ECONOMIC DEVELOPMENT COMMITTEE **EDC 03-02(p7)**

Date:	**30 January 2002**
Time:	**2.00 – 5.30pm**
Venue:	**Committee Room 3, National Assembly for Wales, Cardiff Bay**
Title:	**EDC Energy Review: 'A discussion paper on energy policy in Wales following a review of relevant energy literature'**

Paper commissioned by the Innovation and Sustainable Growth Division of the National Assembly for Wales.

Author: Professor Nick Syred, Head of Mechanical Engineering Division, Cardiff University.

1. Against the background of the terms of reference of the EDC review of energy policy in Wales, the attached paper provides the committee with an overview on energy following a review of relevant literature on a Wales, UK and European basis. It has been commissioned by the Innovation and Sustainable Growth Division, following a request by the then Chair of the Committee, Ms Val Feld, Mr Mike German and Professor Phil Williams. The paper has been submitted by Professor Nick Syred, Head of Mechanical Engineering Division, Cardiff University.

2. The EDC will therefore wish to be aware of the attached report in the context of your review. It will provide a good background to the Performance and Innovation Unit's UK energy review which is likely to be published shortly.

Innovation and Sustainable Growth

A DISCUSSION PAPER ON ENERGY POLICY IN WALES FOLLOWING A REVIEW OF RELEVANT ENERGY LITERATURE

Centre of Excellence in Sustainable Energy and Process Management

January 2002

PAPER FOR THE ECONOMIC DEVELOPMENT COMMITTEE'S REVIEW OF ENERGY FROM THE CENTRE OF EXCELLENCE IN SUSTAINABLE ENERGY AND PROCESS MANAGEMENT

Title: A discussion paper on energy policy in Wales following a review of the most relevant literature available in Wales the UK and Europe.

Author: Professor Nick Syred, Head of Mechanical Engineering Division Cardiff University.

Executive Summary

Following a review of relevant literature, this paper summarises the views of the CETIC Centre of Excellence in Sustainable Energy and Process Management concerning Energy Policy in Wales and how the various targets for CO_2 and Greenhouse Gas emissions can be met. A number of major points emerge:

Better Welsh statistics are required

Fossil fuel price and utilisation are governed primarily by external factors both economic and political. It is likely that natural gas prices will be forced upwards in the medium to long term, thus changing the economics of renewable energy technologies. This will have substantive effects on fuel poverty and emphasises the need for drastic improvement in energy utilisation in the housing market. New developments in power generation with 'clean coal technology' are likely to be limited by economic considerations, the high CO_2 emissions and probable requirement for CO_2 sequestration after 2020.

Undoubtedly there is going to be slow but steady growth in the use of fuels for transportation. Despite some growth in the use of natural gas and liquefied petroleum gases, the primary source of transportation fuels in the near to medium term will be diesel and gasoline. Because of improvements in the efficiency of diesel engines there would appear to be substantial possibilities for bio-diesel fuels. Major vehicle manufacturers now favour methanol fuel cells to replace gasoline engines, primarily due to the liquid nature of the fuel and the ease with which it can be distributed. Hydrogen fuelled vehicles do not appear to be realistic in the near to medium term (apart from niche markets) because of the expense of production, storage and distribution of hydrogen in the volume necessary for transportation purposes. Dramatic technological advances are necessary for us to achieve a 'hydrogen economy'.

Fiscal, legislative and related techniques are required to obtain widespread acceptance of renewable energy power generation. Local ownership and involvement is necessary to obtain widespread acceptance and avoid or minimise the 'Nimby' phenomenon

Decisions on whether or not to replace existing nuclear power stations will have decisive effects on technological, fiscal and legislative paths to be followed.

Renewable energy technologies give rise to generation costs which are nearly always significantly greater than those arising from conventional fossil fuel fired power stations with the present price of fossil fuels.

In detail measures, which are cost effective, can promote energy efficiency, the use of renewable energy and can be implemented by public persuasion, fiscal incentives and legislative measures include:

Improvement to the housing stock, insulation, better glazing, heating systems, passive solar for new buildings etc., techniques to minimise non-essential use of electricity for heating, air conditioning, cooking etc.

Wind Power systems

Photovoltaics in the medium to longer term as the price of cells reduce.

Utilisation of biomass residues/wastes such as forest wastes, chicken litter etc, (which often have associated disposal costs) for power generation.

Wave power systems, possibly followed in the medium term by tidal current generation and longer term by tidal power.

1 INTRODUCTION

1.1 Background

Securing sustainable energy supplies is a global problem with local variance in the problems and solutions. Worldwide energy demand is met predominantly by the use of fossil fuels; however, there are major concerns the levels of these world fossil fuel reserves, their security of supply, and the environmental impact of using them.

Fossil fuel reserves have been of major concern and under constant review since the 1970s when it was considered that recoverable oil reserves would soon be depleted. Estimates have since been a little more optimistic with the discovery of new oil fields and the advancement of extraction technology.

A greater problem in the short term is security of supply. The greater proportion of fossil fuel comes from Middle Eastern nations. These nations political volatility raises concern as to security of supply. Domestic oil prices rose 23% between 1995 and 2000, industrial oil prices by 32%[1]. With the current unbalanced political situation in the Middle East and certainly in the wake of the recent American terrorism incident this problem looks only set to worsen.

Security of supply is seen as such an issue that The Energy Security of Supply Working Group has been set up by the DTI and OFGEM and will meet for the first time in September 2001. It will monitor security of supply issues and assess any risks to supplies in the future.

The environmental impact of the use of fossil fuels and potential scarcity of supply are the other major driving forces behind energy policies. Their extraction and use releases carbon dioxide, methane and to a lesser extent nitrous oxide (N_3O) to the atmosphere, contributing 80% of world total greenhouse gases for energy production alone. Measures such as the Kyoto protocol aim to reduce these emissions by forcing improvements in efficiency and diversification to alternative renewable energies.

1.2 The Aims of a Welsh Energy Policy

Energy policy is influenced by political, economic and climatic circumstance. Driving forces come from the EU and it is important to integrate with the UK framework, but defining a local strategy for Wales will give structure and clarity to taking the country forward towards 2010 and beyond. The aims can be listed as follows:

- To ensure an adequate and secure energy supply for Wales.
- To integrate with the overall UK market but to boost production within Wales in order to achieve more self sufficient and local production.
- Modern efficient use of primary fossil fuels.
- Attention to clean technologies to ensure cutting edge, efficient and greener fossil fuel power.
- To achieve diverse energy production over the range of all available energy sources and technologies in order to reduce dependence and ensure security of supply.
- To preserve a high quality natural and built environment.

- To promote renewable energy and combat CO2 emissions to comply with the Kyoto protocol and meet UK renewable energy targets.
- To implement a structure of sustainable renewable energy supply to stay ahead of European and UK climate change legislation so as not be left in a situation of battling for compliance.
- Promotion of Wales as a region of technical excellence in new and renewable energy systems.
- To promote an improved spatial distribution of economic development.
- To provide the industry with the economic, safety and environmental regulatory framework for a structured, integrated and effective energy strategy.

2 THE CURRENT WELSH SITUATION

2.1 Supply and Demand

Supply and demand in Wales is at the moment difficult to gauge, as (Welsh) national data is publicly unavailable, the only statistics of use are the overall UK energy statistics[2]. An attempt was made to address this problem for national statistics as a whole and in 2000 the first Digest of Welsh Statistics was published[3]. However, the energy section of this is particularly void of data necessary for assessment and planning such as this.

Welsh energy demand is highest along the heavily populated M4 strip and at the very north of the country, whereas most of the rest of Wales is heavily rural with sparse and scattered energy demand.

There are several substantive plants generating electricity in Wales. There is the one remaining nuclear plant of Wylfa in Anglesey (generating electricity since 1971 and operated by BNFL Magnox Generation) but this is due to close in 2004. Trawsfynydd in North Wales was taken out of commission in 1993 although as of May 2000, the new owners Magnox BNFL have been seeking Environment Agency approval to produce electricity there. There are also the hydroelectric storage plants at Ffestiniog and Dinorwic. The only coal-fired power station is at Aberthaw and this is not fitted with flue gas desulphurisation equipment, so its operation will be limited in the future. There is the large Baglan Energy Park in Port Talbot (where a new, prototype General Electric Gas Turbine is to be tested as part of a natural gas fired combined cycle power generation plant). There is a hope to gradually develop an energy park at the derelict oil terminal site at Rhosgoch on Anglesey. There are two large Natural Gas Fired Combined Cycle Power Stations at Deeside and Connahs Key. The very large pumped storage generating facilities in North Wales also form a very significant power store system for the whole of the UK grid

It is important to maintain Wales's lead in new energy systems and the market advantage and employment benefits which comes with this.

2.2 The UK Electricity Market

Since privatisation at the turn of the 1990s, the structure of the UK electricity supply market has evolved considerably. Generation, supply and distribution are now kept as entirely separate activities and competition is encouraged to ensure efficiency and cost effectiveness.

There are several large, privatised, fossil-fuel generating companies - including National Power (now Innogy), PowerGen and TXU. There are two nuclear generators - the publicly owned British Nuclear Fuels Ltd. (BNFL), which owns the older Magnox nuclear stations and the privatised British Energy. Renewable energy is currently a minor contributor to the UK electricity market; companies are small, abundant and varied.

The transmission system through which bulk electricity at high voltage (400 kV and 275 kV) is taken from the generators to the Regional Electricity Companies (RECs). It is owned and managed by the National Grid Company plc (NGC) which was privatised in 1995.

Electricity is locally distributed by the 12 RECs (at 132 kV down to 220 volts) in their own franchise area in the UK. Distribution Companies are now split from electricity sales. For example Western Distribution manages the South Wales distribution grid while SWALEC manages sales. Both of these companies are now non-Welsh based. Similarly North Wales is managed by MANWEB, again a non-Welsh based company. It seems to be unlikely that an integrated Welsh distribution Company will form as the primary grid connections are east-west into England. Control of these Companies is now outside Welsh borders and influence is only marginal. The supply of electricity was fully liberalised in 1998-99 and all consumers are now free to choose their supplier.

Electricity is bought by RECs through the New Electricity Trading Arrangements (NETA). It determines electricity pricing and balances production.[4] NETA is discussed in more detail in section 3.4.1.

Licensing issues for generation, transmission, distribution and supply are to be found in Section 3.4.3.

3 POLICY AND CURRENT EU POSITION

3.1 The Environment

As a direct consequence of the release of greenhouse gases to the atmosphere, global warming has become a serious reality. Carbon stored for millions of years within the earth's crust is being released at a frightening rate to the upper atmosphere by its extraction and use as fuel. Methane is also released by the mining of coal; this is a gas with 21 times the global warming potential of carbon dioxide over a 100-year time horizon. These greenhouse gases throw the world's energy budget off balance by trapping an increased amount of heat within the earth's atmosphere rather than allowing it to naturally radiate out into space. The net result is a global increase in temperature. The United Nations has recently increased its prediction for the global average surface temperature rise to 5.8°C between 1990 and 2100. By the analysis of tree rings, ice cores, corals, and historical records for the Northern Hemisphere, the Intergovernmental Panel on Climate Change (IPCC) could trace a historical global temperature profile. It showed that over the last millennium, the 1990's was the warmest decade with 7 of the 10 warmest years on record. In fact 1998 was the warmest year in a 140-year record. There has been a 40% decrease in the summer thickness of arctic ice in recent decades, and a 10% decrease in mid and high latitude snow-cover since the 1960's. The rise in temperature has coincided with a 31% increase in the concentration of atmospheric carbon dioxide since 1750.[5]

As such it is imperative that we cut our greenhouse gas emissions. The global energy industry is not geared to carbon free or carbon neutral energy production. However we must make every effort to curtail these emissions (or even potentially capture them, an approach being explored primarily in the USA) and legislation has been brought out to facilitate this.

It must be pointed out that climate change can have severe effects on Wales and indeed many sources feel that these changes are irreversible without drastic action. Drastic action seems to be unlikely in the near future, in view of the USA views on the Kyoto Protocol. Effects that may have severe long-term effects in Wales include:

- A rise in sea levels.
- Increase in storms, rain, temperature levels and yearly profile etc.
- Changes in the Gulf Stream due to melting polar ice caps etc.

The first two effects can give rise to events similar to those which occurred with the east coast of England floods in 1953. As a consequence low lying areas of Wales, where much of the population is concentrated (Cardiff, Newport, Swansea etc.) will probably need increased sea protection defences. Indeed some projections indicate that in 50 to 100 years many major UK coastal cities will require substantive flood defences. Technologically this presents few problems, 50% of the area of the Netherlands is below sea level, but there are major use and resource implications, which need to be addressed. Effects on energy use patterns and agriculture are likely to be subtle and subject to slow, but continuous change.

Other scenarios suppose that melting of the Polar Ice Caps/Greenland glaciers could produce switches in the direction of the Gulf Stream, which warms Northern Europe to far beyond the temperatures expected at Northerly latitudes more than 50 degrees. The resulting drop in ambient temperatures would produce severe problems and require drastic action with the Welsh housing and building stock, whilst causing drastic changes in agricultural practices.

3.2 Global Climate Change Policy

Although not legally binding, in 1992 the United Nations Framework Convention on Climate Change founded the Rio commitment, which was the first real piece of climate change policy to prevent dangerous man-made interference with the climate system. The UK honoured this commitment to bring the UK’s greenhouse gas emissions back to 1990 levels by the year 2000 (although this was mainly due to the dash for gas which is a less CO_2 intensive fuel than coal or oil).

It also the set in motion a mindset which led to Kyoto in 1997 which set a cut in overall greenhouse gas emissions to 5.2% below 1990 levels by 2008-2012 for those developed countries who agreed. The United Kingdom agreed to further cut its emissions by 12.5%. Once ratified this is the first ever legally binding climate change commitment. Achieving this without reducing economic activity would require improved energy efficiency and greater use of alternatives to fossil fuels.

Woefully, President Bush in March 2001 turned his back on the protocol, much to the displeasure of the rest of the world, labelling it “Flawed, unrealistic and not based on sound science.” It seems he is not prepared to participate in environmental targets, which would risk economic penalties. Furthermore, the President has pledged to maintain the American way of life via a controversial new plan for the country's power facilities. The National Energy Policy envisages the building of between 1300 and 1900 new power stations over the next two decades; the 're-launch' of nuclear power as a viable and safe option; and the exploitation of federally owned areas of natural beauty by oil and gas companies. The administration argues that the United States simply has no choice if it wants to avoid the shortages seen currently in California, and protect business and the economy. However, there are dissident voices that are beginning to make themselves heard - people who are not willing to sacrifice the environment to maintain all those energy-rich lifestyles.

President Bush thinks Kyoto is unfair on the United States, as it leaves out developing countries and penalises countries which have large coal (high CO2 emissions), and small gas and oil reserves. He fears that it would lead to higher energy prices in the United States and, at heart, he probably doesn't think it would do much good anyway. The United States is facing an economic downturn and an energy shortage. He doesn't want to do anything, which makes that worse. He argues that in order to reduce greenhouses gases (especially carbon dioxide) without "harming the economy and hurting American workers", as he puts it, the United States would need to use much more natural gas - and it does not have the means to do this. There is at the moment not enough infrastructure to import and distribute it nationwide. Recent discussions with boiler and combustion equipment manufacturers confirms that massive investment in plant to utilise natural gas and to a lesser extent oil is expected over the next 5 years in the USA, so as to mitigate the energy shortages recently felt in California, but also expected in much of the rest of the USA in the near future.

This is confirmed by the recent US National Energy Policy Development Group May 2001 report[6] which urges a big push in power plant construction (1300-1900 over the next two decades) from diverse sources – oil, gas, coal and also hydro & nuclear.

Compounding this problem is also the failure of the USA to force the improvement in vehicle fuel economy, which has been happening in Europe and Japan. It is hoped that the tragic recent events in New York and Washington may refocus American minds to the problems of long-term energy supplies and the need for restraint in the use of fossil fuels, which are primarily supplied from regions of high political instability.

The European Commission has launched the European Climate Change Programme (ECCP) aimed at identifying additional policies and measures that will be necessary if the EU is to meet its climate change targets. Several of these are already well developed, including a Directive aimed at encouraging renewable sources of energy, proposals for a CHP strategy, an energy efficiency action plan and initial proposals for the development of a European-wide greenhouse gas emissions trading scheme.[7] Virtually all of the major members of the European Union have key programmes aimed at reducing greenhouse gas and other emissions, both by seeking performance improvements in existing and new plant, legislation aimed at vehicle greenhouse gas emissions and by actively promoting alternative energy strategies. A typical document is such as that produced by the VGB in Germany, which represents a consortium of mainly German Electrical power Utilities.

3.3 UK Climate Change Initiatives

In November 2000 the UK launched a detailed Climate Change Programme[8] which outlines measures to combat climate change. The measures apply to all sectors from forestry to agriculture, transport to energy and include all sections of the population. In the area of transport, for example, the Government is running programmes to increase penetration of next generation fuel-efficient technologies and vehicles and is introducing various taxation schemes such as an emissions differentiated vehicle tax.[7]

As part of this, the Climate Change Levy (CCL) was introduced in April 2001. It increased corporate companies energy bills as it taxes non-domestic customers on the basis of their energy use.

The UK's Royal Commission on Environmental Pollution (RCEP) report, Energy – The Changing Climate[9], predicts that the UK is likely to see an increase in CO_2 emissions after 2012, reaching a 2 per cent rise on 1990 levels by 2020. The DTI's Energy Paper 68 (December 2000), is slightly more optimistic, forecasting with its middle ground scenario a 2.6 per cent decrease on 1990 levels of CO_2 emissions by 2020. The problems with CO2 emissions after 2012 arise because of the expected retirement of Nuclear Power Stations, which have recently accounted for more than 25% of total Power generated. There are also limits on the amount of renewable energy that can be generated with the present pricing structures.

3.4 UK Policy Instruments

Government energy policy mantra is "to ensure secure, diverse and sustainable supplies of energy at competitive prices". There are certain pieces of legislation, which aid to promote and maintain that.

The Utilities Act 2000

This is a significant piece of legislation, which laid the foundation for further policy and aimed to promote greater competition in energy markets and more effective regulation in the interests of consumers. It gave impetus to development of renewable sources of energy by way of the Renewables Obligation. It lays the groundwork for forming energy efficiency targets.

It replaces the Director General of Gas and Electricity Supply with the Gas and Electricity Markets Authority. It draws together the gas and electricity markets by replacing the Gas Consumers Council and some of the functions of the Director General of Electricity Supply with the Gas and Electricity Consumers' Council which will have new powers as a voice for the consumer. It imposes the objective of protecting the interests of consumers in relation to electricity and gas.

It instigates the requirement for distribution licences by RECs, now necessary since privatisation. It prohibits the holding of both a supply and a distribution licence by the same legal person.

The Secretary of State for Trade and Industry may determine standard licence conditions (whether it be generation, transmission/transportation, distribution/shipping or supply) for any type of gas or electricity licence, under the provisions of the Utilities Act. Conditions were due to be finalised in September 2001 but until they are formally published, provisional licence conditions to assist licensees in their planning are available on the DTI website.[10]

New Electricity Trading Arrangements (NETA)

NETA is the means by which RECs buy their electricity from producers in England and Wales. It commenced on 27 March 2001 and abolished the old Electricity Pool, Pool Purchase Price and Non-Fossil Fuel Obligations (NFFO). NETA aims to reduce both wholesale and customer prices, while improving supply efficiency. To do this it will reward those who can accurately forecast what they will produce. In order to guarantee output, electricity suppliers will need to accurately predict their output a minimum of three and half-hours before delivering it. This is the cause of considerable concern for small generators and intermittent renewable energy producers. Because the supply of wind cannot be guaranteed or controlled, the market for the energy produced is at risk.[11] This fundamental problem with the market for renewable electricity has caused some to predict that the 2010 10% renewables target is unlikely to be met until 2015.[12] The Office of Gas and Electricity Markets (OFGEM) is currently reviewing of the impact of NETA on such generators, and any further measures to refine the policy will depend on the outcome of that review. A three month review has so far been published[13] but the main overview and recommendations will come from a one year review. A further parallel report[14] shows a fall of 27% over one year for the price paid to wind plant for electricity export. Output from smaller generators has fallen substantially. It shows that other than wind power, the output of smaller generators does not appear to be significantly less predictable than that of other generators. Some action has been, and can be, taken which has the effect of limiting the impact on less predictable generation but the principles of NETA cannot be changed. The only piece of optimism available for wind (and potentially other intermittent energy sources such as wave and solar) is a proposed modification within the three month review suggesting to reduce the Gate Closure period from 3½ hours to 1 hour although this has yet to be accepted. It is suggested that the Government should review whether renewable targets can be met within the current trading framework with current levels of subsidy and highlights the need for support for less reliable often intermittent green energy. Small renewable suppliers of energy are not the only suppliers who are worried. At a recent PIU meeting major suppliers from CCGTs were indicating that under certain circumstances due to the low price of electricity offered, and the increased price of gas it will not be economic to run their equipment at critical times of the year, such as when very low temperatures occur. Indeed it was more profitable for them to sell their natural gas back into the gas grid. As there is no legal requirement to supply, the margin of excess capacity could be greatly reduced and we could face a California brown out situation. These are inevitable teething troubles with the new arrangement and hopefully corrections will be made to the arrangements to prevent this occurring.

The Renewables Obligation

The Renewables Obligation (RO), springing from the Utilities Act and part of the UK's Climate Change Programme, is due to come into effect 1st January 2002.[15] It requires electricity suppliers to source a proportion of their energy from renewables and is the mechanism by which the Government seeks to achieve its 2010 target of 10% of electricity from renewables. This way it promotes the advancement of renewable energy while leaving the choice of technologies to the market.

Although the scheme does not provide a subsidy for renewable technologies, as the current schemes effectively do, it does create a limited, protected market for them, in which they do not have to compete with more established fossil fuel and nuclear sources. At present some 2.8% of UK electricity derives from renewable sources.[16] Subject to the cost to consumers being acceptable, the RO specifies Electricity suppliers to provide 3% of their electricity sales from renewable sources by March 2003, rising to 10.4% by March 2010. In the longer term, the Government intends to set more ambitious targets up to at least 2027.

The DTI predicts the scheme will be worth more than £1 billion by 2010, and even more in the following years. Expected prices will rise 0.5% each year until 2010, adding up to a total increase of just under 5%, equal to about £780 million for the country as a whole.[17]

In energy from waste incineration plants only those which treat a minimum of 98% organics will qualify for the renewables obligation, no UK plant does. The obligation is more accommodating to advanced cleaner technologies (pyrolysis and gasification), although the fossil component of the waste used as fuel will naturally not qualify.[18]

When the Renewables Obligation is introduced, OFGEM will be responsible for monitoring and enforcing the compliance of electricity suppliers with the details of the Order.[16] Renewable Obligation Certificates (ROCs), awarded to suppliers for renewable energy generation, are tradable to those electricity suppliers who fail to meet their stipulated targets.[19]

Climate Change Levy

The Climate Change Levy (CCL) came into effect on 1 April 2001 through legislation within the Finance Act 2000. It is a tax on the use of energy in industry, commerce and the public sector. It entails no net tax increase but offsets cuts in employers' National Insurance Contributions and additional support for energy efficiency schemes and renewable sources of energy. The levy forms a key part of the Government's overall Climate Change Programme and will help meet the greenhouse gas emission targets. It only applies to industrial and commercial use of energy for lighting, heating, and power for appliances by consumers in business. It does not apply to fuels used by the domestic or transport sector, or fuels used for the production of other forms of energy (specifically electricity or heat generation). It also does not apply to oil, which is already subject to excise duty. The UK Government has also brought out a programme with measures that could cut greenhouse gas emissions by 23% below 1990 levels by 2010; a domestic goal of cutting CO_2 emissions by 19% by 2010 has also been set. This is the driving force behind many other pieces of legislation such as the Renewables Obligation, the Carbon Trust and the Climate Change Levy.[20] & [21]

The Energy Efficiency Commitment

Under the Energy Efficiency Commitment for 2002 to 2005 (EEC), electricity and gas suppliers will be required to achieve targets for the promotion of improvements in energy efficiency. There will be a focus on helping lower income consumers, including those in receipt of income and disability benefits. The EEC will also contribute to cutting greenhouse gas emissions. It builds on the Energy Efficiency Standards of Performance (EESOPs), which have operated successfully since 1994. It is currently at the statutory consultation stage and includes a draft statutory order. Government will lay the Order in autumn 2001 so that the EEC can commence in April 2002.[22]

The Home Energy Efficiency Scheme (HEES) is a scheme that provides grants of up to £2000 to improve the insulation and heating of eligible low-income households.

UK Emissions Trading Scheme

This is a £215 million government scheme launched in August 2001 with this financial incentive being available over five years from 2003-04 for companies to join the scheme. It is the first of its kind in the world and could cut up to 2 million tonnes of carbon a year from the atmosphere by 2010 and simultaneously generate new job and investment opportunities for industry.[23]

Green Electricity Tariffs

Green Electricity Tariffs are offered by some suppliers at a premium price for electricity generated from renewables. They reflect the willingness of some customers to pay extra in order to support the development of renewable energy projects. They operate either by RECs matching their subscribers' energy use with electricity generated from renewable sources or by the support of green investment funds that invest in renewable energy. They have had modest success, with over 20,000 consumers signing up. The Government believes that green tariffs should not be used to meet a supplier's costs in fulfilling their Renewables Obligation but rather the intention is that any green tariff should lead to additional generation, over and above a supplier's obligation. The government believes that green tariffs have an important role in promoting and raising awareness of renewables but it is unclear whether, and to what extent, green tariffs will continue after the introduction of the Obligation. The future of such voluntary schemes for renewables will be discussed with the electricity industry.[15]

Carbon Trust

Part of the UK Climate Change Program, the Carbon Trust become operational in April 2001. It's aim is to help business save energy, commit to developing low carbon technologies, bring together business, Government, researchers, Consumers and Non-Government organisations (NGO's) and help achieve long term reductions in greenhouse gas emissions through development of a new strategic vision of a low carbon economy. It will promote research and development. The integrated programme will make available up to £200 Million over the following two years to help business invest in low carbon technologies. It announced a programme of incentives to help accelerate business take-up of energy efficient technologies with particular emphasis being placed on SMEs (small to medium sized enterprises). The Trust encompasses a tax incentive scheme for low carbon investments and an expansion of the business energy auditing and advice service.[24]

Other Policy Instruments

Further instruments which promote the sustainable use of renewable energy through financial grants are available. This includes Capital Grants, the DTI's Offshore Wind Scheme or The New Opportunities Fund. The Prime Minister announced £100million of additional renewables funding in March 2001. Climate Change Levy Exemptions allow non domestic customers to purchase electricity from qualifying renewable sources without paying this tax. The Renewables & Sustainable Energy Research and Development Programme is a way in which the government hopes to stimulate growth in this sector. It has made available £55 million over the next 3 years to research in biofuels, fuel cells, solar, wind, embedded generation, small-scale hydro, wave and tidal stream power.[15]

3.5 R&D

Energy matters and associated environmental issues are of key concern through Europe and a push for R&D comes even from this level. "Energy, Environment and Sustainable Development" is one of the four thematic programmes of the Fifth (EC) RTD (research, technological development and demonstration activities) Framework Programme (1998-2002). There is a drive to ensure a sustainable reliable energy supply.[25] The Framework Programme supports research, technology development and demonstration (RTD) projects, across member countries of the European Union. It reflects priorities selected on the basis of the needs of industry and improvements in the quality of life. Each Programme lasts four years. Subsequently Framework Programme 6 (FP6) will be developed over the years 2002-06. The Fifth Framework Programme (FP5) supports five British-led wave and tidal energy projects, with grants of approximately £1.5 million, as well as having UK participants in many solar and biomass/biofuel projects

The Engineering and Physical Sciences Research Council (EPSRC) is responsible for supporting basic, strategic and applied research in the engineering and physical sciences. It has a research programme aimed at promoting sustainable energy generation, with grants totalling £6 million for 2001/02. It mainly concentrates on relatively small, academic-led research. It currently supports eight wave energy and two tidal energy projects in the UK, with grants totalling £1.1. Million

The Department of Trade and Industry (DTI), through its New and Renewable Energy Programme, supports industrially led research and development. It generally supports larger-scale, proof-of-concept projects. The DTI's renewable energy budget is managed by ETSU (the Energy Technology Support Unit, part of AEA Technology - formerly the Atomic Energy Authority - and has specialised in consultancy on sustainable energy. (See www.etsu.com). At present, the DTI provides funding to seven wave energy and one tidal energy project, with grants of £1.27 million over a number of years.[26]

3.6 Predictions on the Future of Energy Supply

Projections in energy trends for the UK have been drawn up in “DTI ENERGY PAPER 68 ‘Energy Projections for the UK’”. The projections are based on an analysis of historical trends in energy use and its relationship to factors such as economic growth and fuel prices. They also reflect the impact of existing Government and devolved administration policies on energy and the environment. Ranges of forecasts are shown, based on a set of different scenarios of growth in the economy and of world fossil fuel prices. Viewing the central forecasts suggests strong growth in the domestic (1% pa), transport (1.7-1.9% pa) and service (1.1% pa) sectors of energy demand. It predicts 44% of primary energy demand will be from gas, 35% from petroleum, 9% from coal and 7% from nuclear and states a 47-61% reliance on gas for electricity production by 2010 (and a 68-75% reliance by 2020) which is a far from diverse energy market. Other sources for electricity production are fairly evenly spread – coal 10-22%, nuclear 17%, renewables 11% and 2% imported. It predicts CO_2 emissions although strangely omits those emissions arising from land use change. An IPCC basis methodology should be used for reporting emissions to the United Nations Framework Convention on Climate Change (i.e. consistent with the 1996 Revised Guidelines for Greenhouse Gas Inventories, published by the Intergovernmental Panel on Climate Change (IPCC).) This requires the inclusion of emissions from land use change. Data for these emissions are annexed in a simple table but accurate CO_2 forecasting should be referenced from the UK Climate Change Program policy paper, which includes the land use change emissions within its structure.

4 ENERGY SOURCES

4.1 Gas

With the decline of projected North Sea oil and gas production from 2004, oil and gas will be increasingly imported. By 2006, the UK is expected to be importing up to 15% of its gas compared with 2% currently.[27] Also, there has recently been dramatic increases in gas prices. For the first three months of 2000 gas cost 12p/therm. Prices started to rise in March reaching a high of 26p/therm by November since when they have levelled off at around 23p/therm. This was because UK started exporting gas through the normally incoming UK-continental gas pipeline to cash in on a hike in international prices along with the rise in oil prices. This clearly identifies the volatile market and the danger this presents to the UK energy market with increased dependence on foreign supply.[28] As discussed earlier the projected USA increases in the use of Natural Gas are bound to have an significant effect on UK prices long term and affect the economics of electricity generation.

OFGEM controls trading of gas in the UK. OFGEM is the Office of the Gas and Electricity Markets, regulating the gas and electricity industries in Great Britain. OFGEM's aim is to bring choice and value to all gas and electricity customers by promoting competition and regulating monopolies. On 1 October 1999 it implemented a series of reforms to the trading arrangements governing the wholesale gas markets in the UK. These reforms became collectively known as the New Gas Trading Arrangements and were based on the results of over two years of consultation and discussion with the gas industry, customers and other interested parties through a series of workshops, seminars and consultation documents. The reforms were considered necessary to overcome the serious deficiencies of the old regime. Specifically, it was identified that under the old regime:

- the overall costs associated with Transco managing gas flows through the system, were much higher than expected;
- in addition, these costs were not being targeted at those people causing them to be incurred;

To overcome these deficiencies OFGEM implemented a series of reforms to the existing arrangements. These included:

- the introduction of a new, screen based, within-day gas market that allows Transco to undertake the balancing of its pipeline system and shippers (who pay Transco to use its pipeline to flow gas) to fine tune their gas positions on any given day;
- improved incentives on shippers to balance their inputs and offtakes of gas from the system and new commercial incentives on Transco to minimise the costs associated with the balancing of the system (when offtakes of gas do not equal inputs of gas);
- a series of price auctions of system entry capacity (access to Transco pipeline) based on the physical capabilities of the system;
- commercial incentives on Transco to maximise the amount of capacity that it makes available day-ahead and to manage constraints efficiently;
- the introduction of a within-day entry capacity market (from 1 June 2000) that allows Transco to sell additional entry capacity.

OFGEM is proposing a further series of significant reforms to the current gas trading arrangements, to further improve the efficiency of the regime. These reforms are set out in a number of recent OFGEM documents and include:

- the introduction of longer term auctions of entry capacity to improve the long term signals and incentives that Transco faces for investment in entry capacity on the new trading arrangements;

- encouraging shippers to balance their inputs and off-takes of gas from the system by moving to shorter balancing periods, to reduce the costs to the industry of system imbalances;
- the sale of storage in the pipeline to shippers to enable them to better manage gas flows throughout the day;
- reforming current exit capacity arrangements to ensure consistency with the entry capacity arrangements.[29]

A production licence has been awarded for an innovative offshore power generation project in the eastern Irish Sea. The scheme may use gas to generate electricity at sea and wind generation can easily be linked up to the same cable.[30]

The UK government's stance is clearly in opposition to more gas power generation and a 50 MW gas-fired power station at Hirwaun in South Wales was refused in 1999. However, also in 1999 the government announced it would not oppose a 500 MW gas power station at the BP Chemicals site at the Baglan Energy Park in Port Talbot as it would bring necessary employment and regeneration benefits to the area.[31] South Wales will now house the worlds most technically advanced gas fired power station which uses GE Power System's new H class combined cycle gas turbine. The £300million investment will be a flagship development not only for the Energy Park but also for Wales. The plant should be operational within the next couple of years.

4.2 Coal

The UK coal industry has gone through dramatic decline over recent years. Whereas gas has taken off coal has suffered, total coal consumption has fallen 62% within 30 years and production has fallen by a drastic 89%. As a result imports are fast approaching the level of national production.[2]

As a result of concentrating activities in the most productive mines and sustained efforts to improve viability, the United Kingdom is the only Community country where the coal industry has received no State aid from 1995 to 2000. That said, a number of factors, including the sudden fall in prices on the international markets in 1999, have compelled the British authorities to consider granting aid, albeit on a very modest scale, of around £110 million over the period 2000-2002. The aim of the assistance plan in the United Kingdom is to provide temporary support - until the expiry of the ECSC Treaty - to production units that are economically and financially viable in the long term but which are experiencing certain temporary problems that could result in their closure.

The current high price of natural gas and oil (hiked last year) has brought British coal back into contention. Coal burning rose 14% in 2000. Coal has to have a major presence to meet the government's fuel diversity requirement. Flue gas desulphurisation is of paramount importance but further to this, a good energy conversion efficiency is essential to make coal less CO_2 polluting per unit of electricity generated. It has been argued from an emissions point of view that advanced gasification technologies present the best option for coal. IGCC (integrated gasification combined cycle) cuts CO_2 emissions by 25%. It can also be multi-fuelled and so substitution by biomass is an option. Natural gas fired plants use CCGT and some (with appropriate modifications) will be able to use gasified coal if Natural Gas prices rise prohibitively or supplies become scarcec. Gasification could also produce large quantities of hydrogen kick-starting any move towards a hydrogen based economy.[32] However discussions with utilities still suggests that conventional pulverised coal power stations would still be the preferred option due to their still superior economics. This arises from multitudinous improvements to conventional plant, including the use of supercritical steam cycles and the very high capital costs of proposed IGCC plants. Indeed a major problem has been that so-called advanced clean coal power plants (IGCC) have not delivered cost and efficiency advantages beyond those arising with developed conventional pulverised coal fired power plants.

Underground gasification of coal promises the exploitation of inaccessible coal deposits (especially offshore), it involves no solid waste disposal, and has less surface impact. Techniques developed in the oil and gas industries involving horizontal drilling would appear to be applicable here, but so far the economics do not appear to be viable. There are EU projects in this area and it would appear to be sensible to keep a watching brief

All hard coals contain methane. Methane migrates both between closed and active mines and to the surface. Methane control is necessary both to reduce the risk of explosion to active coal workings and to curtail the emission of this powerful greenhouse gas to the atmosphere. There is potential energy to be generated from this gas. The DTI has done considerable work on methane gas flows and controlling the methane emissions from abandoned mines. Ocogan Energy has started 5MW (£2.5m) electricity production from methane migrating from coal mines at the Hickleton site near Barnsley, S Yorks. They want to develop 50MW of coal gas capacity by end of 2002.[32]

The DTI has a history of coal R&D since the 1993 White Paper “The Prospects for Coal - Conclusions of the Government's Coal Review”.[33] A large proportion of this has been into exploration, extraction, and coal preparation but there has also been some in environmental issues such as flue gas treatment and clean coal technologies. American R&D has recently had a massive boost. The US DOE has selected 5 new research projects to improve combustion, reduce pollutants, and capture carbon gases (“Carbon sequestration” is the capture and long-term storage of carbon gases that can contribute to global climate change). SRI International, Menlo Park, CA, proposes to investigate two concepts for converting carbon dioxide released from coal-burning plants back into fuel. In one approach, researchers will investigate a novel process that uses solar energy in a photochemical reaction along with common iron minerals and water to convert carbon dioxide into methanol and other products. The second approach studies ways to use heat to convert carbon dioxide into fuel-grade chemicals also using iron-containing minerals.

4.3 Oil

The UK currently exports far more oil than it imports. The trend, however, is to produce less, export less and import more. By 2006/07, the UK is likely to be a net oil importer.[27] If current UK policy remains unchanged, initiatives to promote domestic renewable energy sources and reduce demand will be insufficient to reduce dependence on imported oil and gas. Therefore, UK energy security will be increasingly tied up with that of Europe as a whole. In the Welsh context gas has been found in the Irish Sea, close to the coast of Southern Eire, as well as off the coast of North Wales, where exploitation is proceeding in the form of new power plant. The harbour and facilities at Milford Haven would appear to be an excellent base for Celtic Sea oil/gas exploration and possibly if the expected rise in oil/gas prices do occur, incentives should be found to increase their use. Geological surveys and information on potential sites for oil and gas exploration are obviously very sensitive; possibly universities with expertise in this area should be asked to provide independent geological assessments of the most promising areas, so that a wider spectrum of oil exploration companies could be encouraged into the area. Co-operation with the Eire authorities might be beneficial here.

It is however in the area of fuels such as biodiesel that substantive progress might be made. Providing the tax on bio-diesel is kept low there would appear to be many opportunities to promote this fuel in Wales, both in terms of use and production. In terms of engine fuel efficiency the common rail diesel engine is giving major advances in fuel economy; in terms of passenger vehicles diesel engines now account for up to 40% of sales in Europe and are predicted to continue to increase. Emission problems with fine particulates are being overcome with continuous regenerative filter systems (as sold for instance by Peugeot on many of their vehicles) and technologically there appears to be considerable further development left. This technology will inevitably spread to the medium and heavy-duty truck market with similar gains. Although the direct injection spark ignition gasoline engine has attracted a similar high level of attention fuel efficiency gains have not been so high and problems have emerged of ultra fine particulate emissions, which are in some ways worse than those given off by diesel engines. Indeed there is enormous Japanese R&D effort at the moment to improve the fuel consumption of the spark ignition gasoline engine. Although gas fuelled and possibly fuel cell powered vehicles will make inroads in respect of inner cities and urban regions there is little doubt that liquid fuels will predominate as power sources for vehicles for the foreseeable future.

Thus in the Welsh context development and production of high quality biofuels would appear to be attractive providing taxation is kept to a reasonable level. Indeed the authors experience with direct combustion of biofuels for energy production suggests that even at reasonable scale (say 30MW electrical), typical electricity costs are at least twice typical grid prices with the associated need for subsidy in some form or other. In terms of energy crops it would thus appear to be most desirable to concentrate on those capable of producing bio-diesel, rather than grasses or short rotation coppicing suitable for small power stations.

4.4 Nuclear

The nuclear industry is split into British Nuclear Fuels Ltd (BNFL) and British Energy, the latter being the privatised generator of nuclear power. BNFL chairman Hugh Collum said at a conference last December that they have the designs for new mixed-oxide fuelled reactors and the sites to put them but two days before the national election the Labour Government said they have absolutely no plans to increase nuclear power. In the UK Nuclear plants are gradually being retired and it seems that there are no plans for new plant at the moment.

Very careful deliberation is needed before allowing nuclear power generation to disappear from the country’s energy structure as old stations close. The energy diversity requirement shows that it is not nuclear against renewables, but a combination of both is beneficial. However the problem of a safe storage mechanism for waste always raises questions, as it requires political and economic stability for thousands of years.

We are still awaiting the long promised government document regarding nuclear waste. Whether or not to replace our existing Nuclear Power Stations is one of the most controversial and difficult decisions for this or any future Government. There is evidence that countries, like Finland and the USA are starting to consider new programmes of Nuclear Power Station construction and this will doubtless influence any UK decision. The more than 25% electricity production free of CO_2 emissions will, however, be hard to replace, unless projects like the Severn Barrage are reconsidered. In Europe clear dichotomies of opinion are appearing with Countries like Sweden, Germany and Italy deciding to close down their existing Nuclear Stations when they reach the end of their operational life, whilst France is still pursuing a strong Nuclear programme. Security of fuel supply is good in the UK context. Generation costs are difficult to quantify when decommissioning and long term waste storage are considered. Nevertheless indicators are that total cycle generating costs are only slightly greater than those of conventional, large, fossil fuel plant. Thus replacement of UK Nuclear Power Generating by mostly renewable power would result in significant increases in the cost of electricity as discussed later. In the USA the Californian 'Brown Outs' have caused a change in attitude to Nuclear Power, with a recent 66% vote to allow Nuclear development. As a result planning applications are being made for at least 5 new Nuclear stations. Projected generating costs on a UK basis are 2.3 to 3p/kWhr

4.5 Renewables

At present less than 3% of Britain's electricity comes from renewable sources. By 2010 the UK has the strategic aim to have reached a level of 10%. This represents excellent investment in the technology of these eco-friendly plants and also a considerable opportunity to further the country's expertise in renewable sources of power. However, it must be remembered that considerable subsidy has been given to these plants from schemes such as NFFO and its successors. For instance the recent 30MW straw-fired power plant at Ely is paid some 6p/KWhr of electricity exported to the grid, this subsidy extends to beyond 2012. Present Pool electricity prices are in the range up to 1.7/2.5p kWh. Farmers are paid only £20/ton for straw used in this Power Station, much lower than other agricultural products. Long term plant development may reduce capital and running costs, but certainly not to the level of existing large fossil fired power stations

The aim of developing Wales as a global showcase for clean energy and to encourage the development of strong environmental goods, services and renewable energy technology industrial sectors is laudable, but needs to be carefully managed and orchestrated with long term planning over 10 to 20 year cycles. This will also involve an increased emphasis on energy efficiency, use of clean energy, recycling, waste minimisation and better management of landfill sites. The French example of long term infrastructure and industrial development needs to be studied and lessons learnt. Wales is well on the way to having 5 per cent of electricity generated from renewable sources. The latest figures based on Non Fossil Fuel Obligation (NFFO) indicate that there are 16 operating wind farms in Wales with a Declared Net Capacity (DNC) of 62.209 MW. This is equivalent to approximately 24 per cent of all the live wind farms and 41 per cent of the overall DNC in the UK under the various NFFO schemes. Again despite this success much of the technology is imported from for instance Denmark and other continental countries, lessening the long term benefit to Wales.[34]

Renewables are currently receiving substantive economic boosts. They come in the form of the government market stimulation programme and the New Opportunities Fund. Money is being made available for solar, wave power, wind and offshore wind, energy crops and biomass heat projects. Latest figures show the government is investing £260 million over the next three years (as of 20th July 2001).[35]

A personal view is that although this investment is laudable, renewables has been supported for many years by various UK and EU funding sources, to my knowledge for more than 20 years. In terms of Industry created, success has been low and the UK's overseas competitors have benefited considerably. Recent renewable success stories include;

Wind Power- basically overseas technologies, little real UK manufacturing benefit up to now.

Gas from landfill Sites- much extraction technology UK, but equipment, such as engines for power generation purchased abroad.

Sewage Gas- comments similar to above.

Biomass power Stations-after some teething troubles the chicken litter power stations have been successful, but again Scandinavian technology.

Again a personal view is that much of the existing renewable energy systems installed have been developed at a time when they were needed (i.e. Chicken litter Power stations) and using resources which were not too difficult to utilise, giving reasonable economic returns under the then existing regimes. This will not be the case with most future applications of renewable energy, with the economic case being much more difficult to justify without much larger subsidies.

The following now considers each of the renewable energies separately and considers their potential

4.5.1. Hydroelectric power

Most of the UK's electricity generated from renewable sources comes from hydroelectric power and has been developed over a long time frame. Natural flow and pumped storage together, in 2000, constituted 2.1% of total UK electricity capacity. This compares to 1.4% for all the other renewable sources.[2]

The benefits are high and it is a tried and tested form of energy production, which has already proved successful. However, it requires a dam to be built which environmentalists report risks disturbing river or estuarine ecosystems and the structures are also large and expensive to build. There is also limited space left for more hydro plant and very strong resistance arises from the local residents in respect of new schemes

General opinion is that hydro on a large scale is already at maximum capacity over the UK with all suitable sites currently being utilised. However, government support is increasing with support through the Renewables Obligation and funding opportunities. Refurbishing old plant increases efficiency by around 10%, Pitlochry in Scotland being the first to benefit from this renewed investment. It is expected that 30 such power stations over the UK will be upgraded in this way.

Small-scale hydropower (up to 5MW) has the potential to produce 10,000 GWh per year over the UK, which is enough to meet 3% of the countries energy needs. The economic potential is somewhat lower and estimates range from 500-2000 GWh per annum. At present only a fraction of this is being exploited. Although the resource is only at most about 0.6% of our energy needs, it can still be a beneficial diversification.[36]

Hydro electric power benefited from NETA although small scale CHP and renewables have been squeezed due to their variability and unpredictability of generation (such as is the case with wind power especially). However, to an extent even hydro is seen as variable – the lack of rainfall in 1996 evidently reduced output by nearly 40%, and global warming could effect this either way.

Hyder, in response to NFFO, has successfully developed 5 separate yet interconnected hydropower schemes in the Elan Valley, Mid Wales. The 5 reservoirs and 4 impounding dams that provide the scheme’s infrastructure are in an outstandingly beautiful and environmentally sensitive area. The hydropower stations are housed within listed historic monuments, produce 4.2MW of electricity and are linked to the local grid via 20kms of underground cable.

The colossal pumped storage plant of Dinorwic in North Wales is capable of reaching maximum generation of 288MW in less than 16 seconds, this can last for 5 hours. It's sister plant Ffestiniog is of similar characteristics. These plants are of very considerable benefit to the UK's electrical grid system, but unfortunately there do not appear to be any more suitable sites available.

4.5.2. Wind Power

Wind Power is one of the world's fastest growing energy technologies. There are currently 62 wind farms around the UK generating a maximum of 409 MW of electricity[37]. The first offshore farm was opened last year off Blyth, Northumberland. However, wind power currently only represents just 0.25% of the UK's energy needs [2].

The UK wind industry benefits from the UK being one of the windiest countries in Europe. There is the potential to provide over and above the UK's energy requirements with wind power alone. We could rely more heavily on this source in the winter when the weather is windier. It is also cheap to harness. However, each wind turbine is large – about 70m across - and many people have environmental objections, including their obtrusive nature, low frequency noise and interference with TV and other telecommunications equipment. Turbine by turbine they generate a relatively low amount of power (currently the largest at most 1 MW) and a considerable number would be needed to generate a sizeable portion of Welsh demand. Also, the wind is inconsistent so for use on a very large scale we would need to use a technology to store the energy (such as hydro pumped storage, compressed air in existing geologic formations or advanced batteries), although there are large costs associated with these. Typically in the UK situation wind turbines generate on average only 25% of their maximum, and thus infrastructure in terms of cabling, transformers have to be installed which has four times the typical average power transmission capability. This seriously affects their economics and there are many arguments that wind power could never provide more than about 10% of a countries total power requirement, because of its irregularity. Developments of storage techniques using fuel cells in the UK may help to at least partially alleviate this problem. Denmark now has 25% of its it's installed generating capacity in terms of wind power and aims to install much more. However, Denmark is in an exceptional position, analogous to Wales in some respects, in that it is interconnected to much larger electrical grid systems from Scandinavia and Germany, and thus is in a position to generate much more wind power (via offshore installations) than if it were just operating its own grid. The large European grids provide a "buffer " allowing this to happen. Germany has now some 6,000MW of installed wind farm capacity (2001) and this has created some 30,000 new jobs over the last 10 years, this provides only about 1.6% of total German generating capacity and thus there is a very adequate 'buffer' in the main grid system. This has occurred through policies of local ownership and benefit far beyond that occurring in the UK and Wales. In the Welsh context this means that we could generate much more wind power than was strictly needed in Wales, exporting the surplus/ importing the deficit as appropriate according to the total wind farm output

There are currently 12 wind farms in Wales. Together they generate a maximum of 148 megawatts of electricity - enough to meet the needs of over 92,500 households annually. To put this in perspective this is enough power to supply about two thirds of the households in Cardiff. This is by far the highest concentration of Wind Farms in any part of the UK.[37 http://www.britishwindenergy.co.uk/]

There is undoubted scope for considerable expansion of wind farms in Wales, sensibly this may have to happen offshore, owing to inland opposition and problems of obtaining planning consent. However this will add considerably to costs and viability and the techniques by which Germany has developed 6,000 MW (15 times higher than the UK) of land based wind power should be closely studied

4.5.3. Wave and Tidal Power

Waves can be used to turn a generator or turbine. Tides can be used to fill a hydroelectric dam. As an island nation, Britain has a huge coastline, which it could use for these forms of power. Although there are few sites over the UK with a great enough difference between low and high tides to make harnessing tidal power possible. Wales and the West of England is blessed, especially with the huge range in the Severn estuary. There was a fairly dismissive approach to tidal power in the DTI's recent Energy Paper 62 but its useful market potential is slowly being recognised. One of the reasons why both the Severn tidal barrage and further nuclear plants were ruled out under the Conservative Government was the privatisation of the electricity supply industry. This made public investment in projects like this unlikely and provided more lucrative options for the private sector in other projects, namely gas/CCGT. Funding and the will to develop these alternative technologies is only now coming together. A US company is considering building a plant to harness tidal power off the Welsh coast, using the aggregate from slag heaps to build a "hollow island" which would have its own regular tides.

Tidal acceptability depends on detailed environmental assessment, consideration of the statutory and regulatory constraints for its construction and operation, and its overall economic feasibility. Sadly in the UK scene short term economics dominate, and it seems that tidal barrages have been written out of the energy agenda.

The Severn estuary holds one of the greatest tidal ranges in the world. An 8.6 GW tidal barrage across this estuary could supply 17,000 GWh pa or about 6% of UK energy needs in the form of CO_2 free electricity. Ideas to harness this power have been dreamed of and feasibility studies date back to the late 1970’s. The 1989 full-scale review floundered mainly on the grounds of cost. The Severn Barrage General Report suggested a figure of 8 billion pounds plus environmental effects although this has since risen to 10 billion.[38] The main problem was the requirement for capital to be paid back over 20 years, despite the plant having a projected life, with maintenance, of over a hundred years. Since then, there has been some progress in the UK along the lines of joint private / public funding of beneficial major projects. Under current circumstances, this is an area well worthy of re-evaluation and interest was again sparked in May 2000. Some of the cost could also be offset by the non-energy benefits – carbon dioxide abatement, employment, transport link, marine leisure activities and tourism.

The mudflats are world-renowned home to birds such as waterfowl and turning this estuary into a lagoon horrifies conservationists. However, at the time the project was shelved, the environmental impact assessment studies had not been completed but, at that stage, no insurmountable barriers had been identified. Claims regarding the certainty of dire consequences were premature. The incomplete areas of work related, in the main, to the question of how seriously food supplies of the wildfowl and wading bird populations would be affected by predicted changes in the estuary's water chemistry and sediment patterns. The birds stand to lose about half of the area they feed on but, on the other hand, the biological productivity of the waters enclosed within the barrage would rise significantly, as they become much less murky and less hostile to life.

It is essential to achieve confidence in the environmental impact of these systems. To ensure this it is necessary to carry out pilot projects and these need to be done as early as possible.

However, there are also many potential economic benefits from a Severn barrage, both to Wales, but also to the West of England and Bristol. Effects would spread up the River Severn to past Gloucester. A direct road connection could be made across the top of the Barrage, giving excellent communication between west Cardiff, the Vale of Glamorgan and Swansea with Southwest Bristol and Exeter regions. This would compliment the existing Severn Bridges, where capacity constraints could well be evident within the construction time frame. Moreover the South Wales/South West of England area has lacked a major International Airport and such a road link could allow such a development to occur, possibly around the site of the present Cardiff Airport, where it is believed that land is available for development. A direct road connection across this barrage could make such a project feasible if a Penarth/Weston-Super-Mare route is chosen. This could provide a focus for a developing South Wales Aerospace Industry. In the West of England the existing Bristol Airport is poorly located for the Severn Estuary and is in a 'sensitive' area, whilst the very long Filton runway in Bristol is constrained by adjacent building and resident protest. Similar comments apply to rail connections to South Wales; the existing Severn Tunnel is old, suffers from seepage problems, thus making electrification of the main London to South Wales line problematic (water is a serious problem to 25KV electric overhead cables). Again an electrified rail connection could be easily provided across a barrage, indispensably improving infrastructure. Government support for the Channel Tunnel-London link should be noted. Clearly bearing in mind the massive investment, planning and other problems involved, partnerships with the Bristol and South West of England regions would have to be set up to maximise economic potential for all. The effect that the Bay development has had on Cardiff should be noted; the effect of a barrage would be far greater and encompass the whole of the South Wales region.

In the field of wave power, much has been learnt from the innovative 75kW wave facility built on the coast of Islay. Although now at the end of its working life, the new generation wave energy devices now under development draw heavily on the experience gained at Islay. The original device used received £1.5 million support from the DTI through five separate stages which covered initial design, civil construction, design and installation of the mechanical electrical plant, plant operation and optimisation and finally decommissioning. The device demonstrated the effectiveness of an oscillating water column concept and the operation of the Wells turbine which rotates in one direction irrespective of the driving air flow direction. Larger versions of this turbine (1MW) were installed in the world's first near-shore prototype, the Osprey.[39]

It is also possible to generate electricity from thermal or tidal currents in near shore regions with reversible turbines, which take energy from tides (or waves) without increasing the head by building a barrage. Indeed there are very recent proposals from such turbines to be installed in and around Milford Haven. A prototype hasa been constructed and demonstrated.

The parliamentary wave & tidal report[40] outlines the enormous potential advantages of wave and tidal technology as sources of energy as follows. They use predictable, natural resources, which the UK enjoys in abundance; they are both far cleaner than nearly any other energy source currently available and with less negative environmental impact, and they are largely based upon tried and tested engineering and technology, in which the UK has an excellent skills base. The report recommends significant increases to public support for wave and tidal energy, to allow the technologies to develop fully. In comparison with other areas of

Government expenditure support is very small. Yet, the potential return on investment could be huge. The UK could harness some of the massive potential energy of its marine resource to supply part of its energy needs, and create a new multi-billion pound domestic and export industry, employing thousands of people. This could benefit Milford Haven in particular, where the geography and existing facilities lend themselves to such work. The UK has the resource, the technology and the skills base; we have a unique opportunity to seize the lead and develop a world-class industry. We can no longer afford to neglect the potential of wave and tidal energy.

The current level of public spending on wave and tidal energy research is insufficient to give the technology the impetus it needs to develop fully. Targeted research funding for wave and tidal energy technology should be steadily increased year on year to create a critical mass of researchers in the field. We recommend that the EPSRC introduce a managed programme for wave and tidal energy technology to achieve this.

The UK is at the forefront of wave and tidal energy but other national development programmes will undoubtedly overtake ours unless the Government acts quickly and decisively to support the industry. Valuable lessons could be learned from the long-term approach adopted by the Danish and German Governments toward the exploitation of renewables energy sources. Indeed the size of the present Danish and German Wind Power Industry should be noted. [41]

If the Government is serious about developing a UK wave and tidal energy industry, it must make a clear commitment via policy statements and funding. Such a commitment would reduce the perception of risk surrounding the technology and help to attract private investment. It is recommended that the Government increase the amount of funding available for full-scale wave and tidal energy prototypes (from the PM's £100 million of funding for renewables) to prove the concept at a realistic scale and eventually achieve full commercial realisation. It is recommended that the Government establish, as soon as possible, a National Offshore Wave and Tidal Test Centre to facilitate the development of wave and tidal energy. Again Wales should be bidding for such a centre, based on technological expertise in the Universities.

Owing to the reliability and predictability of their output, there would be few problems for an electricity company in integrating wave and tidal energy into its supply. The difficulties of Grid connections are probably the single most serious problem facing the successful exploitation of wave and tidal energy in the UK, and one, which no single company can solve alone. It is recommended that the Government should work with the National Grid Company, and other utility companies, to organise the strengthening of transmission lines required, if wave and tidal energy are to provide a significant amount of energy to the electricity market. However the problems are no greater and probably less than those faced with Wind Power.

The Government should examine the implications of the discount rate on renewable energy schemes involving high initial costs. The enormous potential export market for wave and tidal energy devices easily justifies the public investment now needed to ensure success. The report recommends that consideration be given to a system of 'banding' in the Renewables Obligation, with different prices being paid for different renewable technologies, to stimulate growth in key areas – especially promising, but as yet immature, technologies, such as wave and tidal energy. The evolving conditions in the electricity market and their implications for renewable technologies should be kept under close examination by the Government to ensure that the market is increasingly favourable to renewables.[40]

4.5.6 Solar

Solar energy systems can be small enough to meet specific energy needs such as heating a house's water or grouped together in large banks to produce electricity.

Power from the sun is clean, silent, limitless and free, but in the UK and Wales, intermittent and irregular. In terms of Solar Flux, Wales is one of the more favoured regions of the UK apart from parts of the South Coast of England. Emphasis has switched from solar heating of hot water to Photovoltaics, as the economic returns from solar heating are so low in the UK situation. Photovoltaics (PV) release no CO_2, SO_x, or NO_x gases which are normally associated with fossil fuel combustion and don't contribute to global warming. Photovoltaic systems are very expensive at the moment, but are reducing in price, with some predictions giving generation costs as low as that for Wind Power within a decade. The concept of Photovoltaic roofs and cladding for buildings is now well established, but these are unlikely to gain widespread acceptance unless costs are drastically reduced or large subsidies are offered. Photovoltaic cladding/roofs are more attractive for industry/commercial buildings than for domestic situations as the electrical demand of such buildings much more closely matches that produced by the cells. In the authors opinion serious technological advances are needed for the domestic market, especially in terms of cheap storage systems, so that power generated during the day could be released in the evening period, when it is normally needed and solar flux is negligible. Conventional/advanced battery systems are uneconomic here as storage devices for photovoltaic generated electricity, unless they are used in off grid applications, where connection charges to the grid are prohibitive. Possibly combinations of photovoltaic cells and fuel cells could be of use here (the power generated by the solar cell electrolyses water in the day; at night the hydrogen and oxygen so generated recombine in a fuel cell to generate power). One UK utility has already developed such storage technology on a large scale. At least one company has also developed a cell, which can be used in moonlight.[42]

The manufacture of photovoltaics involves the use of toxic materials to obtain the necessary standards of purity, which are vital to performance. It lies with the manufacturer to ensure that dangerous substances are dealt with and handled correctly. Over its estimated life a PV module will produce at least 20 times the electricity used in its production and every square metre will prevent the emission of over two tonnes of CO2. They make no noise and cause no pollution in operation.[42]

Domestic water heaters have been a proven technology in sunny arid dry climates but are unlikely likely to provide any cost effective energy gain for Wales. Wales averages year-round around 2.75 kWh/m^2 per day in solar radiation flux, which compares to 4 for southern France and 5 for Sicily. However the sun's energy can still be utilised in Wales. On a clear summer day the UK receives almost as much energy from the sun as Africa! The problem is that over a year we only receive a fraction of that because of our changeable climate. An array mounted on a south-facing roof will on average produce around 700 kilowatt-hours for every kW of panels installed.[42]

All 14 stations on the Heart of Wales railway line from the Welsh Valleys to Shrewsbury are lit using solar power. Plentiful roofspace in industrial buildings is available for solar generation. There is a PV powered service station in Bedford. BP Solar is one of the world's largest and most successful solar energy companies. The solar panels on the roof of Ford's Bridgend plant in South Wales represent the largest application of solar photovoltaics in the UK. Covering 25,000m^2, and incorporating BP Solar PV panels, the arrays are capable of generating approximately 100kW of power. The 26 south-facing rooflights are solar panels, the north are clear glazed to allow in natural light. The total cost of the project was £1.4 million, a large proportion of which came from a European grant with £100,000 support from the DTI N&RE Programme.

The Welsh solar technology development situation is very promising. Thermomax produces state-of-the-art evacuated tube solar collectors at its factories in Wales and Northern Ireland. They export over 90 per cent of their production, largely to Europe, where they are the largest supplier. Thermomax doubled the size of it's manufacturing base over the last 12 months and won contract to design a solar wall for US Department of Energy headquarters in Washington DC. The Intersolar Group (another Welsh Manufacturer of PV cells) manufactures thin film silicon photovoltaic material at its factory in Bridgend, with 75 per cent of its output being exported. This British product is used in a variety of ways: framed as panels for use as Solar Home Systems in the developing world, laminated for use in buildings, designed as modules for professional applications, or cut and integrated into consumer products. The company has announced that it will be tripling its capacity after securing £3.5 million financing from the City.

The DTI have estimated that solar panels installed on buildings have the potential to provide all the electricity that Britain currently uses, however that would mean photovoltaics on most south facing roofs which is unlikely in the near future. However, an ambitious solar roof programme coupled with other renewables such as wind and wave power could play a significant part in the move toward a more sustainable future. Nevertheless substantive subsidy would be needed, as electricity generated would be much higher in cost than that generated by present nuclear and fossil fuel stations.[42]

Globally, solar power is a fast growing market expanding at about 20% a year with increasing numbers of countries implementing ambitious solar programmes to try and stimulate the market further. Compared to other electricity generating technologies, however, photovoltaic cells are still very expensive with a unit price of around 30-40p/kWh, however improvements in technology will hopefully bring this cost down to around 11p/kWh by 2005. Developments in the thin film field are likely to provide the next breakthroughs. Grid linked solar buildings certainly offer the greatest potential in the UK and may well be the power stations of the future reducing the dependence on large centralised generators. Increased research and development in this area in Wales would certainly be beneficial, especially in the areas of system development, interconnections and storage.[42]

4.5.6 Biomass or Energy Crops

Fast growing plants such as willow, elephant grass or miscanthus can be harvested and turned into woodchips, or baled and then burnt in power stations. Other fuels include Chicken Litter, fed as the well-known demonstartion plant at Eye in Suffolk. A recent, well-known plant in the UK is the Arbre biomass gasification plant. It is a 10.5MW plant with 8MW output taking 43,000 tpa from forestry and Short Coppice Rotation (SRC). It aims to commercially demonstrate the generation of significant quantities of electricity from energy crops currently thought of as not commercially viable at today's fuel prices. It hopes to offset higher capitol cost with higher efficiency. If supply of cheap oil diminishes over next 5-10 years with coal and gas prices subsequently increasing, many renewable energy technologies close to market surface such as this may become truly competitive. Unfortunately as Arbre is a modest size plant, a suitably sized gas turbine was not available on the market so the generated producer gas is split between a small turbine and a boiler. Hence the overall efficiency is 31% where it should be 40% with a bigger plant; therefore naturally the economics of Arbre suffer. The writer's experience is that one of the main problems is the high capital cost of the gas turbine, suitably modified to take the medium calorific gas generated by the gasifier. [43]

There is a new straw fired plant at Ely in Cambridgeshire operated by Energy Power Resources Limited. The facility cost £60m, consumes around 200,000 tonnes/annum and generates 36MW. The same company has developed and operated poultry litter plant and has plans for more.[44] There is also the 38.5MW Thetford Power Station – fuelled by 430,000 tonnes of poultry litter per year developed by Fibrothetford Limited. It demonstrates a technology with significant export potential already being realised with projects currently being developed in continental Europe and the USA.

An international warning on the use of biofuels comes from Europe. There is a long term experience of working with biomass fuel wheat straw & other wastes in Denmark. They have a history of developing the technology for their own use and for sale to asian and far eastern customers. They are moving away from the technology as they are proving to be too expensive and troublesome. Two out of the three developers of such technologies have now shut their operations in this area (or are selling off their operations), the emphasis in Denmark moving to Wind Power.

The European Commission is to propose offering big tax incentives and impose mandatory minimum take-up for biofuels. They are set to receive a significant boost according to draft documents from the European Commission's Transport and Energy Directorate, which could be proposed as soon as September. The directorate suggests a minimum biofuel share up of 2% by 2005 AND proposes that by 2010, 5.75% of all fuels sold should be biofuels.[45]

The problem with the technology is that huge amounts of crops have to be grown in order to make the use of biomass worthwhile and result in distributed, often low efficiency generation of power. Biomass waste materials, such as chicken litter, have already proven to be effective small power station fuels. Co-combustion with coal of waste materials such as sewage sludge, refuse derived fuels, or powdered animal residues in large power stations is already widely practised in Europe, driven often by legislative measures. Typically up to 3% substitution is achieved, although the aim is to extend this to higher levels. The high temperatures and long residence times ensure complete incineration of all organic matter, whilst existing clean up systems are very effective in minimising emissions. In the South Wales context there could be benefits for the Aberthaw plant in terms of reduced CO_2 and SO_2 emissions. Cement plants are very vulnerable to fuel prices with typically up to 50% of costs lying in this area. All UK plants manufacturing cement have extensive programmes to substitute coal by waste materials such as tyres, sewage sludge, waste contaminated organic solvents (RLF), wood and paper waste. Indeed Blue Circle Cement have a target of zero fuel costs by 2006. The reason they feel this is achievable is because they receive revenue for burning these waste materials, and although there are plant modifications necessary to accept these materials, they are more than offset by the savings in fuel. These moves are controversial, but detailed measurement programmes have shown that the use of well controlled and defined wastes in cement plant can substantively reduced fossil fuel CO_2 emissions as well as NOx. Effectively the strong chemical reactions in the cement kiln, precalciner units absorb noxious emissions and heavy metals.[46] An example of good practice is the proposal by Castle Cement at Padeswood in North Wales to replace an existing cement plant with a new state of the art plant with energy input per kg of cement produced reduced by 40%, providing substantial redeuctions in all emissions, whilst having the capability of utilising a very wide range of fuels, wastes and other materials.

The author has had many years experience with these technologies and is familiar with most of the associated UK Government/DTI support programmes in this area. A number of clear conclusions arise with respect to small dedicated biomass/waste fired power stations :

Because of the distributed nature of biomass material, and relatively high transportation costs, collection of fuel can only occur economically over about a 20 mile radius, and typically limit maximum economic size of plants to 30MW electrical or less.

There have been teething problems with most of the plants arising from the different nature of the fuels and the requirements of subtly different combustion and boiler equipment. These problems are undoubtedly solvable, but contribute to high capital costs and high running costs.

To facilitate development of this technology very favourable prices for electricity have had to be offered through NFFO, typically 6p/KWhr for long time periods. Technological advance is unlikely to bring the economic price to even close to that of existing nuclear or fossil fuel generating plant.

Growers/farmers/producers of these fuels in the U.K. seem to achieve a maximum of £20/ton (In Denmark farmers obtain £40/ton for straw). At this level it is scarcely economic for the fuel providers, unless it is a by-product or waste material. The classic example is chicken litter, which used to be spread on fields, but due to new legislation has to be burnt. Producers close to the plant receive £20/ton, at 20 miles collection of the material is merely a disposal service.

The conventional plants described above have efficiencies of around 30% and arise because of the nature of available components. Long term development of conventional technology should allow this efficiency to pass the 40% level, this is based on extrapolation of developments with conventional pulverised coal power stations (i.e. efficient small steam turbines/efficient superheat boilers are not available). Prototype gasification/gas turbine/heat recovery steam boiler systems have been constructed and show promise in terms of very low emissions and high efficiency. However at the moment projected generating costs are still some 15 to 25% higher than conventional biomass technologies; these figures arise from demonstration programmes such as that at Varnamo in Sweden

In Sweden and Scandinavia biomass fuelled power stations are very widespread with 18 to 25% of total power being derived from this source (fuel is basically wood waste from the extensive forestry operations). This arises due to market manipulation by governments and taxes on fossil fuels, so that for instance natural gas fuelled power stations produce marginally more expensive electricity than biomass powered units. Figures indicate that generating costs for wood chip fired boilers are at least twice that for power from the UK grid. Scandinavian economics are eased by their severe climate and the need for heating virtually all year round; this is the reason for the widespread use of Combined Heat and Power (CHP). In Wales the economic use of CHP is much more limited, owing to the much shorter heating 'season', typically limited from October to end of April for large building complexes

4.5.6 Power generation/Energy from Waste

The Energy from Waste (EfW) Industry is regulated by the European Landfill Directive and The European Incineration Directive, but there are also influences from the IPPC , the renewables obligation & NETA, and the climate change strategies. The Government has excluded energy from the incineration of mixed waste from support under the Renewables Obligation. However energy from the non-fossil derived element of mixed waste using advanced technologies (pyrolysis, gasification & anaerobic digestion) will be eligible. It is hoped this will kick-start their development.

The Integrated Pollution Prevention and Control (IPPC) Directive 96/61/EC aims to prevent or reduce emissions by using best available techniques (BAT). Emphasis is placed on environmental impact and EfW is included in the regime.

The Utilities Act 2000 introduced the Renewables Obligation (as a replacement for NFFO) which oversees the 10% renewables target by 2010. Landfill gas will be included. Although The DTI and The Royal Commission On Environmental Pollution say EfW should be included, The House of Commons has decided that it will be omitted because it would either encourage too much EfW incineration or would simply be giving a subsidy to incineration schemes that were going to be built anyway as a response to the landfill directive. This opens up the industry to the rigor of the marketplace and to price uncertainty under NETA.

Considering the climate change perspective from the Kyoto Protocol EfW is favoured because it is cleaner than conventional power stations and produces virtually no net CO_2 emissions. Therefore it is exempt from the Climate Change Levy.

In summary EfW is exempt from Climate Change Levy but does not qualify under the RO. There has in contrast been government endorsement under the RO of co-firing biomass in stations powered by fossil-derived fuel where operational and emissions standards are significantly less stringent than conventional energy from waste plants. The rationale behind this is obvious and based on European experience where these practices are widespread. Providing the level of substitution is low (say 5% on an energy-input basis or less) plant experience is that existing emission regulations can be readily met, with only minor plant modifications. Although not well received this pragmatic approach overcomes the 'Nimby' problem with waste to energy plants, although plant is still needed to produce Refuse Derived Fuel (RDF) as raw refuse cannot be fired directly into coal fired power stations. A further advantage is disposal of ashes from waste to energy plants. These ashes generally contain high levels of heavy metals and are expensive to dispose of. Again European experience is that the ash material generated in co-fired coal fired power stations can still be used for existing purposes, such as additives for cement or with flue gas desulphurisation provision of gypsum for plaster board.

The above has referred to systems for disposing of large quantities of wastes and the important role of existing plant (i.e. cement plant and power plant). In the Welsh context large waste to energy plants would need the co-operation, normally, of several authorities and planning would probably flounder due to opposition and the

‘Nimby’ syndrome. There is however much scope on the smaller scale. Here recycling plant for wastes are needed, where sorting, reclamation of materials etc occurs. Residual organic material can be transformed into refuse derived fuel (RDF), which has a fairly consistent composition and is much easier to gasify or burn, with potential for low emissions and high efficiency. In fact this is the type of fuel that Power Stations or cement plants want; it is consistent in quality and their processes can be readily adjusted to accept, whilst supplies can be accepted from a number of authorities over a fairly wide geographical area. RDF as a fuel also lends itself to small-scale utilisation via gasification, the route being encouraged by central government. Cardiff University is involved with Welsh SMEs in developing small biomass fired gas turbine sets which could readily accept such a fuel and produce very low emissions. The production and utilisation of RDF is thus something which could be developed in Wales, providing at the same time utilisation is encouraged by appropriate legislative and fiscal measures.

5 COMBINED HEAT AND POWER

In combined heat and power plants (CHP), as well as turning a turbine for electricity, the heat created is used to provide steam for industrial processes or hot water and heating for use in buildings or domestically. This can greatly increase energy efficiency of power generation processes.

Energy policy clearance has been given to three new combined heat and power (CHP) schemes as of July 2001. The stations will supply the additional heat and electricity needs of the British Salt works at Middlewich; the Sudbrook Paper Mill at Caldicot and the iXguardian site at Hounslow.[47]

Such schemes are the type that is most suitable for the application of CHP, where the demand for heat and electricity is fairly continuous throughout the year. However there have been several major setbacks for CHP schemes in the UK, with major power utilities withdrawing from CHP programmes. This arises from their analysis that the market opportunities for CHP in the UK are very limited, whilst returns from electricity generation have seriously deteriorated under the new NETA arrangements. Indeed, unlike Scandinavia, there are few sites in the UK where there is year round demand for heat as well as electricity. Taking the University as an example of a large building complex, the heating season is October to end of April, with heating to all main areas Monday to Friday say 6 a.m. to 4 p.m. This corresponds to about 1470 hours heating per year or some 17 % of the total year. Installation of a CHP plant to service this heat load is not economically viable, as very high costs are associated with the heat distribution network. It is normally only in situations such as Hospitals or similar where CHP may be more economic, where the heating load is much more regularly spread over the day/night and year. One other possible area of expansion is micro-CHP for instance in the large domestic, block of flats etc, whereby a small natural gas fired engine could be fired to produce electricity at times of high demand, with waste heat being used for an additional heat source for existing central heating systems. The economics of such systems are debatable.

It must also be reported that recently two major UK utilities have reduced their commitment to CHP due to the new NETA arrangements, which severely affect the economics and returns on investments. Similarly Boots has stated it will not consider any more CHP investment under the present regime.

6 EMBEDDED GENERATION

Embedded Generation is plant, which has been connected to the distribution networks of the public electricity distributors rather than directly to the National Grid Company's transmission systems. They are generally smaller stations located on industrial sites, combined heat and power plant, renewable energy plant such as wind farms, some waste to energy plants, and even some domestic generators such as electric solar panels. This sector could expand considerably if for instance small-scale domestic CHP plants ever became widely accepted.

7 CO_2 COMPARISONS BETWEEN THE TECHNOLOGIES

Gas-fired generation emits less CO_2 than coal-fired generation, both because of the high design efficiency of CCGT generation, (which current coal-fired stations cannot match), and because of the higher carbon intensity of coal as a fuel (which means that coal generation is very unlikely ever to match the level of CO_2 emissions of efficient gas-fired generation). Today a typical new CCGT would be designed to emit less than half as much CO_2 per unit of electricity generated as an existing coal-fired station. Current CHP installations (only about half of which, on an energy input basis, are fuelled by natural gas) together achieve a reduction of around 30% in CO_2 emissions in comparison with generation from coal-fired stations, and over 10% in comparison with gas-fired CCGTs. New CHP stations are capable of even better performance. Renewable forms of generation generally emit no CO_2 or (in cases such as biomass) emit no net CO_2 taking the cycle as a whole. For example, if renewables were to increase to 10% of electricity supply (the Government is examining what is necessary and practicable to meet this target), this would reduce CO_2 emissions by around 2% of total current UK emissions. Increases in energy efficiency is in many cases a highly effective way to reduce both costs and greenhouse gas emissions.

The Government's policies recognise the importance of energy efficiency, renewables and CHP, as these technologies have low or zero CO_2 emissions. These all make a strong contribution to sustainable development. Taken along with the need, both for energy policy and sustainable development purposes, to ensure that energy supplies are secure and available to all at reasonable prices, the issue is not therefore simply whether we should use gas or coal for power generation, but about the range of measures which, in the medium to longer term, can reduce greenhouse gas emissions cost-effectively across the whole economy. These measures include promotion of renewables and high quality CHP schemes; promotion of energy efficiency; measures in the transport sector; economic instruments such as taxes or tradable permits; and a range of other measures. The consultation document on climate change[8] will discuss and invite views on the range of policy options for delivering the UK's climate change targets. The essential task will be to find the optimum balance between these measures, to develop a comprehensive and equitable programme for meeting the UK's climate change targets.[48]

8 ENERGY EFFICIENCY

Efficiency is of key importance to reducing climate change emissions. In power plants, an increase in power conversion efficiency will beneficially reduce CO_2 emissions per unit of electricity generated (for example by switching to gasification, which has the further advantage of partially working within the carbon free hydrogen shift reaction). Similarly increasing efficiencies and insulation should encourage cutting energy usage in industry, commerce and the home.

The latest directives from the European Union in Brussels confirm that energy efficiency measures are a much more effective way of reducing emissions of greenhouse gases than nuclear power, hydrogen-fuelled cars and carbon “sinks” (i.e. separation of CO_2 from exhaust gases and storage in underground reservoirs). The low-cost way to cut greenhouse gas emissions is through better loft and house insulation and double-glazing, European Union Officials are claiming. Energy efficiency is nothing new – European governments have been promoting it since the oil shocks of the 1970s as a way of easing their economies’ reliance on energy imports. But with the Kyoto Protocol likely to come into force in the next 12 months, saving energy for environmental reasons has become a major priority in European Union. As buildings consume more than 40 percent of all energy used in Europe – more than any other single sector – they are in the front line for potential energy savings. EuroACE, a lobby group representing companies making energy saving technologies, believes the 15-country EU could slash 12.5 percent of its greenhouse gas emissions by improving building efficiency by 2010 – more than achieving its Kyoto target. The 12.5 percent cut is what the industry thinks is feasible through improving insulation, heating, cooling and lighting standards within the next 10 years. Under Kyoto the EU only has to reduce its emissions by eight percent. However, the European employers’ federation, Unice, ever sceptical of added administrative burden, has shown little enthusiasm for the buildings directive. Unice says the EU should look to maintain and expand its nuclear power capacity as an effective way to ensure secure supply without generating increased greenhouse emissions. The prospect of the nuclear industry benefiting from measures to combat climate change horrifies mainstream environmentalists who have battled for years against the threat of nuclear accidents and radioactive waste.

“The European Commission has decided to put forward legislative measures to ensure that improvements are made in energy performance in buildings to the benefit of all – better protection of our environment, increased security of energy supply and lower energy bills,” said Loyola de Palacio (the European Commission vice president and energy and transport commissioner). The main elements of the draft legislation are as follows:

- Minimum energy performance standards to be adopted by member states for each building type. The methodology behind these standards will take into account climatic differences and will integrate insulation, heating, ventilation, lighting, orientation of the building, heat recovery, and renewable energy sources.
- Application and regular updating of minimum standards based on this methodology for new buildings and also for existing buildings over 1,500 square meters when renovated.
- Certification schemes for new and existing buildings. Energy performance certificates, including advice on how to improve energy performance, will be available for all buildings when they are constructed, sold or rented.

In the domestic sector fuel poverty (where a household cannot afford to keep warm) presents a massive problem. It damages the health of those living in cold homes and affects their quality of life. The old, children, and those who are disabled or have a long-term illness are especially vulnerable. People in these higher risk groups are found in more than half of UK households. The main cause of fuel poverty in the UK is a combination of poor energy efficiency in homes, arising from the age of the housing stock and low incomes. Other factors include the size of some properties in relation to the number of people living in the properties, and the cost of fuel. The DTI's "UK Fuel Poverty Strategy – Consultation Draft" looking at this problem was published on 23 February 2001.[49] The New Home Energy Efficiency Scheme in Wales grants aid to improve heating and insulation, the HEES+ scheme even offers gas or electric central heating. In response to concerns over the difficulties in improving rural housing (lack of mains gas, solid walls) the Assembly intends to develop, over the next twelve months, a pilot scheme based on the use of oil fired central heating.

New UK policy enforces efficiency in domestic buildings. Electricity and gas suppliers will have to improve the energy efficiency of their domestic customers by meeting new energy saving targets, detailed in a new consultation document published by the Government. Under the proposed Energy Efficiency Commitment (EEC) for 2002 to 2005, energy providers with customers in England, Scotland and Wales will be required to achieve targets for the promotion of domestic energy efficiency, such as by encouraging customers to use insulation, energy efficient boilers, appliances or light bulbs, and can also include the use of combined heat and power (CHP) systems. The commitment is to cut greenhouse gas emissions by 25 percent from new and existing homes. The country's draughty buildings produce between a third and a half of the total national CO_2 emissions, compared to a European average of one fifth. A major problem in the UK is the age of the building stock and the poor insulation and glazing standards of these buildings and dwellings. In the Welsh context this is an area where much progress could be made over the next few years, by targeted help to vulnerable groups.

Passive solar heating has also much to recommend it, where the orientation of the dwelling, coupled with large window areas to south facing walls (much reduced on other walls), coupled with appropriate blind systems to prevent overheating, can give rise to substantive reductions in heating requirements. Indeed it is perfectly possible to construct houses which require virtually zero heating throughout the year.

Shoppers can instantly recognise the most energy efficient appliances in retail stores by looking for an energy efficiency logo. The Energy Saving Trust, a non-profit company set up by the Government and major energy companies, launched the Energy Efficiency Recommended logo in October 2000, a government-backed label.

9 Discussion and Conclusions

The energy market is extremely diverse and influenced by a multitude of external factors; the most important of which is the USA and the Middle East. Contact with manufacturers of combustion and power equipment indicates that there is going to be an expected 30% increase in the use of gas and oil in the USA in the next three to 5 years. Much of this arises from this summers 'brown outs ' in California and the expected occurrence in much of the rest of the industrialised USA. This coupled with increased use of oil in transportation infers serious increases in oil and gas prices over the next 5 to 10 years, bearing in mind the USA already uses some 40% of World oil production. President Bush has dressed this up by seeking greater efficiency and by committing, by European Standards, large sums to clean coal technology. Indeed there have been large USA clean coal programmes over the last 10 to 15 years involving billions of dollars, but ironically the recent main developments have occurred via incremental changes in existing Coal Power Station Design in Europe and Japan. Obviously the above scenarios are influenced by economic cycles; planning allowances need to be made for substantive real increases in the prices of fossil fuels, both in terms of price spikes, but also average prices. This has very important influences on what can and maybe should be done in Wales. The following points are commended:

More Welsh statistics are needed, separate from those of the rest of the UK.

One of the most cost-effective measures that can be done is to improve the quality and standards of the existing and new building and housing stock. Building standards are normally set nationally in the UK and increasingly by the EU. In the Welsh context, pressure should be developed to increase insulation and related standards to the highest that can be sensibly achieved. Appropriate fiscal instruments need to be developed and applied to persuade people to upgrade insulation/window standards in the existing building and domestic dwelling stock to the highest levels. Measures are already in place to increase the energy efficiency of a wide range of domestic and industrial appliances and this will doubtless continue. However increasing prosperity means that domestically a far wider range of electrically powered appliances is available, contributing to increased electricity utilisation. This is dealt with very simply in countries like Italy and Spain, where electrical power to domestic dwellings is limited to 6 kW. In the UK the normal limit is 18 kW, but essentially this is upgradable on demand. This results in extensive use of electricity for cooking, heating and other unnecessary purposes, remembering that the overall efficiency of electricity generation, plant to domestic use is about 25%. Gas cookers, heaters, central heating etc is conversely between 50 and up to 90% efficient. Clearly legislative and fiscal incentive measures could be beneficial here.

Coal, oil and natural gas utilisation. The use of all these fossil fuels is inextricably intertwined, with prices increase in one, feeding into others, albeit with lead and lag times (as has recently been seen by the effects of an increase/decrease in oil prices). Their prices are, and will be for the foreseeable future governed by external factors, especially the USA and Middle East. A concern for the UK and Wales is Natural Gas and its price effect on electricity generation and heating costs. The 'dash for gas' has served the UK well over the last 10 years in considerably contributing to a reduction in Greenhouse Gas emissions. However there now appears to be a Global 'dash for gas', lead by the USA, probably Germany as it reduces its dependence on coal and eliminates nuclear power. As UK supplies start to run low this must feed through into increased gas prices as imports increase, resulting in more opportunities for renewables as electricity prices increase. There have been arguments for Clean Coal demonstrator plant for more than 10 years; indeed the author served on the UK Coal task force in the early 1990's when this matter formed the basis of intense discussion. Feuding between British Gas and British Coal personnel, who both had different gasifier and system designs ensured that no advanced clean coal demonstrator was built. Limited funding has been subsequently provided to keep research work on the British Coal system alive, but not at any significant demonstration level, apart from useful work directed at gas turbine combustors, enabling them to effectively utilise the fuel gases generated in the gasifier. In this context thoughts should maybe given towards the British Gas/Lurgi slagging gasifier, which was developed by British gas over many years and demonstrated at significant scale. This device was originally designed to produce synthetic natural gas from coal, but was then demonstrated to be able to form the basis of a highly effective gasifier to form part of an advanced, high efficiency, coal fired, combined cycle power generation system (IGCC). The advantage of this unit is that it can be made to produce synthetic natural gas from coal (SNG); this can be fed into the existing natural gas grid at any point and be used to supply gas to virtually any of the existing natural gas fired CCGT plants. This is a far more flexible arrangement than a direct-coupled coal fired gasifier/IGCC system as the gas distribution network has considerable storage potential. In terms of sequestration or long term storage of CO_2 it will be much easier to remove CO_2 in the production of Synthetic Natural Gas, than from a power plant (as gas volumes are much lower). Moreover predicted efficiencies of practical coal fired IGCCs are still less than 50% for electricity generated, substantially less than natural gas fired units. Conventional, advanced clean coal technology is producing efficiency figures close to these, with substantially lower capital costs and better economics. Sequestration of CO_2 produced by coal fired plants will probably be necessary by 2020, contributing to increased costs for coal.

Transport proves to be both the biggest consumer of final energy demand and the largest producer of CO_2 and is set to remain this way at least over the next 20 years. Draconian restrictions of personal transport will always be met with resistance, as it is a denial of personal freedom. Fuel efficiency and cleanliness need to be addressed and target air quality standards should be drawn up. Naturally these should simultaneously be forged into an overall transport strategy. Biodiesel would appear to be one area where Wales could be involved and a ready market could develop, providing the fuel is treated in a similar manner to LPG for road vehicles, with excise duty being applied at a low level. Although there is much discussion of the hydrogen economy and development of fuel cells for transport, the long term problems of efficient hydrogen production, storage and distribution have not been addressed, and although fuel cell powered vehicles might become popular in City and Urban environments their widespread use is unlikely in the future, unless very special technical advances occur. Very recent discussion documents from Daimler/Chrysler show that they feel that the long term future will be based on methanol powered fuel cells. Such systems emit some CO_2, albeit at levels some 30% less than equivalent gasoline engines. The rationale is that methanol is easily manufactured, is a liquid at normal conditions, is relatively safe and can be utilised in existing distribution systems with minor modifications. Hydrogen powered fuel cells do appear to be creating niche markets in certain power generation situations and as buffer store systems for electrical power. Hybrid vehicles with small gasoline engines, batteries and electric motors have been developed primarily in Japan and offer good fuel consumption, which is however only about the same as that developed by modern designs of common rail diesel engine. Hybrid vehicles are generally heavy and clumsy, but do offer emission advantages over diesel systems. It does seem likely that development of the diesel engine and fuels will narrow this gap. The important point with diesel engines is that the high efficiencies and technologies found in modern common rail diesel engines as fitted to passenger vehicles, and mass-produced, are applied to the whole range of vehicles, including HGVs. Generally diesel engines in large trucks are of less refined design, production volumes are low and there is less incentive to use the advanced technologies fitted to mass produced engines.

Renewables is an area where there are many technologies which can be made to work, but virtually all have the common problem of producing power that is significantly more expensive than conventional plant. There is scope for technology cost reductions as they become more mature, but they will not give economics as good as those with fossil fuel systems at present. There are also very significant planning and consent problems, with the ‘Nimby’ syndrome prevailing. Wind Power is the most successful, aided by the NFFO and successor schemes, although at substantially lower levels than some European Union Countries. Larger scale take up of other forms of Renewable Energy will require continuing subsidy and public acceptance, via legislation and schemes such as green tariffs, grants etc. It is only when there are significant and real increases in the price of fossil fuels, or public and political acceptance of significantly higher energy prices, that many of the discussed renewable technologies will take off.

The following attempts to put some timescale to the possible application of renewables[50]:

Near term (those technologies closest to being competitive in UK or with immediate export potential):

UK and Export Market: wastes and some biomass residues landfill gas, onshore wind, hydro, passive solar.

Primarily Export Market: photovoltaics (stand-alone), biomass residues, and active solar

Medium Term (By 2010) (Additional technologies which could contribute by 2010 and would be needed to meet a 10 per cent UK target, and with export potential):

UK and Export Market: some biomass residues, offshore wind, and energy crops.

Primarily Export Market: photovoltaics, fuel cells

Longer Term (After 2010) Technologies with longer term potential if pursued via R&D programme:

UK and Export Market: fuel cells, photovoltaics (building integrated), wave, photoconversion.

Primarily Export Market: solar thermal electricity

Very Long Term (After 2025) Technologies unlikely to be worth pursuing extensively at this time except at the fundamental research level where this would be perceived as necessary:

UK and Export Market: tidal barrage, hydrogen, geothermal hot dry rock, and ocean thermal currents.

10 GLOSSARY OF TERMS

BAT	Best available techniques
BNFL	British Nuclear Fuels Ltd.
CCGT	Natural Gas Fired Combined Cycle Power Plant
CCL	Climate Change Levy
CHP	Combined heat and power
CO_2	Carbon dioxide
DTI	Department of Trade and Industry
EEC	Energy Efficiency Commitment for 2002 to 2005
EfW	Energy from Waste
EPSRC	The Engineering and Physical Sciences Research Council
ETSU	The Energy Technology Support Unit
EU	European Union
HGV	Heavy Goods Vehicle
IGCC	Integrated gasification combined cycle
IPPC	Integrated Pollution Prevention and Control
NETA	New Electricity Trading Arrangements
NFFO	Non Fossil Fuel Obligation
NGC	National Grid Company plc
Nox	All nitrogen oxide emitted by a combustion or gasification process
PV	Photovoltaic
RECs	Regional Electricity Companies
RO	Renewables Obligation
ROCs	Renewable Obligation Certificates
SNG	Synthetic Natural Gas
Sox	oxides of sulphur as emitted by combustion or gasification processes
UK	United Kingdom

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