe (0.2%).
- Total final consumption in 2002 was 3.4 Mtoe.

Table of Contents

List of Figures

List of Tables

1 Introduction

The purpose of this report is to inform deliberations relating to a number of key developments[1] currently underway in Ireland, namely the

- extensive review of renewable energy policy by the Department of Communications, Marine and Natural Resources,
- establishment of an All-Ireland Energy Market Development Framework,
- work of the Renewable Energy Development Group,
- work of the Bioenergy Strategy Group,
- development by the Commission for Energy Regulation (CER) of the new Market Arrangements for Electricity[2].

While informing current deliberations, the report compiles a comprehensive dataset and accompanying analysis of renewable energy in Ireland. It places some of this data in the public domain for the first time.

The report documents the contribution of renewable energy to Ireland's energy supply over the period 1990 to 2002, identifying and discussing the trends that have occurred. More recent data has been included where possible.

Renewable energy consumption is assessed both generally and in terms of individual renewable energy sources and technologies. The year 1990 is significant, not least because, Ireland's targets under the Kyoto Protocol as well as a number of EU Directives are referenced against that year.

Renewable energy is defined by the International Energy Agency (IEA)[3] as *"energy derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources".*

This distinguishes renewable energy sources from fossil fuels (coal, oil and gas, and particularly in the case of Ireland, peat) and uranium (nuclear energy), which are finite resources that are not replenishable at the same rate as they are consumed and will therefore eventually run out.

It is important to distinguish between renewable energy technologies that generate electricity, thermal (heating and cooling) energy and transport energy. These are essentially three separate modes, representing three different markets with their own separate dynamics. Table 1 provides an overview of the different renewable energy technologies, currently used in Ireland, grouped according to the mode they principally operate within.

The report is structured as follows:

- Section 2 provides the context for renewable energy development, examining recent energy trends and the impacts relating to the environment and security of supply.
- Section 3 explores the major policy developments in the area of renewable energy at an international, European and national level.
- Section 4 analyses the total contribution made by renewable energy to meeting Ireland's needs for electricity, thermal energy and transport. It also introduces the *primary energy equivalent* for renewables and links it to avoided CO_2 emissions through fossil fuel displacement.
- Section 5 assesses recent energy production trends for individual renewable energy sources and technologies.
- Section 6 provides a view from Northern Ireland on renewable energy.
- Section 7 compares renewable energy developments in Ireland since 1990 with trends internationally, and places it within the context of current and future targets.

Table 1: Renewable Energy Technologies Currently used in Ireland Grouped by Energy Mode

Renewable Energy	Sources Renewable Energy Technologies by Mode		
Sources	**Electricity**	**Thermal**	**Transport**
Wind Energy	Wind Energy		
Biomass	Landfill Gas, Solid Biomass,	Solid Biomass Biogas	Biofuels
Solar Energy	Photovoltaic (PV)	Solar Thermal	
Hydropower	Hydropower		
Ambient Energy		Ambient Energy	

[1] Further information on these initiatives is available from the Department of Communications, Marine and Natural Resources website at www.dcmnr.ie

[2] The specific aspects relating to renewable energy are contained within: *CER (2004) Implementation of the Market arrangements for Electricity in relation to CHP, Renewable and Small - scale Generation*. In addition, SEI has commissioned a study on this issue, which is due for publication in quarter 3, 2004.

[3] IEA Renewable Energy Working Party (2002) *Renewable Energy - into the Mainstream.*

2 Context for Renewable Energy Deployment

This section provides the energy context within which renewable energy trends are assessed. It draws on trends in primary energy supply, final energy demand and modal energy shifts in the period 1990 - 2002. These trends are discussed in more detail in a separate SEI publication[4], but more recent data has been included here, where possible.

2.1 Energy Supply

Ireland's total energy supply is discussed in terms of changes to the total primary energy requirement (TPER)[5], also known as gross inland consumption. TPER represents the consumption of energy by all five sectors of the Irish economy, namely industry, transport, commercial and public services, residential and agriculture. TPER includes the energy consumed in conversion processes such as electricity generation and oil refining.

Figure 1 illustrates the trend in energy supply over the period 1990 - 2002, indicating the overall growth pattern and the contribution of individual fuels to gross energy consumption.

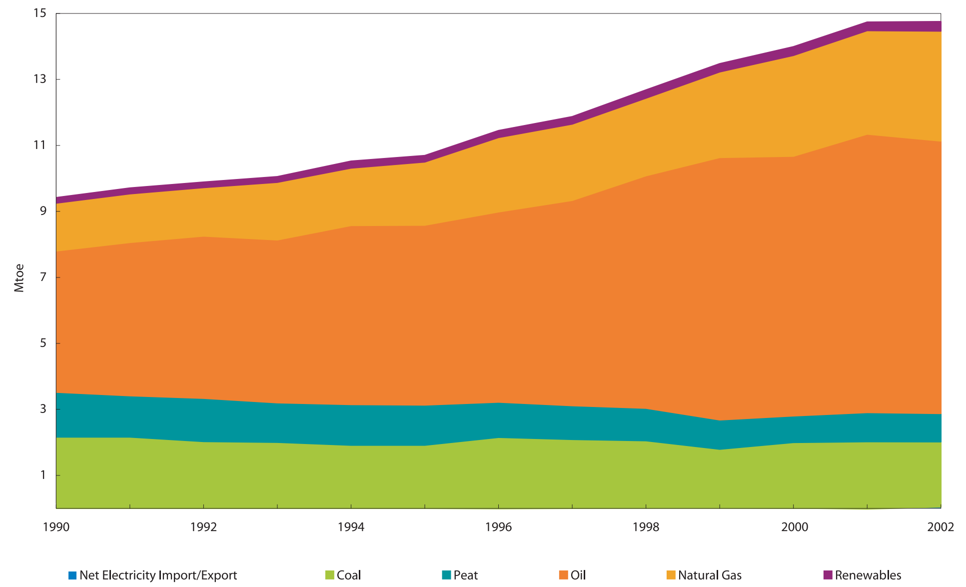
The small contribution from renewable energy sources to Ireland's primary energy supply is clearly illustrated in figure 1. Although annual average growth in renewable energy was 4.9% (based on an absolute growth of 71% over the period 1990 - 2002) the contribution of renewable energy to TPER increased only slightly from 1.8% in 1990 to 1.9% in 2002. The energy supply fuel mix has changed considerably over the period 1990 - 2002, due to varying levels of growth of individual fuels. Natural gas has increased considerably with an annual average growth of 7.2% (absolute growth over the period 131%), as has oil, with an annual growth rate of 5.6% (93% absolute growth). On the other hand, there have been considerable reductions in energy from solid fuels. Peat consumption has decreased at an average annual rate of 3.8% (37% absolute reduction) and coal has reduced by 0.8% per annum (8.7% absolute reduction).

The significant recent increase in energy consumption in Ireland is also clearly visible in figure 1. Over the period 1990 - 2002, the average annual growth rate was 3.8% (based on 57% growth in absolute terms). This growth is largely attributed to the levels of economic growth[6], achieved over the period. The average annual economic growth rate was 7.1% (based on 128% growth in absolute terms).

The year 2002 was interesting in that energy consumption was almost constant (0.1% growth compared with 2001), despite economic growth of 6.9%. This represents a significant decoupling of energy consumption from economic growth. This was attributed to a number of factors[7], namely

- an increase in electricity generation efficiency[8],
- reduced energy consumption in industry[9],
- a reduced space heating requirement[10].

Figure 1: Total Primary Energy Requirement by Fuel 1990 - 2002



Source: SEI

[4] SEI (2004) *Energy in Ireland - Trends, issues and indicators 1990 - 2002.*
[5] TPER is defined as the total amount of energy consumed in a given year
[6] Measured in terms of Gross Domestic Product (GDP).
[7] See *Energy in Ireland - Trends, issues and indicators 1990 - 2002* for more details.
[8] Due to new high efficiency plant, an increase in electricity imports and changes in the fuel mix
[9] Due in part to the closure of energy intensive plant.
[10] There was a reduction of 8.4% in the number of heating degree days (measure of heating requirement) in 2002 compared with 2001.

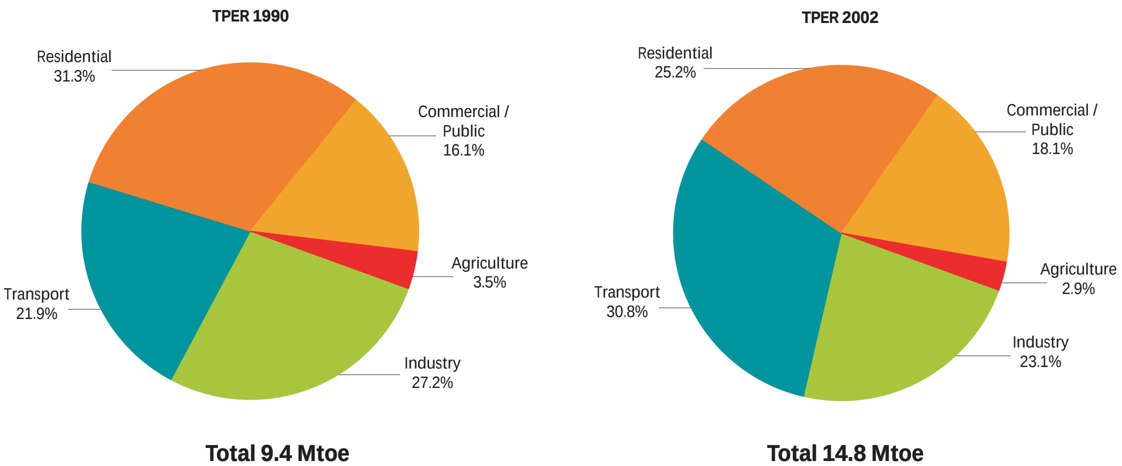
The growth in energy consumption has varied across the different sectors of the economy and this is evident from the changing sectoral shares shown in figure 2.

In 1990, the residential sector accounted for the highest share (31%) of energy consumption followed by industry (27%), transport (22%) and the commercial and public services sector (16%). Only transport and the services sector increased their percentage shares over the period and by 2002 transport accounted for a greater share of energy consumption than either industry or the residential sector. In 2002, 31% of energy consumption was associated with the transport sector, 25% with the residential sector, 23% with industry and 18% with the services sector.

The changing shares arise from differing rates of energy consumption growth across the sectors. While all sectors recorded an increase, the largest increase was in the transport sector (120% absolute, or 6.8% per annum). The services sector followed (76% absolute, or 4.8% per annum), then industry (33% absolute, or 2.4% per annum), agriculture (27% absolute, or 2% per annum) and finally the residential sector (26% absolute, or 1.9% per annum).

In addition to fuel and sectoral breakdowns of energy supply, it is important to understand what the energy is used for, namely thermal energy (for heating and cooling), electricity (power) or as mobility (transport). As shown in table 1, different renewable energy technologies are associated with each of these modes of energy usage. Wind energy is principally used to produce electricity, for example, whereas solar energy is largely used for heat generation. Targets set for renewable energy are also linked to the different modes of usage, within for example EU Directives relating to electricity from renewable energy and to biofuels contributing to the transport energy mode.

Figure 2: Total Primary Energy Requirement by Sector 1990 and 2002



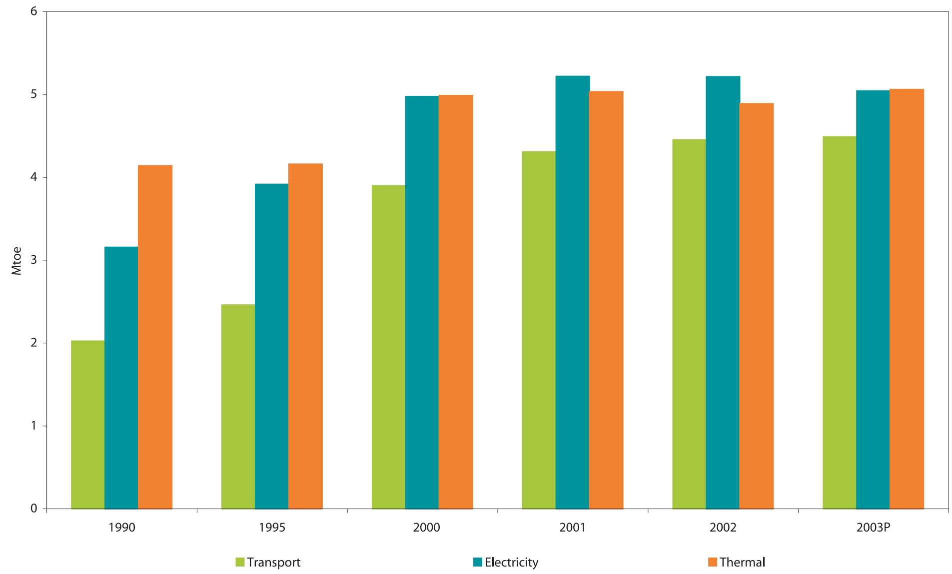
Source: SEI

Figure 3 shows the allocation of Ireland's primary energy to each of the three modes and illustrates the growth of transport and electricity, relative to thermal energy.

2.2 Energy Demand

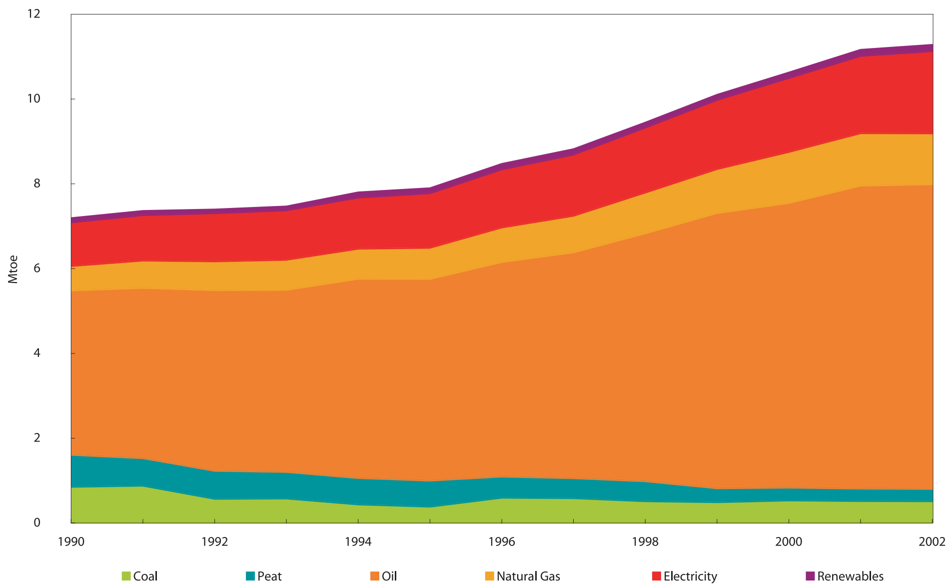
Final energy demand[11] is a measure of the energy that is delivered to energy end users in the economy to undertake activities as diverse as manufacturing, movement of people and goods, essential services and other day-to-day energy requirements of living. This is also known as Total Final Consumption (TFC) and the changes in TFC by fuel over the period 1990 - 2002 are shown in figure 4.

Figure 3: Total Primary Energy Requirement by Mode 1990 - 2003



Source: SEI

Figure 4: Total Final Consumption by Fuel 1990 - 2002



Source: SEI

[11] Essentially the total primary energy requirement less the quantities of energy used to transform primary sources such as crude oil into forms suitable for end use consumers such as refined oils, electricity, patent fuels etc. (Transformation, processing or other losses entailed in delivery to final consumers are known as "energy overhead".)

Ireland's TFC in 2002 was 11.3 Mtoe, an increase of 1% on 2001 and 3.8% per annum on average since 1990 (absolute growth of 57%). The 2002 increase in final consumption (1%), although small, is significant given that primary energy consumption increased by only 0.1%. This again points to the impact of increased electricity generating efficiency during the year.

Natural gas has shown the highest growth over the period with a 6.3% average annual growth (absolute growth of 108%). Final consumption of electricity and oil increased over the period by 5.4% and 5.3% per annum on average (or 88% and 85% in absolute terms) respectively. Renewable energy consumption increased by 43% but there was a slight decrease in the contribution of renewable energy to TFC from 1.5% in 1990 to 1.4% in 2002.

It is important to note that the renewable energy share of TFC here includes only those renewables contributing directly to final thermal energy consumption, namely solid biomass, solar thermal energy, geothermal energy, biogas and biofuels. The electricity generated from the other renewable energy technologies (wind, hydro and landfill gas) is included within the *electricity* portion of TFC, rather than under the *renewable energy*, in line with international convention.

Finally, consumption of peat and coal by final customers declined by 7.6% and 4.2% per annum on average (40% and 61% in absolute terms) respectively.

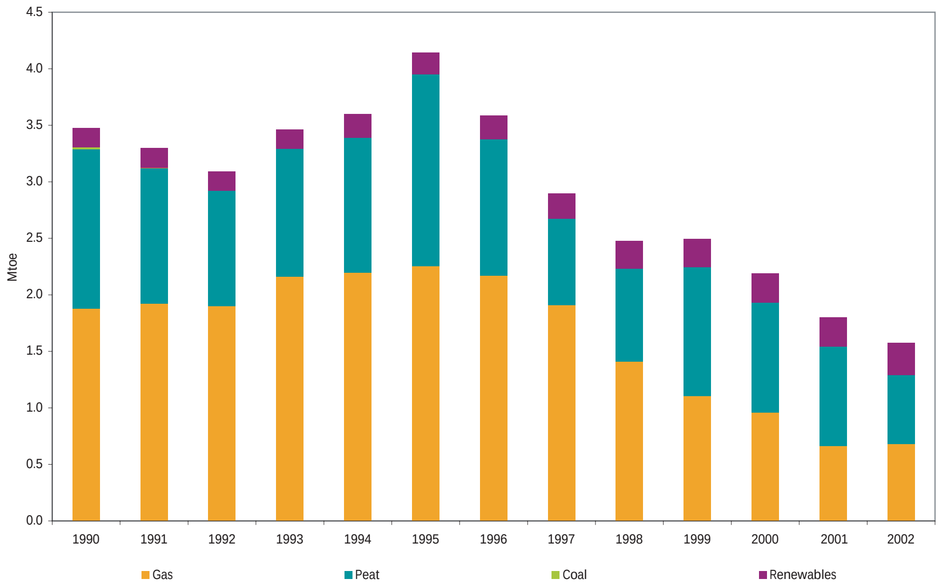
2.3 Security of Supply

One of the key features of renewable energy is the indigenous[12] nature of the energy source in contrast to fossil fuels most of which are imported into Ireland. This factor (in addition to the inexhaustible nature of the resource) enables renewable energy to contribute to security of energy supply, because energy supply from renewable sources is not exposed to the same price or supply disruption risks that are associated with oil and gas.

Figure 5 shows the indigenous supply fuel mix in Ireland for the period 1990 - 2002. An interesting feature is that renewable energy is the only indigenous energy to have increased over the period. Renewable energy has consequently increased its contribution to the indigenous fuel mix from 5% in 1990 to 18% in 2002. The contribution from natural gas has dropped from 54% to 43% with the reduction in output from the Kinsale gas field and peat's share has decreased from 41% to 39%.

The overall reduction in indigenous energy supply coupled with the increase in energy consumption discussed in section 2.1, have resulted in Ireland's energy import dependency increasing from 65% in 1990 to 89% in 2003, as shown in figure 6. This trend contrasts with that for the EU 15, where import dependency has remained at between 45% and 50%. 2003 data is provisional.

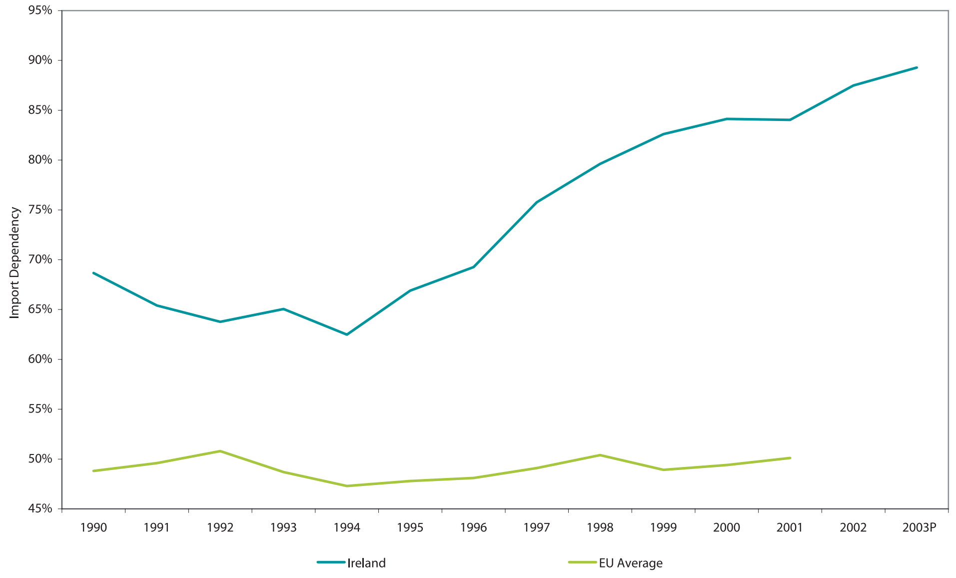
Figure 5: Indigenous Energy by Fuel 1990 - 2002



Source: SEI

[12] There may be instances where renewable energy is imported, as in the case of certain biofuels for example, but for the most part renewable energy consumed in Ireland is produced in Ireland.

Figure 6: Import Dependency of Ireland Compared with EU 15 1990 - 2003



Source: SEI and Eurostat

2.4 Environmental Impact

One of the key drivers underpinning the increase in renewable energy in Ireland is the associated reduction in environmental impacts of energy consumption. The combustion of fossil fuels to release their energy results in the emission of carbon dioxide (CO_2) and other pollutants, for example sulphur dioxide (SO_2) and nitrogen oxides[13] (NO_x). By displacing fossil fuels with renewable energy, the environmental impacts associated with energy consumption can be reduced[14].

The increase in energy consumption in Ireland since 1990 has resulted in a significant increase in energy related greenhouse gas emissions, as shown in figure 7. The recent reduction in emissions is also energy related, associated with improved efficiency, the closure of a number of large energy consumers and to a lesser extent, the increased penetration of renewable energy.

The emissions in figure 7 are grouped according to the individual source, including land use change and forestry, energy, industrial processes (including cement production), solvent and other product use, agriculture and waste. Increases in forestry cause a reduction in emissions and hence appear as a negative in the graph.

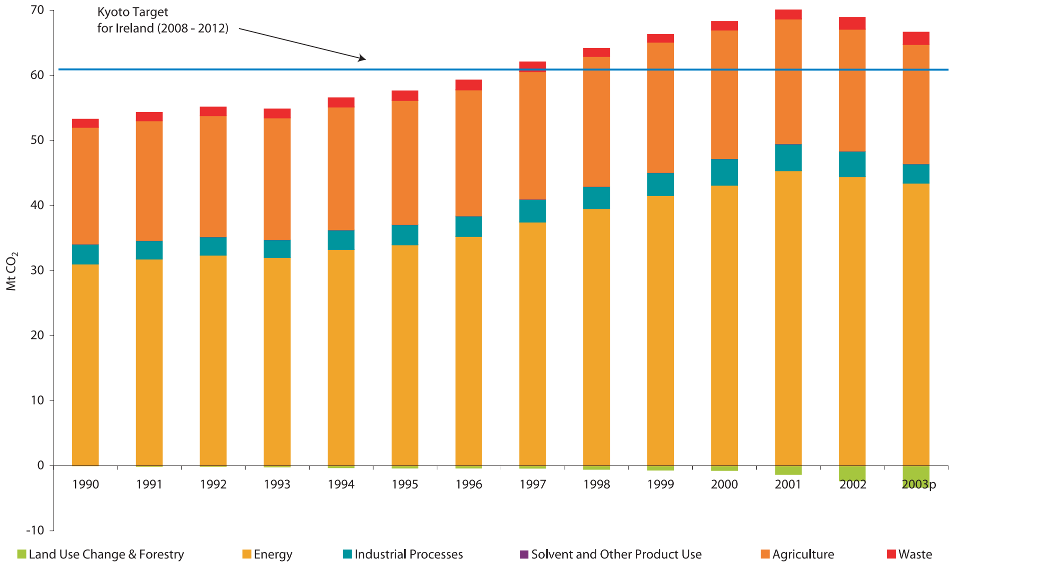
As can be seen from figure 7, Ireland's target for the period 2008 - 2012 under the Kyoto Protocol was reached in 1997. By 2001, emissions levels reached 31% above 1990 levels, followed by a reduction in emissions in 2002 and 2003. Based on provisional data, Ireland's GHG emissions in 2003 were 24.7% above 1990 levels. Given that energy consumption in 2002 and 2003[15] remained at 2001 levels, this constitutes a significant decoupling of emissions growth from energy growth. It is largely attributed to fuel mix changes associated with the increased consumption of gas and renewable energy, which are less carbon intensive than oil and the solid fuels.

[13] Collective term for nitric oxide (NO) and nitrogen dioxide (NO_2).

[14] Biomass combustion will, of course, cause the release of harmful emissions but it is considered "carbon neutral" because the CO_2 released during the generation of energy from biomass is balanced by that absorbed by the plants during its production. In the case of landfill gas the emissions released from burning the gas is less harmful that the CH_4 (methane) that would be otherwise released.

[15] Based on provisional data.

Figure 7: Greenhouse Gas Emissions in Ireland 1990 - 2003



Source: EPA[16]

Sections 2.1 to 2.4 indicate a general trend of growing energy consumption, an associated increase in energy related emissions and in import dependency. It is in this context that renewable energy policies and trends are assessed in this report.

[16] EPA (2003) *Ireland National Greenhouse Gas Inventory Report.*

3 Policies Underpinning Renewable Energy

3.1 Global Energy Developments

Prior to the industrial revolution, global energy supply was based entirely on renewable resources. Thermal energy was provided by wood, transport energy was provided entirely by renewable sources from humans, animals, and the wind (at sea), watermills and windmills provided our mechanical energy requirements for milling, etc.

In the mid 1800s[17], coal began to be used widely in steam engines as a transport fuel for trains and ships. It was also used to heat homes and run factory equipment and it was primarily coal that fuelled the industrial revolution. Energy consumption increased and the contribution from renewable energy decreased accordingly. Towards the end of the century the first cars were powered by electricity or steam, produced using coal. However by the beginning of the 1900s, the petrol-powered internal combustion engine had taken over. Oil then became the main rival to coal in energy supply.

By the year 1973, global energy consumption had reached 6 Gtoe[18]. The largest contribution was from oil (45%) followed by coal (25%) and then gas (16%). Renewable energy accounted for 13% of energy supply and the remaining 1% was provided by nuclear energy. The extent of oil dependence coupled with political conflicts in the Middle East resulted in a sharp increase in oil prices in 1973 and again in 1979 and supply shortages that had a dramatic impact on the global economy.

3.1.1 Security of Supply Concerns

The oil crises stimulated a shift in energy policy towards the inclusion of a goal of increasing fuel diversification. This prompted the introduction of policies both to promote energy efficiency and to encourage research into alternative energy sources. Research, Development and Demonstration (RD&D) programmes in renewable energy were initiated in a number of countries, including Ireland.

These programmes facilitated the advance of a number of renewable energy technologies, notably wind energy, but did not directly impact significantly on the contribution from renewable energy to the overall energy supply mix. In 1990, the contribution from renewable energy to global energy supply remained at the 1973 share of 13%.

3.1.2 Environmental Policy

During the 1980s, oil prices stabilised and the focus on renewable energy diminished, as evidenced in the reduced budgets available for RD&D. While concerns relating to shortages in oil supply decreased, awareness began to grow regarding the environmental impacts of our increasing energy usage, and this was to become the second driver for renewable energy development, prompting renewed interest and activity.

The first major global conference on the environment was the United Nations (UN) Conference on the Human Environment in 1972[19]. It was hosted by Sweden in Stockholm following severe damage to thousands of Sweden's lakes from acid rain arising from air pollution in Western Europe. Arising from the conference, one of the Principles of the Stockholm Declaration, an output of the conference, was that "*the Earth's capacity to produce renewable resources must be maintained*." One of the main outcomes of the event was the establishment of the UN Environment Programme (UNEP) later the same year.

Two parallel policy processes linking energy and the environment that have had a key role in stimulating renewable energy emerged following the UN Conference in Stockholm, one addressing concerns relating to air quality and the other dealing with climate change.

Air Quality

Air quality is a term used to describe issues relating to acid rain, smog and other environmental impacts (including acidification and eutrophication) largely associated with emissions of sulphur dioxide (SO_2) and nitrogen oxides[20] (or NO_x). The concerns relate back to the 1960s when scientists demonstrated the interrelationship between sulphur emissions in continental Europe and the acidification of Scandinavian lakes. Following the Stockholm conference in 1972, several studies confirmed the hypothesis that air pollutants could travel several thousands of kilometres before deposition and damage occurred. This also implied that cooperation at the international level was necessary to solve problems such as acidification.

A ministerial level meeting was held in Geneva in 1979, which was organised by the UN Economic Commission for Europe (ECE). The meeting resulted in the signature of the *Convention on Long-range Transboundary Air Pollution* by 34 Governments and the European Community (EC).

[17] Elliot (1997) *Energy, society and environment - Technology for a sustainable future*.

[18] IEA (2003) *Key World Energy Statistics*.

[19] UNEP (2002) *Global Environment Outlook 3*.

[20] Collective term for nitric oxide (NO) and nitrogen dioxide (NO_2)

The Convention entered into force in 1983 and was the first international legally binding instrument to deal with problems of air pollution on a broad regional basis. In addition to laying down the general principles of international cooperation for air pollution abatement, the Convention set up an institutional framework that brings together research and policy. By June 2004, 49 Parties had ratified the Convention.

The Convention has been extended since 1983 by eight Protocols[21], each dealing with different emissions. The key ones relating to energy being the

- *1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent,*
- *1988 Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes,*
- *1994 Oslo Protocol on Further Reduction of Sulphur Emissions,*
- *1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.*

The reduction limits for SO_2 and NO_x contained in these protocols provide a stimulus for renewable energy development.

Climate Change

A key event that linked energy trends to climate change was the first World Climate Conference in Geneva in 1979, which concluded that anthropogenic carbon dioxide emissions could have a long term effect on the climate. It lead to the establishment of the World Climate Programme, providing the framework for international cooperation in research and the platform for identifying important climate issues of the 1980s and 1990s.

Linking energy and the environment within policy debates intensified during the 1980s with the establishment in 1983 of the World Commission on Environment and Development (WCED) also known as the Brundtland Commission and the publication of the Brundtland report[22] in 1987, providing a definition for sustainable development. Another key development was the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1989 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO).

In 1992 the UN organised a Conference on Environment and Development (UNCED, also known as the Earth Summit), which was held in Rio de Janeiro. The evidence provided by the IPCC at the Summit of the threat posed by climate change, played a key role in convincing Governments to agree on the text of *the UN Framework Convention on Climate Change (UNFCCC)*. There were 166 parties to the Convention when it came into force in 1994 and by May 2004, this had grown to 189 countries.[23] The primary goal of the UNFCCC is to stabilize greenhouse gas (GHG) emissions at levels that will prevent dangerous interference with the global climate. An initial target set by the parties to the Convention was to reduce GHG emissions to 1990 levels by the year 2000. This was enhanced in 1997 through the Kyoto Protocol, whereby individual countries agreed to quantified GHG emission reductions that would result in an overall reduction for Annex 1 countries[24] of 5.2% below 1990 levels by the period 1998 - 2012.

For the Kyoto Protocol to enter into force there is a requirement that 55 parties to the UNFCCC ratify it, including a number of Annex 1 Parties accounting for 55% of that group's CO_2 emissions in 1990. By May 2004, 122 Parties had ratified the Kyoto Protocol, but only including Annex I Parties accounting for 44.2% of 1990 emissions.[25] For the Protocol to become legally binding, either Russia or the United States must ratify it.

3.1.3 Renewable Energy Policy

While the global responses to security of supply concerns and global environmental policies both acted as a stimulus for renewable energy development, it was not until the UN World Summit on Sustainable Development (WSSD) in 2002 that the development of a specific global policy for renewable energy was initiated.

The WSSD Plan of Implementation[26] states that there is a *"need to substantially increase with a sense of urgency, the global share of renewable energy sources with the objective of increasing its contribution to total energy supply"* and recognizes *"the role of national and voluntary regional targets as well as initiatives".*

Building on this negotiated outcome, 66 countries formed the Johannesburg Renewable Energy Coalition (JREC) and declared in the Johannesburg-Declaration[27] their intention to *"go beyond the (WSSD) agreement reached in the area of renewable energy".* In particular, they underlined that time-bound targets are important instruments to express a government's vision and to develop and implement integrated policies.

[21] UNECE (Various Years) *Protocols.*

[22] WCED (1987) *Our Common Future.*

[23] UNFCCC (2004) *Ratification list.*

[24] Annex 1 Parties are industrialised countries, who have historically contributed most to climate change.

[25] Ireland ratified the protocol, along with the rest of the EU, on the 31st May 2002.

[26] UN (2002) *Report of the World Summit on Sustainable Development, Johannesburg August 26 - September 4, 2002.*

[27] JREC (2004) *Information note no. 1 - Members, Objectives and Roadmap.*

By June 2004, 87 countries were represented in JREC and the momentum established continued in the build up to the International conference for renewable energy (renewables 2004) held in Bonn, Germany. The outcome of this event was the adoption of [28]

- a political declaration containing shared political goals for an increased role of renewable energies,
- an international action programme comprising 1970s[29] concrete actions and commitments by governments and other actors,
- policy recommendations for renewable energies based on experiences and lessons learnt from policies, programmes, projects and other initiatives in the public and private sectors worldwide.

3.2 European Renewable Energy Policy

The European Union has a long history of promoting renewable energy and has provided financial support for research and technological development since the 1970s, through a number of energy programmes, including

- Energy Demonstration Programme of the 1980s,
- EU 3rd Framework Programme - JOULE and THERMIE (1990 - 1994),
- EU 4th Framework Programme - Non-Nuclear Energy (1995 - 1998),
- EU 5th Framework Programme - ENERGIE (1999 - 2002),
- EU 6th Framework Programme - Sustainable Energy Systems (2003 - 2006).

In addition to support for technology research, the EU has also funded programmes that address the non-technical barriers to increased renewable energy deployment including measures to increase awareness, develop and deliver educational and training tools, innovative financing mechanisms and improved spatial planning techniques. These have largely been funded under the ALTENER (1992 - 1997), ALTENER II (1998 - 2002) and the ALTENER III (2003 - 2006) programmes, the latter forming one of four fields within the EU Intelligent Energy - Europe (EIE) Programme.

3. 2.1 Key Policies

In addition to funding technological development, the EU has increasingly integrated renewable energy policies into the overall energy policy framework. The European Council listed the promotion of renewable energy sources among its energy priorities[30] as early as 1986.

The European Commission's first step towards a strategy for renewable energy was the adoption of a Green Paper on Renewable Energy[31] in November 1996. It was, designed to stimulate debate on *"the most urgent and most important measures relating to renewable sources of energy, identifying the objectives, the obstacles and the means to be deployed".*

Following receipt of more than 70 detailed written responses to the Green Paper and a twelve month period of consultation, the European Commission published *Energy for the Future: Renewable Sources of Energy White Paper for a Community Strategy and Action Plan* in November 1997[32]. A key element of this White Paper was the ambitious but realistic objective of doubling the contribution of renewable energy to the EU primary energy supply from 6% to 12% by 2010.

The European Council Resolution on the White Paper agreed "*that there is need to promote a sustained and substantially increased use of renewable sources of energy throughout the European Union*", welcomed "*the general thrust*" and considered that the 12% target "*provides useful guidance for increased efforts at Community level as well as within Member States".*

In addition to setting an overall target of 12% target, the White Paper detailed the expected contribution from each renewable resource separately and detailed the role of renewables in the individual electricity, transport and thermal energy markets. Two further important legislative changes since 1997 have strengthened the renewables targets in the electricity and transport modes.

The target and strategy for the contribution of renewable energy to the electricity market was further developed in 2001, with the publication of the EU Renewable Energy Directive[33]. In this Directive indicative targets for each Member State are provided for the contribution of renewable generated electricity to gross electricity consumption[34] by 2010. These targets are consistent with the indicative target contribution of 22.1% to electricity

[28] The conference outcomes are available from http://www.renewables2004.de/en/2004/outcome.asp

[29] IEA (2004) *Renewable Energy - Market and Policy Trends in IEA Countries.*

[30] European Council (1986) *New Community Energy Policy Objectives for 1995 and Convergence of the Policies of the Member States.*

[31] European Commission (1996) *Energy for the Future: Renewable Sources of Energy Green Paper for a Community Strategy.*

[32] European Commission (1997) *Energy for the Future: Renewable Sources of Energy: White Paper.*

[33] European Union (2001) *Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market.*

[34] Gross electrical consumption is defined as the total amount of electricity generated before losses any are taken into account (excluding generation from pumped storage) plus electricity imported minus electricity exported.

consumption for the EU as a whole, which in turn is consistent with the White Paper target contribution of 12% to overall primary energy consumption.

Regarding renewable energy use in the transport energy market, the EU Biofuels Directive[35] aims to promote "*the use of biofuels or other renewable fuels to replace diesel or petrol for transport purposes in each member state*". It stipulates that Member States "*should ensure a minimum proportion of biofuels and other renewable fuels is placed on their markets, and, to that effect, shall set national indicative targets.*" The Directive establishes a reference value of 2% for 2005 and 5.75% for 2010 and Member States were required to set the national indicative target with respect to the first phase by July 1st, 2004.

3.2.2 Other Policies Supporting Renewable Energy Indirectly

The European Union (EU) and its Member states are signatories to the Kyoto Protocol, which requires reductions in emissions of greenhouse gases by specific amounts over a period from 2008 to 2012 and beyond. The EU committed in Decision 2002/385/EC[36] to an average reduction of greenhouse gas emissions by 8% below 1990 levels. Europe's climate change policies and targets act as a key driver for renewable energy policy.

The EU Green Paper[37] on Security of Energy Supply in 2001 reiterated the importance of renewable energy and links it to climate change policies as follows:

"With regard to supply, priority must be given to the fight against global warming. The development of new and renewable energies (including biofuels) is the key to change".

There are a number of other EU energy and environment policies that affect the deployment of renewable energy within the EU. A full review of these goes beyond the scope of this document but the following list provides an indication of the amount of policies and legislation impacting on this area.

- Directive 2002/91/EC on the energy performance of buildings, supporting among others the application of renewable heating applications,
- Directive 2003/96/EC on taxation of energy products and electricity, specifying minimum tax rates and allowing for tax exemption of energy products and electricity from renewable sources,
- Directive 2004/8/EC on the promotion of high-quality CHP in the internal market, providing possibilities to support the use of CHP from renewable sources,
- Directive 2003/54/EC on the completion of the internal energy market in the European Community, aiming at achieving full competition in the European electricity production and supply market in 2004. It furthermore requires electricity companies to disclose the fuel mix as well as the environmental quality of their electricity supplies,
- Directive 2003/87/EC establishing a greenhouse gas emissions trading system that will result in a clear and transparent carbon market price, thus lowering the price gap between conventional fuels for power production and renewables,
- Directive 2001/80/EC, the 'Large Combustion Plant Directive' limiting pollutant emissions from combustion plants larger than 50 MW rated thermal input, resulting in a small cost increase in the costs of conventional fuelled electricity,
- Directive 96/61/EC concerning integrated pollution prevention and control, also likely to result in small cost increases for conventional power, therewith positively affecting the competitive position of renewables,
- EU State Aid guidelines for environmental protection, allowing direct support for investments in renewable energy and other environmentally beneficial projects,
- EU Competition guidelines, requiring Member States to prevent and restrict distortion of competition within the common market, specifically the use of resources,
- EU enlargement, possibly resulting in new opportunities for exploitation of renewable energy resources, specifically for bio-energy,
- Common Agricultural Policy (CAP) reform, including a proposal to introduce direct support schemes for producers of energy crops,
- Framework Waste Directive 91/692/EEC, requiring intensified actions for recycling and re-use of products, and setting a legal requirement to the preference of waste incineration with energy recovery over land filling waste streams. Therewith it inevitably will result in fewer opportunities for landfill gas and increase of energy production from waste.

It is also worth noting that the European Commission is monitoring the progress on achieving indicative renewable electricity targets at Member State level, possible harmonisation of promotion policies and specification of future (2020) targets.

[35] European Union (2003) *Directive 2003/30/EC of the European Parliament and of the Council on the Promotion of the Use of Biofuels or Other Renewable Fuels for Transport.*

[36] European Union (2002) *Decision 2002/358/EC on an EU Burden Sharing Agreement.*

[37] European Union (2001) Green Paper *Towards a European Strategy for the Security of Energy Supply.*

3.3 Irish Policy

As in most countries, initial support for 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 late 1970s. The overall trend of Government RD&D expenditures for renewables peaked in the early 1980s and declined notably after 1983, with no significant funding between 1990 and 2001[38]. Biomass R&D received the highest level of funding securing approx €1.5m in the 1974 - 2002 period.

The late 1980s and early 1990s saw organic growth of biomass and small hydropower development, the latter supported by EU Energy Demonstration and later THERMIE support.

3.3.1 Renewable Energy Policies

In 1993, the Irish Government committed to achieving an additional 75 MW installed capacity from renewables and CHP by 1997 and launched a competition in 1994 to secure this target. The Alternative Energy Requirement (AER) competition set individual targets for different renewable resources and required ESB to pay a fixed price (linked annually to the consumer price index) per unit electricity for successful projects. The subsidy relative to the best new entrant (BNE) price for electricity is then recovered by ESB[39] through a public service obligation (PSO) imposed on all electricity consumers. The AER I power purchase agreements between ESB and the project were of 15 years duration and proposers were invited to compete based on the level of grant aid sought. The results were announced in 1995 and a review of strategy was undertaken in parallel. A total of 22 projects were commissioned under AER I, with a combined total installed capacity of 70.62 MW, of which 60 MW was associated with renewable energy projects, the remainder being CHP.

Arising from the interest shown in biomass energy projects in AER I, a second competition, AER II, was launched in December of the same year with the goal of supporting a single project of up to 30 MW electricity generating capacity. Given that a number of AER I proposers had bid negative grant aid, the competitive focus shifted from grant support to the electricity price. The European Regional Development Fund (ERDF) capital grant was fixed and proposers competed on price, subject to a price ceiling. The winning applicant proposed to build, own and operate a 30 MW plant at a site in north Dublin but the project did not proceed.

The first policy document on renewable energy in Ireland was published in 1996 and was entitled *Renewable Energy - A Strategy for the Future*[40]. The strategy set a target of an additional 100 MW of installed capacity using renewable energy sources by the end of 1999. The support mechanism employed to achieve this target was additional AER competitions, characterised by fixed capital grant support, similar renewable energy technologies competing in their own bands on the basis of price, subject to ceilings. In addition, the strategy proposed an additional 300 MW target for wind energy in the period 2000 - 2010 and 10 MW for hydropower. Market access was guaranteed to EU THERMIE funded projects through a 15 year power purchase agreement with ESB and a tax incentive to encourage increased investment in renewable energy. Regarding the latter, section 62 of the 1998 Finance Act allowed for tax relief for investment in renewable electricity generation. Corporations could invest their profits as equity in new renewable energy projects and enjoy tax relief on investments capped at the lesser of 50% of the project investment or €9.52m.

AER III was launched in 1997 to deliver the further 100 MW renewable energy installed capacity by the end of 1999. A number of projects were delayed and some failed to secure planning permission. By the end of 2001, AER III renewable energy projects with a combined installed capacity of 42 MW were commissioned.

In 1999, the second significant Government policy document was published, the *Green Paper on Sustainable Energy*[41]. The Green Paper set a new renewable energy target, namely, the installation of an additional 500 MW of electricity generating capacity from renewable sources by 2005. It was envisaged that this would increase the percentage of electricity generated from renewable sources from 6.3% in 2000 to 12.4% by 2005 and increase the percentage of Total Primary Energy Requirement (TPER) to be derived from renewable sources from 2% in 2000 to 3.75% by 2005.

In addition, the Green Paper committed to

- the establishment of a Renewable Energy Strategy Group to review and report on the deployment constraints facing renewables, with an initial focus on wind energy, anticipated to deliver the bulk of the 500 MW target,
- continued guarantee of market access to renewable energy demonstration projects supported by the EU 5th Framework Programme,

[38] IEA (2004) *Renewable Energy - Market and Policy Trends in IEA Countries.*

[39] The Electricity Supply Board (ESB) is the state owned electricity utility in Ireland.

[40] Government of Ireland (1996) *Renewable Energy A Strategy for the Future.*

[41] Government of Ireland (1999) *Green Paper on Sustainable Energy.*

- €47m for infrastructural investment in the electricity network to accommodate renewable energy, for small scale renewables projects and for CHP projects,
- €51m for energy research, development and demonstration.

The full remit of the Ministerial appointed Renewable Energy Strategy Group was to develop an integrated strategy addressing the significant technical and non-technical barriers that faced wind energy. This strategy was articulated in the report published by the Group in 2000[42].

The principal conclusion of the Group was that three key elements, Electricity Market, Electricity Network and Spatial Planning, need to be integrated into a plan led approach to wind energy deployment. This approach sees spatial planning considerations as crucial in determining suitable areas where wind farms may be accommodated. These decisions should be informed by the availability of the resource (wind), the strength of the electricity networks and landscape and other planning considerations. The locations thus identified should then determine the appropriate grid infrastructure required. Within the context of the agreed planning framework, the market mechanisms chosen should aim to minimise the cost of achieving the target deployment of wind energy.

A number of key recommendations outlined in the Group's report were incorporated into energy policy and addressed a number of key barriers

- securing of planning permission became a prerequisite for entering the AER V and AER VI competitions, thus addressing the mismatch in AER III between projects with planning and those with guaranteed market access,
- the project and ownership cap sizes of previous rounds that restricted large scale wind farms were removed from AER V and VI,
- a Grid Upgrade Programme for Renewable Energy was established to facilitate wind farm grid connection where bottlenecks exist. The Programme establishes a mechanism to address the challenge that existed for developers where they must raise the entire capital expenditure for any upgrade forming part of a potentially shared connection with money subsequently remitted as others connect to the facility,
- areas deemed preferred, open for consideration and no-go, with respect to wind energy development have been identified by a number of local authorities providing clarity and removing a level of uncertainty associated with the planning system. The recent publication by the Department of the Environment, Heritage and Local Government (DEHLG) of *Draft Planning Guidelines on Wind Energy Development*[43] has further clarified the process.

The net result of these policies has been an accelerated level of wind energy activity in Ireland. Planning is no longer a barrier to wind energy deployment in Ireland, as evidenced by the number of wind farms with planning permission, (2004 MW in November 2003[44]). However, the challenge of designing an appropriate and effective market support remains significant, as does integration into the electricity grid.

The AER V call for tenders for 255 MW of new renewable generating capacity was launched in May 2001 and results were announced in February 2002. Contracts were awarded for 365 MW, with the goal of allowing the 255 MW to be comfortably reached. All applicants to this call were required to have previously secured planning permission for proposed developments. AER V offered 15-year power purchase agreements with the ESB at the successful applicants' bid price with 25% of the output attracting an annual inflation adjustment based on the consumer price index (CPI).

Reduced investor confidence affected a number of AER V projects following the removal of a tax incentive (a seperate incentive to section 62 of the 1998 Finance Act) in the 2003 budget relating to capital allowances. This incentive had not been designed to support renewable energy projects specifically but was being incorporated into some AER V project financing arrangements.

AER VI was announced in April 2003 and called for a total capacity of 578 MW including the 365 MW from AER V. Successful bidders to AER V were allowed to submit a new bid under AER VI for the same project, in order to address the reduced investor confidence. AER VI differed from AER V in that the full bid price would attract CPI adjustment. An additional significant difference was that bidders could chose a front weighting price provision that increased the price by 35% for the first 7.5 years of the contract and decreased the price by 35% for the remaining 7.5 years.

The AER VI results were announced in July 2003. In total, contracts for 365 MW were awarded, 152 MW of which were from bidders holding AER V contracts. Thus currently there are a total of 578 MW under contract from the two rounds: 213 MW in contracts remaining under AER V and 365 MW in contracts under AER VI.

In July 2003 an additional offer of 140 MW to AER VI bidders in the large wind, small-scale wind, and biomass

[42] Renewable Energy Strategy Group (2000) *Strategy for Intensifying Wind Energy Deployment.*

[43] DEHLG (2004) *Draft Planning Guidelines on Wind Energy Development.*

[44] Gonzalez, Ó Gallachóir, McKeogh and Lynch (2004) *Study of electricity storage technologies and their potential to address wind energy intermittency.*

categories was announced. If EU State Aids approval is granted for these projects, it would bring the total MW offered contracts in AER V and VI to 718 MW.

3.3.2 Other Policies Affecting Renewable Energy

Ireland's target under the Kyoto Protocol is to limit annual greenhouse gas (GHG) emissions to 13% above 1990 levels by the period 2008 - 2012. This is part of an EU Burden Sharing Agreement whereby the overall EU target reduction of 8% in emissions is to be achieved through the combined efforts of the member states.

The Government in October 2000, published the *National Climate Change Strategy*[45] (NCCS). This strategy provides a framework for achieving greenhouse gas 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.

The NCCS specifically advocates the increased use of renewable energy and included in the Strategy is the reduction of annual CO_2 emissions by 1 million tonnes by 2010 based on the Green Paper 500 MW target of additional generating capacity from renewable sources. In addition, the NCCS calls for the "*maximisation of renewables capacity"* and commits to the setting of targets for the period 2005 - 2010.

Another key policy development affecting renewables is the liberalisation of the electricity market in Ireland. *The Electricity Regulation Act 1999*[46] provided for the partial opening of the electricity market from February 2000. This allowed "eligible customers" (those with an annual consumption above a certain threshold at a single load) and 'green electricity customers' (those who wish to use green electricity, regardless of annual consumption) to choose their electricity supplier. As a result, since February 2000, brown electricity suppliers can sell only to large customers but green electricity suppliers can sell to customers of any size, providing them with a competitive advantage until 2005 when the market for brown electricity is anticipated to also open fully. This has lead to the development of 98 MW of electricity generating capacity from renewable energy with a further 111 MW under construction.

The Act also established the Commission for Energy Regulation (CER) with a duty to encourage research and development into methods of generating electricity using renewable, sustainable and alternative forms of energy.

Additional policies and measures that will impact on renewables include

- the proposed introduction of a carbon tax by the end of 2004, as stated by The Minister of Finance in the 2003 budget speech[47],
- the *National Allocation Plan* for CO_2 emissions allowances, implementing the EU Emissions Trading Directive[48] and placing a monetary value on the environmental cost of fossil fuel power production and thus affecting the relative market position of renewables,
- the implementation of a number of EU Directives relating to energy and the environment, as listed in section 3.2.2.

3.3.3 Current Policy Developments

The Department of Communications, Marine and Natural Resources (DCMNR) is currently undertaking an extensive review of Irish renewable energy policy. The review focuses on setting new targets for renewables for the period 2005 to 2010 and beyond to 2020 - the target to 2010 will at the very least meet the target of 13.2% of electricity consumption from renewable energy sources set for Ireland in the EU Renewable Energy Directive 2001/77/EC[49].

Other key issues which are being covered by the review include policy goals, barriers to renewable energy sourced electricity/heat deployment, market support mechanisms and other requirements under the Directive 2001/77/EC referred to above.

DCMNR published a document in December 2003 entitled *Options for Future Renewable Energy Policy, Targets and Programmes*[50]. The paper requested comments on a range of renewable energy penetration targets for the electricity market. 46 submissions on the review were received from the public. These are currently being analysed with the technical assistance of Sustainable Energy Ireland. In addition, Sustainable Energy Ireland has commissioned a number of strategic studies and organised a series of lectures entitled *Perspectives from Abroad* to further inform the review process. After the

[45] Government of Ireland (2000) National Climate Change Strategy.

[46] Government of Ireland (1999) *Electricity Regulation Act 1999*.

[47] McCreevy (2002) *Financial Statement December 4, 2002.*

[48] European Union (2003) *Directive Establishing a Scheme for Greenhouse Gas Emission Allowance Trading Within the Community and Amending Council Directive 96/61/EC.*

[49] European Union (2001) *Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market.*

[50] DCMNR (2003) *Options for Future Renewable Energy Policy, Targets and Programme.*

current assessment period, DCMNR will formulate a new renewable support policy, which will then be submitted to Government for approval.

DCMNR also established a Bioenergy Strategy Group in December 2003 to consider the policy options and support mechanisms available to Government to stimulate increased use of biomass for energy conversion. The Group is expected to make specific recommendations for action to increase the penetration of biomass energy in Ireland. The Group is consulting with interested parties as appropriate in the development of its work. It is expected to report before the end of 2004.

In May 2004, Dermot Ahern TD, Minister for Communications, Marine and Natural Resources established a Renewable Energy Development Group involving key players in the renewable energy sector. The Group is to report back by the end of the year on a range of issues that need to be addressed so that the sector can continue to grow and expand. Among the issues to be tackled are

- the next market support mechanism,
- the introduction of net metering - which allows small producers to paid for energy supplied into the grid,
- research and development,
- Grid Upgrade Development Programme,
- applications backlog,
- wind moratorium.

The Commission for Energy Regulation is currently restructuring the liberalised electricity market and developing *New Market Arrangements for Electricity* (MAE). Under Statutory Instrument 304 of 2003[51], the current interim bilateral trading market will be replaced with a mandatory centralised pool ("the spot market") requiring all electricity exported to or imported from the transmission system or distribution system to be sold to and bought from the System Market Operator (SMO) (located within ESBNG).

For renewable plant reliant on intermittent power sources such as wind, offering into the market and adhering to dispatch instructions carries particular problems. In order to clarify how renewables will interact with the new market structure, CER published a decision[52] on how the MAE will be implemented in relation to renewables, CHP and small-scale generation in June 2004.

Sustainable Energy Ireland 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 and a revised programme strategy was published in May 2004[53].

[51] Government of Ireland (2003) *Electricity Regulation Act 1999 (Market Arrangements for Electricity) Regulations 2003.*

[52] CER (2004) *Implementation of the Market Arrangements for Electricity (MAE) in relation to CHP, Renewable and Small-scale Generation. An MAE Decision by the Commission for Energy Regulation under S.I. 304 of 2003.*

[53] Sustainable Energy Ireland (2004) *Renewable Energy Research Development and Demonstration Programme.*

[54] ESBI and ETSU (1997) *Total Renewable Energy Resource in Ireland.* This study was EU Altener funded.

[55] Kirk McLure Morton et al (2000) *Assessment of Offshore Wind Energy Resources in the Republic of Ireland and Northern Ireland.*

[56] Lewis (2000) *Strategic Assessment of the Irish Wave Energy Resource.* Funded by the Marine Institute

[57] The EU White Paper set a target of increasing the renewable energy contribution to TPER to 12% by 2010 for the EU-15.

4 Contribution from Renewable Energy

This section of the report examines the contribution made by renewable energy to Ireland's energy supply. Data in this section is generally up to 2002 but more recent data is included where available. TPER and TFC data for each renewable energy source is contained in Annex 1.

It is important to understand the scale and potential of renewable energy resources in Ireland and a number of studies have been commissioned in recent years to assess this. Table 2 lists some of these studies, which demonstrate that Ireland has very significant potential in terms of renewable energy.

The table refers to the practical resource and this is the portion of the total resource that could deliver electricity at a realistic cost, taking a range of limiting factors into account. The result is a conservative estimate of the renewable energy resource available.

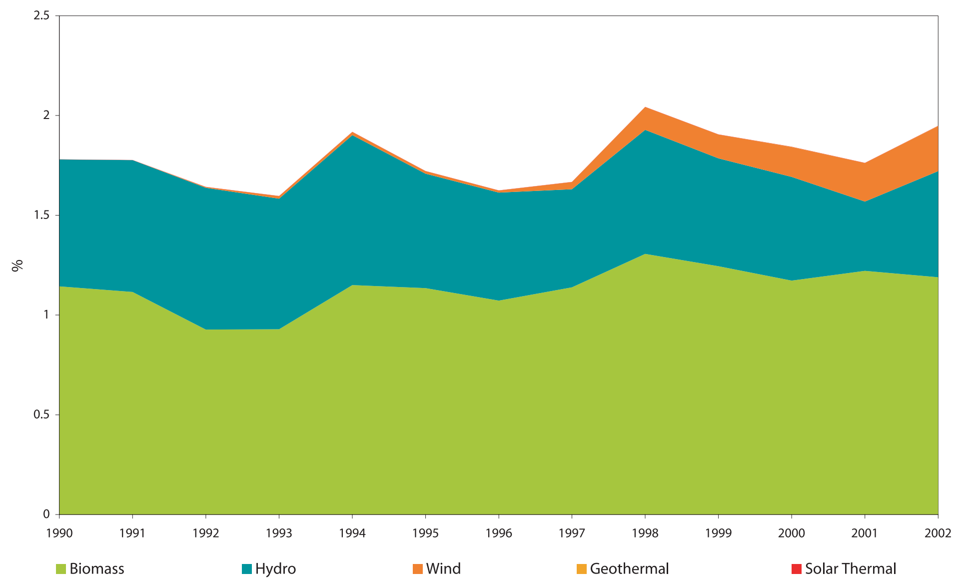
4.1 Contribution from Renewable Energy to TPER

As already mentioned, the total contribution from renewables to TPER is relatively low and has not increased its share in recent years, 1.9% in 2002 compared with 1.8% in 1990[57]. The trend is shown in figure 8, where the contribution of the different renewable energy sources is clearly illustrated. The largest contribution is from biomass, followed by hydropower and then wind power, with modest contributions also from solar and geothermal.

Table 2: Examples of Commissioned Work on Potential of Renewable Energy Electricity in Ireland

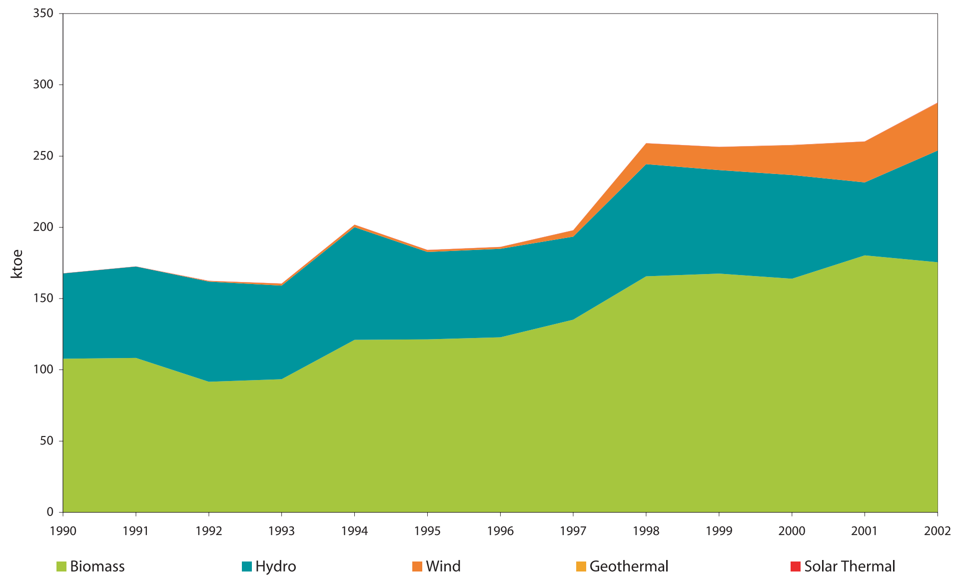
Study	Technology	Potential
Total Renewable Energy Resource in Ireland[54]	Onshore Wind	772 GWh per annum
	Landfill and Sewage Gas	155 GWh per annum
	Waste Combustion	355 GWh per annum
	Small Scale Hydro	52 GWh per annum
	Farm Wastes	362 GWh per annum
	Energy Crops / Forestry	700 GWh per annum
Assessment of Offshore Wind Energy Resources in the Republic of Ireland and Northern Ireland[55]	Offshore Wind Energy	11.1 TWh per annum
Strategic Assessment of the Irish Wave Energy Resource[56]	Ocean Wave Energy	833 MW Practical Resource Capable of Short Term Development

Figure 8: Renewable Contribution to TPER 1990 - 2002



Source: SEI

Figure 9: Renewable Energy TPER 1990 - 2002



Source: SEI

The significant increase in TPER, particularly in the period 1998 - 2001 hides the fact that renewable energy has grown considerably in absolute terms since the mid 1990s, as demonstrated in figure 9. The contribution from renewables[58] to TPER was 168 ktoe in 1990 rising by over 71% (4.9% per annum) to 288 ktoe in 2002. There was a 10% increase in the year 2002, compared with 2001 figures. This growth in 2002 is for the most part attributable to hydro electricity production returning to normal levels after low rainfall in 2001.

There are many reasons why renewable energy does not constitute a larger share of TPER, one of the main ones being that within current energy economics, fossil fuels are generally cheaper. The market price of fossil fuels does not however reflect their true cost as the externalities associated with them, (for example the costs of addressing environmental damage, health costs, etc.) are not internalised into the fuel sale price. This is due to change with the implementation of the EU Emissions Trading Directive and the planned introduction of carbon tax in Ireland by the end of 2004, which will internalise some of the external environmental costs.

Other reasons for the slow penetration of renewable energy include

- the early stage of technological development of a number of renewable energy technologies,
- the shortage of adequate infrastructure (for biofuels for example),
- absence of a predictable long term financially secure framework for renewable energy investors,
- a weak Irish renewable energy industry,
- key information gaps necessary for the successful integration renewable energy into existing energy networks.

It is likely that renewable energy sources will become increasingly important as fossil fuels become more expensive before they eventually run out. In addition, recent advances in technology have seen the cost of the electricity and heat produced from many types of renewable energy decrease; thereby making renewable energy more competitive. This trend is expected to continue.

Figure 10 shows the contribution of renewable sources to TPER in 1990 and 2002 broken down by individual source. Wind energy was absent in 1990 and accounted for 12% of renewable energy in 2002. The share of hydropower reduced from 36% in 1990 to 27% in 2002 and the share of biomass also reduced despite its growth in absolute terms (illustrated in figure 9).

The TPER average annual growth rates[59] for each technology over the period is shown in figure 11. It can be seen that the highest annual growth has been wind (55% per annum) followed by geothermal (35%), although the contribution from the latter remains less than 1%. The high growth rate for wind energy is likely to continue with a significant amount of installed capacity added during 2003 and 2004. The growth rates for the other technologies are: solar thermal 11%, biomass 4% and hydropower 2.3%.

[58] Including large scale hydropower and excluding electricity generated pumped.

[59] The annual growth rates for wind and landfill gas are from 1992 and 1996 to 2002 respectively, the first years of output.

Figure 10: Share of Renewable Energy Sources TPER 1990 and 2002

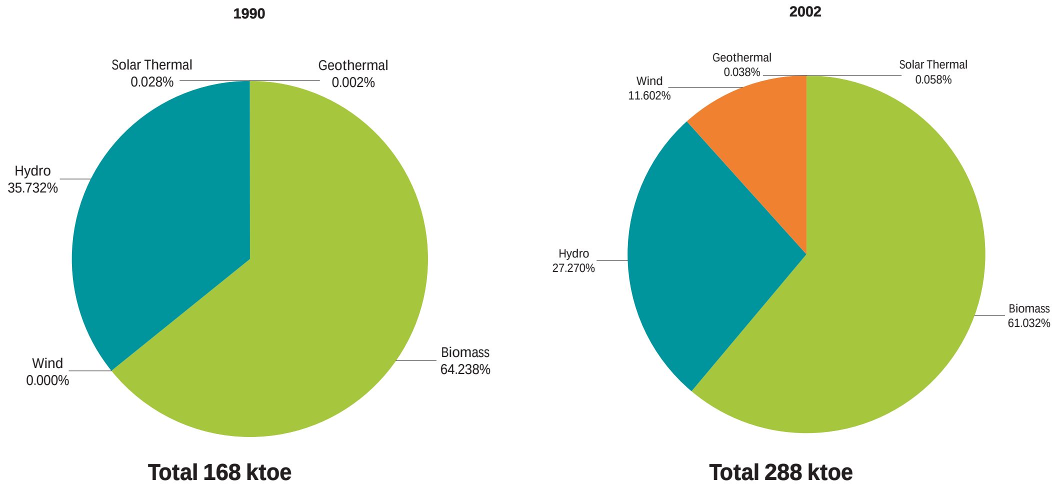
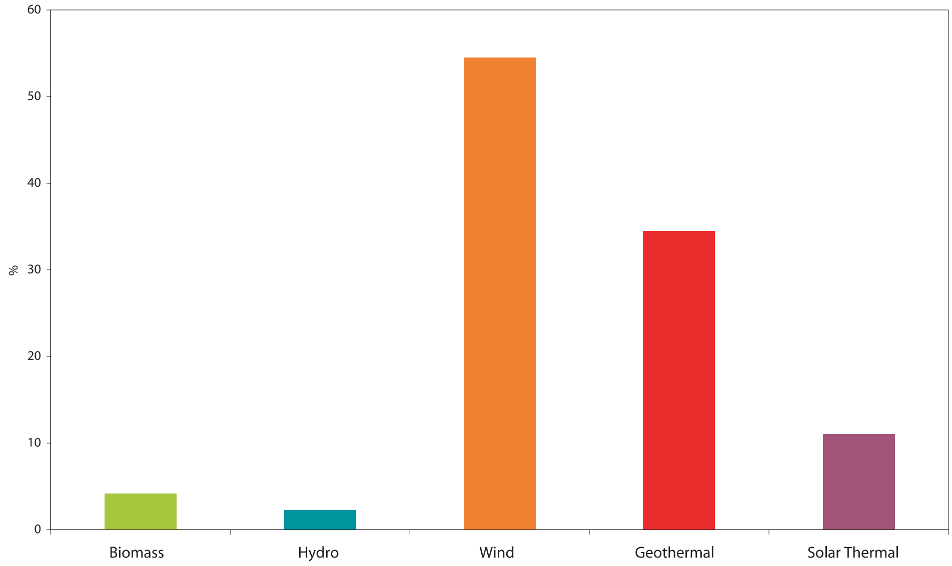


Figure 11: Annual Growth Rates in TPER of Renewables Energy Sources from 1990 - 2002



Source: SEI

4.2 Contribution to TFC

Figure 12 shows the TFC contribution from renewable energy to the thermal and electricity markets. The contribution to the transport energy market was zero during the period but there have been some developments since 2002[60].

From figure 12, it can be seen that renewable energy contributes more to thermal energy, 56% of the total in 2002. It increased in absolute terms from 108 ktoe in 1990 to 157 ktoe in 2002, an increase of 45% (3% per annum). It is this thermal renewable energy contribution that accounted for 1.4% of Ireland's TFC in 2002, as mentioned in section 2.2. Adding to this the electricity generated from renewables, the total contribution from renewable energy to TFC in 2002 is 276 ktoe, or 2.4%. The data for this is presented in Annex 1.

The amount of electricity generated from renewable increased from 60 ktoe in 1990 to 119 ktoe in 2002, an increase of 98% (6% per annum), double the growth rate of thermal renewable energy.

Figure 13 graphs this electricity from renewable energy as a share of Ireland's gross electricity consumption in the period 1990 - 2002, showing the contribution from the individual technologies. While the contribution from hydropower has declined, figure 13 shows how electricity production from wind energy and landfill gas has increased. Wind energy in 2002 accounted for 1.5% and landfill gas 0.3% of gross electricity consumption. The total contribution from renewable energy in 2002 was 5.3% (compared with 4.9% in 1990), providing an indication of the scale of the task to achieve the 13.2% indicative target contained within the EU Renewable Energy Directive[61]. Provisional figures for 2003 indicate that this reduced to 4.0%, due largely to reduced hydro production.

4.3 Primary Energy Equivalent

Figures 9 and 12 illustrate that TPER and TFC (including the contribution from electricity generated from renewable energy) are very similar for renewables. For most fuels, this is not the case, due to the energy conversion losses associated with electricity generation. Depending on the efficiency of electricity generation, typically between 25% and 55% of the energy content of the fuels inputted into power plants is outputted in the form of electricity.

For fossil fuels the primary energy is the energy content of the fuel, whereas for non-combustible renewable sources (wind and hydro) the primary energy is set equal to the electricity generated. This follows the IEA principle that "*the primary energy form should be the first energy form downstream of the production process for which multiple energy uses are practical*"[62].

This is a sensible principle as it allows harmonised international comparisons, but it does not accurately represent how fossil fuels used for electricity generation are displaced by renewable energy. In primary energy terms, the fuel input into a fossil fuel plant is currently equated with the electricity output from a wind farm. An alternative approach would be to equate the wind farm output with the energy of the fuel that would have been required to produce the equivalent amount of electricity in the absence of the wind farm.

This is the principle behind the *primary energy equivalent* based on the partial substitution method[63]. The primary energy equivalent for non-combustible renewable energy is the thermal fossil fuel energy avoided through the generation of electricity from wind or hydro.

This raises a key question however-what electricity generation is being displaced by wind-or hydro-generated electricity? Currently in Ireland, the coal fired station at Moneypoint and the combined cycle gas turbine (CCGT) plants are operating as baseload plant and the peat fired stations have a special status associated with the indigenous nature of the fuel. Wind farms and hydro plants are therefore more likely to be displacing electricity from the other plants on the system, namely the conventional oil fired and open cycle gas plant.

In the absence of detailed data on the generation efficiencies of these plants in the period 1990 - 2002, an approximation can be used for primary energy equivalent based on the average generating efficiency of thermal fossil fired electricity generation. This assumes a theoretical displacement by each kWh from wind energy of a kWh generated from the entire fossil fuel plant mix. This approach is in accordance with the method formerly used by the IEA to calculate primary energy equivalent of renewables[64].

[60] From May 2003 to May 2004 18,000 litres with a total energy value of 576,000 MJ (0.014 ktoe) was sold in Ireland (see section5.1). It is likely that this is set to grow especially in light of the removal of excise duty on Department of Finance approved bioenegy production projects.

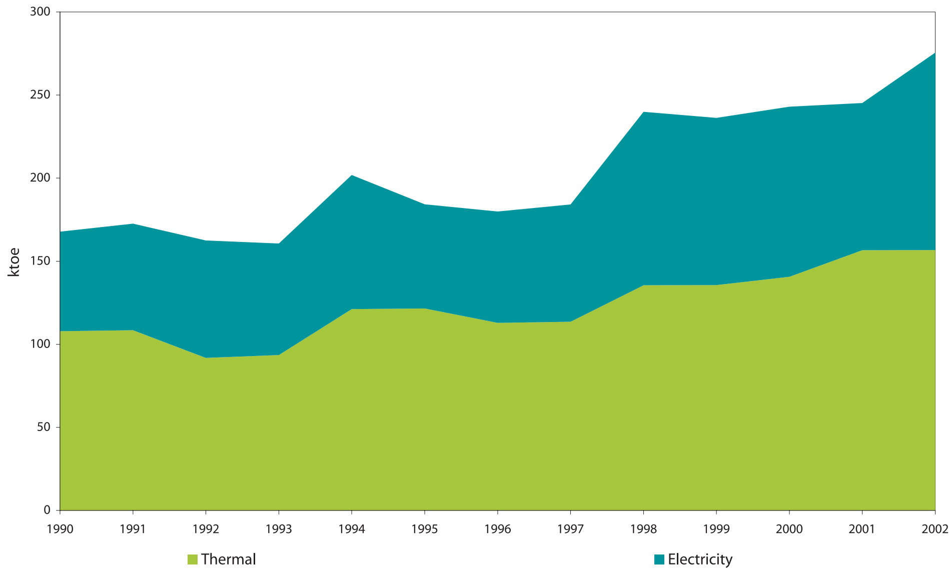
[61] European Union (2001) *Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market.*

[62] International Energy Agency (2004) *Energy Balances of OECD Countries 2001 - 2002.*

[63] Ibid

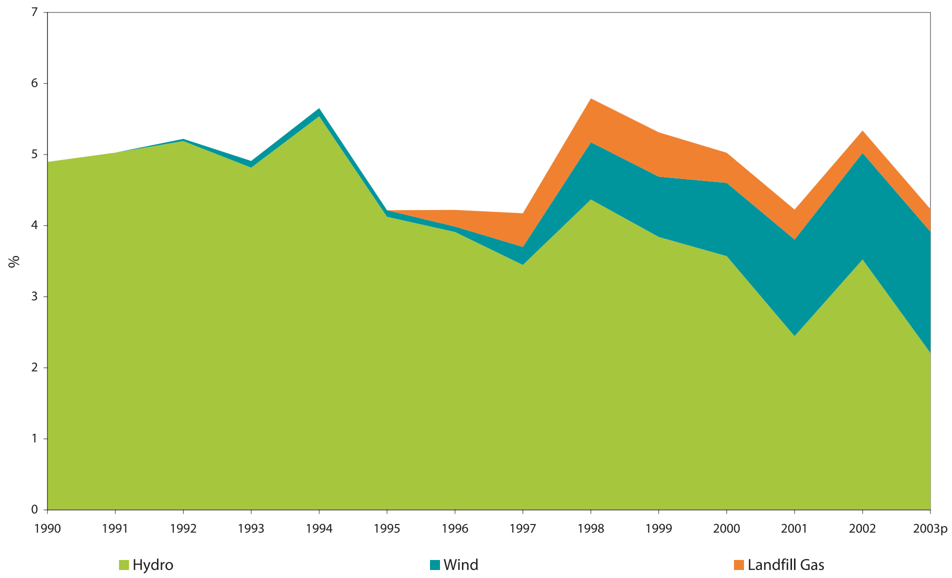
[64] Ibid

Figure 12: Total Final Consumption of Renewable Energy by Mode 1990 - 2002



Source: SEI

Figure 13: Renewable Energy Contribution to Gross Electricity Consumption 1990 - 2002



Source: SEI

The primary energy equivalent of renewable energy is shown in figure 14 rising from 262 ktoe in 1990 to 441 ktoe in 2002. Recall from figure 10, page 25, that the primary energy from renewable energy in 2002 was 288 ktoe. The primary energy equivalent in 2002 thus represents a 53% increase compared with the primary energy and more accurately reflects the contribution in terms of fossil fuels avoided. Note that biomass remains the same as this is a combustible form of renewable energy, thus having a primary energy value associated with its energy content as a fuel.

There are a number of limitations and caveats associated with this methodology. As wind energy penetration increases for example, more open cycle gas plant may be used to meet the associated reserve requirements. This open cycle plant will typically generate increased CO_2 and NO_x emissions compared with CCGT and these emissions should be incorporated into the analysis. The purpose of presenting a simplified analysis here is to provide initial insights into the amount of fossil fuels that are displaced by renewables and the amount of emissions thereby avoided.

Projecting forward in time, future wind capacity can be assumed to displace the least cost alternative for new plant, which is currently CCGT plant[65]. Figure 15 shows how the primary energy equivalent for renewable sources would have developed in time, had the electricity generated from non-combustible renewable energy displaced CCGT generated electricity. Clearly applying this approach to historical data trends is purely hypothetical, but it is presented to inform discussions regarding primary energy equivalent associated with future plant.

The total amount of primary energy equivalent in this case rises from 213 ktoe in1990 to 379 ktoe in 2002. The primary energy equivalent is lower than that shown in figure 14, due to the higher efficiency of a CCGT plant compared with the average efficiency of the entire fossil fuel plant mix. In 2002, the primary energy equivalent for renewables associated with displacing CCGT was 32% higher than the TPER value for renewables. This compares with the 53% increase on TPER when renewables displaces the average plant generated electricity.

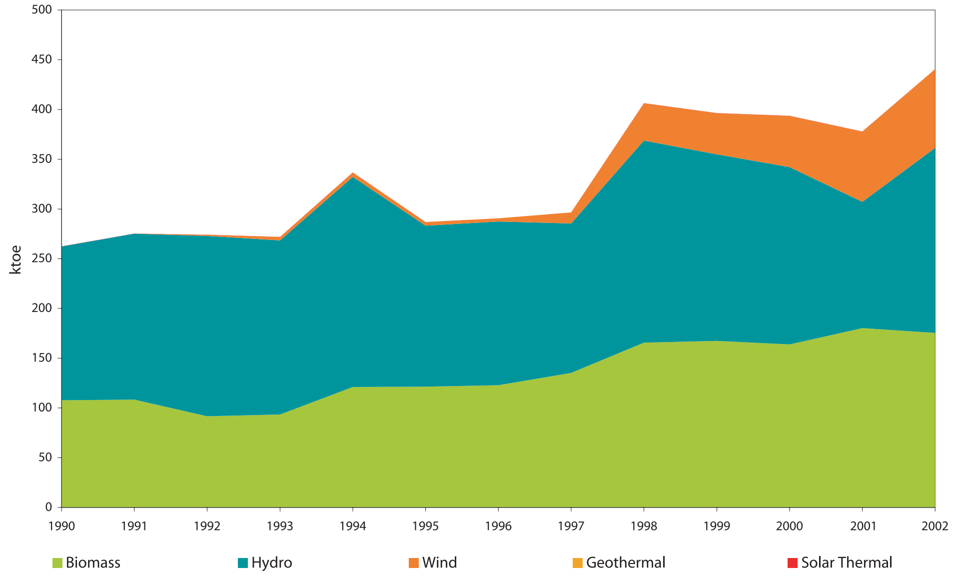
4.4 CO_2 Displacement

The key benefit of determining the primary energy equivalent associated with non-combustible renewables is that it can be used to calculate of the amount of CO_2 avoided through the use of renewable energy. The caveats associated with the results for primary energy equivalent apply equally to the calculated CO_2 avoided. In the absence of detailed data of actual fuel displacement, it is assumed that the electricity from wind and hydro plants displace

- an average electricity unit generated by the complete fuel mix (as a proxy for marginal fuel generated electricity displacement). The emissions avoided in this case provide an estimate for historic and current emissions avoided.
- electricity generated by a CCGT plant (representing likely future displacement of cheapest new plant alternative). The emissions avoided in this case are designed to provide insights associated with future renewable energy penetration.

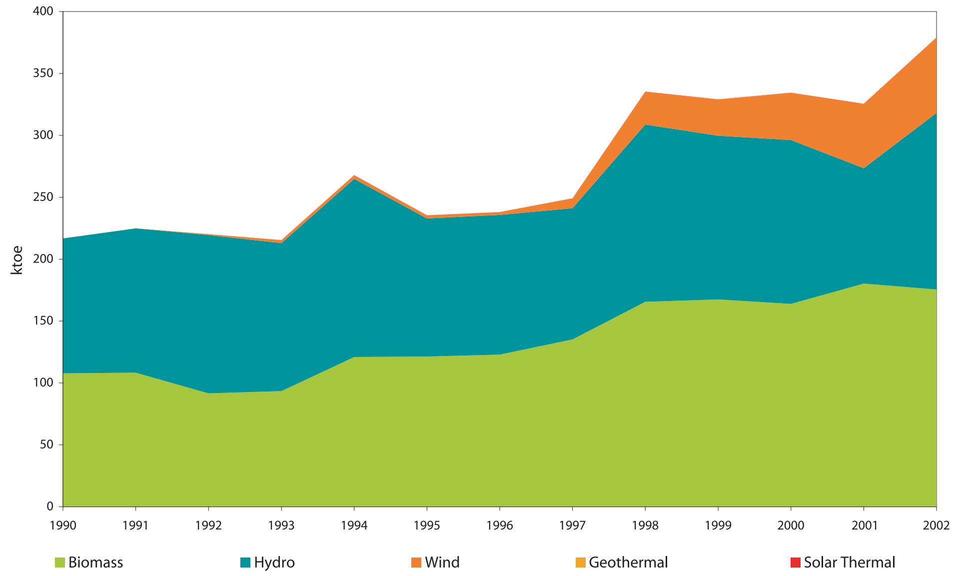
[65] This is in line with the findings of Garrad Hassan and Econ (2000) *The potential of wind energy to reduce CO_2 emissions.* IEA Greenhouse Gas R&D Programme Report PH3/24, namely that wind turbines up to 2020 would displace the least cost new capacity option. This is likely CCGT plant in the EU, whereas in China and India it would displace coal fired plant.

Figure 14: Primary Energy Equivalent for Renewable Energy Sources 1990 - 2002 - Wind and Hydro Compared with Average Generating Efficiency



Source: SEI

Figure 15: Primary Energy Equivalent of Renewable Energy Sources 1990 - 2002 - Wind and Hydro Compared with CCGT



Source: SEI

Figure 16 shows the trend in avoided CO_2 emissions from renewable energy for the period 1990 - 2002. It is assumed the electricity from renewables (wind, hydro and landfill gas) avoids the amount of CO_2 produced by an average kWh of electricity produced across the entire fuel and plant mix. The CO_2 displaced per kWh has thus reduced over the period, in line with the reduction in the CO_2 intensity of electricity generation, due to improved efficiency in electricity generation and the increased use of lower carbon fossil fuels.

It is further assumed that the thermal energy from renewable energy (solid biomass, biogas, geothermal and solar) displaces thermal energy from oil fired boilers. The CO_2 avoided from thermal renewable energy is equated with the CO_2 emissions that would have arisen from this oil consumption.

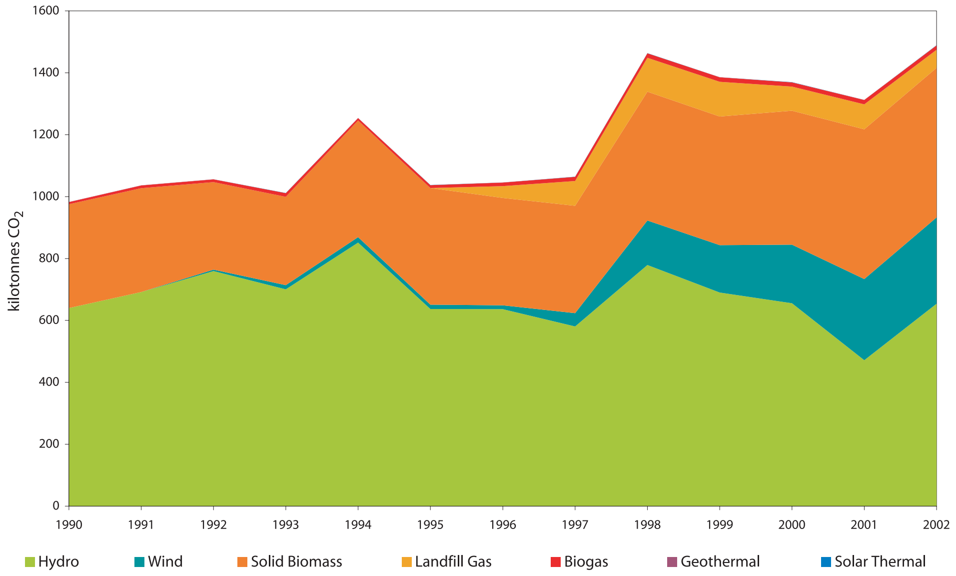
The amount of CO_2 avoided from renewable energy increased by 52% (3.5% per annum) over the period 1990 - 2002 reaching 1489 kt CO_2 in 2002. The emissions avoided from hydro were most significant, although the share has dropped from 65% in 1990 to 43% in 2002. Wind energy in 2002 avoided 278 kt CO_2 in 2002 and this is likely to grow due to the recent acceleration in deployment. The emissions associated with all biomass sources increased by 62% over the period and accounted for 37% of emissions avoided in 2002.

Figure 17 shows the emissions avoided from renewables in the scenario where the electricity generated by renewable sources displaces CCGT generated electricity. The assumptions relating to thermal renewable energy displacing oil fired heating also apply here.

The difference between figures 16 and 17 is the reduced emissions avoided associated with the renewable generated electricity. This difference is lower in later years as the gap narrows between the carbon intensity of the entire electricity plant mix and that for CCGT electricity narrows. The emissions avoided by hydropower for example in figure 17 were 70% of the emissions avoided in by hydropower in figure 16.

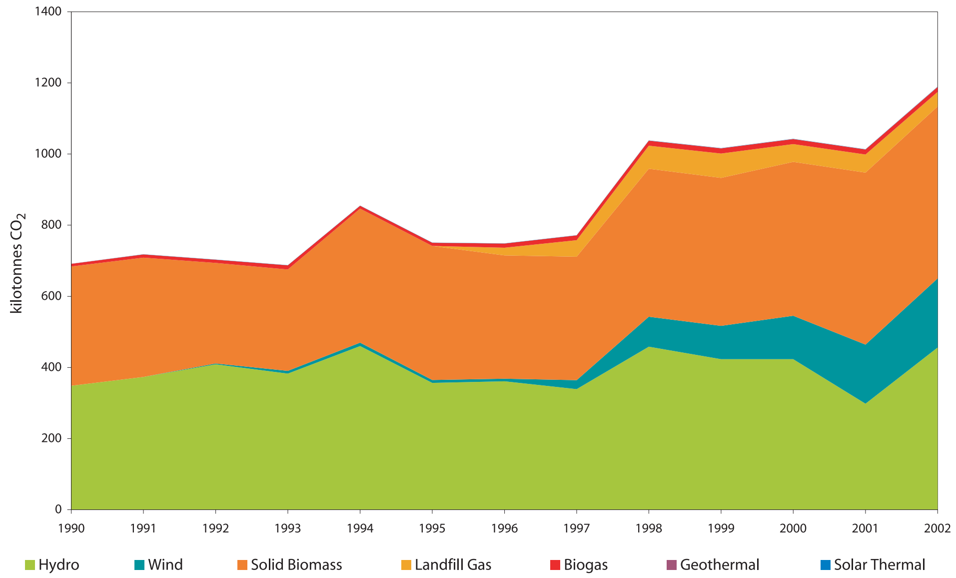
In addition to quantifying CO_2 emissions avoided, the primary energy equivalent approach can be used to estimate quantities of fuel displacement. This is important in the context of Ireland's growing import dependency coupled with escalating fuel prices and the finite nature of fossil fuel resources, all contributing to security of supply concerns.

Figure 16: Avoided CO_2 from Renewable Energy 1990 - 2002 - Wind and Hydro Displacing Actual Generating Mix



Source: SEI

Figure 17: Avoided CO_2 from Renewable Energy 1990 - 2002 - Wind and Hydro Displacing CCGT



Source: SEI

5 Individual Renewable Energy Sources

5.1 Biomass

Biomass refers to a wide range of organic materials that have the potential to be converted into either heat, electricity or transport fuels. The technologies used to convert biomass to useful energy range include wood stoves, kilns, CHP plants, gasification units, anaerobic digesters, gas engines and Elsbett engines.

The Renewable Energy Directive[66] defines biomass as "*the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste".*

Biomass can be specifically grown for conversion to energy or may be the residue from industries such as agriculture, forestry or timber and wood processing. Energy can also be recovered from the organic component of municipal and agricultural waste.

This section groups biomass according to the physical state of the fuel, under the headings Solid Biomass, Biogas and Liquid Biofuels where

- solid biomass includes wood and wood wastes,
- biogas is derived from agricultural wastes, wet industrial waste, the organic fraction of municipal solid waste (OFMSW), sewage sludge and includes landfill gas,
- liquid biofuels comprise vegetable oils and animal fats, plant oil and bioethanol.

Solid Biomass

Wood and wood residues (also known as solid biomass) have been used in Ireland for many generations as a source of thermal energy. This category includes wood burned for domestic heating and wood burned in sawmills and board mills. Because of its widespread use in developing countries, solid biomass is by far the largest renewable energy source globally, representing 10.4% of world energy supply in 2001[67] (and accounting for 74% of global renewable energy).

Solid biomass accounts for the bulk of Ireland's biomass consumption and represented 55% of total renewable final energy consumption in 2002. Figure 18 presents the trend in solid biomass by sector for the period 1990 to 2002. It can be seen that solid biomass increased from 105 ktoe in 1990 to 152 ktoe in 2002, an increase of 44% (3% per annum).

The bulk of this solid biomass is used in the wood processing industry (58% in 1990, increasing to 72% in 2002), firing the boilers and kilns of the four main board manufacturing plants in Ireland and a larger number of sawmills and joineries. In addition, there is a considerable portion of solid biomass providing heat in the domestic sector, through the combustion of wood logs and pellets.

Construction has recently been completed on a solid biomass CHP plant at a West Cork sawmill. The plant is supported under the AER VI programmes. This represents the first electricity generation from solid biomass in Ireland.

Gaseous Biomass (Biogas)

Biomass in the form of wet industrial waste, sewage sludge, agricultural waste and Organic Fraction of Municipal Solid Wastes (OFMSW) is converted to biogas through a process called Anaerobic Digestion (AD). This involves the breakdown of organic waste by bacteria in an oxygen-free environment. AD can take place in a specially designed biogas plant or at landfill sites.

The result is methane rich gas (typically composed of 65% methane and 35% carbon dioxide), which can be used to produce heat and or electricity or it can be upgraded to natural gas and supplied to consumers using the natural gas network infrastructure.

In Ireland there are 4 industrial sites that use AD technology to produce biogas for heating purposes. More recently there is a growing number of farm based digestors and sewage sludge biogas plants.
The production of biogas thermal energy from 1990 to 2002 is presented in figure 19. Over the period biogas increased from 2.3 ktoe in 1990 to 4.3 ktoe in 2002, an increase of 89% (5.4% per annum). Most of the consumption is in the food subsector of industry with small consumption levels in the public services sector (waste water treatment plants) and agricultural sector (farm based AD).

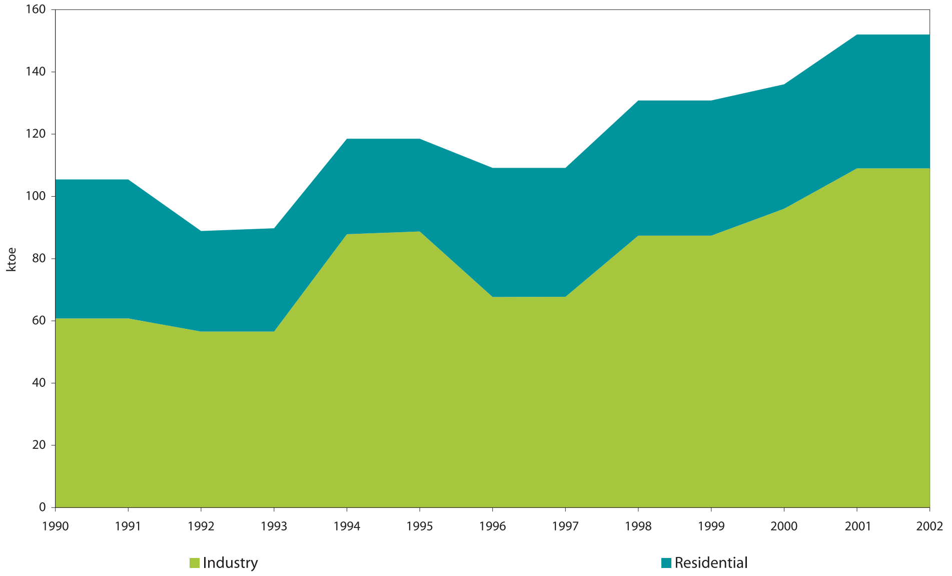
Landfill gas is the name given to biogas produced at landfill sites, through the decomposition of OFMSW. Landfill gas contains methane, a greenhouse gas 21 times stronger (in terms of global warming potential) than CO_2. This is released naturally into the atmosphere if no controls are put in place. Collecting this landfill gas and using it for energy purposes reduces the GHG impact and also displaces fossil fuel based energy.

Wells are inserted into the waste to collect the gas through a series of perforated pipes. A suction pump collects the gas, which is then cleaned and used as an energy source. Depending on the amount of gas collected, this can then be used in a gas engine or turbine to produce electricity and heat.

[66] European Union (2001) *Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market.*

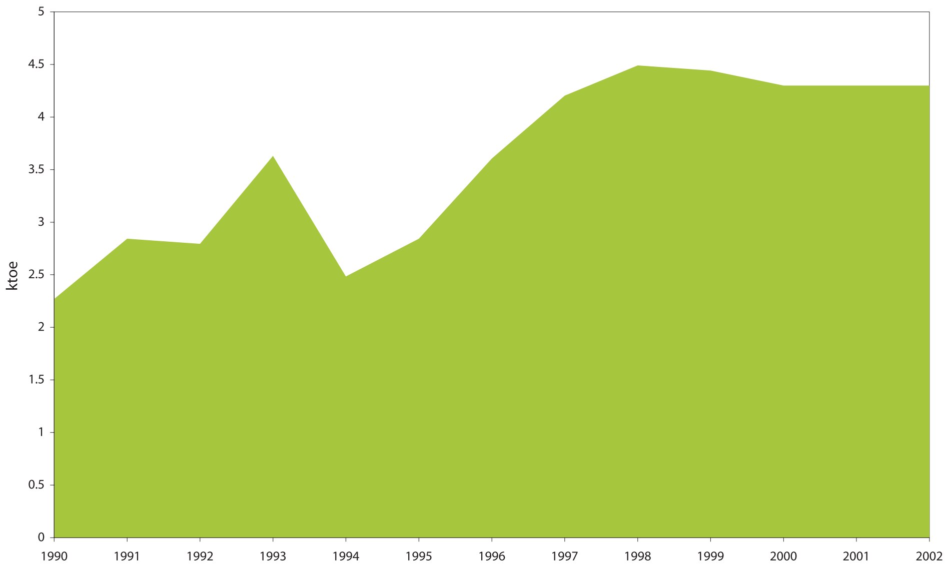
[67] IEA (2003) *Renewables Information.*

Figure 18: Solid Biomass Final Consumption 1990 - 2002



Source: SEI

Figure 19: Biogas Thermal Output 1990 - 2002



Source: SEI

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

The electrical output from landfill gas is presented in figure 20 for the period 1996-2002. We can see that there has been a significant increase from 0 ktoe in 1995 to 6 ktoe in 2003 with a peak of 11.8 ktoe in 1999.

Liquid Biomass (Biofuel)

Biofuels can be considered as potential replacements or extenders for mineral fuels such as diesel or petrol. They can be sub-divided into a number of categories[68]:

- vegetable oils / animal fats which can be converted to biodiesel;
- pure plant oil (rapeseed oil) can be used in unprocessed form as biofuel;
- bio-ethanol produced from the fermentation of organic materials such as sugar beet, cereals, etc.

In Ireland there have been a number of research, development and demonstration activities in biofuels. One such project is part of the EU programme CIVTAS I, which promotes radical strategies to achieve Clean Urban Transport. Cork City Council has modified the engines of 17 light commercial vehicles with Elsbett engine conversion kits. These vehicles operate on pure rapeseed oil. The cost of the conversion was approximately €1,000 per engine. The scheme has been in operation since May 2003 and the fleet has used 18,000 litres[69] of rapeseed oil yielding 576,000 MJ energy.

One of most notable success stories in relation to the use of biofuels is Brazil. Ethanol is produced from sugarcane and has replaced approximately 50% of the gasoline that would otherwise be consumed. Four million hectares of land were required to produce this amount.

5.2 Hydropower

Hydropower is an indirect form of solar energy, which evaporates water from oceans. This in turn falls (through condensation) as rain, resulting in the formation of rivers. By moving to lower altitude areas under the influence of gravity, the kinetic energy associated with flowing water can be converted into electricity in a hydro turbine.

At global level hydropower is a mature and proven technology and is second only to biomass in terms of overall share of renewables. Hydropower is also one of the most developed forms of renewable energy in Ireland. In the early 1930's the generation of electricity was almost 100% renewable, based on the hydropower of the Shannon River, harnessed at the Ardnacrusha plant. The ESB owned Ardnacrusha plant is still the country's largest renewable energy generating unit with a capacity of 91 MW spread across four units. During the 1950s, most of the other large scale hydro plants were built, linked to the expansion of the electricity network and capacity.

Hydropower is also used to store night generated electricity for daytime consumption in pumped storage plants. There is a 292 MW plant in Turlough Hill but the electricity generated is not considered as renewable (but rather as stored) energy and therefore not included in this analysis.

The growth in hydropower capacity over the period 1990 - 2002 is shown in figure 21. Hydropower is typically divided into two categories[70] large scale (≥10 MW) and small scale (<10 MW). There has been no growth in large scale capacity and only a small number of additional small scale plants since 1990.

Large hydropower

There are five large - scale hydropower projects in Ireland having a combined installed capacity of 205.5 MW. The installed capacity (all owned by the state electricity utility, ESB) has not changed over the period 1990 to 2002. No new large hydro projects are planned.

Small-scale hydropower

At the end of 2002, there was a total installed capacity of 34.09 MW small - scale plants in operation an increase of 6.2 MW (22.2%) over 1990.

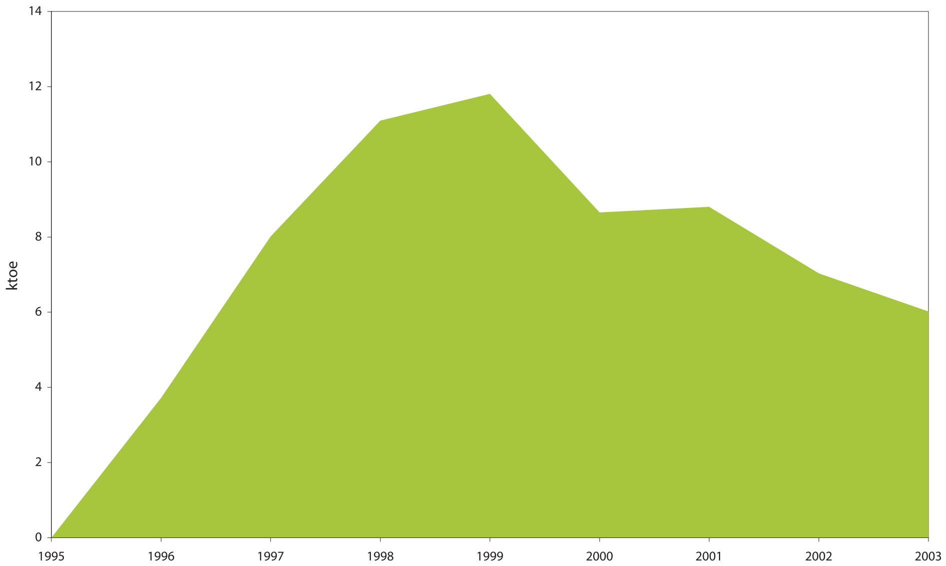
Combining small and large scale hydropower gives a total installed capacity in 2002 of 239.6 MW, an increase of 6.2 MW on 1990 (2.7%). The evolution of small scale hydropower is contained in table 3.

[68] SEI (2003) *Liquid Biofuels Briefing Note.*

[69] Cork City Council (2004).

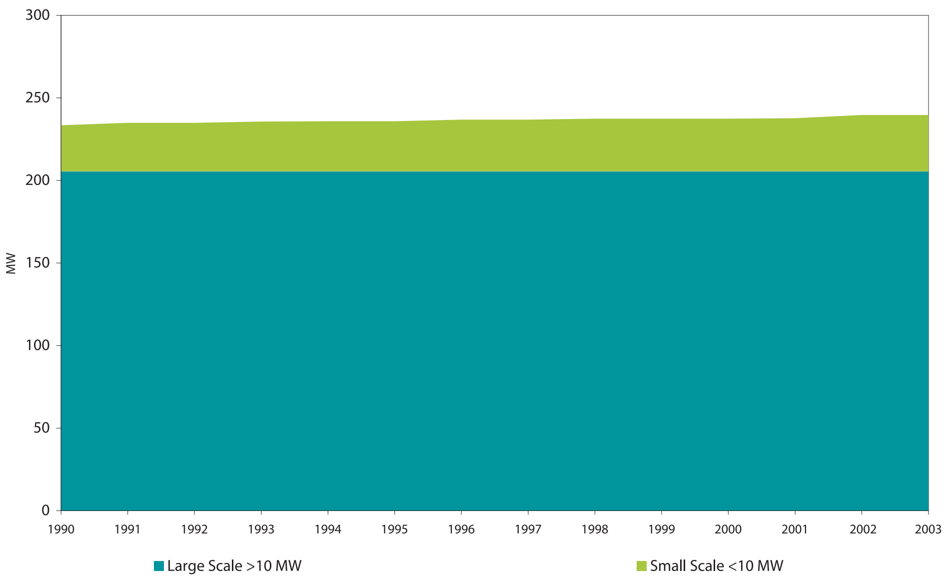
[70] Further classification can also be used for projects≥≥100 kW but < 1 MW (mini) and projects < 100 kW (micro).

Figure 20: Landfill Gas Electrical Production1995 - 2003



Source: SEI

Figure 21: Installed Capacity of Hydropower 1990 - 2003



Source: SEI, ESBNG, Eurostat, SERG (UCC)

Table 3: Installed Capacity of Small Scale Hydropower 1990 - 2003

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
MW	22.87	29.34	29.41	30.16	30.32	30.32	31.31	31.31	31.87	31.87	31.87	31.12	34.09	34.09

Source: SEI

The practicable Irish resource for small hydro has been estimated as approximately 38 MW[71]. It is unlikely that this will be realised in the short to medium term. ESBNG in its *Generation Adequacy Report*[72] project an additional 1 MW per year (for a total of 7 MW) of installed capacity over the period 2004 - 2010, in line with the *Green Paper for Sustainable Energy* targets for renewables.

Examining the results of AER competitions with regard to small-scale hydro, AER 1 delivered 2.3 MW of capacity and AER III resulted in an additional capacity of 1.7 MW. The most recent competition, AER VI, offered 5 MW of hydropower under the scheme but only 1.3 MW was finally awarded.

Figure 22 shows the electricity generated from hydropower since 1990 and emphasizes the large degree of variation from year to year associated with changing annual rainfall levels.

Provisional data for 2003 is also included in figure 22 and it can be seen that the electrical output is the lowest in the period 1990 to 2003 at 587 GWh (50 ktoe).

In terms of electricity generation however, hydropower remains the largest renewable energy source but with the recent acceleration in wind this is likely to change in the next few years. Hydropower's share of gross electricity consumption is shown in figure 23. We can see that the share has fallen from 4.9% to 3.5% over the period 1990 to 2002, despite the 31% increase in real terms over that period. Provisional data for 2003 indicates that the share of hydro fell to 2.2% in 2003.

5.3 Wind

Like hydropower, wind energy is also an indirect form of solar energy as winds are caused due to uneven heating of the air by the sun, resulting in hot and cold air pockets, resulting in the generation of winds. The energy contained in the wind is converted into the mechanical energy of a rotor, through aerodynamic lift forces acting on the turbine blades. This mechanical energy is converted to electricity in a wind turbine generator.

Onshore wind turbine technology for converting wind energy to electricity is well developed and is now commercially available and approaching open market competitiveness.

Ireland's onshore wind resource is among the best in Europe, particularly along the western seaboard. The first wind farm (comprising 21 wind turbines and located at Bellacorrick, County Mayo) was brought on line in 1992 with an installed capacity of 6.45 MW. Growth was slow during the 1990s and has accelerated since 2000. There are currently 37 wind farms operational in Ireland, with a combined installed capacity of 228.5 MW (onshore and offshore). In addition there wind farms currently under construction with a combined installed capacity of 259 MW.

The largest onshore wind farm in Ireland is located at Kings Mountain, Co. Sligo and has an installed capacity of 23.75 MW. This will be surpassed in the near future by the 70 MW wind farm currently under construction in Meentycat, Co. Donegal.

Currently there is one offshore wind farm in Ireland situated 10 km off the coast of Arklow. The project began operation in 2004 and has an installed capacity of 24.8 MW comprising seven 3.6 MW turbines.

Table 4 shows the growth in wind capacity in Ireland by year, also showing the support mechanisms under which they were built, where applicable. The wind farms are onshore unless otherwise indicated.

Table 4: Wind Capacities with Support Mechanisms

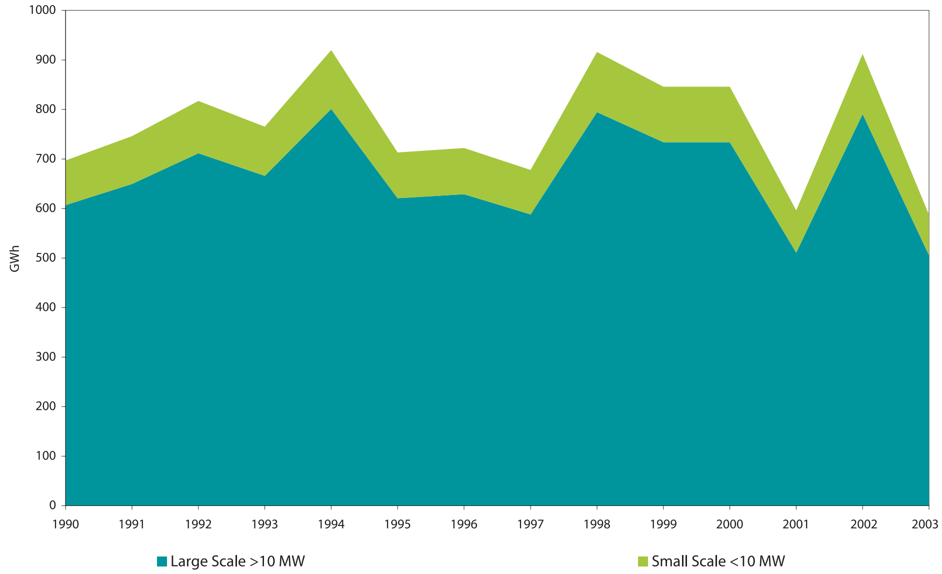
	1992	1997	1998	1999	2000	2001	2002	2003	2004	Total
Number of Windfarms	1	4	4	2	9	2	3	6	6	37
Installed Capacity MW VALOREN	6.5									6.5
Installed Capacity MW THERMIE		3	5	2.6	5.6					16.2
Installed Capacity MW AERI		21	24.8							45.8
Installed Capacity MW AERIII				4.6	29.9	3.4				37.9
Installed Capacity AER V							1.3	24.5	13.6	39.4
Installed Capacity MW TPA					15	3	11.9	27.2	0.9	58.0
Installed Capacity Offshore MW TPA									24.8	24.8
Total	6.5	24	29.8	7.2	50.5	6.4	13.2	51.7	39.3	228.6

Source: DCMNR

[71] ESBI and ETSU , 1997, *Total Renewable Energy Resource in Ireland ESBI and ETSU*.

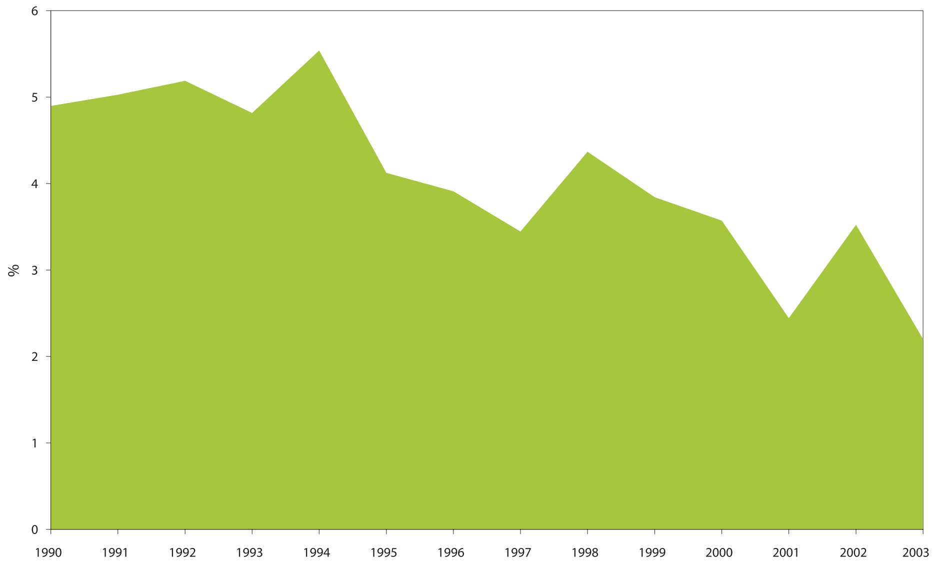
[72] ESBNG (2003) *Generation Adequacy Report 2004 - 2010*.

Figure 22: Electricity Generated from Hydropower 1990 - 2003



Source: SEI, ESBNG, Eurostat, SERG (UCC)

Figure 23: Share of Hydropower Electricity as a Percentage of Gross Electricity Consumption1990 - 2002



Sources: SEI

Figure 24 illustrates the evolution in wind capacity in graphical form from 1990 to (August) 2004 including the projects which are currently under construction. The recent surge in activity is very clear from figure 24, with the expected deployment in 2004 matching the cumulative deployment over the past 10 years.

The most important support mechanism, in terms of installed capacity to date, has been the AER price support competitions. The various AER competitions have been responsible for 123 MW of installed capacity (up to July 2004). AER VI was launched in February 2003 and support for 365 MW of wind capacity was announced following the tendering process. For the first time in the programme, a separate category allocating 50MW capacity for offshore wind projects was included. Wind farms with AER V and AER VI contracts with a combined capacity of 148 MW are currently under construction.

VALOREN and THERMIE were EU programmes, which contributed capital grant support for 6.45 MW and 16.27 MW of wind capacity respectively. Projects supported under the THERMIE programme (and subsequently the ENERGIE programme) also received 15 year power purchase agreements providing a guaranteed market for the wind generated electricity.

Third Party Access (TPA) projects refer to wind farms built without capital grant support or a guaranteed power purchase agreement. These projects are built to supply customers who choose green electricity. The electricity market remains partially opened for brown electricity suppliers (currently approx 56% open) and fully open for green electricity suppliers. This provides green electricity access to customers not open to brown suppliers (until 2005) and has facilitated the deployment of wind plant to meet their electricity requirements. The combined installed capacity of TPA wind farms deployed to date is 82.7 MW (including offshore) with 111 MW currently under construction.

It is worth noting that some developers who were successful in the AER V competition opted out of the scheme and proceeded to build wind plant under TPA instead. It should be noted that the majority of the capacity developed in the TPA model is associated with a single wind power company, which also has a green electricity supply business.

There have been a number of changes in wind turbine and wind farm size as the technology has developed. Table 5 provides a profile of wind farm and turbine size in terms of annual deployment.

This data refers only to operational onshore wind farms. Data for 2004 is not complete and thus is not included.

The average windfarm capacity size has increased, while the number of turbines as fallen, due to the increase in size of turbines over the period. The range of turbines used is from 225 kW to 2.5 MW, showing the 10 fold increase in capacity in 10 years. The average turbine size installed in 2003 was 1.29 MW, somewhat smaller than the average worldwide. Possible reasons for this include the fact that road access limits turbine size on many sites in Ireland, turbine size is fixed to a certain degree at the planning stage, but project development periods are protracted.

There are a number of indications that the recent rapid increase in deployment is set to continue. In addition to the 229 MW already installed and the 259 MW under construction, there are a large number of wind farms with planning permission and with grid connection agreements. In July 2004[74] signed connection agreements were in place for 823 MW (including those built and under construction) with additional live offers totalling 39 MW, 1369 MW of applications being processed and 271 MW of applications that are being checked by the Transmission System Operator TSO, (ESBNG). As the signing of a connection agreement indicates a significant level of commitment from a developer (even a connection application may involve substantial cost) this would indicate that the increasing trend might continue for some time. A further indication is the fact that there are over 2000 MW of capacity with planning permission.

This rapid increase in activity prompted ESBNG to seek a moratorium on new connections from wind farms. This was in place from 6th December 2003 to 9th July 2004. While the amount of wind generation connected to the system is relatively small, the rate of increase raised concerns relating to the future safety, stability and security of the electricity system[74]. These concerns mainly relate to the technical characteristics of wind turbine generators and their behaviour during system faults, a transmission grid code that did not take account of these characteristics and a deficit in regard to the computer models to simulate their performance within the electricity system.

A number of key aspects were addressed in the grid code for wind farms and CER's decided that this moratorium should end once the Distribution Grid Code is finalised.

In addition to the concerns mentioned above, there are several other issues, which arise from incorporating higher levels of wind penetration on the Irish electricity

[73] ESBNG (2004) *Wind Power Generation In Ireland.*

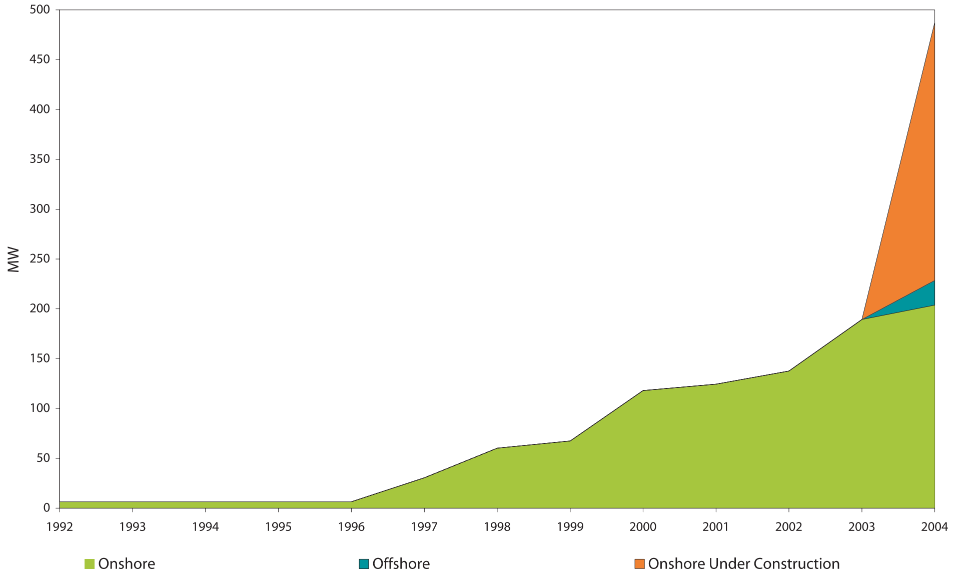
[74] CER (2004) *Wind Direction Connection Policy.*

system. The issues range from those on a localised scale such as voltage control, reactive power provision, line capacity and protection systems, to those on a system wide scale such as frequency regulation, reserve provision, capacity margins and the effects on conventional generator commitment and dispatch.

Wind power intermittency has been highlighted as the major technical challenge. This could be mitigated to some extent through the planned increased interconnection with the U.K. However, interconnection does not constitute the sole solution and the regulatory environment, electricity market design, system operation and the conventional generation mix are all factors that will contribute to limits on wind power penetration at any particular point in the future.

The concerns will present technical challenges to the TSO and Distribution System Operator (DSO) as wind penetration increases. In recent years a number of studies have been commissioned to examine the issues in detail[75].

Figure 24: Installed Capacity of Wind Projects 1992 - 2004



Source: DCMNR

Table 5: Onshore Wind Profile 1992 - 2004

	1992	1997	1998	1999	2000	2001	2002	2003
Number of Windfarms	1	4	4	2	9	2	3	6
Average Wind Farm Size MW	6.45	6	7.45	3.63	5.61	3.20	4.41	8.60
Average Number of Turbines	21	10.25	13.50	5.50	8.67	3	6	6.67
Average Size of Turbines MW	0.31	0.59	0.55	0.66	0.65	1.07	0.74	1.29

Source: DCMNR, REIO

[75] Garrad Hassan, ESBI and UCC (2003) The Impacts of Increased Levels of Wind Penetration on the Electricity Systems of the Republic of Ireland and Northern Ireland, published by CER. This report provided indications of what the future limits of penetration in the electricity network would be. Since its publication, SEI has commissioned a study on the effects of higher wind penetration on electricity system reserve requirements and also a study on the implication of the proposed new electricity trading arrangements upon renewable electricity generators. SEI anticipates that these studies will be the first in a programme of work to address issues on renewable electricity integration.

Figure 25 shows the electricity generated from wind energy and illustrates the rapid rise in electrical output since 1997 when the first of the wind farms supported by the AER programme came online. Total electrical output from wind in 2003 was 454 GWh an increase of 17% on 2002.

Figure 26 quantifies the contribution that wind made to gross electricity consumption from 1992 - 2002. The share has increased from 0% to 1.5% over the period. Although wind generated electricity increased by 17% in 2003 over 2002, gross electrical consumption increased by 2% in the same period.

5.4 Solar

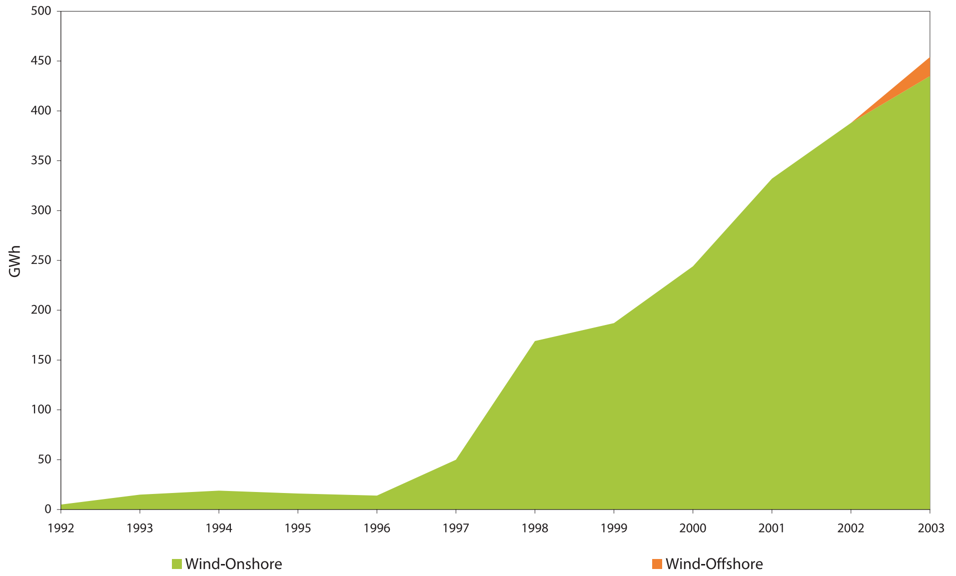
Solar energy can be exploited in a number of ways, for example using it passively for lighting or converting it into electricity or heat. Ireland's climate is quite suited to development of passive solar, solar thermal and solar photovoltaic systems, but system costs remain a barrier to increased deployment. The following sections discuss each of these in turn and analyse the current situation and development in Ireland.

Passive Solar

Buildings can be designed in such a way as to maximise the passage of solar energy into the building and insulation materials within the building to maximise the absorption of this heat.

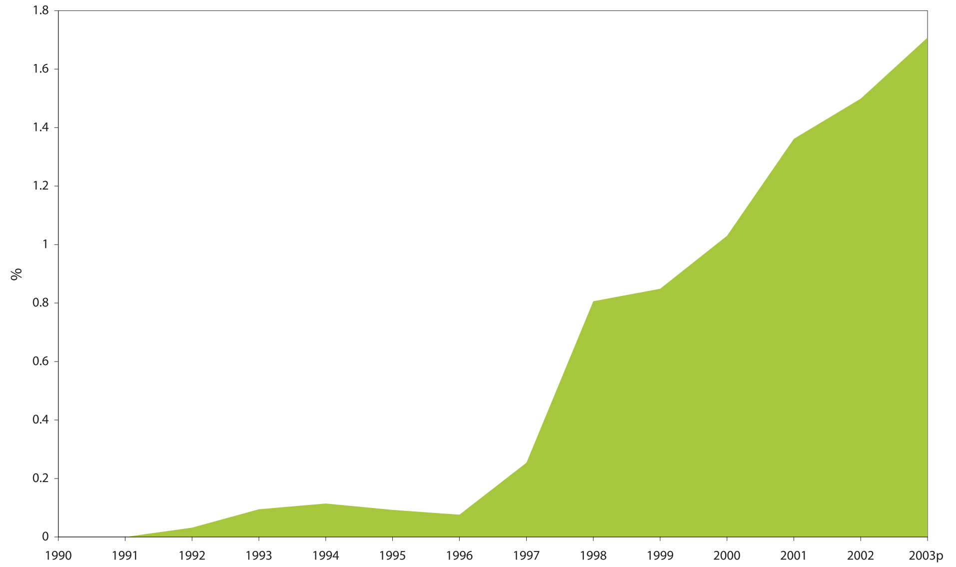
Architects and developers are increasingly taking advantage of the energy emitted from the sun through good orientation and layout. Combined, orientation and insulation, mean that heat in a structure is built up during the day and slowly released during the night. This can reduce the amount spent on heating bills. As it represents a reduction or avoidance of energy consumption, it is difficult to quantify and include in statistical analyses in a transparent manner.

Figure 25: Electricity Generated by Onshore and Offshore Wind 1992 - 2003



Source: SEI

Figure 26: Wind Electricity as a Percentage of Gross Electricity Consumption 1990 - 2002



Sources: SEI

Active Solar Thermal (Heat)

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.

This technology has been used in Ireland for some time and the trend in heat output from 1990 to 2002 is presented in figure 27. It can be seen that there has been a significant growth of 250 % (11% per annum) during the period, albeit from a very small base of 0.05 ktoe. This growth may reflect the falling capital cost that occurred during the 1990's.

Solar PhotoVoltaic (PV)

Photovoltaic cells, made of semiconductor materials (often crystalline silicon), directly convert solar energy into DC electricity.

The individual cells are grouped into modules and encapsulated between a sheet of glass and a backing material within a frame. Modules are then connected together to provide the voltage and current levels required to meet a particular load[76].

The use of PV is becoming more widespread, largely in niche small consumer applications like watches and calculators but also in places to grid connected power plants. There are also used when a grid connection would be expensive or impractical for example, isolated housing or in telecommunications and navigation aids.

There was one grid connected PV plant in Ireland from 1992 to 1997 with a panel area of 790 m^2. The plant was decommissioned in 1997 and currently the most visible use of PV in Ireland is to power parking meters.

5.5 Ambient Energy

Ambient Heat (Heat Pumps)

Heat is widely available from the air, ground and water. 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.

It is worth noting that unless the electricity used in the heat pump is from renewable sources, then the energy used to produce that electricity is based on non-renewable sources and should not be included in renewable energy statistics.

According to Sustainable Energy Ireland's Renewable Energy Information Office over 3000 heat pumps (mainly ground source) are installed in Ireland and over 1000 were installed in 2003 alone.

Geothermal

Geothermal energy is renewable energy derived from the heat within the Earth's crust. Geothermal resources range from surface hot water springs to hot rocks several miles beneath the earth's surface. This energy can be used for water and /or space heating and even for the generation of electricity, pioneered in Italy in 1913, if the water is hot enough.

In countries such as Iceland, Italy, France and the USA geothermal energy is commercially exploited. In Ireland, near surface geothermal resources are limited but there are several projects in operation, one such example being located at Trinity College Dublin.

Ambient energy is currently only a modest resource in Ireland. The output or TFC associated with geothermal and heat pumps is presented in figure 28. It can be seen that there has been a significant increase over the period from a very low base of 0.04 ktoe in 1990 to 0.23 in 2002, an increase of 400% (14% per annum).

5.6 Ocean

Ocean energy includes wave energy, ocean current (also called tidal stream or marine current) energy, tidal energy and ocean thermal energy conversion (OTEC) whereby the energy contained within the waves, ocean currents or tides is converted into electricity, heat (OTEC) or mechanical energy (for desalination for example) or electricity. The ocean energy technologies are mostly relatively immature and have not secured the same levels of research funding as other new renewables (for example wind energy or PV).

Wave energy is an indirect form of solar energy since the winds that produce waves are caused by pressure differences in the atmosphere arising from solar heating. The initial solar power is concentrated in waves, which can have power levels of over 1 MW per metre of length at their crest. Ireland is particularly well suited to wave energy due to the geographic location[77]. Wave energy devices extract and convert this energy, using a variety of technologies, into a form from which electricity can be generated[78].

[76] European Union *The Atlas Project* Available from: http://europa.eu.int/comm/energy_transport/atlas/home.html

[77] A significant short term resource (833 MW) has been quantified in Lewis (2000).

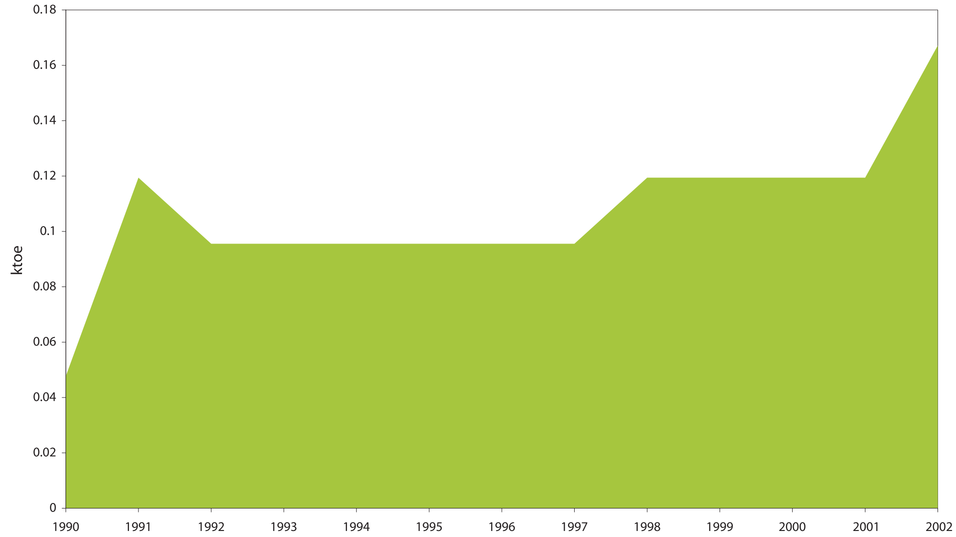
[78] Marine Institute and SEI (2002) *Options for the Development of Wave Energy in Ireland A Public Consultation Document*. Annex 2 provides an overview of wave energy technologies.

Tidal energy can be exploited either by constructing a dam across an estuary with a high tidal range or by harnessing tidal streams (or marine currents). The former is similar to a conventional hydro scheme where water is released from a dam, which drives turbines, which in turn converts the energy into electricity. The main barrier to development is the high construction costs.

Tidal streams can be harnessed using offshore underwater devices that in appearance are similar to wind turbines. The technology is at an early stage of development, but is displaying a promising rate of acceleration.

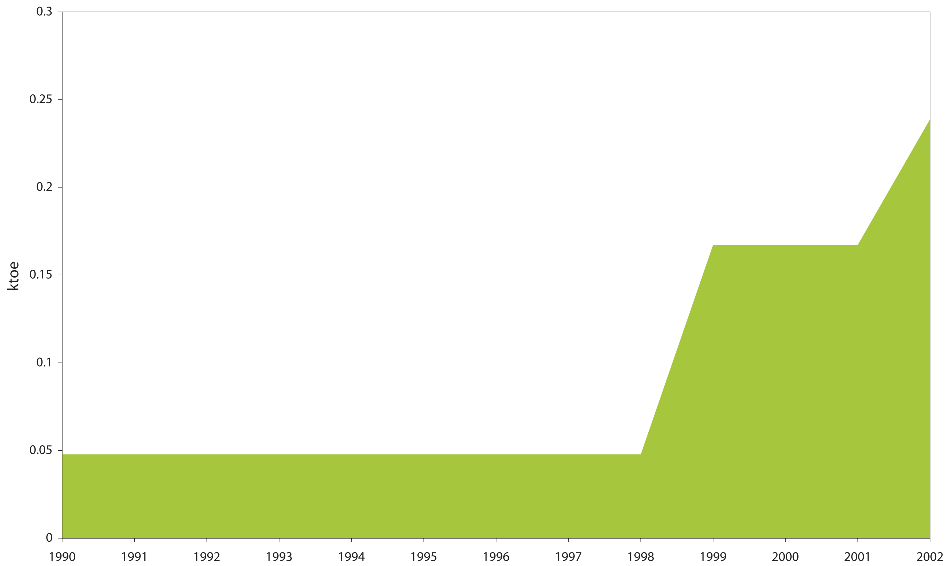
The Marine Institute and Sustainable Energy Ireland[79] carried out a joint public consultation on the future of wave energy published in 2002. Sustainable Energy Ireland is currently in the process of commissioning a tidal resource map for the island of Ireland and is engaged in a co-funded study with the Marine Institute on the economic and industrial possibilities for the ocean sector.

Figure 27: Solar Thermal Final Consumption 1990 - 2002



Source: SEI

Figure 28: Final Consumption of Ambient Energy 1990 - 2003



Sources: SEI

[79] Ibid

6 A View From Northern Ireland

6.1 Introduction

This view from Northern Ireland briefly examines the total demand and supply of energy in Northern Ireland with a particular focus on the portion of total energy sourced from renewable energy.

The various sources of renewable energy in Northern Ireland are detailed, together with the overall current situation. The discussion is confined to electricity generating renewable sources i.e. thermal sources are not considered. There is a particular focus, with the help of extracts from a recent six counties resource assessment[80], commissioned by Action Renewables on the future potential for each of the different technologies.

6.2 Context for Renewable Energy Deployment

This section gives a brief overview of the current situation with regard to energy usage in Northern Ireland in 2002. It draws on trends in primary energy supply and final energy demand. The purpose of the section is to provide a context for the increasing importance being placed on renewable energy.

6.2.1 Energy Supply

Northern Ireland's total energy supply is discussed in terms of changes to the total primary energy requirement (TPER), also known as gross inland consumption.

Northern Ireland's energy supply has progressed considerably over the past 5 - 10 years to providing more efficient generation, less reliance on solid fuels (particularly in the residential sector) and improvements in energy efficiency. There is still, however, considerable scope for improvement.

The development of gas pipelines will make gas available to nearly 80% of the residential population and also to industry over the next 3 - 4 years. Such developments will have an impact on the efficiency of energy supply and electricity generation and there will be a consequential knock-on effect for oil, coal and other fuels. European directives will also have an impact on the promotion of renewable energy sources. Changes in electricity generation in the years 2006 - 2012 are likely, with the second biggest predicted change being the continued growth of renewable sources.

Due to a shortage of capacity in the Republic of Ireland, ESB has entered into a three-year contract to purchase 180 MW of capacity from the Ballylumford generating station. This deal covers one of the existing units and has the potential to be extended after the three years.
An unknown factor at this stage is how much of the output from the new plant at Coolkeeragh will be exported to customers in the Republic of Ireland.

Figure 29 illustrates Northern Ireland's TPER by fuel for 2002. It can be seen that coal is the dominant energy source for Northern Ireland with 1.44 Mtoe (29.4%) of total primary energy. This was followed by oil and LPG, natural gas, fuels for transport and imports of electricity with 1.29 Mtoe (26.3%), 1.09 Mtoe (22.4%), 0.93 Mtoe (18.9%) and 0.14 Mtoe (2.8%) respectively. Finally, renewable energy generation in 2002 made up a small percentage of the total with 9.82 ktoe (0.2%).

Fossil fuels are a finite resource and Northern Ireland's own energy supplies will increasingly depend on imported gas and oil from Europe and beyond. This raises security of supply concerns and it is imperative that alternatives to fossil fuels are exploited where possible.

6.2.2 Energy Demand

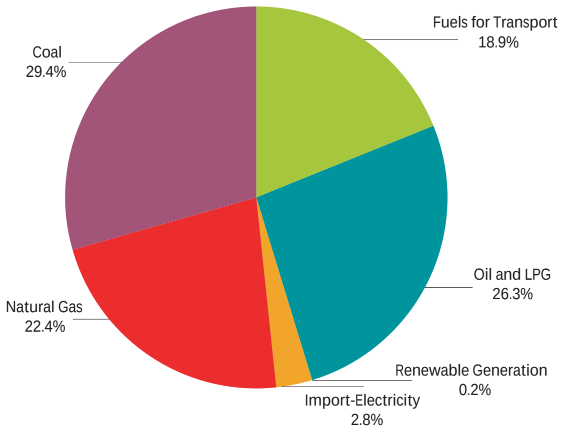
As we have seen in section 2.2 (page 11) final energy demand, also known as total final consumption is a measure of the energy that is delivered to energy end users in the economy to undertake activities as diverse as manufacturing, movement of people and goods, essential services and other day-to-day energy requirements of living.

Northern Ireland's final energy consumption is presented in figure 30. It can be seen that the residential sector is largest in terms of final energy consumption with 1.5 Mtoe (43.9%). The remaining sectors in order of significance are transport (0.95 Mtoe 27.6%), industry (0.57 Mtoe 16.8%), commerce and buildings (0.22 Mtoe 6.4%) and finally, the public sector (0.18 Mtoe 5.3%).

Demand for electricity in Northern Ireland is growing at 3 to 4% per annum. It is against the background of increasing energy consumption and security of supply concerns that renewable energy is discussed in the next section.

[80] PB Power, Action Renewables (2004) *A Study into Renewable Energy Resource in the Six Counties of Northern Ireland.*

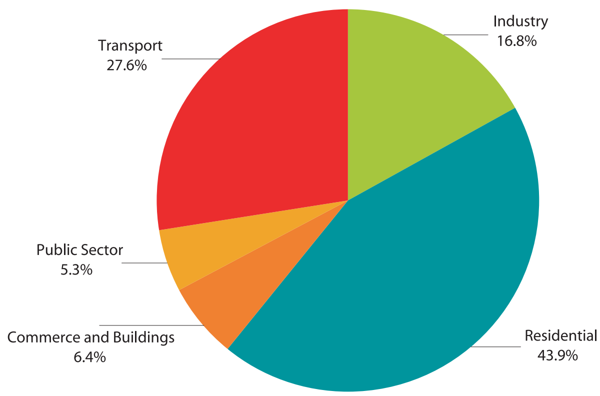
Figure 29: Northern Ireland Total Primary Energy Requirement 2002



Total 4.9 Mtoe

Source: The Carbon Trust

Figure 30: Northern Ireland Total Final Consumption 2002



Total 3.4 Mtoe

Source: The Carbon Trust

6.3 Renewable Energy Sources In Northern Ireland

Northern Ireland possesses some of the best renewable energy resources in Europe. Yet, as we have seen in section 6.2.1, only 0.2% of Northern Ireland's primary energy came from renewable sources of energy in 2002.

This 0.2% consists of wind, hydropower and biomass electricity generating capacity. The total installed capacity of renewable energy sources is illustrated in figure 31.

It can be seen that installed capacity is dominated by wind providing 100% of the installed renewable capacity in 1994 falling to 96.9% in 2003. The dominance of wind is set to continue as a further installed capacity of 22.86 MW (two plants) is due to be brought online by the end of 2004. There is also a biomass plant (2.7 MW) due for completion in 2004. It is important to note that data is not available for projects, which have an installed capacity less than 0.02 MW and only refers to electricity generating capacity.

Northern Ireland's first wind farm was brought on line in 1994 and by the end of that year there was a total of 10 MW installed at two sites (Corkey and Rigged Hill, both 5 MW). Most recent data (August 2004), shows that there are 10 wind farms operational in Northern Ireland. In 2003 total installed capacity was 111MW, per annum growth rate of 11%. It is worth noting that all wind farms in Northern Ireland are onshore.

The largest wind farm in Ireland is located at Altahullion, Co. Londonderry and has an installed capacity of 26 MW.

Hydropower in Northern Ireland has, to date been confined to small scale projects. The first plant was installed in January 1995 with an installed capacity of 0.08MW and by the end of that year a further two projects were added for a total of 0.48 MW. By August 2004 the total installed capacity of 3.14MW or an 11.3% per annum increase. The largest hydropower plant has an installed capacity of 0.78 MW and is located at Sion Mills, Co Tyrone.

Finally, there are two biomass plants with a combined installed capacity of 0.304 MW.

The exploitation of renewable energy resources has been actively encouraged for a number of years in Northern Ireland. In 1993, the Department of Economic Development (DED) in Northern Ireland, in line with UK Government Policy, announced its intention to encourage the development of commercially viable renewable energy sources. A scheme was developed, which involved placing a non-fossil fuel obligation (NFFO) on NIE to initially secure about 16MW Declared Net Capacity (DNC) rising through successive NFFOs to 45MW DNC by 2005.

The results of the 1993 NI-NFFO Order (NI-NFFO1) were announced by DED in March 1994 resulting in 20 contracts being awarded to 12 different companies. Under NI-NFFO1 there were three technology bands (wind, hydro and sewage gas) and the average bid price was 6 p/kWh.

The NI-NFFO2 tender process was broadly similar to that of NI-NFFO1. At the end of December 1998, 16 schemes were commissioned for 14.93MW DNC for both NFFO1 and NFFO2. The second Order was made in 1996, and 16 MW DNC of generation was contracted at an average bid price of 4 p/kWh. Most of these NI-NFFO2 projects are, however, yet to be commissioned. The second order included six technology bands namely: wind, hydro, biomass, energy from waste, landfill gas and farm-based biogas.

Table 6 examines the installed capacity detailed above in terms of the NFFO support mechanism. It can be seen that the majority of installed capacity (69%) has been constructed outside the NFFO programme but a significant number of wind projects were installed in NFFO 1.

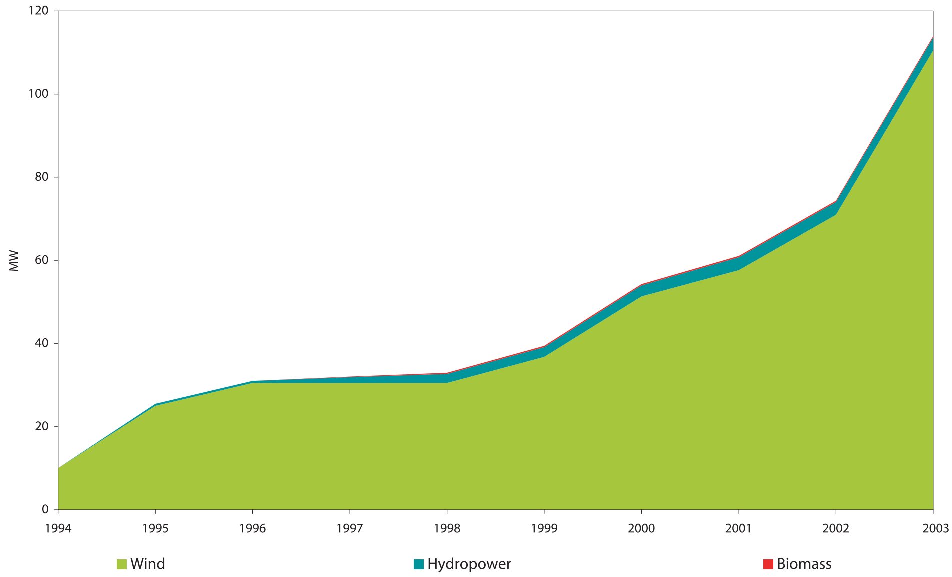
Recent research carried out by Millward Brown[80], on behalf of Action Renewables, has revealed the following with regard to renewables in Northern Ireland

- overall low awareness and knowledge of renewable energy,
- electricity is taken for granted and the environment is a low priority issue,
- sense that renewable energy is not open to the individual,
- overall empathy for renewable energy is also low.

Therein lies the purpose of Action Renewables - to significantly raise awareness of the potential consequences of climate change, to stimulate awareness of the issues associated with conventional energy use and to promote renewables generally in the context of a possible solution.

[80] Milllward Brown Ulster Ltd. Details available from www.actionrenewables.org

Figure 31: Installed Capacity of Renewable Energy Sources in Northern Ireland 1994 - 2003



Source: Northern Ireland Authority for Energy Regulation

Table 6: Northern Ireland Installed Capacity by Support Mechanism

Source	NFFO 1	NFFO 2	Non NFFO	Total
Wind MW	30.5	1.66	78.36	110.52
Hydropower MW	2.7	0	0.44	3.14
Biomass MW	0	0.30	0	0.35
Total MW	**33.2**	**1.96**	**78.80**	**114.01**

Source: Northern Ireland Authority for Energy Regulation

6.4 Potential for Renewable Energy in Northern Ireland

This section summarises briefly the results of a study commissioned by Action Renewables and conducted by PB Power[81]. The report published in July 2004, examined the potential for electricity generation from renewable energy in Northern Ireland. Exploitation of renewables in Northern Ireland depends on four factors: size of the resource, cost of the resource, state of the development of the technology and physical and environmental considerations.

Two of the feasible resources focussed on in the report are wind and hydropower. The purpose of this section is not to provide a comprehensive summary of the available resource in Northern Ireland. It is only intended to give a flavour of the rich natural resources that are available for exploitation in Northern Ireland. In addition to wind and hydropower the following technologies are considered in the PB report

- biomass (straw, poultry litter, spent mushroom compost, short rotation coppice and miscanthus grass, forest products and residues, sawmill residues),
- tidal stream,
- municipal and agricultural wastes,
- landfill gas and sewage gas.

6.4.1 Wind

The greatest resource identified in the PB report is wind. Onshore wind resource is 565 MW in total, and the offshore wind resource has nominally been put at 500 MW. The resource, which is available for exploitation offshore, however is heavily dependent on many factors, which are beyond the scope of the PB report, including a more detailed analysis of available wind data and seabed geology. Both onshore and offshore would be subject also to a detailed environmental impact assessment.

6.4.2 Hydropower

Two major factors, which must be considered when identifying potential sites for hydro schemes are head (the vertical distance between the water intake and the outlet levels) and the volume of flow. Hydro schemes also require a suitable sized rainfall catchment area to produce enough power to make the scheme economically viable. Attempts have been made over the past 50 years to build large-scale hydro projects in Northern Ireland, but these did not go ahead, because of environmental constraints. The feasible resource for hydropower by county is contained in table 8.

Hydropower is one of the most expensive technologies to install. Introducing the Renewable Energy Obligation from April 2005 will place an obligation on energy suppliers to purchase a percentage of their electricity from renewable sources. This may lead to an improvement in renewable generator return and in hydropower investment.

Table 7: Feasible Resource Identified for Wind - Northern Ireland by County

County	MW	GWh/annum
Antrim	94	313
Armagh	12.5	42
Down	92.5	308
Fermanagh	89.3	297
Londonderry	70.5	235
Tyrone	205.8	685
Total	**564.6**	**1880**

Source: Action Renewables /PB Power

Table 8: Feasible Resource Identified for Hydropower - Northern Ireland by County

County	MW	GWh/annum
Antrim	4.7	22.8
Armagh	0.7	3.3
Down	0.4	1.7
Fermanagh	0.2	1
Londonderry	1.7	8.2
Tyrone	0.6	2.7
Total	**8.3**	**39.7**

Source: Action Renewables /PB Power

[81] Full details can be found in the PB report which is available to download from Action Renewables website www.actionrenewables.org

6.5 Conclusions

Overall renewable energy is not well developed in Northern Ireland at the moment and that is reflected in 0.2% share of TPER. A constraining factor is that the NIE grid can only absorb a limited amount of intermittent power generation.

The major challenges facing Northern Ireland are set in the global context in which all economies now operate. Action Renewables has made an impressive start across a wide range of crucial initiatives to stimulate growth in the adoption of renewable energy in Northern Ireland. Working with diverse sectors and agencies it has managed to break though some of the institutional barriers that have hampered development to date. Though much work remains to be done, significant progress has been made in public awareness and in the important area of supplier and market development.

7 International Comparison and Irish Targets

This section examines the evolution of renewable energy in Ireland relative to other countries. It also charts progress towards national and EU targets.

7.1 International Comparison

Figure 32 records the trend in the contribution of renewable energy to TPER for Ireland, the US, Denmark, Finland and France, as well as the EU 15 for the period 1990 to 2002[82]. It can be seen that Ireland's use of renewables is quite low compared to other countries. However the direction of the comparative trend in 2002 is upwards. The trend is likely to continue in this direction as a consequence of the increasing use of wind in 2003 and 2004 (as illustrated in section 4.3).

It is interesting to note that Iceland (not shown) has the highest proportion of TPER from renewables in the developed world with 73% in 2002; the majority sourced from hydropower with the remainder coming from geothermal. There are a number of developing countries, (such as Sudan, 81% in 2001) which use a higher percentage of renewables than the countries in figure 32, but this is mostly as a result of low economic growth levels and low energy consumption that is largely dependent on traditional renewable sources. The renewables share of primary energy is likely to decease as the economies of these countries grow and with it fossil fuel energy consumption.

Figure 33 examines the renewable energy's share of (thermal) TFC for Ireland, Finland, France and the EU 15. We can see that Ireland is again at the lower end of the range. It is interesting to note that the EU 15 average has remained relatively constant over the period, rising from 4% in 1990 to 4.1% in 2002.

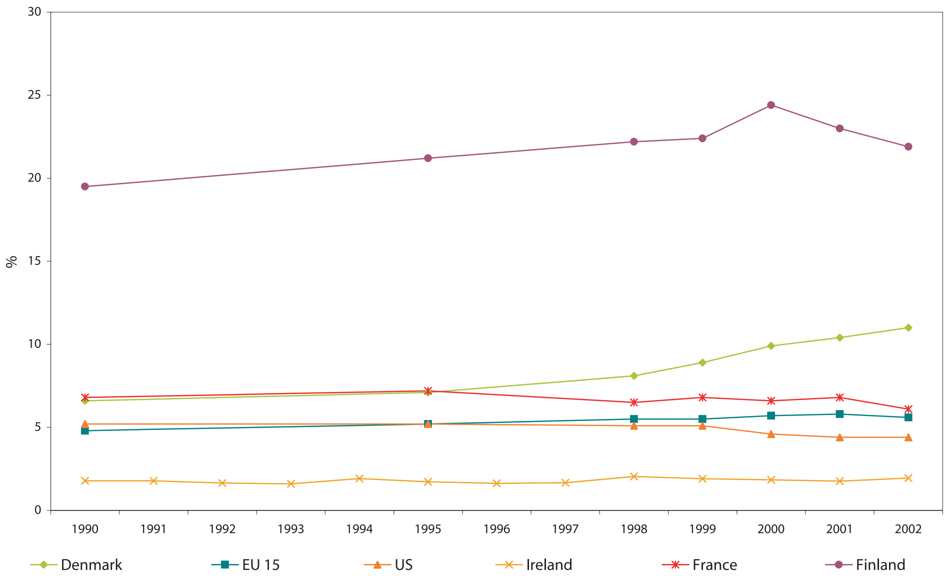
The ratio between the electricity produced from renewable energy sources and gross electricity consumption for a given calendar year is presented in figure 34.

Electricity produced from renewable energy sources comprises the electricity generation from hydropower plants (excluding pumped storage), wind, solar, geothermal and electricity from biomass/wastes.

Gross national electricity consumption comprises the total gross national electricity generation from all fuels (including autoproduction), plus net electricity imports.

It can be seen from figure 34 that there is a wide range of variation in the amount of electricity that is sourced from renewable energy. In 2002 Ireland was at the lower end of the scale but as stated in the last section this would be expected to increase with the large amount of wind that is coming on line in 2003 and 2004.

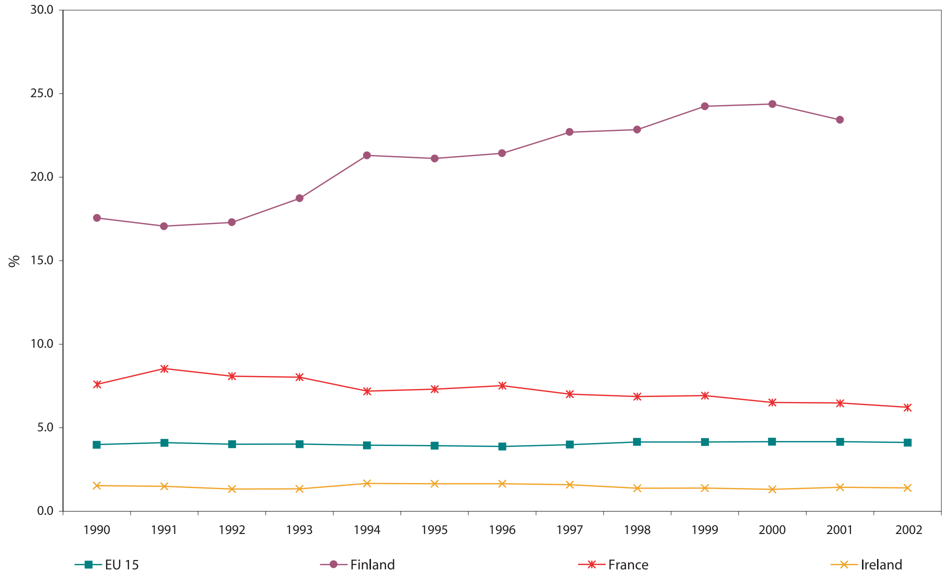
Figure 32: Renewable Energy Share of TPER -International Comparison 1990 - 2002



Source: IEA, SEI

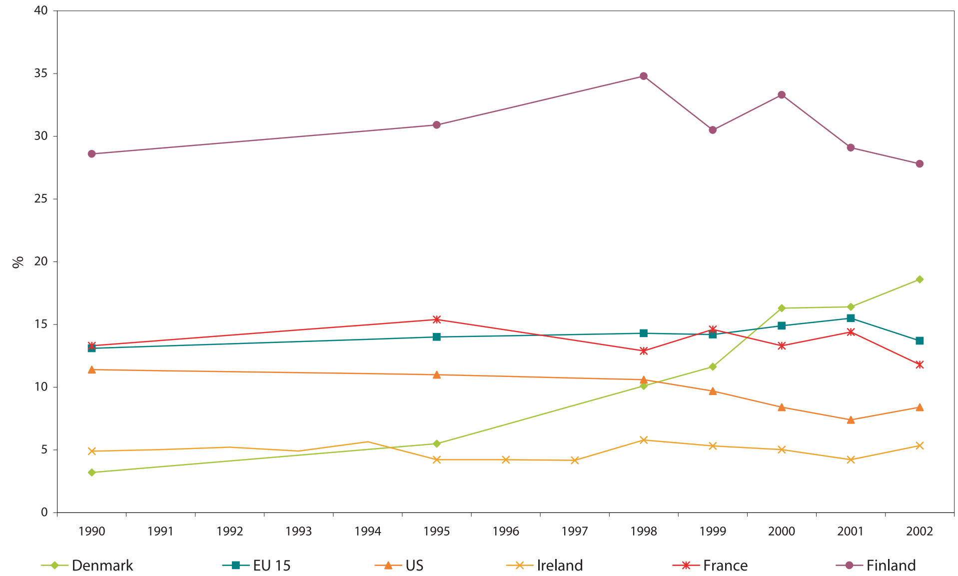
[82] Data for figure 32 and 34 is only available for counties other than Ireland for 1990, 1995 and 1998 to 2002 so data is interpolated linearly for the missing years. Also note that 2002 data for countries other than Ireland is provisional.

Figure 33: Renewable Share of TFC- International Comparison 1990 - 2002



Source: Odyssee

Figure 34: Share of Gross Electricity Consumption from Renewable Sources - International Comparison 1990 - 2002



Source: IEA, SEI

7.2 Targets

As outlined in section 2 and 3 there are a number of national and EU targets that Ireland is committed to and this section charts the progress towards meeting the most significant targets.

7.2.1 Kyoto

Section 2 outlined the large increase in energy consumption which has resulted in a consequent increase in energy related CO_2 emissions. The Kyoto protocol seeks to limit the increase in emissions.

Ireland's target under the Kyoto Protocol is to limit annual greenhouse gas (GHG) emissions to 13% above 1990 levels by the period 2008 - 2012. This is part of an EU Burden Sharing Agreement whereby the overall EU target reduction of 8% in emissions is to be achieved through the combined efforts of the Member States.

Ireland's national target reflects a number of factors, including the relatively underdeveloped state of the economy in the base year (1990). As shown in figure 7 (page 14), in 2001 Ireland was already 31% above 1990 levels, mainly as a result of high economic growth. 2002 shows a reversal in the upward trend for the first time with GHG emissions dropping slightly to 29% above 1990 levels. Based on provisional data, this downward trend has continued in 2003 with emissions under 25% above 1990 levels for that year.

As mentioned in section 2, the improvement is largely attributed to fuel mix changes associated with new efficient electricity generating plant, closure of some large energy consumers and the increased consumption of gas and renewable energy, which are less carbon intensive than oil and the solid fuels.

7.2.2 Green Paper on Sustainable Energy

The Green Paper on Sustainable Energy[83] target with regard to renewable energy is to increase renewable energy electricity generating capacity by 500 MW in the period 2000 - 2005. This was anticipated to

1. Increase the percentage of electricity generated from renewable sources to 12.39% by 2005.

2. Increase the percentage of Total Primary Energy Requirement (TPER) to be derived from renewable sources from 2% in 2000 to 3.75% by 2005.

Referring to table 4, page 36, wind farms with a combined capacity of 122 MW together with 5.5 MW landfill gas and 2.2 MW hydro brings the total to 129.7 MW. Adding the renewable energy capacity currently under construction (259 MW wind and 1 MW landfill gas) would bring the total to 389 MW. Based on this, together with the amount of additional AER V and AER VI capacity and current status of grid connection agreements, it appears likely that the Green Paper 500 MW target will be met by 2007 (i.e. during 2006) rather than by 2005, as targeted.

In 2003, provisional data suggests that the proportion of electricity generated from renewable sources was 4.1% (down from 5.4% in 2002). The reduction was due to reduced rainfall and increased total electricity generation. Based on the deployment rates it is not anticipated that the share from renewables will reach more than between 6% and 7% at most in 2005.

In 2002, Ireland's share of TPER from renewables was 1.9%, an increase of 0.1% percent on 1990. The anticipated Green Paper 3.75% level was based on a certain amount of biomass penetration in addition to the significant expected wind growth. Due to the discussion in section 4.3 regarding the treatment of wind energy in calculating TPER, increasing wind penetration and decreasing biomass results in a lower renewables contribution to TPER. This coupled with the slower than anticipated wind deployment rate leads to a reduced renewables contribution to TPER. It is not anticipated that the Renewable Energy contribution to TPER will be higher than 2.5% in 2005. This will also depend on the trend in TPER, which has slowed in 2002 and 2003, suggesting that the increase in renewables may not be overshadowed by the increases in TPER as happened during the 1990's.

7.2.3 RE Directive 2001/77/EC

The 2005 target from the Green Paper relating to renewable energy electricity is extended to 2010 by the *Directive 2001/77/EC on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market*[84].

It sets an overall EU target of 22% of electricity to be generated by renewable sources by 2010 and a target of 13.2% for Ireland. This target does not specifically refer to wind but it is expected that wind power will contribute the bulk of increased capacity required.

Provisional data for 2003 suggests that renewable energy contributed 4.0% of gross electricity consumption in 2003[85].

[83] *Government of Ireland (1999) Green Paper on Sustainable Energy.*

[84] European Union (2001) *Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market.*

[85] Slightly less than the contribution to electricity generated due to electricity imports.

Data Sources

Department of Communication, Marine and Natural Resources, Dublin.

Energy Policy Statistical Support Unit, Sustainable Energy Ireland, Co. Cork.

Environmental Protection Agency, Johnstown Castle Estate, Co. Wexford.

EU Funded SAVE II Odyssee Project.

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Annex 1 Renewable Energy Data 1990-2002

RE TPER ktoe	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Solid Biomass	105.47	105.47	88.87	89.76	118.54	118.54	109.13	109.15	130.84	130.84	136.02	152.03	152.03
Biogas	2.27	2.84	2.79	3.63	2.48	2.84	3.61	4.20	4.49	4.44	4.30	4.30	4.30
Geothermal	0.0031	0.0013	0.0023	0.0001	0.0017	0.0031	0.0019	0.0050	0.0047	0.0273	0.0458	0.0419	0.1099
Solar Thermal	0.05	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.12	0.17
Hydropower	59.93	64.14	70.25	65.78	79.11	61.31	62.08	58.30	78.76	72.74	72.74	51.25	78.42
Wind	0.00	0.00	0.43	1.29	1.63	1.38	1.20	4.30	14.53	16.08	20.98	28.55	33.36
Landfill Gas	0.00	0.00	0.00	0.00	0.00	0.00	10.15	21.85	30.26	32.20	23.60	24.00	19.18
Total	**167.73**	**172.58**	**162.45**	**160.55**	**201.86**	**184.16**	**186.27**	**197.91**	**259.01**	**256.45**	**257.81**	**260.28**	**287.56**

Source: SEI

RE TFC ktoe	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
THERMAL													
Solid Biomass	105.47	105.47	88.87	89.76	118.54	118.54	109.13	109.15	130.84	130.84	136.02	152.03	152.03
Biogas	2.27	2.84	2.79	3.63	2.48	2.84	3.61	4.20	4.49	4.44	4.30	4.30	4.30
Geothermal	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.1672	0.1672	0.1672	0.2388
Solar Thermal	0.05	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.119423	0.11942	0.16719
Total Thermal	107.84	108.48	91.81	93.53	121.17	121.52	112.88	113.50	135.50	135.57	140.6086	156.611	156.731
ELECTRICITY													
Hydropower	59.93	64.14	70.25	65.78	79.11	61.31	62.08	58.30	78.76	72.74	72.74	51.25	78.42
Wind	0.00	0.00	0.43	1.29	1.63	1.38	1.20	4.30	14.53	16.08	20.98	28.55	33.36
Landfill Gas	0.00	0.00	0.00	0.00	0.00	0.00	3.72	8.01	11.10	11.81	8.65	8.80	7.03
Total Electricity	59.93	64.14	70.68	67.07	80.74	62.68	67.07	70.61	104.39	100.63	102.38	88.60	118.81
TRANSPORT													
Biofuel	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Transport	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**167.77**	**172.63**	**162.49**	**160.60**	**201.91**	**184.21**	**179.89**	**184.11**	**239.89**	**236.20**	**242.99**	**245.21**	**275.54**

Source: SEI

This data is available on the SEI website and will be updated when new data becomes available.