Sustainable Development Commission

SDC position paper

The role of nuclear power in a low carbon economy

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Introduction

1.1 Why the SDC is re-examining its nuclear position

The SDC's previous position on nuclear power was agreed in 2001 as part of our input into the Energy Review conducted by the Performance and Innovation Unit of the Cabinet Office. This formed the basis of our input to the Energy White Paper (EWP) process.

The 2003 Energy White Paper was a watershed in energy policy, and was unique internationally for committing the UK to a 60% cut in CO_2 emissions by 2050. Although it is now possible that this target will need to be increased, in order to meet the international obligation to avoid dangerous climate change, the EWP contained a bold vision for future energy supply and demand. The four primary goals were:

> **Putting the UK on a path to cut CO_2 emissions by 60% by 2050, with real progress by 2020**

> **To maintain the reliability of energy supplies**

> **To promote competitive markets in the UK and beyond**

> **To ensure that every home is adequately and affordably heated.**

The EWP outlined a vision for energy supply in 2020, which saw electricity supplies still based on a market-based grid, but with increasing commitment to more local generation and microgeneration. With a strong focus on energy efficiency, renewables, and greater use of combined heat and power (CHP), the EWP stressed the need for technological and economic innovation to help bring new technologies to the market, thereby creating future options.

Since then, there has been mixed success with the policy measures put in place to deliver these goals. Carbon emissions have been rising for the past three years, mainly as a result of increased use of coal in power stations due to high gas prices, but also due to increased demand for energy, despite the effect of a number of energy efficiency measures. Progress with renewables has been reasonably encouraging, and despite concerns over delays in the offshore wind sector, it is still considered possible for the UK to meet or get close to its 10% renewables target by 2010.

However, rising oil and gas prices have put pressure on consumers, and there is increasing concern that, over the longer term, the inevitable decline in the UK's North Sea reserves will lead to energy security problems. In the electricity sector there are worries that the decline of the UK's nuclear power capacity, due to scheduled closures, will reduce total generating capacity and could increase CO_2 emissions unless this capacity is replaced by carbon-free generation.

In response to these concerns, the Government has announced a new Energy Review, which will report after the Climate Change Programme Review finishes, in mid 2006. As the Government's advisor on sustainable development, the SDC decided during 2005 that it needed to revisit its position on nuclear power so that it was well placed to advise the Government on this important and controversial issue.

1.2 Nuclear power in context

Nuclear power currently provides around 20% of the UK's electricity. This translates into 8% of the UK's energy needs once other sources of energy, such as transport fuel and non-electric heating, are taken into account. Our evidence base shows how this contribution is scheduled to decrease over the next 30 or so years, assuming no plant lifetime extensions.

Since the 2003 Energy White Paper the fundamentals have not radically changed, and many of the measures introduced since 2000 are still in the process of bedding down. However, a number of commentators have since expressed concerns over the UK's energy policy, which can be broadly grouped as follows:

> **The 'generation gap': with nuclear and coal plants expected to close down, there is concern that the UK faces a shortfall in electricity generating capacity over the next 15 years**

> **Carbon emissions: there is concern that the 'generation gap' will lead to the construction of more gas-fired electricity generation, which will increase CO_2 emissions**

> **Security of supply: with increasing reliance on gas imports, there are concerns over the security of these sources, with potential impacts on both electricity generation and heat supplies; there is a feeling among some commentators that this issue was not sufficiently dealt with in the EWP**

> **Price instability: reliance on gas leads to the fear that energy prices will become more unstable, and could rise substantially over time, with potential impacts on the economy and fuel poverty**

> **Technology gap: the development of new technologies such as carbon capture and storage and hydrogen fuel cells may take longer than needed to fill the gaps identified above**

These concerns have led to calls for a commitment to new nuclear capacity, to replace the capacity coming offline over the next 30 years.

1.3 Energy supply options

Nuclear power is not the only option available to replace old nuclear plants, and there is therefore a choice to be made. Some commentators question whether the alternatives to nuclear would be able to deliver the capacity, carbon savings, and security of supply benefits that nuclear can. This point is addressed in our evidence base[1].

Having examined a broad range of studies that offer different scenarios of our energy future, it is clear that there is more than enough renewable resource in the UK to provide a diverse, low carbon electricity supply. All the scenario results suggest that it is possible to meet our energy needs in a carbon constrained economy without nuclear power.

[1] Paper 2 – *Reducing CO_2 emissions: nuclear and the alternatives*

Regardless of what we do on nuclear power a broad range of renewables will be required, and we will need to achieve the substantial energy savings that have been identified as cost effective using currently available technologies. Significant improvements in energy efficiency, leading to overall reductions in demand, is a priority for action. Developing renewables' capacity to the levels required will take time, so many models project greater use of combined heat & power (CHP) to use fossil and renewable fuels more efficiently, and the development of carbon capture & storage (CCS) technologies to help bridge the gap over the next 50 or so years.

In view of the widespread agreement by respected analysts that a viable energy future is possible for the UK without new nuclear power, the SDC has approached this issue as a ***choice*** rather than an absolute necessity. It is in this context that the SDC has examined the role of nuclear power in a low carbon economy.

1.4 The process for the SDC's review

The SDC has spent several months gathering an extensive evidence base in the following areas:

Paper 1: *An introduction to nuclear power – science, technology and UK policy*

Paper 2: *Reducing CO_2 emissions: nuclear and the alternatives*

Paper 3: *Landscape, environment and community impacts*

Paper 4: *Economics of nuclear power*

Paper 5: *Waste management and decommissioning*

Paper 6: *Safety and security*

Paper 7: *Public perceptions and community issues*

Paper 8: *Uranium resource availability*

We have attempted to provide a balanced and comprehensive view – both the positives and the negatives – so far as we are able. Therefore the papers will have elements that reflect the pro-nuclear and the anti-nuclear perspectives.

We are publishing the evidence base at the same time as our own position to provide a resource for Government and the general public to draw on. We believe such an evidence base is vital for there to be a truly informed debate on this issue.

Too often the debate around nuclear is highly polarised, with heavily entrenched positions on both sides. This does not help with a considered analysis of nuclear power, and tends to result in reports that seek to justify a pre-determined position. Such reports are easily dismissed by opponents and will be regarded with suspicion by those that are truly 'neutral'; they are therefore of limited value to the public debate.

Our stand-alone evidence base is published alongside this paper, as a separate resource.

1.5 Our approach

In March 2005 the UK Government and the Devolved Administrations jointly published a shared framework for sustainable development, '*One future – different paths*', in which five new principles of sustainable development were agreed across Government for all policy development, delivery and evaluation – see Figure 1. Based on these principles, the UK Government published its Sustainable Development Strategy, '*Securing the future*' to guide its policy-making process across different departments. We have therefore examined new nuclear development against these five principles.

In this paper we have not followed the five principles slavishly, as some are more significant for the nuclear issue than others. We have dealt with 'environmental limits' and 'sound science' together; we have looked in considerable depth at 'sustainable economy'; we have covered 'good governance' in relation to public engagement and in conjunction with 'a healthy and just society'.

In examining the evidence base, and taking into account the context of the five principles and the 2006 Energy Review, we have

Figure 1: UK sustainable development principles

Living within environmental limits

Respecting the limits of the planet's environment, resources and biodiversity – to improve our environment and ensure that the natural resources needed for life are unimpaired and remain so for future generations.

Ensuring a strong, healthy and just society

Meeting the diverse needs of all people in existing and future communities, promoting personal wellbeing, social cohesion and inclusion, and creating equal opportunity for all.

Achieving a Sustainable economy

Building a strong, stable and sustainable economy which provides prosperity and opportunities for all, and in which environmental and social costs fall on those who impose them (polluter pays), and efficient resource use is incentivised.

Promoting good governance

Actively promoting effective, participative systems of governance in all levels of society – engaging people's creativity, energy, and diversity.

Using sound science responsibility

Ensuring policy is developed and implemented on the basis of strong scientific evidence, whilst taking into account scientific uncertainty (through the precautionary principle) as well as public attitudes and values.

Securing the Future – delivering UK sustainable development strategy prepared this paper following extensive discussions at the Commissioner level with the following questions as our framework:

A. If we replace or expand our nuclear electricity generating capacity, what is the public good for the environment? (Living within environmental limits and using sound science responsibly)

> Is nuclear a truly low carbon technology, taking into account a full lifecycle analysis?

> What contribution can it make in combating climate change?

> What are the waste and decommissioning implications, and how will they be dealt with?

> What are the wider environmental impacts – in the UK and overseas?

B. What is the public good for our economy? (Achieving a sustainable economy)

> What are the total costs of nuclear power over the lifetime of planning through construction and operation to decommissioning and disposal of waste?

> What are the implications for security of supply?

> How would new nuclear capacity be delivered in the context of the UK's energy market?

> Is the lack of appetite for new nuclear power a case of market failure? Does the current market structure need reform?

> What are the implications for alternatives to nuclear power?

C. How is the public good best served in the decision-making process for new nuclear and how does it contribute to social well-being? (Good governance; strong, healthy and just society)

> How should policy on nuclear power be developed to assure public confidence?

> What are the implications of a UK decision for overseas governance issues of the nuclear supply and waste disposal chains?

> What are the implications of a decision on nuclear for planning and licensing conditions?

> What are the health implications of a new nuclear programme?

> What are the security risks associated with a new-build programme and how are these best managed?

> What are the risks associated with nuclear proliferation and how are these best managed?

2. Sustainable Development Analysis

This section will look at the case for nuclear power based on three areas of analysis, and using the five principles of sustainable development. The analysis below draws exclusively on the SDC's evidence base, which consists of eight separate reports that are published alongside this paper.

2.1 Environment

2.1.1 Low carbon status[2]

No energy technology is currently carbon free. Even renewable technologies will lead to fossil fuels being burnt at some point in their construction due to the high levels of fossil fuel usage in almost every transport mode and industrial process, including electricity generation. For example, wind turbines are built of steel, and fossil fuels are therefore consumed in their construction either directly, during manufacture, and also from petroleum usage when the parts are transported to the construction site. However, the fossil fuel used over the life of the turbine is 'repaid' in less than 10 months, as the turbines themselves generate zero carbon energy[3].

Nuclear power stations are no different, with large up-front energy requirements during construction[4], although this is balanced by the high power output of each plant. However, nuclear differs from many renewables in its requirement for mined fuel (uranium ore). Although the total volume of fuel used is low compared to the volumes of fossil fuel required in gas or coal plants, uranium mining and the subsequent fuel processing is an energy intensive activity that must be included for full lifecycle emissions analysis. Decommissioning and waste activities are also likely to require energy inputs, and therefore their long-term impact on nuclear power's CO_2 emissions will depend on the carbon intensity of future energy supplies.

Our evidence shows that taking into account the emissions associated with plant construction and the fuel cycle, the emissions associated with nuclear power production are relatively low, with an average value of 4.4tC/GWh, compared to 243tC/GWh for coal and 97tC/GWh for gas[5].

However, emissions from decommissioning and the treatment of waste also need to be assessed but this is difficult for two main reasons:

- **in the UK, decommissioning of existing plant is highly complex and involves plant that was not designed with decommissioning in mind**
- **the UK has not decided on its approach to waste management, which makes it difficult to assess the associated CO_2 emissions.**

The carbon impact associated with the 'back-end' of the nuclear fuel cycle is spread across all of the UK's nuclear power plants (active and decommissioned) and includes all of the electricity generated over their lifetime. Newly commissioned plants are likely to have lower lifecycle carbon emissions than for previous reactor designs, because of improvements in plant design (for example, smaller size, and improved thermal efficiency and use of fuel), and because new plant is designed so that it can be dismantled and decommissioned more easily.

A number of commentators have expressed concerns that any move to low-grade uranium ores could substantially increase the carbon intensity of nuclear power. Our evidence on uranium resource availability[6] shows that predicting if and when this might happen is very difficult to do with any accuracy. Resource availability is discussed in more detail below, but it is by no means certain that all the high grade ores have been discovered, and any increase in the price of uranium could trigger renewed interest in uranium prospecting.

It is worth noting that the CO_2 emissions associated with many of the construction inputs into a nuclear power plant could be subject to emissions trading schemes, depending on their country of origin. This presents a possible solution to the lifecycle emissions problem if

[2] Paper 2 – *Reducing CO_2 emissions: nuclear and the alternatives*
[3] Sustainable Development Commission (2005). *Wind Power in the UK*.
[4] In addition to carbon emissions from the production of concrete.
[5] These figures are for carbon (C) rather than CO_2. They have been converted from the data used in our evidence base by multiplying the CO_2 figures by 12/44.

as many of the inputs as possible could be brought within a comprehensive emissions trading regime. This could be achieved directly, by including those industries that supply nuclear plants, or indirectly by requiring carbon certificates for the calculated carbon value of imported inputs.

In the long-term, the move towards a low carbon economy more generally should lead to a reduction in the emissions from nuclear-related activities, but this will depend to a large extent on the uptake of low carbon technologies in the relevant sectors (e.g. mining, and fuel processing).

Our evidence leads us to conclude that nuclear power can currently be considered a low carbon technology, but that a number of concerns remain over its long-term energy requirements from 'back-end' liabilities, and the potential impact of increasing the use of low-grade uranium ores. The priority should be to internalise any outstanding carbon costs as far as possible so that it competes equally with other low carbon technologies.

In our analysis of the possible contribution of nuclear power to reducing CO_2 emissions, the lifecycle emissions from nuclear power are not included. This allows a fairer comparison with other low carbon technologies, all of which will have some associated emissions.

2.1.2 Climate change benefits[7]

In the 2003 Energy White Paper, the Government outlined its long-term objective to cut CO_2 emissions by 60% from 1990 levels by 2050, with significant progress by 2020. On the basis of this goal we have assessed the potential contribution nuclear electricity generation could make to reducing CO_2 emissions over the long-term, based on two scenarios for nuclear new-build.

Nuclear power currently makes up around 20% of UK electricity, and around 8% of total UK energy supply. Electricity generated from nuclear power currently displaces around 14 million tonnes of carbon (MtC) per year, with a range of 7.95MtC to 19.9MtC (depending on whether it is assumed to displace coal or gas-fired electricity generation). This is equivalent to around 9% of total UK CO_2 emissions in 2004 (with a range of 5-12.6%).

As the large range in these figures illustrates, the actual contribution of nuclear power to reducing CO_2 emissions depends heavily on what type of plant, or fuel, it displaces. If the fuel is carbon intensive, such as coal, then the savings are large, but if nuclear were to displace a low carbon technology, such as wind power, then there may be no carbon saving. The DTI currently assumes that the standard least-cost comparison plant is gas CCGT (combined cycled gas turbine). This seems a reasonable assumption over the next 20 years, although in reality this is very dependent on gas and carbon prices.

Our evidence assumes that new-build nuclear plant would displace new-build gas CCGT plant, which has an emissions level of around 90tC/GWh – i.e. if nuclear plant is not built then gas CCGT would be built instead. The case is similar for renewables, which at present are displacing output from old coal and possibly gas plant, but in the long-term would most likely displace new-build gas CCGT. There is no overlap between nuclear and renewables, or any other low carbon technology, and until the combined capacity of such technologies is very high (which is not a realistic prospect for many decades based on current trends), they are all likely to result in CO_2 savings from the displacement of gas plant.

Our evidence looks at two scenarios for nuclear new-build above our current baseline of declining capacity: replacement of existing plant (10GW), and an expansion that would roughly double current capacity (20GW).

It is important to note that there are constraints on how quickly a replacement or expansion of nuclear capacity could be constructed. Our replacement and expansion scenarios assume a maximum build rate of 1GW per year starting in 2015, which would deliver 10GW by 2024, with a similar rate of new-build under the expansion scenario delivering a further 10GW by 2034.

Although the build rate may be faster during 2024-2034 (for example as lessons learned from early projects are applied to later ones), it may equally be more protracted between 2005 and 2024 (for example due to licensing and planning problems, opposition from the public, or problems of supply if several countries demand new orders from a limited number of suppliers). We note that Britain has no recent track record of nuclear plant construction, and the most likely reactor designs would be imported.

Detailed analysis, and a full explanation of the assumptions used, is given in our evidence base. However, it is clear that the nuclear contribution to a 2020 CO_2 reduction target would be limited, with the full carbon benefits occurring over the following decades. To avoid any uncertainties over the build rate, the emissions savings figures for the total capacity installed under each scenario should be used.

These show that a replacement programme consisting of 10GW of new nuclear capacity would displace 6.7 MtC, which represents a 4% cut in CO_2 emissions from 1990 levels (165.1MtC). An expansion programme would double these figures, with 20GW delivering around 13.4MtC of emissions savings, equal to an 8% cut in emissions.

[6] Paper 8 – *Uranium resource availability*

[7] Paper 2 – *Reducing CO_2 emissions: nuclear and the alternatives*

It is therefore clear that a new nuclear power programme would deliver sizeable reductions in CO_2 emissions. However, it is also important to realise that cuts of at least 50% would still be needed from other measures to meet the 2050 target, even with a doubling of nuclear capacity from current levels. Nuclear power can therefore be seen as a potential carbon reduction technology, but this must be viewed within the context of the much larger challenge we face. We will need a wide variety of solutions; those that decrease our demand for energy, and those that can deliver low or zero carbon energy supplies.

2.1.3 Waste and decommissioning issues[8]

There is a need to distinguish between the legacy impacts of decommissioning and waste management of the existing nuclear capacity, to which the UK is already committed, and the impacts that would result from a new nuclear programme.

The current legacy for decommissioning existing nuclear power plants is not directly relevant to decisions about whether to progress with nuclear new-build. However, such a legacy is one of public concern, particularly in relation to the cost. A recent review by the NDA suggests that their accelerated approach for the decommissioning of existing sites will cost approximately £56bn. Much of this covers a large number of non-power producing facilities, but certainly the costs of decommissioning old Magnox reactors are substantial. Our evidence points to costs of £1.3bn and £1.8bn in two cases, and this is before waste disposal.

The proposed new nuclear plant designs are expected to require much less expensive decommissioning, as unlike most existing plants, decommissioning has been given more consideration in the design process. They are also expected to produce less waste by volume. Our evidence estimates decommissioning costs at between £220m and £440m per GW of capacity, but this is before long-term waste disposal costs.

A new-build replacement programme (10GW) would add less than 10% to the total UK nuclear waste inventory (by volume). Assessing the increase in radioactivity of the inventory is complex and depends on reactor design and use, and the time chosen for the comparison. Thus, ten years after removal, the increase in activity could be a factor of nine, declining to a factor of 0.9 of current total activity 100 years after final fuel removal.

The role of reprocessing as a waste management tool is complex because of the costs (relative to the price of primary uranium) and safety and security issues (for example, the risks of proliferation – this is discussed further in Section 2.3.3 on security).

All wastes have to be managed over the long-term so as to protect people and the environment. A dominant challenge of much nuclear waste is the period of hundreds of thousands of years over which it must be effectively isolated from people and the environment. This raises issues that are unique to nuclear waste, such as the long-term stability of our civilisation and climate, and the extent to which future technological advances might bring forward solutions so-far unknown.

Nuclear wastes in the UK are divided into three categories:

> **High level wastes (HLW)** are those in which the temperature may rise significantly as a result of radioactive decay. This factor has to be taken into account in the design of storage or disposal facilities. HLW comprises the waste products from reprocessing spent nuclear fuels.

> **Intermediate level wastes (ILW)** are those exceeding the levels of radioactivity for Low Level Waste (LLW), but which do not require heat production to be taken into account in the design of their storage facilities. ILW include nuclear fuel casing and nuclear reactor components, moderator graphite from reactor cores, and sludges from the treatment of radioactive effluents.

> **Low level wastes (LLW)** are wastes not suitable for disposal with ordinary refuse but do not exceed specified levels of radioactivity. Most LLW can be sent for disposal at the National Low Level Waste repository at Drigg. LLW that is unsuitable for disposal is mostly reflector and shield graphite from reactor cores, which contains concentrations of carbon-14 radioactivity above those acceptable at Drigg.

Spent fuel, which contains uranium and plutonium, is currently not classified as waste in the UK because it contains resources that can be reprocessed and used again as fuel or for other uses. If, however, the UK decided to abandon reprocessing as part of its waste management strategy, then spent fuel would need to be reclassified as HLW.

The Committee on Radioactive Waste Management (CoRWM) has established a baseline inventory, based on planned closure of existing plant, no new-build, reprocessing of spent fuels, and continuation of current practices for the definitions of waste. All radioactive wastes, including spent fuel, are packaged so that they are in a form suitable for storage, volume estimates are based on packaged wastes. The baseline inventory includes all wastes both in existence and forecast to arise in the future (for example from decommissioning). The baseline inventory shows that over 90% of radioactivity is associated with HLW and spent fuels, but

[8] Paper 5 – *Waste management and decommissioning*

these comprise less than 2% of the inventory by volume.

The relationship between managing historic and current waste arisings and waste arising from any potential new-build is complex. CoRWM's priority, as defined in its terms of reference, is to develop a publicly acceptable solution to current and historic waste arisings. But the issue of new waste arisings has generated sharply opposing views among stakeholders, and the public perception of nuclear power is strongly conditional on solutions to the waste management problem (see section 2.3.1).

Phased deep geological disposal is generally seen as a strong contender for dealing with the UK's nuclear waste, and one that offers a reasonable compromise between intergenerational justice and scientific certainty. Site-specific geology is important for deep geological disposal but in the past it has been difficult to survey and select the most suitable sites due to local opposition, as was shown with the rejection of the planning application for the Nirex Rock Characterisation Facility in Sellafield in 1997. Attempts to survey sites during the 1970s and 1980s were abandoned on economic grounds and because of public opposition.

Thus, although 30% of the UK may theoretically be considered to have suitable geology for deep disposal of nuclear waste (including clay, crystalline and sedimentary rocks), it has proved difficult to match technical suitability with public acceptance.

Although CoRWM is due to present its recommendations to Government in July 2006 as part of the ongoing Managing Radioactive Waste Safely programme, it would appear that implementation of an agreed policy for the long-term management of radioactive wastes could remain several years away. Indeed, it has taken Finland (the only country with an agreed waste management policy) around 25 years for an acceptable solution to be agreed and implemented.

Evidence to CoRWM estimates that the cost of phased deep geological disposal of nuclear waste would be around £13bn, although it is unclear what impact a new nuclear programme would have on these costs, and whether more than one repository would be necessary. This may not cover the total cost of waste disposal, such as the low level arisings which are generally dealt with through near surface disposal.

2.1.4 Reprocessing

Reprocessing can be used as a means of managing waste, in that it reduces the amount of problematic HLW from the waste stream[9], leaving higher volumes of non-heat producing ILW and LLW. As the spent fuel is separated into plutonium (for use as mixed oxide fuels, or MOX) and uranium, it can be enriched again for use as fuel. However, this practice is controversial mainly because:

> **stockpiles of separated plutonium risk being exploited in an uncontrolled way, leading to concerns about proliferation (see Section 2.3.4)**

> **the majority of nuclear discharges into the NE Atlantic are from reprocessing plants[10] (Sellafield and Cap de la Hague) and therefore these are the major source of pollution**

> **it is often claimed that reprocessing is uneconomic.**

Such evidence would suggest that reprocessing should not be part of the nuclear fuel cycle of a new generation of nuclear plants. However, the UK may want to consider making use of its existing plutonium stockpile by burning MOX fuel in existing or new nuclear power plants.

2.1.5 Environmental and landscape impacts[11]

Mining is the dominant landscape impact from nuclear power. Although there are no uranium reserves in the UK and most is extracted from Australia, Canada and Kazakhstan, it is important from a sustainable development perspective to recognise the landscape and community impacts of this activity wherever it occurs as part of the 'footprint' of nuclear power.

In many respects the environmental impacts of a uranium mine are similar to those of metalliferous mining, its land-take depending on the concentration of ore – but the radioactive content of waste materials (e.g. spoils and tailings[12]) is a significant difference.

Underground extraction is the most commonly used technique. In-situ leaching[13] is widely used as a low cost method and has the least visible landscape impact, but groundwater rehabilitation and pollution can be a concern. There are significant legacy issues including aquifer pollution in countries of the former Soviet Union and Central and Eastern Europe.

The total land requirement for 1GW of nuclear capacity, including mining and the fuel cycle, is between 100 and 1,000ha. This is similar to the land-take for terrestrial wind energy.

Key concerns about uranium extraction in both developed and developing countries include:

> **the exclusion of traditional owners from the management and protection of their lands including site selection, and ongoing environmental regulation, monitoring and reporting**

> **the need to review a complex regulatory regime to clarify roles and responsibilities,**

[9] Paper 5 – If spent fuel were not reprocessed in the UK it would be classified as HLW; therefore, reprocessing reduces the total theoretical volume of HLW by separating out plutonium and uranium.

[10] Paper 6 – *Safety and security*

[11] Paper 3 – *Landscape, environment and community impacts*

[12] These are the sands left after uranium has been chemically removed.

[13] This technique involves using acid or alkaline solutions to leach out uranium from highly porous deposits, such as sands, underground

including whether the extent of self-regulation is appropriate

> **ongoing surface and ground-water pollution issues both for current and future activities.**

Some of these problems can be managed through regulation and management, but this can be compromised by, for example, poor governance, short-term cost considerations and possible conflict with economic goals and development aims. This can result in products being brought to world markets at prices that do not reflect the full social and environmental costs of their production.

However, any mining impact from nuclear power activities needs to be balanced against the potential environmental and health impacts of the energy sources it might displace. The health and safety impacts of coal, for example, are significant, as are coal's environmental impacts in the form of air and groundwater pollution. Oil and gas exploration also have environmental and health impacts.

There is general agreement that any new nuclear power programme would try to make use of existing nuclear sites, thereby limiting landscape and visual impacts. It is also the case that nuclear power plants are very similar to conventional fossil fuel plants in terms of local environmental and landscape impact, so the net impact of additional nuclear capacity is likely to be minimal[14].

However, some coastal sites may not be suitable for new nuclear power stations and flood-risk criteria may lead to a preference for new inland sites. This is because of the need to 'climate change-proof' decisions on where to locate new plant to be sure they take into account changes in climate that are already in the pipeline. The criteria that were used to select the current mainly coastal locations are up to 50 years old and will need to be reviewed, as many nuclear power stations and other facilities are vulnerable to sea-level rise, storm surges and coastal erosion over the next few decades.

In view of the need to reassess the suitability of existing sites, further consideration needs to be given to their viability over the longer term.

2.1.6 Summary

Our evidence shows that nuclear power could theoretically make a substantial contribution to efforts to reduce CO_2 emissions, as a viable low carbon technology. However, the evidence also shows that even by doubling our existing nuclear capacity, a new nuclear power programme can only contribute an 8% cut in emissions on 1990 levels, so a wide variety of other measures will be needed.

Nuclear power is therefore a viable option for tackling climate change, but as we state in Section 1.3, for the UK it is a choice whether it is part of the overall energy supply mix, rather than a necessity.

Nuclear waste and decommissioning raise a set of complicated issues with very long-term impacts. Considering the impact of nuclear new-build in isolation, we accept that future nuclear plant designs will be far easier to decommission and that it is possible to do this in a way that limits the environmental impacts. However, the long-term management of nuclear waste poses significant environmental problems that are difficult and costly to resolve.

We look at intergenerational considerations in Section 2.3.6, but on the environmental side it is difficult to be completely confident that the solution proposed for long-term waste management will avoid any adverse environmental impacts over the time periods involved.

On reprocessing, there remain serious concerns over the long-term security and economic viability of this form of waste management, with many in the industry now calling for a 'once-through' fuel cycle. The evidence would seem to support this conclusion, although there remains the question of dealing with the UK's plutonium stockpile.

Other environmental impacts from nuclear power centre on uranium mining, which can have a number of adverse effects in producer countries. However, such impacts must be balanced against the environmental and health & safety concerns related to alternatives sources of energy, especially fossil fuels.

2.2 Economy

What is the public good for our economy? (Achieving a sustainable economy)

2.2.1 Total cost of nuclear power[15]

Our evidence strongly suggests that attempts to estimate the cost of a new nuclear programme are unlikely to be accurate. This is primarily because there is not enough reliable, independent and up-to-date information available on the nuclear plant designs available for such calculations to be made. In addition, waste and decommissioning costs are, at present, not fully known.

The levelised cost of nuclear power (the p/kWh cost of output) is heavily dependent on capital costs. This makes the cost of nuclear output very sensitive to both construction costs, and the discount rate used (the required rate of return for the project).

[14] Paper 5 – This is under the assumption that nuclear capacity would most likely be replaced by fossil fuel plant, with or without carbon capture and storage technologies.

[15] Paper 4 – *Economics of nuclear power*

History shows us that construction costs for nuclear power plants can be inflated by regulatory issues, delays, bad management, and on-site problems. Our evidence also suggests that there may be a degree of 'appraisal optimism' in the industry projections of construction costs, and, with the only recent example (the EPR under construction in Finland) clouded by hidden subsides, it is unlikely that this information deficit can be filled.

The nuclear industry claims that private sector discipline, lacking in previous programmes, would help to ensure that any appraisal optimism is recognised and overcome. However, even if the private sector were to deliver a new-build programme, there is the possibility of moral hazard, which could act as a form of Government guarantee even when this is not part of Government policy. The term moral hazard is commonly used in the insurance industry to describe the phenomenon whereby individuals or organisations may purposely engage in risky behaviour, knowing that any costs incurred will be compensated by the insurer.

Moral hazard may affect the nuclear industry because investors and companies who decide to take part in nuclear projects, both directly and indirectly, may be willing to take on higher levels of risk than otherwise under the expectation that the Government would be unwilling or unable to let the project or enterprise fail. An example of this can be seen with the rescue of British Energy, Rover and the Millennium Dome. This will tend to depress balance sheet costs, but could in the long run lead to large costs for the taxpayer, in effect acting as a form of subsidy that is virtually impossible to avoid.

The waste and decommissioning elements of the cost calculation are fraught with complications, particularly because these costs occur so far in the future. With UK nuclear waste policy still undecided, there are no certain estimates of the total cost of waste disposal for new-build plant. Therefore any attempt to 'put aside' funds to deal with these costs may expose future generations to cost overruns, especially if the scientific requirements for waste storage and disposal change over time or the plant generates less revenue than forecast (for example because of operating and maintenance problems).

Nuclear power also has a number of external costs which are not usually calculated as part of standard cost calculations. These costs include safety and security arrangements, limited liability guarantees, health issues (either from routine operation or the risk of accidents), complex licensing and planning arrangements, and the cost of possible foreign policy interventions in securing access to uranium.

This does not mean that nuclear power is not a viable, economic option. Once built, nuclear reactors produce useful, low carbon electricity[16] for many years, and have low operating costs. However, this means that it is cheaper to supply nuclear output than to switch reactors off and this makes nuclear power a 'price taker', as it is unable to dictate the market price.

This fact, along with the technical characteristics of nuclear reactors (e.g. long start-up times), means that nuclear output performs a baseload function in virtually all cases. This will continue to be the case until large-scale electricity storage technologies become much cheaper, enabling nuclear power (and, possibly, some renewable technologies) to perform a load-following function.

2.2.2 Security of supply[17]

The fuel component of nuclear electricity generation is a very small part of the overall cost, and is relatively small in volume per unit of output. Therefore, nuclear is often referred to as a domestic source of energy, as it does not need a continuous supply of fuel – rather, fuel is loaded every year or so.

However, the small quantity of delivered fuel originates from a much larger supply of raw uranium and in the UK all of this is imported. Our evidence shows that there are some serious concerns over the short-term availability of uranium supplies, and although this is unlikely to be relevant to new-build plant, it does raise questions for security of supply due to the long lead times for developing new uranium mines.

However, our evidence also suggests that on current predictions, there are no major concerns over the long-term availability of uranium. A manageable increase in price would stimulate a significant increase in economically viable reserves, without allowing for further exploration.

Our evidence also points out that in the past uranium reserves have been consistently underestimated, and that as a resource it has had far less prospecting than other minerals. This would suggest there is probably enough uranium at a reasonable price to match future demand, and that as uranium represents a very small part of the overall cost of nuclear power, the impact of future price rises will be limited.

The long-term security of uranium supplies is heavily influenced by geo-political factors, particularly as countries such as Kazakhstan and Russia become important players in the world uranium market alongside traditional suppliers such as Australia and Canada. Despite an official policy on ensuring diversity in supplies, instability in a major producer country could have a serious impact on both price and, more importantly, fuel security. The predicted

[16] As discussed in section 2.1.1 above, nuclear power does not emit CO_2 directly, but there are lifecycle emissions to take into account.

[17] Paper 8 – *Uranium resource availability*

temporary shortfall in uranium supplies over the next decade also highlights a potential weakness in the uranium market: the long lead times for developing new resources.

For domestic electricity supply, nuclear power may offer a hedge against high fossil fuel prices or temporary supply disruptions, but cannot offer complete security due to its reliance on imported uranium. In this regard, nuclear power is not a domestic source of electricity in the same way as renewables.

Uranium resources may also show price volatility, particularly in the short-term when shortages are expected. However, evidence on portfolio theory suggests that greater diversification of supply sources tends to reduce price risk, particularly when fuel costs are zero (as in the case of most renewables) or low (as in the case of nuclear)[18].

On balance, nuclear power has positive attributes for security of supply consideration, but these should be viewed on a portfolio basis and are not exclusive to this technology. Diversification into any basket of electricity generating options will help to reduce price risk and increase security.

It is also frequently claimed that nuclear power is necessary to provide baseload power. However, there is no justification for assuming that other plant cannot also perform a baseload function, and contrary to popular perception, the increased variability (sometimes termed 'intermittency') of some renewable technologies does not increase the need for more 'firm', or baseload, capacity[19]. Therefore, nuclear plant will need to be assessed against the long-term wholesale price of electricity within the confines of a carbon constrained, and environmentally sensitive, economy.

2.2.3 Market delivery

Our evidence suggests that nuclear power may find it difficult to compete in the UK's liberalised energy market without some form of public sector support. This is due to the long lead times of nuclear power and its high risk profile, which may discourage investors. However, the Government has made it clear that any new nuclear programme will need to be delivered solely by the private sector.

This does not rule out the possibility that the Government may decide to help support the development of new-build plant, either financially or through 'practical measures'. Our evidence points to a number of financial support options that the Government may consider, but there is uncertainty over whether they would be both legal (under EU state aid rules), or compatible with the Government's stated belief in liberalised markets.

2.2.4 Market design[20]

The concept of specifying the ideal proportion of each single technology in the UK's generating mix belongs to a previous regime, where electricity supply was a nationalised industry. If liberalised markets are to be the primary mechanism for the delivery of electricity supplies, then this constrains the ability of Government to centrally plan the fuel mix, without major interventions in the market.

Energy policy aims such as CO_2 emission reductions and security of supply can be delivered by markets if the right structures are put in place. The market has so far performed well on security of supply, and the incentives are in place to ensure that new capacity is developed before shortfalls in supply develop – this is done through a simple price mechanism. To deliver this new capacity whilst reducing CO_2 emissions requires the electricity market to take account of national or international carbon constraints, and to factor these in to long-term investment decisions.

The current market for carbon is based on the EU Emissions Trading Scheme (EUETS), which is currently designed to run in three year periods, with caps set by national governments in advance of each commitment stage. This inherently short-term system provides no long-term framework for investors, and is currently based on emissions cuts from projected baselines rather than absolute cuts from current levels.

The SDC believes that the EUETS should aim towards total downstream emissions trading, which would eventually need to include the whole economy – business, transport (including aviation), the public sector, agriculture and, very importantly, individuals. EU-wide caps on emissions should be determined by a long-term emissions reduction target, which should then be divided into annual decreases which would form the basis of the EUETS or its successor. This system would give near complete certainty of intention, and should assist investors in taking long-term decisions on low carbon investments.

There are two alternatives to this approach: develop mechanisms which intervene in the market to encourage specific technologies or technology groups, or reform the current market design to allow for more centralised planning.

The Renewables Obligation is an example of market intervention, and was justified by the Government as necessary to promote the innovation and scale needed to create a viable, large-scale renewables sector. In this regard, renewables were identified as suffering from market failure due to their lack of collective technological maturity. Can the same be said about nuclear power?

[18] Shimon Awerbuch (University of Sussex) has done extensive work in this area.

[19] A large percentage of variable renewables would increase the need for 'balancing services', but would not lead to the need for additional baseload capacity, as the increase in reserve requirement is met from remaining plant. In addition, diversity of sources will always reduce the need for reserves. This issue is explained in detail in the SDC's publication, *Wind Power in the UK* (2005).

[20] Paper 4 – *Economics of nuclear power*

There would not appear to be a case for innovation support for a new nuclear programme with reactor designs based on existing technologies ('Generation III' designs). The technologies that might compete for a UK order are all versions of mature technologies, with a long history of operation combined with substantial public subsidy. In addition, the nuclear industry itself claims that these reactors are 'market ready'.

Our assessment therefore is that new nuclear development should not qualify for market intervention in the same way as renewables do through the Renewables Obligation (RO). The RO was established to provide the fixed-term support necessary for renewables to meet Government targets and was justified on innovation grounds. On the basis of this assessment we would not, therefore, support a proposal to amend the RO to enable public resources from fuel bills to be used to support the development of nuclear power.

The Government has consistently put liberalised energy markets at the heart of energy policy, a policy started by the previous administration. It therefore seems unlikely that any major changes would be made to the basic design of the market.

2.2.5 Impact on alternative energy sources

Our evidence[21] looked at the possibility that investment in nuclear power would detract from investment in renewables. Assuming that new nuclear plant would be privately financed, the conclusion from the evidence was that there was unlikely to be an economic impact, although this did not rule out a political impact. The SDC is concerned that political attention would shift and undermine efforts to increase the proportion of renewables in the energy mix, and the efforts to improve energy efficiency throughout the economy.

Government support for renewables and energy efficiency since the 2003 EWP has been mixed. On the one hand the Renewables Obligation has been raised to deliver 15% of electricity from renewables by 2015, and progress with commercially viable, large-scale renewables such as wind and biomass co-firing has been encouraging. On the other hand the Government has done less to stimulate the market for microgeneration, and the funding on offer for this sector over the next three years is small (at £30m), and unlikely to put the UK on course for mass-market penetration. Similarly, many of the planning barriers to microgeneration have not been adequately tackled.

On energy efficiency, good progress with the Energy Efficiency Commitment (EEC) by energy suppliers has been overshadowed by rising energy demand, and the Government's commitment to much tougher building standards for new buildings is now seriously in question. While changes to the Building Regulations are encouraging, the proposed Code for Sustainable Homes, intended to be the 'pull' for more advanced buildings standards including encouragement for microgeneration, is currently inadequate in this regard.

It is clear that the Government has largely been successful when dealing with centralised and relatively straightforward policies, but has struggled when faced with more complex, decentralised issues, or those that require a large number of minor fixes, rather than a single over-arching solution. This 'attention deficit' on the part of Government is very relevant to the nuclear issue, where a single-minded focus on one large solution could lead to a significant decrease in both political and economic attention for the wide variety of smaller solutions that we will need over the long-term to move to a low carbon economy.

The SDC is also concerned that commitment to a new nuclear programme would send a strong signal to all energy users that the pressure for reducing individual energy demand has been lifted. Such a signal would be extremely problematic for any future sustainable energy strategy, as the need to reduce demand is a key part of delivering the carbon savings we need, irrespective of whether a new nuclear programme goes ahead.

There is also some evidence to suggest that making consumers more aware of their energy consumption can lead to more sustainable energy use, and more sustainable consumption of other goods and services[22]. Bringing energy generation closer to the point of end use is one way of doing this, but efforts to achieve this may conflict with a nuclear-centric approach.

While our evidence indicates that new nuclear investment is unlikely to detract from private sector investment in renewables (considering the size of the financial markets involved), we are concerned that an expanded RO that also supports nuclear might undermine the Energy Efficiency Commitment (EEC). This is because both add a levy to consumers' bills, so there may be political pressure to keep the total burden to a minimum – this could reduce future increases in EEC.

From an infrastructural perspective, there are concerns that investment in a new nuclear programme would reinforce the UK's reliance on a centralised grid system and could therefore decrease the investment available for the network reinforcement needed to cope with much higher levels of decentralised generation (microgeneration) and large-scale renewables.

[21] Paper 4 – *Economics of nuclear power*

The evidence suggests there is some disagreement over these costs, but if they are high, there is the potential for conflict. This is because the transmission and distribution of electricity in the UK is a regulated industry, and all investments need to be approved by Ofgem as part of the district network operators' (DNO) price control agreements. Faced with calls for large investments across the network, Ofgem might have to prioritise what it allows, unless it is willing to accept higher costs for consumers.

There is also the related problem that continued reliance on centralised supply may exacerbate the current institutional bias towards large-scale generation, and the reluctance to really embrace the reforms necessary to ensure a more decentralised and sustainable energy economy. The role of Ofgem is central to this issue.

The lack of flexibility, or 'lock-in', associated with investment in large-scale centralised supply like nuclear power is also a concern. This relates to the issue of sunk costs. A new nuclear programme would commit the UK to that technology, and a centralised supply infrastructure, for at least 50 years.

During this time there are likely to be significant advances in decentralised technologies, and there is a risk that continued dependence on more centralised supplies may lock out some alternatives. Decentralised supply is generally more flexible because it is modular, and can adapt quicker and at less cost to changed circumstances. More locally-based energy provision may also be conducive to the sustainable communities agenda, a key part of the UK Government's Sustainable Development Strategy.

Any bias towards one mode over another essentially prevents a level playing field, and does not therefore encourage true competition. It may be hard for the microgeneration sector to overcome such bias, and this may prevent or slow it from reaching the economies of scale necessary to show its full potential.

2.2.6 Summary

Nuclear power may be able to make a useful contribution to the UK's economy, by providing low carbon electricity at a competitive price. However, our evidence shows that it is very difficult to assess the total cost of the available nuclear technologies, particularly as the only recent development that is relevant to the UK (in Finland) has a number of hidden subsidies that obscure its true cost.

In our view commercial investors are best placed to make a real assessment of the risks, and will have much better information on likely construction costs and therefore the final cost of power produced. They will also be able to account for wholesale electricity prices, and for the price of carbon, which is likely to be central to their business case.

There are still a number of outstanding costs that, unless internalised, may not allow a full reflection of the cost of nuclear power in those investor calculations. There is also the issue of moral hazard, and the impact that might have on reducing the apparent cost of nuclear power by increasing the financial risks to the taxpayer.

The case for nuclear power tends to be viewed in isolation, but this takes no account of the impacts that a nuclear development route might have on other alternatives, and on the prospects for a level playing field for all technologies. Although the measurable economic impacts may be limited, the political implications of a shift in emphasis towards nuclear could be to further weaken the commitment of Government, and therefore the investment community, to renewables and specifically microgeneration technologies.

On balance, the economic case for nuclear power is heavily dependent on its position in relation to other low carbon alternatives, and the effect it might have on the long-term ability of the UK to meet its emission reduction targets. If nuclear power can prove itself to be an economically viable competitor in a low carbon economy, without leading to a drain of investment for other alternatives, then its contribution to a sustainable economy may be positive. If, however, nuclear power requires public support (whether immediately or in the long-term) and/or it diverts funds away from other viable alternatives, then its contribution may well be negative.

It is of little doubt where the UK's current nuclear capacity stands. The burden of proof would now seem to be on the nuclear industry to show that updated designs, combined with private sector financing and project management, could lead to a different outcome. However, this must take place on a truly equal and transparent basis, so that costs are internalised and the taxpayer is protected from long-term liabilities. An assessment of the cost – and public acceptance – of nuclear waste policy is essential for this to take place.

[22] Sustainable Consumption Roundtable (2005). *Seeing the light.*

2.3 Society

How is the public good best served in the decision-making process for new nuclear and how does it contribute to social well-being? (Good governance; strong, healthy and just society)

2.3.1 Developing a policy on nuclear power[23]

'Good governance' is one of the five principles of sustainable development, as is 'ensuring a strong, healthy and just society'. In the decision-making process on development of nuclear power, engaging the public must be a requirement. Controversial decisions by Government have in the past led to considerable public outcry (such as the controversy around GMOs), and Government would be well advised to avoid such confrontational approaches on this issue.

Our evidence on public perceptions shows limited explicit support for nuclear power (less than 30%) and demonstrates that public support depends strongly on factors such as a solution to dealing with long-term waste, decommissioning, and nuclear proliferation, the level of trust in Government, and trust in the nuclear industry more generally.

While climate change is seen as a reason to re-consider new nuclear development, acceptance is conditional on first resolving the waste issue convincingly. Our evidence also shows that if the nuclear industry appears to lobby Government, public suspicion of the secrecy of the industry is raised.

Our conclusion from this research is that, for good governance reasons, a comprehensive national debate will be needed to explore all possible sustainable energy options with the public, ***before*** any decisions are made on a new nuclear power programme by Government. It is dangerous for any government to appear to ride over a social framing that is not wholly willing to embrace a mistrusted technology, and where deep feelings are evident for sustainable futures in economy and society.

In the 1989 Electricity Act energy projects above 50MW in England and Wales are referred to the Department of Trade and Industry; and projects in Scotland are referred to the Scottish Executive; in Northern Ireland all energy projects over 10MW require consent from the Department for Trade, Enterprise and Investment. Common practice is for the Government to conduct a planning inquiry undertaken by the relevant body.

Whilst any planning or consent process should be as efficient as possible, it would be a cause for concern if standard procedures for planning and licensing of nuclear power plants were streamlined in any way that undermined the public's right to consultation and due process.

As the consents process for large power projects is a devolved matter, it is worth noting that the 'no nuclear' policies in Scotland and Wales could prove problematic if the UK Government decided to proceed with a new nuclear programme, as three existing nuclear sites are currently located in Scotland, with two more in Wales. There are no nuclear power stations in Northern Ireland.

2.3.2 Employment opportunities

Employment opportunities in the vicinity of nuclear sites is clearly advantageous to the economy of the local region during operation and would stimulate employment for the construction industry and for decommissioning the plant in the future. But employment opportunities also exist for alternative low carbon energy sources, and these are often more widely spread through a range of industrial sectors. In addition, the employment potential of carbon capture and storage technologies, which are often seen as in direct competition with nuclear power, is extensive.

It is therefore very difficult to calculate any net employment impact from a new nuclear power programme, as any jobs created may come at the expense of jobs in other sectors.

2.3.3 Safety and security issues[24]

Nuclear power stations are designed with strict safety procedures, and stringent standards for emergencies both on and off-site. UK civil nuclear power stations have a very good safety record; however experience at a UK military reactor (Windscale) and elsewhere (Chernobyl, Three Mile Island) show just how dangerous a major accident can be. While we recognise that these events are rare, they are also one of the main reasons for public concern and cannot be dismissed.

The high levels of security at nuclear power stations are regularly reviewed against current intelligence about the intents and capabilities of terrorist groups. The possibility of a terrorist strike on a nuclear plant has been a focal point for security analysts since 9/11. Modern reactor designs have substantial containment buildings which are unlikely to be breached even by a crashing commercial airliner, and the reactor fuel is protected against impact and fire by other structures.

The industry assessment is that attempts at damaging the plant, either by external attack or sabotage, will probably cause the reactor to shut down safely once a fault is detected. However the mode of a terrorist attack cannot be accurately predicted and therefore there

[23] Paper 7 – *Public perceptions and community issues*

[24] Paper 6 – *Safety and security*

cannot be complete confidence that such an attack would not lead to significantly adverse consequences.

Use of nuclear fuel (reactor grade and spent fuel) by terrorists is raised as a concern. Reactor grade fuel must be processed to produce weapons-grade material to raise it from 4-5% uranium-235 to over 90% uranium-235. Spent fuel is an even more difficult starting material because it contains much less Uranium-235 than fresh reactor fuel.

However shipments of spent fuel for reprocessing could be attacked en route from the station to the reprocessing plant, either with the intention to spread contamination over a wide area or to steal the material for future use in a nuclear weapon. Reactor grade fuel could be used to make a 'dirty bomb'.

The industry assessment is that spent fuel containers are robust and undergo stringent testing and that the spent fuel pellets they contain are not easily dispersed even under severe impact and fire. But an alternative view is that stolen spent fuel would be valuable as a dirty bomb in itself and is therefore of value to terrorists. It would appear, therefore, that the potential use of nuclear fuels by terrorists remains a risk, and therefore a concern.

Nuclear accidents are recorded and ascribed levels on a scale 0-7 (Chernobyl was level 7), and most accidental releases in the UK are at levels 0,1 or 2. While major accidents are rare, evidence from Sellafield and Japan reveals that human error and management lapses are most often responsible – circumstances which undermine public confidence in the industry, even in industrialised countries with tight regulatory regimes.

Public confidence in the regulatory regimes for nuclear power stations in ***all*** countries, not just the UK, is also important because unplanned discharges can have serious transboundary effects. This raises a number of problems, including the difficulties of ensuring that the regulatory institutions in less developed countries are sufficiently resourced, and for identifying and dealing with poor health and safety practices which could lead to transboundary environmental or health risks.

2.3.4 Proliferation risks[25]

Terrorist organisations, almost by definition, operate outside national and international law, and therefore safeguards to protect against proliferation are almost irrelevant to such groups. Similarly it is very difficult to protect against civil nuclear power being developed into a military nuclear capability where motivations are strong enough, as has been shown in a number of countries.

The UK therefore needs to be fully aware of the implications of developing new nuclear capacity, particularly in the context of international treaties such as the Framework Convention on Climate Change. If nuclear power is part of the UK's chosen solution to climate change, then it would be considered a suitable solution for all countries. The UNFCCC explicitly encourages "the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emission of greenhouse gases" (Article 4.1c).

Reprocessing nuclear reactor fuel can raise it to the quality required for nuclear warheads, most easily from light water reactors. Pressurised water reactors would have to be closed down for several months, but in a country that wishes to do this the only barriers are political, as there is no engineering constraint.

Several international treaties have been concluded with the aim of making sure either that civil nuclear power is not used for military purposes or that any attempts to do so are detected. The two principal treaties that concern the UK are the 1970 Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Euratom Treaty, to which the UK became a partner on joining the European Community in 1973.

Out of the 188 states that have signed the NPT, the UK is one of five declared Nuclear Weapons States (NWS), the others being France, the USA, the USSR and China. The only states that have not signed the NPT are India, Pakistan and Israel, all of which are known to have nuclear weapons, while North Korea has chosen to withdraw from the NPT.

The provisions of the NPT are implemented by the International Atomic Energy Agency (IAEA). Following the difficulties of carrying out inspections in Iraq before 2003, additional protocols were developed giving IAEA inspectors greater rights of access and requiring administrative procedures to be streamlined so that, for instance, states cannot delay the issuing of visas as a means of delaying an unwanted inspection.

States also have to provide significantly more information, including details of nuclear-related imports and exports, which the IAEA is then able to verify. The IAEA concludes that without the NPT, there might be perhaps 30 to 40 Nuclear Weapon States, whereas more states have abandoned nuclear weapons programmes than started them.

Nevertheless, a number of difficulties in the relationship between civil and military applications continue to cause concern among many commentators, including:

[25] Paper 6 – *Safety and security*

> **the difficulties of enforcing international treaty obligations**
> **proliferation risks associated with the widespread use of nuclear technologies in countries with very diverse systems of governance**
> **the capacity and resources available to enforce international obligations in a potentially growing number of states with a nuclear capacity, and**
> **how to deal with states that withdraw from treaties or develop nuclear capability outside of them.**

In the global environment that we inhabit today, such considerations are pertinent to the UK's deliberations about its own energy needs.

2.3.5 Health impacts[26]

Within the UK, the operators of nuclear plants must conform to the general health and safety standards laid down in the Health and Safety at Work Act 1974 (HSW Act) as well as the Nuclear Installations Act 1965 (as amended) and related legislation.

The nuclear industry is regulated by the Nuclear Installations Inspectorate (NII), on behalf of the Health and Safety Executive (HSE), who set out the general safety requirements to deal with the risks on a nuclear site, in conditions attached to the Site Licence. Radiological protection of employees and the general public in the UK is covered by this strict legal framework.

Permitted dose levels to the public, as a result of civil nuclear industry operations, are only a small fraction of natural background radiation. Most of the collective dose in the European Union arises from industrial activities and is attributable to the phosphate industry and oil and gas extraction. The nuclear industry accounts for 12% of the EU collective dose from all industrial activities.

Radioactive discharges from electricity generation are low, whereas fuel reprocessing discharges account for 83% of the EU collective dose attributable to the nuclear industry. In contrast to existing nuclear facilities, spent fuel from new nuclear power stations may not be reprocessed, on the grounds of risks to human health and proliferation.

Current expectations are that spent fuel from any potential new stations would be stored on site, potentially for the whole operating lifetime of the station, before a final disposal option is selected. The options for waste disposal and decommissioning therefore remain the same as for existing facilities.

Overall, the health impacts of well-managed nuclear power facilities are small, especially in comparison to some other energy sources, such as coal (mining and combustion) and oil (combustion). However, the risk of a nuclear accident, however small, places nuclear power in a unique category where the low risk of routine activities must be balanced against the very low probability, but potentially high impact, of a serious accident.

2.3.6 Intergenerational issues

One of the features of sustainable development which perhaps distinguishes it from simply an environmental or economic focus is the requirement to analyse the long-term impacts of any policy decision. Nuclear power, with its waste legacy, has clear inter-generational impacts as nuclear waste is expected to remain radioactive for tens of thousands of years.

No civilisation foresees its own demise, but a brief look at history shows the cycle of civilisations developing to peak power and influence and declining to marginal influence, and sometimes disappearing. During this decline the fruits of an advanced civilisation – whether engineering expertise, artistic or linguistic skill etc – will also disappear, leaving a hiatus in knowledge about the civilisation, and certainly a hiatus in knowledge about how to deal with any legacy from that civilisation.

It is estimated that some elements of radioactive nuclear waste will continue to be toxic for hundreds of thousands of years. In view of historical evidence of the decline of civilisations, it would seem appropriate to take seriously the issues of leaving a radioactive legacy for many future generations, when knowledge of where and how that waste is stored could die away over time.

Our evidence[27] shows that information transfer is a key factor, with the management system more important than the media used, and that the greatest threat to information transfer is institutional change. A number of external events, such as climate change, natural disasters, wars, and civilisation collapse could all affect the long term management of radioactive wastes, but it is the more 'trivial' causes such as destruction of archives by paper decay or disruption of electronic media that could lead to problems.

While it is recognised that the nuclear waste legacy is a serious problem that the UK and other countries already have to deal with (as a result of existing nuclear capacity), any decision to increase that waste legacy with a new nuclear power programme naturally adds additional weight to this issue. Therefore any

[26] Paper 6 – *Safety and security*

[27] Paper 5 – *Waste management and decommissioning*

decision to develop new nuclear capacity has to be taken in the context of the current waste legacy, albeit that future waste arisings are likely to be considerably smaller than existing volumes.

2.3.7 Summary

Our evidence shows that it is essential for the Government to allow the fullest public consultation in developing a policy on nuclear power. Not doing this would compromise the principle of good governance, and risks a huge public backlash against top-down decision-making. The Government needs to engage the public in a wider debate where nuclear power is considered as one of the many options that could be required for a sustainable energy policy.

We are satisfied that any new nuclear power plant in the UK would be built and operated to the highest safety and security standards. However the same level of confidence cannot always be applied to other countries, and this remains a cause for serious concern. In addition, nuclear power facilities and processes are vulnerable to attempted exploitation by terrorist groups, and although standards may be high, this does not rule out the possibility of a successful strike.

The proliferation of nuclear materials is equally a cause for concern in this context. A decision to develop nuclear power in the UK essentially removes our ability, both morally and legally, to deny the technology to others. The widespread adoption of nuclear power would greatly increase the chances of nuclear proliferation, both through the efforts of nation states and possibly terrorist organisations.

Whilst the health impacts of a well-regulated nuclear power industry are low, the risk of a low probability, but high impact event must be considered, especially in the context of the international concerns raised above.

Finally, we remain deeply concerned about the intergenerational impacts of the legacy of nuclear waste. Considering the current uncertainties over total costs and the science of long-term waste management, we find it difficult to reconcile these issues with sustainable development principles.

3. SDC Position on Nuclear Power

3.1 Our energy challenge

The previous section analysed nuclear power against the principles of sustainable development. Using this, along with an assessment of the alternative energy options available, the Sustainable Development Commission has developed a position on nuclear that will form a central part our advice to Government in the current Energy Review.

The two overriding concerns for Government are the need to:

> **reduce carbon dioxide (CO_2) emissions as part of efforts to tackle climate change, and**

> **increase confidence in the security of energy supply**.

The challenge of reducing emissions of CO_2 quickly enough to avoid severe and dangerous climate change is huge. The UK needs to make large cuts in its CO_2 emissions, and we need to start doing this immediately. Current measures to reduce greenhouse gas emissions are inadequate for this task.

There is no single large measure which will solve the climate change problem. Diversity of energy supply options will increase our ability to meet our carbon reduction goals and help provide energy security – it will also reduce the risk of price fluctuations. Reduced energy consumption combined with new and renewable energy sources will lead to reduced dependence on imported fossil fuels. Viewed as such, climate change and energy security aims are highly complementary.

3.2 The starting point

The 2003 Energy White Paper authoritatively established the rationale for a long-term energy policy based on energy efficiency, renewables and the cleaner and more efficient use of fossil fuels. We reaffirm that this strategy is a sound one and should be pursued with vigour. There is a continued case for action on these three fronts, regardless of a decision on nuclear power.

3.2.1 Reducing energy demand

The starting point for implementing the 2003 Energy White Paper has been and must continue to be, energy efficiency. This must include efforts to encourage energy conservation and to restrain the growth in energy demand.

So far efforts to boost energy efficiency, although increasingly successful, have been insufficient for making a real impact when set against our rising demand for energy. There is still vast potential for promoting energy efficiency in all sectors, with great benefit to the economy and consumers. We could more than halve the energy consumption of our homes and offices using existing energy efficiency measures combined with on-site generation of renewable or low carbon energy.

But policies are not yet sufficiently strong to set us on the right trajectory. Efforts to encourage energy efficiency in the business sector through emissions trading schemes have not gone far enough, and engaging and incentivising households to dramatically improve the efficiency of their homes is urgently needed.

We must aim for overall reductions in energy demand, not just marginal improvements in carbon intensity. And we must do this across the complete energy spectrum, by reducing electricity consumption (which is only around a third of total UK energy supply) but also by reducing our demand for heat and transport fuels.

3.2.2 Increasing the contribution of renewables

The UK's renewable resources are some of the best in the world, and could provide all the UK's electricity over the longer term. Despite some significant developments, our current approach remains half-hearted, and the levels of public investment needed to bring forward new technologies are inadequate when compared to our international competitors.

It is critical that the Government should now invest far more (both politically and financially) in renewables, particularly microgeneration and biomass technologies, and marine renewables and offshore wind, where the UK has a clear natural advantage.

3.2.3 The clean and more efficient use of fossil fuels

It is clear to us that fossil fuels will remain a necessary part of our energy mix for some time. We fully support the Government's stated target for 10GW of good quality CHP by 2010 as a way of increasing the overall efficiency of energy supply. However, based on our lack of progress on this target, the foundations for expanding the use of this energy efficient technology are not strong.

We also support the recent interest from Government in carbon capture and storage (CCS) technologies, which could effectively remove the CO_2 emissions that come from burning fossil fuels such as gas and coal. These could provide a bridge to a more sustainable energy future whilst providing the UK with significant export potential in another area of expertise. Of course we must recognise that CCS is as yet an unproven technology, and its development could allow a future role for coal, about which we have concerns both for reasons of sustainability and human health.

3.3 Nuclear power: our advice

It is clear that nuclear power could generate large quantities of electricity, contribute materially to stabilising CO_2 emissions and add to the diversity of the UK's energy supply. However, even if we were to double our existing nuclear capacity, this would bring an 8% cut on total carbon emissions from 1990 levels by 2035, and would contribute little before 2020. Nuclear cannot tackle climate change alone.

A key issue that the Commission explored through the evidence base was whether the UK could have a viable energy future without nuclear power. Or in other words, whether nuclear power is a ***choice***, or whether is it an ***absolute necessity***.

The conclusion from the analysis was that the UK could meet our CO_2 reduction targets and energy needs without nuclear power, using a combination of demand reduction, renewables, and more efficient use of fossil fuels combined with carbon capture and storage technologies.

In this context, the Sustainable Development Commission assessed whether nuclear power has a role to play in future UK electricity supply. We have a number of serious concerns:

Intergenerational issues

The intergenerational impacts of a new nuclear programme are of great concern, particularly with regard to decommissioning and the disposal of nuclear waste. Even if a policy for long-term nuclear waste is developed and implemented, the timescales involved (many thousands of years) lead to uncertainties over the level to which safety can be assured. We are also concerned that a new nuclear programme could impose unanticipated costs on future generations without commensurate benefits.

Cost

There is very little certainty over the economics of nuclear power. A new nuclear power programme could divert public funding away from more sustainable technologies that will be needed regardless, hampering other long-term efforts to move to a low carbon economy with diverse energy sources. Nuclear power is also prone to moral hazard, which could lead to forced public subsidy regardless of the Government's original intentions.

International safety and security

If the UK cannot meet its climate change commitments without nuclear power, then under the terms of the Framework Convention on Climate Change, we cannot deny others the same technology. The UK has been a world leader on climate change, and must take account of the implications of this legal issue. We are concerned that other countries who adopt nuclear power may have much lower safety standards than the UK, and this increases the risk of accidents (transboundary contamination) and radiation leaks from waste materials. Greater use of nuclear power also increases the risk of nuclear proliferation, which impacts on international security.

Technological lock-in

A new nuclear power programme could lock the UK into an inflexible, centralised electricity-generating system for the next 50 years. Investments to develop the electricity networks to cope with more decentralised, small-scale technologies will be suppressed just as their potential is growing.

Reducing energy demand

To meet our carbon reduction targets, we will need much greater action to reduce energy demand. We are concerned that a new nuclear programme would give out the wrong signal to consumers, encouraging the impression that the challenge of climate change can be tackled by a large-scale technology fix. Greater use of decentralised, small-scale energy generating technologies helps to increase awareness of energy consumption and foster more sustainable behaviour. We are concerned that a new nuclear programme could indirectly reduce political support for policies aimed at energy efficiency by competing for public funding.

Therefore the majority view of the Sustainable Development Commission is that in consideration of these issues, there is no justification for bringing forward plans for a new nuclear power programme, at this time, and that any such proposal would be incompatible with the Government's own Sustainable Development Strategy. This is our advice to Ministers.

Nonetheless, the majority of the Commission also believes it is right for the Government to continue to assess the potential contribution of new nuclear technologies for the future, as well as pursuing answers to our nuclear waste problems as actively as possible. We believe a full and thorough national debate on sustainable energy options will be needed in the future, particularly if new nuclear power is to be pursued.

A sustainable energy policy would combine an aggressive suite of policies for energy efficiency and renewables, with the development of the carbon capture & storage (CCS) technologies, to effectively remove the CO_2 emissions that come from burning fossil fuels such as gas and coal. The Sustainable Development Commission believes there is an urgent need to drive forward a low carbon innovation programme, with public funding dramatically increased to the levels of our international competitors. This should be combined with long-term targets for absolute reductions in CO_2 emissions to provide certainty to the business community and stimulate private investment. Uptake should then be encouraged through the smart use of fiscal incentives, targeted regulations, and an expanded role for emissions trading schemes.

Following our suggested pathway would make the UK a leader in low-carbon technologies. If we take full advantage of this, we will enhance our economic competitiveness.

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