The Irish Academy of Engineering

# Future Energy Policy in Ireland

## Part 1

## Conclusions and Recommendations

March 2006

The Academy wishes to acknowledge the financial assistance given by the organisations listed below towards the cost of researching, publishing and printing the Report:

These donations were made on the basis that responsibility for content, conclusions and recommendations would be solely a matter for the Academy Steering Group.

Organisations

*Bord na Mona*
*Coilite Teoranta*
*The Commission for Energy Regulation*
*ESB*
*Sustainable Energy Ireland plc.*
*Viridian plc*

## CONTENTS



***Note:*** ***Cross-references refer to the detailed sections in Part 2.***

# FUTURE ENERGY POLICY IN IRELAND: PART 1

## FOREWORD

This report is being submitted to the Minister for Communications, Marine and Natural Resources by the Irish Academy of Engineering as an input to the formulation of the national energy policy.

The Irish Academy of Engineering, which was founded in 1997, has as its overall objective the advancement of the science and practice of engineering as an essential element in the development and enhancement of living standards on the island of Ireland. It produces reports on medium to long-term issues, whose purpose is to inform and stimulate discussion in advance of policy formulation and decisions.

The Academy is conscious of the critical importance of energy in a modern society and undertook this report to highlight a number of issues facing policymakers in this area. The report is a collation of edited inputs of a wide range of Academy members with relevant experience, and of other specialists. It does not necessarily reflect the personal views of all Academy members or of the Academy as a whole.

The report is in two parts; Part 1 being a synthesis of a wide range of papers on a variety of energy related topics contained in Part 2. The papers in Part 2 form the basis for the findings and recommendations contained in Part 1 of the report.

The various and numerous contributors are listed at the back of the report and represent a considerable body of expertise in the energy field. The Academy is extremely grateful for their contributions and assistance.

The Academy also wishes to acknowledge the financial assistance given by the organisations listed on the inside front covers, who contributed funds toward the costs of research, publishing and printing the report.

Irish Academy of Engineering
March 2006

## A. INTRODUCTION

With the exception of the air we breathe, every other aspect of modern living is highly energy dependent, for example:

- Water supply
- Food production
- Housing
- Services (for example, health and education)
- Transport and telecommunications
- Industry and agriculture

The list is endless, and without energy the economy would quickly grind to a halt and **modern society would disintegrate.**

Given this situation, an effective energy policy and strategy is essential and energy policy is clearly a priority in many countries (such as the USA, UK, Germany and France). The same priority is not evident in Ireland. However, recent developments are highlighting the critical nature of the issues and the stated intention of the Minister to publish a policy is most welcome.

The developing energy problems in Ireland and elsewhere are extremely serious and can be addressed if tackled with determination, speed and understanding. The Academy will be pleased to lend support as required.

The Academy is a totally independent body, the aim of which is to provide impartial, objective and accurate comment.

This report by the Irish Academy of Engineering can be viewed as an input into this emerging comprehensive policy and it ranges over all the key aspects of energy, including supply and consumption in the transport, electricity and heating sectors. It also looks at the important parameters of climate change, fossil fuel availability, evolving technology, international practice and economic implications.

The Academy has drawn on a very wide range of sources and studies and is not attempting to replicate the work of various expert bodies that have studied particular developments in detail. Rather, the aim is to provide an overview of the many issues and factors and attempt to provide a basis for a comprehensive policy that is pragmatic, practical, soundly based and implementable in policy and framework terms.

The recommended objective of a government energy policy is to create the conditions where the best result is delivered **from the point of view of the following:**

- The wider community in national terms, and compatible with the wider global perspective.

- The economy as a whole in the short, medium and long term.

- The individual consumer or business.

- Succeeding generations, by avoiding the creation of a legacy of major problems (depletion of critical resources or irreparable environmental damage).

In this context, all policy proposals and related developments should be assessed using defined **criteria** (parameters or objectives). The generally accepted criteria are as follows:

1. Economic cost
2. Environmental impact
3. Security and continuity of supply
4. Efficient use of scarce, non-renewable resources

These criteria can be either compatible or contradictory, and the challenge in developing policy is to strike a pragmatic balance between the various aims of a comprehensive energy policy. Detailed comments on each are given below, but the essential trade off (or optimum balance) is between economic cost on the one hand and environmental benefits, security and efficiency on the other. Over time, almost anything can be achieved at a price, but the price in turn can seriously undermine the economy and all the other services that stem from positive economic conditions.

## 1. *Economic cost*

Issues include the following:

- Affordability at the personal and business level.
- Fuel poverty in households.
- Non-competitive energy prices (vis-à-vis EU partners).
- Attracting and retaining modern industry and services.
- State subsidies and supports for the energy sector.
- The economic cost of discontinuities in energy supply.

## 2. *Environmental impact*

Issues include the following:

- Effects of climate change.
- International commitment (such as Kyoto).
- The image of Ireland.
- Destruction of habitats.
- Legacy for future generations.
- Health and safety.

## 3. *Security and continuity of supply*

Issues include the following:

- Indigenous or imported energy.
- Potential terrorism and disruption.
- Balancing intermittent supply (such as wind) with continuous sources.
- Reliability of technology.
- Diversification of sources.
- Market incentives to attract investment.
- Long-term availability of resources.

## 4. *Efficient use of scarce, non-renewable resources (such as fossil fuels)*

Issues include the following:

- Consumer attitudes and related publicity/education in relation to conservation.
- Conversion efficiency of plant (high efficiency optimises fuel and related emissions).
- High/low consumption in transport vehicles.
- Poor housing insulation (waste of energy).
- Efficiency of appliances (lighting, refrigeration and so on).
- Inappropriate subsidies.

In compiling the report over the last two years, a number of general points emerged:

- Prediction of future energy developments over the medium to long term is characterised by marked uncertainty. For this reason, experts in the field agree that a flexible approach is essential, with a range of options being kept open until reliable practices emerge. The alternative is to try to select potential 'winners' from the emerging technologies and practices.
- There is a tendency in Ireland to pin hopes on esoteric emerging technologies and ignore the advances that can be achieved using the more conventional established technologies and practices.
- In energy terms, disproportionate attention is paid to the production of electricity by comparison with the very problematic transport sector or the heating of buildings and general conservation programmes that have considerable scope for reducing energy demand.
- In examining the four key criteria to establish some priority, the rapidly developing environmental problems associated with greenhouse gas emissions appear to be the most critical. However, the overriding tendency when there are conflicting

objectives is to prioritise economics and security. This is happening in many countries, and also in Ireland.

The main aim of the Academy report is to strike a realistic balance between the four criteria across all sectors. The ideas and recommendations contained in the report should form the basis for a set of policies that will address the major energy challenges confronting our society.

## B. GENERAL PARAMETERS OF FUTURE ENERGY POLICY: SUMMARY OF FINDINGS (SECTION 1)[1]

### Energy Use in Ireland (Section 1.2)

Total primary energy use grew from 9.4 million tonnes of oil equivalent (mTOE) in 1990 to 14.63 mTOE in 2003 and is projected to reach ca. 16 mTOE by 2010. Barring a serious economic downturn, this upward trend will continue. Emissions grew correspondingly and are firmly on track to break the agreed Kyoto protocol targets.

**Primary** energy demand falls into three major sectors of similar size, which are as follows:

- Transport
- Electricity production
- Heating/cooling of buildings

In terms of **secondary** energy use (that is, after conversion) the big sectors are:

- Transport
- Heating/cooling of buildings
- Food production and distribution

All of these use **combinations** of primary energy sources.

Some 97% of all primary energy is **fossil fuel based,** and at present over 90% of this is imported. No significant change is likely before 2010, except in terms of the percentage of gas imported.

The **high growth** sectors are transport and the heating/cooling of commercial and public sector buildings. Residential buildings, industry and agriculture have lower growth rates.

In terms of relative fuel usage, oil and gas have surged ahead at the expense of coal and peat, with renewables showing a very small increase.

Irish residential consumption is approximately 35% above the EU average (climate corrected). There is a negative trend in the transport sector in energy efficiency terms, unlike other sectors where new technologies and regulations are helping to improve energy efficiency, thus partially offsetting the increasing growth in demand.

The above statistics relate to the Republic of Ireland. The pattern in the Northern Ireland is more moderate, reflecting lower economic growth and tighter regulations. However, both economies face similar problems and challenges.

*1 Section numbers in these headings refer to Future Energy Policy in Ireland, part 2.*

Finally, it is disturbing to note that in 2001, 62,000 households experienced persistent fuel poverty and a further 165,000 were subject to intermittent fuel poverty. These are the people who are most vulnerable to the negative impacts of energy policy and practices.

### *Climate Change (Section 1.3)*

There has been a considerable increase in the public understanding of the issue of climate change over the last five years. This reflects the emerging strong consensus in the scientific community and the growing body of evidence, which is discussed in section 1.3.

The current trends and patterns point clearly towards massive problems on a global scale during this century. If they continue, they will threaten the future existence of homo sapiens on the planet.

The correlation between population growth stemming from the Industrial Revolution and the increase in greenhouse gas emissions is no longer seriously disputed. The concentration of $CO_2$ in the atmosphere is unprecedented in scientific evidence stretching back some 750 million years.

The scientific view is that a point of no return, leading to **irreversible damage**, can come within 30 years and the consequences for the global food chain and habitat may well be catastrophic.

While it is important to focus on **adaptation strategies**, it is even more important to restrict and eventually **reverse** the emission trends. Current steps in this regard cannot impact within 25–30 years because of the momentum of the change, but current inaction is a recipe for passing on an irretrievably damaged environment to future generations.

This is an issue on which Ireland, working with its EU partners, can provide global leadership. To be credible, the serious emission problems and trends in Ireland must be tackled aggressively. Kyoto compliance is a start to this process.

### *Future Availability of Fossil Fuel (Section 1.4)*

Availability of coal is not an issue, but it cannot continue to be used unless ‘clean coal’ technology is developed. Section 1.4 addresses the oil/gas scenarios from a scientific perspective, unlike some commentators who use hypothesis and conjecture to deny that a future problem exists.

The rate of consumption of oil has exceeded the rate of new discoveries for the last 25 years. Looking at the total global reserves of regular conventional oil, for every barrel being added to the reserve five barrels are being consumed. As a consequence total reserves are now at their peak and will decline steadily until oil runs out in approximately 2050/2060. Non-conventional oils from shale, bitumen and so on are estimated to add approximately 10 years consumption at a very high cost. With demand outstripping supply, the existing trend will lead to ever higher prices. In addition, there is also the threat of serious political instability in the major production areas.

The position with regard to gas is similar and the same problems characterise the industry. Although the gas cycle is running some 20–30 years behind oil, scenarios suggest that demand appears to be escalating at a greater rate.

Oil is not only critical to transport, heating and electricity production, but it plays a vital role in the production of food and an enormous range of manufactured goods. All modern economies are substantially built on oil and gas. By any standards, a global crisis is in the making.

### *Conservation of Energy in Ireland (Section 1.5)*

Section 1.5 sets out the history of conservation initiatives in Ireland over the last 30 years. In the 1970s, the oil crisis triggered a series of initiatives, but interest diminished with the collapse of oil prices in the 1980s. During the 1990s, growing environmental issues provided a new stimulus and focus on the question. This has accelerated since 2000.

The section lists a total of 32 initiatives grouped under five headings:

- Financial
- Regulatory
- Institutional
- Developmental
- Informational/promotional

It also refers to the Green Paper on Sustainable Energy (1999) and the National Climate Change Strategy (2000). The key question is: how effective have these initiatives and the consequent expenditure been?

This is examined in terms of:

- Changes in demand
- Changes in structure
- Changes in efficiency

The section also attempts to analyse the changes in energy intensity (energy/GDP), which has fallen by 33% since 1990. This form of analysis and measurement is still at an early stage, and it is not possible to segregate the impact of the variety of conservation initiatives. Some general observations can be made:

- Despite major improvements in engine technology, transport is negative because of larger private cars, higher vehicle mileages and, particularly, congestion. Total fuel use has increase by approximately 150% since 1990.
- Industry is positive, driven by effective programmes, structural change and commercial targets. In addition, newer appliances are more energy efficient.
- Heating is becoming more efficient as revised regulations take effect.
- Electricity production experienced a marked improvement in conversion efficiency with the swing to combined cycle gas turbines (CCGTs). This is now being offset due to a combination of higher fuel costs, excessive base load plant, catering for peat and renewable outputs and operators playing the market.

- Commercial and public service buildings' energy use is growing rapidly because of excessive air conditioning, 24hour lighting, refrigerated displays and so on.

There have been success stories and improved public awareness, but this has not translated into widespread behavioural changes that are more evident in some continental and Scandinavian countries. This transition is extremely difficult, as evidenced in the UK.

The key question is whether conservation initiatives and programmes are keeping pace with the rapid changes in the total energy market. The answer, looking at the overall position in Ireland, is no, for reasons of indifference, underinvestment and outright opposition.

### *North/South Cooperation (Section 1.6)*

Co-operation in energy matters has been consistently positive, dating back to the 1950s and the Erne Scheme. This positive approach continues, with good examples relating to electricity, gas and transport.

The section identifies a number of areas (energy related) where there is scope for continuing co-operation and mutually beneficial improvements. The Academy plays a very positive role in this regard by highlighting issues in an all island context.

### *Energy-Related R&D (Section 5.5)*

Expenditure in the area of energy related R&D is relatively small, even though government funding for Sustainable Energy Ireland (SEI) and the Marine Institute is significant.

The basic research programmes are typically small scale, scattered over a large number of participants and not evidently clearly prioritised or coordinated. There is a bias toward renewable technologies and little expenditure on research in areas where very large amounts of energy are being used, such as food production and distribution.

### *Energy Subsidies (Section 5.7)*

Energy subsidisation is essentially an area for economic analysis. The total expenditure on annual subsidies, payments and cross-subsidies probably exceeds €1 billion per annum.

From an energy efficiency perspective, it is a reasonable assumption to conclude that the behaviour induced by these subsidies is inconsistent with the aims of an optimum energy policy in many instances.

## GENERAL RECOMMENDATIONS

1. A **national energy policy** should be launched as a matter of urgency. The government should take the opportunity to highlight the vital role of energy and should consider using the title 'energy' in the name of the department responsible.

2. For the policy to be effective at the national level, it must address **all of the relevant user sectors**, including transport, heating, electricity production and conservation. This implies the involvement of the Departments of Communications, Marine and Natural Resources; Environment; Transport; and Finance.

3. It is desirable to clarify the underlying aim of the policy in terms of:

   - Environmental objectives
   - Fuel security and conservation
   - Economic parameters
   - Social considerations

   This will provide the foundation for specific sectoral policies and programmes.

4. The following targets are recommended for inclusion in the national policy:

   a) A **reduction** in energy consumption per capita by a minimum of 20% over a 15-year period: that is, by 2020.

   a) The simultaneous **displacement** of at least 15% of fossil fuels (oil, gas, coal and peat) by non-fossil fuels: that is, environmentally neutral fuels.

   The **technology already exists** to achieve these targets and the main approaches in each key sector are described in detail in the sections on electricity, transport and heating in Part 2 of this report.

5. Responsibility for achieving government targets should be clearly assigned, with appropriate measurement mechanisms established. The targets should not be seen purely as end targets, but should be annualised to ensure progress.

6. Considerably enhanced conservation programmes are strongly recommended. Achieving the goals will involve a very large increase in the scale of the programmes, the setting of measurable targets and a review of the institutional arrangements. Sustained publicity and consumer education is a key factor.

7. The government should fully utilise the powerful instruments at its disposal to achieve rapid progress in energy matters. These include:

   - A wide range of financial instruments
   - Regulations/legislation
   - Planning criteria
   - Effective institutional arrangements with defined delivery targets
   - Investment in carefully planned and focused R&D

8. Comprehensive reports should be sought addressing the effectiveness of existing energy subsidies and the relevance of major 'new' technologies to the Irish situation.

9. Continuing close cooperation between the Republic of Ireland and Northern Ireland should be maintained, with a view to optimum all island solutions in all the energy sectors.

10. Ireland should aspire to the status of a leading practitioner in energyrelated matters. Working with our European partners and using the strong political influence that Ireland enjoys, leadership should be provided on global energy issues.

**In energy matters there are good reasons, including significant vulnerability, as to why Ireland should aspire to lead change rather than settle for compliance.**

## C. ELECTRICITY SECTOR: SUMMARY OF FINDINGS (SECTIONS 2.2–2.11 AND 5.1–5.3)

Electricity is the most versatile form of energy. It can be produced from a range of fossil and non-fossil sources and is used for a wide variety of applications. It could be described as the nervous system of a modern economy, linking every premises in the country by means of the National Grid.

Electricity consumes 30% of primary energy and supplies approximately 22% of all secondary energy. These percentages have grown steadily and are likely to continue growing.

Up until 1999 the semi-state monopoly company, ESB, was responsible for electricity supply. The track record of the company was first class, despite constraints on capital investment in the 1980s and 1990s. Since 1999 the market has been liberalised, largely at the behest of the EU and potential investors, who highlighted the benefits of competition. The new regulatory regime is gradually settling in, but the benefits to consumers from liberalisation are not evident to date.

Electricity is a capital intensive business, where assets have lifetimes of 20 to 60 years. This requires policies that are medium to long term, rather than short term or reactive. While a flexible approach must be adopted to cater for the vagaries of fuel supply, a general policy framework is necessary to ensure efficient and reliable electricity supply on a continuous basis.

### *The Cost and Price of Electricity (Section 2.2)*

In January 2005, Irish industrial electricity prices were the highest of the 27 EU countries (according to Eurostat). Domestic prices were fifth highest. Relative to the average prices in the EU, Irish prices moved rapidly upwards from 1999 to 2005, raising competitive issues.

***Note**: The January 2006 Eurostat report, which has now been published, updated the January 2005 statistics. Industrial electricity prices in Ireland were second highest (Cyprus tops the list) and were approximately twice the corresponding price in France and 25% above UK prices. Ireland's domestic electricity prices remained fifth highest. The rate of increase of prices in Ireland between 1999 and 2006 has been exceptionally high by European standards.*

The value chain that effectively determines the prices of electricity is shown below.


Ireland's electricity value chain, 2004

Supply at 5% is open to competition, but has limited impact. Networks (that is, transmission and distribution) are a natural monopoly under direct regulatory control, and at 35% have a significant impact. Generation at 60% has the most significant impact and may be supplied competitively within a broad framework of government policy.

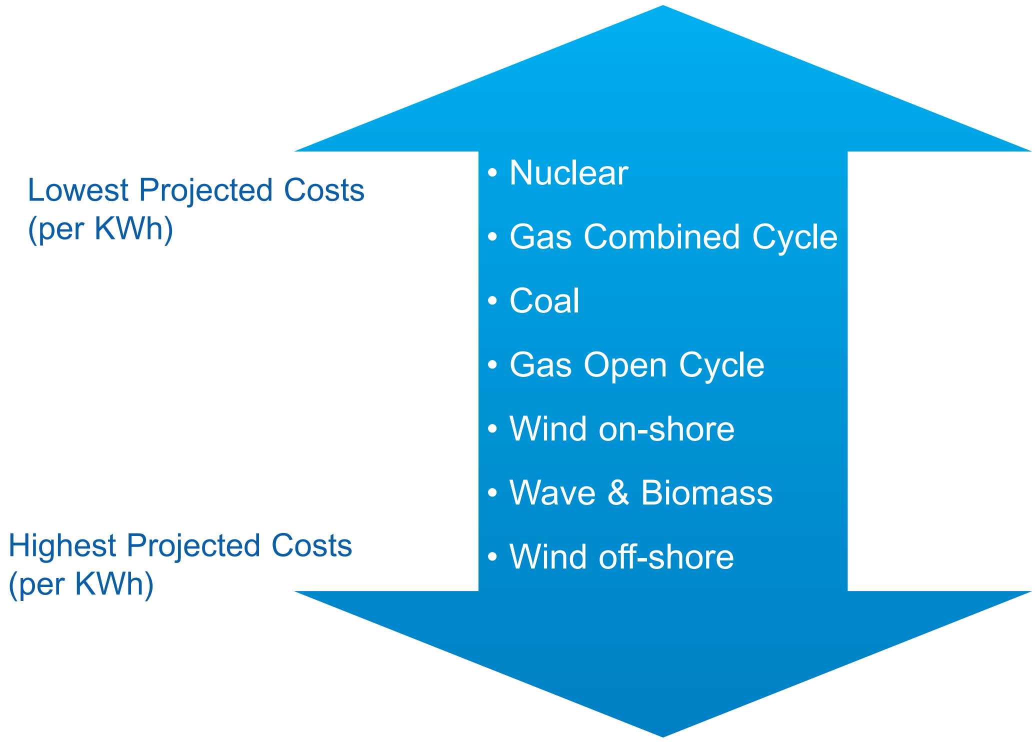
The factors that have driven up Irish prices include:

- **Fuel costs** – a major factor.
- High level of **capital investment** in networks and new generation plant – a significant factor.
- Liberalisation of the market, including investor incentives.
- **Others**, including subsidisation of renewables and peat, planning delays, emission penalties and sub-optimal load factors.

These 'drivers' are still in existence and could be exacerbated by bad policy decisions or inappropriate regulation. **A primary policy issue is the future price of Irish electricity vis-à-vis our EU competitors.**

## Generation Technology and Projected Cost (Section 2.3)

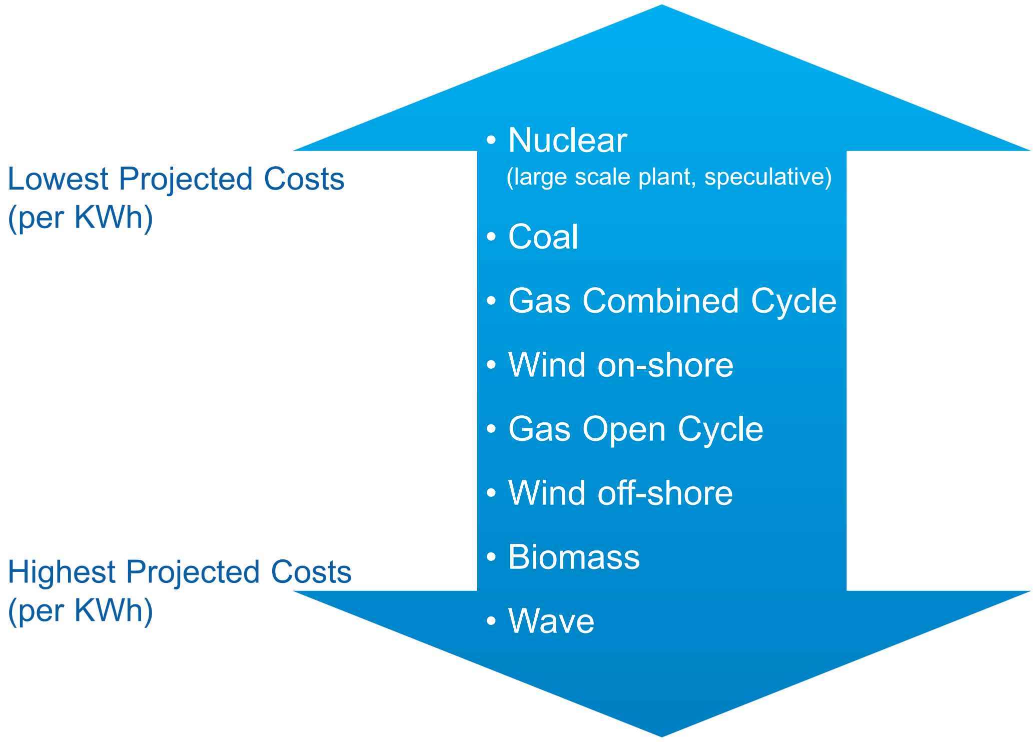
The choice of new plant types for the future is an important strategic issue. In March 2004, the Royal Academy of Engineering (UK) published a report on the subject. The ranking of the various technologies shown below ranges from the lowest projected costs of electricity to the highest:



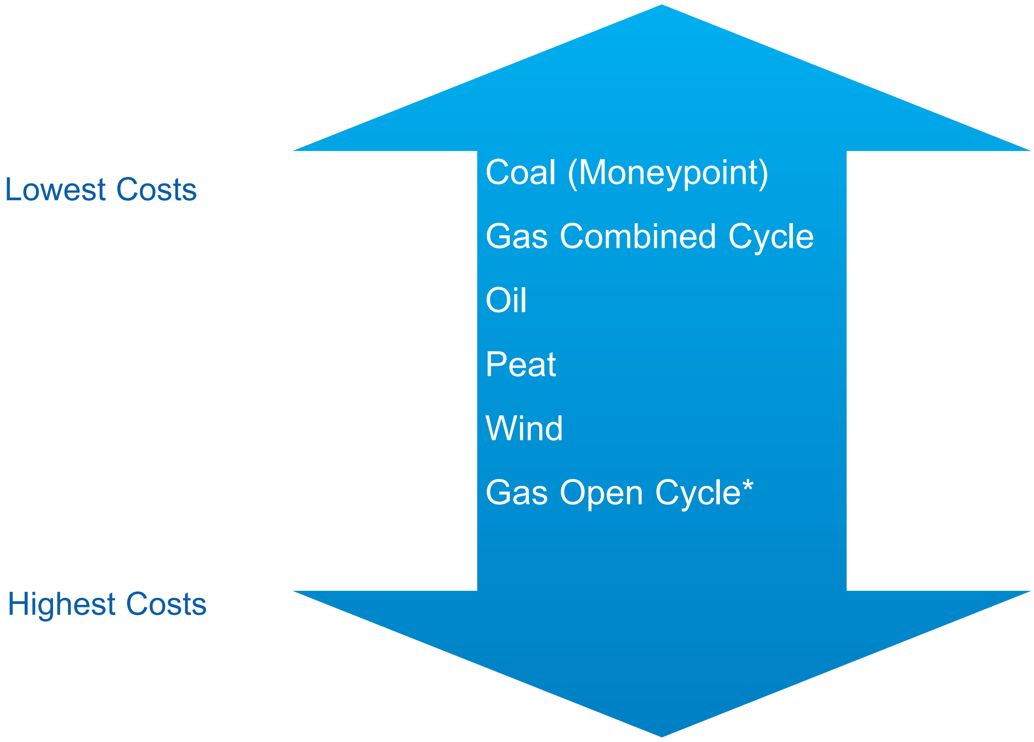

***Note**: Included are the decommissioning costs of nuclear, the costs of $CO_2$ emissions and the costs of intermittency for renewables. Hydro is excluded, as there are no sites.*

***Note**: In March 2006, the above projections and related estimates were updated by P. B. Power Ltd. as an input to the UK Energy Review. They took into account updated costs for construction, fuel, $CO_2$ emissions, etc. Despite the large increase in gas prices, the ranking shown above did not change significantly. Tidal/wave power was included, and showed the highest projected cost.*

Translating these estimates to Irish conditions, and allowing for the 2005 increases in $CO_2$ costs and the cost of gas, would result in the following hypothesis:[2]




Finally, factoring in recent Irish experience of the cost of existing generation using the same criteria suggests a ranking in 2005 as follows:




**Note**: *Standby gas peaking plant is very expensive. Market and contract conditions make it difficult to ascertain the precise real costs of the options.*

*2 New peat plant is not considered.*

## Investment in Networks and Interconnections (Sections 2.4 and 2.5)

Excluding interconnectors, the estimated capital investment in transmission and distribution networks during the current decade will be approximately **€5 billion.** This will give rise to ongoing annual financial charges (at current financing rates) of approximately €300 million, which must be funded from electricity income.

Some €1 billion is being expended on extending and reinforcing the transmission grid. Of the distribution expenditure of €4 billion, 60% is to cater for the additional +400,000 new consumers and the balance for refurbishment of the network, much of which was constructed during rural electrification starting in the 1940s.

The high level of expenditure reflects some under-investment in the 1980s and 1990s and also the target of improving the quality of supply to consumers. The new networks will lead to some gains in energy efficiency as a result of the reduction in network losses.

These investments are authorised by the regulator. In view of the monopoly position of EirGrid and ESB Networks, rigorous and informed challenge of these large investments is necessary, as is a simultaneous monitoring of the efficiency of network asset utilisation. There are pressures to extend networks, particularly the grid, to facilitate developers. Unrestrained, this can lead to additional costs for the existing consumers and poor asset utilisation.

**Investment in interconnectors** (section 3.5) is a different issue. The justification for these tends to be strategic or liberalised market driven. The present policy is to build a new interconnector between Northern Ireland and the Republic, and to build a double circuit interconnector between GB and Ireland. The gross cost of these additional investments is likely to be close to €1 billion, the bulk of which will be carried by the consumers in Ireland.

The intention to invest is based on expectations that it may promote competition, rather than energy economics. Pending the full alignment of the electricity markets north and south, which is unlikely to occur much before 2010, and the determination of a sound rationale for the GB interconnector, these proposed investments should be seriously challenged. Before proceeding, a clear economic energy case and a proper engineering assessment should be undertaken.

The existing north-south interconnector, which has a circuit capacity of 1200MW is generally adequate for the level of power flows that can be anticipated pending radical market changes. The case for a GB interconnector might be clear only if it was decided to locate significant **'Irish' generation capacity in GB**. Suggestions that it could be justified by exporting wind power from Ireland to GB have little economic justification.

## The Potential of Wind Power and other Renewables (Sections 2.6–2.7)

***Note**: The time span being considered here is 2006 to 2025. Predicting the technological developments beyond that point is too speculative.*

### *Wind Power (Section 2.6)*

Wind power, the most important of the renewables, is a welcome addition to the Irish system for environmental and indigenous reasons. There is in excess of 400MW of capacity installed, supplying about 3% of total energy needs. Ireland is reasonably abreast of general practice elsewhere. There are plans approved to take the capacity to +1000MW, with corresponding energy inputs to the system.

Wind energy is a complementary source of energy for the following reasons:

- While modern thermal plants have a load factor (availability) in excess of 90%, wind power in Ireland is in the 30% to 35% range due to the intermittency of wind conditions.
- For this reason, if there are plans to provide 5000MW of peak capacity on a system, the options are ca. 6000MW of thermal plant or ca. 5000MW of thermal **plus** ca. 3000MW of wind, that is ca. 8000MW total. The latter option obviously involves **greater total capacity and capital investment**, which requires careful analysis of the economic, environmental and security issues.
- The higher the percentage of wind penetration on a system, the greater the operational and other problems: providing 10% to 15% of total energy from wind raises a number of issues.
- One of these is the type of 'cover' provided to cater for intermittency. As the penetration increases, more use has to be made of expensive thermal peaking plant to provide cover, with negative environmental consequences.
- For reasons of this nature, the real cost of wind power rises rapidly with the rising penetration level. Given that the economics are marginal at low penetration levels, this is a major issue.
- Improving technology of wind plant coupled with rising fossil fuel costs will help the case for wind, but with higher penetration the real cost is likely to remain uncompetitive, at above the 10% to 15% of total energy level. In other words, it will remain an important source of complementary energy.

### *Wave and Tidal Energy (Section 2.7.1)*

Capturing the natural energy of the sea is a challenging and exciting notion that has attracted much interest. Ireland's location heightens this interest, and a number of institutions are undertaking R&D work in this area.

Despite much investment in other countries (such as Japan and Norway), no major breakthrough has been made and the technology is still at the prototype stage. There are formidable technical, economic and intermittency problems to be addressed and solved. The most promising technology at this stage involves inshore tidal stream installations.

The best prognosis that can be made at this point is that by 2025 there could be 40MW to

50MW of capacity installed in Ireland that meets reasonable economic and reliability criteria. As with other renewables, the price of fossil fuels and other non-fossil technologies will be a consideration.

### *Energy from Thermal Treatment of Waste (Section 2.7.2)*

Energy in the form of electricity can be produced as a byproduct of the burning of municipal waste. If this is done, it will alleviate the cost of waste disposal on a marginal basis. If all the projected municipal waste in Ireland (after recycling, streaming, etc.) was burnt it could generate approximately 4% of total electricity demand at a competitive price and help to reduce the gate fee for waste. The technology is well developed – for example, in France – and 'fuel' is indigenous. There are no clear-cut benefits in terms of greenhouse gas emissions. Burning methane from landfilled waste sites is already established practice, but the energy contribution is very small and unlikely to change.

### *Energy from Photovoltaics Solar Panels (Section 2.7.3)*

This is an evolving technology that faces major economic hurdles. There is a lot of international R&D expenditure underway to drive costs down and progress is reported.

It is difficult to envisage any significant contribution to the grid before 2025, but photovoltaics will have application in remote locations, in portable equipment and in specially designed buildings and will bring clearcut environmental benefits. Moreover, if there are technical breakthroughs earlier than predicted, photovoltaics could play a significant role in general electricity supply before 2025.

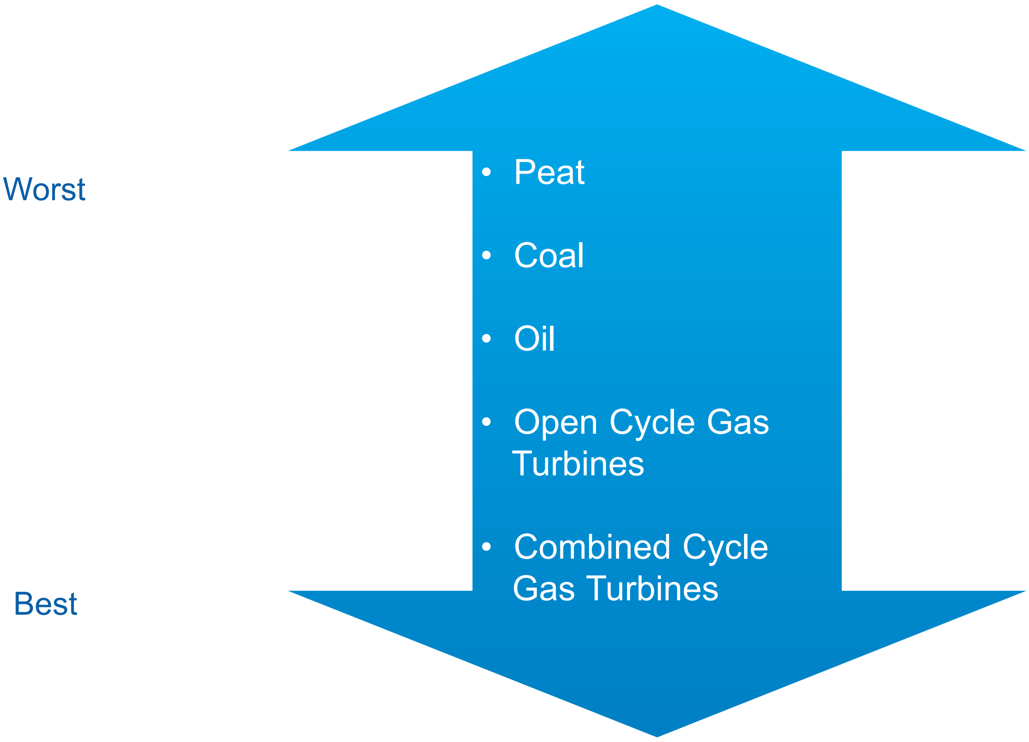
### *Biomass for Producing Electricity (Section 2.7.4)*

This is not an economic proposition at present and is only likely to become competitive if fossil fuel prices escalate dramatically and $CO_2$ penalties do likewise. Even then, the reliability of biomass fuel supplies is by no means certain, as it will be in direct competition with boardmaking plants.

Substituting 25% of peat with wood biomass in existing power stations would bring pro rata environmental benefits. The issue is the availability of the fuel at the same price as peat, allowing for the $CO_2$ penalties/credits.

## $CO_2$ Emissions from Power Stations and Carbon Abatement Technology (Sections 2.8 and 2.9)

Power plants in Ireland are large emitters of greenhouse gases, as approximately 95% of electricity is produced from fossil fuels. In $CO_2$ emission terms per unit of electricity produced, the order from worst to best is as follows:




**Because of high economic growth, Ireland's carbon reduction task is proportionally one of the most difficult in Europe.** Progress was made with the major changeover to combined cycle gas technology, but this is now running into high fuel cost and security problems. The hope that coalfired generation could be reduced is becoming remote for fuel diversity/security reasons, and new thermal plants in Ireland will tend to be peaking (more polluting), as distinct from base load plant.

The prospects for $CO_2$ reductions are poor at present and it is now likely that purchase of emission quotas from Eastern European countries will be necessary if Irish electricity prices are to remain reasonably competitive. From a global environmental perspective it is a reasonable strategy, particularly in the short to medium term.

In the long term, coalfired plants are likely to be acceptable only if they develop 'clean coal' technologies: that is none, or very low, carbon emissions. There is a considerable amount of R&D work underway, driven by the coal industry in the USA, Australia and elsewhere. The EU is also supporting R&D in this field and there is a strong degree of confidence that a competitive clean technology will be delivered within 20 years.

Because of the large scale of coal deposits worldwide and the fact that it could replace oil/gas power generation, it is important for Ireland to keep abreast of developments.

## Nuclear Energy for Producing Electricity (Section 2.10)

***Note**: This is a complex and controversial subject. Those with a serious interest in the issues are strongly advised to read section 2.10 to gain a better understanding of the current position.*

Nuclear energy power plants, or large hydro plants, are the only established technology that can provide base load power for a grid with zero greenhouse gas emissions. Fuel security is not a major problem and the economics of modern nuclear plant are competitive. It is the main alternative to fossil fuelled power plants.

The technology dates back 50 years and by 2003 there were 441 operating reactors in the world, providing 359GW of power (Ireland's total capacity is approximately 5GW). This total represented 17.5% of world production of electricity, and in the 25 EU countries nuclear provided 31% of the total in 2002. France is 78% nuclear, Japan 35%, Germany 30% and the UK 22.5%.

In 2002 there were 30 new reactors under construction, mainly in Asia, and more projects have started since then, examples being France, Finland, South Africa and the Ukraine. There is a resurgence of interest in the technology for climatic and fuel availability reasons and other countries, including the USA and the UK, are seriously considering the matter.

Apart from the depletion of oil and gas reserves and the related security issues, the other main factor is avoidance of emissions. The quantities involved to date are well in excess of 1 billion tonnes of $CO_2$ (avoided), a huge amount in global terms.

The other important factor is that the technology has progressed considerably since the 1950s and 1960s, partially as a result of the catastrophe in Chernobyl in 1986. Modern plants are significantly safer in both design and operating terms.

There is a high level of apprehension about nuclear power plants, particularly in countries that have no direct experience of the technology or have had serious accidents. Despite the fact that natural nuclear radiation is essential to human existence and man-made radiation is in widespread use in modern medicine, the strong association with military armaments in the form of bombs, missiles and nuclear submarines is deeply rooted and a source of understandable anxiety.

Over its 50 year history, the actual safety record of the nuclear power industry has been good. The 1986 Chernobyl disaster, which was caused by a combination of poor design, bad maintenance and dangerous operations, has led to 59 fatalities to date. In addition, it is estimated that there may be 4,000 premature deaths due to radiation induced cancers (Chernobyl Forum Report in 2005).

The next most serious accident was in Three Mile Island in the USA in 1989. This was economically disastrous, but there were no resultant fatalities. The statistics for the rest of the industry are exceptionally good by industrial standards, reflecting the considerable emphasis that has always been placed on safety.

The most common concern nowadays relates to spent fuel, particularly what is termed high-level waste, which contains some substances that will remain radioactive for more than 100,000 years. Management of this power plant waste has not caused any serious problem to date, mainly because of the small volumes, and the informed view is that storage in stable geological rock formations under controlled conditions will ensure no dangerous legacy for future generations.

Nuclear power, in common within a wide array of other industries and technologies, involves the management of risk. This can never be entirely eliminated and the issue may well be that of **which is the lesser problem**. When one considers the level of atmospheric pollution directly associated with fossil fuel burning and other industries, the degree of risk to people can be placed in perspective.

Current Irish government policy is opposed to nuclear power. Taking account of the recent developments mentioned above, this policy may well give rise to significant penalties in terms of uncompetitive electricity service and unfavourable climatic emissions in the years ahead. This may be particularly so, given that there is no other credible solution to the replacement of fossil fuelled generation on a relatively large scale (that is, not intermittent) before 2025 at the earliest.

## Natural Gas and LNG

### Natural Gas (Section 5.3)

Nearly 50% of electricity production and 20% of residential/industrial energy comes from natural gas. Any major interruption would be devastating in economic terms.

Gas is the cleanest of the fossil fuels and lends itself to high energy efficiency conversion. The transmission grid of approximately 2000km is both adequate and versatile, but does connect to one pumping station in Scotland. Some 90% of gas is imported.

The potential future vulnerability of gas supplies has been well illustrated in recent months. Until Corrib comes on stream, Ireland is particularly vulnerable (at least in price terms) and Corrib will only provide a 10 to 12year window for 50% of demand.

### Liquified Natural Gas (LNG) (Section 5.1)

There is a marked upsurge in the use of this well established technology (+40 years) mainly driven by security/diversity reasons. During the last 10–15 years, there have been significant technical advances in the liquefaction, shipping and storage of LNG. As a result, the delivered gas price can compare favourably with pipeline gas, which is transported over long distances from Russia, for example.

LNG supplies come from diverse locations, where LNG may be the best means of exporting the product to world markets. It currently provides over 10% of world gas demand through approximately 45 major import terminals.

This technology places considerable emphasis on all aspects of safety and its track record is good.

A modern terminal installation in Ireland would have the capacity to supply ca. 50% of total demand at a competitive price using the existing gas grid.

### Structure of the Electricity Sector in Ireland (Section 2.11)

This is currently the subject of a report being prepared for the Minister. Outstanding issues to be addressed include:

- Government policy and related legisation or directives.
- The future role of the regulator.
- Fostering effective and cost efficient competition in the generation sector.
- Aligning the north/south market structures.
- Responsibility for ensuring long term security of supply within economic and environmental parameters.

These issues are an intrinsic part of an effective energy policy framework.

## ELECTRICITY SECTOR: CONCLUSIONS AND RECOMMENDATIONS

Medium and longer term government policy should be based on two fundamental aims:

- To address the problem of future oil and gas supplies by moving to other technologies for producing electricity.
- To address the extremely serious climatic issues that are linked to power station emissions and other factors.

Policy initiatives must take into account security of electricity supply and the relative cost of Irish electricity vis-à-vis other countries. There are compelling economic, environmental and security reasons for early adoption of a policy framework. Two main phases are suggested.

### *Phase 1: 2006–2025*

The aim should be to make **major progress** in solving these issues and to have put in place the basis for the second phase.

### *Phase 2: 2025–2050*

The aim should be to **complete the transition** to sustainable electricity supply with no reliance on oil or gas.

Solutions are likely to be based on improved technologies, a range of productivity and operational efficiencies and market structures that lead to adoption of these best practices. It must be borne in mind that in a modern economy, **high quality electricity supply** has to be provided to match demand at all times. Technology that is not already in the pipeline will have little or no bearing before 2025.

Bearing in mind the two fundamental aims and the related economic and security constraints, the following scenarios are conceivable. Some variations could also be envisaged.

### *Scenarios for future generation (based on four key criteria)*

#### *2006–2012*

- Renewables, including hydro, rising to ca. 12% of total output.
- Coal/peat static, with possible biomass partial substitution.
- Gas the major fuel, with the Corrib field providing extra security.
- Oil being phased down/out.

#### *2012–2025*

- Renewables, including waste to energy and some marine going to ca. 20–25%.
- Gas continuing as a major fuel.
- LNG replacing imported pipeline gas (partially).
- Nuclear a possibility from 2018 onwards.
- More imports of electricity a possibility.
- Existing coal/peat being phased down/out.

#### *Beyond 2025*

- A combination of renewables, nuclear, clean coal technology and the final phasing out of gas.

## SPECIFIC RECOMMENDATIONS

In the context of future objectives for the electricity sector and the findings contained in the report, the following specific recommendations are addressed to the government:

1. Establish an LNG import terminal.

2. Ensure network investments (transmission and distribution) are both essential and fully justified on an ongoing basis.

3. Put construction of any major interconnectors on hold until markets are aligned and there is a positive economic and operational case for the investment.

4. Maintain Moneypoint Power Station in production until at least 2012 for diversity and economic reasons.

5. Seek a report that will project the real cost of the main technologies in an Irish context. This should take into account $CO_2$ costs; back-up cover for intermittent generation; special connection costs; nominal value of security from indigenous sources; decommissioning and longterm storage or disposal costs; and capital and operational costs, including fuel. **Power station technology priorities should be based on the above, and subsidies should be removed for all but the purely experimental and smallscale technologies.**

6. Phase out oil fired generation by 2012, unless a major security issue arises.

7. Commission comprehensive studies into:

- The current state of nuclear power (covering all aspects).

- The outlook for new clean coal technology.

- Progress in developing wave/tidal technology.

8. Address the organisational, regulatory and policy formulation issues for the sector.

9. The recommendations above are aimed at providing an efficient and secure supply of electricity. Of equal importance is the need to implement **demand side management** strategies in a much more vigorous manner, in order to curtail growth in demand with all the benefits that will result.

In view of the volatility of fuel markets and the wide range of security issues, policy cannot be carved in stone. Contingency plans (regularly updated) are a necessary factor and periodic reviews of policy are also required. The temptation to seek refuge in fanciful 'solutions' should be avoided, and the policies adopted should result in electricity prices that are well within the EU range and trending positively.

## D. TRANSPORT SECTOR: SUMMARY OF FINDINGS

The transport sector is the most problematic area in terms of energy policy. Fuel consumption continues to rise rapidly, with corresponding increases in greenhouse gas emissions. Unlike the other sectors, prospects for improvement are poor at present.

This sector accounted for 31% of primary energy consumption and 25% of energy related greenhouse gas emissions in 2003, with energy requirements increasing at a rate of approximately 6% every year. At the same time, it is the only sector to show a reduction in energy efficiency.

In terms of the use of fuel, the breakdown is:

- Cars – 40%
- Trucks/vans – 40%
- Aviation – 15%
- Rail/bus – 5%

**Aviation** is not specifically addressed in this report because of the international dimension. However, it is an area of serious concern in terms of rapidly increasing fuel use and emissions, which are facilitated by zero excise duties on aviation fuel.

In terms of transporting people, approximately 80% of passenger kilometres are by car, 16% by bus and 4% by rail. The universal trend to private rather than public transport is evident in Ireland, and car ownership continues to rise rapidly. In addition, the trend towards bigger cars is resulting in a drop in energy efficiency in the sector and very negative trends in terms of fossil fuel use and related emissions.

In analysing the problems and seeking possible solutions, two main aspects are examined:

- The associated technologies (such as engines and fuels) and modes of transport.
- The infrastructural and planning issues.

## MODES OF TRANSPORT (EXISTING AND NEW TECHNOLOGIES)

### *Hydrogen fuelled vehicles (Section 3.10)*

This technology is promoted as a substitute for fossil fuels (as seen, for example, in USA energy policy statements). Hydrogen can be burned directly in engines or used in fuel cells. Technology is at the development stage, with small pilot projects in operation. Challenges are the production of hydrogen in large quantities and the subsequent distribution across the country.

Unless hydrogen is produced from non-fossil fuel sources, such as nuclear and renewables, there is no environmental benefit. The cost of a hydrogen distribution infrastructure is a huge economic barrier. Overall, it is not a realistic prospect for Ireland within the next 20 years.

A subsidised pilot project could be run for the **Dublin bus flee**t, for example. To produce the necessary hydrogen for the fleet from renewables would require 300MW of wind turbines. This indicates the problem of **scale**.

### *Fuel cells for vehicles (Section 3.8)[3]*

These are at the development stage. They have **no economic prospects within 15 years**, but have longer term potential if hydrogen is produced from non-fossil sources.

### *Biofuels for transport (Section 3.9)*

This is certainly worth pursuing in terms of substitution of fossil fuels. Fuel cost is a problem and production in Ireland requires subsidisation. A realistic alternative is to import the fuel from Brazil, provided there are no local environmental downsides.

There is also a scale issue in Ireland, as the amount of arable land required to produce significant quantities (3%) is not available.

There is a strong case for achieving a **5% substitution of fossil fuels by 2010 using blends**. While there are environmental benefits in terms of reduced emissions, these are marginal and the energy savings are partially offset by the energy used to produce the biofuels. **Substitution/security** is the main benefit.

Longer term prospects are realistic, but a lot of economic and technical barriers remain to be addressed.

### *Energy efficiency of different modes of transport (Section 3.5)*

In urban and suburban areas, efficiency is time of day related and depends heavily on average occupancy rates:

- During peak periods, rail/buses are considerably more energy efficient.
- In off-peak periods, cars are comparably efficient because of low occupancy rates in public transport and the nature of journeys.

For inter-city or rural travel, buses (coaches) are clearly the most efficient, with rail somewhat better than cars, again due to the average occupancy rates on rail. This may change with new rolling stock.

*3 Hydrogen infrastructure is not essential to permit use of fuel cells. R&D investment in the USA is very substantial. Fuel cells could be used domestically and elsewhere for general energy purposes.*

In summary, the case for buses at all times and rail at peak times in urban areas is very clear, while the case for inter-city rail is marginal in energy use terms at existing occupancy levels.

In emission terms on a per capita basis, cars are most polluting, rail next and buses best.

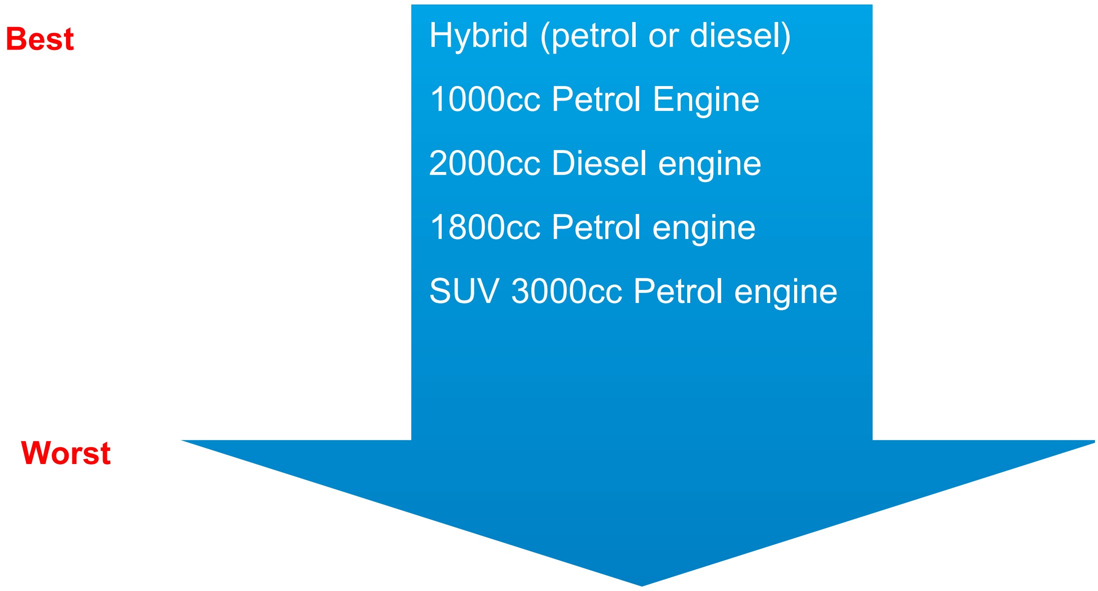
There are clear energy benefits in urban areas from switching people to bus and rail in peak periods and increasing the occupancy rate of cars. Switching to coaches for inter-city travel is energy efficient.

***Note**: Bus/coach solutions appear to be a lower priority for planners and relevant government departments. Bus infrastructure – for example, QBCs – is considerably cheaper than fixed rail solutions on a capacity basis and is more energy efficient. When rail routes reach saturation, unlike bus/car solutions, additional capacity poses major problems. There has been very limited investment in bus rolling stock, and as a result designated QBCs cannot be optimised at present. Similar observations can be made in relation to intercity travel.*

*Both modes are an essential part of public transport, and the issue is the optimum balance in investment and energy terms. New investment in fixed rail solutions is appropriate to transport corridors conveying ca. 100,000 passengers per day. Below this level, bus/coach solutions are likely to be more effective unless spare capacity is available on the existing rail infrastructure.*

## COMPARATIVE ENERGY EFFICIENCY OF FIVE TYPES OF PRIVATE TRANSPORT (SECTION 3.6)

In terms of fuel consumption and $CO_2$ emissions, the range of typical vehicles is as follows:




A particular comparison is shown below.

| Type | Fuel Consumption over 100,000km | $CO_2$ Emissions |
|---|---|---|
| 1800cc petrol saloon | 8,000 litres | 17 tonnes |
| 4700cc petrol SUV | 20,000 litres | 38 tonnes |

Viewed from a national perspective the differences are large, and a major shift to hybrids, small petrol engines and diesel engines has the potential **to reduce overall consumption by up to 20% over a 10/15year period.**

### Commercial Transport and Rail Freight (Section 3.7)

Rail freight has limited potential in Ireland, mainly for geographical reasons.

Commercial transport, which is a very large consumer of energy, generally uses diesel engines and appears to operate efficiently. Improvements must be sought in analysing the underlying need for the journeys undertaken and in the tackling the gridlock issues.

### The Infrastructural and Planning Issues (Sections 3.2, 3.3 and 3.4)

The current high level of investment in roads and public transport is essential to permit continuing economic growth, but it should simultaneously address the energy issues. With rising GDP, road transport and aviation are likely to grow rapidly unless there is major intervention at the policy level.

Road transport as a percentage is growing at the expense of public transport and cycling/walking. In many cases, the reason is directly related to the pattern of housing development in Ireland.

The economic cost of gridlock (reflecting inadequate infrastructure) is variously estimated in the **€2 billion to €5 billion per annum range.**

In the Republic, **transport planning and land usage** are still not properly **coordinated** – for example, in the greater Dublin area – but some promising initiatives, such as Adamstown, are taking place.

The planning of transport in conjunction with housing development, services and employment, has been reactive rather than progressive. The rapid growth of the last 10+ years has meant that the die is effectively cast for the future and catch-up solutions have to be applied.

The geographical spread of greater Dublin with low density housing effectively rules out rail solutions (unless the infrastructure exists), and a coach/bus strategy will be more effective in energy terms. However, this will require continuing improvement in the infrastructure and absolute priority given to tackling gridlock using technical and operational methodologies. Overall, effective coordination and control of transport is essential.

Planning for the future is extremely important, and measures to improve coordination are essential. To address the basic energy issues, it will be necessary to tackle the fundamental question of why people travel.

There are accepted 'solutions', such as increasing the density of housing in urban areas or creating satellite towns. People still have to travel to work, school, shops, entertainment and so forth, and it is at this level that the planning should concentrate. Spatial planning is more advanced in **GB** and **Northern Ireland** than in the Republic, which has faced more rapid expansion. There are lessons to be learned, both positive and negative.

## THE TRANSPORT SECTOR:
## CONCLUSIONS AND RECOMMENDATIONS

Of all of the sectors reviewed, transport is most vulnerable to a reduction in the availability of oil or the prospect of changing to non-fossil energy sources. It is also the most rapidly growing in energy consumption and greenhouse gas emission terms.

Given the intrinsic nature of transport in a modern economy, **a range of solutions** will be needed over a **sustained period** to address the problems. It should be borne in mind that cars, vans, trucks and aviation combined use approximately 90% of fuel, and improvements must be sought in these areas.

The range of strategies proposed include:

- Improved planning and coordination of transport.
- Financial instruments to encourage energy efficiency.
- Fossil fuel substitution.
- Switching to more energy efficient modes of transport, such as public transport, where appropriate.
- Switching to more efficient vehicles and engines.
- Traffic management measures to tackle gridlock, tailbacks.
- Investment in infrastructure.

## SPECIFIC RECOMMENDATIONS

### *Improved planning and coordination*

- Planning of housing, services, work locations and transport needs should be fully integrated to optimise transport energy use. There are a small number of recent good examples, but the bulk of planning is still not coordinated between authorities.
- In tandem, there needs to be overall planning of transport, getting the optimum mix, and full co-ordination at the operational level.
- All major infrastructural investments (road and rail) should require an **energy impact study** as a **pre-condition** to investment approval.

## *Financial instruments to encourage energy efficiency*

- Ireland has a progressive policy for annual motor tax, which is related to engine size. There is a strong energy case for **increasing the difference** between small, efficient engines/vehicles and larger, inefficient ones, whether privately owned or employer provided. Hybrids and diesel engines are particular examples.

- Given the major $CO_2$ emission problems related to transport, there is a case for introducing an **emissions levy on fuel** as a deterrent and to avoid the general taxpayer paying emission penalties.

- There is a case for undertaking a comprehensive economic/engineering study of the application of the 'user pays' principle in Ireland. The UK is giving a lead in this regard, but each country requires tailor made solutions. Such a study should simultaneously examine the effectiveness of existing or proposed transport subsidies from an energy perspective.

## *Fossil fuel substitution*

- Biofuel substitution for 5% of total petrol/diesel use by 2010 is a reasonable and worthwhile target.

- Other substitution prospects face technical and environmental barriers that require considerable R&D expenditure.

## *Switching to more energy-efficient modes of transport*

- Bus/coach travel should be strongly promoted and facilitated.

- Fixed rail solutions should be provided for transport corridors carrying +100,000 passengers per day. If the infrastructure already exists, the issue is to optimise the available capacity.

- To gain greater acceptance of public transport for those who have a choice, proposed solutions will have to overcome the perceived negatives by providing a more attractive alternative than personal transport, using the following criteria: total elapsed journey time, comparable or lower gross cost, reliable frequencies, reasonable comfort and adequate capacity at peak times.

### *Switching to more efficient vehicles/engines*

- People need to be **strongly incentivised** in financial terms using the full range of taxation instruments. UK experience indicates that a differential of up to €1,500 per annum is necessary to get people to choose the lesser option.

- A sustained promotional programme featuring environmental benefits and future generation legacy issues will be required.

### *Traffic management measures*

- Urban traffic congestion is giving rise to huge energy inefficiencies in Ireland. The focus on investment in major new infrastructure is timely and welcome, but more attention needs to be focused on measures to improve traffic flow on existing roads and to raise the average speeds, which are extremely low in Dublin and elsewhere.

- Relatively modest expenditures can bring real payback in terms of better traffic flow and related reduced energy consumption. There needs to be clearer responsibility for improving flows and meeting targets.

- Existing technologies are available to deliver improved traffic flow, provided it is correctly policed. The Munich model appears suitable for adoption in Dublin and other urban areas.

### *Investment in infrastructure*

- Investment in infrastructure is essential to cater for both existing and future traffic volumes and to address public transport requirements. The basis for **prioritising investment** based on traffic volume and energy saving is not clear, and it is suggested that criteria need to be agreed and published.

### *Implementation*

- **Making it happen is the major challenge.** This will require clearer definition of who is to be responsible for delivery of approved Government Targets among the numerous and overlapping agencies in the Transport Sector.

## E THE BUILDING AND HEATING SECTORS: SUMMARY OF FINDINGS

The building sector is an important area in energy usage terms, currently consuming approximately 46% of all secondary energy used on the island of Ireland. This includes energy for space heating, hot water, lighting, power and communications. As outlined elsewhere in this report, Ireland is particularly vulnerable to a steep rise in the prices of the fossil fuels it imports, as well as to disruptions in their normal supply.

As an outcome of population growth in recent years, the decrease in average occupancy levels per dwelling and the unprecedented rate of housing construction, energy usage in the housing sector has increased by 20% between 1990 and 2003. However, energy efficiency has improved by 18% as a result of better building standards and heating system efficiencies, but there is scope and a need to do much more.

Improvements in the energy efficiency of existing buildings and an application of higher standards to all new buildings will bring about a significant reduction in energy usage, with immediate financial benefits to the householder or building operator/tenant; a reduction in the total energy requirement for the island of Ireland; and the environmental benefit of lower greenhouse gas emissions.

These measures should be an integral part of any energy policy and are consistent with the three fundamental policy criteria of cost competitiveness, security of supply and environmental protection. Energy policies in both jurisdictions on the island of Ireland should reflect these considerations through translating them into active and aggressive programmes of energy conservation, application of appropriate technology and measurement/monitoring of programmes.

## Building and Heating Sectors: Specific Findings (Sections 4.2–4.7)

### Current Heat Energy Requirements in Irish Buildings (Section 4.2.3)

Before considering the energy requirements in Irish buildings, it is appropriate to look at how the building sector is placed in total energy consumption terms.

Total energy use in Ireland in 2002 was 14.63 million tonnes of oil equivalent (mTOE), of which 11.29 mTOE was in the Republic of Ireland and 3.34 mTOE in Northern Ireland.

Residential and commercial/public buildings in 2002 consumed 6.16 mTOE, which was 42.1% of Ireland's total secondary energy use. Northern Ireland, at 55.7%, is substantially higher than the 38.1% in the Republic of Ireland as percentages of total energy consumed in each jurisdiction.

Estimates as to the amount of energy used for space and water heating in the industrial sector vary, but a figure of about 20% has been taken, which would add 0.55 mTOE to the 6.16 mTOE mentioned above, bringing the total to 6.71 mTOE, representing just 46% of total Irish secondary energy consumption in 2002.

### Measures to Reduce Future Building Energy use (Section 4.2.4)

While an increase in the use of renewable energy in buildings will reduce energy needs (and hence greenhouse gas emissions), a major impact can be made by adopting relatively simple, well-practiced building technologies.

The preponderance of buildings located in urban settings limits the practical use of renewable energy in built-up areas, and to a lesser extent, the conservation measures available. Renewable sources include solar thermal radiation, the burning of wood or other organic material in a boiler or air heater, micro-generation and solar photovoltaic electricity generation. Combined heat and power (CHP) and heat pumps will also be discussed.

Conservation also includes **improvement of a building's thermal envelope** so that less of the heat supplied for space heating is lost by conduction through the fabric, and **improving a building's air-tightness to prevent warm air leakage.**

Conservation also includes reducing wasteful use of all forms of energy. This is particularly important in the case of electricity, as its generation and delivery results in the release of up to 2.5 times as many greenhouse gasses as would be released by an efficient in-house combustion device. Effective activities here include efficient use of appliances and controlled use of lighting. Some commentators have suggested that savings of the order of **10–20%** could result from proper management of the use of electricity in buildings.

### Weaknesses of Current Irish and UK Building Practices (Section 4.2.5)

It is widely agreed that a significant portion of the Irish and UK building practices, with notable exceptions, **have lagged behind those of Continental Europe and North America** in the thermal quality of the building fabrics constructed and their degree of air-tightness. This applies to most of the houses built in Ireland in recent times and to many houses still being built.

In Ireland and the UK, air-tightness had, and still has, a low priority and was rarely referred to by building professionals until recently. In past years, it was hardly every measured. In some circumstances, a draughty house can increase the calculated heat requirement by as **much as 25%**, and more in certain cases.

Ireland has been slow to ensure that the sections of the building regulations dealing with energy conservation and the thermal performance of buildings are enforced to an adequate degree. **The time lag in the implementation** of these measures has been costly in energy-efficiency terms, particularly when taking account of the accelerated house construction outputs of recent years. There is doubt about how well the insulation requirements of the various issues of the Irish regulations were achieved. The concerns relate to the attention given to the placing of panels of insulation in wall cavities, the air-tightness of the building fabrics and the avoidance of thermal bridging. **Such investigations as have been carried out revealed heat losses in walls to be higher than calculated/designed.** Similar results were reported from work in Belgium and the UK.

## Introduction of the EU Energy Performance Building Directive (EPBD) (Section 4.2.6)

The introduction of the EPBD will focus the attention of those owning or investing in buildings on the financial advantages of a building with a good building energy rating. Each new dwelling constructed after 1 January 2007 must have an energy rating certificate. The advent of the EPBD will prove an effective way of conveying the message about the value of energy saving and the importance of energy conservation to a considerable number of people. In spite of the difficulties in introducing it, any moves to defer its implementation should be strongly resisted, and a blunting of the message it conveys should be avoided.

Local authorities will need, and should be provided with, additional building control resources to enable its full and effective implementation. The focus should be an adequate ongoing inspection, with emphasis on the quality of wall construction and the placement and fixing of insulation.

## Improvement of Fabric Heat Loss and Air-Tightness of all Buildings (Section 4.2.7)

Apart from meeting the requirements of the EPBD, building practice in Ireland needs to produce building fabrics that conserve heat and reduce air leakage to the figures designed. New regulations in the UK (from April, 2006) will seek a ‘whole building’ approach, based on achieving specified target $CO_2$ emissions and a ‘target emissions rate’ (TER) will be set for each building. It is understood that a similar revision, based on a TER, is being considered for the Republic of Ireland.

Regulations should seek to achieve:

- A lowering of the maximum elemental U-values or setting a TER for $CO_2$.
- A specified degree of air-tightness for each building fabric.

Final target rates for $CO_2$ emissions should be those produced if the maximum average elemental U-values ($W/m^2K$) and other provisions were of the order set out below:

1. Walls to have a U value of 0.18 $W/m^2K$ or lower, floors and ceilings U values of 0.15 $W/m^2K$ or lower.

2. Windows by double glazed units coated E = 0.1 or 0.05 with 16mm pane spacing; glazing having a U value of 1.5 $W/m^2K$ or lower. Frames to have a U value of 1.6 $W/m^2K$ or lower, unless special conditions apply.

3. Thermal bridging avoided where possible, and where this is not possible all reasonable measures must be taken to minimise it.

4. All buildings sealed to minimise uncontrolled air leakage inwards or outwards, so that it does not exceed 0.5 air changes per hour.

5. Ventilation to health authority standards, fan introduced and extracted unless special conditions apply, with heat recovered from warm exit air being transferred to the incoming filtered fresh air; both sets of fans driven by high-efficiency motors.

6. In occupied residential accommodation, the fan-assisted ventilation would normally operate 24 hours per day, albeit at a reduced level at night and at times of low occupancy.

7. All buildings pressure tested to verify that they meet or are below the air leakage rate specified, such as 1.5 air-changes/hr at 50 pascals in dwellings, or 7.0 $m^2/hr/m^2$ in office buildings. Testing of a random sample chosen by the building control officer could be deemed to satisfy this requirement in multi-unit developments.

More use is now being made of the increasingly available off-site fabricated wall panel structural elements with a range of low U-values. Several such panels are already on the Irish market and, as the choice grows, will be used significantly in house building in the future.

## Population Growth in Ireland by 2030 (Section 4.2.8) and Housing to Meet this Growth (Section 4.2.9)

The population of Ireland in 2002 was 5.62 million, with 3.92 million in the Republic of Ireland and 1.70 million in Northern Ireland. It is estimated that the population could reach 7.25 million by 2030, growing by about 1.25 million to 5.20 million in the Republic and by 0.35 million to 2.05 million in Northern Ireland. Therefore, a growth in population of 1.63 million postulated by 2030 would require more buildings, including an increase in public buildings for healthcare, education, commercial, leisure and other purposes.

Taking account of the decreasing average occupancy per dwelling in Ireland, a postulated Irish population increase to 7.25 million by 2030 would require about **870,000 additional dwellings, about 620,000 in the Republic of Ireland and 250,000 in Northern Ireland.** This averages about 23,000 new-built units per year, to which must be added up to 17,000 units to allow for dwellings demolished or converted to other uses. This brings the new build rate in Ireland to about 40,000 dwellings per year after 2010, by which time it is anticipated the current high levels of housing output will have levelled off.

**This considerable increase in the total housing stock anticipated by 2030 provides an imperative and an opportunity to ensure that they are built to the best possible energy-efficiency standards.**

## Public and Commercial Buildings to Meet Population Growth by 2030 (Section 4.2.10)

CSO data shows that energy used in the public and commercial buildings sector in the Republic of Ireland rose from 1.113 mTOE to 1.758 mTOE in the 10 years between 1993 and 2003, **a rise of 58%**. This increase is much higher than the 33.3% registered in the residential sector over the same period, despite the high rate of dwelling construction. While no figures are currently available, it is apparent that there has been a significant increase in the number of large buildings for commercial, office and retailing purposes.

With some notable exceptions, **minimising annual energy use appears not to feature at design stage** in a number of offices built for single clients, with the choice of air-conditioning system governed by desire to minimise initial costs. Property advisors in recent times have tended to stress to clients that air conditioning is essential for successful letting or subsequent sale. Minimising annual energy use appears to feature even less in investment-driven, multi-tenanted buildings, where the costs of energy used by tenants for heating and cooling the building can be included with the operation and maintenance charges.

As a result of this absence of concern about energy costs and lack of motivation to reduce the impact of high energy use on the environment, considerable amounts of energy are wasted. Many air conditioning and heating plants are left operating long after most of the staff have departed; much of the lighting is left on until late in the evening; and most of the occupiers' PCs, photocopiers and printers are left at the ready. **In some cases, this alone accounts for up to 10% of electricity consumption**. It is known that energy consumption expressed as kWhr/m$^2$/yr could be reduced considerably by good housekeeping regimes, **with savings of up to 20% claimed**. However, little information is as yet available as to how good or bad many individual installations are in the Republic of Ireland. An investigation into the situation in Ireland and the resulting information could be a major plank in highlighting the significance of housekeeping regimes in the drive to reduce energy consumption.

The Building Research Establishment in the UK has produced a series of 'introduction to energy efficiency' guides, covering a range of buildings. These guides are available in Northern Ireland, and SEI is understood to be considering the adoption of a similar approach in the Republic of Ireland. Such guides could be a core element in a campaign addressed to building designers, owners and occupiers in Ireland, explaining how they could reduce their energy use.

## Energy Reducing Measures Specific to Residential Buildings (Section 4.2.11)

### *Existing housing stock*

Based on the 2002 Census figures, the Republic of Ireland housing stock at the end of 2005 was about 1,696,000 units, allowing for obsolescence and new builds. At the end of 2005, about 34% of the housing stock had been built since the introduction of building regulations, leaving 66% pre-dating the regulations. The building envelope's thermal performance from this earlier stock is likely to be relatively poor compared to that of a well-constructed dwelling complying with the 2002 regulations.

Residences in urban areas in Ireland are depending to an increasing degree on imported fossil fuels for their heat requirements. Many households living in such areas could suffer as their fuel prices double or increase even more. Methods of promoting and assisting the necessary upgrading of the thermal performance of houses will need to be devised to ease the burden on householders, so as to reduce the greenhouse gas emissions and the costs of continuing to purchase energy from abroad.

To do this effectively, as much as possible of the **existing** stock of housing will require its thermal performance to be upgraded by ensuring the following:

1. It is double glazed with 16mm pane spacing, argon filled and coated E = 0.1, with window frames not less than 60mm seasoned timber, to give a window U value of 1.50 or lower; walls should be **insulated externally** to reduce wall thermal conductivity to 0.20 w/m$^2$K or lower, and roofs insulated to 0.15 w/m$^2$K or lower.

2. It is draught sealed to the maximum amount possible.

3. All open fireplaces are fitted with adjustable dampers, air tight stoves or other devices, which when not in use will prevent warmed air escaping to the atmosphere and being replaced by cold air, thereby reducing the effect of draught sealing.

4. Solar panels are fitted, with improved storage and distribution systems for hot water.

5. Where a piped heating system exists, a high-efficiency boiler and all necessary system controls should be installed, the boiler being carefully sized to match the . revised heat load of the upgraded house.

6. Where no piped heating system exists, houses could be fitted with a solar warm air panel, supplying a warm air heating system that could also provide the hot water. The system should be backed by an air heating battery served by a small wood-fuelled oil or gas back boiler.

5. Ventilation should be fan introduced, with full fan-induced heat recovery.

Providing a satisfactory, practical and adaptable system at an affordable cost, as underlined in the first measure above, poses a major challenge. Should hydro-carbon fuel prices not increase to the extent postulated, Ireland still needs to address how best to achieve good external insulation, given that the quality of the existing housing stock in relation to fabric heat loss **is so low in relation to other EU states**. This is particularly important in dwellings occupied by persons at risk of, or experiencing, fuel poverty.

## *New dwellings*

By 2030, the number of dwellings built in compliance with the 1997 regulations in the Republic of Ireland will be about 450,000, out of a housing stock of almost 2.0 million, which is about 23%. Unless their thermal performance is addressed, it will be more difficult to move toward reducing the energy in use in the residential sector in Ireland to a significant degree, such as 50% of the present usage.

As well as complying with improved thermal conductivity figures, new residential accommodation should be designed to avail of as much **passive solar heating** as possible. Even when the burning **of wood** or other biomass fuel in a boiler is provided, consideration should be given to the provision of a solar thermal air panel installation in new housing. This would reduce the biomass house-heating load.

Many new housing units are well suited to **heat pump** installations, and this will be commented on separately. The fitting of **photovoltaic panels** to new housing units is not considered economic at present. Some houses in rural areas could avail of small wind turbines to reduce energy requirements.

It is difficult now to visualise how many of the new housing schemes could obtain their heat by a **CHP-secured group heating scheme**, given the extension of the natural gas distribution system. (Some further comments on this process are in Section 4.5.) The extent to which micro-generation can be availed of is not clear.

### *'Very low-energy' and 'passive' houses*

A passive house is now accepted as being one designed to maximise heat gain from the sun and store it in the building fabric, thus reducing the space heating requirement to a level that no longer requires a conventional heating system. The passive house concept is now established in a number of EU states, particularly Germany, Austria, Switzerland, Belgium and to a lesser extent France. They are expensive, and in Germany have been estimated to cost between 8% and 17% more than conventional compliant build.

Since the Irish climate is relatively mild compared to that of Central Europe, it has been suggested that a **very low-energy** house complying with current Republic of Ireland building regulations could be designed and built to operate on about 15% of the energy required for space heating and hot water in a normal house.

One Irish timber-framed housing supplier has introduced a low-energy house concept that incorporates a number of features of the passive solar house, albeit to a lower standard, but significantly higher than the Republic of Ireland 2002 Regulations, and almost identical to those put forward for new housing in Ireland, as set out earlier in this section. These principles could be applied to both single and more standard dwellings with very beneficial results.

There is an opportunity here for R&D work to be carried out on design and construction aspects, and on following developments internationally.

## Energy-Reducing Measures Specific to Commercial and Public Sector Buildings (Section 4.2.12)

Construction of large, complicated buildings can involve complex cladding systems and **structural** elements, and their size and depth can produce problems with regard to lighting and maintaining comfortable conditions. Since outside temperatures in Ireland do not often rise to those experienced on Continental land masses, the case for universal installation of full air conditioning is not strong. However, it has tended to be adopted as the easiest way of achieving comfort and controlling temperature and humidity. Whatever about its capital cost, its environmental cost is high, as it adds to the electrical loading and consumption and resultant increases in greenhouse gas emissions.

Given the need to reduce the consumption of energy derived from fossil fuels in all buildings in the commercial public building sector, the setting of targets at an early stage is very important. Firm information is needed from a selection of all the classes of buildings involved, so that a representative sample can be identified of energy usage across a wide range of conditions. There is considerable scope for reducing profligate energy use, as well as reducing the hours of fuel operation of heating and cooling systems. This can be achieved through good, energy-efficient design and subsequent good energy use management during the operational life of the building. Many examples exist of recently built public buildings, among them a number of local authority head offices, where best practice energy-efficient design and good energy use management have been applied. **These examples should be followed in the commercial sector.**

## Targeted Energy Savings for Housing (Section 4.2.13)

This section endeavours to look at the extent to which the total energy consumption of the residential sector in Ireland in 2030 could be reduced to considerably less than half its 2005 level, while catering for 7.25 million people, the additional 1.63 million requiring about 870,000 additional dwellings.

Building regulations in Northern Ireland are different from those in the Republic, and came into effect on different dates. The average age of housing in Northern Ireland is somewhat older than in the Republic. Otherwise, the differences are not of enough significance to distort the estimates of the energy reductions possible in Northern Ireland.

It is assumed that all dwellings constructed in the Republic of Ireland after 2010 embrace all the conservation measures outlined earlier, and that from 2008 onwards, an updated standard involving a 20% reduction in $CO_2$ over that required under the 2002 regulations applies.

Based on the example at the back of the 2002 regulations, the following table shows how the various conservation measures set out in the previous section could reduce the energy requirements of a semi-detached dwelling built to the 2002 regulations, even if the calculated heat load was increased by 15% to compensate for errors during construction, as has been measured in Sweden and the UK.

**Worked Example: the effects of the conservation measures 1 to 7, if applied to the example taken from the end of the 2002 Regulations Documents L**[4]

| | **Space-heating kWhr/yr** | **Hot Water kWhr/yr** | **Total kWhr/yr** |
|---|---|---|---|
| 2002 Regulations, semi-detached house | 6171 | 2632 | 8803 |
| Suggested 15% adjusted for cavity insulations; defects as described in BRE study | 7097 | 2632 | 9729 (100%) |
| 1–3: Lower U-values, better air-tightness, plus tight damper for fireplace flue, etc. | 3395 | 2632 | 6027 (61.9%) |
| 4: Solar panel for hot-water | 3395 | 1026 | 4421 (50.0%) |
| 5/6: Better boiler, better control etc, or installation of warm-air heating | 3000 | 877 | 3877 (39.8%) |
| 7: Heat recovery ventilation | 2500 | 877 | 3377 (34.7%) |

In their 2005 report, SEI listed energy-related improvements by dwelling age carried out between 1997 and 2002. This shows that 77% had window replacements, 65% had door replacements, 54% replaced boilers and 25% insulated roofs or added to existing insulation.

The following paragraph indicates the energy usage reduction that can be achieved for different house types, built to the various editions of the regulations between 1991 and 2002, if a full retrofit of insulation measures was carried out.

The figures would indicate that the savings in energy consumption of apartments would be of the order of 40% for buildings built to the 2002 regulations, and about 55% and 40% respectively for semi-detached and detached dwellings built to a similar standard. There would be additional savings on apartments and semidetached dwellings built to earlier building regulations.

With respect to houses built pre-building regulations, large savings of up to 70% could be expected if all the measures recommended earlier were applied. Since the pre-building

*4 Measures 1-7 as set out in section 4.2.11* regulations houses will still comprise nearly half of the housing stock by 2030, these savings could contribute significantly to reducing the housing sector energy requirements to about **half the current level**.

## Targeted Energy Savings in Commercial and Public Sector Buildings by 2030 (Section 4.2.14)

This sector is substantial and increasing. There are opportunities for greater energy efficiencies at each phase of a building's development: design, construction and operation. More consideration is now required at the design stage of new buildings to ensure that the fabric of the building is as energy efficient as possible, consistent with its use, and that the most energy-effective scheme for building services is proposed. Options for consideration here include the use of CHP for power and heat, the use of heat pump technology for space and water heating, and the question of whether to incorporate AC. There is an imperative in increasingly energy-sensitive times to consider whole-life costings. It is essential that both government and planning authorities make this approach mandatory by 2010 or earlier.

As in the housing sector, quality of build has a significant impact on the energy efficiency of a building during its operating life. While there have been considerable advances made in recent years in the development of energyefficient materials, it behoves builders to install those materials effectively for them to perform as designed and contribute to the energy efficiency of the building. Adequate supervision and inspection at the construction stage is vital.

Equally important is that there is a positive disposition toward running the building services efficiently. Best practice procedures should be adopted for heating, lighting, ventilation, air conditioning and other services management.

These comments are general in nature, as there is an absence of comprehensive data on either floor areas of buildings of this type or information on their energy usage levels. Such data is required in order to classify buildings by type and use. A useful classification system has been in use in the UK for 10 years, of which the SEI statistical unit is aware.

Most building services engineers believe that the energy consumption in these buildings could be reduced to something approaching **half of its present level**. There are many notable examples where performance levels of this order have already been achieved (many of them are new public buildings). Their success should be celebrated, and others encouraged to follow.

### *Summary (Section 4.2.15)*

Consideration of the foregoing indicates that the present level of energy use in buildings in Ireland could be reduced **to less than half its present level**. The energy conservation technologies proposed are well known, tried and proven. Applying them in new buildings will not be difficult, but to achieve the desired effect they need to be applied to most of the existing building stock that will be in use in 2030. This will be more difficult in some instances, and further development work will be necessary.

This part of the report looked at what might be done to reduce the present energy use in buildings to a significant degree. No attempt was made to work out likely costs. It is appropriate to look at how many years it would take to recoup an expenditure of, for example, €12,500 per dwelling on the conservation measures outlined, if the price of the required fuels doubled.

Using data in the SEI report of 2005, it is estimated that the annual cost of fuel per dwelling is about €1,531. Should the costs of the required fossil fuels double, this would rise to about €3,060 per dwelling, which after a 50% reduction in energy use, would be recouped in about eight years, ignoring all externalities. The problem lies with the buildings that pre-date the building regulations and account for most of the energy use in the housing and the public and commercial buildings sector. Well over half of the housing stock and, as far as can be estimated, about half of the non-domestic buildings in 2030 will pre-date the application of the building regulations.

A **community action plan** is needed to reduce the effects of Ireland's vulnerability with regards to its natural gas and heating oil requirements, the likelihood of substantial price increases, the necessity to reduce greenhouse gas emissions and the overriding concern to reduce usage and dependence on fossil fuels. The preparatory period for such an action plan to implement current conservation measures should cover necessary consultation with the building design professions, planners, building industry contractors and suppliers and local authorities. While a single organisation might be charged with the provision of guidance and technical support, monitoring projects, setting of standards, approval of firms deemed to have the necessary competences, both promotion and organisation of such work should be assigned to local authorities. Such local involvement is necessary to exert a powerful influence on public awareness of the need to conserve energy.

## Heat Pumps (Section 4.3)

In one of its publications, SEI has defined heat pumps as an environmental energy technology that extracts heat from low-temperature sources (air, water and ground), upgrades it to a higher temperature and releases to where it is required for space and water heating. Heat pumps can also be operated in a reverse mode for cooling purposes. Heat can be extracted from shallow soil or from close-to-surface aquifers. The moist, warm air (10–11° C) soil conditions in Ireland are ideally suited to ground-source heat pumps.

The energy needed to drive a heat pump is generally electric. For every unit of electricity used, it will generate 3–5 units of useful heat. The penetration of heat pump technology has been slow in Ireland, with approximately 1,500 domestic ground-source heat pump installations currently in place, typically in the range of 10–14kW. Over 30 large-scale or commercial systems have been installed. Swimming pool projects use heat pumps in favour of direct heating. A good example is Mallow swimming pool, which has been in operation for a number of years, as have a number of smaller domestic pools. Recent successful examples of the application of heat-pump technology are Glucksman Art Gallery in UCC and the Motor Tax building in Tralee, County Kerry. In the Tralee case, the energy usage has been reduced to one-third of the heat required for space heating and cooling in a typical office building of similar size using conventional technologies. With these levels of proven efficiency, why has the technology not had a better uptake in Ireland? In their report for SEI on a strategy for the development of a self-sustaining heat pump market in Ireland, Austrian consultants Arsenal Research categorised the barriers as **awareness** (reliable information and bad history of poor installations), **economics** (up to three times cost of conventional), **education** (little technical information or know-how among installers – FÁS/SEI addressing this), **quality** (including building fabric), **policy** (need for government strategy).

## CONCLUSIONS AND OBSERVATIONS ON THE HEAT PUMP SECTOR

Heat pumps represent an important technology in the drive to reduce greenhouse gas emissions, reduce energy costs and improve the efficiency of electricity use in the domestic housing sector and public and commercial buildings. There is wide scope for the application of this technology when the number of houses now being constructed is taken into account. There is a significantly high number of new self-build private houses being constructed (up to 36% in 2002), which are more amenable to the application of this technology than those in an urban environment.

The following conclusions emerge:

- More information should be made available on heat pump technology and techniques through a concerted information programme.
- A package of economic incentives should be devised, which takes into account the energy efficiency of heat pumps and the reduction in greenhouse gasses deriving from their use.
- The issue of skills levels of installers needs to be addressed through an extension of the current training arrangements, including appropriate certification.
- The quality issue should be dealt with by good design, skilled installation, and appropriate supervision and inspection, including the setting up of an industry association.
- Visible political support at both policy and legislative levels is required if the technology is to be more widely applied.

## Heating from Wood Biomass (Section 4.4)

Wood can be burned in an enclosed system using logs, chips or pellets to provide room or central heating for a house, a large building complex or even for a district or neighbourhood. There are a number of benefits deriving from burning wood for heat in this manner, including replacement of fossil fuel, import substitution, reduction of greenhouse gas emissions and benefits to the local economy where the fuel is produced.

There are a number of locations in the island of Ireland where wood biomass has been used successfully, and a number of companies have entered both the retrofit and the new build market. Thirteen demonstration projects have been in receipt of 50% support under an Interreg programme in the seven border counties, and a large plant for the production of pellets is now in production in Enniskillen, County Fermanagh using local sawmill by-products and forest residues. This market has seen several new entrants over the past year, offering a full service from fuel supply to boiler installation and maintenance. They are presently targeting commercial and industrial heating customers.

For the domestic market, smaller units that incorporate fuel storage and automatic feeding arrangements are becoming available, and can be used in a retrofit situation, provided space is available for fuel storage. Costs are still high, but their selective use is worthwhile in the general move to reduce dependence on fossil fuels, for example, in new houses with high standards of insulation.

For countries like Ireland, beginning to develop wood biomass, the European Renewable Energy Council recommends that promotion and awareness-raising take place, that capital subsidies are provided to assist with the high installation costs and that appropriate standards are developed for both equipment and skills required. For Ireland, these are interesting developments, and should be pursued to reduce the growing dependence on fossil fuels. SEI is in a pivotal position to encourage this trend with appropriate awareness and technical and financial supports, now that reliable sources of fuel are becoming available.

## District Heating (Section 4.5)

District heating (DH) is a process that has been successfully used for over 100 years in many parts of the world, particularly in Europe and the United States. It involves the distribution of heat from a power plant, either a combined heat and power (CHP) plant or a central boiler, in the form of hot water through a pipe network to provide a heat source for domestic, communal and commercial buildings. When heat is derived from a CHP plant, the overall efficiency is relatively high, giving reduced carbon emissions per unit of useful energy delivered.

In Ireland, very little use has been made of DH, arising from the fragmented nature of the market. Investors would need a large customer base to justify the substantial initial investment. A report for SEI in 2002 concluded that a DH system supplied from a heat-only boiler is not normally cost-effective, even in a new build situation, and that a heat-only boiler system does not provide any significant environmental benefits in terms of $CO_2$ emissions, compared with gas boilers in individual homes. Consideration should be given only to schemes based on heat recovered from CHP plants. The key issues that affect the uptake of DH in Ireland are the mild climate and the relatively low housing density.

In Ireland, experience has been confined to a small number of projects, the largest being the Ballymun Plant. This scheme was difficult to operate economically as the insulation levels were low, and will probably be closed down after the demolition of the tower blocks. A number of other small DH plants are in operation, notably Dublin Civil Offices and Temple Bar, Portlaoise Prison and certain third-level institutions.

The most attractive possibilities will likely be in densely populated, inner-city areas with a wide mix of commercial and domestic customers. Proximity to a CHP plant is also desirable to derive the benefits of electricity. Such an opportunity presents itself in the new Ringsend Development, associated with the proposed waste-to-energy (WTE) facility in Poolbeg where there are plans to recover up to 42MW of electricity from Dublin's municipal waste. The intention is to design the plant from the outset as a CHP plant, which in full CHP mode will make up to 90MW of heat available. This is sufficient to meet the winter heating demand of up to 18,000 homes. A DH network is proposed, in order to bring the benefits of this heat to housing and other developments. Dublin City Council is confident that the scheme can be made viable.

In its energy policy development, the government should encourage any opportunities that present for CHP/DH projects as part of a carbon emissions reduction programme.

## Conversion Efficiency of Heating Fuels and Heating Technologies (Section 4.6)

## Cost Comparison of Heating Fuels (Section 4.6.2)

The delivered energy cost to the consumer of common heating fuels varies quite significantly between fuels. Natural gas is currently the least expensive home heating fuel and electrical energy is the most expensive. At present fuel prices, it is generally uneconomical in the short term to switch fuels, as annual savings will not be large enough to justify the initial investment. Greater savings can be made in the short term by improving the overall energy efficiency of a typical Irish residence.

## Efficient Energy Conversion for Heating (Section 4.6.3)

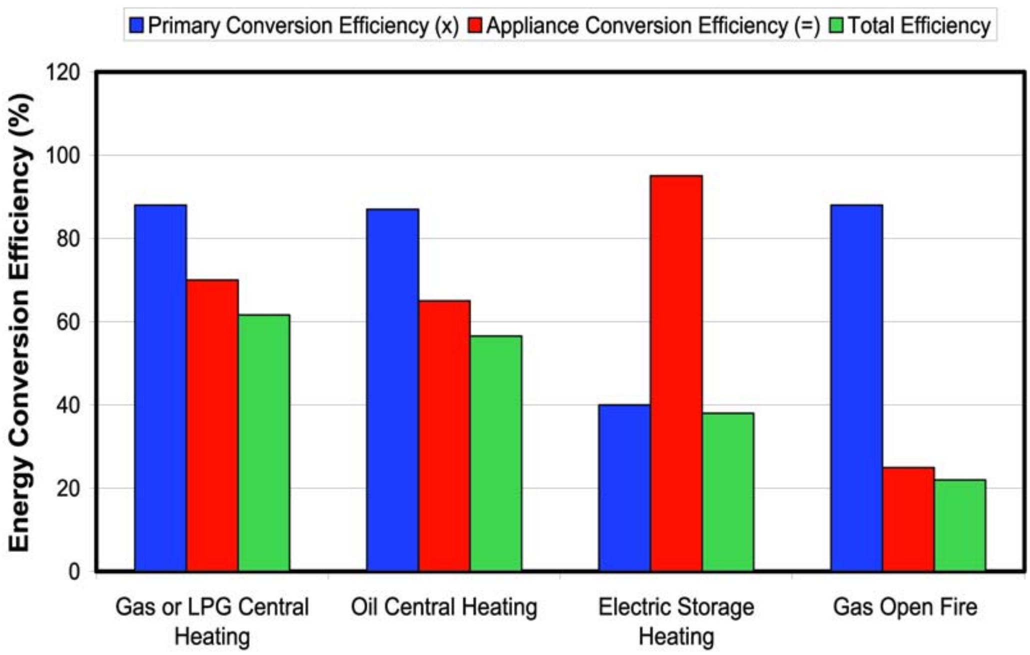



Fig.1: Total Energy conversion efficiency of common heating fuels and home heating technologies. [5]

*5 The efficiency of electricity supply in Ireland is taken to be 40% - see M. Howley and B. O'Gallachoir, Energy in Ireland, 1990–2002 (Sustainable Energy Ireland, 2004). Seasonal energy efficiencies of common heating appliances are quoted from Sustainable Energy Ireland, 'Domestic Fuels Comparison of Useful Energy Costs for Space Heating'(2005).*

## Carbon Intensity of Energy Sources

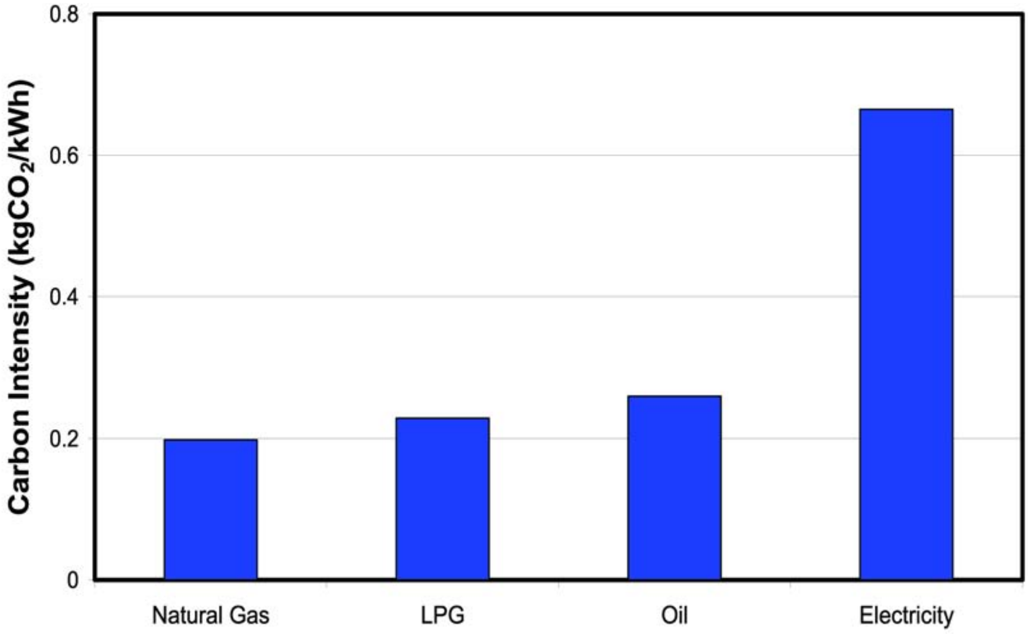



Fig.2: 4.2: The Carbon Intensity of common Irish heating primary energy sources: natural gas, LPG, Oil[6] and Electricity [7]

6 Environmental Protection Agency, 'CO2 Emission Factors for Fossil Fuels for Industrial Users' (2003). Available from <http:www.epa.ie>

7 M. Howley and B. O'Gallachoir, Energy in Ireland, 1990–2002 (Sustainable Energy Ireland, 2004).

## THE BUILDING AND HEATING SECTORS: CONCLUSIONS AND RECOMMENDATIONS

It is apparent from the foregoing discussions that the building and heating sectors are a most important part of energy usage consideration, both in terms of the large share of total energy consumed (46% of secondary energy) and the opportunities that exist to reduce that usage significantly. The reduction of the total amount of energy used in these sectors is vital in the short to medium term in view of the anticipated increases in energy costs, in light of security of supply considerations and reducing the greenhouse gas emissions on the island.

There are concerns regarding the approach to building design, the current state of building practice, the thermal performance of buildings and the generally low level of promotion of energy efficiency. **Ireland has been slow** in ensuring that the sections of the building regulations dealing with energy conservation and the thermal performance of buildings are enforced to an adequate degree. There has been **too long a transition period** between the introduction of new regulations and the time by which industry is fully compliant. This lag reduces the overall benefit that can be derived from the introduction of higher thermal standards. The speedy introduction of the forthcoming EU Energy Performance Building Directive (EPBD) affords an opportunity to bring the energy performance of buildings into sharp focus for the general public when energy rating of all buildings will be mandatory.

Building practice in Ireland needs to be upgraded to produce building fabrics that conserve heat and reduce air leakage to designed levels. Research has shown that a large percentage of houses and buildings under-perform in energy terms against their designed performance levels. To achieve this, the resources being applied to enforcement of the standards and regulations must be significantly augmented. The measures and suggested U-values have been set out in the section entitled 'Energy-Reducing Measures Specific to Residential Buildings'. They are all achievable using current technologies, and could be delivered if more emphasis is placed on better thermal performance of buildings.

The progressive implementation of the current building regulations and the application of the measures described above were taken into account and indicated that a substantial reduction in energy usage was possible in this sector, **of the order of 50%**. This is a conservative estimate, but clearly indicates what could be achieved through a concerted effort.

## GENERAL RECOMMENDATION

**The government, as part of its energy policy, should adopt a target of reducing energy consumption in the building and heating sectors by 50% by 2020 through the structured and progressive application of a wide range of conservation measures, ranging from upgrading the thermal performance of existing housing stock and ensuring that new buildings are energy efficient, to the use of renewable energy sources where possible.**

### *Specific Recommendations*

1. The revision of the building regulations now under consideration should provide for a significant upgrading of building thermal performance, and should be introduced as soon as possible.

2. Appropriate resources should be provided to the local authorities to ensure compliance with current and new regulations.

3. Methods of upgrading the energy efficiency of the current housing stock should be examined and publicised through an aggressive national promotional campaign that emphasises cost savings, fossil fuel usage reductions and environmental good practice. Some financial incentives should also be included to encourage participation.

4. The pace of current work should be accelerated on the development of the low-energy house, with a view to wider use of the most practical design principles. This is best achieved through a structured R&D procedure.

5. Target energy usage levels, derived from research and measurement, should be set for various types of public and commercial buildings.

6. Maximum use, where appropriate, should be made of renewable energy technologies in the energy mix of public and commercial buildings.

7. The use of heat pump technologies should be promoted where appropriate, with emphasis on comprehensive technical information, high quality installation work and some financial incentives.

8. Wood biomass has the potential for much more extensive use in Ireland, particularly in the large number of single house situations that exist. SEI is in a pivotal position to encourage this with appropriate awareness programmes, R&D and technical and financial support, to the extent that reliable sources of suitable fuels are available.

9. District heating opportunities, while not expected to be numerous, should be kept in mind by planning authorities and developers and introduced if feasible.

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* Ireland's Environment
* The Government's Technology Investment Fund
* Spatial Development for an Island of 6 million
* Creating Europe's most attractive environment for intellectual property.

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