Geofile Online
JANUARY 2011
636

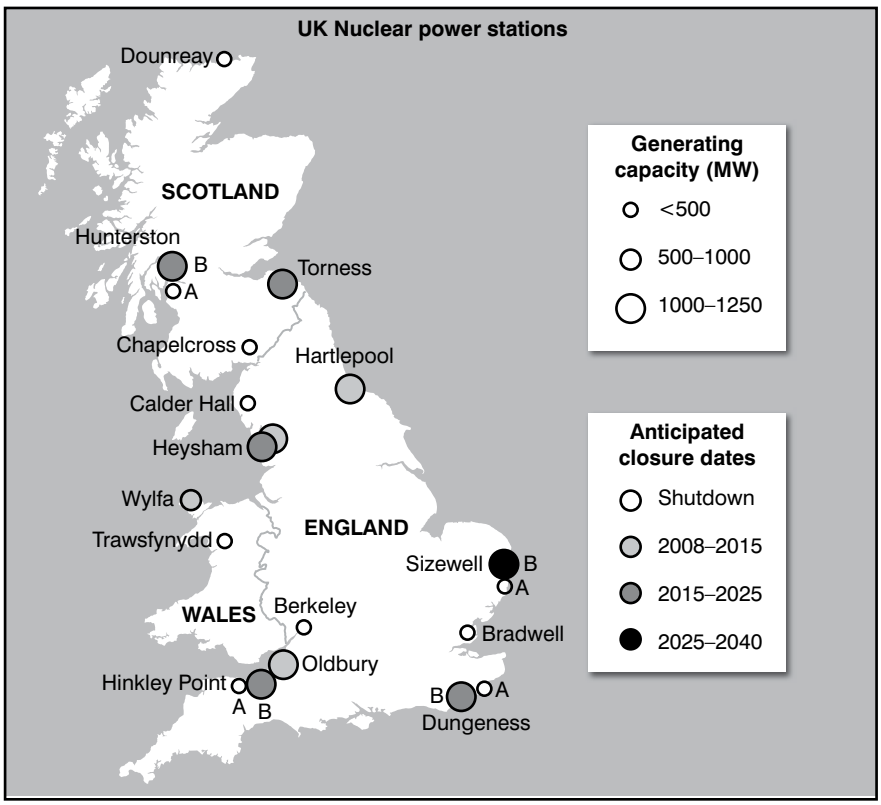
NEIL PUNNETT

# NUCLEAR ENERGY IN THE UK

## Background

The United Kingdom was once a world leader in the development of nuclear energy. The world's first commercial-scale nuclear power reactor was opened at Calder Hall in what is now Cumbria in 1956. A rapid construction programme followed: 11 'Magnox' power stations were built, the last starting operations in 1972. A second generation of advanced gas-cooled reactors (AGRs) were then constructed, with eight operational by 1989. The first of a third generation, a pressurised water reactor (PWR) opened at Sizewell in Suffolk in 1995. The contribution of nuclear power reached its peak in 1998, when 28% of British electricity was generated by nuclear power stations. Subsequently the early Magnox stations were closed, and the contribution of nuclear power fell to 14% by 2008 (Figure 2).

*Figure 1: Map of nuclear power stations in the UK 2011*




The development of further nuclear power in the UK was disrupted by accidents at nuclear power stations at Three Mile Island in the USA in 1979 and a much more serious event at Chernobyl in the Ukraine in 1986. The Chernobyl disaster, when a fire broke out in a nuclear reactor plant, killed 40 people within a few days, and in the years since then hundreds of early deaths due to cancers have been blamed on the radiation that was dispersed over an extensive area from the blazing reactor. These events led to increased public opposition to new nuclear power stations. Private industry became reluctant to invest in nuclear power as the negative public image of the sector and the sheer scale of the costs of decommissioning

*Figure 2: Fuels used for electricity generation 1990–2008*

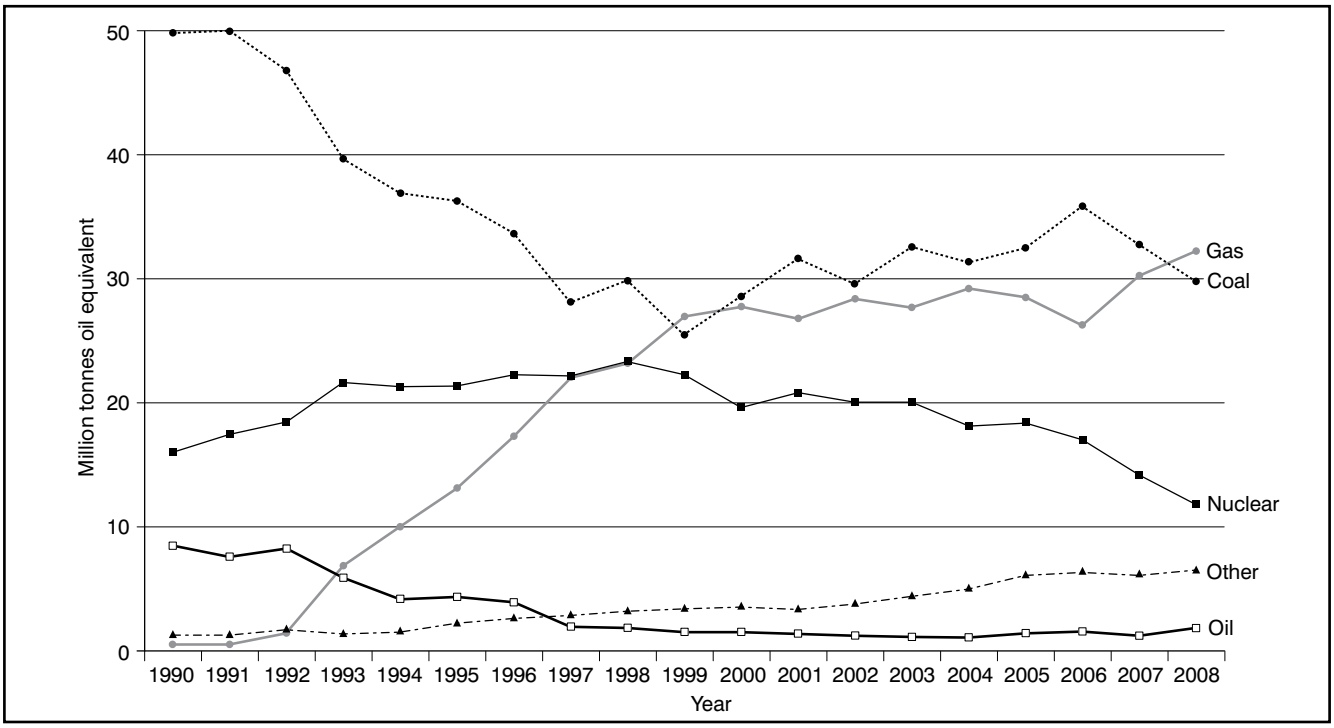


*Figure 3: Operating and decommissioned nuclear power reactors in the UK*

Power reactors operating in UK

| Reactors | Type | Net capacity each | Start Operation | Expected shutdown |
|---|---|---|---|---|
| Oldbury 1 & 2 | Magnox | 217 MW | 1968 | Dec 2010** |
| Wylfa 1 & 2 | Magnox | 490 MW | 1971-72 | Dec 2010** |
| Dungeness B 1 & 2 | AGR | 545 MW | 1985-86 | 2018 |
| Hartlepool 1 & 2 | AGR | 595 MW | 1984-85 | 2014 (2019?) |
| Heysham 1 & 2 | AGR | 615 MW | 1985-86 | 2014 (2019?) |
| Heysham 3 & 4 | AGR | 615 MW | 1988-89 | 2023 |
| Hinkley Point B1 & 2 | AGR | 620 & 600 MW | 1976-78 | 2016 |
| Hunterston B 1 & 2 | AGR | 610 & 605 MW | 1976-77 | 2016 |
| Torness 1 & 2 | AGR | 625 MW | 1988-89 | 2023 |
| Sizewell B | PWR | 1196 Me | 1995 | 2035 |
| Total (19) | | 11,035 MW | | |

Decommissioned power reactors in UK

| Reactors | Type | MW each | Shut down |
|---|---|---|---|
| Berkeley 1 & 2 | Magnox | 138 | 1988-89 |
| Bradwell 1 & 2 | Magnox | 123 | 2002 |
| Calder Hall 1-4 | Magnox | 50 | 2003 |
| Chapelcross 1-4 | Magnox | 49 | 2004 |
| Dungeness A 1 & 2 | Magnox | 225 | 2006 |
| Hinkley Pt 1 & 2 | Magnox | 235 | 2000 |
| Hunterston A 1 & 2 | Magnox | 160 | 1989-90 |
| Sizewell A 1 & 2 | Magnox | 210 | 2006 |
| Trawsfynydd 1 & 2 | Magnox | 196 | 1993 |
| Windscale | AGR | 28 | 1981 |
| Dounreay PFR | FBR | 254 | 1994 |
| Winfrith | SGHWR | 92 | 1990 |

became apparent. The result was that no new nuclear power stations were built in the UK after Sizewell B (Figure 3).

## The nuclear renaissance

A change in public perception of nuclear power occurred during the first decade of the 21st century. The World Nuclear Association states that on the question of maintaining the share of electricity provided by nuclear power by building new reactors, UK public opinion reversed from 20% support and 60% opposed in July 2001, to 67% agreeing that nuclear is needed as part of the UK's energy mix and only 10% opposed in November 2009. As recently as 2003 the UK government was very negative about the need for nuclear power, and a White Paper published in that year concentrated entirely on renewable sources of energy, but this had changed by 2006 when a review of energy policy was undertaken. The review concluded that replacement of the existing nuclear capacity should be a priority, as all but one of the existing nuclear stations were scheduled to close by 2023. Government ministers and advisers have mentioned nuclear as 40% of UK supply as realistic and desirable, though the government did not go beyond replacement (20%) as its policy target. A number of factors had emerged to place nuclear energy in a more favourable light.

First, increasing concern over greenhouse gas emissions and global warming led to a re-evaluation of nuclear power as a low-carbon form of energy production. A target of reducing UK greenhouse gas emissions by 80% by 2050 was announced by the government in 2008, along with the observation that nuclear power would be essential to have any hope of achieving this.

Secondly, it became apparent that renewable energy sources such as wind and solar power would not be able to fill the gap resulting from the closure of elderly power stations including the Magnox and AGR plants and most of the coal- and oil-fired power stations. Nuclear power is the only readily available large-scale alternative to fossil fuels for production of the continuous, reliable supply of electricity that is essential to meet the minimum constant demand, known as the base-load demand. Wind, solar and tidal power are variable sources and cannot meet base-load demand. In effect this means that for every new wind farm, an increase in fossil fuel or nuclear capacity is needed to accompany it.

Thirdly, fears grew concerning the security of supply of energy imported from overseas. The action of the Russian government in turning off the supply of natural gas to the Ukraine and Western Europe in 2009 brought this into stark focus. In 2010 half of British gas was imported, double the level of only three years previously, and this is expected to increase to at least 75% by 2015 as domestic reserves are depleted. This has major implications for electricity generation, with the amount to be from gas expected to double between 2007 and 2015.

Fourthly, the economics of electricity generation have swung in favour of nuclear power. Increasing oil and gas prices have greatly improved the economics of nuclear power for electricity. Unlike fossil-fuel generation technologies, fluctuations in fuel prices do not significantly affect the cost of electricity from nuclear power stations. This is because fuel costs for gas-fired generation are estimated to be approximately 70% of the total costs, compared with approximately 10% for nuclear power. Several studies have shown that nuclear energy is the most cost-effective of the available base-load technologies. In addition, as carbon emission reductions are encouraged through various forms of government incentives and emission trading schemes, the economic benefits of nuclear power will increase further.

The government's view was summarised in the National Policy Statement for Nuclear Power Generation, published in November 2009:

> 'Nuclear Power is low-carbon, economic, dependable, safe, and capable of increasing diversity of energy supply and reducing our dependence on any one technology or country for our energy or fuel supplies. Excluding nuclear power as an option for generating electricity would make it harder and more expensive to meet our emission targets. It could also jeopardise the security of the UK's energy supply… The Government is satisfied that effective arrangements will exist for management and disposal of radioactive waste. Plans

*Figure 4: Proposed sites for the new generation of nuclear power stations*

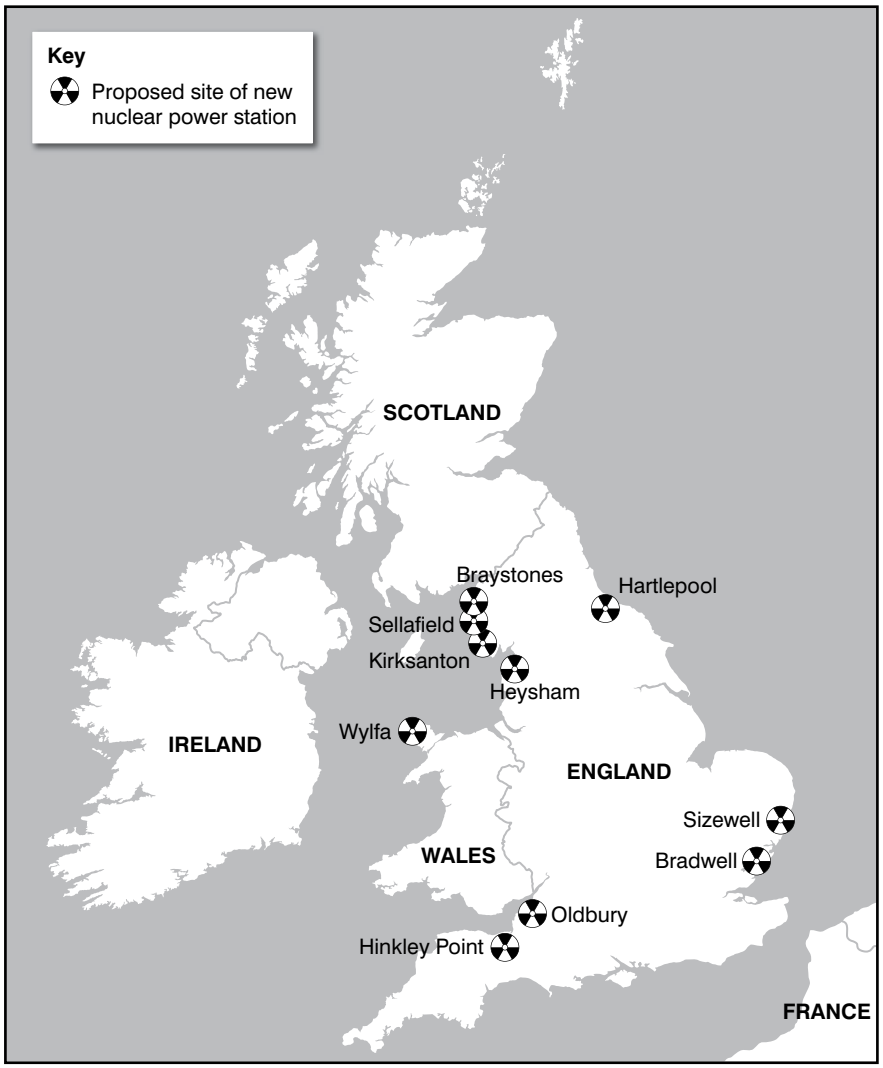



*Figure 5: Nuclear power reactors planned and proposed*

| Proponent | Site | Type | Proposed capacity MW | Start-up |
|---|---|---|---|---|
| EdF/BE | Sizewell, Suffolk | EPR x 2 | 3300 | 2019 |
| EdF/BE | Hinkley Point, Somerset | EPR x 2 | 3300 | 2018 |
| Horizon (RWE + E.On) | Oldbury, Gloucestershire | EPR or AP1000* | 2500-3300 | 2020+ |
| Horizon (RWE + E.On) | Wylfa, Wales | EPR or AP1000* | 2500-3300 | 2020+ |
| Iberdrola + GdF Suez + Scottish & Southern | Sellafield, Cumbria | ? | 3600 | 2020+ |
| Total planned & proposed | | | 15,200-16,800 | |

are for long-term disposal in a geological disposal facility, preceded by secure storage until a suitable location is identified by the government.'

The last point dismisses one of the major concerns of opponents to nuclear energy, the problem of disposing of hazardous waste. The government's view was attacked as highly optimistic and complacent by pressure groups opposed to nuclear power. Roger Higman of Friends of the Earth stated:

> 'The most radioactive waste is going to be high level in a thousand years' time so whatever happens, we have got a problem. There is no safe way of disposing of nuclear waste and one of the most important lessons is not to create any more, which means we should not have nuclear power plants.'

In November 2009 Friends of the Earth campaigner Simon Bullock added that 'radioactive waste will need to be stored on-site before it can be safely removed. Communities will have high-level nuclear waste stored in their area for 160 years.'

Despite such opposition, the nuclear renaissance since the turn of the century has already resulted in construction starting of over 50 new reactors worldwide, mainly in Asia, in 2011. Plans are well advanced for new nuclear power stations in the USA, Canada, France, Finland, Italy and several eastern European countries. The UK can now be added to this list (Figures 4 and 5).

In 2009 the UK government approved 10 sites in England and Wales for new nuclear power stations, most of them in locations where there are already plants. The 10 sites approved for future nuclear plants are: Braystones, Kirksanton and Sellafield in Cumbria, Bradwell in Essex, Hartlepool, Heysham in Lancashire, Hinkley Point in Somerset, Oldbury in Gloucestershire, Sizewell in Suffolk and Wylfa in North Wales (Figure 4). Eight of the proposed locations are already home to nuclear plants. An 11th proposed site at Dungeness was rejected. In Scotland the governing Scottish National Party had decided that no new nuclear plants should be built in that country.

The governments' Strategic Siting Assessment criteria for the new sites included:

- the risk of flooding, tsunami and storm surge
- local coastal geomorphological processes
- proximity to hazardous industrial facilities
- proximity to civil aircraft movements
- local demographics
- proximity to military activities
- the presence of any internationally designated sites of ecological importance
- the presence of any nationally designated sites of ecological importance
- the presence of areas of amenity, cultural heritage and landscape value
- the size of the site to accommodate operation
- access to suitable sources of cooling.

By mid-2010 five companies and consortia had applied to build new nuclear stations (Figure 5).

## Case Study: Hinkley Point

The most advanced of the new power stations is that at Hinkley Point C. Here, the French state-owned electricity company EDF plans to commence construction in 2012 for a 2018 opening. Hinkley Point provides a fascinating case study with many aspects applicable to the British nuclear sector as a whole. A headland on the Bristol Channel some 10 km north of Bridgwater in Somerset, Hinkley Point was the site of one of the early Magnox stations opened in 1965. During its 35 years of operation, Hinkley Point A generated more than 103 TWh of electricity, finally ceasing generation in 2000. The station is now being decommissioned, one of nine of the fleet of 11 Magnox stations being decommissioned.

In 1976 the second power station on the site opened, Hinkley Point B, an AGR. This station is still generating electricity and is planned to remain open until at least 2016. In the 1980s a planning enquiry was held on a proposal to build a third station at the site, Hinkley Point C. This was to be a pressurised water reactor (PWR) similar to that at Sizewell B. The public enquiry opened in October 1988 and lasted a year. It was almost a year later before a decision was made by the government to grant planning permission. However, Hinkley Point C was subsequently abandoned when the electricity industry was privatised; as stated earlier, private industry was not convinced of the profitability of nuclear power at that time, not least because low-rate government loans were no longer available.

Nearly 20 years later, in 2009, Hinkley Point C reappeared, but this time as a European pressurised reactor (EPR). The French state-owned electricity generator EDF Energy bought the British company British Energy in January 2009 and purchased land adjacent to the existing Hinkley Point power stations. EDF has built and operates 58 nuclear power plants in France and it is currently building a new EPR nuclear power station at Flamanville in Normandy, similar to what it plans for Hinkley Point C. EDF Energy operates a further 15 nuclear power plants in this country. Details of the proposal can be found in the website mentioned in the bibliography.

The construction of Hinkley Point C will have a considerable impact on the local area, with new roads, new accommodation, increased traffic and increased employment opportunities.

The nuclear renaissance imposes pressure on British industry, especially in terms of the capacity and skills within the construction and engineering sectors. In order to address the skills agenda, the sector skills council for the nuclear industry (COGENT) established a National Skills Academy for the nuclear sector. The NSAN is based in the North West of England, with regional hubs. Bridgwater College, close to Hinkley Point, is the hub for the South West of England and is the site of a new £8 million Energy Skills Centre intended to meet much of the local training needs of the nuclear sector. NSAN has overseen the introduction of a range of new training qualifications for the nuclear industry, ranging from short awareness courses and a nuclear skills passport to full NVQs and foundation degrees. EDF calculates that over 4000 jobs will be provided in the construction phase at Hinkley Point, and 700 once the station starts operations; in addition the new power station will support hundreds of jobs in the supply chain. Many of these jobs will be filled by people new to the industry, and EDF has a commitment to employ local people. Early indications show how attractive careers in the new nuclear industry will be. There were 50 applicants for every place on EDF's 2010 nuclear graduate training programme, and 850 applicants for 25 jobs in their Nuclear Engineer Development Programme.

## Conclusion

After being one of the pioneers of nuclear energy in the 1950s, the UK ceased construction of further nuclear plants in the early 1990s. Now, nearly 20 years later, there is a nuclear renaissance. Concerns over safety and the ultimate disposal of radioactive waste have been overtaken by the need to develop low carbon energy and ensure security of energy supply. The result is that up to 10 new nuclear plants may be in operation in the UK by 2030, by which time all but one of the existing plants will have closed.

## Bibliography

Department of Energy and Climate Change 'National Policy Statement for Nuclear Power Generation', The Stationery Office, London, November 2009

*Meeting the Energy Challenge: A White Paper on Nuclear Power*, January 2008, CM 7296, URN 08/525
http://www.berr.gov.uk/files/file43006.pdf

http://hinkleypoint.edfconsultation.info/websitefiles/PPS_SW_3031_EDF_HINK_POINT_PROPOSAL_SUM_Final.pdf

'Warning on nuclear waste disposal' 4 April 2005 BBC website:
http://news.bbc.co.uk/1/hi/sci/tech/4407421.stm

## Focus Questions

1. Study Figure 2 showing the fuels used for electricity generation in the UK between 1990 and 2008. Total electricity generation in 1990 was 76.3 million tonnes of oil equivalent; by 2008 this had risen to 84.5 mtoe.
(a) Explain the meaning of the term 'million tonnes oil equivalent'.
(b) Compare the pattern of fuels used in 1990 with that used in 2008.
(c) Comment on the contribution made to global warming in each year.

2. (a) Why were no more nuclear power stations built in the UK following the completion of Sizewell B in 1995?
(b) What factors caused the British government to approve 10 sites for new nuclear power stations in 2009?