Environmental implications of new Nuclear Power Stations

Introduction

Following a detailed consultation paper, published in May 2007 (1), in January 2008, the Department of Business, Enterprise and Regulatory Reform (BERR) published a White Paper on Nuclear Power (2). The White Paper presented the Governmentõs conclusions following the latest public consultation on the future of nuclear power. In summary these were that the Government believes new nuclear power stations should have a role to play in this countryõs future energy mix alongside other low-carbon sources; that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the Government should take active steps to facilitate this.

This paper provides information on the potential environmental effects, both positive and negative, of the process of a new nuclear programme which may involve the building of a new nuclear power station at Hartlepool. Environmental is here interpreted in a broad sense to include both global and local effects and also to encompass safety issues as these would have knock-on environmental consequences.

The paper has been produced by the Environment Partnership of the Hartlepool Local Strategic Partnership. Its aim is to provide an overview of those potential effects and to provide links to other papers for those who want to consider them in more detail. It should be stressed that this paper is not in any way a formal assessment of the environmental effects. These will be addressed through the regulatory processes of Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA). SEA evaluates policies, plans or programmes to ensure that all environmental consequences are fully addressed. EIA evaluates a specific project, which in this case would be to build a specific type of nuclear power station in a specific location, in sufficient detail such that every potential environmental impact is fully assessed.

This paper is largely a summary of several evidence-based papers on various aspects of nuclear power, produced by the Sustainable Development Commission (SDC) in 2006. The SDC is the Government's independent adviser on sustainable development, reporting to the Prime Minister, the First Ministers of Scotland and Wales and the First Minister and Deputy First Minister of Northern Ireland. It is led by a board of 18 Commissioners, from a mix of academic, scientific, business and NGO backgrounds and is chaired by Jonathon Porritt. After reviewing the evidence on nuclear power in 2006, the SDCõs Commissioners took the position, albeit by a very small majority of 8 to 7, that there was no need to bring forward a nuclear power programme at that time though it was right for the Government to continue to assess the potential for new nuclear technologies in the future. However the evidence papers themselves do not state a position and merely review the evidence, therefore they are referred to as providing a thorough but relatively concise summary of the issues. The full papers can be viewed and downloaded from the SDCõs website (3)

As a separate source of information reference is made to a Screening Report that has been produced by BERR as the first stage of an assessment under Article 6 of the EU Habitats Directive. This assessment considers whether the Governmentõs nuclear programme would have any adverse effects on those areas of nature conservation interest designated under the EU Habitats Directive. In the absence of any nominated sites, the Screening Report is of necessity very general and concludes that a further Screening Report would be required once specific sites are chosen. Nevertheless the document is very useful as it considers the full range of potential effects on nature conservation. The screening report can be viewed on the BERR website (4). A related BERR report, which sits alongside the screening report is entitled ñApplying the

Strategic Siting Criteria: a study of the potential environmental and sustainability effectsòand can also be viewed on the BERR website (5)

This paper is divided into four themes: reducing CO2 emissions; environmental & landscape impacts; radioactive waste; safety & security. These reflect the topics in the SDC papers that deal with the environmental and safety aspects of nuclear issues. Most of the information has been obtained from the SDC papers themselves though additional sources are highlighted as numbered references.

Reducing CO2 emissions – (SDC Paper 2)

Emissions of the greenhouse gas, carbon dioxide, are one of the main contributors to human-induced climate change. Based on a Royal Commission report in 2000, the UK government had a goal of achieving a reduction in CO2 levels of 20% by 2010 and 60% by 2050 from the baseline of 165 MtC (million tons of carbon) produced in 1990. A 60% reduction would require emissions to fall to 66MtC by 2050. More recently independent expert opinion has pointed to a the need for the UK to produce an 80% reduction in greenhouse gases by 2050 in order to restrict global warming to the critical threshold of 2 degrees above pre-industrial levels. In Oct 2008 the Energy and Climate Change Secretary Ed Miliband committed the UK to cutting greenhouse gas emissions by 80% on 1990 levels by 2050. (6)

In 2004, nuclear energy supplied 19.3% of the UK electricity supply, which equated to 7.8% of the total UK energy supply. This had decreased slightly by 2007 to 15.1% of the UK electricity supply. As power stations currently generate almost 1/3 of UK carbon emissions the replacement of fossil fuel power stations by nuclear power stations could significantly reduce the total CO2 emissions. However a new generation of fossil fuel power stations will produce less CO2 per unit of electricity and therefore the net benefit in CO2 reduction from nuclear generation will be less. In addition the development of carbon capture and storage technologies have been calculated to have the potential to reduce emissions from fossil fuel power stations by up to 90% (7). If successfully implemented such technology would further reduce any advantage nuclear power stations would have in terms of lower carbon emissions.

The ability of nuclear energy to contribute to CO2 reduction targets in the short term is limited by the time it would take for new nuclear power stations to come on line and achieve full operating capacity. Under the governmentõs recent proposals the first new power stations will begin operating between 2017 and 2020at the earliest. (8)

The SDC paper looks at carbon emission reducing scenarios involving either replacement of existing nuclear power stations with an equivalent number of new stations or the doubling of the current capacity. With either scenario nuclear power would deliver around a 2.4% reduction in CO2 by 2020. This is based on the assumption that existing power stations close on their scheduled decommissioning date rather than applying for extensions to remain operating. If, as seems likely, some power stations would be granted an extension to continue operating then CO2 reduction would be slightly more than 2.4%. By 2030 these figures are likely to have increased to a 4.1% reduction for the like for like scenario and a 6.5% reduction with a doubling of the number of current capacity. The latter scenario could achieve cuts of 8.1% by 2050 as the building programme is completed. While a new nuclear programme would deliver significant CO2 reductions it is clear that CO2 reduction targets will not be met by an increase in nuclear energy alone. Rather it should be viewed as only one part of a low carbon economy.

It has been argued that it is possible to produce the reductions in CO2 required without the need for nuclear power. For example a significant proportion of the UKõs energy consumption could be reduced by increasing energy efficiency. SDC calculated that a reduction of 20MtC could be achieved by 2020 with the potential for further cuts by 2050 as new technologies are developed.

The UK has considerable potential for renewable energy resources and, in practice, this could provide in excess of 60% of current electricity production. However even if it were feasible to achieve targets for CO_2 emissions without nuclear energy this would require substantial investment in renewable energy, carbon capture and other technologies in order for it to happen. To give some idea of the scale of investment required, renewable energy supplied 5% of the UK's electricity in 2007 and the Government has a target of increasing this to 10% by 2010 and 20% by 2020 (9). It should be noted though that a doubling of nuclear capacity, or even replacement of existing capacity, would itself require substantial investment.

While the production of nuclear power does not directly produce CO_2 there are some carbon emissions connected with the life cycle of nuclear power plants. Construction is a carbon intensive process particularly given the large amounts of cement required to create the super-structure of a power plant. The fuel cycle will also result in carbon emissions including those generated through the mining and processing of uranium and the transport, storage and processing of spent nuclear fuel. It should be born in mind that other energy generating technologies, including major renewable technologies, would also have indirect carbon emissions though for such as wind turbines these are lower as a proportion of the life-time energy generation.

Environmental & Landscape Impacts – (SDC Paper 3 & BERR Screening Report)

The landscape and environmental impacts of any development usually extend beyond the boundaries of the site's footprint. In the case of the nuclear industry the main landscaping issue is mining for uranium ore. Although this doesn't occur in the UK its impact globally should be considered. Most mining sites use an area up to 50ha in size though this could increase several-fold if mining occurs in areas where uranium ore deposits are less concentrated. However techniques for in-situ leaching of uranium are increasingly used where the geology is suitable. These have a minimal impact on the landscape. As with other aspects of its environmental impact, nuclear energy needs to be compared with its alternatives. In this respect it should be noted that mining for coal or extraction of oil and gas all have significant effects on the landscape. Though with each of these operations, including mining for uranium, sites are usually reclaimable for after-uses without restrictions on access.

The infra-structure associated with the nuclear industry also has an effect on the landscape. A nuclear power plant itself does of course have a significant impact on the landscape character of its surroundings and its visual impact may be noticeable for several kilometres in various directions. In terms of the actual amount of land required to build a power station, this is estimated to be similar to that of coal and gas-fired power stations and to the infra-structure required for an onshore wind farm which has a similar generating capacity to the nuclear power station. Such a wind farm would occupy a much larger total site but the space between the turbines can still be used for other purposes within certain restrictions. However the dispersed nature of a wind farm means that it might have a greater visual impact on the landscape than a power plant. In this respect, nuclear power stations are very efficient in terms of land use per unit of installed capacity compared with other forms of generation.

Nuclear power plants are usually surrounded by an exclusion zone though this land can often be used for other purposes not associated with nuclear power. In particular the lack of disturbance can make them of high value for nature conservation. This is in fact the case with approximately 20ha of land to the west of the Hartlepool Nuclear Power Station which has been designated as a Site of Nature Conservation Interest in the Hartlepool Local Plan.

The BERR Habitats Regulations Screening Report referred to in the introduction looks at potential impacts on biodiversity, flora and fauna in general terms. Not all of those potential impacts would relate to each potential site and particular sites when chosen will be subject to detailed scrutiny through the Environmental Impact Assessment process, which will include measures to mitigate any adverse effects.

The Screening Report relates the potential impacts to the phases of activity in the life of a nuclear power station, ie construction, operation and decommissioning. The most likely effects during construction are noise and visual disturbance and an increase in dust emissions and surface run-off. There is also the possibility of accidental contamination of water courses and soils from construction materials, which potentially could also affect the human population. The construction process itself will of course utilise areas either temporarily or permanently that might have had value as a habitat. It should be noted however that these potential effects are common to all major developments and that it is possible to mitigate their effects to varying degrees.

During operation there will be routine releases of radioactive material. However these discharges are subject to strict regulation by the Environment Agency and would be within established dose limits; as such they should not have any adverse ecological effects. There is of course the possibility of the release of radioactive materials resulting from an accident. While this would have a significantly adverse effect, the likelihood of an accident is extremely small and is likely to reduce further with new reactor designs. (These issues are addressed more fully in the Safety & Security section)

When operating, a nuclear reactor requires large quantities of water to cool the reactor. The water abstraction can lead to high mortality of aquatic species though new technologies have been designed to minimise these impacts. The water that is discharged after cooling can be up to 10°C higher than the surrounding water; this can change the ecological communities in the local area but this change is not necessarily detrimental. Other potential adverse effects during the operational phase could be caused by movement of vehicles, the management of non-nuclear materials and the presence of the site buildings and staff but again these are common to all large developments.

Many of the decommissioning activities would have similar potential effects to those during the construction and operational phases. Additionally there is the transport of radioactive waste for final disposal to consider. This could have an adverse effect on biodiversity, flora and fauna through unplanned releases although past experience suggests that the risk of this is low.

The decommissioning process also provides an opportunity to restore the site in such a way that it benefits nature conservation. The recent Planning Policy Statement 9 states that the aim of planning decisions should be to maintain or enhance biodiversity and geological conservation interests. In addition, under the Natural Environment & Rural Communities Act (2006) guidance, Local Authorities are required to actively seek opportunities for biodiversity enhancement through the planning process. Therefore the planning process should ensure that the nature conservation value is enhanced above the site's original value prior to the nuclear build.

Radioactive Waste - SDC Paper 5; CoRWM report & Government response

The SDCøs paper 5 looked at Waste & Decommissoning. The paper summarised the development of nuclear waste policy in the UK up to that point in time. Summaries of decommissioning and radioactive waste management programmes in other countries were also provided. It also looked at waste management practice including an inventory of UK radioactive waste materials. The paper raised particular concerns about the lack of an adequate policy on long-term storage of waste at that time. This latter point has been addressed by the Committee on Radioactive Waste Management, (CoRWM), who published their long-term management options in July 2006.(8)

CoRWM made 15 recommendations the principal one being the view that the best available long term approach to dealing with radioactive waste was geological disposal. Given the timescales required to develop geological storage facilities this was accompanied by a recommendation for the development of secure interim storage facilities. Other recommendations were the need for ongoing research into geological storage; a flexible approach in case geological storage was superseded by new technologies and commitments to the involvement of communities in the process. Government accepted these recommendations and published a report on its response (9).

In June 2008, the Department for Environment, Food & Rural Affairs (Defra) published a White Paper entitled ñManaging Nuclear Waste Safely: a framework for implementing geological disposal.ò (10). The White Paper sets out the framework for the future implementation of geological disposal, including:

- Updating the UK Radioactive Waste Inventory;
- The Nuclear Decommissioning Authorityøs technical approach to developing a geological disposal facility
- Arrangements to ensure sound regulation and scrutiny;
- Measures to involve communities in the site selection process.

The Governmentøs plans for geological disposal will be independently scrutinised by CoRWM, which was reconstituted in 2007 to ñprovide independent scrutiny on the Governmentøs and the Nuclear Decommissioning Authorityøs proposals, plans and programmes to deliver geological disposal together with robust interim storageò

Geological disposal would involve isolating radioactive waste deep inside suitable rock formations. One of the key properties of such a rock formation would be its geological stability. Depending on the specific characteristics of the geological formation chosen, the radioactive waste would be stored typically between 200m and 1,000m below the surface. The storage would utilise multiple barriers, the principle being to place the waste beyond disruption by man-made or natural events.

Geological disposal has been chosen as the method of disposal by 25 of the 39 countries with significant amounts of radioactive waste. A further 6 have expressed a preference for this method. No country has chosen indefinite, interim storage as its long-term waste management policy. (11) The United States currently has one such geological disposal facility and, in its case, the waste is stored in vaults excavated in a salt formation, with storage beginning around 250m underground.

Progression to an operational geological disposal facility in the UK is likely to take several decades. The practice of interim storage would be required until such time. Interim storage involves a facility, generally at or close to the site of origin of waste, where the waste material can be suitably packaged and stored. Interim storage facilities are engineered to be resistant to incidents such as earthquakes and severe weather and to provide protection from environmental variables such as humidity and atmospheric salts. They are designed with a life-expectancy of around 100 years.

Safety & Security – (SDC Paper 6)

In discussions over the pros and cons of nuclear power a major concern in the public consciousness is over issues of safety & security. In the SDC paper these are discussed under four headings: accident risk; vulnerability to terrorism; implications for nuclear proliferation and health impacts from background radiation.

Civil nuclear power stations in the UK have an excellent safety record. To date there have been no accidents that have had consequences beyond the site, nor any accident that required all safety measures to contain it. Nuclear power stations are designed so that safety measures are multi-layered. The safety equipment is duplicated and triggered automatically. These measures do away with much of the potential for human error and provide a fail-safe mechanism. It is likely that a new generation of nuclear reactors will reduce the low risk of accident even further. Nevertheless the extremely low probability of an accident occurring beyond the site needs to be balanced against the potentially high impact of a serious accident.

In the wake of the 9/11 terrorist attacks security at nuclear power stations is now at a very high level. The security measures are designed on the basis of current intelligence on groups that might pose a threat to UK security. The safety systems within the power station that would shut down the reactor are triggered automatically and their defence-in-depth strategy means that several layers of defence would need to be breached, by which time the reactor is likely to have shut down.

Also post 9/11 the buildings housing the reactor in current power stations have been assessed in terms of their ability to withstand the impact of a crashed airliner. Although not specifically built with this in mind, they are considered to be sturdy enough to withstand this although that may not be the case with other potential impacts such as certain missiles. The design of new power stations would be able to incorporate further safeguards.

Any new build nuclear power stations would also need to be protected from potential hazards in the future caused by natural events. Of particular relevance given the tendency to build nuclear power stations in coastal locations because of the high requirement for water is the need to “climate-proof” those power stations in the light of rising sea levels.

Under certain circumstances it might be necessary to ship radioactive materials for reprocessing or storage. Such material would be transported in the form of extremely hard ceramic pellets that are difficult to fragment or otherwise process. Likewise spent fuel containers are subject to stringent tests to determine their resistance to impacts or fire. Nevertheless the possibility that terrorists could attack such containers in transit cannot be completely ruled out. It is unlikely that material could be removed in such a scenario to be used for other purposes however the breach of a spent fuel container could in itself act as a “dirty bomb”. To do this would risk a life threatening dose of radioactivity to any terrorist carrying out such an activity but in the context of current terrorist threats that is not necessarily a deterrent.
It should be noted that this scenario would not apply to the transport of fresh fuels as this is of low level radioactivity and is unlikely to be of interest to terrorists.

Safety arrangements for nuclear installations are regulated by the Office of Civil Nuclear Security (OCNS). Under the Nuclear Industries Security Regulations (2003), operators of civil licensed nuclear sites or those who use or store Category I-III nuclear material at other premises must have site security plans approved by OCNS. Furthermore, if a licensed site has a tenant on the site who uses or stores nuclear or other radioactive material, including sources, then the tenant must have a security plan. These plans detail the security arrangements for the protection of nuclear sites, nuclear and other radioactive material and sensitive nuclear information on such sites. (14)

The UK is bound by the Non-Proliferation Treaty (NPT) and the Euratom treaty. Under the terms of these treaties it has been agreed not to divert civilian nuclear material for military use. Worldwide, all but four states are NPT signatories. The signatories are divided into declared Nuclear Weapon States, which are France, USA, USSR, China & UK and Non-nuclear Weapon States. All NPT signatories have signed voluntary agreements to allow independent inspection of their civil facilities to ensure that they aren't being diverted for military use. Nevertheless concerns remain about the effectiveness with which such agreements can be implemented or enforced. Also there is no guarantee given the potential for political instability in certain areas that states will not choose to withdraw from the treaty in the future, as North Korea has done.

The health impacts of exposure to radiation as a result of the normal operating procedures of the nuclear power industry are a separate issue to the risks of exposure following an accidental release. Around 80% of the radiation exposure for an average member of the UK public comes from natural background radiation though this varies from place to place depending on the underlying geology. Of the radiation that comes from human processes, the biggest contribution (around 14%) is from medical exposures. The proportion of radiation exposure that is due to the nuclear industry is actually very small and most of this is from fuel reprocessing. The development of a new generation of nuclear power stations will reduce this further especially as it is intended that nuclear fuel from new nuclear power stations would not be reprocessed.

In terms of cancer in general, the risk of developing a fatal cancer as a result of a new build nuclear power station have been calculated as significantly lower than the 1 in one million level that the Health & Safety Executive considers to be "broadly acceptable." (15)

There has been evidence of a leukaemia cluster around the Sellafield reprocessing plant with seven cases between 1955 and 1985 in young people aged below 25 years. A cluster of five leukaemia cases was also reported from Dounreay in the mid 1980s. However radiological assessments of the areas around Sellafield and Dounreay do not support a link with environmental exposure to radiation. Studies have also failed to show a link between paternal pre-conception exposure to radiation and childhood leukaemia. (16) Since the Sellafield and Dounreay cases came to light, multi-site studies have been performed around 29 sites throughout England with similar studies taking place in several other countries. In general these studies have shown that the probability of a leukaemia cluster occurring is no greater near nuclear sites than elsewhere (16) (17).

While the focus on the potential impacts on human health of the nuclear industry has often been on scrutiny of any potential negative effects it should be acknowledged that a nuclear power station brings a very significant economic benefit and that this in turn has a positive effect on the health of the population as a whole.

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