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Monitored this issue: Nuclear Wastelands

This double-issue of *Nuclear Monitor* is a series of six articles written by Prof. Andrew Blowers OBE, all concerned with nuclear waste. Andrew is Emeritus Professor of Social Sciences at The Open University and is presently Co-Chair of the Department for Business, Energy and Industrial Strategy / NGO Nuclear Forum. He was recently awarded the Alexander and Ilse Melamid Medal by the American Geographical Society for his extensive contributions in the application of geographic principles to energy, planning, and humankind – working in academia, politics, government, and in his retirement, as an anti-nuclear campaigner.

This series of articles draws on Andrew's book *The Legacy of Nuclear Power* (Earthscan from Routledge, 2017). The articles were originally published in *Town & Country Planning* (www.tcpa.org.uk). Thanks to Andrew and *Town & Country Planning* for permission to reprint these articles, and to John Hunt for his maps and other assistance.

Landscapes of the legacy of nuclear power

In the first of a series of articles on the local and social legacies of nuclear energy, Andrew Blowers looks at where and why these legacies have come to pass.

The nuclear industry has left its visible and invisible footprint in landscapes of risk encountered in the 31 countries in which nuclear energy has been developed. In several countries the mark is, as yet, small, related to one or two operating nuclear reactors. At the other extreme there are those countries with long-established nuclear industries, some involved in both the civil and military sectors, where nuclear operations, including electricity generation, reprocessing and experimental processes, are intermixed with redundant facilities, nuclear wastes, and radioactive discharges onto land and into water and emissions into the atmosphere.

These 'landscapes of risk' include places such as Hanford, the most polluted site in the United States and the world's largest clean-up project; Ozersk in Russia, with a calamitously contaminated landscape 'still beautiful to behold, now dangerous to traverse';[1] and Sellafield, Western Europe's most hazardous location, once described as an 'intolerable risk'.[2]

Such sites were created through the routine, if poorly managed, operations of a complex of nuclear production, reprocessing and waste management facilities. Other expanses of nuclear contamination have arisen as a result of accidents occurring through human error or natural disaster, the areas around Chernobyl and Fukushima being the most notorious examples of evacuated and contaminated nuclear landscapes.

The problems of dealing with such sites are complex, tedious and intractable. While such places present the most formidable challenges, every nuclear site sooner or later exposes the issue of what to do with the radioactive materials and wastes that are left behind during operation and lasting long after operations have ceased.

It is the enduring legacy of radioactivity which cannot easily be dispensed with that creates a problem of sustainability at once both physical and social. It is physical in the sense that means must be found to control, remove and contain the radioactive hazard so that eventually the land, or that part of it which is not irremediably contaminated, may be released and recovered for other land uses. But sustainability also has a social dimension in the need to ensure the survival and sustainable development of the nuclear communities that have grown up near nuclear sites. In principle, as the International Atomic Energy Authority (IAEA) puts it: 'Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.'[3]

IAEA personnel at the Fukushima nuclear plant in 2013. *Photo by Greg Webb / IAEA.*

This article is the first in a series in which I will consider the legacy left by nuclear energy from its local and social perspective, both geographical and historical. I shall consider how nuclear communities have developed, why they are where they are, and what their future prospects are. In particular, I shall try to identify the peculiar characteristics of these nuclear communities and explore the shifting power relations between industry and community and between community and wider society. These relations are not simply matters of economics and politics, but raise some profoundly moral issues of how we should deal equitably with the social aspects of environmental risk, for both present and future generations.

I shall explore these issues through four case studies of nuclear landscapes and related communities in four countries. From these I shall draw out some conclusions, reflections and suggestions on how we should deal with the legacy and the communities that live with it. But first let us look at where and why the legacy has come to pass.

The growth of the legacy

The legacy of nuclear power exists in time and space. It stretches back over time to the earliest days of the nuclear industry. Its origins were military, in the making of uranium and plutonium for bombs. The use of nuclear fission power, 'the peaceful atom', for electricity generation came later.

This early phase of the industry, lasting for around three decades, was a period in which a trust in technology and progress fostered a routine culture of secrecy and unquestioning promotion of nuclear technology. Little thought was paid to the legacy that was building up,

The ghost town of Pripyat in Ukraine after the Chernobyl meltdown of 1986.

much of it left in situ or casually dumped into tanks and ponds, buried in shallow repositories or simply tipped into the ocean. Major nuclear accidents were either covered up entirely, as was the case with the huge releases of radioactivity from the Mayak reprocessing and waste facility at Ozersk in the Urals in 1957, or, like the Windscale accident in the same year, their true dimensions were not revealed until many years later. Indeed, some incidents were quite deliberate, like the now infamous 'Green Run' in 1949, when an experimental release of radioactivity from the Hanford site resulted in a plume stretching far and wide across the farmlands of Washington state.

Over the years, nuclear accidents involving loss of life or extensive property damage have been commonplace, as Benjamin Sovacool[4] records (his own compilation totalling 99 incidents costing $20.5 billion between 1952 and 2010), and major catastrophes like Mayak (Russia, 1957), Chernobyl (Ukraine, 1986) and Fukushima (Japan, 2011) have occurred every generation, to the point where Charles Perrow[5] has dubbed them 'normal' and therefore likely to be recurrent.

By the 1970s nuclear energy had reached its apogee in public approval, and programmes of nuclear expansion were under way. Subsequently in many, mainly western, countries enthusiasm for nuclear energy gradually diminished as programmes were completed and the long timescales of construction and high costs placed nuclear at a competitive disadvantage to its fossil fuel rivals, coal and oil. It was a period punctuated by traumatic accidents, the near miss of Three Mile Island, and the catastrophe of Chernobyl. Moreover, attention was increasingly turning to the technological problems encountered with reprocessing and other experimental developments.

Above all loomed the problem of poorly managed wastes accumulating at nuclear sites. The Flowers Report had pronounced in 1976 that any solutions to the problem would need to demonstrate 'beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future'.[6] This statement has been taken as axiomatic in the subsequent search for a deep-disposal repository site in the UK.

Efforts to find sites have been persistently rebuffed by determined opposition able to mobilise coalitions to prevent their territory from providing a permanent resting place for the nation's most fearsome and dangerous wastes. From the Highlands of Scotland to the lowlands of eastern England successive attempts were rebuffed by entrenched and trenchant opposition, organised, coherent and co-ordinated with singular purpose. The final hubristic attempt to foist the nation's radioactive burden on unsuspecting communities by a tactic of 'decide-announce-defend' met its nemesis in the rejection of the proposed underground laboratory (the Rock Characterisation Facility or RCF) at Sellafield in 1997. By that time the legacy of nuclear power had become the industry's Achilles heel, and what to do about it had become an almost existential issue.

Seeking solutions

By the turn of this century, then, and especially in the UK, the political dynamics had profoundly changed. With the nuclear industry seemingly in retreat and its opponents proclaiming its imminent demise, political space was opening up for mutual focus on the problem of waste. For the industry, a solution to the problem was perceived to be essential to any revival; for the opposition, ridding the country of its legacy would spell the end of nuclear's moment. For a few years an uneasy co-operation ensued between two sides, for whom, though the ends might be different, the means were compatible.

With political initiative, a consensual process based on principles of openness, transparency and public and stakeholder engagement developed through the first Committee on Radioactive Waste Management (CoRWM). Its key recommendation that geological disposal was, within the current state of knowledge,

the ‘best available approach’ for long-term management of radioactive wastes became the touchstone for policy development.[7] But, in order to hold the consensus together the policy was qualified by the requirement for a programme of interim storage as an integral part of a long-term strategy.

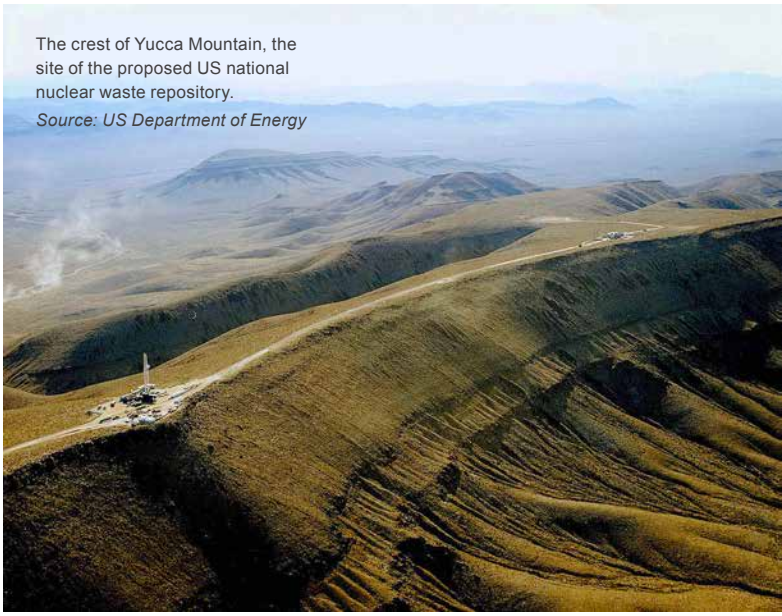
Above all, implementation of disposal would rely on a process of voluntarism, with local communities participating in ‘an open and equal relationship between potential host communities and those responsible for implementation’.[7] The focus on local communities in decision-making for radioactive waste was a far cry from the imperious attempts to impose solutions on communities that had failed at the end of the last century.

Even as CoRWM was making its pronouncements the power relations were shifting again. Seemingly from out of nowhere nuclear energy was, in prime minister Tony Blair’s words, back with a vengeance, and a ‘nuclear renaissance’ was proclaimed. At a time of heightened concern about national security in the wake of 9/11 and economic security following the financial crash of 2008, nuclear energy seemed to offer a more secure future as part of the energy mix than fossil fuel or renewable energy. Its proponents claimed that nuclear could provide base-load electricity and a secure energy supply and that, as a low-carbon form of energy, it answered growing concerns about environmental security in the face of climate change.

In the event, new nuclear in the UK has stuttered, with plans and proposals for reactors at six of the eight coastal locations nominated for new nuclear power stations, but none, with the possible exception of the beleaguered Hinkley Point, likely to materialise before 2030.

Meanwhile, the waste issue remains unresolved, although, in its effort to justify new nuclear stations, the government has claimed that policy meets the Flowers criterion on nuclear waste. In a neat piece of sophistry it pronounces itself satisfied ‘that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations’.[8] But the first attempt to use the voluntary process to find a suitable site has faltered, with the failure to get agreement to proceed with a siting process in West Cumbria. Even in nuclear’s heartland, it has so far proved impossible to impose a site from above (the RCF in 1997) or to entice the local community to volunteer one (the Geological Disposal Facility, GDF, in 2013).

The geography of the nuclear legacy, in the UK and in most western countries, is established and unlikely to change very much in the foreseeable future. New nuclear power stations, if they ever come to pass, will be built at existing nuclear locations, adding eventually to the accumulated legacy of wastes. It is conceivable that, in propitious geological and political circumstances, deep repositories will be able to meet the essential scientific and social conditions in greenfield locations. Bure, in France, may be a case in point. But on the whole the evidence points the other way.



The crest of Yucca Mountain, the site of the proposed US national nuclear waste repository.
Source: US Department of Energy

In Finland and Sweden deep geological repositories to take spent fuel and highly active wastes are being developed in nuclear communities where wastes are already accumulating. Elsewhere progress towards finding sites, whether at existing nuclear or greenfield locations, has been halting and slow. In the UK, efforts to build a repository near Sellafield in the very place where already two-thirds of the country’s wastes are stored have been resisted. In Germany, at Gorleben, and in the USA, at Yucca Mountain, federal government support for repositories in greenfield locations has been mired in political impasse for more than a generation. In most of the other nuclear countries, disposal is the goal of policy but proposals are at a formative stage.

Periphery and ‘peripheralisation’

The nuclear legacy, then, is likely to remain where it is for now and for generations to come, in what may be called ‘peripheral communities’.[8] They are places that can be defined in terms of their distinctive physical and social relations to nuclear activities. The physical relations are spatial and environmental. They are, in a spatial sense, remote, whether in terms of distance or inaccessibility from other areas. Environmentally these are places where hazardous activities have visibly contaminated and degraded the landscape or where there are the invisible risks from routine operations and the low-probability/high-consequence risk of a major incident or accident with potentially catastrophic consequences.

The social conditions of peripherality may be characterised as economic, political and cultural. Economically they tend to be monocultural, reliant on a dominant (in this case nuclear) activity, or underdeveloped places experiencing decline or deprivation. Politically they tend to be relatively powerless, with strategic decisions affecting the community taken elsewhere by governmental and corporate institutions. Socially, they manifest what might be termed a ‘nuclear culture’, a concept difficult to encapsulate very precisely but revealed in an ambiguous relationship between industry

and community, in competing but not necessarily contradictory postures, both defensive and aggressive, resigned and resilient, reactive and proactive.

Peripherality is not simply a set of static descriptive phenomena; it is a set of dynamic processes. The geography and endurance of nuclear's legacy is the product of 'peripheralisation', a rather unlovely word to describe a process of political engagement. By this, peripheral communities are created and sustained through a process of push and pull, attraction and repulsion. Peripheral characteristics are the *raison d'être* of these communities, persistently attractive to nuclear activities and ultimately committed to managing the legacy. Elsewhere, communities able to mobilise the power to resist will be able to prevent the intrusion of nuclear activities. This explains the tendency for nuclear activities to gravitate to existing nuclear sites and why it proves difficult to establish a new nuclear presence in greenfield locations. Resistance will be strongest against proposals for sites for the permanent management of the nuclear legacy, especially from areas with little or no experience of the nuclear industry.

The peripheral characteristics of nuclear communities, taken together, seem to portray places that are vulnerable, victims of processes with inevitable consequences of powerlessness, insecurity and inequality. While this is broadly the case, the places managing the nuclear legacy are neither entirely marginal nor powerless; they exercise some economic and political leverage. Economically, they are relatively secure for, once production ceases, there remain decades of clean-up activity, often sustaining a large workforce. Unlike many industrial activities like mining or iron and steel production, the nuclear industry cannot be swept away once production ceases. The legacy remains and must be managed, probably in situ, for generations to come.

Therefore, politically, these communities are able to claim a continuing and open-ended commitment to clean-up from the state, in recognition of the risks they bear on behalf of society as a whole. In some cases there will be support for investment into regeneration and diversification.

Periphery and inequality

The nuclear legacy is unevenly distributed over space and time, and this raises ethical issues of fairness. There is the issue of fairness between places, which arises where responsibility for managing the legacy is devolved on specific places. And there is also fairness between generations arising from the indeterminate timescales over which the legacy must be managed. So peripheral nuclear communities will experience intragenerational inequality through the concentration of the legacy in space and intergenerational inequality resulting from the continuing responsibility extending indefinitely through time.

It is those places where the bulk of the nuclear legacy is managed that are the subject of this series of articles. They are landscapes of risk that manifest all the conditions of peripherality – geographical, economic, political, and social. They fulfil a fundamental social role in that they take on (or more usually have to accept) the radioactive legacy of nuclear power. They bear the burden of the cost, risk and effort necessary to manage the legacy on behalf of the wider society, a responsibility extending into the far future. At the same time society has a reciprocal responsibility.

This series of articles will look at some of these peripheral places, to try to understand the relationship between the nuclear industry and the community. It will look at how they have developed and the power relations that have moulded and sustained their continuing role. In the next article the focus will be on Hanford, the massive nuclear complex in the north west of the United States, where during the Second World War the plutonium for the bomb that shattered Nagasaki was made. Then I shall look at Sellafield, the heart of the UK's nuclear industry and the focus of conflicts and controversy.

The following article on France will consider radioactive waste management linking the reprocessing plant at La Hague in Normandy, where spent fuel is managed, with the emerging site at Bure in eastern France, where an underground laboratory to receive radioactive wastes is under construction. The fourth place covered will be Gorleben in Germany, a place identified as the resting place for the country's highly active wastes but where indomitable resistance has provided both symbol and success for the anti-nuclear movement.

In the final article I shall try to draw out some of the issues around what can and should be done about the future management of the nuclear legacy, and what this means for the future, not only of these peripheral communities but for the future of the nuclear industry itself. For the problem of the nuclear legacy is ongoing and forces us to confront moral issues about the legacy which we bequeath to future generations.

Notes:

1. K. Brown: *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters*. Oxford University Press, 2013. This is an evocative comparative social historical study of two communities, Hanford in the north west of the USA and Ozersk in the southern Urals in the Soviet Union, which developed simultaneously in the production of plutonium during the Cold War. Both areas became notorious for the extensive contamination and degradation of the landscape
2. Margaret Hodge, Chair of the Committee of Public Accounts, commenting on the BBC, 7 Nov. 2012. The National Audit Office also produced a highly critical report on risk management at Sellafield, *Managing Risk Reduction at Sellafield*, 2012. www.nao.org.uk/report/managing-risk-reduction-at-sellafield/
3. International Atomic Energy Agency, 1995, The Principles of Radioactive Waste Management, Principle 5.
4. See B. Sovacool: *Contesting the Future of Nuclear Power*. World Scientific, 2011. These accidents are quite aside from the accidents and near-misses involving nuclear weapons which are chillingly recorded in E Schlosser: *Command and Control*. Allen Lane, 2013
5. C. Perrow: *Normal Accidents: Living with High Risk Technologies*. Princeton University Press, 1999
6. *Nuclear Power and the Environment*. Cm 6618. Sixth Report. Royal Commission on Environmental Pollution. HMSO, 1976
7. *Managing our Radioactive Waste Safely*. Committee on Radioactive Waste Management, Nov. 2006
8. The term 'peripheral communities' and the process of 'peripheralisation' were first introduced in a paper I wrote with Pieter Leroy – A. Blowers and P. Leroy: 'Power, politics and environmental inequality: a theoretical and empirical analysis of the process of 'peripheralisation''. *Environmental Politics*, 1994, Vol. 3 (2), Summer, 197-228

Hanford, the nuclear frontier

In the second of a series of articles on the local and social legacies of nuclear energy, Andrew Blowers looks at the history of nuclear activity at the Hanford site in the Pacific Northwest of the United States.

Up in the Pacific Northwest of the United States in eastern Washington state the mighty Columbia River bends east, then south before turning west for its long journey to the Pacific Ocean. In this middle reach the river passes through a landscape that has been utterly transformed by the nuclear industry over the past three-quarters of a century. For it was here in December 1942 that Lieutenant Franklin T Matthias, flying over the area on a mission for the Manhattan Project, exclaimed: 'This is it!' He commented later that 'the site was so good that there couldn't be a better one in the country. It looked perfect in every respect.'[1]

It was big country, with few people, and above all isolated – just the place for the secret, war-driven purpose of making plutonium, the deadly fissionable material that, less than three years later, would be used to explode over the skies above Nagasaki. Hanford, in the American West, a frontier land where the Lewis and Clark expedition had passed in 1805, had become, a century and a half later, the American nuclear frontier, the Atomic West.[2] This semi-desert region of bare and barren brown and yellow hills and plains of sagebrush interspersed with homesteads of settlers and homelands of Native Americans was transformed into a landscape of risk and ultimately a nuclear wasteland, 'the little-known reservation that is arguably the most polluted place in the western world'.[3]

Hanford is one of the US Department of Energy's nuclear military reservations, places which have combined to produce the American nuclear arsenal. It is one of the three oldest and key wartime sites, along with Oak Ridge, Tennessee, and Los Alamos, New Mexico. Like them, it has the classic characteristics of a 'peripheral community',[4] but over the years, as its mission has changed and its economy has developed and diversified, it has become less isolated and more integrated into the mainstream – evidence of the dynamic nature of peripheral characteristics. Nevertheless, Hanford remains, to an extent, a place apart, defined by its history and ongoing nuclear activity, which, in a somewhat perverse way, provides a stability and sustainability that will endure for decades to come. Hanford is a long-established nuclear wasteland that has reached a level of maturity and permanency which illuminates the persistence of nuclear in the era of nuclear's decline. Hanford's history, perhaps, also indicates nuclear's future.

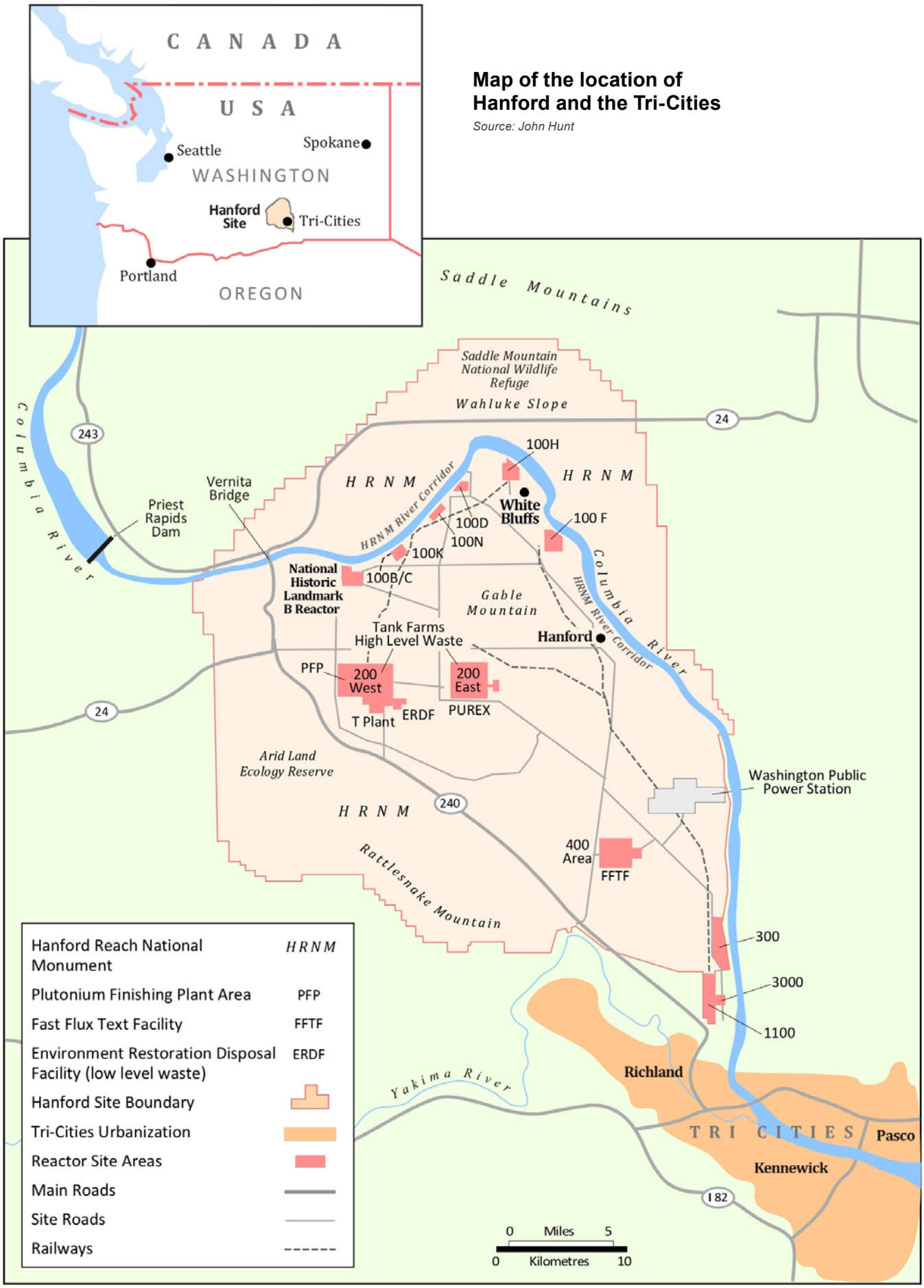
'Peace! Our bomb clinched it!'

It is difficult now to imagine the frenetic activity and scale of the mobilisation of technology, science and human resources that brought about the transformation of Hanford in the wartime years. In these extraordinary circumstances homesteaders were evicted, responding with a passive acceptance of the exigency of war mingled with resentment at the loss of livelihood. Native Americans were banned from fishing and gathering in the area of the Hanford Reach. All that now remains of the pre-war settlements is an abandoned farm warehouse and a crumbling bank and high school marking the site of the tiny settlements of White Bluffs and Hanford.

The Hanford site covers 586 square miles (larger than Bedfordshire and half the size of Rhode Island). The outlying parts of the reservation have been left as wilderness – the protected areas of the Wahluke Slope to the north, the Hanford Reach of the Columbia River, and the Arid Land Ecology Reserve flanking the bare saddleback Rattlesnake Mountain to the west. As Roy Gephart, who has chronicled the nuclear landscape, puts it: 'It contains a portion of the nation's most dangerous waste while preserving some of the most unique desert ecology within the Pacific Northwest.'[5]

Within these precious and pristine surrounds lies the heart of Hanford. In those frantic few wartime years, Hanford became the largest construction site ever assembled in the USA, with at its peak in 1944 50,000 workers recruited from across the nation and housed in barrack-like segregated accommodation with communal facilities. In these primitive conditions in a harsh climate they fashioned an incredible nuclear complex. They built reactors (then known as 'piles') along the Columbia to produce spent fuel for chemical processing, in long and massive plants called 'canyons' which turned out the small amount of plutonium (13.6pounds, the size of a softball) assembled in the 'Fat Boy' Nagasaki bomb.

The Hanford workers had no idea what they were producing until it was revealed that 'It's atomic bombs' on the morrow of the devastating impact on Nagasaki. The revelation was met with a surge of patriotic pride in Hanford's winning the war. As Michelle Gerber, Hanford's historian, commented to me in 2004, 'Nothing can make you that proud ever again.'



Map of the location of Hanford and the Tri-Cities

Source: John Hunt

'Our bomb clinched it!'. *Source: US Department of Energy*

Production and pollution

During the ensuing decades of the Cold War, Hanford was at the heart of the United States' military nuclear production. Along the Columbia a further fleet of reactors was built, and inland, at the centre of the site in the so-called '200 area', giant reprocessing and finishing plants took over from the wartime 'canyons' dedicated to the production of plutonium. Elsewhere, as well as hosting these facilities Hanford became the scene of a variety of non-military experimental facilities, such as the Fast Flux Test Facility breeder reactor. On the Columbia River is the Columbia Generating Station, a public nuclear power plant supplying electricity, the only survivor of a grandiose plan for five nuclear power stations in Washington state which failed in the face of financial overreach and environmental opposition.[6]

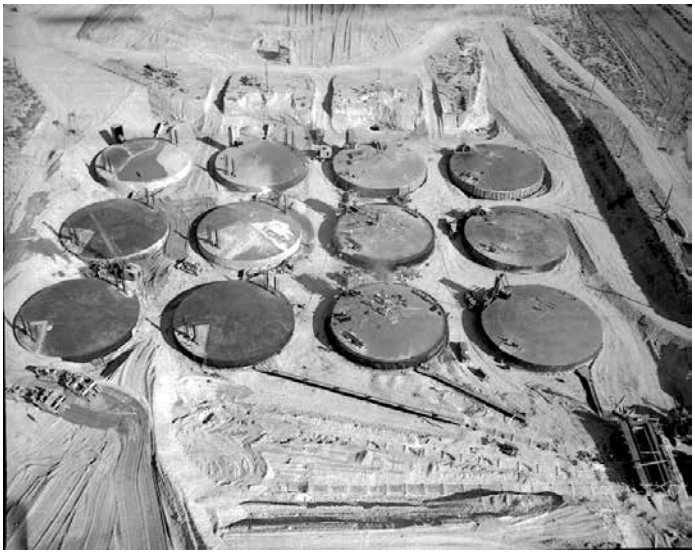
Expansion of production was accompanied by rapid urban development as the temporary settlements of wartime Hanford were replaced in the post-war period, and the population settled in towns just to the south of the reservation. Foremost of these was Richland, a veritable company town built and controlled by the government. In its spacious layout and social purpose it had echoes of Garden City and new town principles, as well as the integrated neighbourhood unit concept of Clarence Perry.[7] Indeed, in its early years Richland conveyed an egalitarian community ethos, regulated and communal, while also expressing hierarchical values in the so-called alphabet ('ABC') housing of varying size and rent designated for different groups – 'upper echelons' (administrators scientists), mid level (managers, engineers), down to blue-collar smaller homes and single-sex dormitory blocks.

The sense of identity with history of this 'Atomic City' is expressed in such features as 'Bombing Range Road' and its identification as 'Home of the Bombers', with its mushroom cloud, the symbol of its high school football team. Remnants of the early days still survive, although since its incorporation in 1958 Richland, with Kennewick and Pasco, has formed the Tri-Cities, a modern small metropolis with a population of 54,000 in 1962, increasing to around 250,000 today.

With the area's almost single-minded focus on wartime and Cold War productive effort, the negative consequences were grossly neglected. By today's standards the treatment of wastes was casual, neglectful and irresponsible. Low-level liquid wastes were siphoned off into cribs and swamps, while an estimated 56 million gallons of highly active liquid wastes from reprocessing were pumped into 177 tanks (149 single shelled and 28 double shelled), some of which have been leaking for many years, posing a threat to groundwater moving to the Columbia. These tanks constitute the most intractable of Hanford's clean-up problems, requiring intense manipulation and management prior to vitrification – a solution which still seems a long way off.

According to one estimate, there are some 1,700 waste sites and 500 facilities to be decommissioned, most of them along the Columbia or on the central part of the site.[8] The inventory includes around 450 billion gallons of liquids discharged to the soil, 5 million cubic yards of contaminated soil, and 80 square miles of contaminated groundwater. The full extent of the contamination of this palpable nuclear wasteland is impossible to gauge with accuracy and, as Roy Gephart argues, 'deciphering this entire inventory is less important than pinpointing, or at least bounding, those portions posing the greatest potential health risk'.[9]

For years the scale of the accumulating problem was unknown and unregarded. The operations at Hanford were shrouded in secrecy and cover-up as the site's overriding priority was to continue to respond to the country's defensive demands. There were myriad incidents and experiments, paying little heed to human health or environment.



Hanford's waste tanks, seen here under construction. Source: US Department of Energy. *Source: US Department of Energy*

The most serious was the notorious experimental 'Green Run' in 1949, when there was a deliberate release of radionuclides, including iodine-131, casting a plume of radioactivity stretching 200 by 40 miles east and south-west of Hanford and giving readings exceeding the contemporary exposure standards by hundreds of times in the downwind communities. The idea was to develop a monitoring methodology to enable the US to simulate Soviet bomb-making capacity.[10] According to historian Jerry Gough, whom I interviewed in 1999, 'The atrocity of the Green Run was not the release itself but the fact they didn't know what its effects might be. This was outrageous.'[11]

From plutonium culture to environmental culture

The outrages enacted on the Hanford landscape during the Second World War and the Cold War were concealed by a 'plutonium culture' – a combination of patriotism, belief in nuclear technology, and unquestioning trust in expertise that pervaded the communities in what Kate Brown has called *Plutopia*.[12] With the ending of the Cold War there emerged a gradual but ultimately decisive cultural transformation. There was a transitional period of a decade or so up to the early years of this century, during which, reluctantly at first but pragmatically, Hanford was coming to terms with its new role and relationship with the nuclear industry. Three key developments in the change can be perceived.

First, and most obvious, was that the ending of the Cold War signalled the end of production at Hanford. Indeed, production had been declining since its peak in the mid-1960s as the era of détente and arms limitation set in. It was the closure in 1987 of Hanford's N reactor (described by President Kennedy shortly before his assassination in 1963 as a project that 'symbolises our strength as a nation') that effectively brought Hanford's military role to an end. Thereafter, apart from some experimental and research facilities, Hanford ceased production altogether.

The second development was the shift from secrecy to greater openness, marked especially by the publication in 1986 by the then site manager, Mike Lawrence, of the records revealing the sheer scale of the legacy and the casual attitudes to risk that had prevailed. In an interview with me in 1999 he argued that 'what went on here was good and necessary' but that 'it was very secretive; we know best ... How can people understand if they are not told?'

The end of production and the revelation of the legacy precipitated the third development, a fundamental change in Hanford's mission to a focus on environmental clean-up. The process is durable, unending and intractable, complex, and, in some ways, controversial. The key challenges are: removing high-level wastes from leaking tanks; decommissioning the reactors along the Columbia; and decontaminating and decommissioning the huge reprocessing canyons. Apart from these massive projects there are the myriad problems associated with redundant facilities, waste dumps and other hazards, including the perhaps impossible task of dealing with radioactive plumes beneath the site.

Some progress has been made, notably the removal of spent fuel and progressive cocooning of the redundant reactors in interim storage, engineering the secure storage of plutonium, decommissioning redundant facilities, and cleaning up contaminated sites. But the most difficult and costly challenge is the clean-up and remediation of the tanks and the vitrification of the high-level wastes in the Waste Treatment Plant (WTP), the construction of which has been plagued by delays, technical problems and cost escalation. The ultimate aim of cleaning up the Columbia Corridor and concentrating the most problematic and hazardous activities in an inner core of 10 square miles at the centre of the site seems some way off.

The management of the clean-up process has been criticised for its institutional inertia, reliance on big contractors with short-term contracts, changing strategies, and low productivity. Bill Dixon, an engineer with experience of working at Hanford, told me in 2013: 'The approach has been for the gold standard, which makes WTP expensive and long term.' Rather than an open-ended commitment, the US Department of Energy, the ultimate paymaster, presses for an accelerated programme based on a risk-based approach to make sure less money is spent in a shorter timescale for a lower standard of remediation.

In the end 'clean-up is a conditional, negotiated state',[13] and a collaborative approach called the Tri-Party Agreement has been in force since 1998, involving the Department of Energy, the federal Environmental Protection Agency, and the state of Washington's Department of Ecology. This provides for a consensual approach on priorities, milestones, and actions. An element of public participation in clean-up is provided through the Hanford Advisory Board, with a broad stakeholder membership advising on major policy issues. Among the continuing controversies are questions such as: should all buildings be demolished; should all tank wastes be vitrified; should all reactors be moved to the central area; which areas should become available for unrestricted use – and when; and, the overarching question, how clean is clean enough? That question, given the uncertainties and different opinions, is a matter of both scientific and value judgement.

Stability and sustainability

Hanford has entered a mature and relatively stable stage in the relationship between its communities and the nuclear industry. The peripheral characteristics that were its *raison d'*être have evolved, and Hanford has undergone a profound change from isolation to integration – a community still marked by its nuclear history but no longer entirely defined by it.

Chosen for its remoteness to undertake a national strategic and secret operation, Hanford, although far from major centres, is far more accessible nowadays. The Tri-Cities is a fully connected and fast growing sub-regional centre. Its economic dependence on the nuclear industry, although still considerable, is much diminished. Fears of a steep post-production decline in the nuclear industry have been eased by the federal appropriation routinely provided to Hanford to the tune of $2 billion per year – around a third of the national nuclear clean-up budget. At the same time, the economy of the Tri-Cities has developed, with research laboratories (originally a spin-off from the nuclear activities) but also health services, food processing and wineries, high-tech industries, and regional retail and distribution services. Hanford's, or rather the Tri-Cities', economy is now neither dependent nor monocultural, but diversified and sustainable.

Hanford, created and supported by the state throughout its heyday, continues to exert political leverage. Politically speaking, Hanford is not just an environmental issue; it is a moral issue, which accounts for the obligation

towards its clean-up mission felt by federal, state and local governments. There is still a residual sense of embattlement in a Republican pro-nuclear community within a Democratic state with pronounced anti-nuclear sentiments in the big cities to the west beyond the Cascade Corridor. But the mutual hostility of the years of nuclear production has abated, and mutual interest in clean-up has fructified. In short, a modernist discourse associated with the nuclear industry has shifted to a postmodern discourse of consensus and co-operation, reflecting the more complex economy and diverse society that constitutes the Tri-Cities area today.

A continuing legacy

Hanford's is a landscape traumatised by its wartime and post-war existence at the heart of the American nuclear-industrial complex. In this vast area are the remnants of a plutonium economy that has left a polluted landscape which will persist down the generations. 'Hanford represents one of the most daunting environmental catastrophes the world has ever known',[14] comparable in scale and contamination to the contemporary Russian Cold War complex of Mayak near Chelyabinsk.[15] The problems arising from an ageing infrastructure are difficult to contain. Major recent incidents include the collapse of a rail tunnel storing waste from plutonium production, further incidents of tank leakage, and risks to workers from demolition work.

It is intended to release most of the land to non-nuclear purposes. Already much is protected or conserved, and the stretch of the Columbia that runs through the site is under conservation as the Hanford Reach National Monument, a wildlife, fishing and recreational area, with the historic reactors dotted along its southern bank. In 2015 some of the historic nuclear structures, including the B reactor, were incorporated in the Manhattan Project National Historic Park, along with similar features at Los Alamos, New Mexico and Oak Ridge, Tennessee, the other main wartime nuclear projects.

It will take time, resources and effort to achieve clean-up and to provide adequate, safe and secure interim storage for the Hanford wastes. The overall costs are estimated at over $100 billion, with a deadline for clean-up of 2060 – both likely to be exceeded. The WIPP (Waste Isolation Pilot Plant) deep disposal facility in New Mexico, the destination for the military transuranic wastes buried at Hanford, has been suspended since 2014 owing to brine seepage. With the suspension of the national repository project at Yucca Mountain in 2008, a new process for finding a suitable site has begun. The slow progress with the vitrification plant and the lack of a national repository make a final solution for the disposal of vitrified high-level wastes a distant and uncertain prospect.

Hanford, the Atomic City of the West, was once at the nuclear frontier, creating weapons of devastating destructive power that left a nuclear wasteland. Today it is at the frontier of a massive clean-up project, described as 'the largest civil works project in world history'.[16] The nuclear pioneers engaged in the defence of the nation appropriated a landscape truly awesome in scale, a sparsely settled wilderness in the mid-Columbia plateau, and transformed it into a scattered industrial complex in the sagebrush desert. Their successors have been left with the legacy of those years – a task of retrieval, containment, remediation and improvement to restore the landscape where possible and to withdraw those parts which are irremediable.

For the foreseeable future Hanford will remain a nuclear wasteland, where risk from wastes not fully comprehended or characterised lurk on and beneath its surface with no final solution yet in sight. It is a place where the impacts from a frenzied period of destructive impulse will linger indefinitely; a place where, in the words often attributed to Native American Chief Seattle, it may truly be said: 'We do not inherit the earth from our ancestors, we borrow it from our children.'

Notes:

1. Quoted in J. Findlay and B. Hevly: *Atomic Frontier Days: Hanford and the American West*. University of Washington Press, 2011, pp.18-19
2. B. Hevly and J. Findlay: *The Atomic West*. University of Washington Press, 1998
3. M D'Antonio: *Atomic Harvest: Hanford and the Lethal Toll of America's Nuclear Arsenal*. Crown Publishers, 1993
4. The concept and characteristics of 'peripheral communities' were explored in the first article in this series ('Landscapes of the legacy of nuclear power'). In brief the characteristics are: remoteness, marginality, powerlessness, cultural resignation and resilience, and environmental risk. It may be noted here that the characteristics are dynamic, responding to changing power relations. For a more detailed analysis of the concepts of peripherality and peripheralization, see: A Blowers: *The Legacy of Nuclear Power*. Earthscan from Routledge, 2017
5. R. Gephart: *Hanford, a Conversation about Nuclear Waste and Cleanup*. Battelle Press, 2003, p.v
6. The Washington Public Power Supply System (WPPSS) planned to build five large nuclear plants during the 1970s to serve Washington state. The project was a disaster, suffering cost overruns and delays, leading to one of the biggest defaults in history, with two stations never built, two halted during construction, and only one, that on the Hanford site, eventually completed. The scandal became popularised as WHOOPS!
7. C. Perry: 'The neighborhood unit, a scheme of arrangement for the family-life community'. In *The Regional Survey of New York and its Environs*, 1929, Vol. 7, 22-140
8. An estimate prepared by United Kingdom Nirex Limited for my visit in 2004
9. *Hanford, a Conversation about Nuclear Waste and Cleanup* (see note 5), p.5.3
10. The Green Run was a release in December 1949 of radioactive iodine-131 from 'green' (less-cooled) uranium fuel, apparently to test instrumentation for detecting Soviet bomb-making capability. It was not revealed until the 1980s, becoming notorious for the harm it may have caused in downwind communities
11. For a downwinder account of the unknown threats from Hanford, see T. Hein: *Atomic Farmgirl*. Mariner Books, 2003. She points out that the Green Run was only one of many deliberate and accidental post-war releases from the site. The Green Run released 8,000 curies in an estimated total of 740,000 during 1944-72 (p.xi)
12. K. Brown: *Plutopia*. Oxford University Press, 2013
13. *Hanford, a Conversation about Nuclear Waste and Cleanup* (see note 5), p.8.6
14. S. Shulman: *The Threat at Home: Confronting the Toxic Legacy of the US Military*. Beacon Press, 1992, p.94
15. D. Bradley: *Behind the Nuclear Curtain: Radioactive Waste Management in the Former Soviet Union*. Battelle Press, 1998
16. G. Zorpette: 'Hanford's nuclear wasteland'. *Scientific American*, 1996, Vol. 274 (5), 88-97

Sellafield, Britain's nuclear heartland

In the third of a series of articles on the local and social legacies of nuclear energy, Andrew Blowers looks at the search for a solution for radioactive wastes in the UK.

I still possess a lapel badge acquired back in the 1980s with the simple legend 'I've been to Sellafield!'. The badges were issued as part of a publicity campaign designed to lure tourists to Britain's notorious and (in)famous nuclear complex – the largest industrial site in the UK. The ironic challenge of the message was underlined more explicitly by a contemporary cartoon bearing the invitation to 'Visit Sellafield before Sellafield visits you'. Such messages endorsed and even promoted an image of Sellafield as distant but dangerous. Other soubriquets such as 'Sellafield – the nuclear laundry' or 'Britain's nuclear dustbin' hint at its mysterious and unglamorous purpose at the heart of the country's nuclear operations.

Sellafield landscape. *Source: Sellafield Ltd.*

The most dangerous place on earth?

So what is Sellafield? Fundamentally, these days, it is the UK's primary nuclear waste-processing, management and clean-up facility. Concentrated on a compact site of 1.5 square miles is a jumble of buildings, pipes, roads, railways and waterways, randomly assembled over more than half a dozen decades, which together manage around two-thirds by radioactivity of all the radioactive wastes in the UK. The Sellafield radioactive waste component includes all the high-level wastes (less than 1% by volume, over half the radioactivity) held in liquid form or stored in vitrified blocks, and half the volume of intermediate-level wastes (the other half being held at various sites around the country). The bulk of the nation's low-level wastes (90% by volume, 0.1% radioactivity) are disposed of in a nearby shallow repository at Drigg.

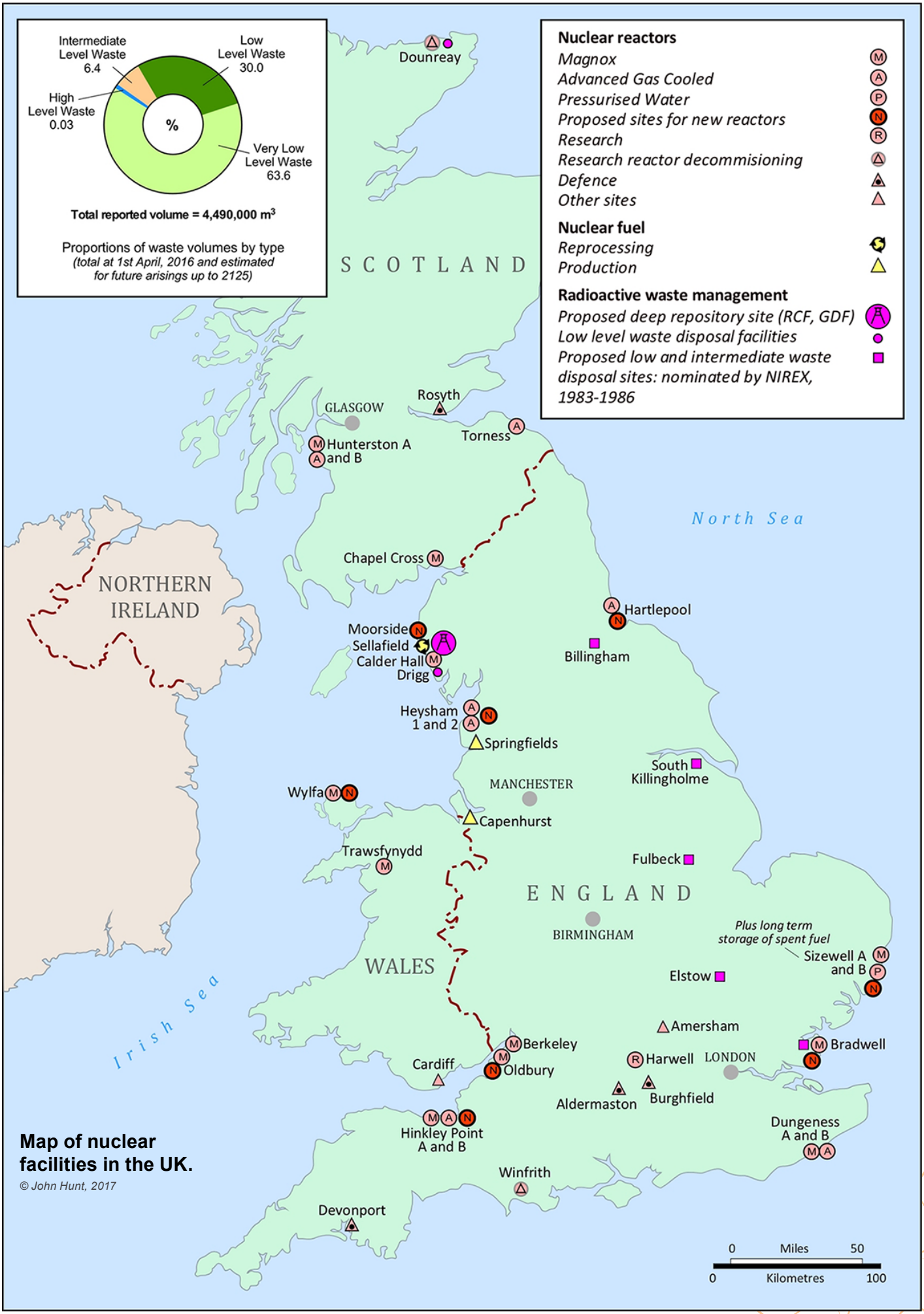
In addition, Sellafield hosts the spent fuel from the Magnox reactors due to be reprocessed by the end of the decade, as well as some spent fuel from AGRs (advanced gas-cooled reactors) awaiting reprocessing or storage. Sellafield also has the world's largest single stockpile of plutonium, amounting to 123 tonnes in 2013 and rising to 140 tonnes by 2020, including around 15 tonnes currently foreign owned and formally due for repatriation in some form.

These wastes arise from the range of nuclear activities carried out since Sellafield (then Windscale) began operations in the early post-war years. They comprise wastes arising from the plant's initial military function of producing plutonium for the atom bomb and subsequently wastes mainly derived from reprocessing spent fuel from the civil nuclear programme (Magnox and AGR) and those originating from reprocessing foreign fuels.

In the early years, in an atmosphere of trust in technology and pride in being in the vanguard of both military and civil nuclear development, far less attention was paid to waste management. Wastes, liquids, metals, fuels, sludges and debris, uncharacterised and often unrecorded, were literally dumped into poorly constructed ponds and silos and left to stew. These structures include building B29, an open, single-skinned storage pond, and B30 ('Dirty Thirty'), considered by some to be 'the most dangerous industrial building in Europe' but rivalled for the epithet by B38, containing cladding and fuels mixed in with other wastes. These and other legacy ponds and silos have deteriorated over the years, and now 'there is increased urgency to reduce the intolerable risks they pose'.[1]

The probability of a major radioactivity incident may be very low indeed, but the possibility persists, a fact brought home to me some years ago when standing on a platform above a massive concrete shield below which were highly active liquor (HAL) tanks containing 99% of the radioactivity from spent nuclear fuel. I turned to my colleague, a renowned radiation scientist, and asked him how safe we were. He looked up at the miles of cables and pipes above us, indicating their exposed vulnerability in the event of disruption which could affect the cooling of the liquors below, releasing a massive burst of radioactivity, and commented: 'You could say we are standing on the most dangerous place on earth.' In rather less hyperbolic language the Office for Nuclear Regulation (ONR) considers HAL 'the most significant hazard on the plant' and its containment a priority.[2]

Safe management of the legacy wastes is by far the most important and challenging function of Sellafield today. The long-term plan is to retrieve, characterise, encapsulate or vitrify the Sellafield inventory in preparation for deep burial in a Geological Disposal Facility (GDF). But that prospect is a far-off possibility; the reality is that for the foreseeable future the bulk of Sellafield's wastes will have to be managed at the surface.



Map of nuclear facilities in the UK.

A community at the periphery

Sellafield is a physical reality in a social context. Like Hanford in the USA,[3] it is a classic example of a peripheral nuclear community, revealing all five characteristics associated with the concept. It is, first, geographically remote, in the sense that it is, in UK terms, relatively far from major population centres, founded on a wartime Royal Ordnance factory, offering safety, security and secrecy for the clandestine operations of the nation's military nuclear project. It is situated in West Cumbria on a plain between the iconic Lake District landscape and the Irish Sea, far from motorways, airports or mainline railways.

Its physical isolation has inspired a second social characteristic, a perception of distinctiveness on the part of West Cumbrians, whom, according to a sociological study in the early 1990s, 'saw their area as 'different' and separate from the rest of society'.[4]

This peculiar cultural identity, which may be described as a 'nuclear culture', has been attested to in several studies of Sellafield and West Cumbria.[5] It is a complex combination of feelings, values and attitudes, pervasive yet contradictory. Within this culture is a sense of resignation, an acceptance of Sellafield as a place of risk and rejection. This inferiority is tempered by a contrary resilience – an assertion of its role as guardian of the nation's dangerous radioactive materials and waste. Overall, there is a sense of realism 'about uncertainties, about lack of power and control... mitigated by positive recognition of the industry's vital role in the area'.[4]

The third peripheral characteristic is economic, a condition of dominance and dependence. Sellafield is unquestionably the dominant economic activity in West Cumbria, with around 10,000 people directly employed and the local economy substantially dependent on the income and investment in related research and local economic projects that the plant produces. This dominance has some negative effects, notably the deterrent effect of Sellafield's high wages and its monopoly of available skilled labour. This is reflected in the quite stark inequalities of income and evidence of deprivation in some parts of the area, a paradox of poverty in the shadow of a nuclear leviathan.

Nevertheless, the priority given to Sellafield's clean-up pretty well guarantees an annual state investment (through the NDA – the Nuclear Decommissioning Authority) approaching £2 billion per year, and it is estimated that Sellafield will absorb around three-quarters (£120 billion) of the total of £164 billion discounted provision for future clean-up liabilities of the nation's nuclear estate over the next 120 years. Sustainable employment is assured for at least 30 years, with slow decline thereafter.

The uneven development of the West Cumbrian economy is reflected in a fourth characteristic: the inequalities of power relations encountered in the region. At one level West Cumbria evinces powerlessness, an industry and an area at the periphery where key decisions affecting wellbeing and welfare are taken outside the region, in corporate headquarters, government ministries, and regulatory bodies. A sense of paranoia is understandable from the recurrent exposures of Sellafield's poor financial management, escalating costs, under-performance, technical failures, accidents and incidents, cover-ups, and organisational deficiencies. But Sellafield seems to hold much of the local community of West Cumbria as some kind of fiefdom, such is its economic, social and political sway over the region. In the context of its national significance and regional importance, Sellafield exercises political leverage that confounds its apparent subordination.

Sellafield draws power from the fifth characteristic of peripheral communities: the fact that the community is living with environmental risk that is unwanted but unavoidable. Rather like Hanford, community and industry have developed a relationship built on a mixture of defensive pride and reluctant recognition of their role and responsibility in bearing a burden on behalf of the nation. Over the years this combination has enabled the community to endure the adversities and respond to the possibilities as it undergoes the vicissitudes of its long transition from production to clean-up.

The long transition

In the frenetic post-war years Sellafield (then Windscale) was almost wholly dedicated to the production of nuclear materials, first for military purposes, later for a range of prototype and experimental facilities. The inevitable accompanying production of waste was of little interest or account. The fundamental function, reprocessing, was initially for plutonium production, using spent fuel from the first reactors.

The scope of reprocessing widened as it became necessary to reprocess Magnox spent fuel, and, later, the Thermal Oxide Reprocessing Plant (THORP) began operating in 1997 to reprocess spent fuel from the second-generation AGR reactors as well as foreign spent fuel (mainly from Germany and Japan). THORP marked a turning point in the transition from production to clean-up at Sellafield as its function, viability and performance were challenged, and subsequently the plant experienced delays, cost overruns, technical problems and chronic under-performance, leading to failure to meet its domestic and foreign business expectations. The plutonium stockpile grew far beyond its military needs and its use in mixed-oxide fuel (MOX).

Legacy waste pond at Sellafield.

The Sellafield MOX plant proved an even more abject failure, opening in 2001 with a capacity of 120 tonnes a year, producing only 5tonnes in its first five years and declared failed and closed down in 2011.

By the end of this decade reprocessing at Sellafield will have finished. Effectively, Sellafield will then have become, like Hanford, almost wholly a waste management and clean-up complex. The transition from nuclear laundry to nuclear dustbin will be complete. Its future was summed up by Adrian Simper, the NDA's Director of Strategy and Technology, during our conversation in 2014:

'There is a hundred years of going forward. A commitment to clean-up and an important mission to carry out. There is no future in reprocessing. Employment is stable and the new priority is clean-up.'

Searching for solutions

Storage of nuclear wastes at Sellafield and at other sites around the country for however long is regarded as an *interim* solution. The search for a *permanent* solution to the problem of managing these wastes began in earnest after the Flowers Report pronounced in 1976 that there should be no further commitment to nuclear energy unless it could be demonstrated that long-lived highly radioactive wastes could be safely contained for the indefinite future.[6]

During the 1980s, efforts to find suitable sites, whether for deep disposal of high-level and long-lived intermediate-level wastes (ILW) or for shallow burial of short-lived ILW and low-level wastes, met with trenchant opposition, both within and between the communities, sufficient to force withdrawal of the proposals. These efforts were focused on finding suitable geology for deep disposal or available locations such as an abandoned mine at Billingham, disused airfields, munitions dumps, or sites in public ownership. They all had in common a classic exercise of 'decide, announce, defend', leading inexorably to abandonment in the face of determined opposition.[7]

The technical focus of these efforts had signally failed to take into account the social context. A new approach was inaugurated, combining economic and scientific criteria to identify a range of possibly suitable sites, but this time involving the public to assist in developing acceptable proposals. By this means Sellafield emerged as the most favourable site where consultation had found a measure of public support. Despite the effort to combine scientific rigour and public acceptability, the selection had all the hallmarks of a predetermined solution concocted through a closed process of decision-making and relying on Sellafield as the path of least public resistance.

Sellafield the solution, or not?

The selection of Sellafield proved premature, as the case put forward unravelled in the face of opposition at the public inquiry into the proposed underground laboratory known as a Rock Characterisation Facility (RCF). The proposal was rejected in 1997 on three counts: local environmental impacts; scientific uncertainties and technical deficiencies; and the site selection process itself. The rejection was comprehensive and decisive, forcing the government, once again, to rethink and regroup.

The turn of the century was a propitious time for a new approach. Nuclear energy had seemingly run its course in the UK, and the discourse had shifted from conflict over nuclear projects to a mood in which co-operation and consensus was possible. This was invigorated by a surging interest in participative democracy, with its emphasis on openness, transparency, partnership and engagement, backed by a panoply of processes and techniques to facilitate public and stakeholder involvement in policy-making.

Nowhere was the opportunity for dialogue more enthusiastically seized upon than in radioactive waste management. In order to find a way out of the policy impasse a new Committee on Radioactive Waste Management (CoRWM) was established, charged to inspire public confidence by finding the best method for the long-term management of the UK's legacy wastes, the bulk of which were at Sellafield.

In the course of its deliberations (during 2003-06) CoRWM integrated different knowledge streams, including an elaborate multi-criteria decision analysis (MCDA) and an extensive public and stakeholder engagement (PSE), as well as drawing on overseas experience and evaluating ethical principles and perspectives. Its main recommendation was carefully crafted: 'Within the present state of knowledge, CoRWM considers geological disposal to be the best available approach for the long-term management of all the material categorised as waste in the CoRWM inventory'[8] – i.e. the legacy wastes at Sellafield and elsewhere and future known arisings. But it was carefully qualified by further recommendations emphasising the long-term nature of the process through a programme of interim

storage, research and development into geological disposal, flexibility to consider other options, and a staged process of implementation.

CoRWM also set out its proposals for implementation, based on the 'three Ps' – principles of participation, partnership, and packages – to ensure acceptability, facilitate involvement, and provide the resources to encourage commitment.

The government adopted the approach in its White Paper, *Managing Radioactive Waste Safely*, and was keen to put these theoretical ideas into practice, to turn concepts into a process that would deliver a site for a deep underground repository (called a Geological Disposal Facility). A general invitation was issued to communities in England, Wales and Northern Ireland (Scotland had adopted storage as its long-term policy) 'to express an interest in opening up without commitment discussions on the possibility of hosting a geological disposal facility at some point in the future'.[9]

Predictably there was no rush of volunteers but, as might be anticipated, West Cumbria was the first, and only, community to enter into a modulated exercise in participatory democracy managed by the West Cumbria Managing Radioactive Waste Safely (WCMRWS) Partnership, including councils, the voluntary sector, and business and trade union interests, and working over three years (2009-12).

The WCMRWS process founded on the tide of voluntarism eventually foundered on the rocks of geology. The claim that there were potentially suitable areas for deep disposal within the region was vigorously challenged. Uncertainties over the issue, along with other concerns including the absence of comparative strategies, combined to create a lack of trust, leading the partnership to reach a tentative conclusion: 'at this stage we are fairly confident that an acceptable process can be put in place to assess and mitigate negative impacts and maximise positive impacts'.[10]

This underwhelming outcome left the decision-makers – the local councils – to reach their own conclusions. The two district councils in pro-nuclear West Cumbria voted to proceed; Cumbria County Council, covering also the wider region further from Sellafield, voted against. The process had stalled in what seemed its most promising location.

Once more into the breach

With this setback the government once more had to regroup and review its policy for geological disposal. There appeared to be three areas where a revised approach was necessary.

First was the fact that site selection had given pre-eminence to voluntarism over geology, giving rise to concerns that a site would be chosen on grounds of what was acceptable to a community rather than what was the best available on scientific grounds. This would be addressed by a process of national geological screening, based on known geological information. While this would not identify specific sites, it would indicate potential

Protesters against the proposed Geological Disposal Facility in West Cumbria.
Source: Irene Sanderson, North Cumbria CND

geological suitability in areas where interest was likely to be expressed and provide more detailed geological information to those communities who wished to pursue their interest. While voluntarism remained the primary principle of site identification, it would now be within a context of voluntarism and geology.

Second was the question of who should be the decision-making body. Although the WCMRWS Partnership was an exercise in participative democracy to achieve consensus, the formal decision on whether to continue was in the hands of the representative authorities, the county and district councils, who had agreed that a decision should be agreed by both tiers. Thus Cumbria's reluctance to proceed was decisive. To avoid such an override in the future, the government stated that all levels of local government should have a voice in the process and that no one level should prevent the participation of another. The revised process would be managed by the government and led by the state-owned developer, working with communities. The crucial underlying principle was that the final decision-making role would sit with people in communities.

A more subtle approach to the issue of 'what is a community?' and 'who should decide?' was devised whereby communities would be 'identified' over time as the siting process evolved and the options were refined to specific locations. The fact that a repository has a 'physical existence' meant that an emerging community would ultimately need to be identified based on a geographical area. The principle that the 'community' decides would be enacted by a right of withdrawal during the process and by confirmation of the decision to develop the repository in a test of public support. The hope was that this elaborate, extended, even elegant approach to voluntarism in practice, backed by a package of community benefits, would have the flexibility and incentives to attract communities to engage willingly in achieving a site for the disposal of the nation's wastes.

Time to decide

The third area concerned the timescale of decision-making.

The technical and scientific challenges involved in making a safety case for a repository with engineered barriers within a host rock capable of ensuring containment of radionuclides for up to a million years were formidable. The key reason for Cumbria's decision to pause the process was that it would be premature to proceed; that uncertainties suggested the risks were too great, certainly in the Cumbrian geological context.

Another uncertainty was the nature and scale of the inventory ultimately destined for the repository. The CoRWM recommendations had been confined to the legacy wastes – those mainly at Sellafield and those arising from existing and known nuclear programmes. A new nuclear programme of uncertain scale being promoted by government would result in spent fuel and other wastes on the sites of new reactors, creating an indeterminate inventory extending over unknowable timescales. Storage of the nation's legacy wastes already at Sellafield was one thing, permanent disposal, including wastes from new build, was quite another. As Martin Forwood of the protest group CORE (Cumbrians Opposed to a Radioactive Environment) put it to me: 'It would be ludicrous to move it from Sellafield given the risks of transport. It would be absolutely ridiculous. But Sellafield shouldn't necessarily be taking more.'

There was also resistance to the government's importunity in seeking a decision to move forward, thereby locking West Cumbria more firmly into the process.

And there we have it. The government's view that 'effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations'[11] is speculation at best. The problem is that effective arrangements scarcely yet exist for dealing with the legacy wastes which, for the foreseeable future, will be stored at Sellafield and other sites, let alone wastes from any new build which would have to be stored well into the next century on fragile, crumbling or inundated coastal sites.

Progress towards identifying an acceptable and suitable site for disposal will inevitably take time. The revised arrangements leave West Cumbria in the ring, probably still the favoured location. The new, evolutionary, self-defining approach to site identification is flexible, placing the veto, test of public support and distribution of investment funds in the hands of the community and not the representative political bodies. This opens up the opportunities for voluntarism, and it is highly likely volunteers will come forward from West Cumbria. Conversely, the geological screening process and the emphasis on suitable geology acts as a potential constraint on finding a suitable site in West Cumbria.

The revised process might tempt other communities into the frame, areas where public support and geological conditions are favourable. There may be potential volunteers with the requisite peripheral characteristics, but few will be likely to maintain commitment over the long timescales involved.

The inescapable fact is that the large volumes of wastes at Sellafield will not be in a fit condition for disposal for decades to come. And it would seem impossible, irresponsible even, to contemplate moving three-quarters of the nation's highly active wastes miles across the country, requiring security, transfer, surveillance and logistical arrangements.

The nation's radioactive waste is mainly held at Sellafield and there it must remain, at least until the programme of management and clean-up is concluded. New production facilities such as for MOX or reprocessing are exceedingly improbable, the proposed new reactors at nearby Moorside are doubtful, and although a GDF, if one is ever developed, might yet be located in West Cumbria, Sellafield will for long be caretaker of the nation's wastes.

Where and when the undertaker will come to bury them remains unclear, and may remain so for the foreseeable future.

Notes:

1. *Nuclear Decommissioning Authority: Strategy.* Nuclear Decommissioning Authority, April 2016, p.27. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/512836/Nuclear_Decommissioning_Authority_Strategy_effective_from_April_2016.pdf
2. *Sellafield – High Level Waste Plant – Waste Vitrification Plant – Lines 1 and 2 – Containment System.* Office for Nuclear Regulation, Jun. 2014. www.onr.org.uk/intervention-records/2014/sellafield-14-018.htm
3. Hanford in the Pacific North West of the USA was the subject of the second article in this series ('The nuclear frontier'). The characteristics of peripheral communities were discussed in the first article ('Landscapes of the legacy of nuclear power').
4. C. Waterton, B. Wynne and R. Grove-White: *Public Perceptions and the Nuclear Industry in West Cumbria – Report to Cumbia County Council.* Centre for the Study of Environmental Change, Lancaster University, 1993 (amended version, 2007)
5. Paul Loeb used *Nuclear Culture* as the title of his book on Hanford (New Society Publishers, 1986). Among the studies of Sellafield and West Cumbria are: C. Waterton, B. Wynne and R. Grove-White: *Public Perceptions and the Nuclear Industry in West Cumbria – Report to Cumbia County Council.* Centre for the Study of Environmental Change, Lancaster University (see note 4); H. Bolter: *Inside Sellafield.* Quartet Books, 1996; S. Macgill: *The Politics of Anxiety: Sellafield's Cancer-Link Controversy.* Pion, 1987; J. McSorley: *Living in the Shadow: The Story of the People of Sellafield.* Pan Books, 1990; and H. Davies (Ed.): *Sellafield Stories: Life in Britain's First Nuclear Plant.* Constable & Robinson, 2012.
6. *Nuclear Power and the Environment.* Cmd. 6618. Sixth Report. Royal Commission on Environmental Pollution. HMSO, 1976. https://webarchive.nationalarchives.gov.uk/20110322144120/http://www.rcep.org.uk/reports/06-nuclear/1976-06nuclear.pdf
7. For a brief history of early efforts at site selection see A. Blowers: 'A geological disposal facility for nuclear waste – if not Sellafield, then where?'. *Town & Country Planning*, 2014, Vol. 83, Dec., 545-53
8. *Managing our Radioactive Waste Safely.* Committee on Radioactive Waste Management, Nov. 2006
9. *Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal.* Cm 7386. Department for Environment, Food and Rural Affairs. TSO, June 2008. www.gov.uk/government/publications/managing-radioactive-waste-safely-a-framework-for-implementing-geological-disposal
10. *The Final Report of the West Cumbria Managing Radioactive Waste Safely Partnership.* West Cumbria Managing Radioactive Waste Partnership, Aug. 2012. p.6. www.westcumbriamrws.org.uk/images/final-report.pdf
11. *Draft National Policy Statement for Nuclear Power Generation (EN-6).* Department of Energy and Climate Change, Jul. 2011. www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure

France, the core on the periphery

In the fourth of a series of articles on the local and social legacies of nuclear energy, Andrew Blowers looks at La Hague and Bure, two places with a crucial role in the storage and disposal of France's more highly active wastes.

La Hague is on the Cotentin Peninsula, the northernmost tip of Normandy, projecting into the Channel. Within this rugged, windswept, remote area is located a vast nuclear reprocessing complex that separates uranium and plutonium from spent fuel transported in from nuclear reactors scattered around France. The process creates large quantities of highly radioactive wastes (HLW) which are turned into glass blocks stored and ultimately destined for deep geological disposal. Nearby is a surface disposal facility, now closed, where low-level wastes were disposed until a new site, Centre de l'Aube, opened in the Champagne area of eastern France.

Not far away, on the western coast of the Cotentin, sunk into the cliff face, is Flamanville, where the latest nuclear reactor under construction is running long over schedule and well over budget. To the north at the Channel port of Cherbourg is the Arsenal, where submarines for the French nuclear fleet are constructed.

This 'Nuclear Peninsula'[1] constitutes the core of the French nuclear industry on the periphery of the country.

Across the country, around 400 miles away in eastern France, in a rolling, rural landscape unremarkable save for the alien intrusion of an isolated scatter of undistinguished modern administrative, hotel and industrial buildings including headworks, is the country's newest nuclear site. Bure, hitherto a tiny hamlet set far from cities and main communications, in *la France profonde*, has emerged as the location for the Cigéo project, the place where the most highly active wastes from the French nuclear programme may, one day, be buried deep underground.

Bure, like La Hague, is on the periphery, an 'internal periphery' in a relatively empty, expansive landscape on the borders of Champagne and Lorraine, and the departments of Haute Marne and Meuse. Slowly, Bure is in the process of becoming host to the deep geological repository for the disposal of the nation's most dangerous wastes.

Nuclear energy in transition

La Hague and Bure together embody the end of the nuclear cycle, two places on the periphery intertwined by their focal role in the storage and disposal of France's more highly active wastes. France has the second-largest nuclear 'fleet' in the world, with 58 reactors contributing three-quarters of the country's electricity, roughly 40% of the country's total energy output. The industry developed rapidly during the decades after the Second World War in response to French espousal of a technocratic, state-centred conception of excellence. Gabrielle Hecht, in the *Radiance of France*, has described nuclear as reflecting a concept of radiance, representing modernity expressed through technology as saviour, redeemer and liberator. Nuclear power stations symbolised 'a tremendous spectacle, a drama propelled by scientists and engineers, and a display of national radiance'.[2]

La Hague reprocessing plant 2008 pictured in 2008. *Photo by Jean-Marie Taillat.*

The French nuclear complex displays a simple, logical geographical pattern. Nuclear reactors, mostly of PWR (pressurised water reactor) design, are sited on the Channel coast, along the country's north-eastern borders and on its major rivers. In the south east, on the Rhone, are the fuel fabrication plants, including a MOX (mixed-oxide fuel) plant, the now closed Superphénix fast breeder reactor, and the first reprocessing works at Marcoule, built to produce plutonium for the French nuclear deterrent.

The cycle is closed by reprocessing, sending plutonium to be made into MOX at Marcoule and vitrifying high-level wastes for storage at La Hague for eventual disposal in eastern France, at the deep repository for high-level wastes at Bure, if it goes ahead. Thus much of France's nuclear cycle passes through La Hague at some point. La Hague, although peripheral in its geographical location, has become the core of the country's nuclear complex.

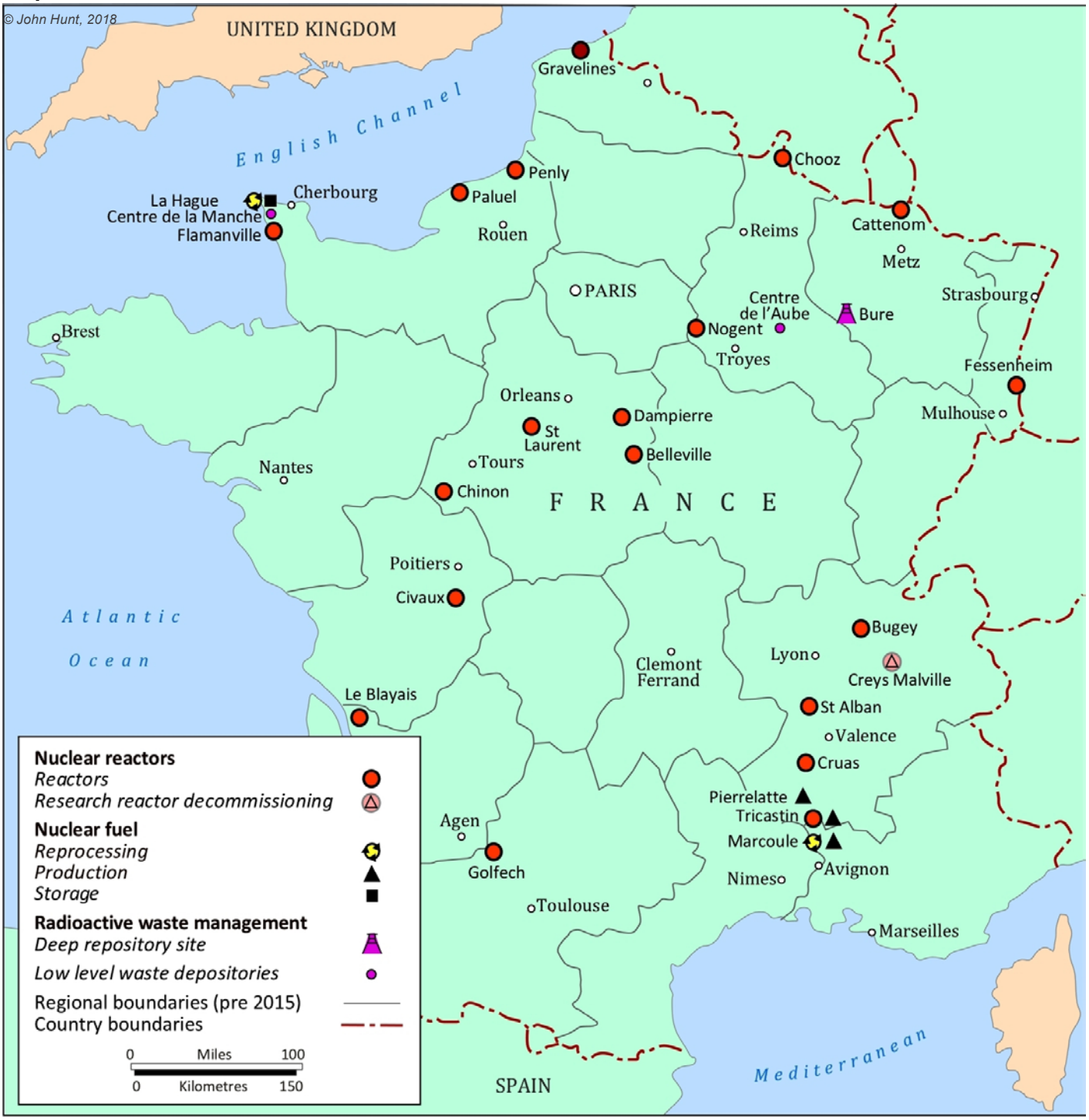
In principle, the various components – fuel fabrication and enrichment, reactors, reprocessing and waste management – comprise a neatly functioning system. But the coherence and interdependence of the system is increasingly threatened as the nuclear industry faces a number of challenges.

In the first place, nuclear's role in the country's energy mix is now more open to question. Although French support for nuclear energy has been relatively strong, it has hardly been enthusiastic or unequivocal. Two decades ago, two-thirds of the population felt that nuclear power should be maintained at existing capacity but not expanded.

By 2010 a Eurobarometer poll revealed majority support (45% maintain, 12% increase nuclear's role), just before the Fukushima disaster caused a marked downturn. A poll by the World Nuclear News in 2013 showed only around a third supported nuclear, although, perplexingly, over half agreed that nuclear should retain its share in the energy mix.

Opinion on a nuclear phase-out seems divided. Perhaps the best that can be said is that opinion on the advantages and disadvantages of nuclear energy has been roughly evenly divided over the past few years.

Map of nuclear facilities in France.



A second challenge is political. The election of President Hollande, in the wake of Fukushima, led to a policy reappraisal, including the aim of gradually reducing nuclear's share of electricity supply from three-quarters to half the total by 2025. The policy has since been modified but remains essentially a long-term aim. This responded to two factors: one, a progressive energy transition with the rise of renewables as a cost-effective alternative; the other, the impending decline of nuclear as a result of an ageing nuclear fleet. The delays and technical problems surrounding the new nuclear station under construction at Flamanville and the escalating costs associated with the French reactor project at Hinkley Point in the UK indicate a faltering prospect for nuclear new build.

The fate of new build, coupled with the costs of maintaining the nuclear fleet, reprocessing and impending decommissioning and waste management, has revealed a third challenge: the parlous state of nuclear finances in France. Électricité de France (EDF), the country's nuclear energy supplier, faces a combination of falling revenues and increasing liabilities as it absorbs the loss-making reactor business of Areva (renamed Orano), making it dependent on state support and, in the longer term, revenue from customers in the UK and France paying premium rates for electricity.

All these problems lead to a fourth challenge: the nature of the industry itself as it comes to terms with its declining role and the shift in the balance of its operations from production to the rear end of the nuclear cycle –

reprocessing, waste management, and clean up. Above all, the moment of transition raises questions about the purpose and function of reprocessing, at the heart of operations at La Hague.

On the one hand, La Hague has a declining production role. As the French nuclear industry begins to shrink, and as the foreign market for reprocessing has disappeared, the original purpose of the plant is diminishing. The market for MOX fuel is limited to 24 French power stations, leaving a surplus of plutonium and uranium stored at La Hague. On the other hand, La Hague is slowly but surely realising if not, perhaps, fully recognising its purpose as the nation's centre for the management of higher-level wastes. In common with other parts of the nuclear sector, La Hague 'must urgently shift its focus to the maintenance of current reactors and decommissioning and nuclear waste management services'.[3]

La Hague – adaptation and survival

The rationale for reprocessing spent fuel at La Hague for plutonium and MOX fuel has been sustained by a combination of denial, policy inertia and adaptation to changing circumstances. But, in reality, reprocessing has become an idée fixe, a persistence based more on belief than truth. Yves Marignac of WISE (World Information Service on Energy), a critic of the policy, described the problem to me back in 2004:

'Nothing much changes. But it's like opening Pandora's box – the whole logical construction falls apart. The more the reality becomes different to what you want to believe, the more difficult it is to recognise it.'

And the reprocessing works have, over the years, become embedded in the landscape and the community. The region is described by Zonabend as 'a great plateau consisting of a series of dome-like moors where gorse and broom, heather and bracken are swept by incessant wind'.[4] It has an austere beauty with ever-changing weather, a harsh unyielding land where farming and fishing are the traditional occupations.

In such an underdeveloped and remote area located *au bout du monde* according to Didier Anger, a veteran campaigner, the works evolved during the 1970s, more welcomed than resisted. Anti-nuclear opposition in the area focused on the coastal nuclear plant at Flamanville. At La Hague, too, strikes and demonstrations focused on working conditions and environmental risks. There was opposition to shipments of foreign spent fuel through Cherbourg, and the repatriation of wastes by rail to Germany triggered the mass protests at Gorleben over the years which have had such a profound impact on nuclear policy in that country.[5] La Hague, a peripheral location, has been the fountainhead of international protests, with profound repercussions elsewhere along the sea lanes and rail routes that link it to controversial sites elsewhere.

The La Hague reprocessing plant has become increasingly integrated into the traditional local community. It has played a role in the modernisation of the area, reducing its former isolation and bringing high technology and jobs to offset the decline in its manufacturing base centred on the port of Cherbourg. Areva (the company that manages the plant, now renamed Orano) is a dominant economic player, directly employing 5,000 people and with a significant multiplier impact on the economy. There was, in earlier years, a palpable ambiguity in the relationship between the industry and the community, put to me by a trade unionist I interviewed: 'The industry is not necessarily popular... but it is necessary... it would be a catastrophe if it closes.'

Areva has made conscious efforts to overcome the wariness and reserve through a policy of openness and participation, support for investment research, and training to contribute to diversification in the region. La Hague has become an established element in the community; indeed it might almost be said that it has become a traditional part of the landscape in the North Cotentin – so much so that even trenchant anti-nuclear activists like Didier Anger of CRILAN recognise the role of the industry in the region:

'The soup is good and we want more. Yet everyone is fearful of nuclear at the same time. They are stuck between fear of nuclear and fear of the economy. We are all ***immediatistes****.'* (Interview, 2013)

Concern about the radioactive risk to the environment has become institutionalised through the CLI (Local Information Commission). Anti- nuclear activities tend to focus on monitoring, and protests over the very presence of the plant and its activities have long since disappeared. Today, it is the continuing presence of the plant that is at issue, although, here too, fears tend to be internalised rather than expressed. There seems to be a reluctance to challenge and an unwillingness to confront the realities of the changing role of reprocessing.

Didier Anger explained the passive acceptance to me: 'Le Cotentin ressemble à l'autruche: elle met la tête dans le sable, elle ne voit pas le chasseur, mais le chasseur lui tire dans les fesses avec son fusil.' ('The Cotentin is like the ostrich. It puts its head in the sand, it doesn't see the hunter, but the hunter fires into its backside with his gun.')

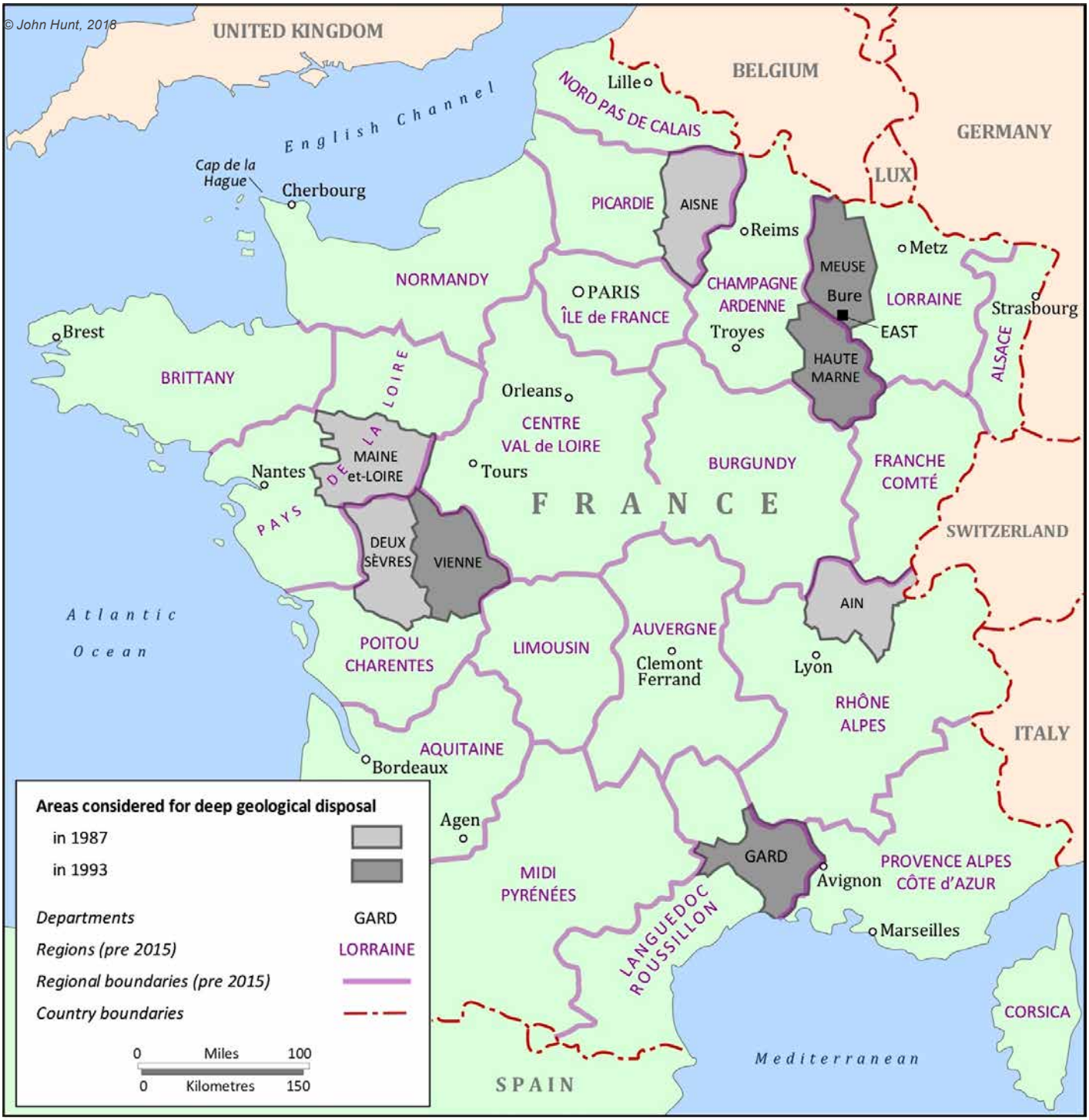
As the nuclear industry in France declines and the original role of reprocessing is questioned, so La Hague will adapt to survive as the centre for management of radioactive waste. It is on that basis that its presence in the Cotentin is secure for the foreseeable future.

Finding a disposal site

Bure is the outcome of a long and contentious process of site selection, the unwitting choice of least resistance. As in other countries, deep geological disposal has become the favoured approach for the long-term management of the most highly active wastes. In France, as elsewhere, the problem was to find a site which could satisfy both geological conditions of safety and social conditions of acceptability.

Early attempts focused on finding suitable geological conditions. During the 1980s four sites with four different rock types were identified: two in western France, in the adjacent departments of Maine-et-Loire (schist) and Deux-Sèvres (granite), one in the north, Aisne (clay), and one in the south east, Ain (salt). In a classic exercise of 'decide-announce-defend-abandon', the sites were revealed to unsuspecting communities, immediately provoking tenacious and resolute opposition and leading in turn to withdrawal of the programme in 1990.

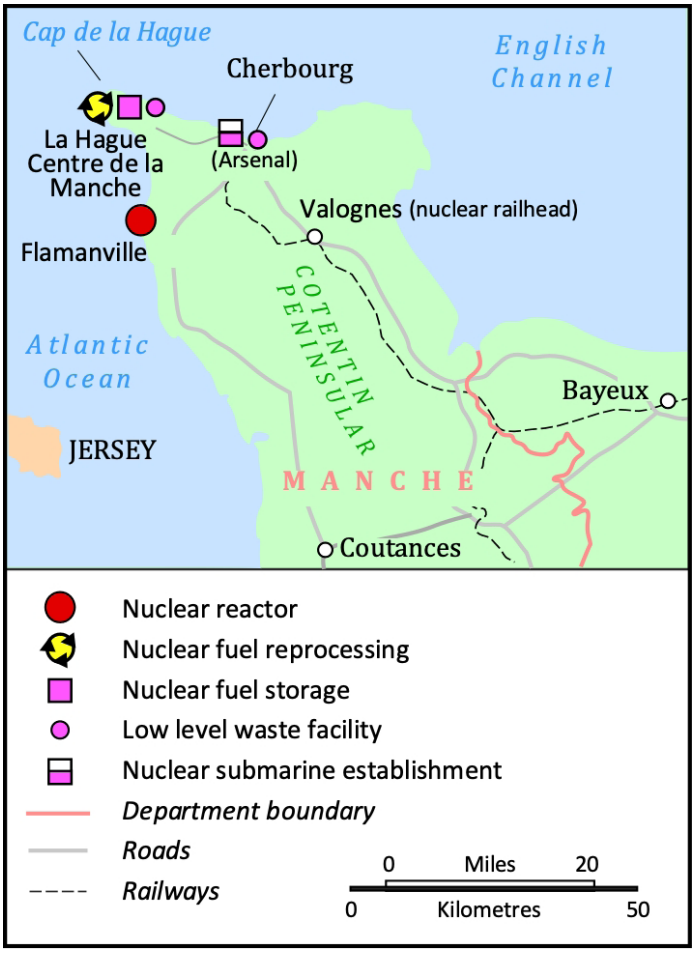
Map showing areas under consideration for deep disposal in 1987 and 1993.



The process of site selection was restarted during the 1990s, this time backed in typical French fashion by the Law on Research in Radioactive Waste Management (1991), which sets out the legislative framework that still governs the process of evaluating and developing approaches. There were three 'axes' of research: one on possibilities of transforming wastes through partitioning and transmutation; another on long-term storage techniques; and a third on evaluating deep-disposal options. The law specified public involvement, including the setting up of a Local Information and Oversight Committee (CLIS).

It was recognised that a successful site selection process would need to satisfy both scientific safety criteria and social acceptability, based on the willingness of local communities. Furthermore, the call for expressions of interest was backed by packages of incentives for economic development.

Site selection was a state-based process led by government through a mediator, Christian Battaille, the architect of the 1991 law and implemented through ANDRA, the national radioactive waste management company. An oversight body of experts, the Commission Nationale d'Evaluation (CNE), provided oversight and advice. Decision- making was partially devolved in a semi-voluntaristic and semi-elitist system of governance. Typically, decision-making was through the representative



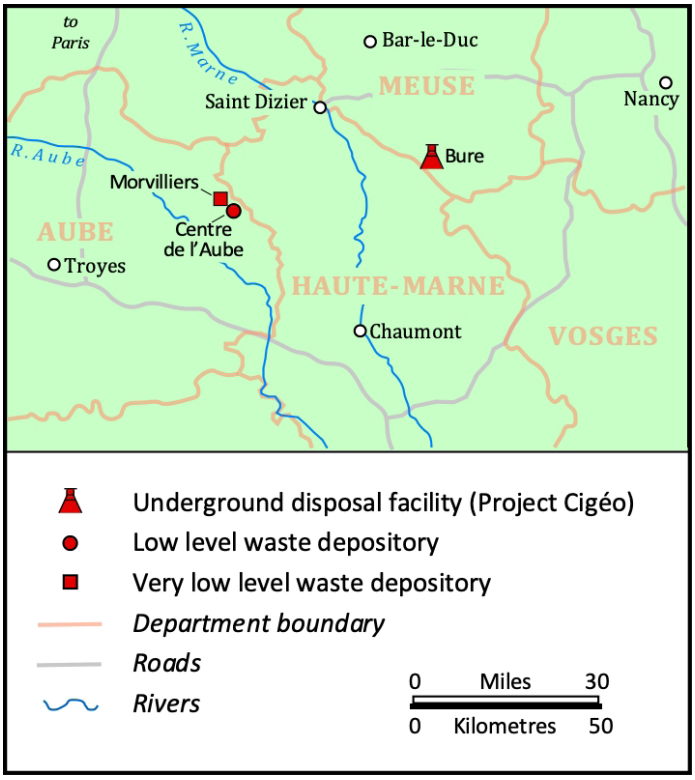
Map of the Cotentin Peninsula. © *John Hunt 2018*

political institutions of regional, departmental and local governments (communes and mayors). The broader public interest was to be taken into account at national level through public consultations called *débats publics* (two of which, in 2005-06 and 2013 have been on radioactive waste) and locally through the CLIS, composed of trade unions, business, agriculture, national, regional and local elected representatives, and environmental groups.

The search for candidate sites was narrowed down to eight departments considered potentially suitable in geological terms, half of which were rejected on grounds of potential opposition. Of the remaining four, which had local support, the western site in Vienne was eliminated on the advice of the CNE as too complex geologically, while the southern site in Gard, near the reprocessing works at Marcoule and in silt formations, was regarded as unfavourable geologically and, perhaps more importantly, opposed by the local wine industry, who felt that their labels could be compromised by association with radioactivity. This left the two adjacent departments of Meuse and Haute-Marne astride favourable clay formations and with public and political support to combine in the selection of a single, so-called East site.

Bure – a nuclear no-man's land

According to Professor Jean-Claude Duplessy, President of the CNE, whom I interviewed in 2013, 'Bure is one of the best sites we might imagine in France.' The local geological conditions are optimal, with deep, thick, hard clay with a good hydro- geological gradient in the Callovo-Oxford clay formation which underlies a wide area in this



Map of Bure and surrounding region. © *John Hunt 2018*

part of eastern France. The precise site was chosen at the border of the two departments, giving each a share in the benefits for economic investment and development put forward in the 1991 law.

Bure is the end of the line, the place where much of the high- and intermediate-level waste from Marcoule and other nuclear sites, and ultimately from La Hague, may eventually be buried. As yet, there are few physical signs of its manifest destiny. In Bure the industry's footprint is growing, although the tranquillity of the region is not yet disrupted.

'Bure is in the middle of nowhere,' according to Gerald Ouzounian of ANDRA (interview), in a 'no-man's land',[6] deeply rural with few inhabitants, tiny settlements and small towns – Bar-le-Duc, Joinville and St Dizier – nearby and bigger cities such as Nancy an hour away.

This obscure area is undergoing a gradual transformation as the modern intrudes on the traditional, in the creation of the country's latest nuclear wasteland. But it will be a wasteland only partly visible, for the idea of the project is to bury the wastes in galleries below 500 metres deep in the body of the earth, with engineered and geological containment that will remove it from the surface for hundreds of thousands of years. It is a wasteland silent and invisible, its function at once transcendent and immanent.

Bure is peripheral in terms of its remoteness, a borderland on the edge of geographical, administrative and cultural regions. It is also economically marginal, underdeveloped and sparsely populated – a rural backwater where development is difficult. The underground laboratory has been created and tests have been undertaken to determine the containment properties of the clay, waste disposal methods, monitoring, and security. The repository itself, if it is eventually constructed, will be in a different nearby location, a 'pilot' project receiving some wastes from Marcoule before taking wastes from La Hague towards the end of the century.

In such a peripheral location the project was able to develop almost by stealth, like a thief in the night. There has been a process of narrowing the options. Of the research axes, deep disposal has become the option for long-term management. The favoured geology has become clay and, therefore, Bure has become the favoured location. The first stage of development at Bure was an underground laboratory, a testing ground for technological feasibility. The repository will be developed as a pilot industrial phase in the first instance, and, in the spirit of cautious compromise of the 1991 law, the project will be reversible for around 100 years before closure. 'Thus, and no one had thought of this before, we can now envisage getting rid of the waste without really getting rid of it, since we bury it while being able to reverse the decision at any time.'[7]

Bure has undergone a metamorphosis over the years, from being one of several possible sites, to a site under investigation, to its present status as an underground laboratory before its future transformation via a pilot phase into a separated, fully fledged deep-disposal facility. Such a gradual evolution from possible to potential to palpable has been achieved with relatively little resistance, from a small local population, acquiescent and passive, accepting of the benefits that go with the project.

Opposition to Cigéo locally is necessarily thin on the ground, and public concerns have tended to be represented through the CLIS. The relationship between community and industry, mediated through the CLIS, has been crucial and creative, although its Secretary-General, Benoit Jacquet, confessed in 2005 that the 'CLIS doesn't have a place in the decision-making process – so it must make its place', which it does through investigations, consultations and raising awareness of issues.

More vigorous and antagonistic opposition has been fomented in typical French fashion through ephemeral 'manifestations', mass rallies organised by anti-nuclear networks drawing on a wider regional base.

More recently opposition has taken a more vigorous turn as opponents have occupied the woodland under which the repository is intended to be built, giving a permanent base for various actions, including damaging the hotel built near the site. The protest settlement was cleared in a confrontation with police in February 2018, while a network of support groups staged protests in other French cities. The insurgency, anarchistic and political, is redolent of the mass protests and confrontations against nuclear power in France in the 1970s. It is set against the erstwhile resignation and patriotic acceptance of this part of eastern France, summed up by Bernard Fauchier of ANDRA: 'We had Verdun, we had Sedan, we are tough people – see what we are ready to do for France.' But, as the project proceeds, so its hitherto relatively untroubled progress will inevitably meet with more resistance as Bure, no longer a backwater, becomes a focus of the conflict over nuclear power.

The Cigéo facility at Bure. *Source: ANDRA*

On the edge but in the frame

La Hague and Bure are two places on the geographical margins but increasingly intertwined as the emphasis of the French nuclear project shifts gradually but inexorably towards the back end of the nuclear cycle – reprocessing, clean-up, and radioactive waste management. La Hague's role is being reinvented as reprocessing of spent fuel moves from producing nuclear materials to vitrifying and storing waste. For the present, La Hague has an accepted role and has become integrated within the local community. By contrast, Bure is at a very early stage in becoming the place where wastes reach their final destination. Industry and community co-exist, but modernity has barely touched the traditional communities that make up this relatively empty landscape.

So, the periphery becomes the centre as the nuclear cycle revolves and resolves the problem of nuclear waste management. There are many social and scientific issues to be resolved before it will be possible to claim that the problem will be solved, if it can ever be. Therefore there is still some way to go before La Hague and Bure can assume their ultimate destinies. France is only now reaching the point where its vast but ageing nuclear fleet will be gradually decommissioned. The future of reprocessing may be open to question, and the repository at Bure is not yet established. But, for a long while to come, inertia is likely to prevail and reinforce these places in their role as guardians of the nation's most dangerous nuclear wastes.

Notes

1. As described by Françoise Zonabend in *The Nuclear Peninsula*. Cambridge University Press, 1993
2. G. Hecht: *The Radiance of France: Nuclear Power and National Identity after World War II*. MIT Press, 1998
3. Y. Marignac and M Besnard: *The French Nuclear Industry in Deadlock: The Burden of France's Nuclear Gamble in the Era of the Energy Transition*. WISE-Paris, for Greenpeace France, June 2015. www.sortirdunucleaire.org/IMG/pdf/wise-greenpeace-2015-the_french_nuclear_industry_in_deadlock-executive_summary.pdf
4. F. Zonabend: *The Nuclear Peninsula*, p. 13 (see note 1)
5. Gorleben and its role in the German nuclear conflict is the focus of the next article in this series
6. B. Cramer and C. Saïsset: *La Descente aux Enfers Nucléaires: Mille Milliards de Becquerels dans laTerre de Bure*. L'Esprit Frappeur, Paris, 2004
7. M. Callon, P. Lascoumes and Y. Barthe: *Acting in an Uncertain World: An Essay on Technical Democracy*. MIT Press, 2009, p.151

Gorleben, the power of the periphery

In the fifth of a series of articles on the local and social legacies of nuclear energy, Andrew Blowers considers the conflict over the nuclear waste facilities at Gorleben, which proved pivotal to the end of nuclear power in Germany.

In the flat middle reaches of the Elbe River in the plains of Northern Germany lies the 'Wendland', a peripheral region of sturdy traditional farms and villages, arable land, forest, heaths and waterland, an area sparsely populated and distant from motorways and big cities. On a straight country road bordered by forest and close to the Elbe is Gorleben, an unremarkable, peaceful village with a most remarkable recent history.

Here, hidden in the nearby woods and ringed by guarded security fences, are two industrial sites. On one site are the headworks, offices and ancillary buildings that serve an excavated salt dome 850 metres below ground, for long explored as the prospective geological disposal facility for Germany's highly active radioactive wastes. Nearby is another complex comprising an interim store for vitrified high-level wastes, a low- and intermediate-level waste store, and a mothballed pilot conditioning plant for preparing wastes in a suitable form for final disposal. Although peacefully secluded now, the mine and the store have been the focus of the most fiercely contested struggle over nuclear energy in Germany, lasting over 40 years. The conflict over nuclear waste at Gorleben ultimately engulfed the whole country, culminating in the phase-out of nuclear energy in Germany. The power of the periphery proved decisive.

In this tranquil land there is still visible evidence of the struggle that has now subsided. On roadsides, in villages and in fields and on farms in the surrounding region, yellow wooden crosses are encountered, the emblem of Gorleben's protest. On walls and on the tall electricity substations graffiti and slogans are daubed, proclaiming 'Stop CASTOR', referring to the huge containers that carried wastes to the interim store. Among other slogans, now fading, are *'Ausstieg'* ('Climb down') or *'Wir stellen uns Que*r' (roughly, 'We make our stand'), belligerent testimony to the determination of protesters.

In a roadside clearing close to the mine is the astonishing site of a ship, the *Beluga*, once used by Greenpeace for protests, now erected on dry land to greet workers, protesters and visitors. A history of anti-nuclear protest is posted in an open-air display, while in a clearing there is a wooden building, an information centre and a place where regular services are still held. The spirit of the Gorleben movement appears indomitable and persistent.

In the middle of Germany, in the middle of nowhere

Wendland is a historical and cultural construct. It derives from the Wends, a Slavic tribe who settled in the area during the late Middle Ages, part of the criss-crossing movement of peoples typical of the boundless and borderless North German Plain. In truth little is known of this peasant community of 'tillers and herdsmen living in small villages and raising corn, flax, poultry and cattle'.[1] Yet, centuries later, the notion of Wendland has been appropriated by a movement dedicated to defending the

Aerial view of Gorleben and the surrounding area.
Main photo: GNS Gesellschaft für Nuklear-Servic. Inset: Andrew Blowers

integrity and identity of its territory against the disruption and risk of an unfamiliar and dangerous intruder.

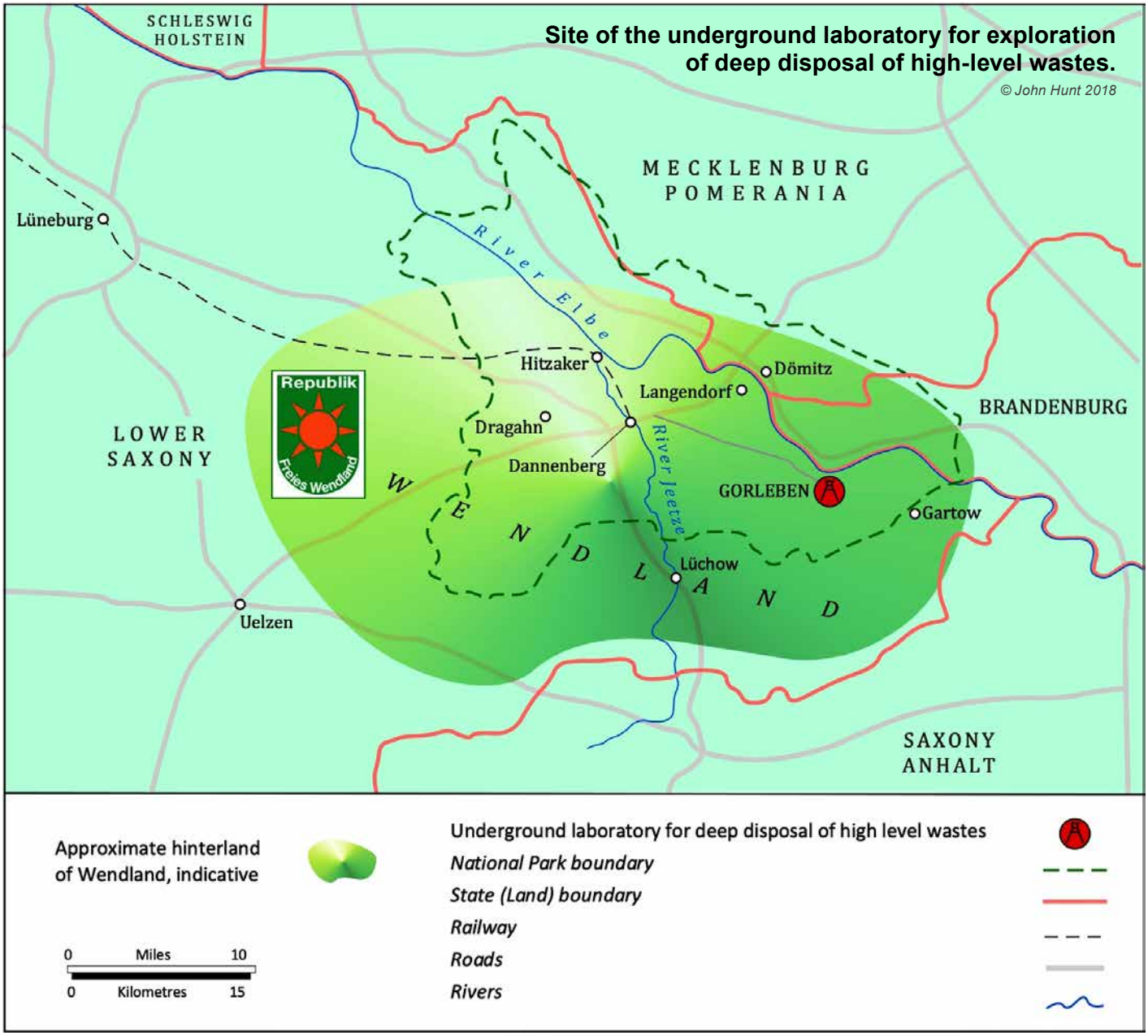
The reinvention of Wendland was made vaguely palpable by the invention of its iconic flag, a startling orange pointed sun on a deep green field, and through the issuing of passports to the Republik Freies Wendland (the Free Republic of Wendland). Its territorial extent was ill-defined. Nonetheless, the idea of a nuclear-free Wendland gained traction, inspiring an incipient tourist industry to promote a land of 'peace and seclusion and pure nature' and to prepare a bid for its traditional landscape and buildings to become a UNESCO World Heritage Site.

Wendland's cultural identity exists within a shared territorial integrity. On its northern side it is bounded by the Elbe, while the border with the former East Germany continues round its eastern and southern sides. The landscape of the eastern part is the waterlands of the Elbtalaue and the forested heathlands, while to the west the agricultural landscape is dotted with traditional 'rundling' villages with their pie-crust layout.

The Wendland is roughly co-terminous with the Landkreis (county) of Lüchow-Dannenberg. Once a borderland, now, as Peter Ward, a manager at the mine puts it, Wendland is 'in the middle of nowhere in the middle of Germany'. When the salt mine was identified as potentially suitable for a deep repository in the 1970s, its peripheral situation of remoteness, low population and underdevelopment seemed to make it a suitable choice. Without comparative site evaluation or public engagement, in a classic exercise in 'DAD', Gorleben was 'decided and announced and defended', with one side defending the nuclear complex, the other rising in defence of their community.

The battle for Wendland

Over the years, the conflict over Gorleben has ebbed and flowed. In the early period, first on the border, then, after reunification, an internal periphery, Gorleben gradually developed its central position in Germany's nuclear politics. As Susan Matthes of Greenpeace described it to me in 2014,



'For many years the only place was Gorleben. It was the end of the world.' The conflict was confrontational almost from the outset and, over time, became increasingly uncompromising. It was played out against competing and shifting discourses being shaped by and shaping vicissitudinous power relations.

From the outset the Gorleben movement was able to mobilise resources – political, economic and social – that rendered an anti-nuclear discourse mainstream and normative. By contrast, pro-nuclear interests, after their initial incursion and establishment of their presence in the Wendland, eventually became marginalised, defensive and ultimately defeated. The resources available for deployment by the protagonists shifted over time in favour of anti-nuclear interests as the conflict over Gorleben escalated into a far wider conflict over nuclear waste and eventually nuclear power in Germany. But, for Gorleben, the conflict is not yet over, victory is not yet complete.

The Gorleben anti-nuclear movement had its foundation and fountainhead in the community. Its local leadership included a Green MP, an MEP, a count who had refused to surrender his land to the mine, and a pastor, as well as environmental activists drawn to the area. Local citizens and activists were able to mobilise under the aegis of the Burgerinitiativen (BI), a network of local groups set up as part of an effort to expand citizen participation in politics.[2]

The Lüchow-Dannenberg BI devoted itself to the nuclear issue and to Gorleben specifically. With a wide local membership it engaged in consciousness- raising, networking and organisation, and was the ideological inspiration of the movement. Another vital group were landowners and farmers, adding a conservative but combative approach, fearful that the nuclear presence might harm the image of their produce and intent on maintaining stewardship of land and forest. The farmers provided practical support, blockading roads with tractors, crops and manure in effective disruptions.

Then there were supporters from beyond the Wendland, from cities like Hamburg, radical and willing to engage in actions and demonstrations. The anti-nuclear protests could also draw on regional and national environmental groups.

Iconic symbols of Gorleben's protests. *Photos by Andrew Blowers*

The Gorleben movement, with its multifarious composition, displayed leadership, determination, organisation and resilience, together with an ability to weld together disparate and cross-cutting groups intent on a single purpose. The protests were on the whole peaceful but forceful, adopting the full panoply of tactics, including rallies, lobbying, demonstrations, marches and sit-ins, supported by pamphlets, petitions and displays of the iconic flag of Free Wendland. Occasionally, a more militant element was attracted in actions attempting to block transports of nuclear casks into Gorleben.

The pro-nuclear interests drew their strength from economic and political sources. The nuclear industry promised jobs and investment in an underdeveloped area. It provided direct financial support, the so-called 'Gorleben Gelder', and indirectly supported the economy through taxes and wages. The workforce, though mainly skilled, was never large, and, according to workers I spoke to, they felt threatened, 'like footballers coming onto a playing field where the opposing team has been playing for some time'. Throughout the conflict, the industry was unable to provide a strong enough presence, and its influence diminished over time as its position weakened both locally and at national level, leaving its workers insecure.

Politically, the nuclear interests could draw on the support of local councils keen to support the project for the economic incentives that it would attract from the federal government. Even so, the strength of political support varied among councils at local, county, regional (Land) and federal levels, often on party-political lines. The pro-nuclear interests were a loose assemblage of industry, workers and politicians, with wavering support from federal government and ultimately no match for the organised, flexible and focused forces ranged against them.

The dynamics of the periphery go some way to explaining the outcome of the conflict. The peripheral location and underdevelopment of the region exerted a pull on an industry being pushed to find a suitable location. At the same time, the community at the periphery found the social and political leverage to push back the invader and eventually pull in external support to halt the project.

With substantial political support at federal and *Land* (Lower Saxony) level, a mine and an interim store were established. But the local community drew its strength and self-consciousness by reviving its cultural identity to defend its traditional values against modernity in the form of nuclear technology. It was not simply a conservative reaction; it was, too, a rather proactive response – an expression of environmental politics, a claim for local democracy, a rejection of risk, and a campaign for a sustainable environment.

The triumph of protest

During the 1970s the federal government was seeking a site in the state of Lower Saxony for an *Integrietes Entsorgungskonzept* (Integrated Waste Management Concept) – a combination of reprocessing plant, waste processing and conditioning facility, and a deep geological repository. The search was pre-empted when the Premier of Lower Saxony identified Gorleben, which became the only site for the project. There is an absence of data about the selection, and in Peter Ward's view 'No one knows the real reason why Gorleben was chosen in the first place'.

This was a time when protests against nuclear power were large scale and sometimes violent as communities 'reacted as if they had been handed a rattlesnake'.[3] In some cases, as at Wyhl in South West Germany in 1975, the mass protests contributed to the abandonment of nuclear projects. In the absence of public and stakeholder participation and a closed, exclusive and elitist decision-making process of institutional expertise, the contest over nuclear energy became inevitably confrontational. As John Dryzek and colleagues explain: 'The environmental movement in Germany therefore encounters passive exclusion in which opportunities for formal political inclusion are limited and unconventional challenges to governmental authority have been strongly resisted.'[4]

The first major action was a long trek from Gorleben to Hannover to a mass protest estimated at 100,000, which gathered in March 1979 at the Gorleben International Review at the time of the accident at Three Mile Island. In response, the proposal for a reprocessing plant was withdrawn, and the failure to find another site led to the abandonment of reprocessing elsewhere in Germany and reliance on La Hague (France) and Sellafield (UK).[5] With reprocessing eliminated, a critical part of the *Entsorgungskonzept* was forfeited, and opponents could focus on the other remaining two components of the project. For the first decade or so, their target was the mine, where various actions were staged, mostly peaceful, others more intimidatory, and all pursued with characteristic inventiveness.

By the mid-1990s attention switched to the interim store and attempts to prevent the giant CASTOR flasks filled with high-level wastes being transported to Gorleben from La Hague in France. The annual protests against the transport were most spectacular around the turn of the century, with large numbers of protesters intent on disrupting the railways and blocking the roads matched by green uniformed police deployments armed with water cannon, riot gear, helicopters, and tanks. As one protester, Thomas Hauswaldt, observed to me at one of the demonstrations:

‘In November, everywhere the leaves have fallen. But, in our forests the leaves are still green – there are so many police.’

By the early years of the new century it appeared that the objectives of the Gorleben movement had been achieved. The Red-Green (Social Democrat- Greens) coalition in federal government passed the Atomic Energy Act of 2002, which reflected a consensus achieved on nuclear policy. Under this there would be:

- a gradual phase-out of nuclear power;
- the abandonment of reprocessing once the contracts with France and the UK had been fulfilled;
- construction of interim spent-fuel stores at power plants; and
- a review of nuclear waste policy.

As a consequence of the review, exploratory work at the Gorleben mine would be suspended for between three and ten years and, in view of continuing protests, shipments of casks to Gorleben even from France and the UK eventually ceased.

The Gorleben conflict had now become intertwined with the wider conflict over the future of nuclear energy in Germany. With the reversion to a more pro-nuclear CDU/FDP (Conservative/Liberal) coalition in federal government in 2009, proposals to slow down the phase-out of nuclear energy kindled spectacular protests across the country during 2010-11, including a 120-kilometre human chain of 120,000 people linking two power stations and passing through Hamburg. There were demonstrations at other power stations and in major cities, and a human chain and rally in Stuttgart. Gorleben, too, became swept up in the national protests when an estimated 50,000 demonstrators came to the Wendland to rally against nuclear power. With forgivable hyperbole, Anika Limbach of AntiAtomBonn, told me: ‘In Germany never before and afterwards had there been mass demonstrations of this dimension.’

The opposition covered a broad spectrum, and opposition, already heavily against any further nuclear power, became almost universal in the aftermath of the Fukushima accident in March 2011. The Federal Chancellor, Angela Merkel, took due note of the political weather and, two months after Fukushima, announced a phase-out of nuclear energy by 2022 and ushered in the *Energiewende*, an energy transition committed fundamentally to renewables and energy efficiency. The policy had been informed and justified by an Ethics Commission which argued that nuclear energy had ‘poisoned [the] atmosphere in society at large’ and, accordingly, the focus must be on energy supply ‘that dispenses with nuclear power as soon as possible and that promotes Germany’s path towards a sustainable development and new models of prosperity’.[6]

A new beginning?

Gorleben, for long on the periphery, had been swept up into a broader conflict. The moratorium at the mine had been lifted in 2009, although it was virtually under siege from the vigorous protests intent on disrupting the resumption of exploratory work. The reprieve was brief, and in 2012 the mine was shut and left in a condition of care and maintenance. After more than three decades of struggle, all that remained of the Entsorgungskonzept was a mothballed conditioning plant, a closed interim waste store, and a shut-down salt mine. The triumph of the Gorleben movement was, almost, complete. But while nuclear energy faced its demise, its legacy of wastes remained. And while the Gorleben mine was closed, it had not yet been finally abandoned, and so its continuing presence could not be entirely ignored in the search for a solution to the problem of the long-term management of highly active wastes.

The geography of the legacy of wastes in Germany is complex, a product of incremental pragmatism and premature opportunism. Some projects, deemed unsafe, have been abandoned.

Gorleben protests, and the iconic Wendland flag.
Main photo: GNS Gesellschaft für Nuklear-Servic. Inset: Andrew Blowers

A low-level waste repository developed near the old border in Morsleben in the former German Democratic Republic is one of several facilities, including power stations, that were closed down and are undergoing decommissioning post-reunification. Not far away, on the other side of the former border in Lower Saxony, in a deep salt and potash mine at Asse, drums of low- and intermediate-level waste have been stored. Flooding and brine seepage and the poor conditions of drum storage make this the most serious legacy issue facing the country. Retrieval is difficult, and it would be practically impossible to clear all the drums. Alternatively, if the drums are left in situ, the mine becomes an impromptu, unplanned repository where leakages will inevitably occur at some point.

A rather more pragmatic and planned solution in the same region is Schacht Konrad, a very deep former iron ore mine, where long-lived, non-heat- generating intermediate-level wastes will be buried at a depth of up to 1,300 metres. The mine was long mired in licensing and planning procedures and is currently undergoing conversion to a repository.

Thus Germany has three incomplete repository projects all within a small region straddling the former border: one, Morsleben, under closure; a second, Asse, where the future is uncertain and controversial; and a third, Konrad, destined to be a permanent deep repository. Around a hundred miles further north of these three sites is the now abandoned deep


Map of nuclear sites in Germany.
© John Hunt 2018
North Sea
Baltic Sea
SCHLESWIG HOLSTEIN
Brunsbüttel
Brokdorf
Stade
HAMBURG
Krümmel
Greifswald (Lubmin)
MECKLENBURG POMERANIA
Unterweser/ Essenshamm
BREMEN
GORLEBEN
LOWER SAXONY
POLAND
Emsland/Lingen
BERLIN
NETHERLANDS
HANNOVER
Repositories to be closed
Gronau
Grohnde
Asse
Morsleben
BRANDENBURG
Ahaus
Schacht Konrad
Under development
SAXONY ANHALT
Kalkar
Closed research reactor
NORTH RHINE WESTPHALIA
GERMANY
Rossendorf
DRESDEN
COLOGNE
Jülich
THURINGIA
SAXONY
HESSE
BELGIUM
Hanau
RHINELAND PALATINATE
Karlstein
Mitterteich
CZECH REPUBLIC
LUX.
Biblis
Grafenrheinfeld
SAARLAND
Obrigheim
Phillppsburg
BAVARIA
Neckarwestheim
Karlsruhe
STUTTGART
Isar
FRANCE
BADEN WURTTEMBERG
Gundremmingen
Wyhl
Abandoned power station proposal
MUNICH
AUSTRIA
Nuclear reactors
Interim storage facility for high level (heat generating) waste
Interim storage facility for low and medium level waste
Underground laboratory for deep disposal of high level wastes
Final repositories for low and medium level waste
International boundary
State (Land) boundary
0 Miles 100
0 Kilometres 150

repository at Gorleben. Until a long-term solution is found, intermediate- and high-level wastes and spent fuel, including wastes retrieved from Asse or repatriated from reprocessing in France and the UK, will be stored in interim stores at reactor sites, decommissioning sites such as Greifswald on the Baltic, research centres (such as Jülich) and purpose-built stores at Ahaus in the north west and at Gorleben, less than a third full before closure.

Finding a solution

With the suspension of the Gorleben mine at the beginning of the century, the way seemed open for a consensual approach to finding a long-term disposal solution. An interdisciplinary expert Committee on a Site Selection Procedure for Repository Sites (popularly known as AkEnd) was established in 1999 and reported to its sponsor, the Red/Green coalition government, in 2002. Its remit was to develop a process for finding a site for deep disposal of high- level wastes. The process would be comparative, on the basis of a 'white map' of Germany, unconstrained by specific geology or preferred location.

AkEnd's approach was truly innovative and imaginative, based on an array of geo-scientific and socio-economic criteria, and introducing concepts such as 'potential analysis' for regional development built upon self-realisation through citizen participation. Its progenitor, the late Detlef Ipsen, described it to me as 'an integrated sociological concept', adding 'if regional building is a process then it cannot be determined in advance'. The whole approach was 'a combination of vision and volunteering', with citizens and councils indicating a willingness to participate in site selection. The emphasis on devolution and participative democracy was remarkable in the context of legalistic and rule-bound German governance. But, as AkEnd commented, 'the civil self-organisation is not only an alternative to the representative democracy, but is only politically effective through and in reference to it'.[7]

Once published, the AkEnd report sank out of sight, but not entirely out of mind. A decade later, in the propitious circumstances of the post-Fukushima settlement on nuclear phase-out, the ideas and approach of AkEnd were resuscitated, as a new commission was established in 2013 to develop criteria and a process for selecting a site for a 'final repository mine with reversibility'.

The commission comprised 32 members in four equal sector groups – federal government, the *Länder*, science, and civil society. As with AkEnd, it began with an entirely clean sheet, or rather a 'white map' of Germany, in which all options were open. The AkEnd criteria-based approach would again be used progressively to eliminate areas until a few sites (two or three) would be subject to comparative assessment through underground investigation to find the 'best' site in terms of safety for a period of a million years. And the concept of applying effective intergenerational compensation to achieve the development potential of the selected region was also adopted.

There was, too, an emphasis on the need for public participation throughout a staged process organised by a new federal implementing body responsible for site identification, since it was assumed that no community would volunteer a site. The challenge was a familiar one: to find 'a solution that is based on broad social consensus and can ultimately also be tolerated by the immediately affected population'.[8]

Under the Atomic Energy Act, no site is ruled in and none is ruled out. Gorleben, though frozen, is not yet irrevocably shut and remains a divisive issue. The industry, in its weakened position, will be in no position to underwrite another location. As Georg Arens, a civil servant with the environment ministry BMUB remarked to me: 'Site selection will be funded by the operators but all the time Gorleben is still there. Gorleben is not officially given up but everyone recognises the low probability that Gorleben will be realised.'

For the workforce committed to the project there was a painful sense of loss and regret. Peter Ward summed up the bitter feelings of defeat: 'To tear the heart out of the project – when nobody is left who will speak up for the project; then it is finished – whether or not it is a suitable site. A victory in conflict is never the end of the story.'

The Gorleben movement is not triumphant, but remains wary and unlikely to relax its vigilance. Its continuing purpose derives from the social dimension of peripherality – that shared sense of identity, of longstanding comradeship and common purpose deeply embedded in the older generation and passed down the generations. Wolfgang Ehmke, one of the leaders of the movement, summed up the struggle: 'Our resistance has never been broken. It is a little bit of a miracle that we have struggled on for more than a generation.' It is a resistance that has resonated beyond the Wendland, inspiring a wider anti-nuclear movement that has brought an end to nuclear power in Germany and opened up the issue of how to deal with its legacy of nuclear waste. The transformative power of the Gorleben movement still casts its long shadow over the legacy of nuclear power in Germany.

Notes

1. E. Christiansen: *The Northern Crusades*. Second Edition. Penguin, 1998, pp.27-28 (first published 1980)
2. B. Doherty: *Ideas and Action in the Green Movemen*t. Routledge, 2002
3. R. Dominick: *The Environmental Movement in Germany: Prophets and Pioneers1871-1971*. Indiana University Press, 1992, p.167
4. J. Dryzeck, D. Downes, C. Hunold, D. Schlosberg and H-K Hernes: *Green States and Social Movements: Environmentalism in the United States, United Kingdom, Germany and Norway*. Oxford University Press, 2003, p.41
5. Subsequent efforts to find a site for a reprocessing plant were thwarted by protests, notably at Wackersdorf in Bavaria. This resulted in Germany sending its spent fuel for reprocessing in France and the UK. In 1994 the requirement for reprocessing was dropped, and then abandoned altogether in 2002. It was the necessity to repatriate the high-level wastes from reprocessing in France and the UK that led to protests against the shipments to Gorleben
6. *Germany's Energy Turnaround – A Collective Effort for the Future*. Ethics Commission on a Safe Energy Supply, May 2011. English translation available at http://stophinkley.org/EngRevu/ENERGY%20TURNAROUND.pdf
7. *Site Selection Procedure for Repository Sites. Recommendations of the AkEnd – Committee on a Site Selection Procedure for Repository Sites*. AkEnd (Arbeitkreis Auswahlverfahren Endlagerstandorte,
   Dec. 2002, p.53. English translation available at www.cienciaensocietat.org/upimages/File/Deliberativa_2/10-Site%20Selection%20Procedure%20for%20Repository%20Sites.pdf
8. *Report of the German Commission on the Storage of High-Level Radioactive Wastes. Summary*. Commission on the Storage of High-Level Radioactive Wastes, July 2016, p.13. English translation available at www.nuclear-transparency-watch.eu/wp-content/uploads/2017/02/Summary_Report-of-the-German-Commission-on-the-Storage-of-High-Level-Radioactive-Waste_EN.pdf

Into the future

In the final part of a series of articles on the local and social legacies of nuclear energy, Andrew Blowers considers the issues raised by the long-term management of radioactive wastes and materials.

'We don't inherit this land from our ancestors; we borrow it from our children.'
– Attributed to Native American Chief Seattle, 1780-1866

Nuclear's wastelands are scattered around the world in places where nuclear activities, accidents or deliberate devastation have occurred. They are, at once, visible creations of dereliction, contamination, clean-up and restoration, and areas where radioactivity creates an invisible but pervasive risk. These areas are usually remote, distant from major population centres and, in some cases, constitute reservations deliberately sealed off to restrict access, like Hanford[1] in the US, or areas from which the population has been removed, as at Fukushima and Chernobyl. More typically they constitute nuclear oases where nuclear facilities and communities co-exist in a state of mutual dependency extending down the generations.

These nuclear landscapes, some of which have been considered earlier in this series, are distinguished by their geographical isolation and their historical continuity, a perpetually reproducing pattern in time and space. They are places that manage the legacy from nuclear activities, comprising existing nuclear wastes and known future arisings. This legacy of nuclear power has created an environmental problem that is intractable and difficult enough to deal with. Wastes derived from new nuclear programmes will compound a problem that is, at least, determinable and potentially soluble to one that is indeterminable and, therefore, insoluble.

What is the problem?

By far the greatest volume of radioactive wastes (90%) is low level, accounting for 1% of the total radioactivity. Most of these wastes (over 80%) are managed in near-surface disposal facilities, such as the shallow repository at Drigg near Sellafield, or the Centre de Stockage de l'Aube in Eastern France. Intermediate-level wastes (ILW – 7% volume, 4% radioactivity) consist of resins, sludges, and fuel cladding; while the short-lived ILW can be managed through shallow disposal, the longer-lived ILW remain radioactive over long timescales and have to be managed in stores at nuclear sites or, as in the case of the graphite cores of redundant reactors as at Bradwell, UK, may be left in situ in so-called passive storage until the end of the century.

The Aube storage centre – Centre de Stockage de l'Aube, operated by the French National Waste Management Agency (ANDRA).

The abandoned landscape around the encased nuclear power station in the Chernobyl exclusion zone. *iStock/fotokon*

Higher-activity, heat-generating wastes are more difficult to manage. High-level wastes (HLW) are very radioactive, mainly fission products from reprocessing spent fuel and are held in liquid form and eventually vitrified for cooling and eventual disposal. In countries with a 'once through' nuclear cycle, spent fuel as waste is held in pools or dry casks, usually at power stations. In some countries, for instance France and the UK, spent fuel is considered potentially usable as recycled mixed-oxide fuel (MOX), although the volumes far exceed any conceivable future market. Similarly, there is far more plutonium in the UK than can possibly be needed for fuel or weapons, rising to 140 tonnes by 2020.

The important point here is that these highly active wastes and materials account for around 95% of the total activity in the inventory but a mere 4%, at most, of the volume. In countries with reprocessing, wastes from military operations have given rise to the most hazardous and intractable problems, such as the tanks at Hanford, the ponds and silos at Sellafield, and the widespread environmental pollution and contamination of villages and the Techa River created by the Mayak reprocessing plant near Ozersk in the Southern Urals in Russia. The problems of managing decommissioning and clean-up of existing nuclear facilities and known arisings of radioactive wastes is formidable indeed, without adding to the burden by creating wastes from new build.

What is the solution?

The favoured option for the long-term management of solid high- and intermediate-level wastes is deep geological disposal. The only deep repository opened so far is the Waste Isolation Pilot Plant (WIPP) facility

Inside the WIPP facility 26 miles outside of Carlsbad in New Mexico, USA – the only operating deep repository. *Paul DeRienzo/TRANSCEND Media Service*

at Carlsbad in New Mexico, USA, in a salt formation, dedicated to disposal of transuranic wastes from the US military programme but suspended from operation for three years (2014–17) because of a problem of radioactive release.

Progress towards disposal has been made in Finland, where the Onkalo project under the hard rock of the Baltic has approval and is under construction. Likewise, in Sweden a site has been approved for a similar project, but has been held up by concerns about corrosion of the copper canisters that contain the wastes.

Elsewhere, at Bure in France, Projet Cigéo, an underground laboratory, has been constructed as a prelude to possibly achieving a full-scale repository. In Germany the salt mine intended for a repository at Gorleben has been closed while a fresh search begins. In the UK, too, where a prospective site near Sellafield failed to gain public support, a new siting process has begun; and in the USA the wheel has come full circle back to Yucca Mountain, but may keep spinning as the conflict over the site is mired in political, regulatory and legal conflicts.

Among the other major producers of nuclear waste, Russia is planning an underground laboratory at Krasnoyarsk in Central Siberia, China is investigating sites in Gansu province in the north west of the country, Japan has initiated a repository siting process, and South Korea is at an early stage of planning.

The concept for deep disposal has to demonstrate that the waste containers, the engineered barrier and the host rock (hard, salt or clay) will isolate the wastes from the environment for hundreds of thousands of years. That is a heroic challenge for scientists and engineers and is a major barrier to progress. A site for a repository not only has to satisfy scientific criteria, it also has to achieve social acceptability. Attempts to land a site without public approval or consultation were rebuffed during the 1980s, as in Eastern England, in Sweden, in France and, most significantly, at Gorleben in Germany as communities confronted the nuclear industry.[2]

In response, most countries turned to site selection processes based on community consent (voluntarism), partnership and a recognition of the need for compensation for the burden of risk taken on by communities hosting a locally unwanted national facility. In those countries, like Sweden and France, where geologically suitable sites were identified and communities were invited to volunteer, there was a successful outcome, and Osthammer (Sweden) and Bure (France) emerged on the basis of elimination. In Germany, the US and the UK, where a 'white map' approach was recommended, the process was either not pursued (US), abandoned and a new process initiated (Germany), or was attempted but failed to proceed, as in the UK, where a revised approach has now begun.[3] But, as the government in the UK observes, 'Finding a suitable location for a geological disposal facility is a complex, long-term process that will take many years'.[4]

Periphery and inequality

While deep disposal is presently favoured as the best approach for the long-term management of long-lived, highly radioactive wastes, alternatives may come into the reckoning, and, in the interim, storage is the only available solution. Although every effort is made to find communities willing to host a repository, it is accepted that, for a long time to come, wastes will be managed in what I have called in this series 'peripheral communities'.

These are geographically isolated, relatively insulated communities. They are defined by their economic dependence on nuclear activities and are distinguished socially by their realistic acceptance, resilience and adaptation to their role. This expression of what has been called a 'nuclear culture' has been described earlier in the series in the long established contexts of Hanford and Sellafield. Politically, these peripheral communities are subordinated as they exert relatively little control as decisions affecting their wellbeing and welfare are taken elsewhere. These geographical, economic, cultural and political conditions combine to produce a pattern of social and spatial inequality.

This pattern is a product of a process of 'peripheralisation', whereby unequal power relations exert a pull that confirms and confines the nuclear legacy in existing locations and a push that generally repels the industry from colonising new ones. There is consequently an association of peripherality and inequality, separating and defining nuclear communities.

The inequality experienced by nuclear communities is differentiated by three characteristics. One is the specific cause of inequality, deriving from the physical proximity of a community to an activity that instils that peculiar fear and stigma associated with living in landscapes of nuclear risk. The second is the particular nature of the inequality, which is not manifested in poverty or relative deprivation but, rather, in a cultural awareness of separation, powerlessness and exclusion. These two characteristics

are mediated and moderated by the relative economic prosperity and political leverage that endows these communities with the power to ensure their sustainability and survival.

A third distinguishing feature of these peripheral communities is their *persistence* over time. Peripheral communities associated with other activities such as mining and some heavy and hazardous industries are evanescent, with a lifecycle of growth and decline and, ultimately, death once the resource runs out or the activity is closed down. Nuclear communities, especially those like Hanford, Sellafield and La Hague, never die but continue so long as the legacy of wastes must be managed. Thus the process of management and clean-up of the legacy of nuclear power is a process that persists long after production ceases. The intra- generational inequality that already distinguishes these peripheral communities persists down the generations as a spatial pattern of inter-generational inequality.

It is the inter-generational aspect, the knowledge that radioactivity poses risk to environments and human health for periods extending well beyond our comprehension, that has prevailed on governments to ensure, at least in principle, that the legacy is safely and securely managed. Hence the International Atomic Energy Agency (IAEA) has pronounced a principle of inter-generational equity, couched in a phrase of anthropocentric sustainability: 'Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.'[5] The focus on human impact is reiterated in the principle that 'predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today'. There is a strong strain of stewardship in these pronouncements, a requirement to ensure a continuing presence, a 'duty to preserve this physical world in such a state that the condition for that presence remains intact'.[6]

Storage or disposal? Is that the question?

The difficulty lies in translating these principles of sustainability into processes of radioactive waste management. Seemingly, there is presently a choice between long-term storage and early disposal of wastes. The concepts of responsibility and timescales are the determining factors in making the choice; the question is: for how long should we take responsibility?

There are two approaches to this question. One, based on the idea of *diminishing responsibility,* favours early disposal, the removal of wastes indefinitely from the accessible environment in a secure containment for hundreds of thousands of years. This relieves future generations of the costs, effort and risks of managing the legacy. The near- term risks of disposal may be mitigated by retrievability and, later, by some form of information transfer, but, over the longer term, responsibility is surrendered and the future is left to itself. Ultimately risks cannot be entirely eliminated, but at such long timescales social and physical conditions are unknowable.

Administration buildings at the Fissile Material Storage Facility (FMSF) at Mayak – Russia's only operational facility for reprocessing spent nuclear fuel from VVER-440 type reactors and spent fuel from nuclear submarines, as well as fuel imported from other countries. Inset: An aged radiation sign on the banks of the Techa River – the Mayak nuclear complex dumped 2.68 billion cubic feet of highly radioactive waste into the river from 1949 to 1956. *Bellona. Inset photo: Ecodefense*

The other approach appeals to the idea of *continuing responsibility* and advocates long-term storage as the appropriate method for managing long-lived highly active wastes. Unlike disposal, storage cannot be seen as a permanent solution, neither can it be regarded as an 'interim' solution on the way to a permanent solution. It is, rather, a recognition that it is the appropriate method for the foreseeable future, beyond which other solutions, including disposal, may exist. It implies that we have a continuing responsibility to account for the impact of our actions, but one that is passed on to future generations, who will be presented with the knowledge and resources to manage the risks. While there is a transfer of some of the burden of management, the future will retain the flexibility for decision-making in a context of what might be termed a 'continuing present'.

In passing, it is worth noting that retrievability and reversibility have been proposed as a kind of middle- way hybrid solution. France favours reversible disposal, while Germany has adopted the concept of a 'final repository mine with reversibility'. While such an approach may assuage public anxiety, reversibility is relative, and in practice increasingly difficult to achieve as disposal proceeds. In any case, 'early' disposal is unlikely to be completed for a century at least, leaving ample time for future generations to consider whether or not it is safe to proceed.

These theoretical positions underlie the different approaches to responsibility and timescales that are being pursued. While, in the present state of knowledge, almost all countries envisage disposal at some future time as the final stage, there are variations in the disposal concepts, geology, inventory, timescales and decision-making. In order to achieve a suitable and acceptable site, many countries, as observed earlier, have adopted a devolved approach to decision-making for a national facility. In nearly every case, Finland excepted, progress

The Waste Treatment and Immobilization Plant (WTP) being designed and constructed by Bechtel National for the US Department of Energy at Hanford in Washington State, USA. When complete, it will be the world's largest radioactive waste treatment plant. *Bechtel National Inc.*

has been necessarily slow, although, in view of the timescales and complexities, a trans- generational and interminable process is inevitable.

In theoretical terms of timescales and responsibility, then, long-term storage and disposal are different approaches. However, policy-makers favouring disposal have tended to see storage as a complementary approach, a prelude to disposal, hence the use of the term interim rather than long-term storage. The UK's Committee on Radioactive Waste Management recognised the relationship in pronouncing that 'A robust programme of interim storage must play an integral part in the long-term management strategy'.[7]

Storage is, plainly, an inter-generational issue. At Hanford and Sellafield the task of nuclear decommissioning and waste management is hugely complex and will take decades to complete (in the case of Sellafield at a cost of £70 billion and taking over a hundred years). Elsewhere, there are a myriad of sites, large and small, where redundant nuclear facilities will be left in situ with no firm plans for ultimate removal. Spent fuel is accumulating at reactor sites around the world, left in storage ponds or in dry stores. Even if repositories become available, it will be decades before they will accommodate all these wastes, if at all.

The notion of these wastes being neatly managed, packaged and transferred to a welcoming and pristine repository there to be entombed for ever, as envisaged in a host of glossy brochures and alluring videos, is fanciful. A more likely outcome is a proliferation of waste stores in peripheral locations in deteriorating conditions as a declining nuclear industry moves from production to decommissioning to waste and clean-up. With or without repositories, the present and foreseeable future management of radioactive waste is interim, indefinite storage.

What future for new build?

The legacy of nuclear waste bequeathed by past and present generations from the generation of nuclear power and development of nuclear weapons requires continuing management in the future. It is as necessary as it is inevitable. The creation of further wastes from new nuclear energy is neither necessary nor inevitable. Nuclear's moment, certainly in the West, has passed, although it lingers on in some countries, including the UK, on the basis that it is a necessary part of the energy mix and provides low-carbon energy necessary to combat climate change.

At best this is a transitional argument, since alternative and cheaper forms of renewable energy production and storage capable of providing base-load power and displacing fossil fuel generation are becoming available. In any case, nuclear energy is proving too costly and inflexible and ultimately outmoded, locking in an expensive source of supply far into the future.

Nuclear energy is also problematic on grounds of safety, security and waste. Safety and security may be compromised by routine, accidental, or deliberate releases of radioactivity. Charles Perrow has argued from evidence that accidents are 'normal' in complex systems like nuclear plants, where 'multiple and unexpected interactions of failures are inevitable'.[8]

But the most inescapable consequence of nuclear power is the enduring legacy of long-lived highly active wastes that create and sustain nuclear's wastelands and the peripheral communities around them. Of all the issues in the debate over nuclear power, including need, cost, safety and security, it is the creation of nuclear waste that provokes the most compelling argument against new build.

New build introduces potentially unmanageable problems. The scale and nature of the existing and committed waste arisings is broadly known and, to that extent, it is possible to plan for its future management, whether by storage, disposal or some alternative method. By contrast, the scale of the inventory arising from a new build programme is unpredictable. Above all, new build introduces new problems of timescale and responsibility. As CoRWM puts it: 'New build wastes would extend the time-scales for implementation, possibly for very long but essentially unknowable future periods. Further, the political and ethical issues raised by the creation of more wastes are quite different from those relating to committed – and therefore unavoidable – wastes.'[9]

In the UK, the eight sites nominated for nuclear new build are scattered around the coast of England and Wales. Of these sites, only one, Hinkley Point C, is under construction by a French/Chinese (EDF/CGN) partnerhip; at three sites (Moorside, Wylfa and Oldbury) developers have dropped commitments to invest; and at two sites, Hartlepool and Heysham, there has been no developer interest. This

leaves only two sites in eastern England, Sizewell C and Bradwell B, where the EDF/CGN partnership is still actively pursuing new nuclear development. It is uncertain when or whether any new nuclear stations will eventually begin generating, but, if they do, they will also become storage sites for spent fuel and other active wastes.

Once again, existing locations are being asked (or rather not being asked) to take on an indeterminable burden for an indeterminate period. It is currently assumed that a repository may be available to take legacy intermediate-level wastes by 2040 and high- level wastes/spent fuel by around 2075, with completion of disposal of legacy wastes by around 2130.[10] Therefore disposal of new build wastes would not even begin until well into the next century.

There are sound reasons for doubting these assumptions. It seems implausible, for reasons stated earlier, that a repository could be operating by 2040 or that there would be available capacity to take new build wastes for a substantial new build programme. The timescales are simply too long and, consequently, 'any statement at all about the impacts of current actions and about obligations of current societies towards the future eventually become meaningless'.[11] It is quite conceivable that the wastes will remain stored on vulnerable coastal sites in deteriorating conditions indefinitely.

The UK Government's claim that 'effective arrangements... will exist to manage and dispose of the waste' that will be produced from new nuclear power stations[12] is truly insupportable. There is neither an agreed disposal concept nor an acceptable site in prospect. A deep repository may not materialise for decades, if at all. But at least the search for a repository is based on the principles of voluntarism, partnership, and compensation. By contrast, community consent and participation have not even been sought, nor compensation offered to communities at the peripheral sites where long- term storage of highly active wastes from new build will have to be managed for at least the next century.

It is an approach that is unethical and unacceptable; it is also unnecessary. There is no long-term solution realistically in prospect and, for that reason alone, there can be no justification for any further nuclear development. For the time being, the pragmatic solution is already present in the safe and secure storage of the nuclear legacy where it already is. Without the pressure of finding a solution to justify a new build programme, the search for a repository can proceed in a measured way to ensure that the components – suitable geology, a safe disposal method, and an acceptable site – can be successfully integrated. In the meantime, and for the foreseeable future, peripheral communities in nuclear's wastelands around the world will live with the legacy.

Notes

1. Hanford is the subject of the second article in this series ('Hanford, the nuclear frontier').
2. The conflict over the Gorleben site is described in the fifth article in the series ('Gorleben, the power of the periphery')
3. The various attempts at site selection in France, the UK and Germany are discussed in earlier articles in this series.
4. *Consultation: Working with Communities. Implementing Geological Disposal.* Department for Business, Energy and Industrial Strategy, Jan. 2018, p. 22. www.gov.uk/government/consultations/working-with-communities-implementing-geological-disposal
5. Principle 5: 'Burdens on future generations', in *Principles of Radioactive Waste Management: Safety Fundamentals*. IAEA Safety Series No. 111-F. International Atomic Energy Agency, 1995
6. H Jonas: *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. University of Chicago Press, 1984, p.10
7. *Managing our Radioactive Waste Safely. CoRWM's Recommendations to Government.* CoRWM Doc 700. Committee on Radioactive Waste Management (CoRWM), Jul. 2006, p.13. www.gov.uk/government/publications/managing-our-radioactive-waste-safely-corwm-doc-700
8. C Perrow: *Normal Accidents: Living with High-Risk Technologies*. Updated edition. Princeton University Press, 1999 (first published by Basic Books, 1984)
9. *Managing our Radioactive Waste Safely* (see note 7), p.13
10. National Policy Statement for Nuclear Power Generation (EN-6), Vol. II of II – Annexes. Department of Energy and Climate Change, Jun. 2011. p.16. www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure
11. *The Environmental and Ethical Basis of Geological Disposal*. Nuclear Energy Agency/Organisation for Economic Cooperation and Development, 2006, p.21
12. *National Policy Statement for Nuclear Power Generation (EN-6), Vol. II of II – Annexes* (see note 10), p.13