STERN REVIEW

"THE ECONOMICS OF CLIMATE CHANGE"

BNFL Submission – December 2005

RECOMMENDATIONS

> The UK should continue to play a leading global role in addressing the challenge of climate change
>
> UK measures to cut emissions should be within the context of a long-term policy framework. This should give clear indications to the market over a period of some decades, therefore providing the best opportunity to deploy all potential approaches for reducing emissions.
>
> Within such a framework, the market should be allowed to deliver the most cost-effective balance of measures to reduce emissions.
>
> Actions are needed to enable low-carbon technologies, including nuclear, to be delivered within this framework. Nuclear will not require subsidy or financial incentive in order to be viable. The actions needed are those that will reduce uncertainty in the areas of consents and approvals, waste policy and market framework.

EXECUTIVE SUMMARY

THIS REVIEW COMES AT AN IMPORTANT MOMENT IN CLIMATE CHANGE POLICY DEVELOPMENT

We welcome this timely review. It will give a valuable perspective on the relative economic efficiency of adaptation and mitigation strategies in climate change strategy. This will support not only the UK Climate Change Programme Review and forthcoming Energy Review, but also contribute to the forthcoming debate on future international approaches to addressing climate change beyond 2012.

It is also important that, when determining measures to address climate change, consideration is given to the broader impacts on the environment, society and economic development.

DEMONSTRATING LEADERSHIP, SUPPORTING UK COMPETITIVENESS

The UK has shown leadership on climate change, by beginning to tackle its own greenhouse gas emissions and by heading the drive towards co-ordinated international action on climate change, as shown by the priority given to climate change during the UK's presidencies of the G8 and the EU.

The UK has been a strong supporter of the Kyoto Protocol, but also has recognised that to bring a practical global solution to climate change we must continue to engage the United States and look at ways to address growing emissions in developing countries, in particular in China and India.

However, the credibility of the UK's leadership has been called into question by recent rises in UK greenhouse gas emissions and reducing those emissions is proving more difficult than expected. It is time for the UK to take further action to reduce emissions and, to be effective, those actions have to include maintaining a significant role for nuclear energy.

The UK should also ensure that its climate change strategy forms part of a global commitment to reduce emissions. Emissions reductions in the UK must be matched by global action, both to ensure environmental effectiveness and to prevent undue harm to UK industrial competitiveness.

BALANCING EMISSIONS REDUCTION AND COST

Reducing greenhouse gas emissions in the UK to sustainable levels will be challenging. This could have a negative impact on the nation's economy and people's standards of living. The partial incorporation of the cost of carbon has already contributed to the recent rise in electricity prices. Such increases have reversed some of the gains made in reducing fuel poverty.

We should strive to make use of the most cost-effective forms of emissions mitigation, and examine those options as yet not fully implemented. Emissions in the electricity generation sector could be reduced with new nuclear generation, at lower cost to consumers and taxpayers than is projected under existing policies.

GREATER CERTAINTY AND LONGER POLICY TIMEFRAMES ARE NEEDED

Current climate change policy, at both national and international level, is focused on achieving short-term emissions reduction targets.

It is important that short-term targets are set to give direction and urgency towards emissions mitigation. However, achieving the ultimate aim of reductions greenhouse gas emissions to a level that will do no further damage to the environment requires a long-term strategic approach. This will stimulate investment in projects with longer-term timescales, such as nuclear, that will deliver large-scale emissions reductions cost-effectively. Such a long-term approach will require policy consistency across Parliamentary terms.

Many of the contributions to addressing climate change will come from current technologies, but there will also be other solutions to the challenge which do not. However, if the market is to encourage new technologies to come forward, policy instruments and market mechanisms must provide strong enough signals for investment in fundamental research, development and deployment of such technologies over several decades. Such an approach would also serve to encourage development and maintenance of the skills required to design, build and operate new technologies.

USING NUCLEAR ENERGY REDUCES EMISSIONS EFFICIENTLY AND BRINGS OTHER BENEFITS

New nuclear generation is a cost-effective option for reducing greenhouse gas emissions. It is a carbon-free form of generation; across the whole lifecycle, greenhouse gas emissions are very low, and are comparable with the lifecycle emissions of the better renewables.

OTHER BENEFITS OF NUCLEAR ENERGY

Using new nuclear contributes towards maintaining security of electricity supply. Incorporating a new series of nuclear power plants will help to retain some diversity within the generation mix. It will also help to provide cost stability within the generation portfolio, which in turn will be helpful in tackling fuel poverty.

The nuclear industry also plays a key role in the UK economy, currently employing 40,000 directly and supporting many additional jobs. Many of these are skilled jobs in rural areas where such opportunities are scarce. Future nuclear build, which would be on or adjacent to existing power station sites, would offer opportunities to maintain and grow the economic benefit delivered by the industry in this respect.

A new generation of nuclear stations – such as the EPR or AP1000, both of which are ready for deployment - would also benefit the UK in terms of GDP and balance of payments. The benefit in GDP terms of a programme to replace the current nuclear fleet would be around £4 billion per year[1] once the stations are all operational.

OBSTACLES TO NUCLEAR REQUIRE GOVERNMENT ACTION, BUT NOT SUBSIDY

Nuclear capacity is relatively capital-intensive and the overall cost of electricity from nuclear is very much determined by an investor’s required rate of return. Perceived risks, such as the time scale and scope of licensing and public inquiry, the current lack of a waste management policy and the current absence of any signals as to how the longer-term electricity market will deal with carbon emissions, will have to be addressed if private sector investors are to come forward. In the case of waste, international experience demonstrates that solutions exist which are both technically and politically acceptable.

A number of the obstacles to nuclear are common to a range of low-carbon technologies, and their removal would enable other longer-term options, such as tidal power and fossil fuels with carbon capture technology, to be developed effectively. For instance, a more timely and efficient planning process and greater clarity regarding how the market will value carbon emissions will both help across the board. The challenge of climate change is so great that **all** low-carbon approaches must be encouraged in a way that allows them to compete within the energy market, so that the most cost-effective mix of solutions can be deployed.

[1] “Macroeconomic Analysis of Nuclear Plant Replacement”; Oxford Economic Forecasting; March 2005

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1) INTRODUCTION

This Review comes at a key time in both UK and international climate change policy development. The Kyoto Protocol has finally been ratified. At the recent UN climate change conference in Montreal, discussions began on how to address climate change in the period after 2012.

In the UK, reducing our greenhouse gas emissions is proving much harder than expected. Emissions of carbon dioxide are now higher than they have been for the past decade. The forthcoming Climate Change Programme Review should highlight a number of additional measures that can help close the gap towards our domestic target of a 20% reduction in CO_2 emissions by 2010.

However, the overriding objective of climate change policy should be to achieve stabilisation of atmospheric greenhouse gas concentrations at a level that avoids excessive global warming. If, as reported[2], the new measures proposed in the Climate Change Programme Review seek to achieve the 20% emissions reduction target by doing "75% more in around half the time" the cost-effectiveness of this approach in achieving long-term UK policy goals - such as the 60% cut recommended by the Royal Commission for Environmental Pollution[3] - must be seriously questioned.

The 2010 target of a 20% reduction is a stepping stone towards longer-term stabilisation of CO_2 levels, and should not be seen as an end in itself. Whilst it is important to be making emissions reductions, and to be seen to be taking the challenge seriously, it is also important not to become locked-in to short-term fixes which are far from cost-effective when viewed from a longer-term perspective, and which thereby reduce public, industrial and commercial support for further longer-term measures.

BNFL are not experts in the field of environmental economics. Where we can best contribute to this Review is on issues relating to the nuclear sector. We have therefore focused this contribution on considering the role that has been played by nuclear in the past - and could potentially be played in the future – in terms of the international climate change situation. We also expand on the economics of nuclear generation, and consider a case study of the UK.

[2] The Guardian, page 10, 14 November 2005
[3] *"Energy – The Changing Climate"*; 22nd Report of the Royal Commission for Environmental Pollution; June 2000

2) SUMMARY OF GLOBAL CLIMATE CHANGE POLICY, PROGRESS AND CHALLENGES

2.1 Summary of Global Policy Situation

The Kyoto Protocol has made valuable progress towards combating climate change, even without the participation of the United States. However in the future more needs to be done to establish a truly inclusive international approach to this global challenge. Key areas where progress is needed are as follows:

- Re-engagement of the United States and retention of existing ratifiers of Protocol
- Greater clarity on how developing countries will participate
- Agreement on longer-term actions
- Improved operation of the Kyoto Mechanisms

The contribution to total emissions made by the UK is relatively small at around 2%, but the importance of UK leadership in this area, both as a leading G8 and EU economy and as a nation which has demonstrated significant early progress in reducing national emissions, should not be underestimated.

We encourage the UK Government to work actively towards international progress as outlined above, and to set a lead in developing and implementing a national framework for reducing carbon emissions which can be used as a blueprint more widely.

Such a framework must predominantly adopt a long-term strategic perspective to the challenge, and must provide an indication to markets on how carbon reductions are to be achieved over the coming decades. Near-term targets are not ends in themselves in the face of the sustained effort needed to reduce emissions substantially (a 60% reduction relative to 1990 is the target by 2050). Shorter-term measures have proved to be a barrier to a number of approaches which have the potential to deliver substantial reductions in emissions, albeit over a long timeframe.

More background to the global situation in respect of climate change policy and progress to date is given in Annex I.

2.2 Developing Countries are Driving Demand Growth

Even at current rates of fossil fuel usage, greenhouse gas concentrations in the atmosphere are on course to reach dangerous levels within a few decades, unless action is taken to make dramatic cuts in emission levels. Yet current projections are for further steep rises in the demand for energy in general, and in particular for transport fuels and electricity. The growth in demand is most pronounced in the developing world, where millions of citizens are starting to expect access to some of the benefits which the developed world has enjoyed for some time, such as ready access to electricity and private powered transport. Population growth is a further driver to increased demand in many countries. A particularly important example is China, where the economy (in real GDP terms) is currently growing at a rate of 8-10% per year[4], with a huge associated growth in energy demand.

These drivers are common across many parts of the developing world. In developed countries such as the UK, both manufacturing productivity and energy efficiency of equipment (from consumer goods to industrial machinery) are steadily improving. However these effects are cancelled out by higher demand for goods and services, and also by social changes (such as the falling average number of people per household), which result in overall energy demand growing steadily year after year. This in turn tends to push up fossil fuel usage and in turn carbon emissions.

The background of steadily increasing energy demand in the developed world, and increasingly dramatic increases elsewhere, reiterates the importance of adopting a wide range of measures across all sectors in order to cut carbon emissions.

2.3 Striking a Balance Between Climate Change Action and Provision of Access to Energy

The majority of the Earth's population either have no access to electricity or their electricity supplies are unreliable. Providing those billions - and the billions of people expected to swell the Earth's population over the 21st Century - with reliable and affordable electricity supplies is a major goal of sustainable development.

The IEA predict that energy-related greenhouse gas emissions could rise by over 50% by 2030.[5] If conventional fossil fuel generation is used to meet these needs the resultant greenhouse gas emissions would have a very damaging impact on the global climate.

Much greater use will need to be made of lower carbon generation technologies if the objectives on climate change and access to energy are to be met. Because of the scale of the challenge ahead it is likely that all such options will be needed – renewables, fossil fuel plant with carbon capture and storage and nuclear.

In the least developed countries it is likely that distributed renewable generation will play an important role, particularly in rural areas that are not well served by transmission network infrastructure. But as the economies of developing countries grow and industrial output increases there will be the same need for affordable, reliable, large-scale, baseload electricity as there is in developed countries today.

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[4] *"Country Focus – China";* International Monetary Fund; September 2005 http://www.imf.org/external/pubs/ft/fandd/2005/09/country.htm

[5] http://www.iea.org/Textbase/press/pressdetail.asp?PRESS_REL_ID=163

2.4 Different Power Generation Options Briefly Reviewed

All generating technologies present a balance of advantages and negative features. In considering the different options, attention must be given to the benefits presented by diversity, as well as the features of individual options. In summary, key features of the different options are as follows:

Coal stations provide reliable baseload generation, and coal supplies can be expected to be reasonably secure (either from domestic mining or imports) based on the track record of coal usage in the UK. Coal is an abundant fuel and relatively cheap. In addition, coal stations can respond rapidly to changing demand, thus providing essential flexibility to the supply side.

However, current coal-burning technology leads to the emission of significant quantities of carbon dioxide. Coal is a cornerstone of power generation in many countries though, and it is inconceivable that such nations will not have coal as a key part of the mix for decades to come. This emphasises the importance of carbon capture and storage (CCS) and of the challenge to see whether this technology can become both technically proven and commercially viable.

Gas has been the fuel for most of the recently constructed power plants in the UK, on the basis of its low price over the past decade or so. However, the UK is now shifting rapidly from using domestic gas reserves from the North Sea to relying on imports. Key sources of such imports are Norway, and in the longer term Russia, Qatar and Algeria. This carries potential risks in terms of supply security, as well as in terms of future costs, recognising the upwards trend and volatility of global gas prices (as witnessed recently). Raw gas costs account for at least 60% of overall generating costs from gas power plants, even at the modest gas price levels seen in the UK over recent years, and so power prices are strongly linked to the costs of gas. In recent months when gas market prices have been much higher, the contribution of the gas cost to the overall economics of power generation from gas has been much higher – closer to 80%. Gas stations still produce substantial quantities of CO_2 - approximately half the emissions of a correspondingly sized coal station - and so CCS technology is needed with gas-fired generation in order for it to represent a truly low-carbon option.

Renewable energy technologies (such as wind, wave, solar, hydro, tidal and biomass) in the main have no direct carbon emissions. They do have some indirect lifecycle emissions, though (as with nuclear) these emissions are generally at least an order of magnitude lower than emissions from fossil fuels. The exception is the burning of biomass, which *does* lead to direct CO_2 emissions, however these are usually cancelled out by the growth of replacement biomass which acts as a corresponding "sink" for atmospheric CO_2.

The economics for most technologies have been uncompetitive in the power generation market over recent years without significant subsidy, and this needs to be overcome in the longer term if the proportion of power from such sources is to grow as hoped. Costs should come down noticeably with increased scale of deployment and as technologies mature, but it remains to be seen to what extent these will become more competitive over time.

Whilst renewables usually have no major concerns over the reliable delivery of fuel supplies *per se* to the power generation facilities, variability of the output has to be taken into account – in particular from wind farms. When the wind does not blow (or blows too strongly for turbines to operate safely) power must come from other technologies. The grid and other sources of power can provide this "backup" up to a certain amount of wind on the system (typically 10 to 15% of all electricity production), but beyond that level additional flexible (fossil-fired) plant would have to be built or retained for this purpose.

Nuclear energy provides reliable baseload power around the clock, and produces very little carbon dioxide, either directly or across the whole life cycle. It therefore makes a major contribution to both supply security and carbon reduction. The raw uranium fuel comes from politically stable countries such as Canada and Australia, and in any case requirements are low in volumetric terms, and the costs of the uranium are only a small proportion of overall costs, so uranium price variability is not a key concern. In fact the economics of nuclear generation are dominated by the relatively high capital cost of building the plant, and associated financing costs. Even so, recent studies[6,7] show that the costs of electricity from nuclear stations are competitive with those from alternative sources.

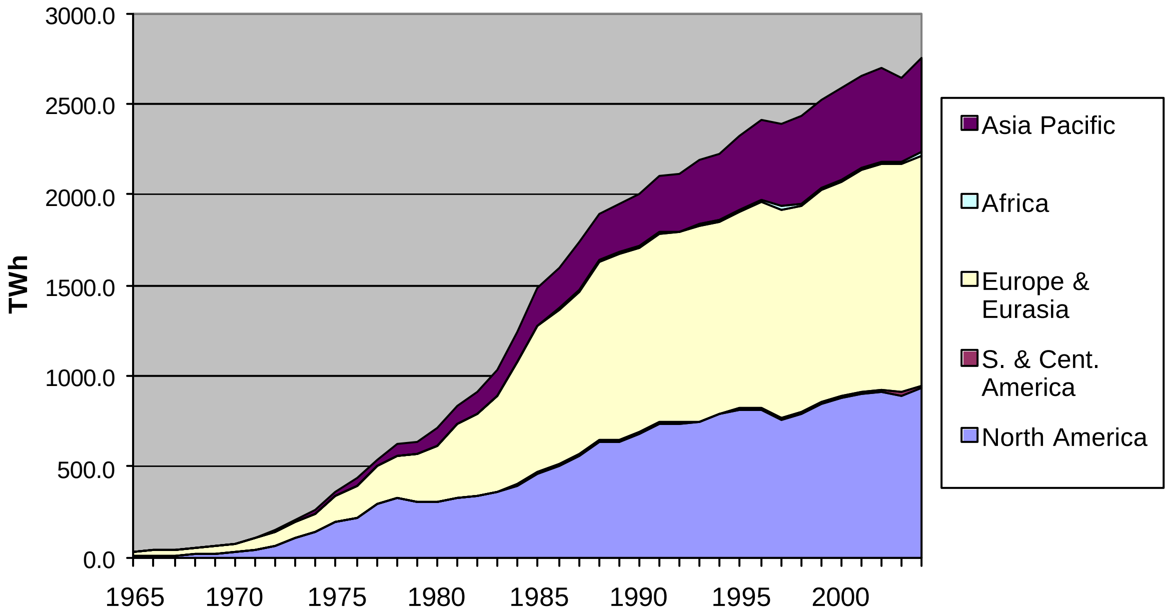
Waste volumes from modern designs of nuclear plants are substantially less than from some existing reactors, and so would represent only a marginal addition to existing waste volumes over the full lifetime of a fleet of new plants. International experience in countries such as Finland and Sweden shows that waste solutions can be delivered in ways which are acceptable to both Government and the public.

[6] For instance *"The Cost of Generating Electricity";* Royal Academy of Engineering; 2004
[7] and *"Projected Costs of Generating Electricity";* OECD / NEA / IEA; 2005

3) NUCLEAR ENERGY AS PART OF A GLOBAL RESPONSE

3.1 Greenhouse Gas Emissions Avoided So Far by Nuclear Energy

Nuclear generation has steadily increased over the last forty years. In 2004 global nuclear generation was over 2700 TWh. This helped avoid the emissions of nearly 2 billion tonnes of carbon dioxide, compared to the global electricity generation mix.[8] This represents more than 7% of total global greenhouse gas emissions, from all sectors including transport and industry as well as power generation. Looking at it another way, if there had been no nuclear generation anywhere during 2004, CO_2 emissions would have been at least 7% higher than they actually were.

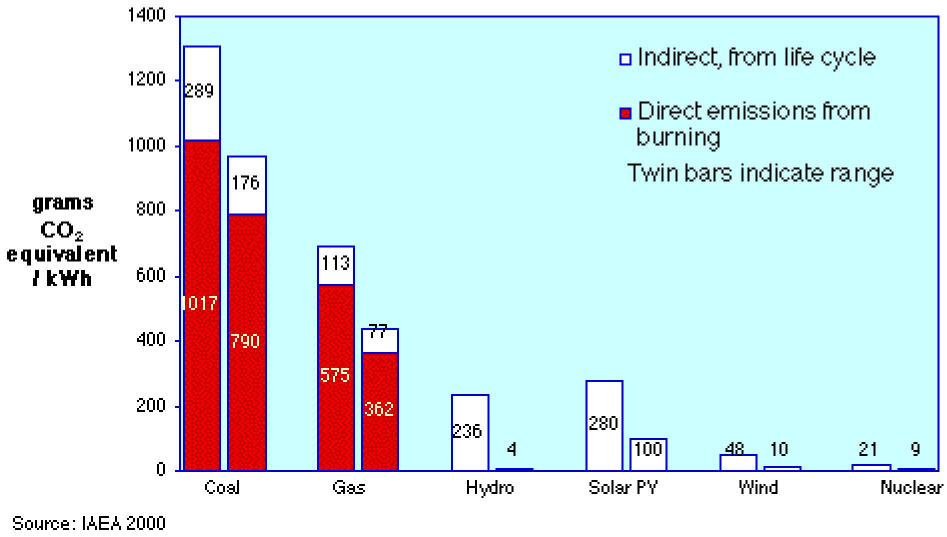


Annual Generation from Nuclear Energy 1965-2005[9]

3.2 The Potential Future Contribution of Nuclear Energy to Reducing Emissions

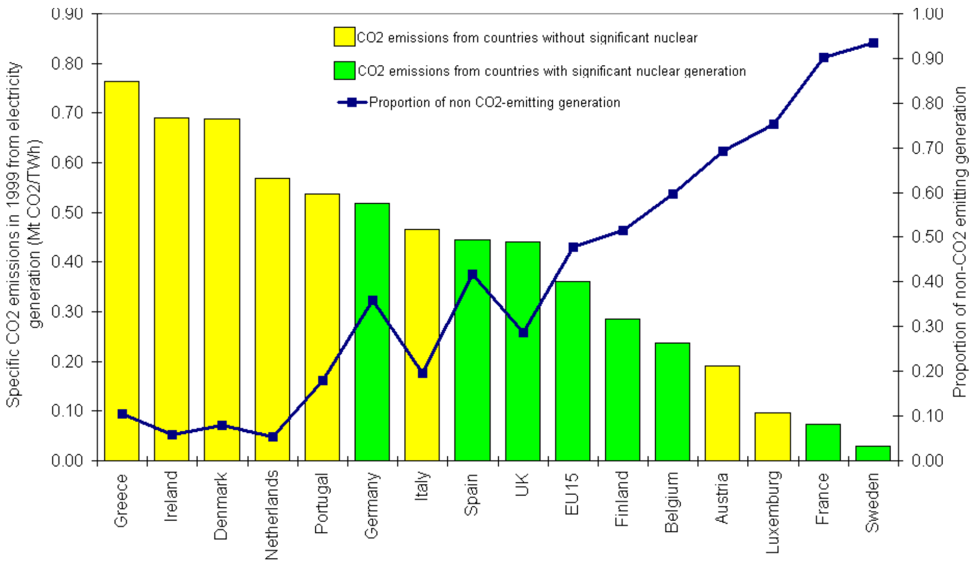
New nuclear generation is a carbon-free form of power generation (at the point of generation). Across the whole lifecycle, greenhouse gas emissions are very low, comparable with the lifecycle emissions of most renewables, as shown in the following chart[10]

[8] Based on data in IEA 2003 report. Using emissions values from IAEA.
[9] BP Statistical Review 2005
[10] IAEA Bulletin 42 (2) 2000



Greenhouse Gas Emissions from Electricity Production

Globally, nuclear energy helps avoid the annual emission of around two billion tonnes of carbon dioxide that would otherwise be generated from fossil fuels. In the EU for instance, nuclear generation is the largest single source of electricity. Out of the (former) EU-15 countries, those which have significant proportions of nuclear energy are consistently amongst those with the lowest CO_2 emissions.



CO_2 Emissions per Unit of Electricity in the EU-15 Nations[11]

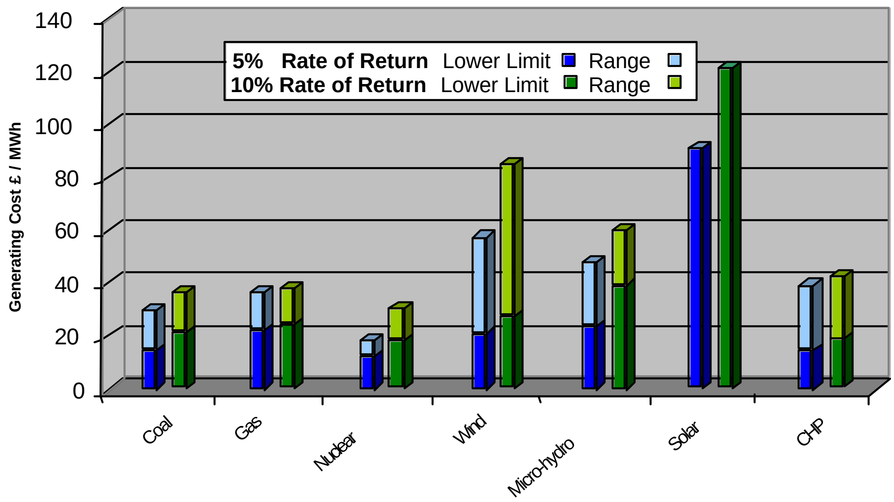
[11] *"2001 Annual Energy Review"*, European Commission; January 2002

3.3 Security of Supply Issues

Whilst the importance of addressing climate change cannot be over-stated, nations will need to consider the wider picture when assessing possible means of reducing carbon emissions. Affordability is important (and is considered explicitly within the scope of this review), as also is supply security. In this respect it is worth recalling that nuclear energy supplies reliable, baseload power. In many countries of the world it is only a modest component of the generation mix, so adding new nuclear plant promotes diversity. This is particularly true in the UK, where gas-fired plants may well supply 65% or more of power needs by 2020.

3.4 Economics of Nuclear

Electricity prices have risen noticeably in the recent past, in part driven by the global rise in gas prices. It has been shown that the overall generating costs of nuclear energy can be competitive with fossil-fired generation if barriers, such as those currently posed by UK-specific planning risks, can be overcome. Nuclear energy could become even more competitive in the future as gas prices are projected to rise further and the costs associated with carbon dioxide emissions begin to play a larger role. Nuclear energy is consistently shown to be much cheaper than the leading renewable alternatives.



OECD Analysis of Power Generating Costs for Different Technologies[12]

[12] *"Projected Costs of Generating Electricity"*; OECD / NEA / IEA; 2005
[Data converted to sterling based on £1 = $1.65. Data also excludes Japan and the Netherlands for which estimated costs differed significantly from the average]

	MIT (2003)	PIU (2002)	Chicago (2004)	RAE (2004)	DGEMP (2003)	Finland (2003)	OECD (2005)	
Generating cost (p/kWh)	3.9 – 4.0	3.0 – 4.0	3.1 – 3.6	2.26 – 2.44	2.0	1.7	1.3 – 1.9	1.8 – 3.0
Rates of return	11.5%	8% & 15%	12.5%'	7.5%	8%	5%	5%	10%
Capital cost	$2000/kW (£1150/kW)	$2000/kW (£1150/kW)	$1500/kW (£865/kW)	$2000/kW (£1150/kW)	€1413/kW (£990/kW)	€1900/kW (£1330/kW)	$1000-$2000/ kW (£610-1210/kW)	
Load factor	85%	75 – 80%	85%	>90%	> 90%	>90%	85%	
Economic life	15 yrs	20 yrs	15 yrs	25 & 40 yrs	35 - 50 yrs	40 yrs	40 yrs	
Construction period	5 yrs	Not identified	5 – 7 yrs	5 yrs	5	5 yrs	4-6 yrs	

Projected Costs of Nuclear Energy from Different Studies

The economic attractiveness of nuclear energy, together with the issues that affect the economics, are reviewed in some detail in a recent comprehensive report from the World Nuclear Association[13]

As noted earlier, the costs of nuclear energy are relatively insensitive to changes in the price of the raw uranium fuel, and nuclear provides an element of stable cost generation in the generating portfolio, which is helpful in keeping overall prices to consumers low. This contrasts with gas-fired generation, where the cost of raw gas represents around 60% of the total generating cost, even at the modest gas price levels seen in the UK over recent years (and closer to 80% at recent – much higher - gas market prices).

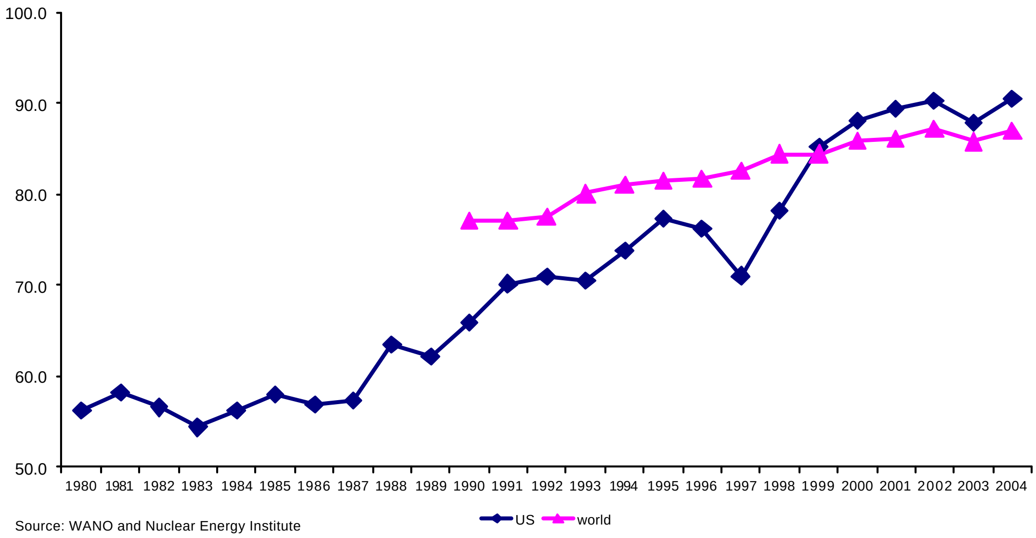
3.5 Nuclear Energy Around the World Today

Nuclear energy has been generating electricity world-wide since the 1950's and there are now nearly 12,000[14] reactor-years of operating experience. There are currently 447 operational nuclear reactor units providing around 16% of the world's electricity.

Nuclear Power Plant Performance

The performance of nuclear power plants around the world has substantially improved over the last decade as illustrated on the figure below which shows the rise in net capacity factors[15]. In the United States, the improvement over 20 years has been even more dramatic from less than 60% to 90%. Levels of 90% and above have been continuously achieved by the best plants in Europe and Asia for many years.

[13] *"The New Economics of Nuclear Power";* World Nuclear Association; December 2005
[14] World Nuclear Association web site
[15] Capacity factor is the percentage of electrical power that a reactor actually produced in a given period compared with the electrical power that could be produced if the unit were operated continuously at full power in the same period. Planned shutdowns for refuelling and maintenance will reduce the maximum possible lifetime capacity factor by 5 to 10%. In addition to these controllable influences on load factor there are also unplanned losses due for example to plant breakdowns.



Net Capacity Factors in Operating Nuclear Plants

Nuclear Projects

Currently 24 new plants are under construction[16]. In 2005, 3 new plants have already been connected to the grid, and a further 2 started commercial operation. In Europe, a 1600 MW pressurised water reactor started construction in Finland in 2005 and another unit is planned at Flamanville in France. China has announced a large nuclear new power station construction programme. In response to renewed Government support, utilities in the USA are actively progressing site and operating licence applications.

Availability of Reactor Designs for Near Term Deployment

A summary of the reactor designs currently available for deployment or under development is shown in the table below. These reactors have in general evolved from designs which are currently in operation and have benefited from over 40 years of reactor experience. Other, even more advanced reactor designs are being developed but these are not expected to be commercially available until well into the next decade.

The leading reactor designs which are likely to form the next generation of reactors in Europe and North America are the Framatome European Pressurised Water Reactor (EPR), Westinghouse's AP1000 PWR and the General Electric Enhanced Safety Boiling Water Reactor (ESBWR).

[16] http://www.iaea.org/programmes/a2/index.html

Reactor Design	Type	Country of Origin	Lead Developer	Deployment Status
ABWR	BWR	US Japan	GE, Toshiba, Hitachi	Operating in Japan. Under construction in Japan & Taiwar
CANDU-6	PHWR	Canada	AECL	Operating in Korea, China,
VVER-91/ 9 9	PWR	Russia	Atomstroyexport	Under construction in China
AHWR	PHWR	India	Nuclear Power Corporation of India	Starting construction
APR-1400	PWR	Korea, US	Kepco	Planned for Shin-Kori
APWR	PWR	Japan	Westinghouse & Mitsubishi	Planned for Tsuruga
EPR	PWR	France, Germany	Framatome ANP	Under construction in Finland. Planned for France. Offered in China
AP1000	PWR	US	Westinghouse	Licensed in USA. Offered in China
SWR	BWR	France, Germany	Framatome-ANP	Offered in Finland
ESBWR	BWR	US	GE	Under development
ACR	PHWR	Canada	AECL	Under development

3.6 More Dramatic Reductions in Emissions Over a Longer Timeframe - The Hydrogen Economy

Much of the debate on energy concerning security of supply, economics and environmental impact focuses on the demand of the electricity sector which represents only a fraction of overall energy requirements and carbon emissions. Another very significant contribution is that of the transportation sector which, by way of illustration, currently accounts for over one third of total energy demand and around one quarter of total carbon dioxide emissions in the UK[17]. Both of these figures are projected to rise over the coming decades. This re-emphasises the importance of a package of measures designed to cut emissions on all fronts as effectively as possible.

Meeting the energy demands of this sector through low-carbon technologies will prove challenging. Unlike stationary large-scale power plants based on burning fossil fuels, carbon capture and sequestration technology for the (mobile) transportation sector is not considered realistic.

This implies that a future transportation fleet may have to run on energy technologies that do not emit CO_2. Options include battery technology, alternative synthetic fuels or hydrogen. Whilst battery technology has been developed and is used for a few small niche applications in the transportation sector, it is only a low-carbon option if coupled to a low-carbon electricity generation technologies. Synthetic fuels are being considered and there are some applications already being pursued. The most developed option is that of hydrogen. Hydrogen can be burnt directly in a combustion engine or utilised through a fuel cell. Whilst it has the attractive prospect of not emitting CO_2 at the point of use and only producing clean water as a by-product, the hydrogen must still be generated somehow.

[17] *"UK Energy Sector Indicators 2005"*; DTI; July 2005

The main options to produce hydrogen are high energy large scale industrial processes such as steam-methane reformation, electrolysis or thermochemical generation. These processes consume either large amounts of electricity or fossil fuels directly. If the transition to hydrogen is to result in an overall reduction in CO_2 emissions, then the hydrogen must be generated by low carbon processes. Otherwise, the generation of carbon dioxide is simply moved from the roads to a new fleet of hydrogen production facilities or power plants with no net environmental improvement.

The energy demand associated with creating the hydrogen is very substantial. Studies have shown that converting the whole transportation fleet of a nation such as the UK from fossil fuel to hydrogen, through the use of electrolysis, equates to an additional electricity demand approximately 70% to 100% of the nation’s existing installed electrical grid capacity. Put simply, to de-carbonise the transportation sector implies virtually doubling electricity production, whilst simultaneously making huge reductions in the CO_2 emitted from this sector.

Renewables technologies will play a role in meeting this challenge over the coming decades but, because of the sheer size of power production requirements, the bulk of the new capacity will need to come from large-scale power plants (fossil-fuelled plants with CCS or nuclear plants).

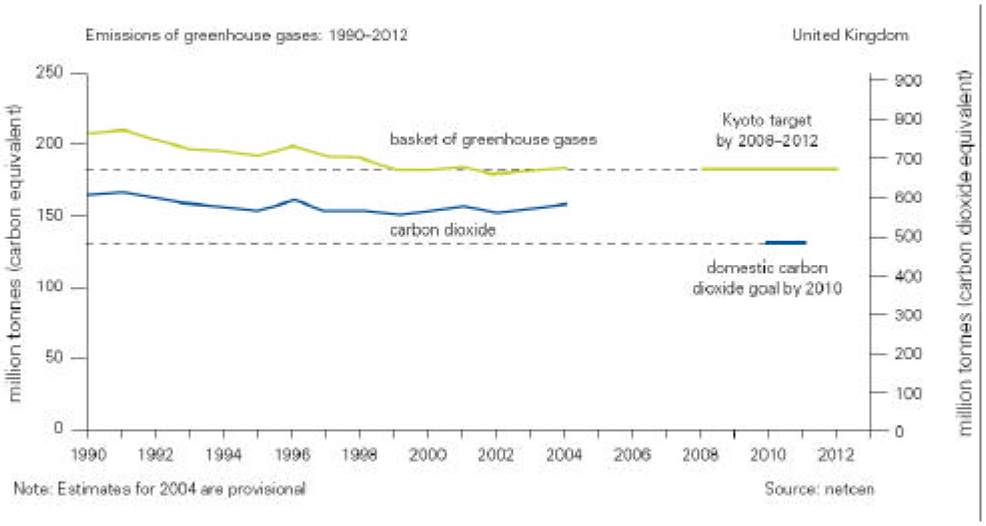
One particularly promising technology to address this challenge is the use of advanced nuclear reactor technology such as High Temperature Gas-cooled Reactors. These reactors operate at very high temperature and enable novel high temperature processes for generating hydrogen to be unlocked. These processes have significant advantage of not emitting CO_2 and only requiring water as feedstock.

The development of new reactor technology not just for hydrogen generation but also for electricity generation is recognised internationally as an important and worthwhile pursuit. The so-called Generation IV technologies, proposed for deployment on the 2030 to 2040 timescale are intended to further improve levels of safety, economics, and performance of nuclear power stations.

4) UK Case Study – Climate Change Policy and the Role of Nuclear Energy

4.1 Progress on Reducing UK Emissions

Reducing greenhouse gas emissions in the UK to sustainable levels will be challenging, even given the long timeframe for addressing the challenge. Latest figures show that UK CO_2 emissions have risen in each of the past two years, and are now higher than at any time since 1996, as illustrated in the following chart[18]. This situation is in spite of a number of market mechanisms and other factors which should have been exerting downwards pressure on emissions:



4.2 Current Climate Change Policies in the UK

The Renewables Energy Obligation (RO) offers renewable generators reasonable certainty that they will receive a premium on their generation, provided the amount of renewables installed remains below the targets set by the obligation.

However, the RO is an expensive economic instrument. By 2010 it will cost £1 billion/year[19] for an emissions saving of 15 $MtCO_2$[20], equivalent to £66/tCO_2.

The Climate Change Levy (CCL) supports good quality CHP, renewables and energy efficiency The levy does not differentiate between coal, gas or nuclear generation, despite the fact that coal emissions are very much higher than gas emissions per kWh, and both

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[18] *"Second Annual Report on the Implementation of the Energy White Paper"*; DTI/DEFRA; July 2005

[19] *"Report by the Comptroller and Auditor General, HC 210 Session 2004-2005"*; National Audit Office, Department of Trade and Industry; February 2005

[20] Taking central case from *"New and Renewable Energy – Prospects for the 21st Century;* The Renewables Obligation Preliminary Consultation, Department of Trade and Industry

fossil fuel generators are much more polluting than the near-zero greenhouse gas emissions from nuclear energy. This perverse nature of the levy reduces its economic efficiency and environmental effectiveness.

Climate Change Agreements (CCAs) offer participants an 80% rebate on the Climate Change Levy if those participants achieve targets set for relative or absolute energy efficiency or greenhouse gas emissions reductions. However, recent modelling by Cambridge Econometrics produced for the 2005 Budget[21] suggests that many sectors would - in any event - have reached the targets set for them under business as usual practices. This calls into question the economic effectiveness of the CCAs.

The EU Emissions Trading Scheme (ETS) has been described as a key element of the Government's climate change programme. Participants in the scheme do not currently pay for the majority of the emissions allowances they require but, as emissions allowances are tradable commodities, they do have a value. When fossil fuel generators operate their plant they face an "opportunity cost" because they have to surrender a proportion of their allowance allocation (which they could otherwise have traded) to account for the emissions produced. Fossil fuel generators may then pass on this opportunity cost to customers.

This price signal should feed through to all generators, which could stimulate deployment of more low-carbon generation. However, under the EU ETS there is no certainty as to the price of emissions allowances in the long term, or the emissions reductions that participants will be required to make. As such, it can only offer a limited incentive to long-term emissions reduction projects. This problem could be addressed by extending the time period of allocation periods after 2012 to give a better indication of what emissions reductions will be required from participating businesses over the long-term.

The allocation of allowances should move from the current emphasis on free allocation to an increased role for auctioning of allowances. This would more directly pass on the cost of carbon emissions to businesses and more vigorously encourage lower carbon options. In addition, the revenues raised from the auction process could be used to fund further greenhouse gas emission reduction policies and actions.

The “Dash for Gas” - In addition to formal incentives, from 1990 onwards there has been a major shift in the electricity generation mix – with a significant amount of coal-fired plant being replaced by gas-fired power stations, due to the relatively attractive economics of gas over coal. This, too, contributed major CO_2 savings given that the

[21] *“Modelling the initial effects of the climate change levy”*; Cambridge Econometrics; 2005.

emissions from gas are typically around half those from coal. Further carbon savings over the same period have come from improved output from the nuclear fleet coupled with Sizewell 'B' coming on-stream.

While the policy instruments identified above may help to stimulate action to reduce CO_2 emissions, it is technology and behavioural change that will actually deliver emissions reductions on the scale that is needed.

Yet despite all of this activity and incentive (as well as the associated cost), Government data shows that CO_2 emissions in 2004 were only 4.2% lower than in 1990, and are projected to be just 14% lower by 2020, falling well short of the 20% target[22].

The implication is that achieving **significant** reductions in CO_2 emissions (for instance the 60% cut recommended by the RCEP, and adopted within the 2003 Energy White Paper) will require substantially greater incentive if the same approaches are to be adopted in future as those deployed to date. It also casts doubt on whether simply persevering with the same measures is likely to have enough impact to put the UK on the road to such large-scale reductions, even if the costs were judged to be acceptable,

4.3 Cost-Effectiveness of Solutions

Clearly significant future expenditure on carbon-cutting measures could have an adverse impact on UK competitiveness – particularly with respect to countries which choose to follow different (more cost-effective) carbon mitigation strategies. This in turn could have a negative impact on the UK economy and standards of living for the UK population.

The partial incorporation of the cost of carbon has contributed to the recent rise in electricity prices. Moves to "price" carbon in this way are appropriate, but the resultant increases in power prices have reversed some of the gains made over recent years in reducing fuel poverty. It should be recognised though, that an increased reliance on gas for electricity generation, and an increased reliance on gas imports, has greatly increased the degree to which UK electricity consumers are exposed to gas price increases across Europe.

Rather than solely following technology-specific approaches, we should in future seek to ensure that the UK makes use of the most cost-effective forms of emissions mitigation, and examines those options as yet not fully exploited.

4.4 The Importance of a Long-Term Policy Approach for the UK

Current climate change policy, at both a national and international level, is focused on achieving short-term emissions reduction targets. For instance, in the UK the focus recently has been on the 20% CO_2 reduction targeted for 2010. As a consequence, the measures put in place are targeted at achieving

[22] Second Annual Report on the Implementation of the Energy White Paper; DTI / DEFRA; July 2005

relatively modest results on short timescales, and therefore are only effective at encouraging the development and deployment of technologies which can play a part over such timeframes.

Whilst short- and medium-term targets are important in order to give direction and urgency towards emissions mitigation, they are means to an end: they must sit alongside the longer-term goals that they support to provide clarity over the ultimate objectives. If the path to 2050 is only seen as a sequence of 5-10 year periods, each with its own targets and measures, but with no "big picture" view, then the solutions delivered by the market will be simply those which can be deployed and can make a worthwhile contribution on such timescales. Any approach with a longer time horizon is very unlikely to feature.

Achieving the ultimate aim (of reductions greenhouse gas emissions to a level that will do no further damage to the environment) therefore requires a strategic long-term approach to stimulate investment in the longer-term projects (such as tidal, effective CO_2 capture and storage, nuclear and major energy savings measures) that have the potential to deliver large-scale emissions reductions cost-effectively. Such a long-term approach will require clear signals to promote confidence in policy consistency across Parliamentary terms.

Many of the solutions to climate change will come from current technologies, but some potential solutions will not. For the reasons outlined above, the current set of policy instruments and market mechanisms do not provide strong enough direction for investment in fundamental research, development and deployment of new technologies. Nor will they encourage the steps needed to maintain the skills required to design, build and operate such new technologies.

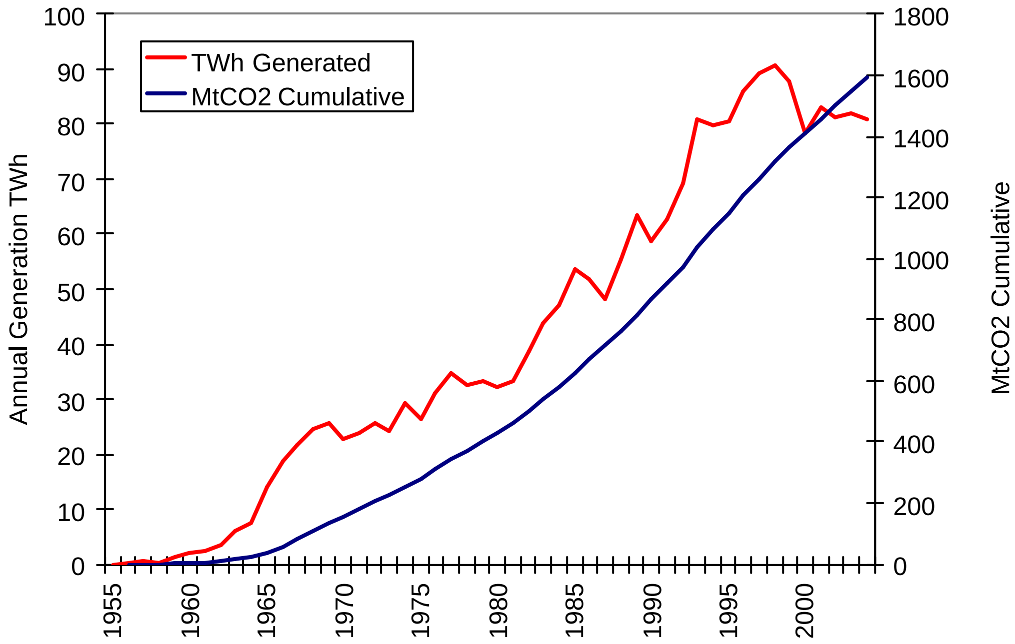
This issue is of particular importance to the UK, where the highly deregulated and competitive nature of the electricity market means that investment decisions are made on a purely commercial basis, without any strategic long-term direction or appropriate incentivisation from Government.

The importance of addressing climate change should also be recognised from the perspective of UK retaining and strengthening a global leadership position. It is essential that the UK ensures its economy is well placed to benefit from such a leading position. For example, the UK should encourage low-carbon technologies and products to be developed and exported. For some technologies, such as wind, this chance has largely passed, but in future new opportunities will emerge, in technology and also in terms of policy. Within nuclear energy the UK has significant historic capability which could benefit the international community. Indeed the UK is an active member of the Generation IV international consortium on advanced reactor technology allowing cost-effective access to the resultant technologies, whilst helping to identify opportunities for utilisation of UK expertise.

By promoting UK capability through technology development, commercialisation and export support in a wide range of disciplines, the UK can position itself as a leading player and can be proactive in formulating climate change policy rather than merely being reactive.

4.5 Contribution of Nuclear Energy to Reducing UK Carbon Emissions

Nuclear energy has been supplying electricity in the UK, virtually carbon-free, for nearly 50 years. It is a proven technology. Over the last 50 years nuclear generation in the UK has reached a cumulative total of over 2000TWh. This has helped avoid the emission of 1.6 billion tonnes of carbon dioxide, compared to the prevailing fossil fuel mix, as illustrated in the chart below. This shows (in red, measured on the left hand axis) the annual energy output from the UK nuclear fleet in TWh, together with the cumulative quantity of carbon dioxide emissions avoided by this nuclear output (shown in blue and measured on the right hand axis).



Annual Electricity Generated and Cumulative Carbon Dioxide Emissions Avoided Through UK Nuclear Generation

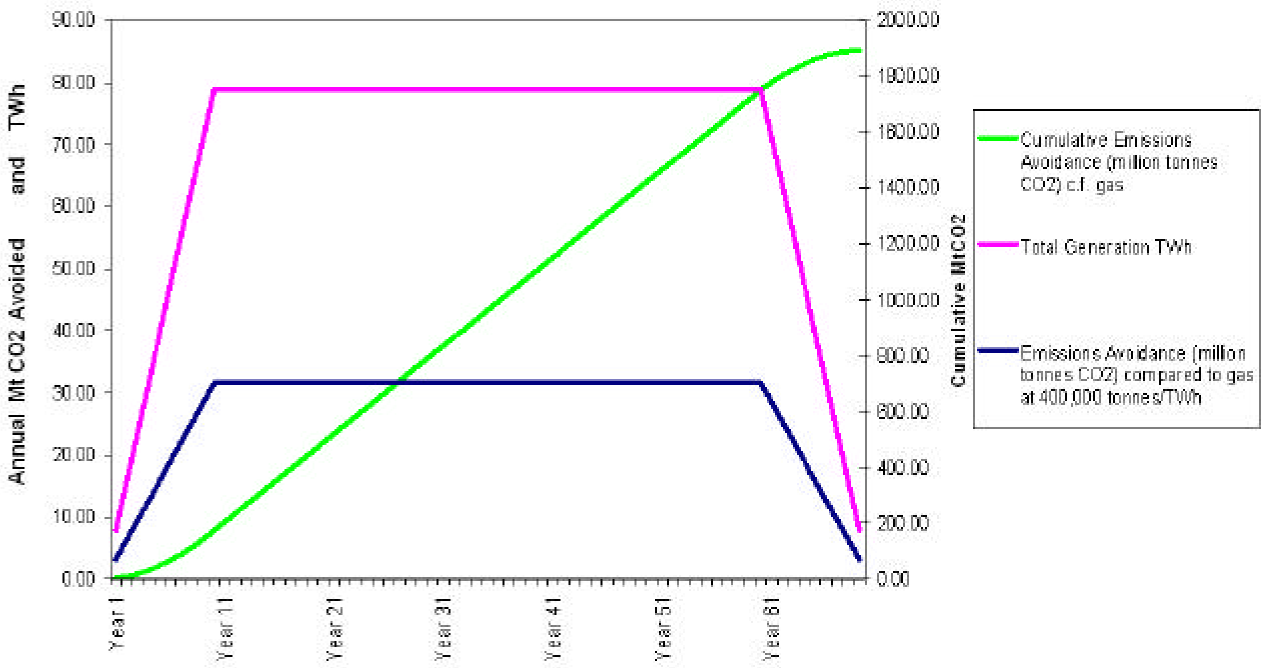
Currently, the UK nuclear fleet avoids the emission of over 32 million additional tonnes of carbon dioxide each year (relative to gas-fired generation). These emissions would be enough to cause greenhouse gas emissions from the electricity generation sector to rise by around 20%. However nuclear generation in the UK is beginning to decline as the current fleet is gradually being shut down.

4.6 Potential Future Emissions Avoidance From UK Nuclear Energy

The exact contribution to avoiding CO_2 emissions made by any potential future UK nuclear new build would clearly depend on the scale and timeframe of the specific programme. The contribution would also depend on what assumptions are made regarding what type of generation is being displaced by the nuclear generation.

However an illustration of what could be achieved is shown in the graph below. This assumes 10 new 1 GWe nuclear power stations are built on a timetable of one new power station per year, with each station operating for sixty years. Each nuclear power station is assumed to displace gas-fired generation, with emissions of 0.4 $MtCO_2$/TWh. (Note that this does not assume that new nuclear stations *replace* gas plant that is closing, simply that were the nuclear plants not built, it would be gas plants that were constructed instead.)

In this chart the annual electricity generation is shown in purple, measured on the left hand scale – leveling off at a steady peak of around 79TWh per year. The annual avoided emission of CO_2 is shown in blue (and again is measured on the left hand scale), and shows that over 30 million tones of CO_2 would be avoided each year. The cumulative CO_2 avoidance is shown in green, measured on the right hand scale, and reaches a total of around 1.9 billion tonnes of CO_2 from the full operation of this new build fleet.



CO_2 Emissions Avoidance and Power Output from Potential New Nuclear

In comparison total UK carbon dioxide emissions for 2004 (including those from industry, transport and domestic use of gas, etc) were around 580 million tonnes. Avoiding over 30 million additional tonnes of CO_2 per year therefore (as a new nuclear fleet would do) prevents a potential increase of 5% in the UK's total emissions.

Note that *without* new nuclear build, CO_2 emissions will tend to rise, as much of the UK's existing nuclear fleet closes over the next two decades. The example outlined above simply identifies the nuclear capacity needed to replace the current fleet and keep the overall contribution of nuclear at around 20-25% of UK demand. *Additional* low-carbon generation (renewables, fossil fuel with CCS or nuclear) would be needed in order to achieve significant reduction in CO_2 emissions from the electricity sector.

4.7 Other Benefits and Issues Associated with Nuclear Energy

Aside from the purely economic assessment of emissions reduction, nuclear offers other benefits.

> Using new nuclear also improves electricity security of supply. As noted earlier nuclear energy supplies reliable, baseload power, unaffected by weather conditions. Given the projected decline in UK nuclear capacity and the prominence of gas, adding new nuclear plant would help to preserve the current diversity within the generation portfolio. Fuel supply concerns are low, since uranium requirements are modest and source countries are generally politically stable ones, such as Canada and Australia.
>
> Incorporating a new series of nuclear power plants will help achieve climate change targets at a lower cost, diversify the generation mix and help tackle fuel poverty. New nuclear technologies, such as the AP1000 and EPR, are ready for deployment.
>
> The nuclear industry also plays a key role in the UK economy, employing 40,000 directly and supporting many additional jobs. Many of these are skilled jobs in areas where these are scarce, and future nuclear build would offer opportunities to maintain and grow the role played by the industry in this respect.
>
> A new generation of nuclear stations would also benefit the UK in terms of GDP and balance of payments, for instance through reducing gas imports. The benefit in GDP terms of a programme to replace the current nuclear fleet would be around £4 billion per year[23] once the stations are all operational. A substantial part of this benefit would come from the reduced need to import gas, which means that as gas market prices rise, the net benefit to the UK of a nuclear programme increases.

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[23] "*Macroeconomic Analysis of Nuclear Plant Replacement*"; Oxford Economic Forecasting; March 2005

There is extensive UK and international experience of managing reactor wastes; waste management and decommissioning is not a barrier to new nuclear build. Quantities of waste from 10 new reactors operating for 60 years would add less than 10% to the UK inventory. The UK can build on the successful approach to waste disposal that is being implemented in a number of other countries and the UK could adapt financial models, that have already been successfully implemented in other countries, to fund the disposal of waste, spent fuel and decommissioning.

4.8 Economic Advantage of Including Nuclear Energy in Climate Change Strategy

As noted earlier, it is important to ensure that policies adopted for emissions reduction represent best value to the taxpayer or energy consumer. A recent study by Oxera[24] concluded that nuclear energy was around three times more cost-effective than renewables (based on the Renewables Obligation) in terms of reducing UK carbon dioxide emissions.

A further recent report by the Public Accounts Committee[25] concluded that *"The Renewables Obligation is currently at least four times more expensive than the other means of reducing carbon dioxide currently used in the United Kingdom,"* Whilst existing RO commitments to investors in renewable projects must be honoured, continuing and extending the RO as the means of delivering much greater renewables capacity clearly appears to be sub-optimal in terms of public investment.

It is important that a future framework for delivering carbon savings is structured to facilitate delivery of the most cost-effective balance of low-carbon solutions – including renewables, fossil fuel with carbon capture, nuclear **and** energy efficiency.

4.9 Actions to Encourage Investment in Nuclear

The private sector is capable of taking forward replacement nuclear build in the UK. However, nuclear projects are relatively capital-intensive and perceptions of cost are very much determined by an investor's required rate of return. Potential risks, such as the possibility of extended timescales and scope of licensing and public inquiry, lack of clarity on waste management policy and the absence of a longer-term framework for pricing carbon emissions in the UK electricity market all lead to investors seeking higher rates of return to compensate for such issues. Such risks therefore have to be addressed if investors are to be encouraged to come forward. In all cases though, the action required to deal with the issue is one of political will and clarity over policy, not any requirement for financial subsidy.

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[24] *"Plugging the Carbon Productivity Gap";* Oxera; April 2005

[25] *"Department of Trade & Industry: Renewable Energy"*; Committee of Public Accounts HC 413; September 2005

The delivery of these actions will enable replacement nuclear build to compete effectively for private sector investment with other forms of generation.

Regulatory Approvals and Planning

Compared to past experience of nuclear build projects, where the approvals process was protracted and uncertain, better management and co-ordination of the delivery of approvals and the planning process is needed to ensure a much more predictable and timely delivery. The actions needed may include:

- Development of a regulatory strategy to improve the predictability of the various approvals processes and so underpin delivery in a timely manner, whilst maintaining robust scrutiny and public accountability. The strategy would set out what needs to be done, when it needs to be done and who needs to do it.
- The strategy also needs to define how regulatory risks during construction (eg due to delays or unexpected additional requirements) are minimised. This is achieved if all key approvals are granted before plant order, before the commitment to a major capital investment is made. Further regulatory approvals that will be needed during construction should be aimed at ensuring that the plant is built as originally specified and thus can have firm and clear timetables and requirements defined. Each organisation involved (eg Government, regulators, owner, vendor) needs to have clear accountability defined for the effective and timely delivery of regulatory consents and approvals and appropriate interfaces need to be set up to achieve this. Two important areas to be covered are the planning and public inquiry process and nuclear safety licensing.
- Early regulatory design review is essential to optimise timescales and incurred upfront costs. It would also be beneficial in preserving essential skills within the nuclear regulators
- For series build of a standard design, any follow-on reactors should benefit from the regulatory reviews completed for the first unit and should require a much shorter approvals process given that the main issues arising for follow-on reactors should largely relate to site-specific aspects.

To do the above will require all parties to make sure that plans are in place for sufficient resources to be available in time to cope with the substantial workload.

Market mechanisms

One of the factors that could help to secure private financing for a replacement build proposal would be a degree of confidence in the future revenues from sales of the electricity produced. Long-term contracts for electricity or carbon could be one way of helping to provide this confidence. For reasons discussed in Annex II, the market is not currently delivering long-term contracts: there may be a case for some form of Government action to help stimulate longer-term market behaviour, which could help the market to deliver the societal benefits of available energy sources, including nuclear energy, in a fair and transparent way. Other mechanisms could address the perception of risk among investment institutions (e.g. the risks associated with early phases of pre-construction activities). Choice of market mechanisms would be influenced by:

- The UK Government’s preferences and priorities in light of its wider energy policy objectives.
- A detailed and objective consideration of the likely impact of any particular scheme (on end consumer prices, competition in the electricity market, existing nuclear and renewables development, as well as on CO_2 emissions and reliability of supply).

Waste Management

The key issue in relation to nuclear waste management is the setting of a clear policy framework for long-term radioactive waste management.

The nuclear industry is able to manage all the technical aspects of spent fuel (including disposal). However, there would need to be sufficient visibility on the long-term arrangements for dealing with the funding and ownership of spent fuel from a new generation of nuclear stations. The UK could adapt financial models that have been successfully implemented in other countries to fund the disposal of waste (including spent fuel).

ANNEX I - GLOBAL CLIMATE CHANGE POLICY

The Kyoto Protocol

The Kyoto Protocol is an important first step towards combating climate change. Securing international agreement, even with the exception of the United States and Australia, has been a great achievement.

However, if future international action is to combat climate change effectively then a number of changes will need to be made:

- Re-engagement of the United States and retention of existing ratifiers of Protocol
- Greater clarity on how developing countries will participate
- Agreement on longer-term actions
- Improved operation of the Kyoto Mechanisms

Re-engaging all Countries in International Co-operation on Climate Change

The effectiveness of the Kyoto Protocol as a tool to promote cuts in global green house gas emissions was significantly reduced by the decision of the United States not to ratify the Protocol. The US is the source of nearly a quarter of the world's greenhouse gas emissions[26] and therefore its emissions will have to be reduced significantly if global emissions are to be taken down to safe levels.

The US *has* taken a number of actions to address climate change, even if the impetus for such actions has come from other drivers, such as concerns over security of supply.

It has embarked on a series of technology development programmes, including encouraging the development of nuclear energy and clean coal with carbon sequestration. In addition there is increasing regional interest in emissions reduction measures, such as emissions trading.

The US has continued to engage at the international level, and remains a signatory to the United Nations Framework Convention on Climate Change (UNFCCC). It has also entered into a number of bilateral and multilateral agreements aimed at tackling greenhouse gas emissions, such as the Asia Pacific Partnership. The US is also a partner in the Generation IV initiative, seeking to develop the next generation of nuclear energy technology.

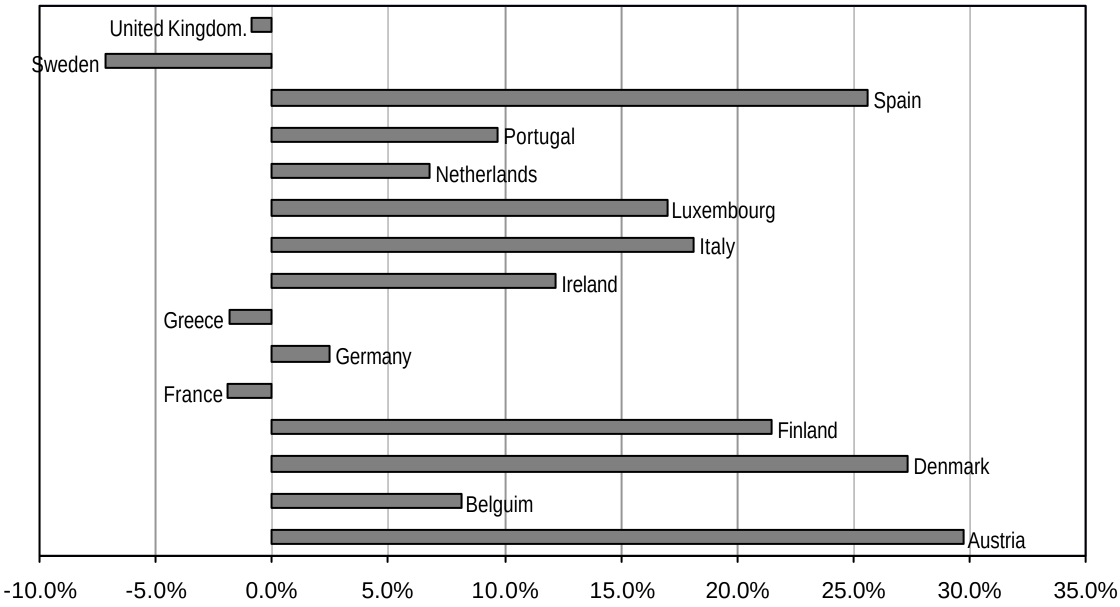
It is unlikely that the US will ever ratify the Kyoto Protocol in its current form. However, it is vital that the US is re-engaged in the wider international process. Global emissions can be reduced more efficiently through international co-operation, including the involvement of the US.

In contrast Europe has continued to show strong support for the Kyoto Protocol process, although many countries in the EU face a difficult task if they are to meet

[26] IEA Key World Energy Statistics 2005

their targets under the Protocol. Indeed, despite the support for the Protocol and efforts made to date, a recent EU report indicates that CO_2 emissions in the former EU15 nations will only be 2.5% lower than the 1990 baseline by 2008-2012 – well short of the 8% target reduction[27].

Percentage difference between 2003 GHG Emissions and Kyoto Protocol Target Under the Burden-Sharing Agreement of the EU-15



Some EU politicians have long described the Kyoto Protocol as "the only game in town".[28] Clearly with a dual track approach possible at COP/MOP1 and COP 11, the Asia Pacific Partnership and other climate change initiatives this is no longer the case. A way forward should be sought that aims to bring together the best characteristics of the different initiatives into a coherent international approach.

Participation of Developing Countries

The greatest growth in greenhouse gas emissions over the 21st Century is expected to take place in developing countries as they seek to meet the energy needs of their rapidly rising populations and expanding industrial economies. In India and China alone the expected increase in energy consumption is huge. China's energy demand has risen 65% in just the past three years – representing more than half of the global growth over that period - and the trend shows no sign of slowing. The new capacity built in China each year is roughly equivalent to the total UK capacity. Similarly, energy demand in India is growing at 7% per year.[29]

Developing countries rightly expect developed countries to demonstrate their commitment to reducing greenhouse gas emissions before discussing their own emissions under the Kyoto Protocol process.

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[27] *"Greenhouse Gas Emission Trends and Projections in Europe"*; European Environment Agency; November 2005
Reported at: http://news.bbc.co.uk/1/hi/sci/tech/4480400.stm

[28] Michael Meacher, BBC, 2002 http://news.bbc.co.uk/1/hi/uk_politics/1249180.stm

[29] *"Statistical Review of World Energy 2005";* BP; June 2005

However, emissions from developing countries will have to be addressed. Developing countries – largely due to their geographic locations and relatively fragile infrastructures - are expected to suffer a disproportionately high level of damage due to the effects of climate change. Furthermore the fragility of their economies will mean they will be less able to adapt to the effects of climate change.

The involvement of the leading energy-consuming developing countries in the so-called "G20" discussions held during the UK's presidency of the G8 is commendable, as a first step towards establishing a balanced approach between developed and developing countries.

The Asia-Pacific Partnership

The Asia-Pacific Partnership was announced in July 2005. It is a technology-led initiative involving the US, Australia, China, India, Japan, and South Korea.

The first full meeting of the APP will not take place until January 2006. The partnership does not require the use of mandatory targets for greenhouse gas emissions, and it is yet to be seen how effective the partnership will be in reducing greenhouse gas emissions. However, the engagement, at any level, of the US in multilateral agreements addressing climate change should be welcomed. The effectiveness of this partnership should be studied, and any lessons learnt should be shared and taken into account in other initiatives.

The Failings of Short-Term Policies

Many of the major sources responsible for greenhouse gas emissions have working lifetimes of decades. A car may be used for a decade or more; an aeroplane may be in service for 30 years or more; some power stations may generate electricity for more than half a century; and buildings, road and railway networks may be in use for centuries.

Decisions on the continued use or replacement of such sources are unlikely to be significantly influenced by the emissions reduction policies set on the timeframes stipulated by the Kyoto Protocol, or by the Government's own domestic target of a 20% reduction in CO_2 emissions by 2010.

Neither are the impacts of such sources likely to be improved by emissions reduction policies that have longer-term horizons, but which have uncertain impacts. The EU Emissions Trading Scheme is planned to run indefinitely, and as such could well be in operation for many decades. However, at present National Allocation Plans are not being set well in advance of the start of the compliance periods, and the lack of long term targets and uncertainty over the future price of carbon emissions allowances fail to give the necessary signals and impetus to business to promote long term investment.

The first commitment period under the Kyoto Protocol runs from 2008-2012. The Protocol itself only entered into force in 2005. Whilst the objectives of the first commitment period were known some years before that date, the compliance period of the Protocol is too short to influence the long-term infrastructure changes that will bring substantial reductions in greenhouse gas emissions.

Discussions on the second commitment period, to run from 2012, are due to start in 2005 and may conclude around 2009. This would only give a three-year lead-in to the start of any future commitments.

As we have no meaningful international targets for emissions reductions beyond 2012 little can be done to address this shortcoming. However, when targets are set for 2012 they must give a clear direction on international climate change policy over a time period much greater than five years, if they are to be fully effective.

THE SCIENTIFIC DEBATE

It is impossible to know exactly what effect the increasing levels of greenhouse gas concentrations in the atmosphere will have on the Earth's climate. This is not only because of uncertainty in the impacts of atmospheric concentrations on the Earth's climate, but also because of uncertainty over what levels of greenhouse gas emissions there will be over the coming centuries.

However, uncertainty over the precise scale and impacts of climate change is not sufficient reason to justify inaction. Decisions on a wide range of economic and policy issues are taken based on uncertain outcomes. We are convinced that the general scientific consensus on the probable impacts of unmitigated climate change is enough to justify urgent action to limit greenhouse gas emissions, and to take steps to prepare for the unavoidable changes to the climate that are likely to occur.

Of course, all policies and strategies should be regularly reviewed to take into account progress in the scientific understanding of climate change effects

The Intergovernmental Panel on Climate Change (IPCC) has provided valuable reviews of the ongoing improvement in scientific understanding of climate change, the impacts climate change will have and the potential contribution of mitigation options. However, it has restricted its scope to reviewing existing publications, rather than carrying out its own research.

It has also limited itself to considering peer-reviewed documents. While this may help in ensuring the quality of the documents being considered it has restricted the breadth of evidence the IPCC could consider. For example many publications from business and industry are not published in peer-reviewed journals for a variety of reasons. Yet many such reports are still of a high standard and contain useful information which could prove to be useful input into the IPCC process.

FUTURE INTERNATIONAL CLIMATE CHANGE POLICY

Options for Future Climate Change Policies

Future international climate change policies and agreements may be reached through one or more of the fora, the Kyoto Protocol, the UNFCCC, the G8 or multilateral agreements such as the Asia Pacific Partnership. The international community should work to ensure that the best ideas and practices are shared.

Extending the Kyoto Protocol

Under the terms of the Kyoto Protocol discussions will start in 2005 on future commitments by developed countries. Considerable effort has been put into developing an operational framework in which those Parties that have ratified the Kyoto Protocol can participate.

If further emission reduction commitments are made under the Kyoto Protocol then they should be over periods much longer than the 5 years timeframe of the first commitment period.

Initial discussions of future emissions reduction commitments will not include discussion of commitments for developing nations. Neither are they likely to include those parties that have not ratified the Kyoto Protocol, most significantly the US and Australia. Emissions will have to be controlled in these countries if a global response to climate change is to be successful. Any future emissions reduction commitments made under the Kyoto Protocol should not prejudice participation of the parties involved in broader climate change actions.

A challenge for those parties who have ratified the Kyoto Protocol will be to ensure they are suitably open to significant changes in future commitment periods. Parties should not be intransigent to change as a consequence of their support for the Kyoto Protocol process. At some stage it may be necessary to recognise that, although the Kyoto Protocol represents a good first step to achieving the long term objectives of addressing climate change, it may be appropriate to pursue a different form of international action.

A New Agreement through the UNFCCC

The United Nations Framework Convention on Climate Change has the ultimate aim of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This remains the objective of the Parties to this convention, whether or not they have ratified the Kyoto Protocol.

It is possible that a new agreement that would complement or supersede the Kyoto Protocol could emerge through the UN COP meetings. It is possible that discussions on engagement by all signatories to the framework could take place through the COP process.

Any such discussions would run as a parallel track to discussions under the Kyoto Protocol agenda. It will be important for the international community to ensure that, if parallel discussions do take place, progress on either track is not hindered by interactions with the other workstream.

Action Outside the UN Process

This year two new approaches for international action on climate change have emerged. Both the Asia Pacific Partnership for Clean Development and Climate and agreements reached at the G8 meetings during the UK's presidency have been described as complementary to the Kyoto Protocol process.

Such initiatives may be successful in reaching agreements more quickly than the somewhat bureaucratic approach of the UNFCCC process. Indeed, actions agreed under such initiatives may assist countries in meeting any targets or objectives set under agreements reached at the UN.

The Need for International Agreement

Climate change is a global problem that requires a global response. International cooperation will reduce the cost of limiting global greenhouse gas emissions.

The overall cost of reducing emissions should be reduced through the use of mechanisms such as Clean Development Mechanism (CDM), Joint Implementation (JI) and emissions trading, if these mechanisms function efficiently.

Agreeing joint action to address climate change can also reassure participants that the effort required to address climate change is being shared and can help alleviate concerns from business that national competitiveness is being harmed.

Adaptation and Mitigation

The early impacts of climate change are already being felt. More severe impacts are thought to be unavoidable, as atmospheric greenhouse gas concentrations will continue to rise and many climate change impacts, such as sea level rise, will continue long after atmospheric concentrations are stabilised.

Adaptation will therefore be an important element of any response to climate change.

However, mitigation must remain the primary objective of climate change policy. Without a significant reduction in greenhouse gas emissions it will not be possible to arrest the impacts of climate change and the costs of adaptation will rise. Ultimately there will be some trade off between the stringency of emissions reduction and the willingness to accept some adaptation costs. However, the threat of positive feedback mechanisms and catastrophic climate change effects are such that the cost of making emissions reductions is very likely to be lower than the potential cost of adaptation.

The Kyoto Mechanisms

The Kyoto Mechanisms, in particular Joint Implementation and the Clean Development Mechanism were designed to assist developed countries in meeting their greenhouse gas emissions targets by promoting international collaboration on projects to reduce greenhouse gas emissions. The Clean Development Mechanism was also intended to promote technology transfer to developing countries.

However, a combination of factors, including a lack of resources for the CDM Executive Board and a lower than expected demand for emissions credits due to the decision of the US not to ratify the Protocol, has meant that a disappointingly small number of projects have been approved. Improving the effectiveness of the CDM is a important objective for any future climate change negotiations.

The effectiveness of the Kyoto Mechanisms has also been reduced because of the arbitrary restriction on the use of credits from projects involving nuclear facilities. This restriction appears to have been included for primarily political, rather than environmental reasons. The restriction has been couched in complex language that makes the precise meaning of the restriction difficult to determine.

Nuclear energy is already being used in a number of developing countries, including China, India and South Africa, to meet their energy needs and contribute to their climate change objectives. The restriction on nuclear projects seems indicative of the unnecessary inefficiency of the Kyoto Mechanisms.

The Broader Policy Impacts of Climate Change

It is likely that the impacts of climate change will be disproportionately felt in developing countries. Small changes in climate could increase the frequency and geographical spread of famines that already blight areas of Africa. Bangladesh is particularly susceptible to rises in sea level.

Developing countries are likely to be more harshly affected by climate change because their economies are not sufficiently robust to allow investment in pre-emptive adaptation measures or to react to the impacts of climate change once they happen.

Efforts should be made through the Kyoto Protocol and other international agreements to promote capacity building in developing countries. Intelligent technology transfer should be encouraged, both to help address the global need to limit greenhouse gas emissions and to support the emerging economies of developing countries.

ANNEX II – LONG TERM POWER CONTRACTS

Introduction

This shortage of long-term contracts is a significant impediment to investment in new power generation projects. In recent years the main investment activity has been in renewables – predominantly wind projects. This is because their revenues are underpinned to an extent by the Renewables Obligation, which provides such projects with additional revenues from the sale of Renewables Obligation Certificate (ROC). ROC revenues are not correlated with the electricity market price.

Various commentators have suggested ways in which the Government may be able to facilitate investment in low-carbon power generation projects in the UK, proposing market-based mechanisms that overcome some of the risks presented by the absence of long-term contracts. Two recent contributions to the debate have come from Helm and Hepburn[30], and the consultancy Deloitte[31].

Long-Term Contracts can be Used to Underpin Investment

- Electricity, gas and carbon prices are very volatile. Would-be investors in a new power generation project are faced with prospective revenues that are linked directly to the electricity price. Even if the spot electricity price was at a level such that an investment initially appears highly profitable, there is no guarantee at all that the project would remain profitable in the long term, or indeed that it would remain in a position to service its debt.

- These issues are particularly challenging for investment in fossil-free generation technologies. In the case of a gas-fired power station, although its revenues are linked directly to electricity prices, its costs are linked strongly to gas and carbon prices. Electricity prices are likely to be strongly influenced by gas and carbon prices for some time to come, so a fossil-fired plant is to a significant extent self-hedging: if costs go up, so do revenues (and vice versa). A fossil-free plant, on the other hand, is completely exposed to floating electricity prices.

- Forward sales via long-term fixed price contracts can in principle provide a hedge to protect the future revenues, helping to guarantee that debts can be serviced. The term of the contracts must match (or exceed) the term of the debt.

- Because it is likely that, in the future, electricity prices will be closely related to carbon prices, it may be that long-term carbon contracts could provide a partial hedge for revenues. This is especially the case for carbon-free technologies, whose input costs are not related to the carbon price.

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[30] "Carbon Contracts and Energy Policy: An Outline Proposal", Helm, D R and Hepburn, C, 2005; available at http://www.dieterhelm.co.uk/publications/CarbonContractsOct05.pdf
[31] "Clearing the air: Moving towards a long-term carbon price", Deloitte September 2005; available at http://www.deloitte.com/dtt/cda/doc/content/UK_EIU_ClearingtheAir_Sep05.pdf

- There are, however, a number of reasons why the market is not currently delivering such long-term electricity or carbon contracts. These reasons are explored below.

There are Currently Major Barriers to Long-Term Electricity or Carbon Contracts in the UK

- Most end-users of electricity have little or no incentive to buy their power on long-term contracts. In most cases electricity costs make up only a small part of users' overall costs; and in the UK the competitive electricity market provides users with an incentive to shop round for their power reasonably frequently (large users have traditionally done this every year.)

- It is possible that an energy-intensive user contemplating investing in a new factory unit (or whatever) may consider backing that investment by a long-term purchase of electricity. There are, however, countries with much cheaper energy resources than in the UK (such as large scale hydroelectric schemes): a more competitive solution would be to locate a new energy-intensive factory where the cheapest energy is, if possible. For this reason it seems unlikely that many new energy-intensive users will choose to locate in the UK.

- In the UK, electricity supply is competitive at all levels in the market. There are no longer any "franchise" customers (customers situated in particular geographical areas within which electricity businesses can bid to acquire a temporary supply monopoly or franchise). So there are no customers onto whom it is possible to pass the risk that a long-term contract may become uneconomic.

- It is possible that the carbon market may turn out to be more symmetrical than the electricity market, in that there may be a better balance between market participants who have a need for long-term carbon permit purchases and those with permits to sell. However, the market is in its infancy, and the supply and demand for carbon permits is dominated by Government policy and international negotiations. There is no guarantee that the market will even exist beyond 2012. So it is unlikely in practice that willing buyers or sellers could be found for long-term carbon contracts.

- Credit risk is an additional barrier to long-term contracting. There can be no guarantee that an initially creditworthy buyer or seller of a long-term contract will remain as solvent in the long run. If a counterparty defaults, the remaining portion of the contract, if it is in the non-defaulting counterparty's favour, is likely to become almost worthless. So even if a willing long-term buyer could be found, there is no guarantee that the contract will be honoured.

- Such credit risks can be managed to an extent by collateralisation: but the mark-to-market value of a long-term contract can be very large indeed (one way or the other), and so the level of collateral required to guarantee it would be concomitantly large. This may make collateralisation impractical.