climate change – hubris or nemesis for nuclear power?

Proposals for new nuclear power installations are often presented as integral to solutions to climate change, but the dangers of sites in low-lying coastal areas only add to a range of threats to security and the environment posed by nuclear power, says Andrew Blowers

'It was now that wind and sea in concert leaped forward to their triumph.'
Hilda Grieve: *The Great Tide: The Story of the 1953 Flood Disaster in Essex*. County Council of Essex, 1959

The Great Tide of 31 January/1 February 1953 swept down the east coast of England, carrying death and destruction in its wake. Communities were unaware and unprepared as disaster struck in the middle of the night, drowning over 300 in England, in poor and vulnerable communities such as Jaywick and Canvey Island on the exposed and low-lying Essex coast. Although nothing quite so devastating has occurred in the 67 years since, the 1953 floods remain a portent of what the effects of climate change may bring in the years to come.

Since that largely unremembered disaster, flood defences, communications and emergency response systems have been put in place right along the east coast, although it will only be a matter of time before the sea reclaims some low-lying areas. 'Managed retreat' and 'coastal realignment' are the approaches for tackling areas left unprotected by hard defences, while 'managed adaptation' is used for vulnerable urban areas and coastal infrastructure.

Among the most prominent infrastructure on the East Anglian coast are the nuclear power stations at Sizewell in Suffolk and Bradwell in Essex, constructed and operated in the decades following the Great Tide. Sizewell A (capacity 0.25 gigawatts), one of the early Magnox stations, operated for over 40 years, from 1966 to 2006. Sizewell B (capacity 1.25 gigawatts), the only operating pressurised water reactor (PWR) in the UK, was commissioned in 1995 and is currently expected to continue operating until 2055. Further down the coast, Bradwell (0.25 gigawatts) was one

Brian Jay

The flooded causeway to Mersea Island after the Great Tide of 1953

of the first (Magnox) nuclear stations in the UK and operated for 40 years from 1962 to 2002, becoming, in 2018, the first to be decommissioned and enter into 'care and maintenance'.

These and other nuclear stations around our coast were conceived and constructed long before climate change became a political issue. And yet the Magnox stations with their radioactive graphite cores and intermediate-level waste stores will remain on site until at least the end of the century. Meanwhile, Sizewell B, with its highly radioactive spent fuel store, will extend well into the next. Inevitably, then, the legacy of nuclear power will be exposed on coasts highly vulnerable to the increasing sea levels and the storm surges, coastal erosion and flooding that accelerating global warming portends.

Managing this legacy will be difficult enough. Yet it is proposed to compound the problem by building two gargantuan new power stations on these sites, Sizewell C (capacity 3.3 gigawatts) and Bradwell B (2.3 gigawatts) to provide the low-carbon, 'firm' (i.e. consistent-supply) component of the energy mix seen as necessary to 'keep the lights on' and help save the planet from global warming. But these stations will be operating until late in the century, and their wastes, including spent fuel, will have to be managed on site for decades after shut-down. It is impossible to foresee how any form of managed adaptation can be credibly sustained during the next century when conditions at these sites are unknowable.

New nuclear power is presented as an integral part of the solution to climate change. But the 'nuclear renaissance' is faltering on several fronts. It is unable to secure the investment, unable to achieve timely deployment, unable to compete with much cheaper renewables, and unable to allay concerns about security risks, accidents, health impacts, environmental damage, and the long-term management of its dangerous wastes. It is these issues that will be played out in the real-world context of climate change. There is an exquisite paradox here. While nuclear power is hubristically presented as the 'solution' to climate change, the changing climate becomes its nemesis on the low-lying shores of eastern England.

A diminishing prospect

So far, the nuclear industry has been unable, even with increasing government support, to deliver anything close to the ambitions of the 'nuclear renaissance'. The government originally set out with the aim that 'new nuclear power should be free to contribute as much as possible towards meeting the need for 25 GW of new non-renewable capacity'[1] and, in 2011, eight sites were designated for new reactors to be developed by private investors. But, as the costs have risen, and the competition from alternatives has intensified, nuclear has obligingly fallen on its sword.

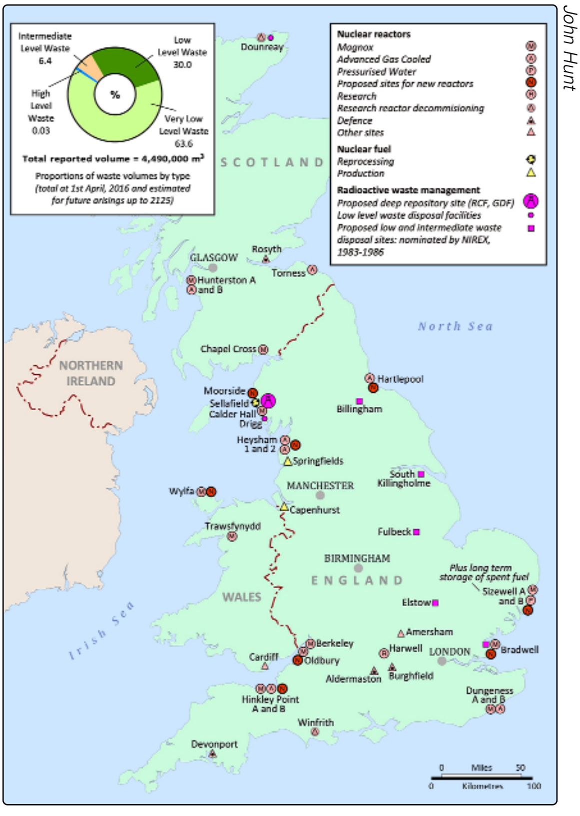
Two of the eight sites, Hartlepool and Heysham, have not attracted any investor interest. Of the rest, Moorside, the site neighbouring Sellafield, intended for three reactors with 3.3 gigawatts capacity, was abandoned by its Japanese investor, Toshiba, in 2018, to the dismay of the local community, which generally supports expansion to keep nuclear production alive at a time when reprocessing at Sellafield is closing down.

Wylfa Newydd on Anglesey has also, for the time being at least, fallen out of the reckoning as its developer, Hitachi, suspended work on the project in early 2019, at the point at which it was awaiting the outcome of its application for development. This effectively took out any chance of development at the proposed Odlbury station on the Severn Estuary, which was an integral part of Hitachi's plans for new nuclear power in the UK. While these projects are not necessarily dead, their imminent revival would seem unlikely at a time when the financial fortunes of nuclear power are at a low ebb.

And yet the nuclear project, in diminished form, continues. It is estimated that existing nuclear power sources offset about 4% of total global carbon dioxide emissions. Development of new nuclear power stations in China is unlikely to arrest long-term decline as ageing plants are retired elsewhere. The reality is that nuclear is more expensive than alternatives, saving less carbon dioxide per unit of investment. Nuclear's opportunity costs are high, it takes far longer to come on stream, and, once it does, there is the possibility that it will displace cheaper, quicker and more effective alternatives. Amory Lovins emphasises the point:

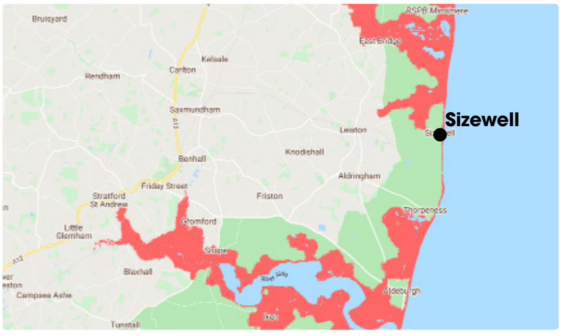
> *'Nuclear new build and often continued operation of existing nuclear plants is not climate-effective because it saves less carbon than closing plants and reinvesting their saved operating cost in carbon-free resources.'*[2]

In the meantime, nuclear energy is declining in the UK as the fleet of advanced gas-cooled reactor (AGR) power stations are phased out during the next decade. But Sizewell B could still be producing electricity at mid-century (60 years from 1995) and, if it finally comes on stream, Hinkley Point C would have a life expectancy until near the end of the century (2027-2087). Thus at mid-century the UK's nuclear generating capacity could be around 4.5 gigawatts (declining to 3.3 gigawatts thereafter),



John Hunt

Nuclear power in UK



Coastal flooding area projection for the area around Bradwell (left image) and Sizewell (right) in 2100

Source: Climate Central, 'Coastal Risk Screening Tool: Map By Year', at https://sealevel.climatecentral.org/maps/ (nuclear power plant locations added)

a continuing substantial, even if increasingly unnecessary, supply.

The National Infrastructure Commission makes a sober assessment of the situation: 'New nuclear power stations are unlikely to be an additional source of electricity in the 2020s, with the possible exception of Hinkley Point C.'[3] Beyond that, it recommends a 'one by one' approach if a case can be made, rather than the government's strategy of aiming for a large nuclear fleet.

The only certainty is uncertainty

By early 2020 only three of the original designated sites were being actively pursued. Hinkley Point C was under construction but had been dogged by controversy over its costs, the parlous financial state of its main developer, EDF, and the burden of repayment which will be placed on future consumers paying a high fixed price for their electricity.[4] Its critics claim that it would make more economic sense to abandon this hopelessly expensive and uncompetitive project.

Apart from Hinkley Point C, which will probably struggle on through a combination of political inertia and a nuclear ideology increasingly remote from economic reality, there remain two projects – Sizewell C and Bradwell B – still in the frame, although precariously so. Even if they survive the financial, technological and regulatory hurdles, both face an obstacle that may prove insurmountable. They require a Development Consent Order (DCO), i.e. planning permission from the Secretary of State on the recommendation of the National Infrastructure Directorate of the Planning Inspectorate, as well as permits from the Environment Agency and the Office for Nuclear Regulation. In the case of these two sites, climate change may prove the showstopper. These coastal, low-lying sites are highly vulnerable to the impacts of climate change, including sea level rise, flooding, storm surges, and coastal processes.

This was recognised as an issue in the rather equivocal statement that accompanied designation of the sites in 2011. Referring to Bradwell (similarly to Sizewell), it was considered 'reasonable to conclude that any likely power station development within the site could potentially be protected against flood risk throughout its lifetime, including the potential effects of climate change, storm surge and tsunami, taking into account possible countermeasures'.[5] By 2017, when the siting criteria were being revised, the onus was more firmly placed on the developer to 'confirm that they can protect the site against flood-risk throughout the lifetime of the site, including the potential effects of climate change'.[6] Lifetime protection was envisaged as a process of 'managed adaptation', requiring developers 'to demonstrate that they could achieve further measures for flood management at the site in the future, if future climate change predictions show they are necessary'.[7]

There are two problems with managed adaptation. The first is the increasing uncertainty of predictions of climate change and related sea level rise, and especially storm surges which greatly increase the impact, by the end of this century. If present trends continue, global warming could reach 3°C-4°C by the end of the century and, even if it can be reduced to 2°C based on the Paris accords of 2015 or, better still the 1.5°C urged by the IPCC (Intergovernmental Panel on Climate Change)[8] (now looking increasingly unlikely), sea level rise of around 1 metre will occur, and rising seas are inevitable beyond 2100.

At that kind of level managed adaptation might still be credible. But managed adaptation must take a precautionary approach to design and factor in 'credible maximum scenarios',[9] which are difficult to establish with credibility given the large uncertainties of climate change impacts. The Met Office forecasts indicate that sea level rise beyond 2100 could reach 4 metres by 2300. Given the uncertainties, 'we don't yet know whether storm surges will become more severe, less severe or remain the same'.[10] The Environment Agency currently suggests that we need to prepare for a 2°C rise but plan for a 4°C rise.[11]

The second problem is that sea level rise and climate impacts will continue into the next century even if counter-measures to hold global warming succeed. It becomes increasingly difficult to rely on extrapolation, assuming past trends will continue into the future. Trends do not continue indefinitely, either because of counter-action (to reduce global warming) or because unpredictable and sometimes unforeseeable events or changing circumstances occur. Even with ocean temperatures held constant from 2020, the loss of a substantial portion of the West Antarctic Ice Sheet may already be inevitable.

A study of ice sheet contributions to sea level rise (SLR) indicates that a high, although by no means improbable, global warming of 5°C could lead to a 2 metre rise in sea levels by 2100, resulting in land loss, disruption of food production, and displacement of up to 187 million people – 'A SLR of this magnitude would clearly have profound consequences for humanity'.[12] At that level of warming, the study indicates that by 2200 instabilities of the West and East Antarctic Ice Sheets could lead to a 7.5 metre sea level rise.

The interactive processes and feedback loops of global warming – including thermal expansion of the oceans, changes in ocean currents, slowing of the Gulf Stream, deforestation, melting permafrost, desertification, changing land use and carbon dioxide emissions – are complex, making prediction uncertain and, in the longer term, indeterminate. This leaves scope for much speculation about trends and tendencies, with some scientists suggesting that global warming may be accelerating exponentially or may be modelled as step functions rather than a linear upward trend. The only certainty is uncertainty.

In the event of worst-case scenarios, the loss of nuclear power stations would be an incidental calamity in the face of an overwhelming global catastrophe.

Into the unknowable

About a quarter of the world's nuclear power stations are on coasts or estuaries. The sites on the east coast and Severn Estuary are especially vulnerable to flooding, tidal surges, and storms. Potential impacts include loss of cooling and problems of access and emergency response in the event of a major incident and inundation of plant, including spent fuel storage facilities.[13]

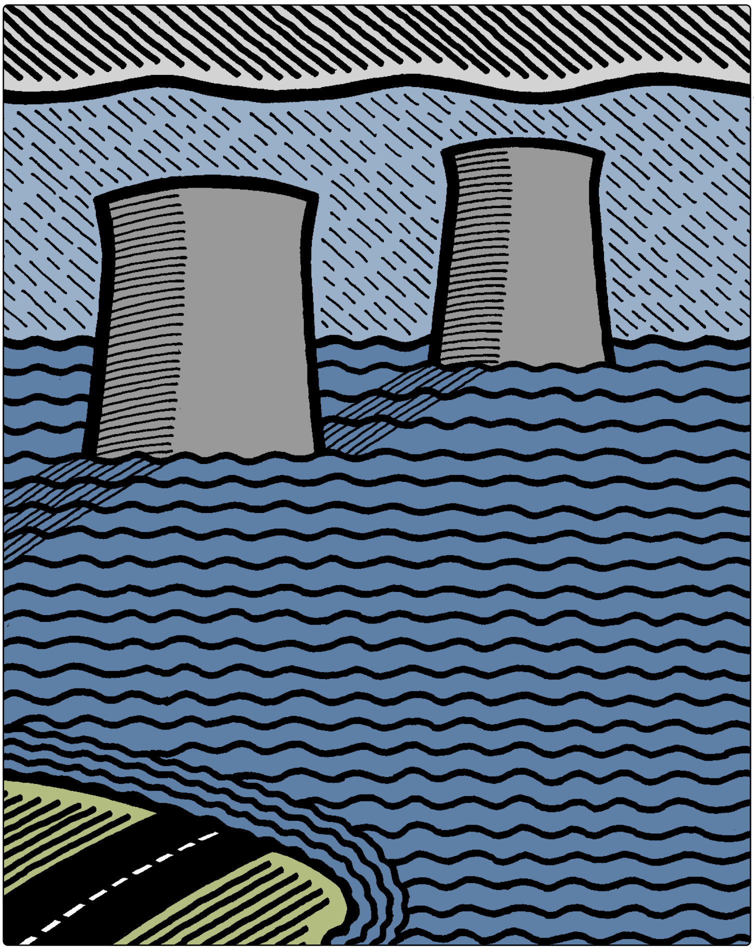
Nuclear power stations are defended against rising seas in various ways, by mounding well above maximum predicted sea levels and by hard defences. In the case of Hinkley Point C, situated on the Severn, with its huge tidal range, a 900 metre-long seawall with a crest height above 13.5 metres to cope with extreme flooding of 9.52 metres is planned. At Sizewell an embankment of 10 metres is planned, which could be increased to 14 metres if sea level trends suggested adaptation were necessary. The initial proposals for Bradwell B indicate a sea-girt fortress with the reactors, generators, spent fuel store and cooling towers on an island mounded up to 7.4 metres above AOD (above ordnance datum) and defended by rock-armoured sea defences at 9.8 metres AOD for protection against an extreme flood event. Such plans respond to the principle that 'flood protection measures are made adaptable to cover possible changes to future estimates of climate change effects, as a way of managing the large uncertainties inherent in flood hazard prediction over the life-time of new nuclear reactor sites'.[14]

The problems of coastal management in a changing climate have recently been set out by the UK Committee on Climate Change.[15] In areas like the east coast, natural protection from saltmarshes, mudflats, shingle beaches, sand dunes and sea cliffs has been rapidly declining. Recent projections indicate substantial parts of the coast below annual flood level in 2100 and a loss of between a quarter and a half of the UK's sandy beaches, leading to extensive inland flooding[16] The problems of managing such coasts through adaptive measures such as managed realignment and hard defences may be insuperable in the uncertain circumstances of climate change over the next century. It seems imprudent and irresponsible to contemplate development of new nuclear power stations in conditions which may become intolerable.

Climate predictions have focused especially on the period up to the end of the century, by which time planned new nuclear power stations starting up in the 2030s will only just have ceased operating. At the turn of the next century the legacy of today's new build will become the decommissioning wastes of tomorrow, adding to that already piled up in coastal locations.

It is conceivable, but not certain, that sea defences will prove technically resilient. But it is not just an engineering issue: managed adaptation depends on institutional continuity and a society with the interest, resources and skills to maintain continuing commitment to nuclear energy and the management of its legacy over the very long term. By the end of the century nuclear energy could be a redundant technology, requiring continued surveillance by a society already struggling to cope with the impacts of climate change.

Beyond 2100 sea levels continue rising and the radioactive legacy of new nuclear power stations will remain at the sites, in reactor cores and in spent fuel and waste stores exposed to the destructive processes of climate change. It is predicted that decommissioning and clean-up of new build sites will last for most of the next century. The logistics, let alone the cost of transplanting, decommissioning and decontaminating the redundant plant and wastes to an inland site, if one could be found, would be well beyond the range of managed adaptation. The government's claim that it 'is satisfied that effective arrangements will exist to manage and dispose of the wastes that will be produced from new nuclear


Clifford Harper

'There is a clear expectation that these most highly radioactive facilities will still be present on site at a time when any forecasts of coastal processes and sea level change are in the area of indeterminacy'

power stations'[17] is an aspiration, and by no means a certainty.

The most optimistic expectation is that it would be at least 2130 before the wastes would be cooled, conditioned and encapsulated and ready for removal from site to a disposal facility. The priority for a Geological Disposal Facility will be to cope with the massive burden of legacy wastes from Sellafield and other decommissioned sites. It is not at all clear whether a repository (or two) will even exist, let alone be ready to dispose of new build wastes when they arise. The developer of Sizewell C merely states that spent fuel 'would be kept on-site until a national geological facility becomes available'.[18] In the absence of a repository, it is vaguely assumed that wastes could be safely stored above ground indefinitely.

New build wastes add further complications to the problem of dealing with the legacy of nuclear power. As the Committee on Radioactive Waste Management (CoRWM) pointed out: 'New build wastes would extend the time-scales for implementation, possibly for very long but essentially unknowable future periods'.[19] In other words, there is a clear expectation that these most highly radioactive facilities will still be present on site at a time when any forecasts of coastal processes and sea level change are in the area of indeterminacy.

Meanwhile, the inescapable legacy of wastes from the existing civil and military nuclear programmes must be managed. Although by far the largest and most difficult wastes are at the Sellafield site, there are significant volumes of intermediate-level wastes scattered around the coasts. At Sizewell there are already wastes from the Magnox station, and Sizewell B is still operating and continuing to produce wastes, including spent fuel stored on site for the (un)foreseeable future.

Even Bradwell, proudly acclaimed as the first of the Magnox sites to be decommissioned and placed in 'care and maintenance', remains as a radioactive waste storage site, with waste stores and the graphite reactor cores remaining in 'passive' storage until at least the end of this century. Managing the existing burden at Bradwell and Sizewell is likely to prove difficult in changing conditions of climate change.

A policy of managed adaptation is essentially reactive and conceptually rational, identifying feasible responses to conditions as they come to pass. But eventually the approach is irrational since it becomes necessary to apply unimaginable responses to unknowable conditions. While managed adaptation may have some credibility in the short term, in the long term it is surely a fantasy. The only rational approach is not adaptation but mitigation; in this instance, mitigation means not developing new nuclear stations at unsuitable and unacceptable sites like Sizewell and Bradwell and stopping development at Hinkley Point C.

Nuclear energy has been in retreat in the face of issues of cost, technology, safety, security, and environmental impact. Increasingly it has come to rely on two arguments. The first is that there is a need for 'firm' power in the energy mix which only nuclear can supply. As alternatives become more flexible and cheaper, any need for new nuclear will diminish, and, in any case, there is already substantial nuclear capacity for the short term in the existing fleet. The other claim for new nuclear is even more specious: that it is a necessary low-carbon investment to combat climate change. In fact, nuclear power is cumbersome, inflexible and will displace or restrain alternative renewable technologies with lower costs and a smaller carbon footprint.

Nuclear energy is portrayed as a moral imperative in the face of climate change. On the contrary, nuclear energy raises moral issues about security and potential destruction and danger to the environment and public health in nuclear communities down the generations. The moral question becomes all the more acute in the very specific circumstances of developing unsustainable nuclear power stations on the crumbling shores of East Anglia and the West Country. In Hilda Grieve's perspicacious words:

> *'But the sea will not be tamed. From time to time, urged on by its only master, the wind, to break the order of its course, it will rise again to strike the land.'*

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Notes

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